

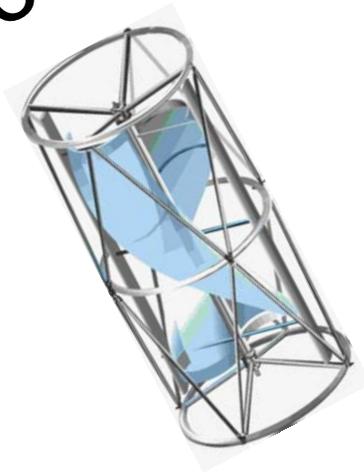
# Urban Windpower: Natural Energy Systems for World Cities

Bil Becker, CEO - Aerotecture International, Inc.  
[www.aerotecture.com](http://www.aerotecture.com)

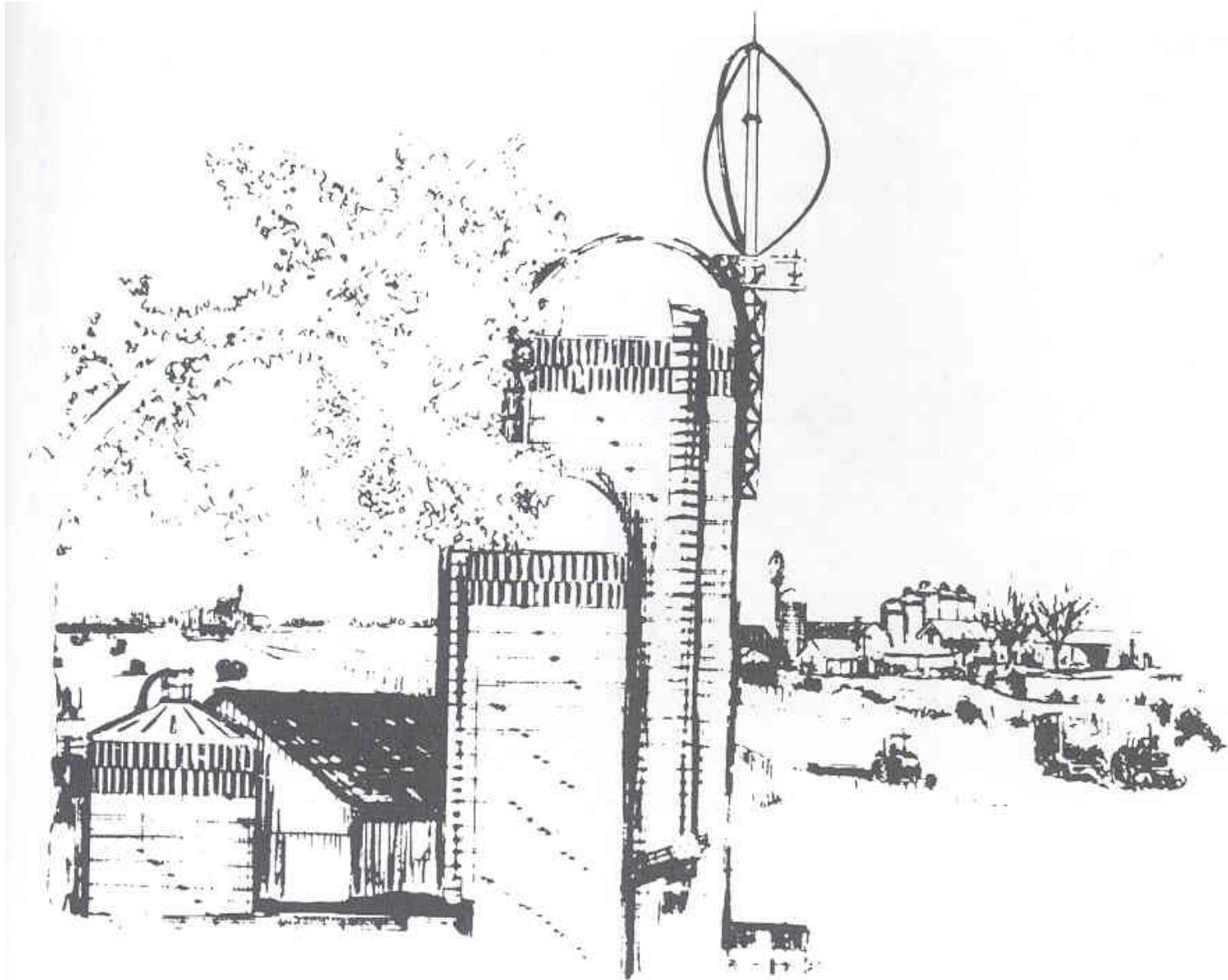
# Aerotechture International, Inc.

BUILDING INTEGRATED NATURAL ENERGY SYSTEMS WORLDWIDE

[www.aerotechture.com](http://www.aerotechture.com)

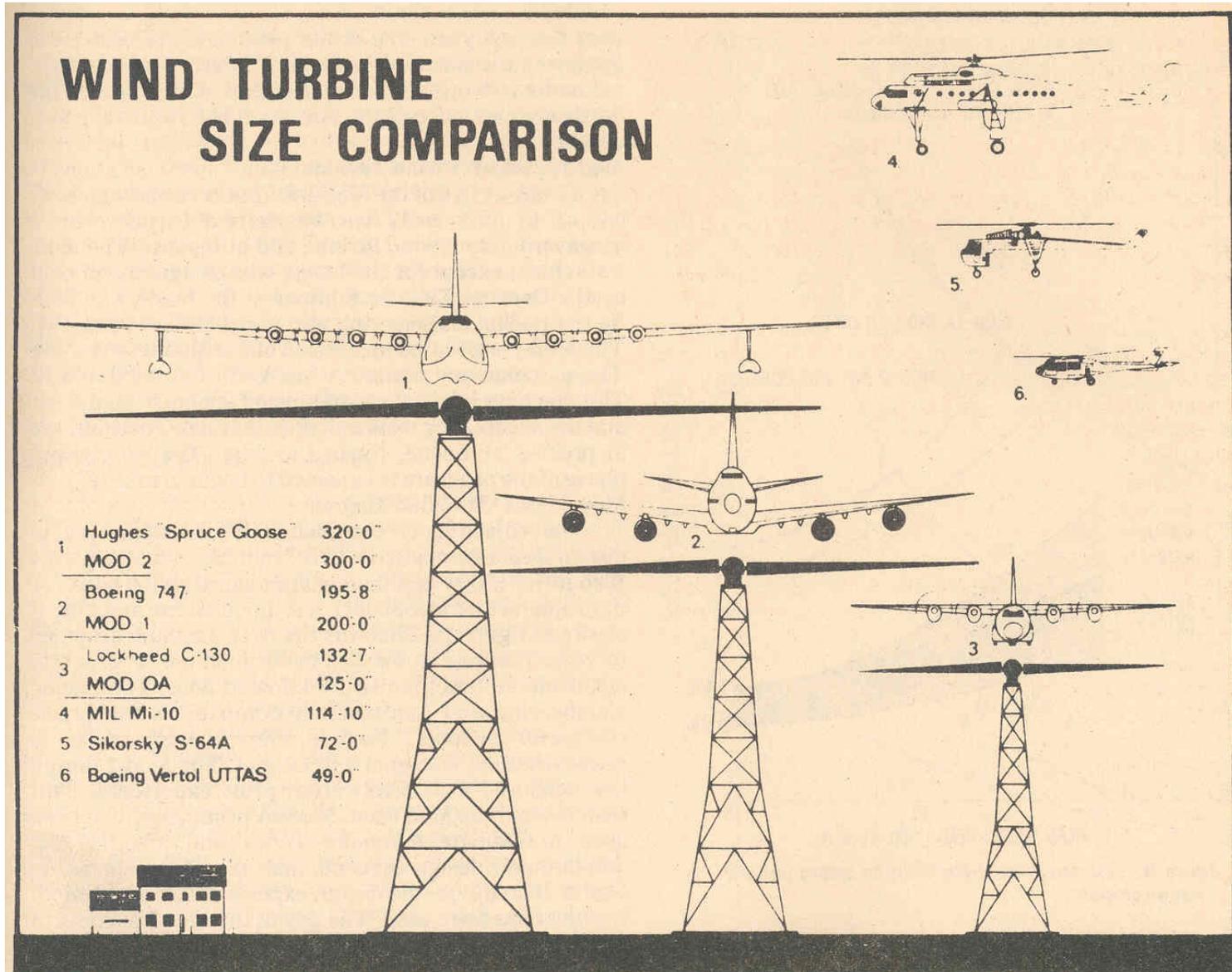


# '70s Alcoa Rural Darrieus Design



# Current Large Windfarm Paradigm

Aircraft Engineers Design Giant Megawatt Windmills



# EU Public Safety Concerns

## Holland experiments with urban windmills

Lighter, quieter and more efficient, turbines are built to take advantage of wind shifts

By DOUGLAS HEINGARTNER  
Associated Press

**Ede, Netherlands** — In this small town whose old wooden mill generates more tourism than energy, a shiny new stainless steel windmill on the roof of a technical school barely whispers as its blades spin in a brisk winter breeze.

Such high-tech turbines, which feed kilowatts to local power grids, are now poised to conquer a new frontier — the modern city center, often fused into building designs and barely noticeable from a distance.

They are lighter, quieter and often more efficient than their lumbering rural counterparts, and built to take advantage of the extreme turbulence and rapid shifts in direction that characterize urban wind patterns.

Germany, Finland and Denmark have also been experimenting with the technology, but the ever-practical Dutch are natural pioneers in urban wind power "mainly because of the lack of space here," said Sander Mertens, a wind energy researcher at the Delft University of Technology.

Dutch cities including Amsterdam, the Hague, Tilburg and Twente plan to install urban windmills in

2003, mostly small-scale projects with fewer than a dozen turbines each.

The prospect of a new, environmentally correct energy source has attracted Dutch energy companies. Cor De Ruiter, a spokesman for one company, Eneco, said research has indicated there are 50,000 locations in the Netherlands where small urban turbines could be installed.

The new windmills pay for themselves in about five years, according to the Dutch manufacturer Prowin.

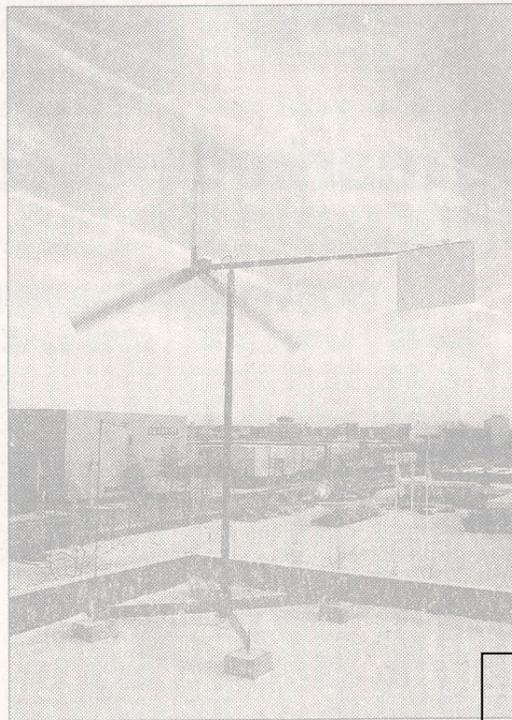
And as the technology improves, prices will drop further. The smallest models weigh roughly 440 pounds and can be installed on a roof in a few hours.

"All the technical problems are behind us now," says Dick Sidler, an engineer at Core International, another company that builds the latest-generation turbines.

Current models cost \$5,000 to \$12,000.

The windmill on the roof of the technical school in Ede can generate about 5,000 kilowatt hours of energy per year, which would cost \$900 if taken from the fossil-fuel-powered grid.

That's more than enough for the average Dutch household, which consumes roughly 3,500 kilowatt



Holland's wooden windmills have been losing ground to turbines like this one atop a school in Ede, Netherlands.

hours per year — the average American family uses 10,000 — although most new windmills are designed more for public or commercial buildings than for private homes.

The Netherlands, with 16 million people crowded into a country twice the size of New Jersey, is the most densely populated in Europe.

It generates less than 1% of its electricity from wind.

In Denmark, that figure is 18%; Germany, 4%.

In the United States, it's a fraction of 1%.

But Holland has on average 245 days per year with wind speeds of 13 to 19 mph, which can power even the biggest turbines.

Many of the new urban turbines can begin spinning with wind speeds as low as 5 mph.

With fewer moving parts than their rural kin, urban turbines generally require less maintenance.

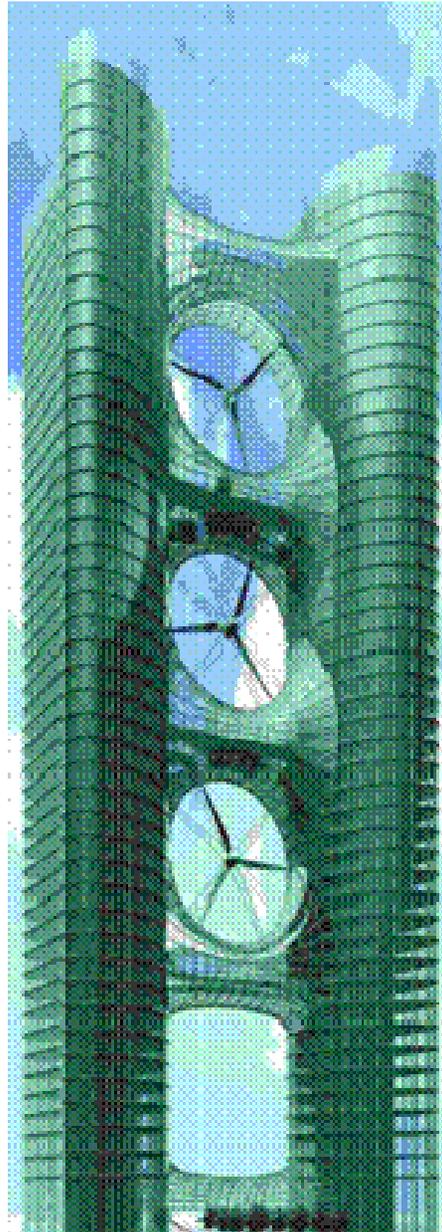
And because the energy they generate is close to where it is consumed, less electricity dissipates while crossing transmission lines.

Problems remain, however: notably public safety concerns.

"Just one accident would be enough" to quash enthusiasm for the idea, said Mertens, the researcher.

One theoretical danger, runaway windmill blades, could be averted by covering the turbines with gratings, he said, but the effect of vibrations on local buildings and inhabitants is still unknown.

# EU Vertical Windfarm Paradigm Fails

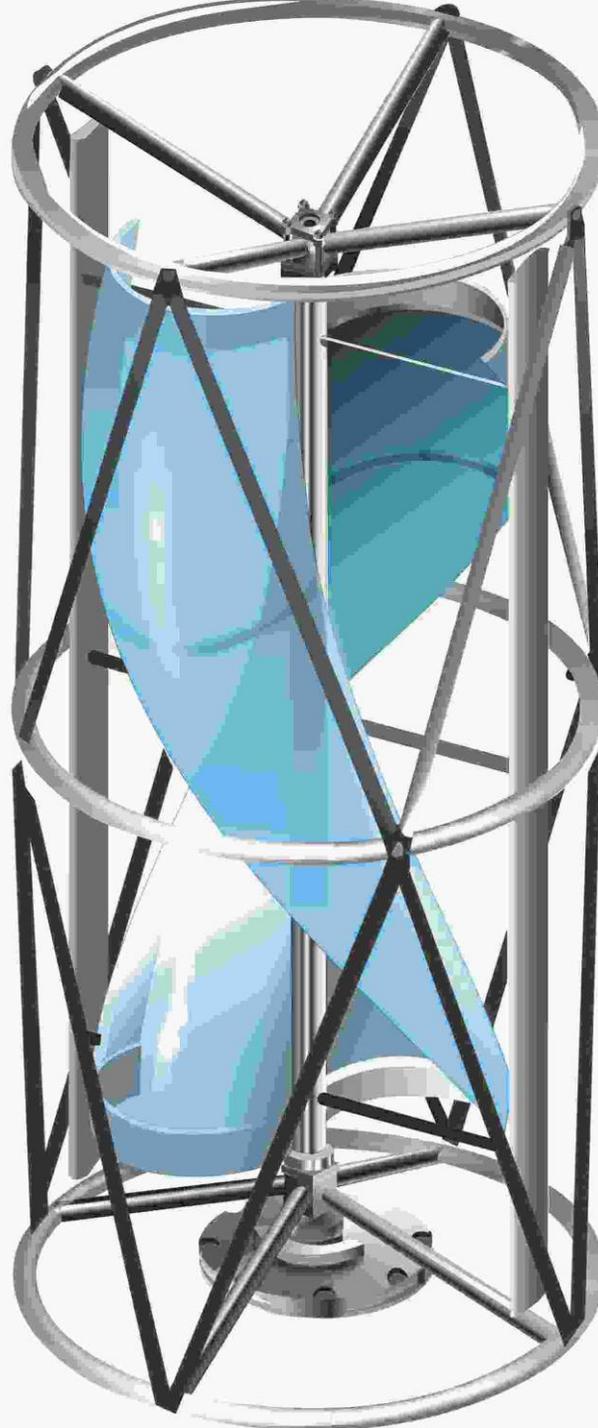


<http://www.bdsp.com>

# Aerotecture Aeroturbine

Patent Pending Serial # 10/629,370

- Safe – self-regulating
- Quiet
- Low cost
- No powerline transmission losses
- Integration with other sources of power
- Portable and/or architecturally design compatible
- Bird safe



## Aeroturbine Characteristics

## Propeller-Type Characteristics

Urban settings best with variable & gusting winds

*Rural settings best with steady, uni-directional winds*

Integrate well with rooftop solar & PV installations

*Tower vibrations work against buildings and best PV installations*

Produce power over a spectrum of low/midrange RPMs – do not run away – with MORE power hours/year

*Produce power ONLY after spin-up to very high RPMs – running away is always a concern*

Operate with low noise & low/no vibration anywhere

*Operate best where noise & vibration are no problem*

Require minimal/no tower supports & no anti-vibration devices

*Require major structural towers & major anti-vibration devices*

Mountable INSIDE towers or ON other built structures – i.e., cell towers, noise barriers, water tank towers, etc.

*Not easily fitted to interiors of typical structural towers – hard to fit within existing structures & buildings*

Low visible rooftop profile or within other structures

*Require high profile above trees & other obstructions*

Require no special code/zoning/liability insurance, etc.

*Require exemptions, special code/zoning, & insurance*

Falls under current rooftop PV codes & zoning

*Require costly tower/noise/vibration abatement systems for safe roof mounting*

AeroTurbines run quietly & protect wildlife

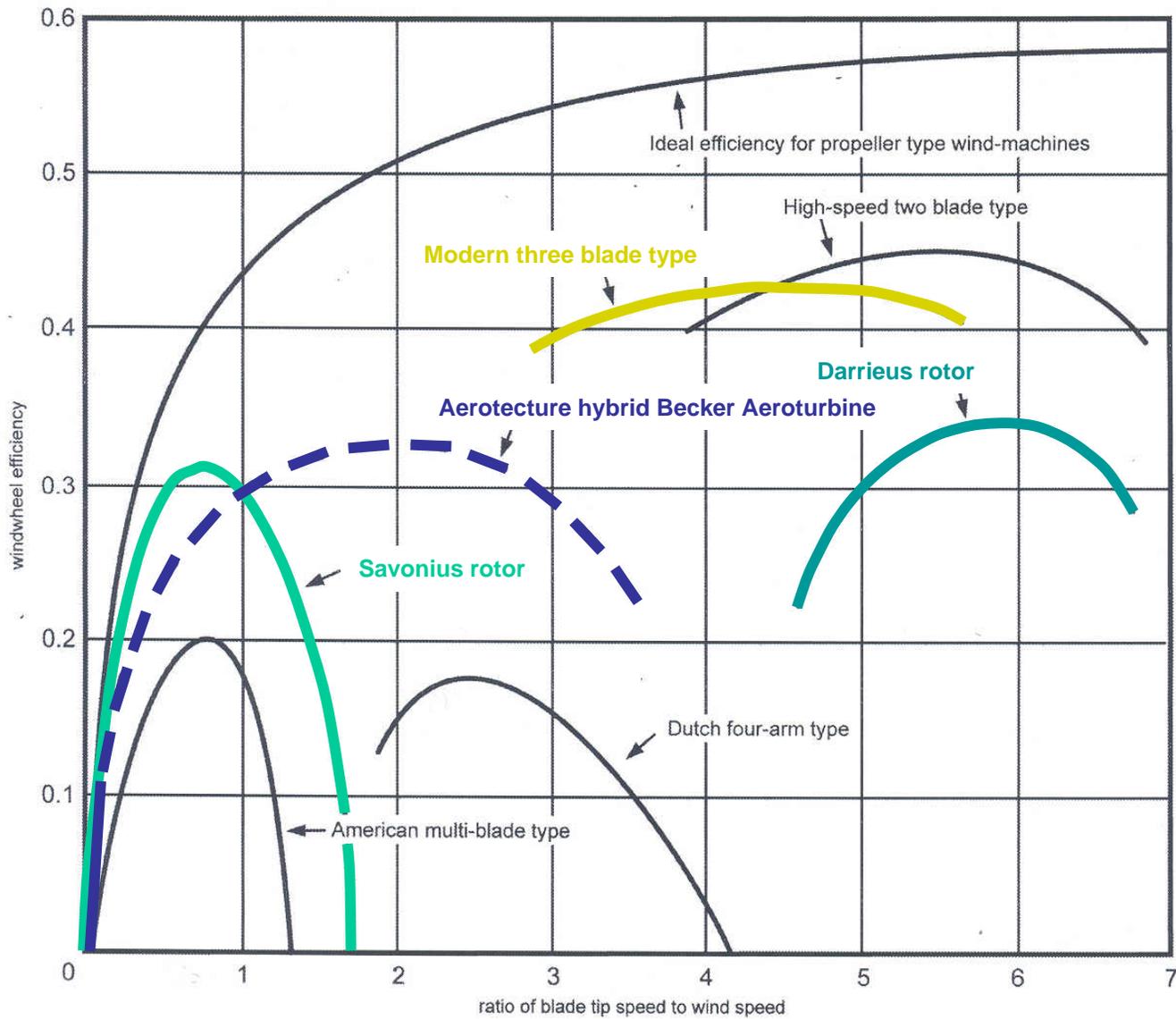
*High speed blades are noisy & kill birds*

Durable systems require low maintenance & repair

*High vibration systems require high maintenance & frequent repair and attention to 'bolt loosening'*

AeroTurbines aesthetically and functionally integrate well with architectural settings

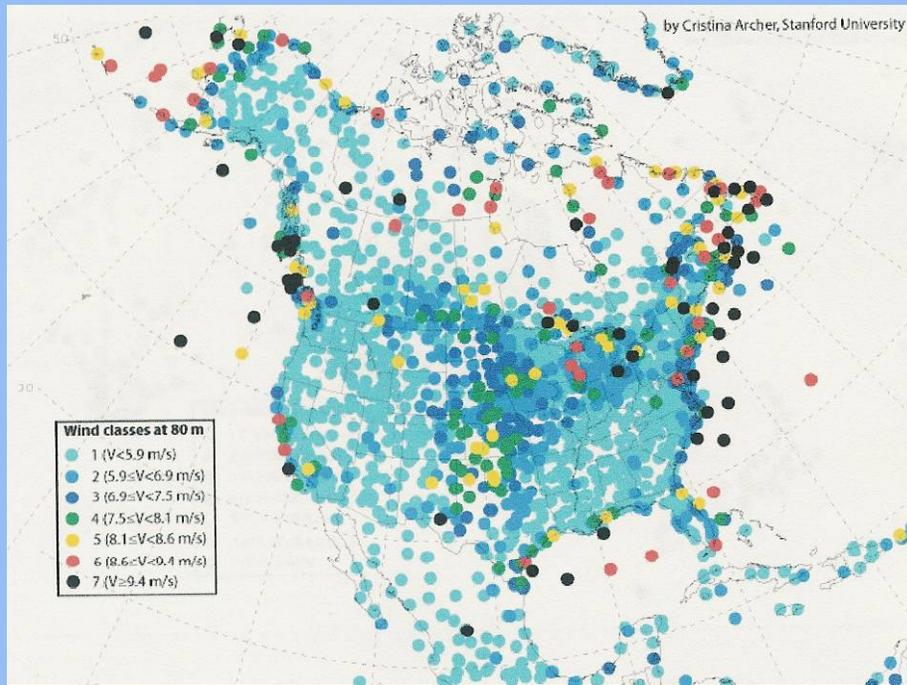
*Propeller systems prove difficult to integrate with architectural settings*



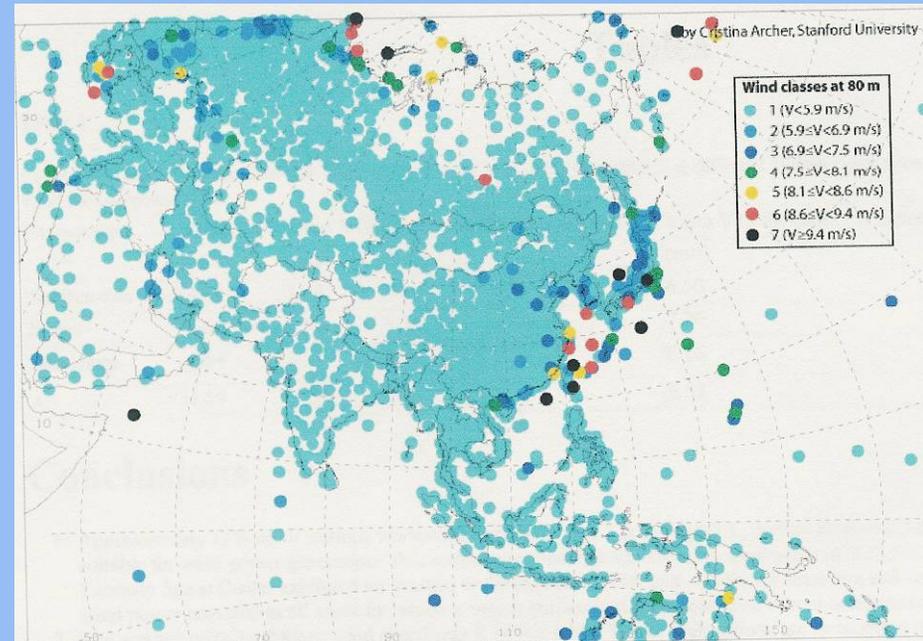
**Typical performance of several wind machines.**

# Global Wind Distribution – 2000-2005

North American coastlines, Mississippi/Great Plains regions and Great Lakes coastlines have highest wind energy resources – approximating 9 TWs of available electricity out of a current global consumption of 1.6-1.8 TWs worldwide\*



Indo-Asian coastlines and Himalayan regions (wind is not well measured there) offer more than 10 TWs of available wind electric power potential – within a current global total use of 1.6-1.8 TWs of electricity\*



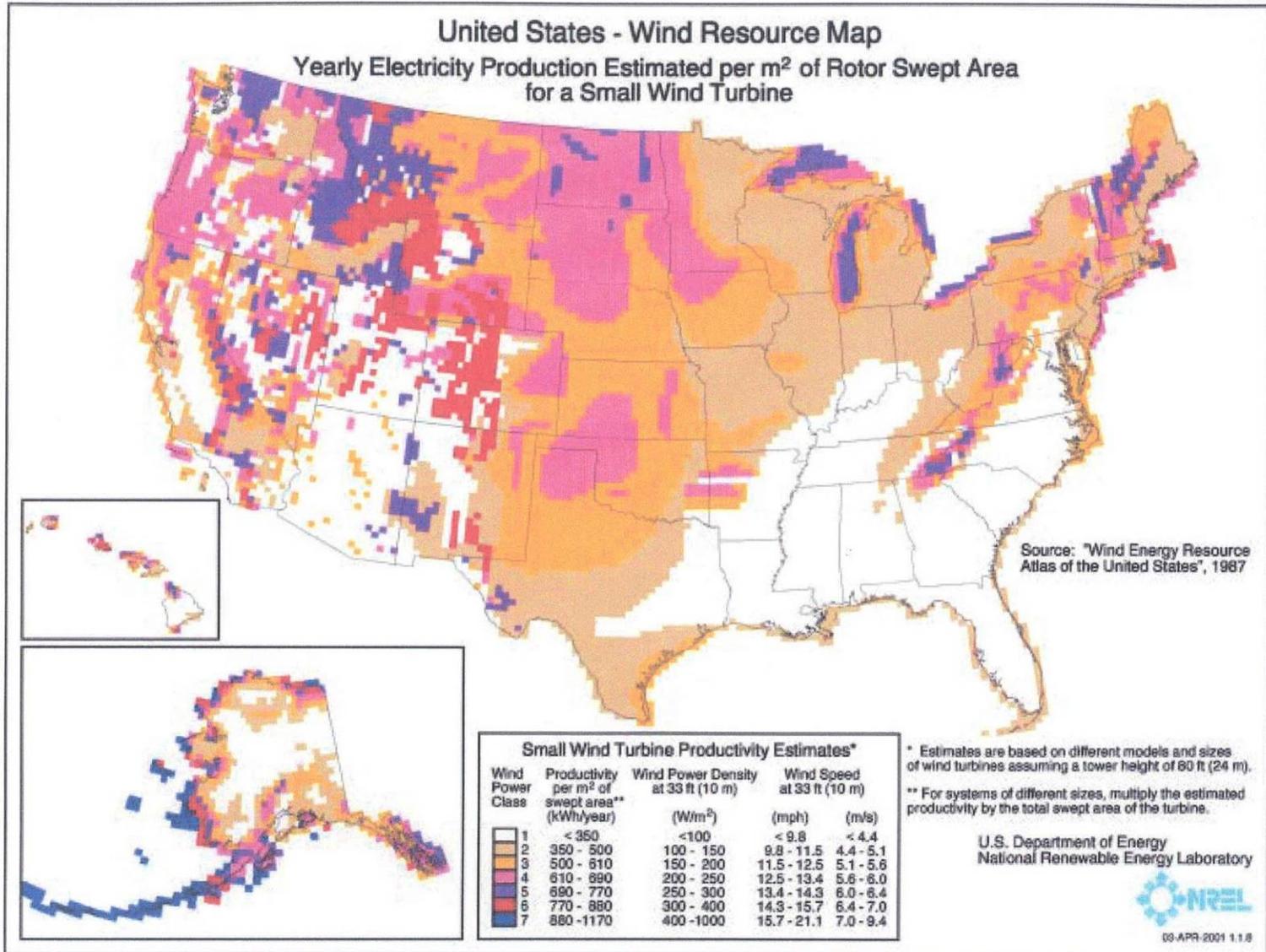
**6 Billion people worldwide need low-cost, safe, quiet village/urban wind energy – of the world's current use of 1.6–1.8 TWs of electricity, wind power offers 72 TWs\***

\*"Evaluation of Global Wind power" 2005 - C. Archer ([lozej@stanford.edu](mailto:lozej@stanford.edu)), and M. Z. Jacobson ([jacobson@stanford.edu](mailto:jacobson@stanford.edu))

Paper available at [www.stanford.edu/group/efmh/winds/global\\_winds.html](http://www.stanford.edu/group/efmh/winds/global_winds.html)

# U.S. Wind Resource Map

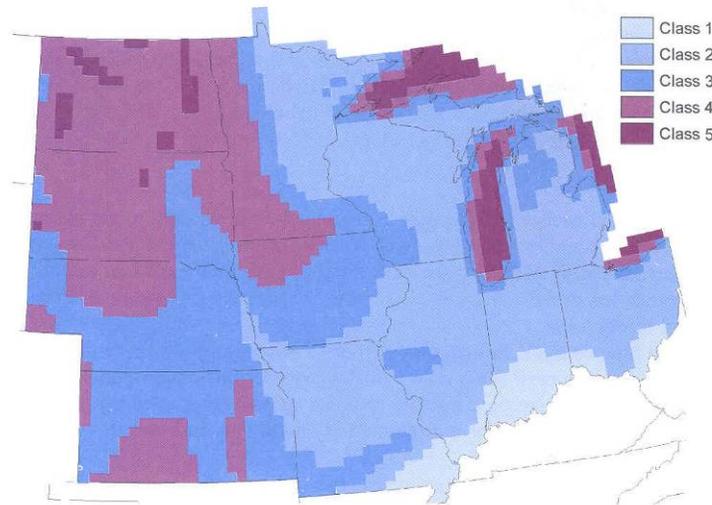
Note: Midwest & Lake Michigan Resources



# Upper Midwest Wind Resources

## Classes of Windpower Potential

**Wind resources**  
Pacific Northwest Laboratory wind map



### Classes of wind power density

Wind Class	At 10m (33ft) Height		At 50m (164ft) Height	
	Power* (W/m <sup>2</sup> )	Speed (mph)	Power* (W/m <sup>2</sup> )	Speed (mph)
1	0-100	0-9.8	0-200	0-12.5
2	100-150	9.8-11.5	200-300	12.5-14.3
3	150-200	11.5-12.5	300-400	14.3-15.7
4	200-250	12.5-13.4	400-500	15.7-16.8
5	250-300	13.4-14.3	500-600	16.8-17.9
6	300-400	14.3-15.7	600-800	17.9-19.7
7	>400	>15.7	>800	>19.7

\*Wind power density is expressed in watts per square meter (W/m<sup>2</sup>) of swept rotor area, or area perpendicular to wind flow.

# U.S. Urban Energy Utilization



A photograph of the New York City skyline at sunset. The buildings are silhouetted against a sky with orange and blue hues. The Empire State Building is prominent on the left, and the Chrysler Building is on the right. A thin, horizontal light streak is visible in the upper part of the sky.

**50 Million Urban Global Citizens –  
await dependable ‘distributed power’ \***

**\*New York City photo after the 2003 Blackout – the worst in US utility history**



Editorial photo by Gary Marx  
 Jameel Sultan Al-Tumaymi shows a picture of his wife slain by U.S. troops.

## As Iraqis die, hate for U.S. spreads

Families left bitter by relatives' deaths  
 By Gary Marx  
 Tribune foreign correspondent

**BAAGHDAD**—Ezhar Mahmood Ridha and her sister saw were on their way to a wake when they met their deaths at the hands of U.S. soldiers. As their broken-down car stood stranded on a dusty overpass, a guerrilla fighter nearby detonated a huge explosive device at a passing U.S. military convoy. As the soldiers hurried and fired, the car carrying the assailant sped away, according to witnesses and U.S. military officials.

The Americans hit the only object left on the overpass: Ridha's blue 1982 Mitsubishi sedan. Bullets ripped through Ridha's body. She slumped over in the back seat, eyes frozen, as her 16-month-old boy slipped from her arms, witnesses said. Ridha's sister-in-law was hit in the stomach.

The shooting at dusk on Aug. 1 was just one of dozens of cases in which civilians have been caught in the crossfire of Iraq's guerrilla war. The firing was over in minutes and warranted only a five-paragraph statement from the U.S. military public-affairs office in Iraq.

But the tragedy and its aftermath reveal much about the chaotic, unpredictable nature of combat here and how the deaths of civilians can turn residents of an entire village, once sympathetic to the U.S. occupation, into bitter enemies.

For each civilian killed — whether Iraqi or American — officials have attempted to keep count of the mounting casualty toll — a new circle of family, friends and tribespeople learns to revile the U.S. soldiers who came to liberate them.

"I hate them! I hate them!" said Jameel Sultan Al-Tumaymi, 40, Ridha's husband and the

PLEASE SEE CIVILIANS, PAGE 19

# Scale of outage jolts nation



Times Square in New York is out of the dark and attracting tourists Friday night after a massive, hours-long blackout affected the Northeast and parts of Canada.

## Grid needs makeover, not just nips and tucks

By Melita Maria Garza and Jeremy Warner  
 Tribune staff reporters

Amid furious finger-pointing over who's to blame for the nation's largest blackout ever, there is one cause on which all parties seem to agree: The U.S. power grid is outmoded, with too few transmission lines to handle Americans' ever-growing appetite for electricity.

Although the problem seems clear, solutions are not. Experts say electric utilities have little incentive to build new transmission lines because the economic return on such investments is often uncertain — until power plants, which tend to provide a reliable stream of income.

After decades of neglect, improving the grid will require a prolonged commitment by government, industry and ordinary



Photo by Andrea Noble/New York Times  
 College student Noriko Kudo, stranded like thousands of others by the power outage, rests while waiting for a flight out of New York Friday.

## Experts stunned as inquiries begin

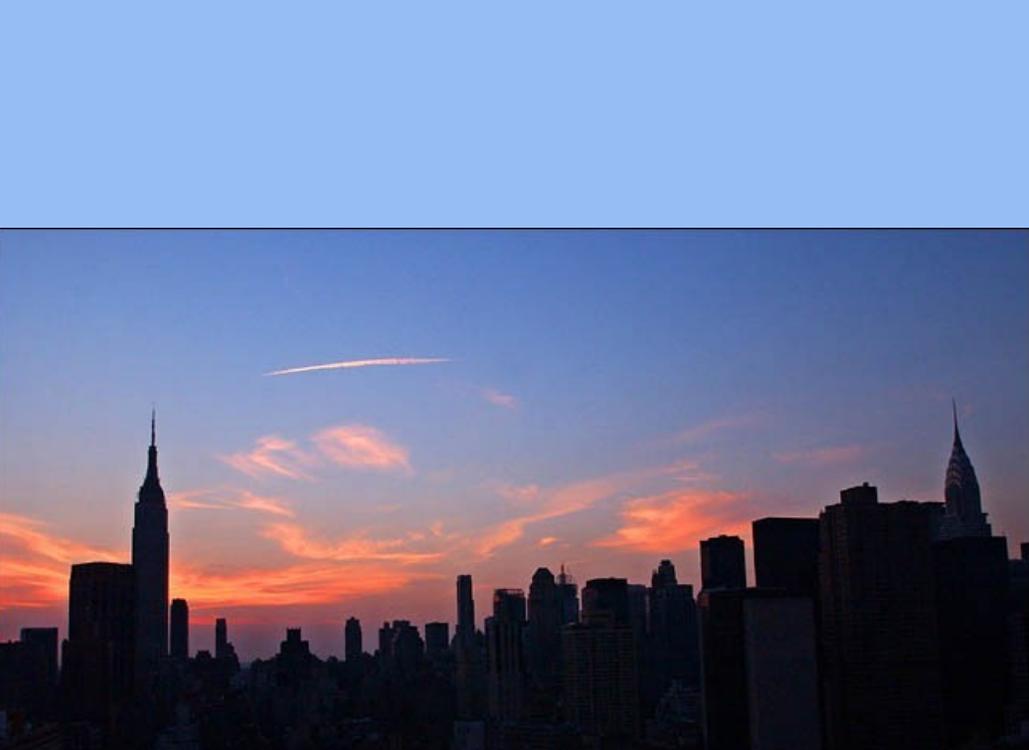
By Mike Dornier and Ron Grossman  
 Tribune staff reporters

**NEW YORK**—As a large swath of the nation struggled to recover from the largest blackout in the country's history, the cause remained elusive but experts agreed on one thing: They were stunned by the scale and speed of the electrical failure.

"We never anticipated we could have a cascading outage of this magnitude," said Michael Gent, head of the North American Electric Reliability Council, the industry-sponsored group that monitors the dependability of the power grid. Fifty million people spread out over the Northeast, the Midwest and Canada lost power in "essentially nine seconds," he added.

New York City had power restored by about 9 p.m. Friday, but Detroit was largely dark for a second night and most of a back but struggled to water supplies. The blackouts imposed serve electricity and left about 100,000 American and Canadian authorities initially blame for the power each pointing a finger at the other side of the line. Late Friday, the House said Secretary Spencer Abraham said a mix of sources. Herb Deal, they would lead a task force to seek the causes of it out.

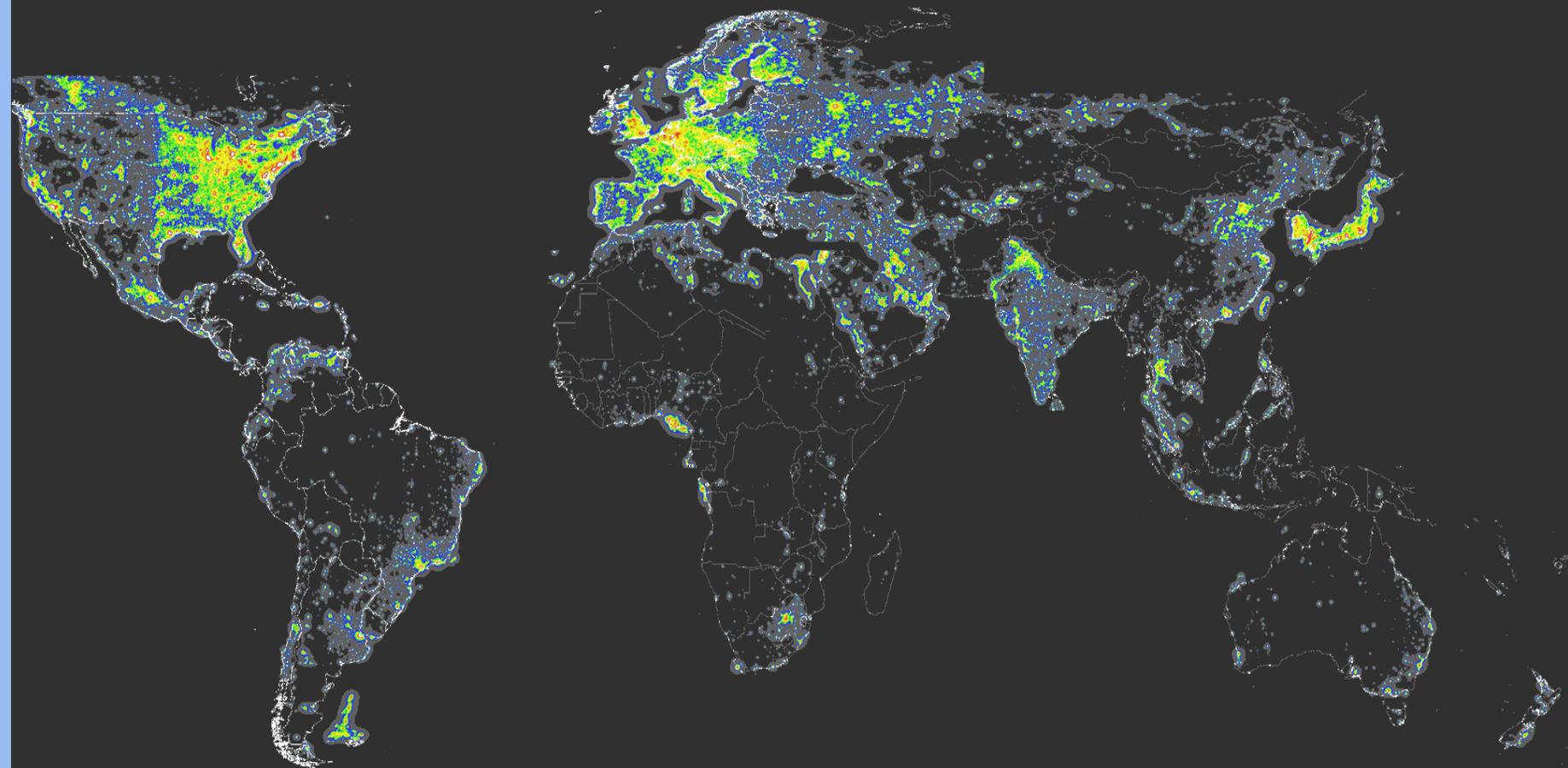
PLEASE SEE POWER, PAGE 14



**50 Million People lost "grid power" on Friday, August 14, 2003 – due to local "technocrats" not understanding the need for "distributed renewable power"!\***

**\* See article – "Solution to the Summer Blackouts?", by R. Perez, et. al; in Solar Today, pg. 32-35, July/August 2005**

**Experts\* in the field of "distributed power" have shown that if urban networks of solar and wind electric generation had been available during the August 2003 NYC "Grid Collapse" – the NYC Blackout might not have BEEN! Terrorists will also have a very hard time blowing up DISTRIBUTED power grids!**



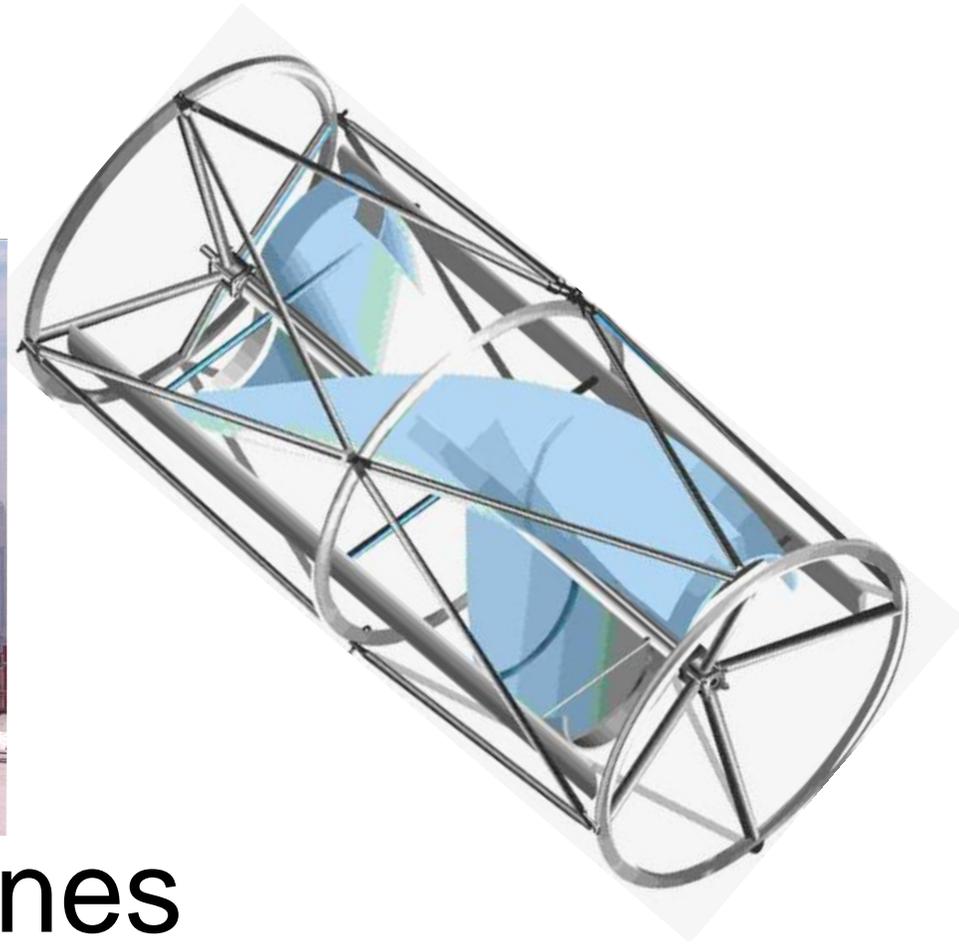
**3.5 Billion Urban Global Citizens\* –  
await 1 Billion Urban Wind Aeroturbines**

**\*Simulated Night Sky Photo of cities from current satellite sources**

# Vertical Aeroturbine

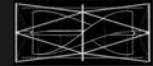
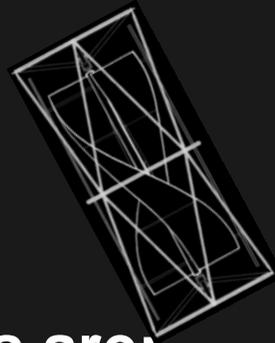
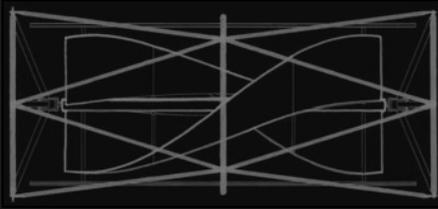


# Urban Turbines



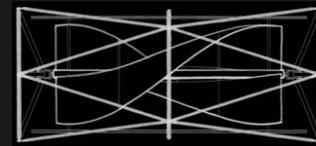
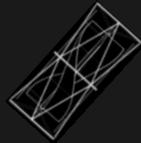
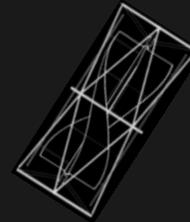
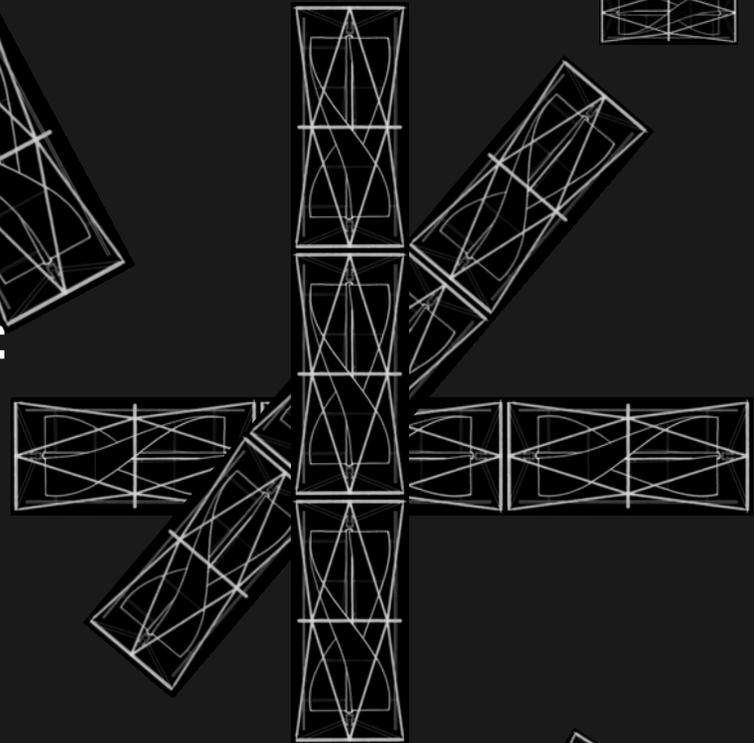
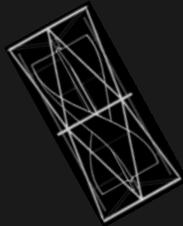
## Becker Aeroturbines

Model	Swept Area	kWh per yr	Cost per sq foot
520	100 SF	1500 kWh/yr @ 11.25 mph avg wind speed per year	\$200 NOW!



## Aerotecture Aeroturbines are:

- modular – like solar panels
- inherently structural cages
- stackable, joinable, integratable
- universal axis
- self-starting
- self-regulating
- easily partnered with PV, solar & daylighting

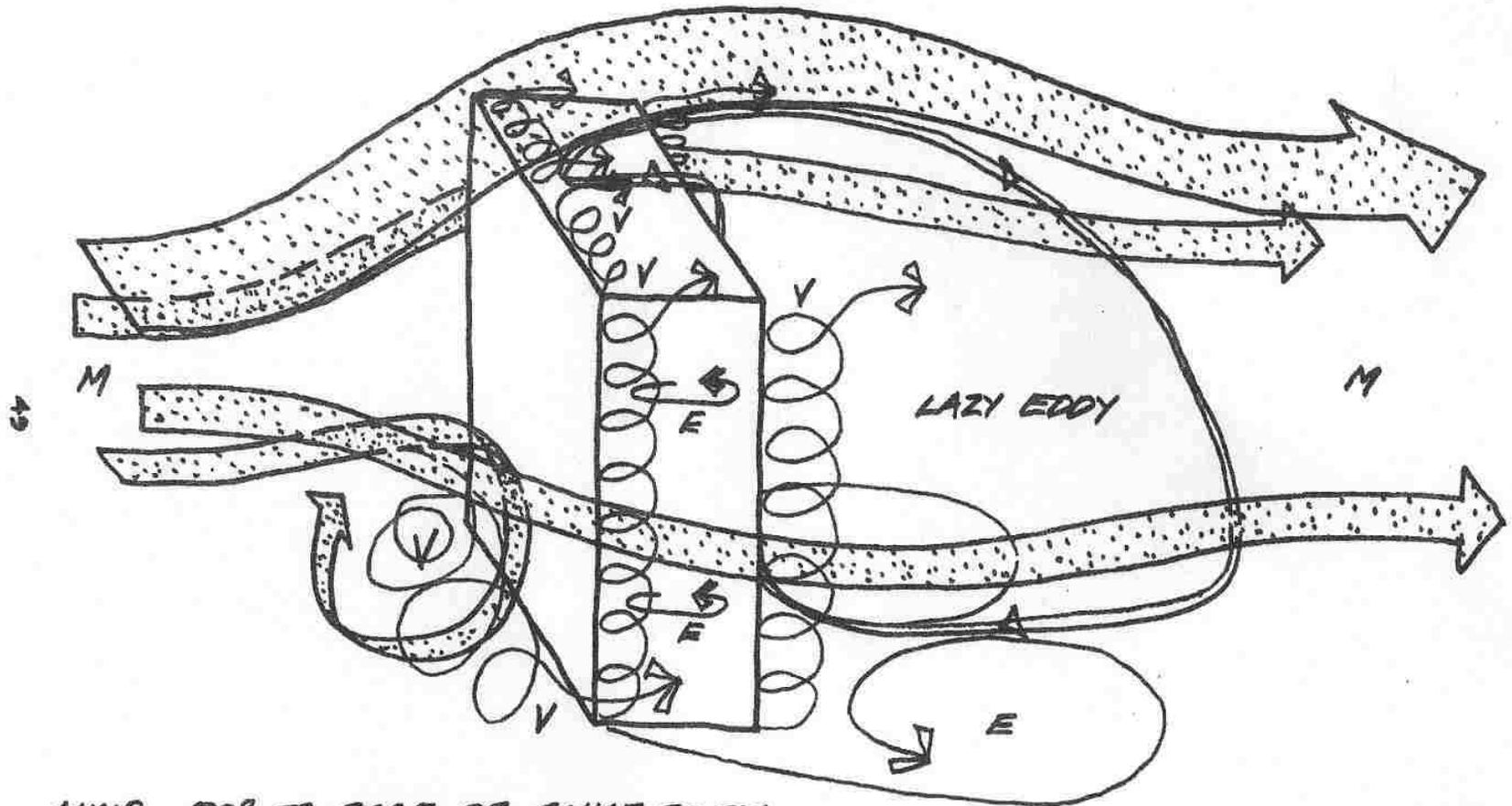




**ALL Zoning & Code  
APPROVED!**



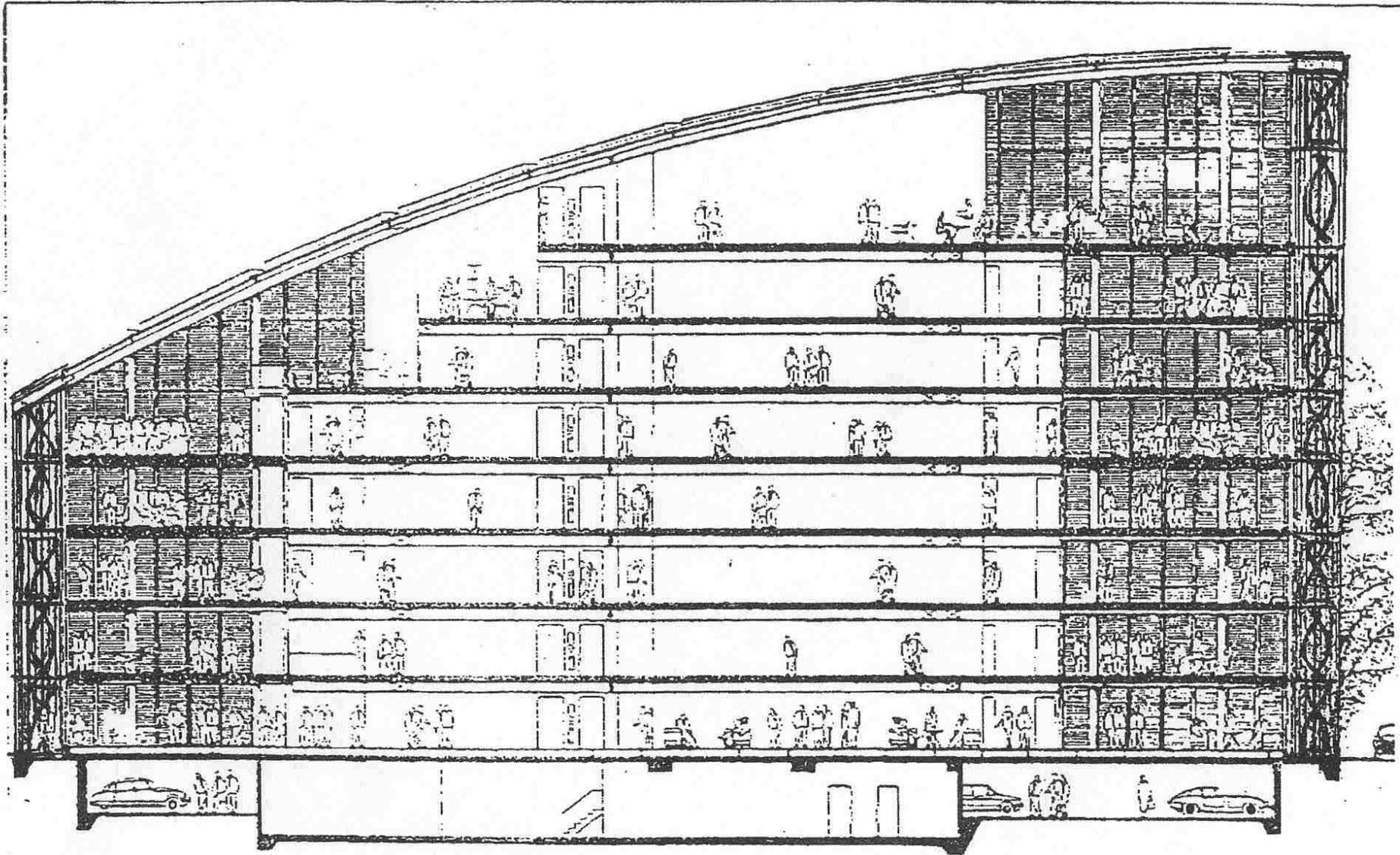
# Wind flow around Buildings - drawing by Douglas R. Coonley, 1974



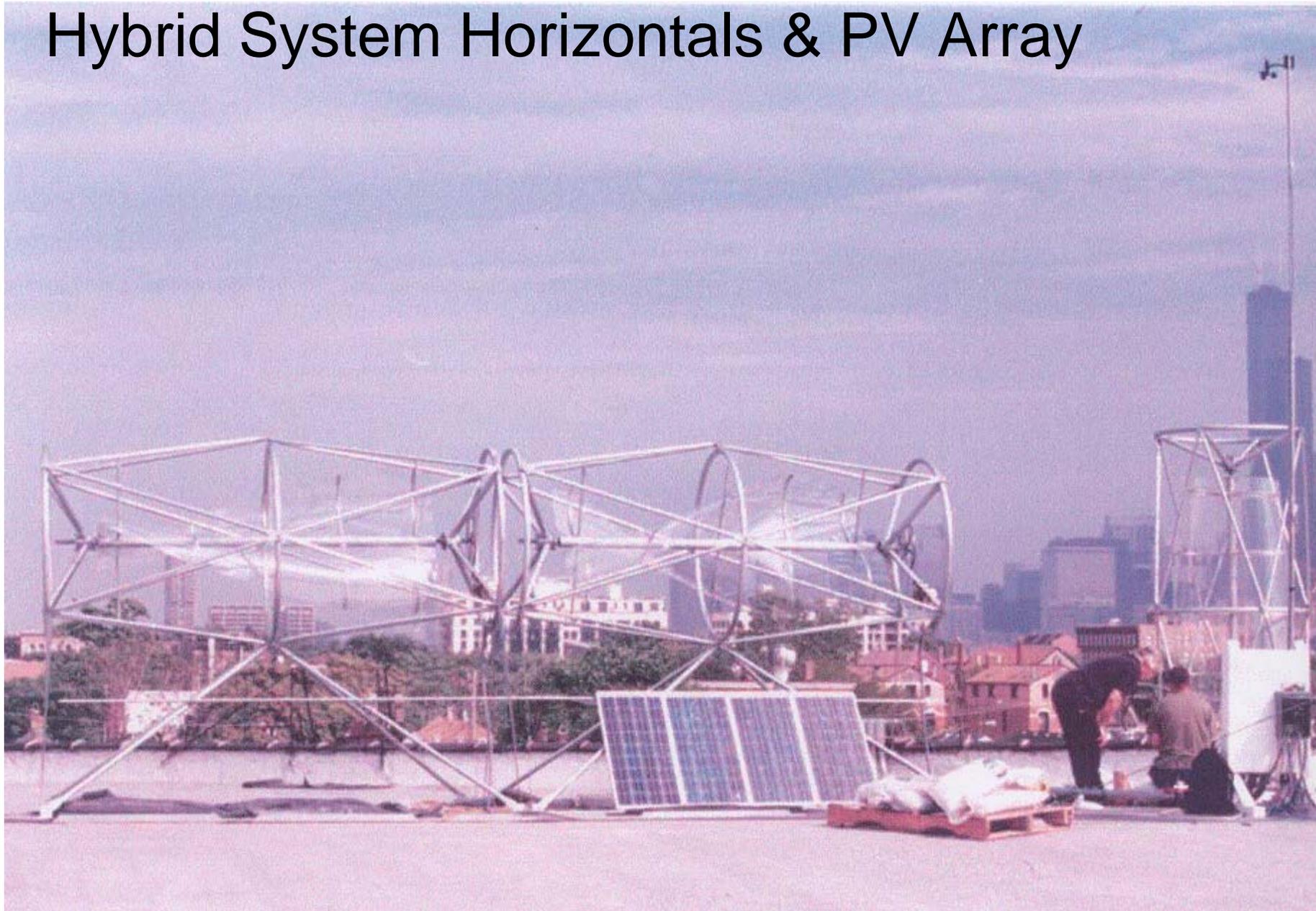
WIND 90° TO FACE OF BUILT FORM  
KEY: M = MAINSTREAM FLOW, V = VORTEX FLOW, E = EDDY FLOW  
(FROM AYNLEY.)  
WIND FLOW AROUND BUILT FORM

FIGURE 1

# 'Ark' Building & stacked, vertical Aeroturbines

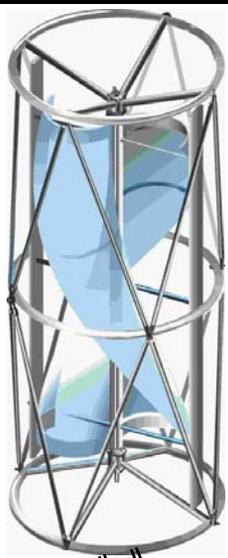


# Hybrid System Horizontals & PV Array

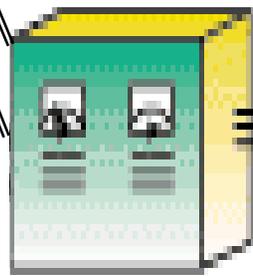


# Randall Museum Aeroturbine

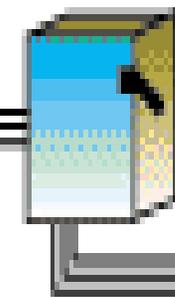




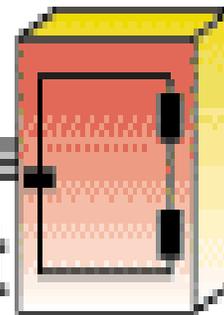
Aeroturbines



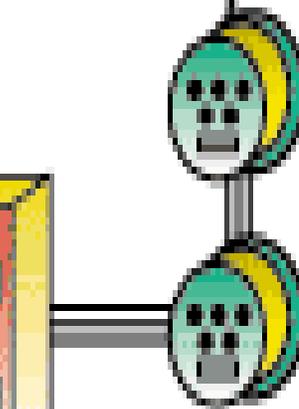
Synchronous Inverter



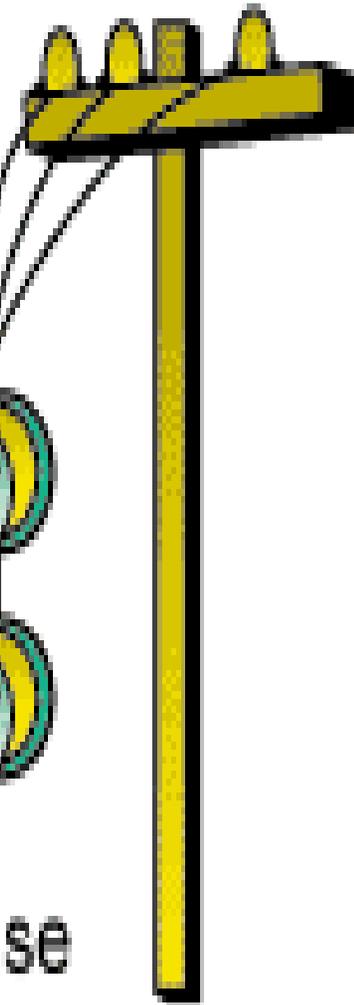
Disconnect Switch for Utility Use



Circuit Breaker Box



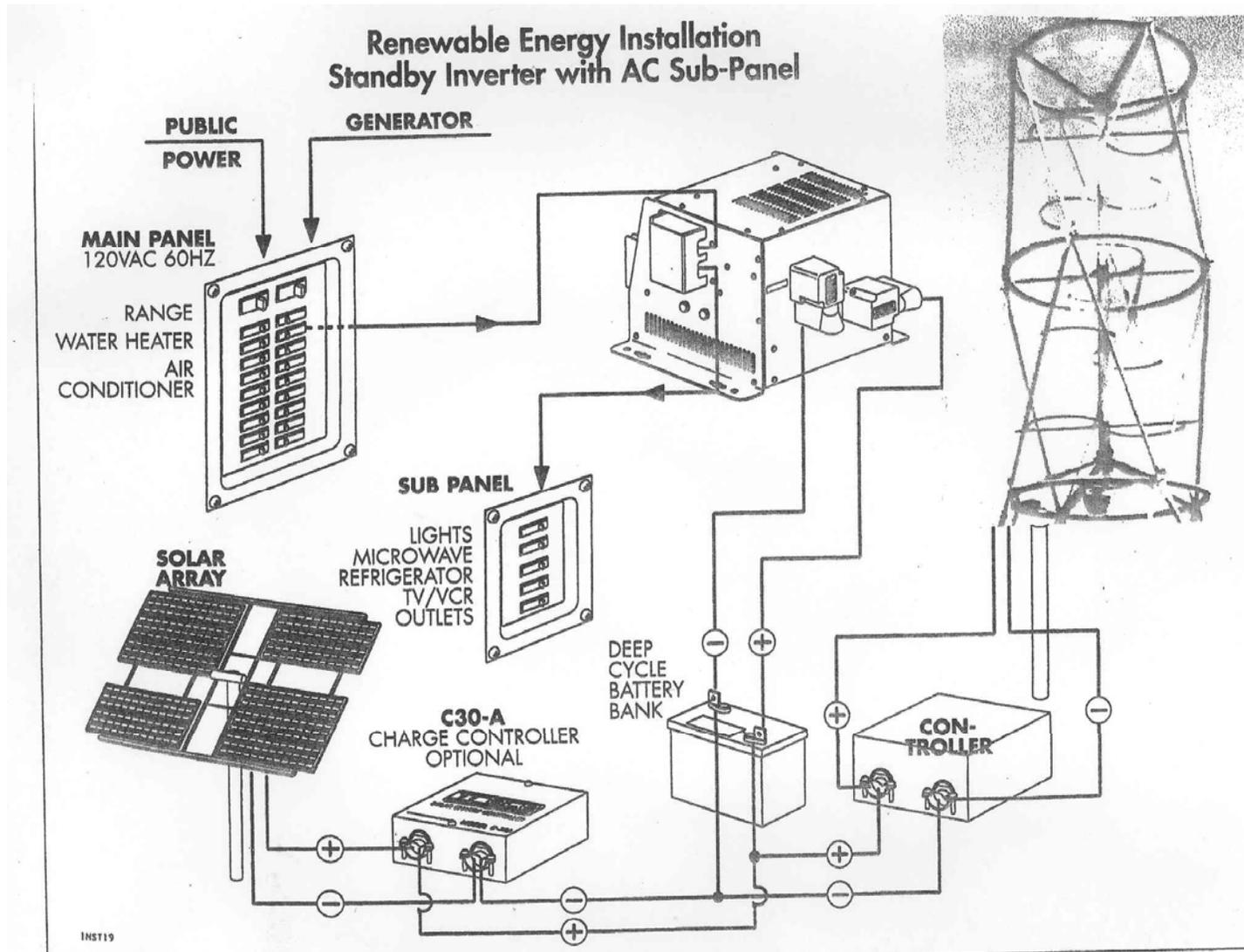
Meters



Utility Lines

To Home Use

# Diagram of Hybrid RE Elements PV and Wind Power Systems on Single Inverter



# PV's Value Profile

## PV'S VALUE AS A TECHNOLOGY THAT ADDS CAPACITY

- **PV has tangible value to utilities in generating capacity.**
- **Regions of high ELCC do not always overlap with regions traditionally targeted for solar energy.** For example, note the high ELCC values in southern California, the central states, and the Mid-Atlantic seaboard states. The “traditional solar areas” of Florida and the arid Southwest states have lower PV ELCC values despite their greater solar

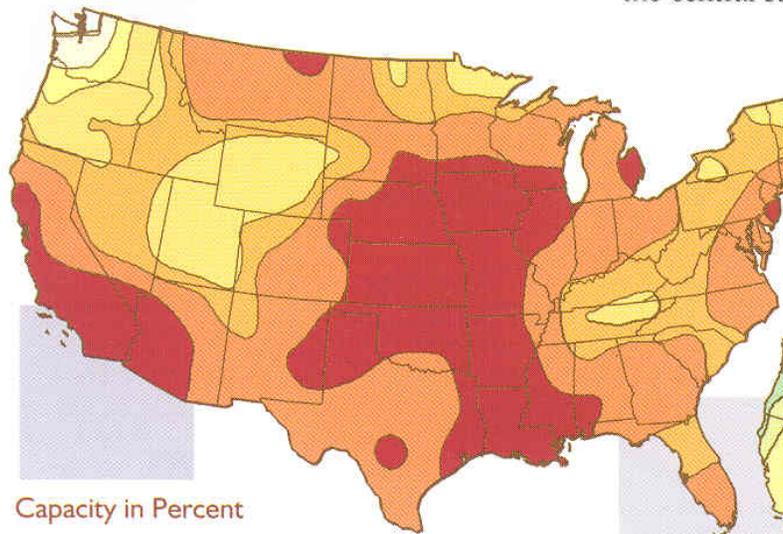
intensity values, because PV output doesn't match the loads as well in those areas.

- **Areas of high PV ELCC are associated with regions that have certain characteristics:**

- Intense summer heat waves
- High daytime commercial demand
- Small electric-heating demand.

- **Isolated pockets with high PV ELCC values may exist within a region having lower PV ELCC values.** For example, high-density urban areas may have a high daytime demand in the commercial sector and thus have a high ELCC value for PV.

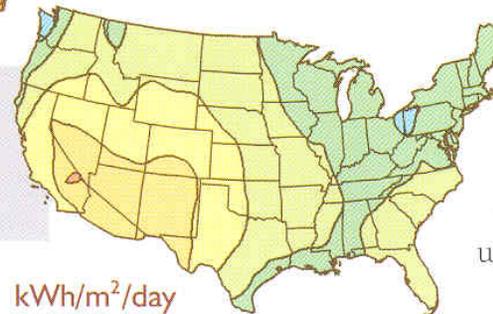
These new findings about PV's ELCC should make decisions on capacity additions and demand management a little easier for U.S. utilities.



Capacity in Percent

>20
  20-30
  30-40
  40-50
  50-60
  60-70
  >70

PV ELCC map of U.S. (based on 500 utility loads)

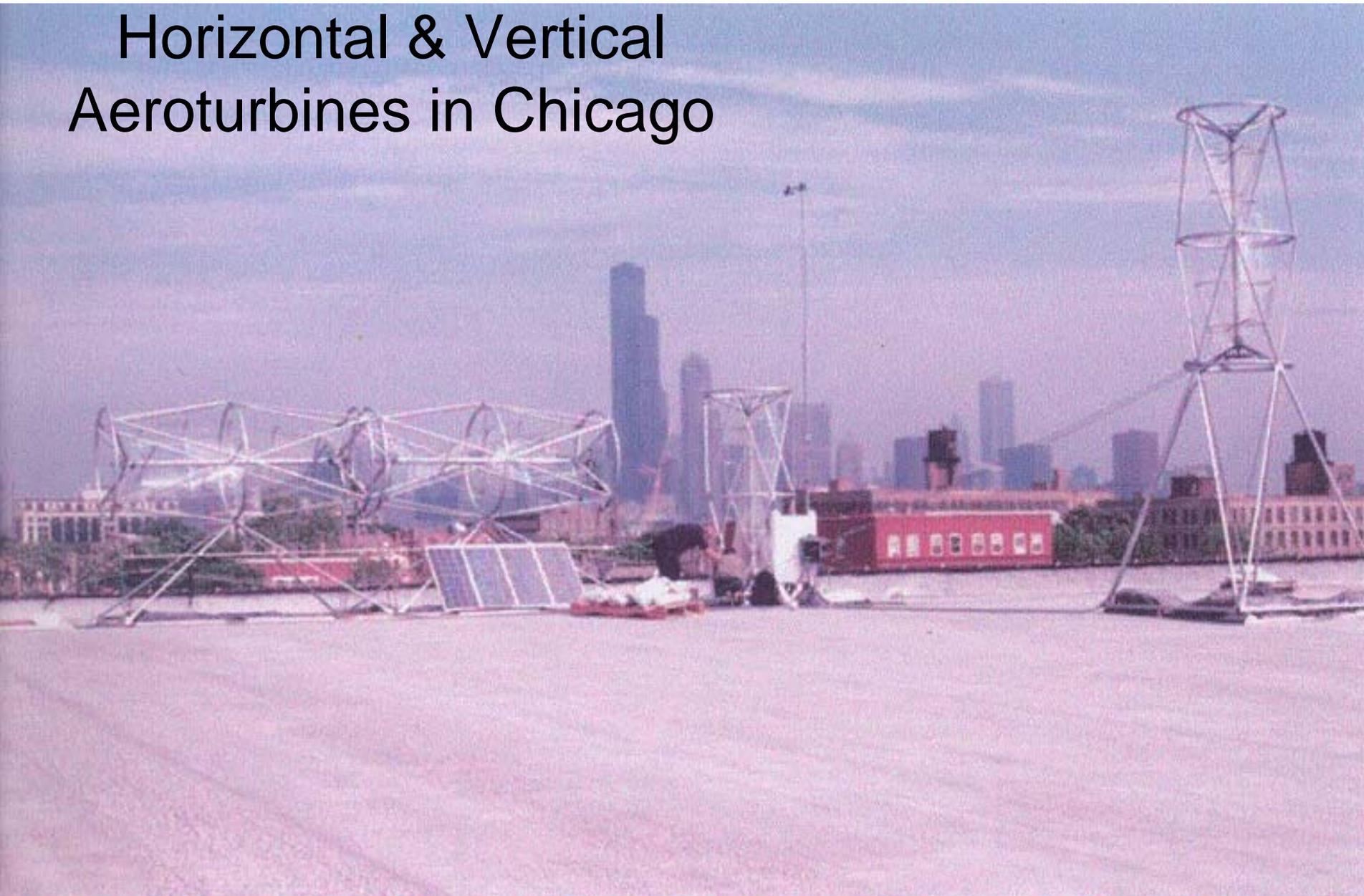


kWh/m<sup>2</sup>/day

3-4
  4-5
  5-6
  6-7
  7-8
  8-10

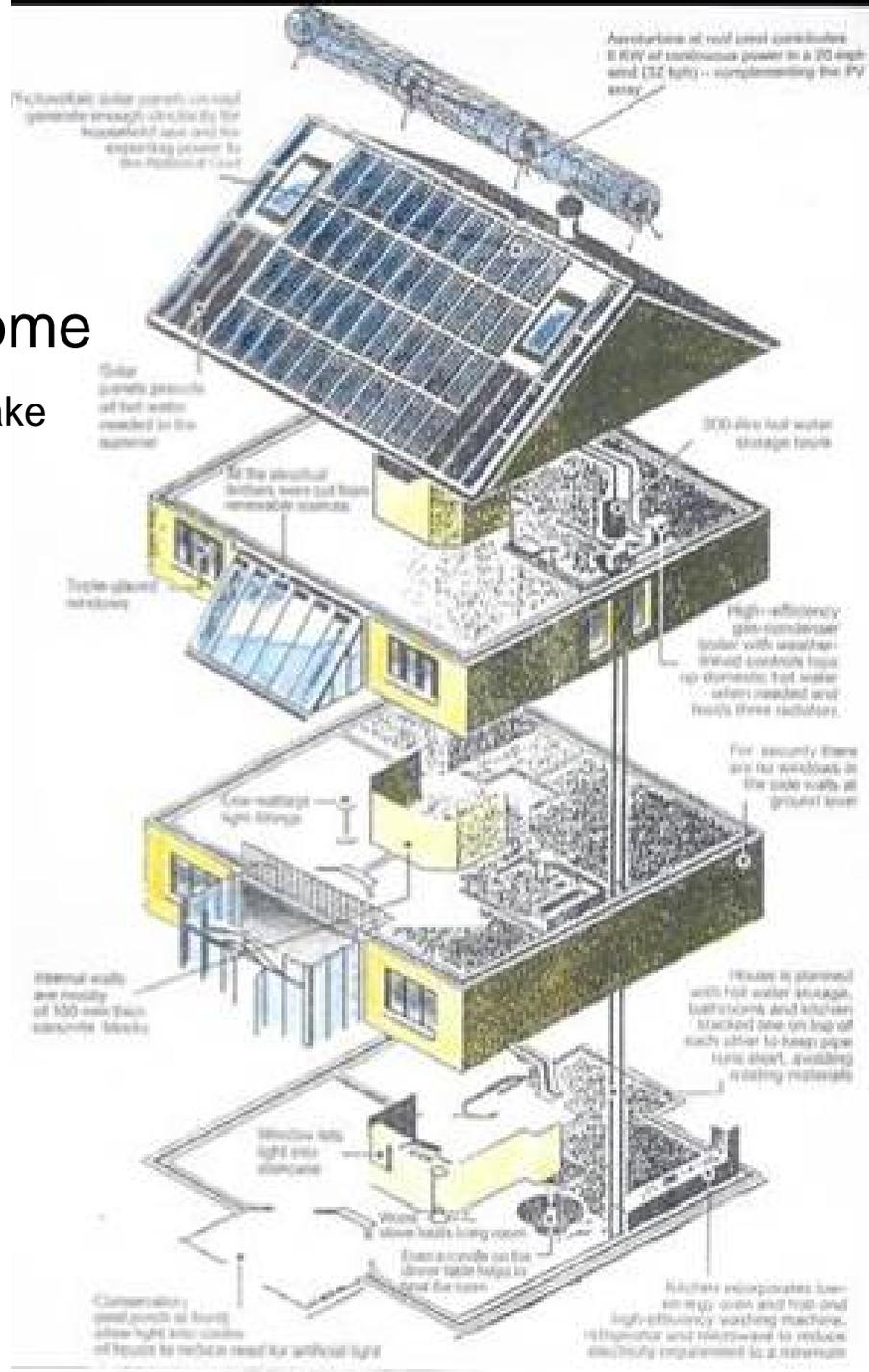
“Traditional” solar-energy map

# Horizontal & Vertical Aeroturbines in Chicago



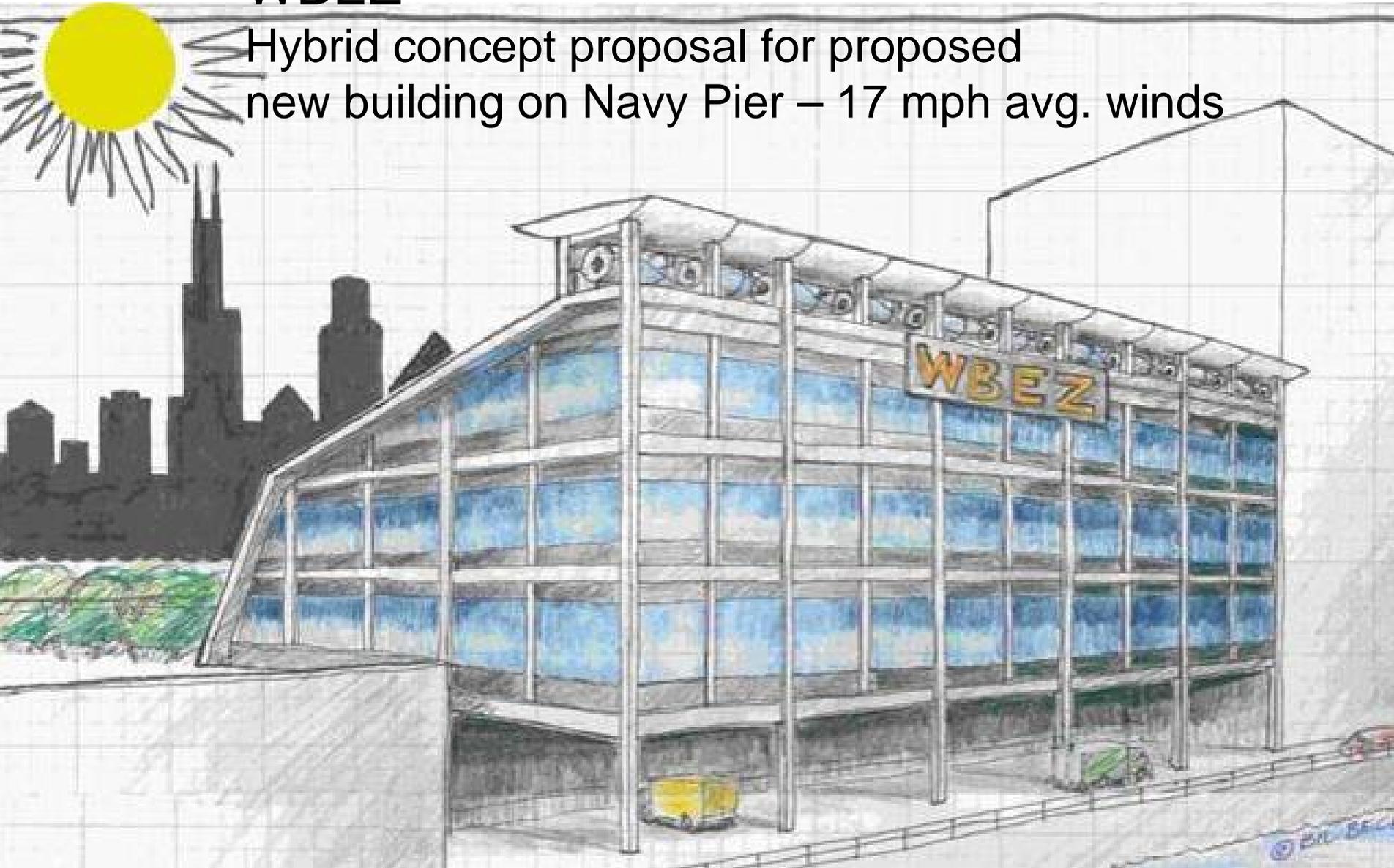
# Oxford House Zero-Energy, nearly Net+Energy Home

Aeroturbines would make  
the big difference here

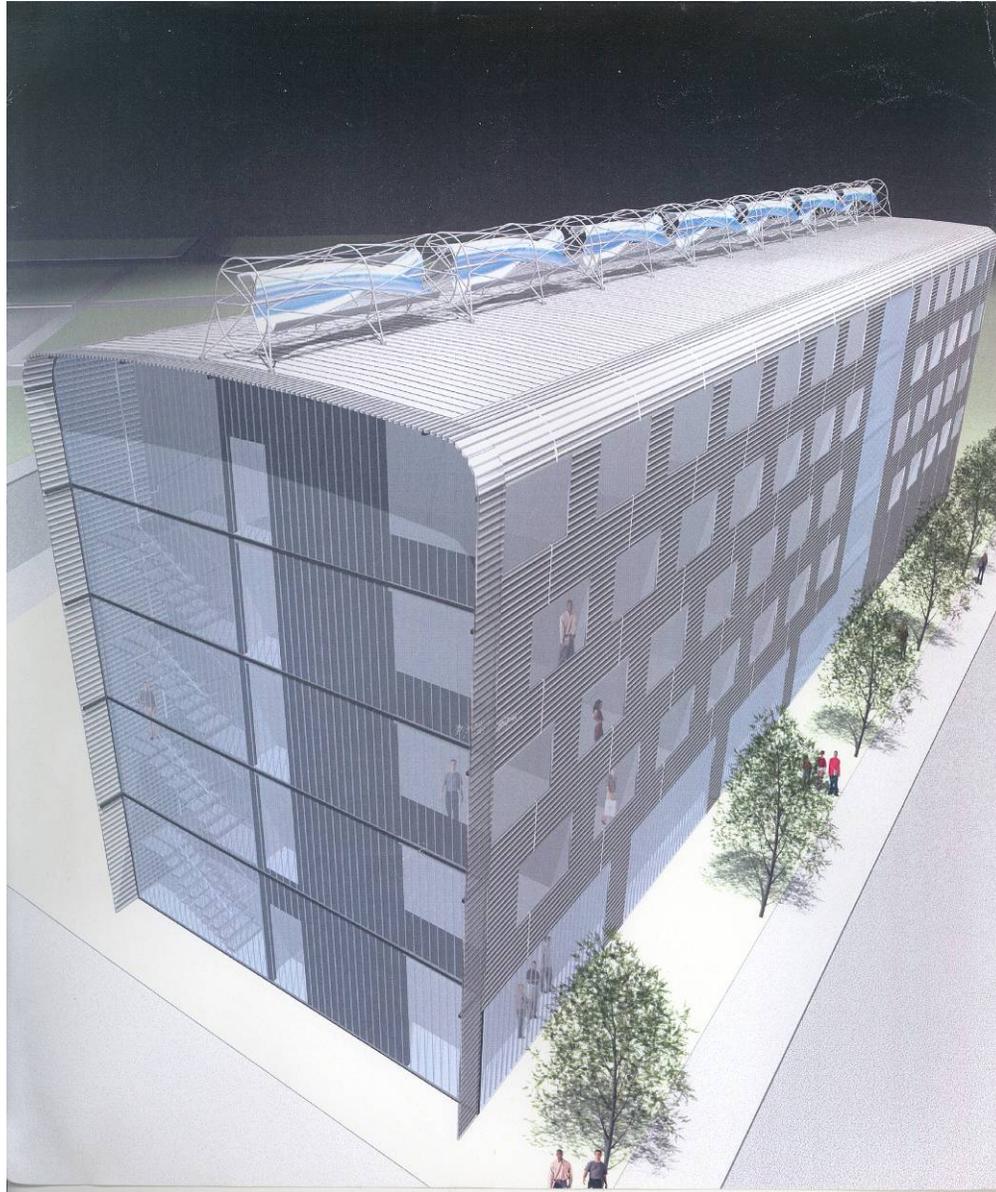


# WBEZ

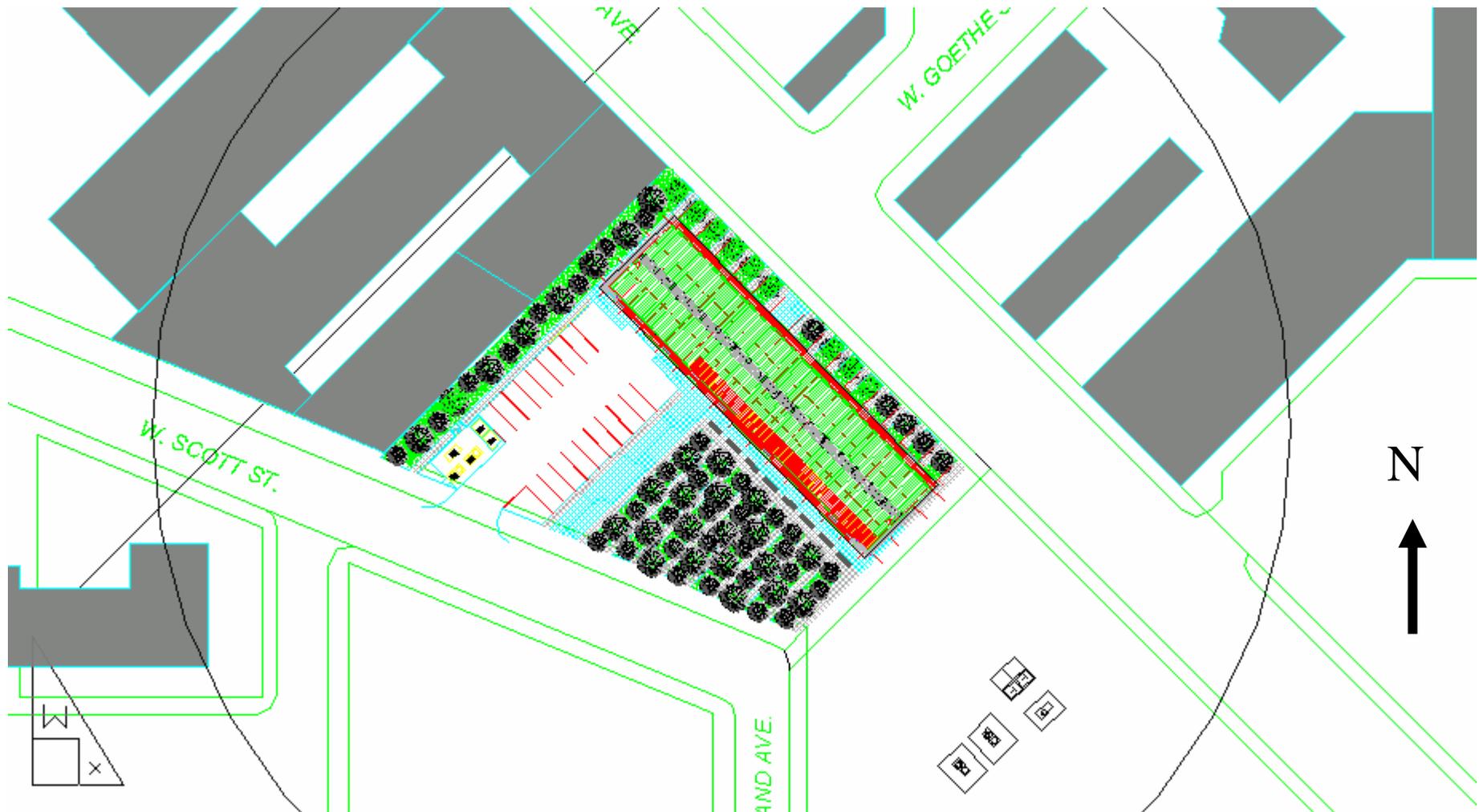
Hybrid concept proposal for proposed new building on Navy Pier – 17 mph avg. winds



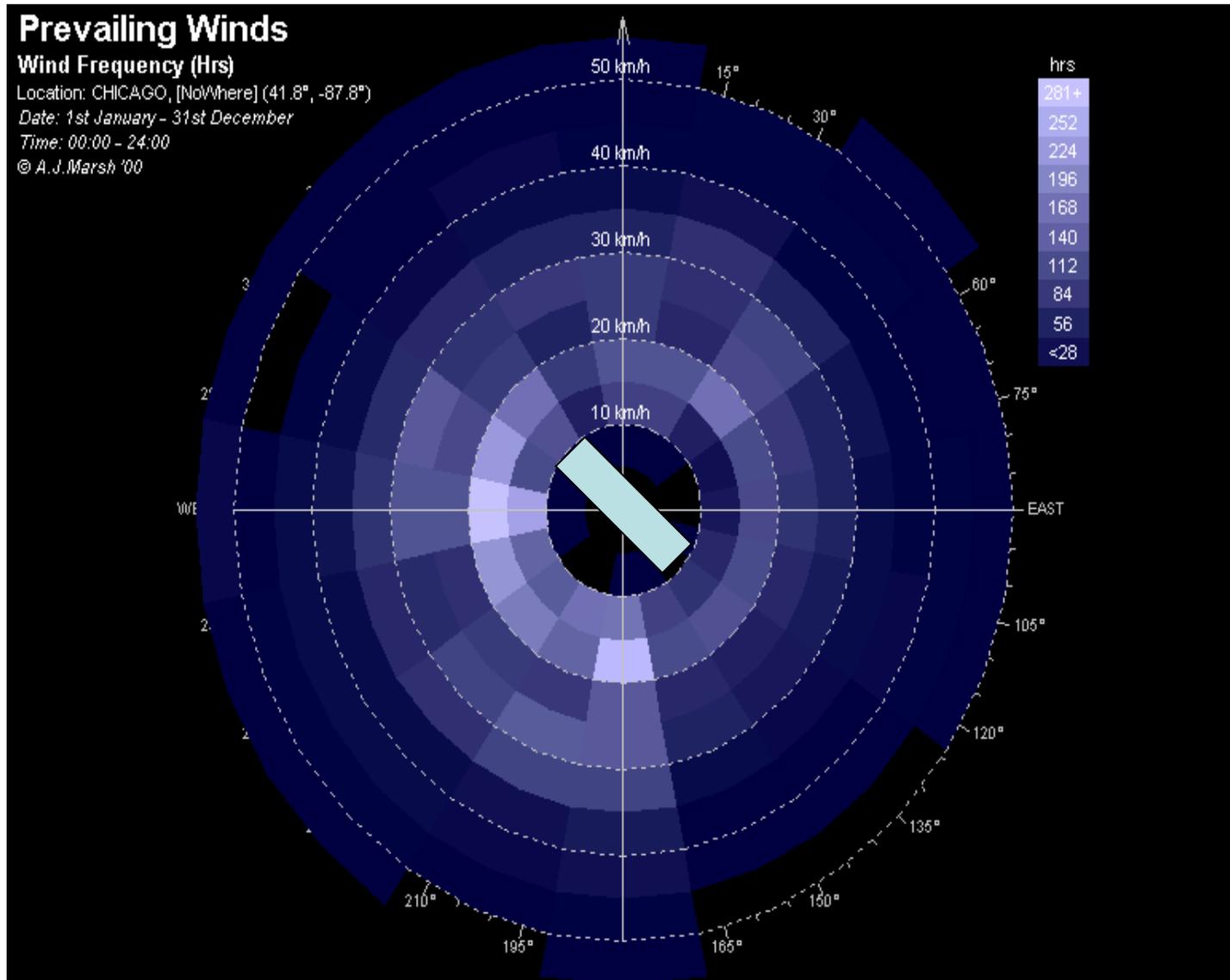
# Murphy/Jahn LSH-Aeroturbines



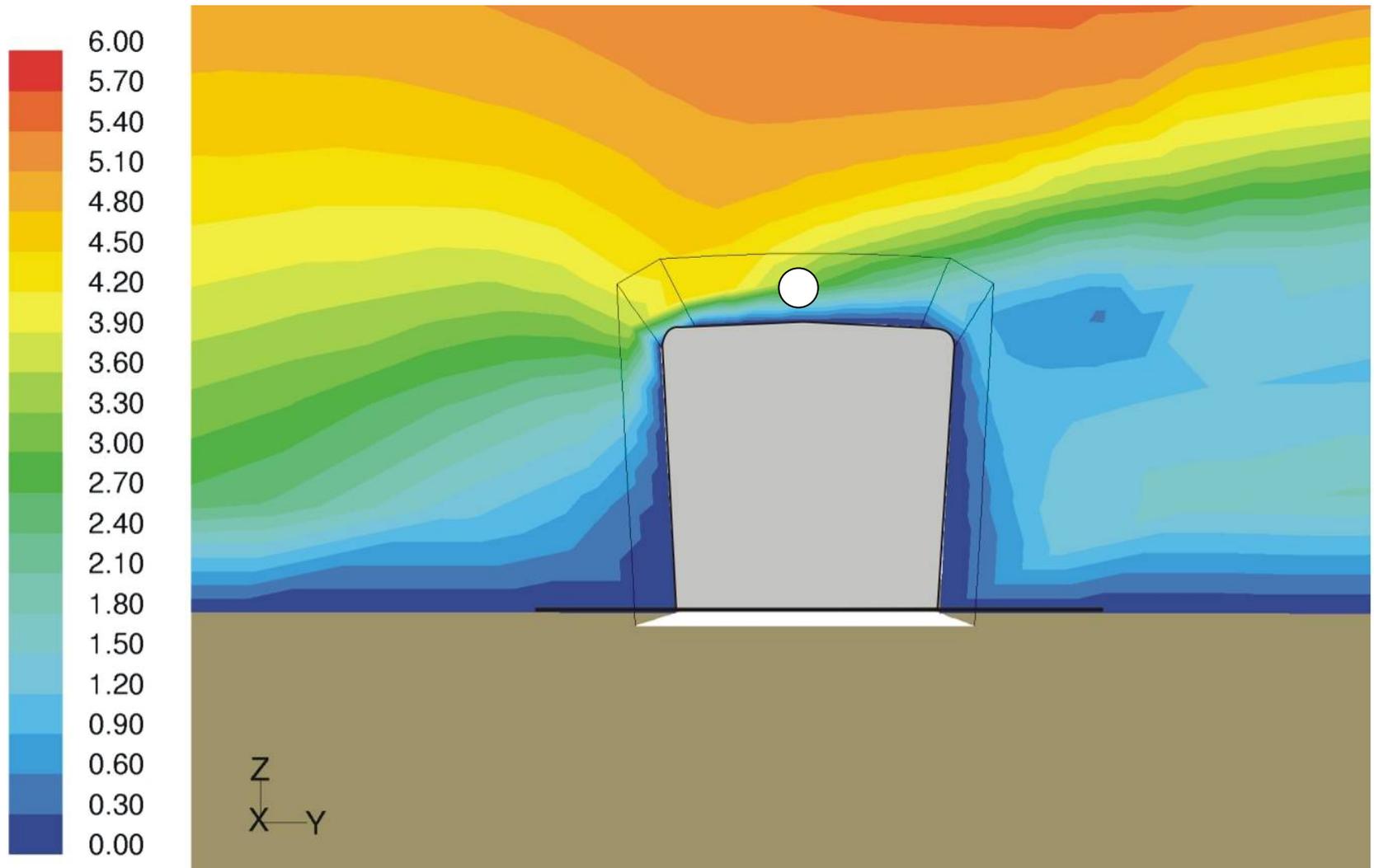
# Lakefront Supportive Housing Site with orientation (Murphy/Jahn Architects)



# Chicago Windrose - main winds from Southwest & Northeast



# Computer simulation of over-streaming winds & Aeroturbines roof location



# Murphy/Jahn LSH-Aeroturbines



# Golden Gate Aeroturbines



# AeroHighway Wind & Solar



*"AeroHighway"*

Aerotecture International, Inc.  
Design: Mark Grabavoy

# AeroTent 1 – MREA 2003

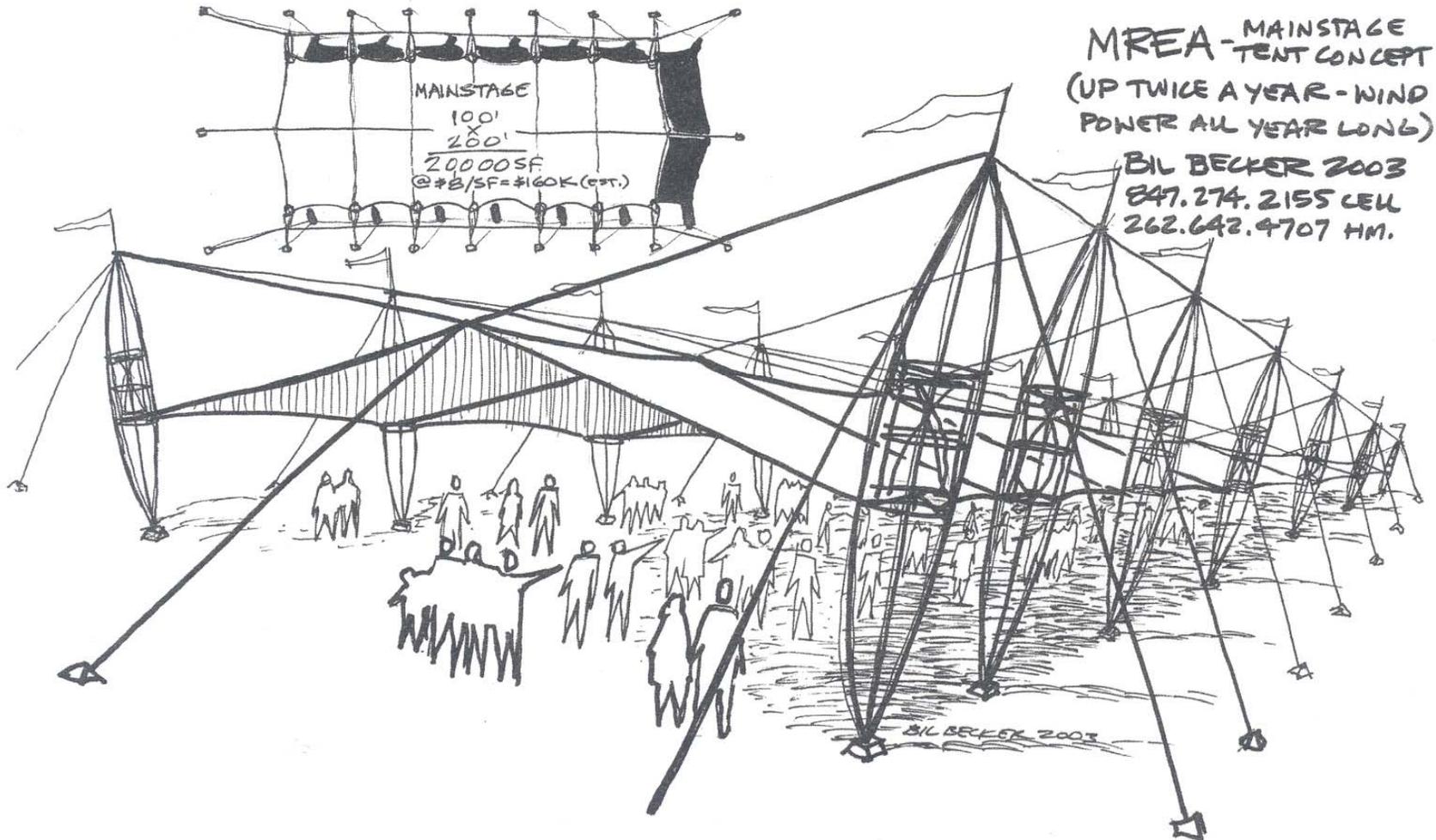


# AeroTent 1 – MREA 2003



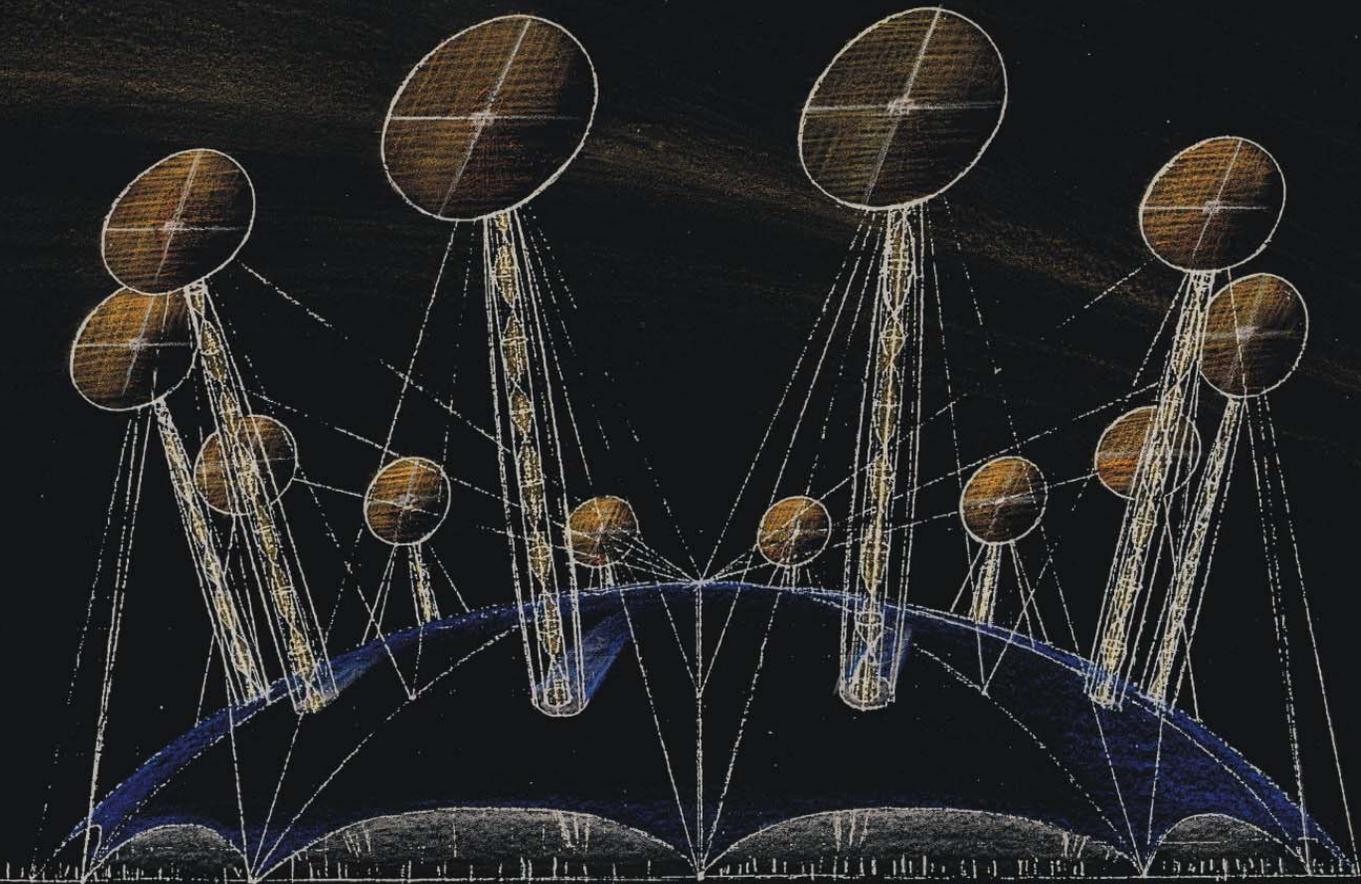
# World Villages Mega AeroTent

## Year-long Power + Seasonal Market Tent



# London Millennium Dome II

## River-based Windpower - Nightly - Year Long



©BILBECKER/2000



# Future AeroTower

DESIGN EARTH SYNERGY



SUSTAINABLE DESIGN & DEVELOPMENT



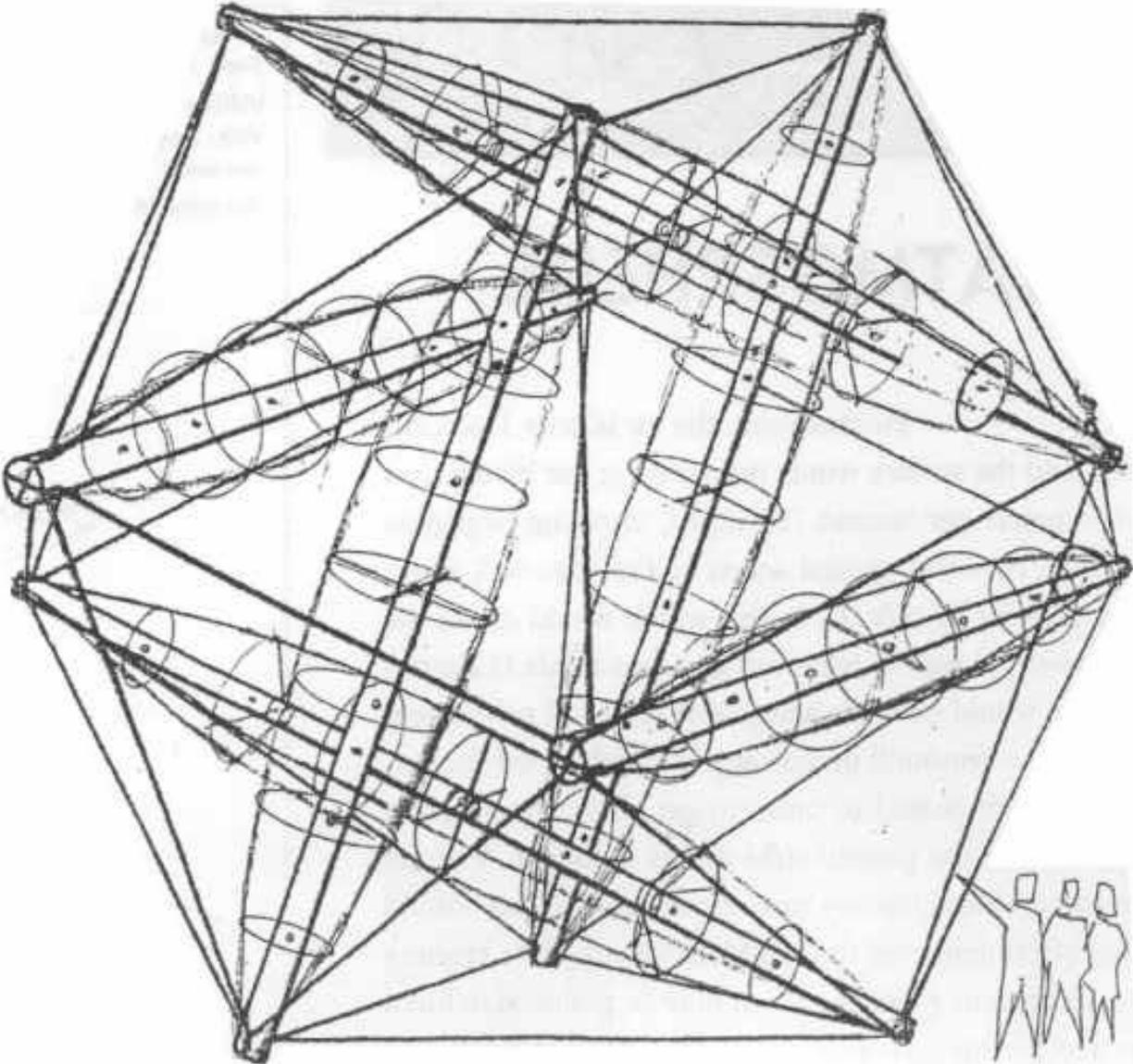
**Symphony Park**  
Honolulu, HI

**Aeritecture Building-Integrated Wind-Turbines**

**Architectural Design:** Christopher Hyde Belknap, WATG  
**Aeritecture:** Bil Becker, Aeritecture Ltd  
**Engineering:** Reinhold Ziegler, Synergy California L.P.

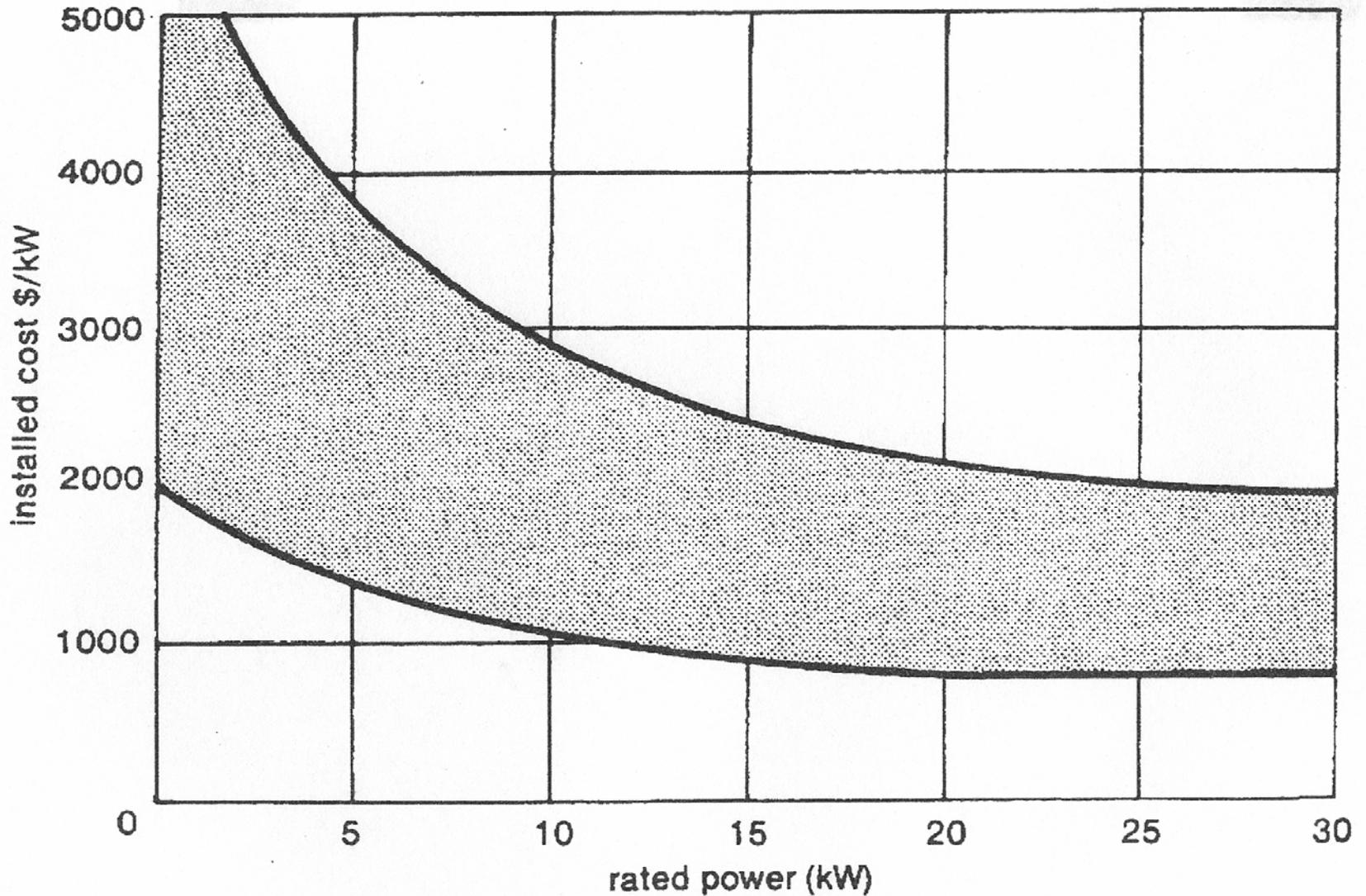
**For further information contact: +1 415 290 4990**

# Six Aeroturbine - Urban Wind Farm



Bill Ruston 2005

# Installed Costs/Rated Power



Costs of complete wind electric systems.

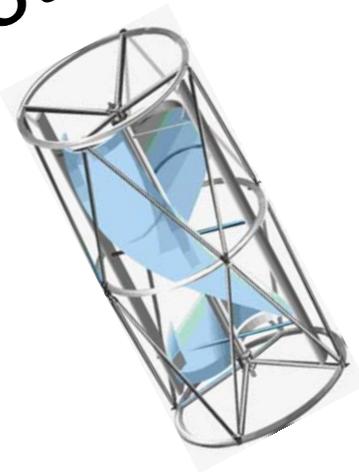


**THANKS**

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# Urban Windpower: Natural Energy Systems for World Cities

Bil Becker, CEO - Aerotecture International, Inc.  
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