out think the box

Community Wind—It's needed in the SF Bay Area

Oakland, CA, USA
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Skystream 3.7 image courtesy of Southwest Wind Power

overview

1. introduction
2. definitions and concepts
3. (why) wind turbines in the built environment (can be a good idea)
4. wind site assessement
   - electrical demand
   - wind resource
   - electricity production
   - does a wind system make economic sense?
   - examples of green gone wrong
5. onshore vs offshore
   - pros vs cons
6. other considerations
7. community wind examples
   - examples of green going right
   - usa community wind accounting
   - wind turbines in the sf bay area?
8. parting thoughts

introduction

Out think the box.
Prepare. Respond. Adapt.

"If Boston, MA can do it, why can't 'green(er)' California? And if we can do it, then why can't we own it..."
–Paul Gipe

defintions & concepts 2

- **Built environment**
- **HAWT vs VAWT**
- **Swept area**
- **Small vs Large WTG**
- **Roughness length**
- **Turbulence vs Smooth/Laminar wind**
- **Concentrator effect in the built environment**
- **Capacity factor**
- **Wind power**

Out think the box.
Prepare. Respond. Adapt.

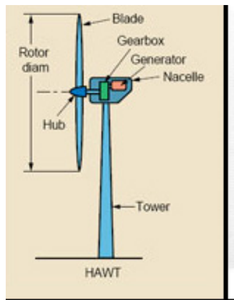
defintions & concepts 3

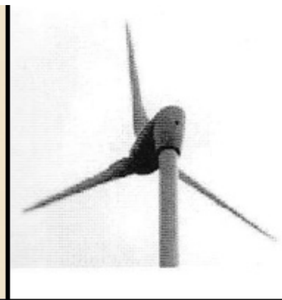
- **Built environment**

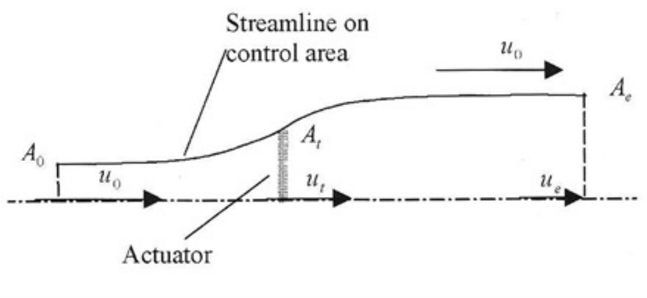
Human-made surroundings that includes buildings, parks, green spaces, neighborhoods, cities.

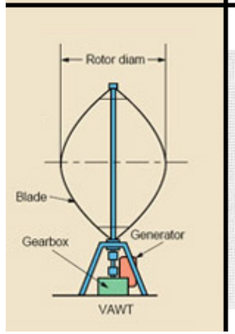
defintions & concepts

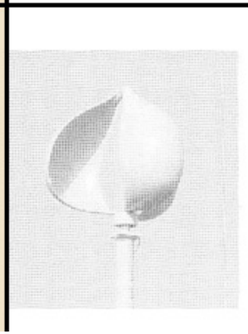
- **HAWT vs VAWT**

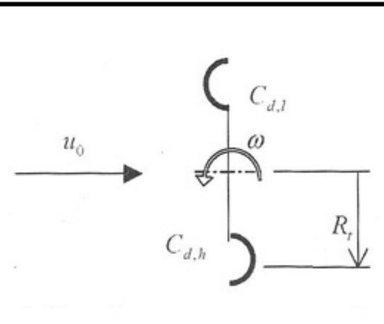












Citations: Mertens, Sander. "Wind Energy in the Built Environment"; http://machinedesign.com/technologies/new-guidelines-promise-reliable-wind-turbine-gearboxes

defintions & concepts

- **Swept area (wind turbine 'collector surface')**
  - Power coefficient, $C_{p,\,max}$

$$C_{p,max} = P / [½\rho u_o^3 A_t]$$

- Lift-driven (HAWT) - 0.59
- Drag-driven (VAWT) - 0.11
- Hybrid-driven (Savonius) - 0.22

The larger the swept area (the longer the blade length), the more energy a wind turbine can capture from the wind.

Linear relationship:

- the greater the swept area, greater the electrical output
- double swept area, double electrical output

Citations: Mertens, Sander. "Wind Energy in the Built Environment"; http://machinedesign.com/technologies/new-guidelines-promise-reliable-wind-turbine-gearboxes

defintions & concepts 6

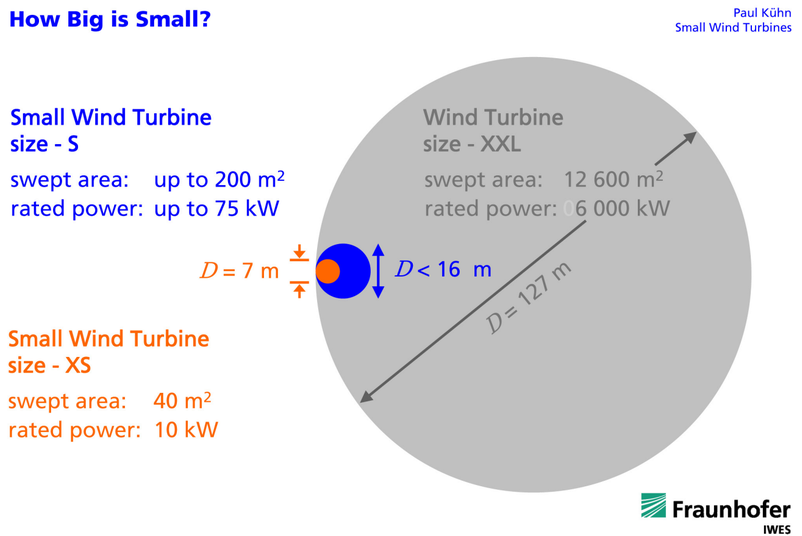
- **Small vs Large WTG (Wind Turbine Generator), according to NREL:**

Small	*Large*
≤ 100 kilowatts (kW)	*> 1MW - 8MW*
Distributed wind includes small and and midsized 100kW - 1MW turbines	*Vestas Offshore V164-8.0 MW rotor diameter 164 m (538 ft.), swept area 21,000m²* *~= 3 futbol/soccer pitches*

Citation: http://www.nrel.gov/wind/smallwind/

defintions & concepts 7

- **Small vs Large WTG (Wind Turbine Generator) cont'd**



defintions & concepts

- **Roughness length**

Roughness length, z_o, is a parameter used in vertical wind profile equations to model the horizontal mean wind speed near the ground; surfaces are more rough if they have more protrusions:

- open sea, z_o = 0.0002m
- grassland, z_o = 0.03m
- city w/high-rise buildings, z_o =≥ 2m

Citation: http://en.wikipedia.org/wiki/Roughness_length

defintions & concepts

- **Turbulence vs Smooth/ Laminar Wind Flow (for a fixed point in space)**

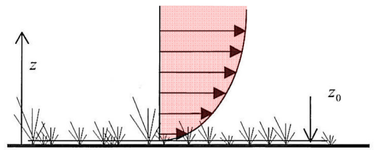
Turbulence - an unsteady flow that can be random; no repeatable sequence/regular variation to the unsteadiness e.g. water splashing from a faucet into a sink

Smooth/Laminar - a steady flow, velocity at a given time and space that does not vary with time

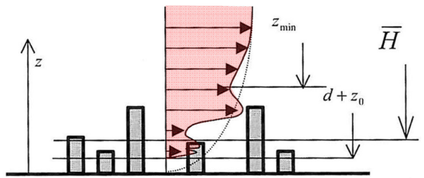
defintions & concepts

- **Concentrator effect in the built environment**

Wind Energy in the Built Environment – Concentrator Effects of Buildings
Sander Mertens, PhD



Wind Flow – typical velocity profile over open grassland



Wind Flow – complex velocity profile over urban environment

defintions & concepts

- **Capacity factor**

Ratio of the actual power output (kWh,MWh) over time to the output of a power plant if operating indefinitely at nameplate/rated capacity

- small wind systems: 10-28%
- wind farms: 20-40%

defintions & concepts

- **Wind power**

$$P = 0.5dAV^3$$

d, air density
A, swept area
V, wind speed

NB: Air density is the least important.

wind turbines in the built environment

Out think the box.
Prepare. Respond. Adapt.

- **Generating proximity**
- **Six R's**
- **Other benefits**

- **Generating proximity**

Generating electricity closer to where it will be used make sense. Adding generation closer to load centers minimizes transmission line losses. Typical losses ~5% of energy transmitted.

- **Six R's**
  - Resiliency
  - Robustness
  - Reliability
  - Redundancy
  - Response
  - Repair

wind turbines in the built environment

- **Other benefits**

Provides:

- local job opportunities
- improved local quality of life
- local reduction in negative environmetal impacts e.g. Greenhouse Gas (GHG) emissions reduction

wind site assessment

Out think the box.
Prepare. Respond. Adapt.

- **Assess electrical demand**
- **Assess wind resource**
- **Economics**
  - Size matters [revisit]
  - Examples of Green Gone Wrong

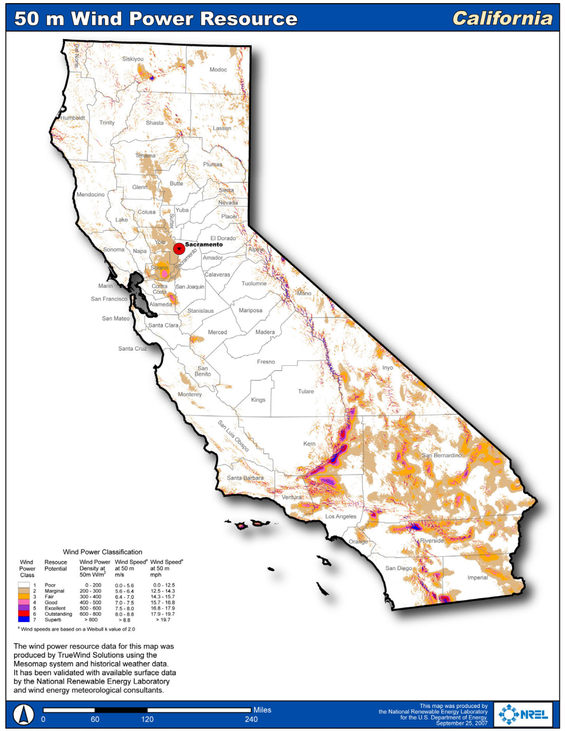
wind site assessment

- **Assess electrical demand**
  - Typically only requires annual electrical consumption for grid-tied systems.
  - Perform a load analysis.
  - Consider energy efficiency measures and practicing conservation first!

wind site assessment

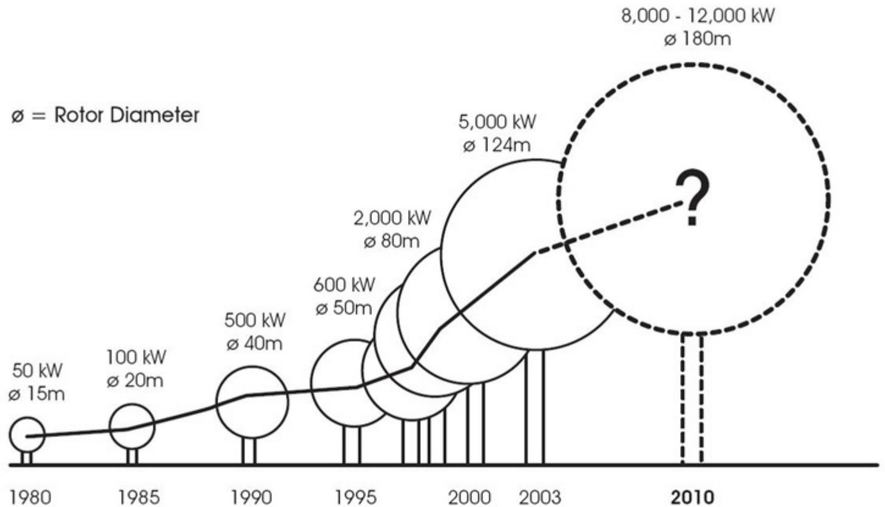
- **Assess wind resource**
  - Direct measurement
  - Local airport and weather service data
  - Wind maps
  - Online resources

NB: Historically, people don't build homes in locations where the wind resource is richest.



wind site assessment

- **Size matters**
  - Visualize the Washinton Monument [~170m]



http://commons.wikimedia.org/wiki/File:Wind_turbine_size_increase_1980-2010.png

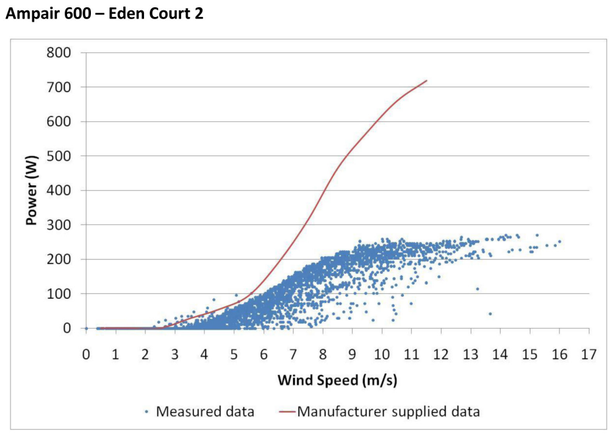
wind site assessment

- **Examples of Green Gone Wrong AKA 'Kinetic Architecture'**
  - Warwick Wind Trials (WWT), UK
  - 12W Bldg Portland, OR
  - Idaho St, Berkeley, CA
  - Greenway Self-Park, Chicago, IL
  - Lexington Farms, Jerseyville, IL

wind site assessment

encraft

- **Green Gone Wrong - WWT, UK, Eden Ct 2**
  - Ampair 600 230 WTG
  - Ave. wind speed: 6.22 m/s
  - Total energy output: 51.64 kWh/yr
  - 141 Wh/day
  - Study capacity factor (avg): 0.85%-4.15% (anticipated: 10%-15%)
  - Study generation mean: 214 Wh/day (enough to power 5 low-energy light bulbs)

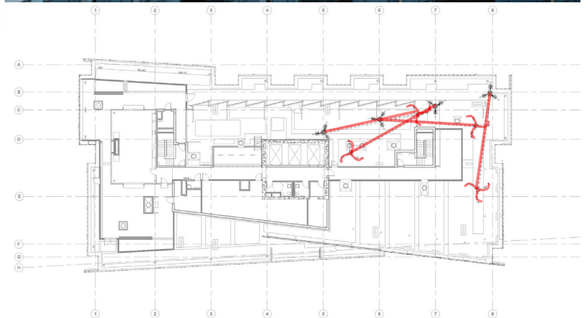


Copyright © Encraft 2009

Citation: "Wind Speed and Energy Yield Analysis of Small Wind Turbines on a 45m High-rise Building in the Built Environment [INTERIM REPORT]", Kimberly King, Loughborough University, Loughborough, Leices, UK

wind site assessment

- **Green Gone Wrong - 12W Bldg, Portland, OR**
  - 4 Southwest Windpower Skystream 3.7
  - Masts installed on rooftop, not vertical support structures
  - Commissioned: Nov2009
  - Energy output (predicted): 10,000 - 12,000 kWh/annum
  - Actual in-use capacity factor: ~1.0%-2.0%
  - LEED Platinum 2x - so what, if science is undermined



Roof Plan

Citation: http://www.zgf.com/portfolio/

wind site assessment

- **Green Gone Wrong**

- Idaho St, Berkeley, CA - Developer oversold:

- Aeropower SL1500 HAWT [1981/1982]
- Generate 400 kW/month
- Cover 90% of the family's PG&E electricity bill
- CEC 55% tax credit incentive
- PG&E purchase excess power generated at $0.072/kWh over 10 years

Citation: http://www.kimgerly.com/projects/wtg_decom.pdf

wind site assessment

- **Green Gone Wrong**

- Greenway Self-Park, Chicago, IL:

- ?? Helix Wind VAWTs
- Orginal company - Aerotecture w/drew from project due to 'low wind', low power output predictions
- Orginal intent - rooftop install

Citation: Conversation w/Helix Wind mechanical engineer, 20Sept2010, http://www.kimgerly.com/wpress/?p=371

- **Green Gone Wrong - Lexington Farms, Jerseyville, IL:**
  - 32 eddyGT Urban Green Energy VAWTs
  - 'First LEED Platinum community of its kind in the USA'—so what if science is undermined
  - "...the solar panels were the 'workhorses' of ths installation"

Citations: http://www.urbangreenenergy.com/case-studies, http://www.urbangreenenergy.com/case-studies; Gipe, Paul, "Questionable Turbines and Siting Give Architects, LEED, Green Builders, and Wind Bad Name", http://tinyurl.com/k9b692v

- **Green Gone Wrong - Lessons learned:**
  - As a consumer, caveat emptor; know...
  - your wind resource
  - your local ordinances
  - how to site your wind turbine generators [WTGs]
  - the WTG(s) specs as per your individual requirements

Out think the box.
Prepare. Respond. Adapt.

onshore vs offshore

- **Definition**

Offshore wind turbine - Fixed bottomed traditional wind turbines or floating structures [deep water areas] installed in bodies of water i.e. ocean, lakes, fjords, sheltered coastal areas.

Citation: RenewableUK 'A Community Commitment' report

Out think the box.
Prepare. Respond. Adapt.

onshore vs offshore

- Onshore wind turbine

- **Pros**
  - cost, cheaper than offshore
  - proximity to electrical infrastructure
  - reduced environmental impacts
  - less costly logistics for installation and O&M required
  - mature as an industry

- **Cons**
  - aesthetics/visual and noise impacts—minimal if sited mindfully
  - avian impacts—minimized if sited mindfully
  - not as efficient as offshore due to terrain roughness

onshore vs offshore

- Offshore wind turbine

- **Pros**
  - less visual impact, less noise issues
  - higher wind speeds
  - bigger projects
  - more predictable, persistent wind patterns
  - scalability to very large size plants
  - oil companies' experience, knowledge-base transfer

- **Cons**
  - higher cost—turbine only ~1/3 cost
  - high levels of policy supported needed (FIT premiums)
  - more O&M, costly logistics required
  - special rules grid connection
  - focus away from locally owned-controlled onshore wind installations

other considerations

- **Zoning**
- **Permits**
- **Covenants**
- **Utility Companies**
- **Insurance**
- **Buying a system**

Out think the box.
Prepare. Respond. Adapt.

community wind examples 32

- **Green Going Right**
  - USA
    - Hull, MA
    - Crow Lake, SD
  - Canada
    - Port Elgin, Ontario
  - The Netherlands
    - Windcentrale
  - UK
    - Cumbria
    - Oxforshire
    - Stirling

Out think the box.
Prepare. Respond. Adapt.

community wind examples (more) 33

- **USA Community Wind Accounting**
- **Where are the SF Bay Area Wind Turbines?**
  - The Other Bay Area
  - SF Bay Area
  - Urban Wind FITs

Out think the box.
Prepare. Respond. Adapt.

community wind examples 34

- **Green Going Right - Hull, MA, USA [as of 8Jun2013]:**
  - Hull 1: Vestas 0.66 MW
  - Commissioned: 27 Dec 2001
  - Total generation: 17,210,661kWh
  - Days commissioned: 4,181
  - Hours generating: ~60%
  - Capacity factor: 26.0%

Citation: http://www.hullwind.org

community wind examples 35

- **Green Going Right - Crow Lake, SD, USA:**
  - Prairie Winds SD1
  - 162 MW installed
  - Owned by 600+ local farmers
  - Crowdfunding kickstart
  - Shares sold in increments of $15,000
  - $6.7 mil grant via 1603 Program
  - Commissioned: Feb 2011

Citations: http://tinyurl.com/ld6nku7; http://energy.gov/eere/articles/want-finance-wind-farm-project-your-community-try-crowdfunding

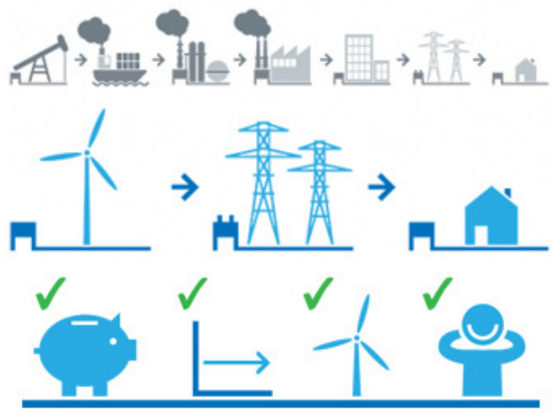
community wind examples 36

- **Green Going Right - Port Elgin, Ontario, Canada:**
  - 500kW WTG
  - Canadian Auto Workers union
  - Timeline: 10+ yrs
  - Commissioned: 25Mar2013
  - Net metering and FIT accepted
  - Pays up to 14.5 cents/kWh
  - Projected payback: 15-18 yrs

Citation: http://www.caw.ca/en/10744.htm

community wind examples 37

- **Green Going Right - Culemborg, NL (SE of Utrecht, NL):**
  - de Windcentrale Co-op wind turbine company [2010]
  - Vestas V80-2MW wind turbine
  - €1.3 mil raised in 13 hours
  - 6,648 shares @ €200/share
  - ~500 kWh/share/yr output
  - €23/yr for maintenance
  - 1700 residential households



Citation: https://www.windcentrale.nl/

community wind examples 38

- **Green Going Right - Cumbria, UK:**
  - Harlock Hill-5 WTGs, 2.5 MW
  - Haverigg II-1 WTG, 600kW
  - Capacity factor (YTD): 22.35%
  - Commissioned: Jan1997
  - 1,300 investors; £2 mil raised thru shares (£300-£20K)
  - Interest payment avg 7% gross/annum to investors
  - Service ~1,000 homes

Citation: RenewableUK 'A Community Commitment' report, http://tinyurl.com/kbvt3ec

community wind examples 39

- **Green Going Right - Oxfordshire, UK:**
  - Westmill Wind Farm Co-op
  - Five 1.3 MW wind turbines
  - 6.5 MW installed
  - Permission gained: Jul 2005
  - Construction start: Fall 2006
  - Commissioned: Mar 2007
  - 100% community-owned
  - £4.6 mil raised + loan
  - ~2,500 homes powered

Citations: RenewableUK 'A Community Commitment' report, http://www.westmill.coop/westmill_home.asp

community wind examples 40

- **Total USA Community Wind Accounting**
  - 2011 - 50
  - 2012 - 27
  - 2013 - ??
- **Are their any community wind projects in California?**

Citation: Community Wind Project Database prepared by Paul Gipe 5Sept2012

community wind examples 41

- **CA Community Wind Example:**
  - Foundation Wind Power
  - Anheuser-Busch, Fairfield, Solano County, CA
  - GE SLE 1.5 MW
  - Commissioned: Nov 2011
  - 3.5 million kWh/annum == ~10% electrical needs

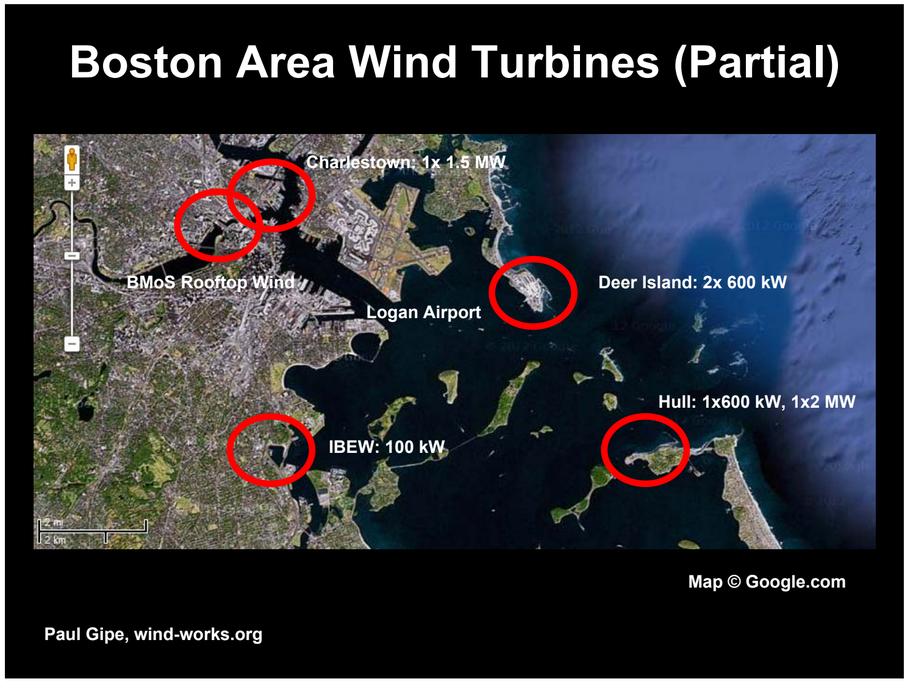
Citation: http://www.foundationwindpower.com/projects/AnheuserBusch.php

community wind examples 42

- **Where are the wind turbines in the SF Bay Area?**
  - Angel Island - 1x50kW, inoperative for 25+ yrs
  - Golden Gate Park, SF - 2x??
  - Idaho St, Berkeley - One 1.5kW wind turbine, freewheeling for 10+ yrs

- **The Other Bay Area vs the SF Bay Area**
  - Boston, MA
  - Paul Gipe's 'Urban Wind in the Bay Area--the Other Bay Area' presentation [Mar2012]

community wind examples 43



community wind examples 44

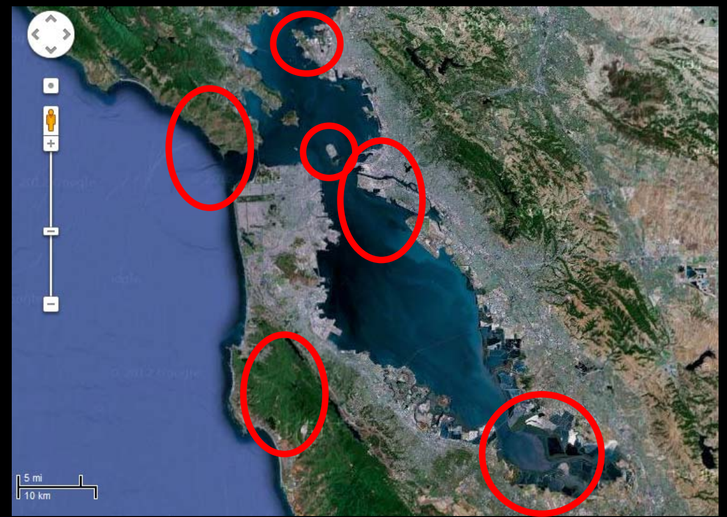
Boston Harbor Wind Turbine Yields

	Area	kWh/yr	kWh/m2
Hull V47	1,735	1,561,032	900
Hull V80	5,027	3,784,320	753
IBEW NPS 100	346	80,000	231

Paul Gipe, wind-works.org

community wind examples 45

Where are the Wind Turbines?

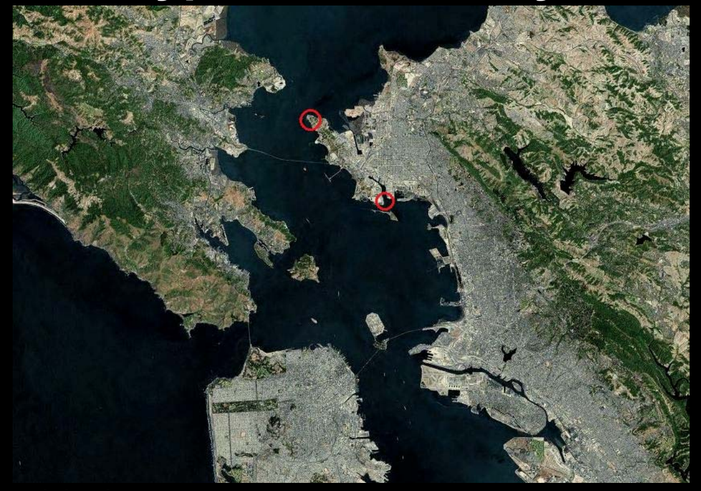


Paul Gipe, wind-works.org

Map © Google.com

community wind examples 46

East Bay Meldan Heaslip MSc Study
Hypothetical--Only!



Paul Gipe, wind-works.org

Map © Bing.com

community wind examples 47

East Bay Meldan Heaslip MSc Study
Hypothetical--Only!

Paul Gipe, wind-works.org

Map © Bing.com

community wind examples 48

- **Point Pinole Regional Park (Hypothetical ONLY!)**
  - 3 Vestas V80 wind turbines
  - Rotor diameter: 80m (262 ft)
  - Tip height: 125m (410 ft)
  - Ave. annual wind speed @ 80m AGL
    - 5.3 m/s - 7.3 m/s (11.9 mph -16.3 mph)
  - Capacity factor: 27%
- **Economics**
  - Installed cost: $2,528/kW
  - Operating cost: $80/kW-yr
  - Discount rate: 7%
  - Project lifetime & financing: 20 years
  - 30% ITC; PTC expired
  - LCOE calculation:
    Annual total energy: 13.1 GWh/yr
    Annual project costs: $1.33 mil
    LCOE
    = $1,330,000/yr ÷ 13,100,000 kWh/yr
    = $0.10/kWh

Citation: Heaslip, Meldan, "Toward Community Wind in the City of Richmond, California"

community wind examples 49

Urban Wind Feed-in Tariffs?

	$/kWh	MW Cap
NIPSCO	0.100	2
Vermont	0.110	1.5
Ontario	0.135	n/a

Paul Gipe, wind-works.org

a parting thought

"Turn farms, homes, and businesses into entreprenueurs."

–Terry Tamminen, Former Chief Policy Advisor to Gov. Arnold Schwarzenegger

another parting thought

Out think the box.
Prepare. Respond. Adapt.

"If Boston, MA can do it, why can't 'green(er)' California? And if we can do it, then why can't we own it..."
–Paul Gipe

For more info go to...
Wind Works News & Articles on Community Power
http://www.wind-works.org/cms/index.php?id=37