



Cornell Club of Cape Cod, Oct. 6, 2004

The Wind Farm

Economics

Politics

Environment

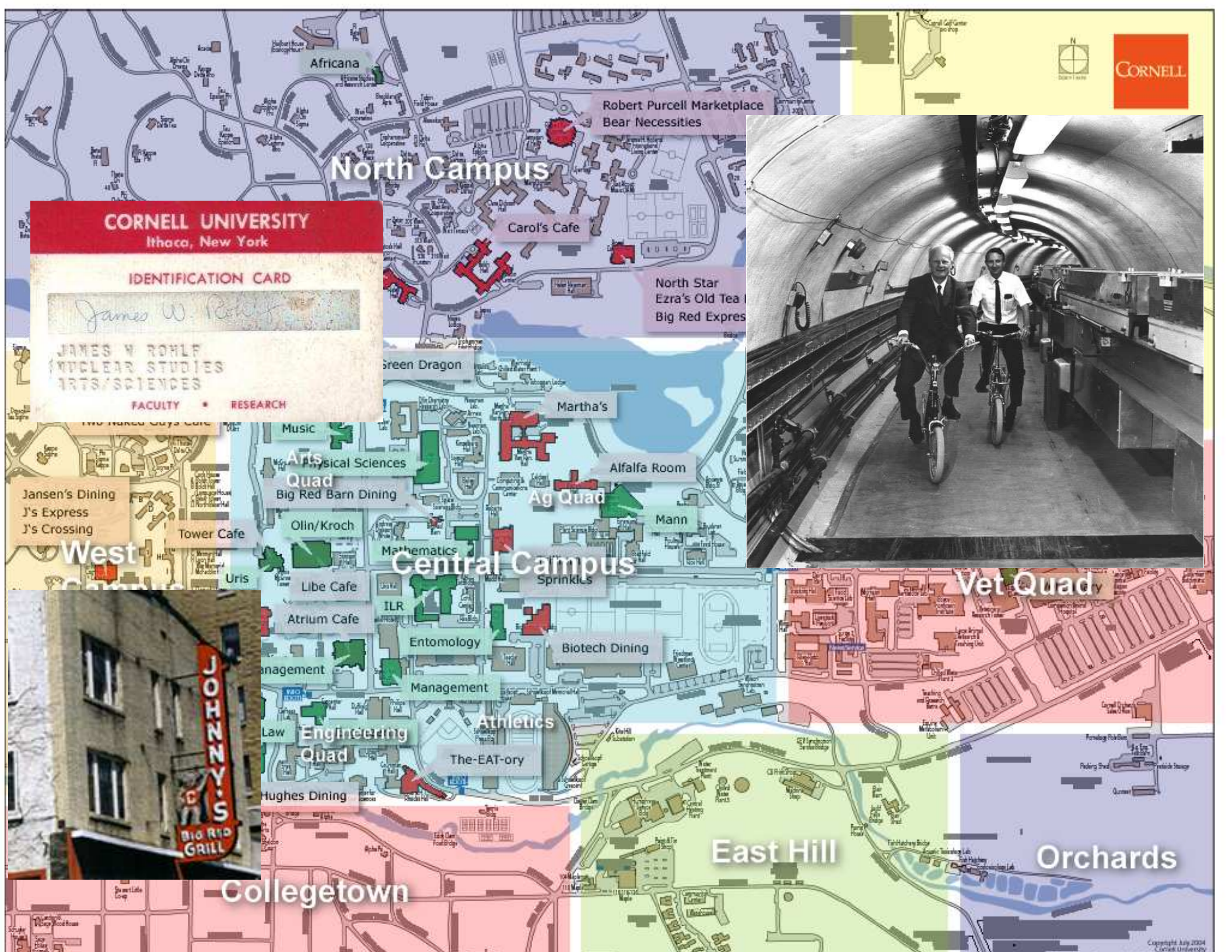
Physics

Jim Rohlf

Professor of Physics

Boston University





North Campus

CORNELL UNIVERSITY
Ithaca, New York

IDENTIFICATION CARD

James W. Rohlf

JAMES W. ROHLF
NUCLEAR STUDIES
ARTS/SCIENCES

FACULTY • RESEARCH

Robert Purcell Marketplace
Bear Necessities

Carol's Cafe

North Star
Ezra's Old Tea
Big Red Express



Jansen's Dining
J's Express
J's Crossing

Tower Cafe

West Campus

Music
Physical Sciences
Big Red Barn Dining
Olin/Kroch
Mathematics
Libe Cafe
Atrium Cafe
Entomology
Management
Law
Engineering Quad
The-EAT-ory
Hughes Dining

Central Campus

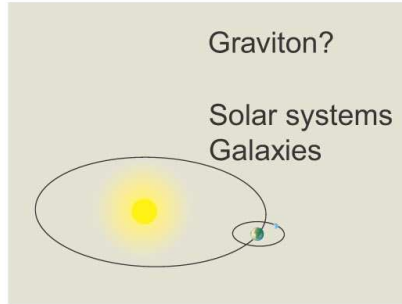
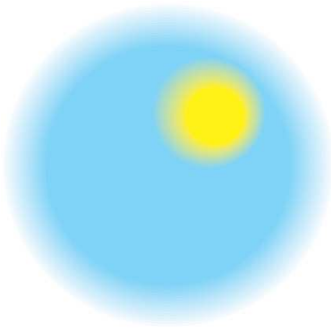
Vet Quad



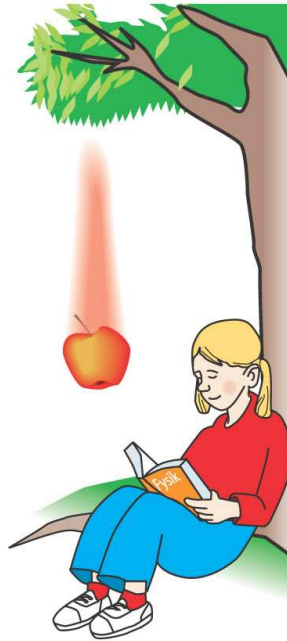
Collegetown

East Hill

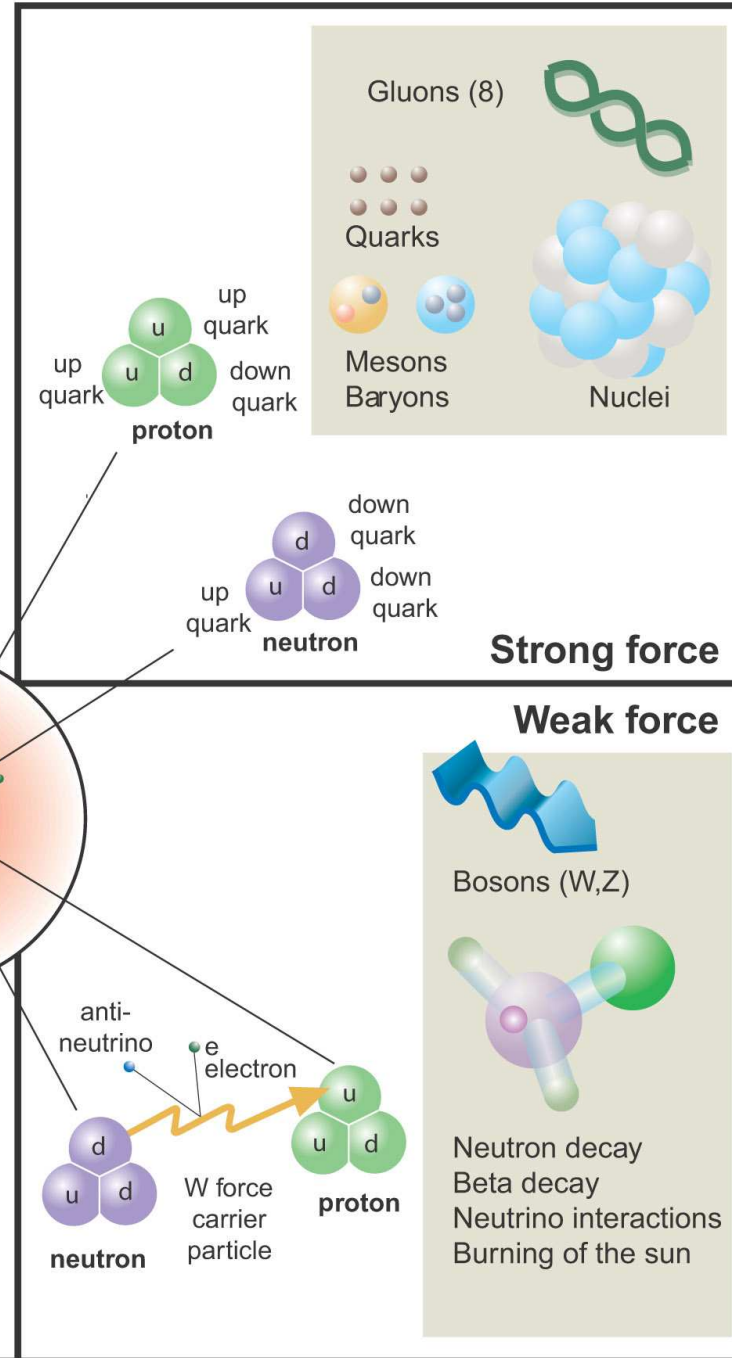
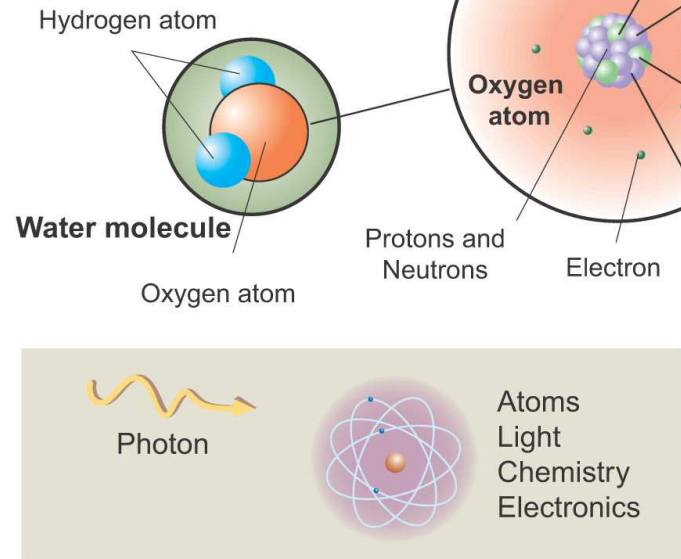
Orchards



Gravity Force



Electromagnetic force







Project at a Glance

130 turbines

Cost \$800 Million

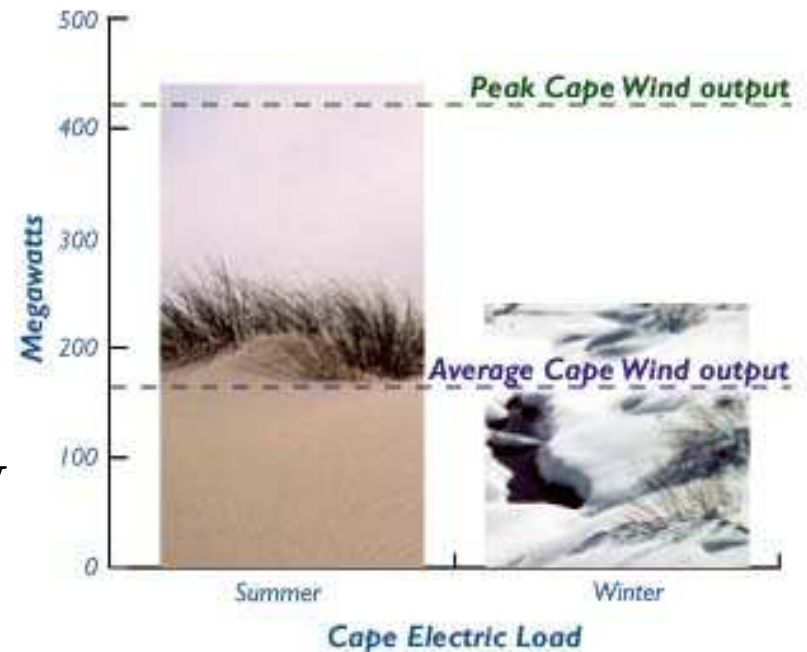
Maximum power output = 420 MW

Need 30 mph wind

Average power output = 170 MW

Need 19 mph wind

Tower spacing 0.3 – 0.5 miles, over an area the size of Manhattan (24 sq. mi)

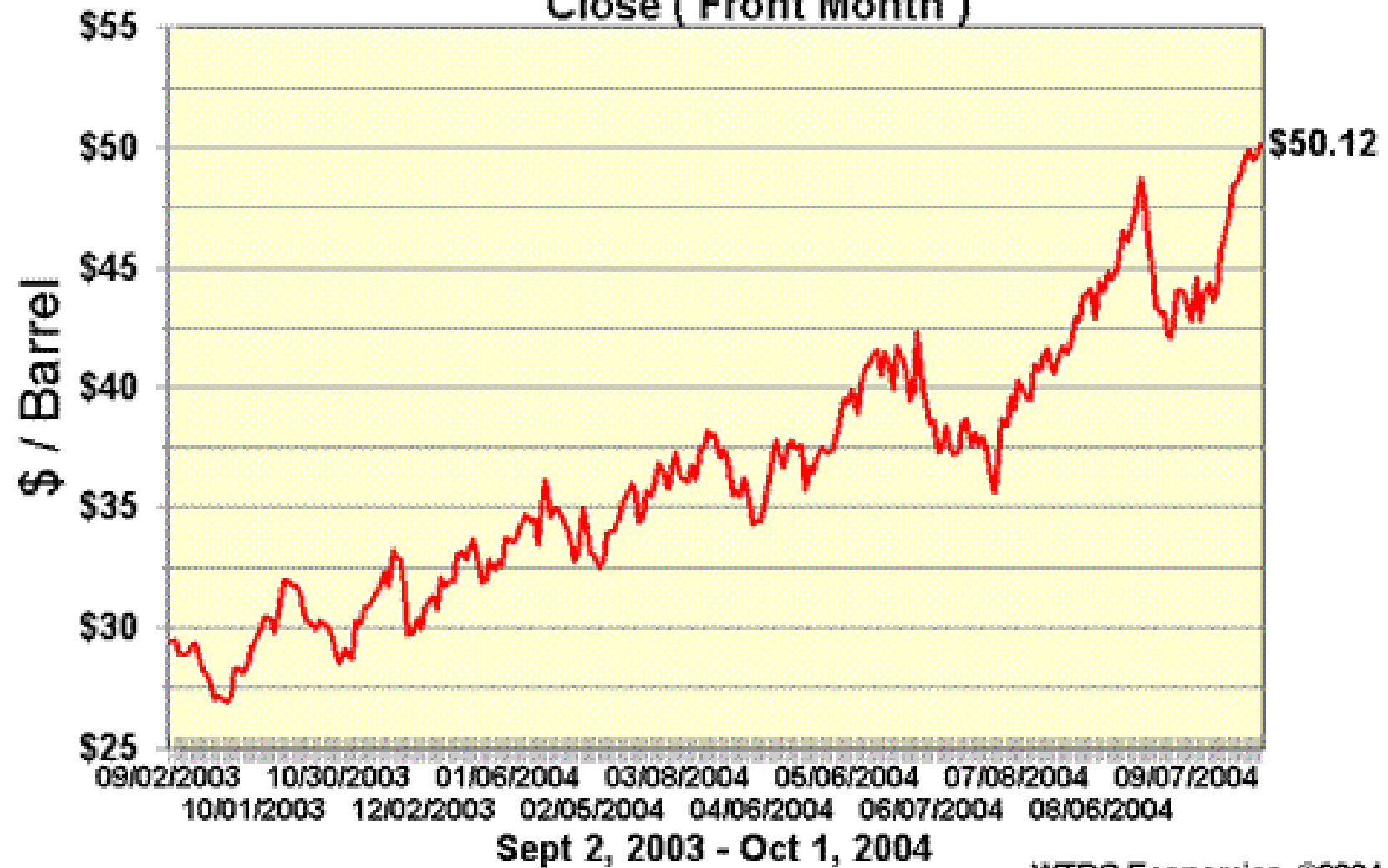


Observation:

The proposed project is BIG (~\$1B);
it is not possible to spend that amount
money and not have a major impact
on the region!

What are the **real costs** (economic
and environmental) to the Cape and
Islands *vs.* potential **benefits** for
placing a major industrial complex in
Nantucket Sound?

NYMEX Crude Oil Futures Close (Front Month)

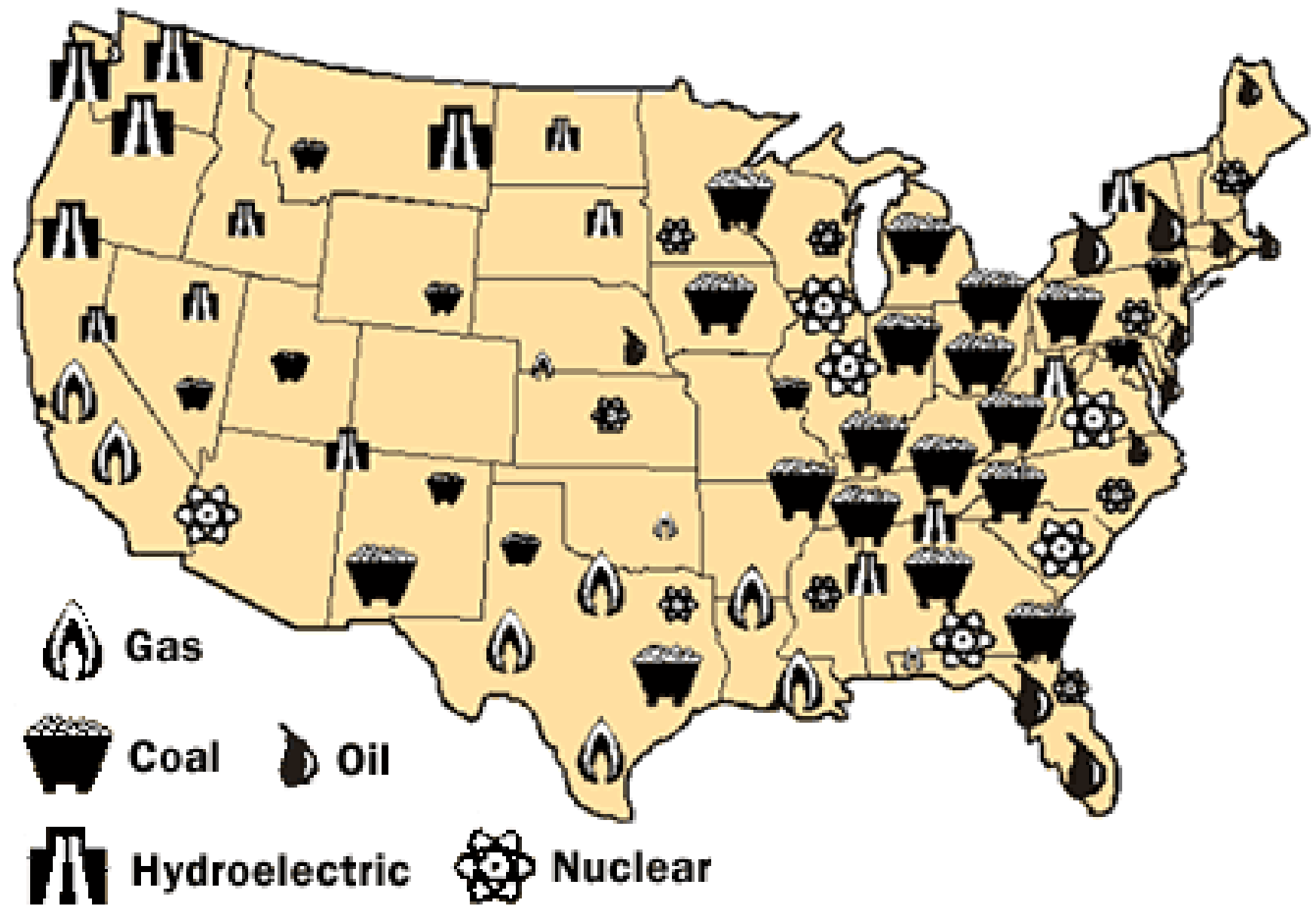


— Close

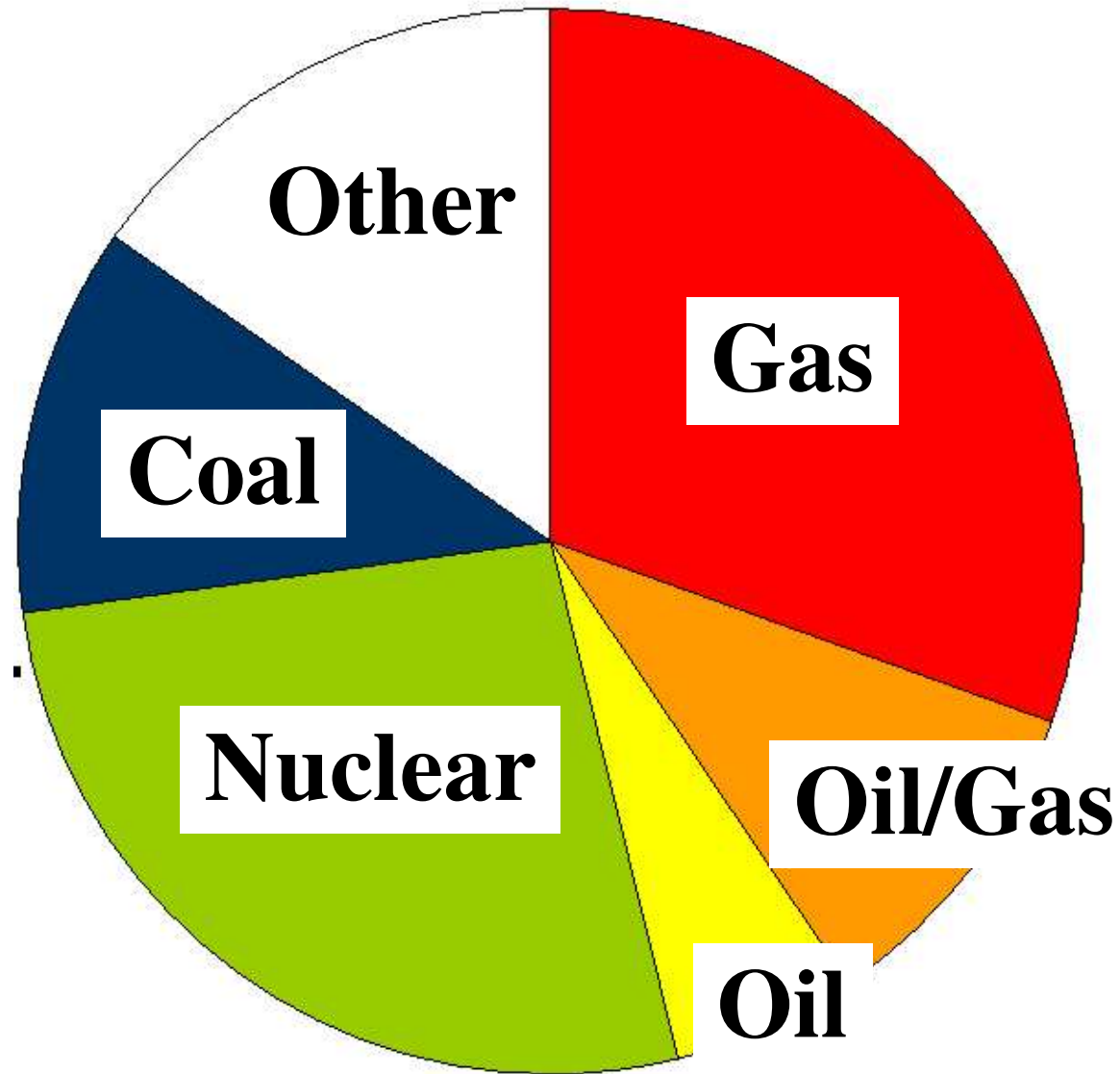
WTRG Economics ©2004

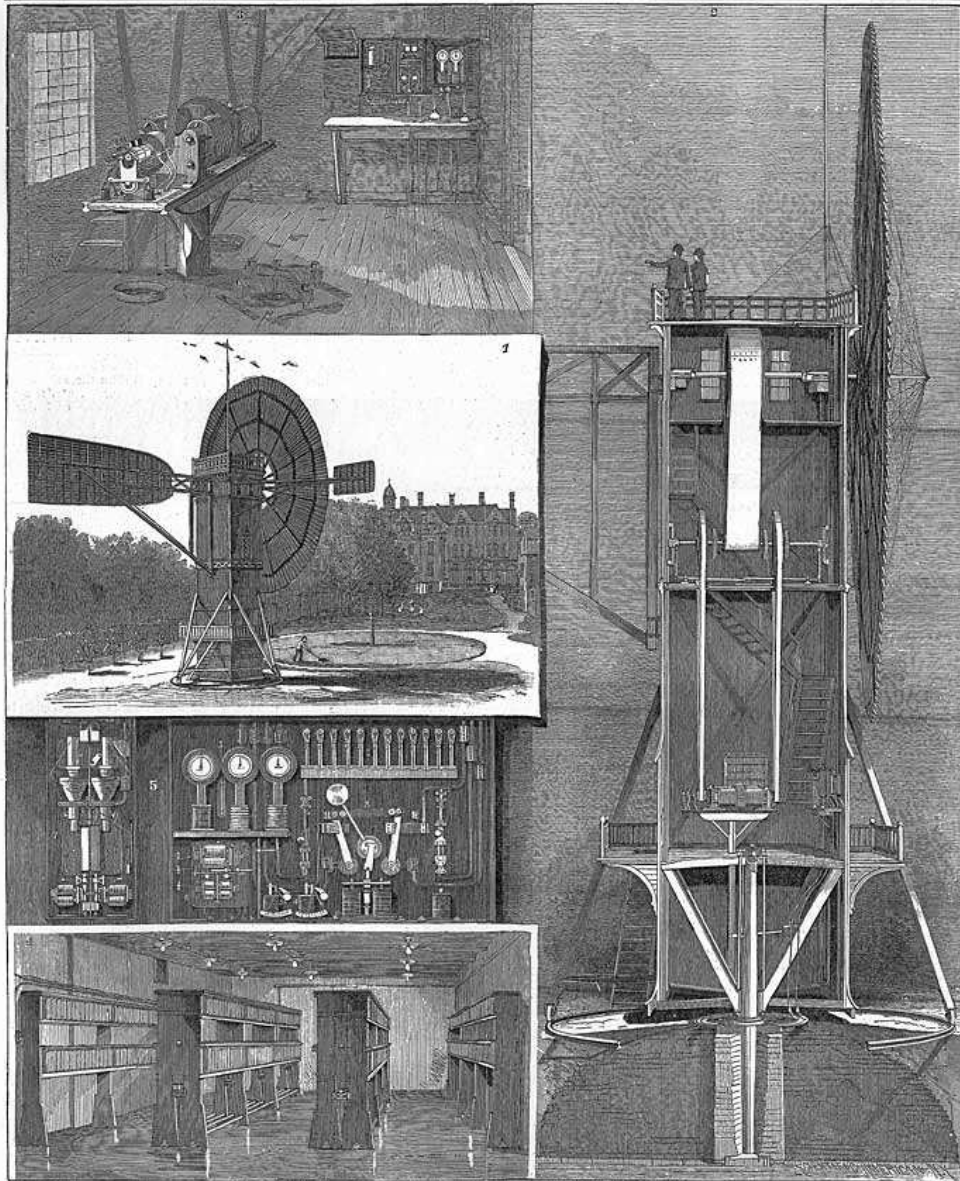
www.wtrg.com

(479) 293-4081



Power Sources in New England



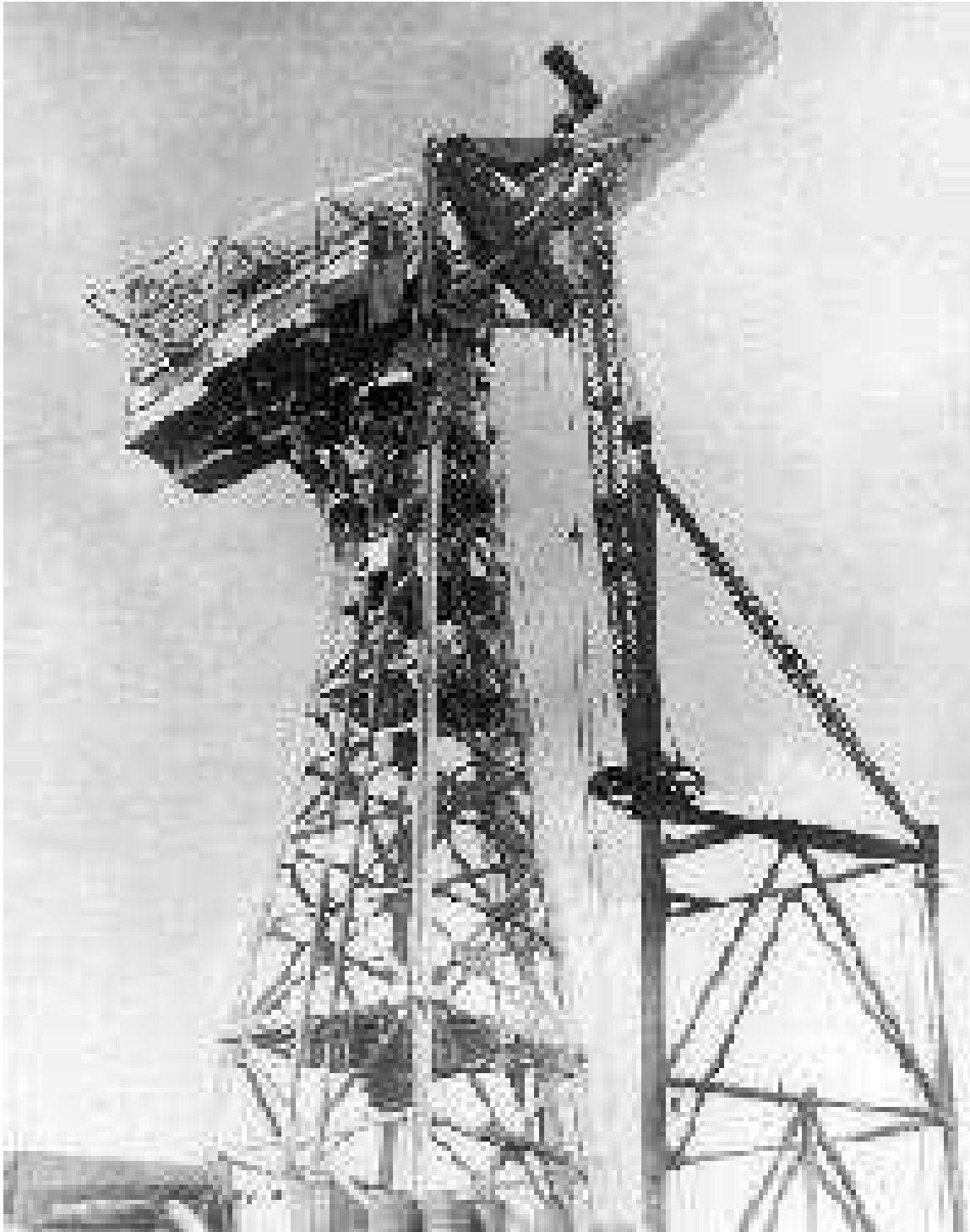


1. Windmill in the park. 2. Vertical section of the tower. 3. Dynamo. 4. Storage batteries. 5. Regulating apparatus.
THE WINDMILL DYNAMO AND ELECTRIC LIGHT PLANT OF MR. CHARLES F. BRUSH, CLEVELAND, O.—[See page 386.]

First Electricity from the Wind

**Brush Wind Mill
(1887)**

DC, 12 kW



Industrial Scale

Smith-Putnam

Vermont

(1941)

1.25 MW

California Wind Rush (1980s)



Micon 55 kW (1000 machines in Palm Springs)

Horns Rev, Denmark (2002)



World's largest offshore wind plant, 80 turbines, maximum capacity 160 MW

Electromagnetic Environment

Everything around us is a direct consequence of the properties of electricity and magnetism.

Atoms-- which make up everything from Kings to cabbages-- are held together by the electromagnetic force.

Light is an electromagnetic wave-- blue skies and red sunsets.

Gravity may hold you on the surface of the earth, but electromagnetism keeps you from falling to the center.

All of chemistry and biology (and most of physics) is electromagnetic.

etc.

Understanding classical electromagnetism has been one of the greatest intellectual achievements of mankind.

Voltage, Electric fields (and all that)

Voltage is (potential) energy per charge.

The kinetic energy that an electron gets is voltage times electric charge.

Current is flow of charge.

Electric **power** is current times voltage.

Electric field is force per charge.

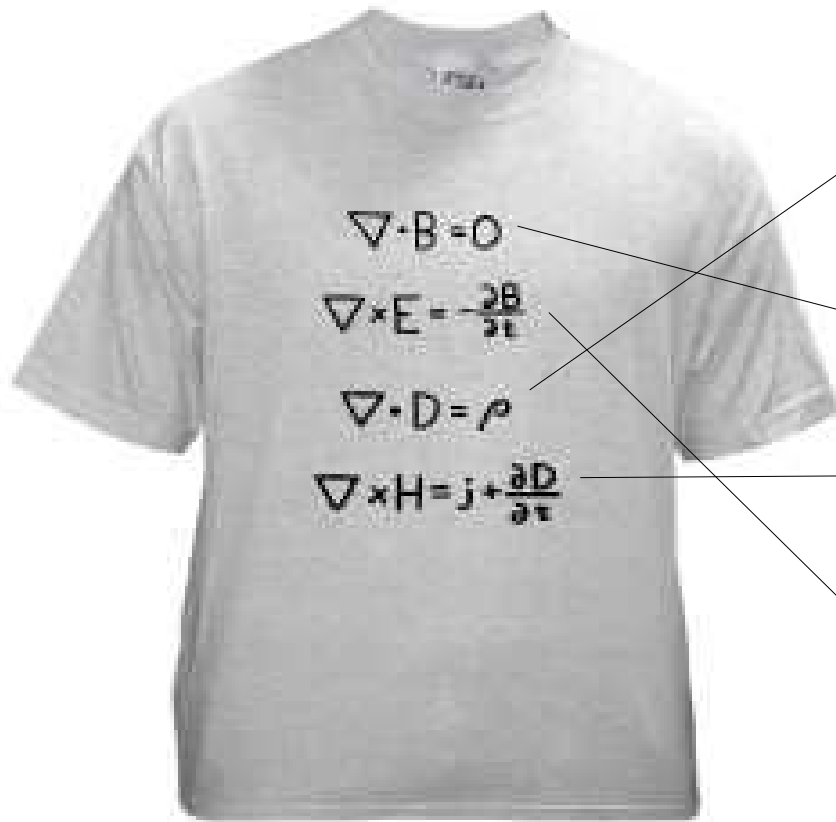
The push that an electron gets is electric field times charge.

Magnetic field is force per charge per speed.

The push that an electron gets is magnetic field times charge times speed.

Classical Electromagnetism (Maxwell Equations)

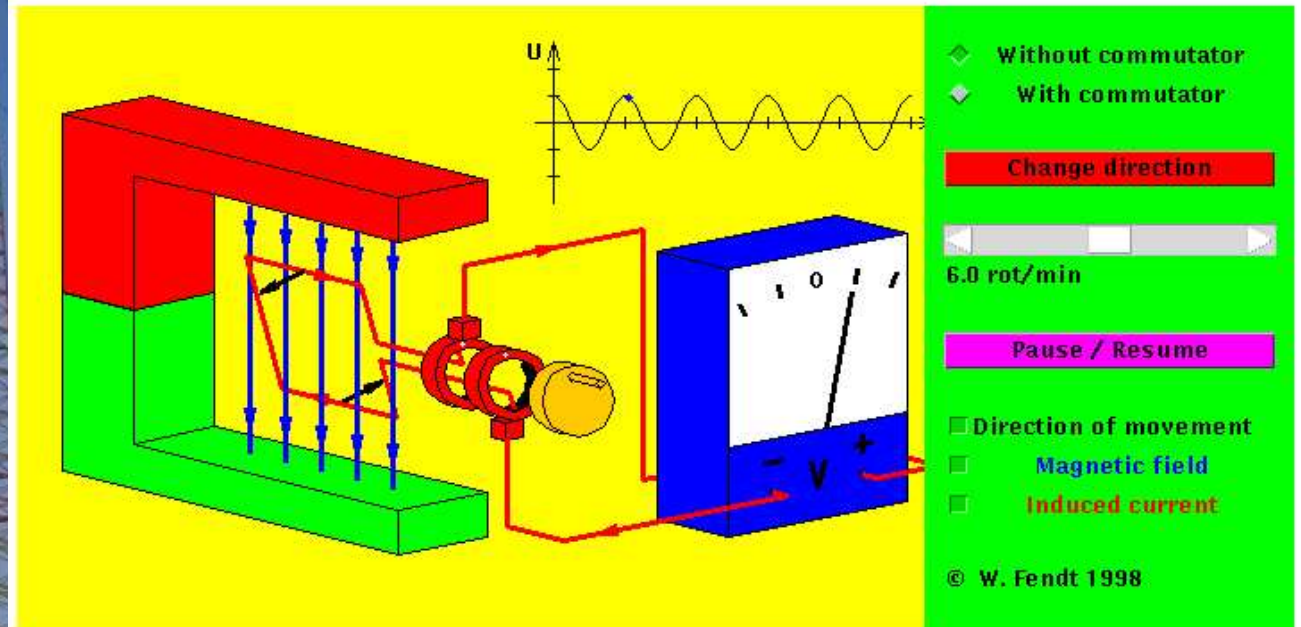
And God said...



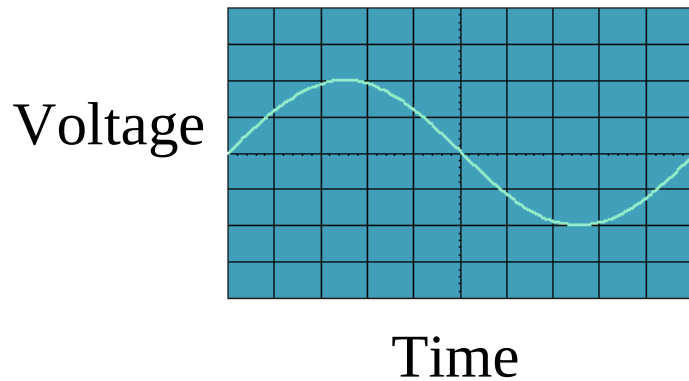
- 1) electric fields are caused by electric charges (*e.g.* electrons)
- 2) there are NO magnetic charges
- 3) electric currents or changing electric fields make magnetic fields
- 4) changing magnetic fields make electric fields

... and there was light!

Faraday's Law



Alternating Current (AC)

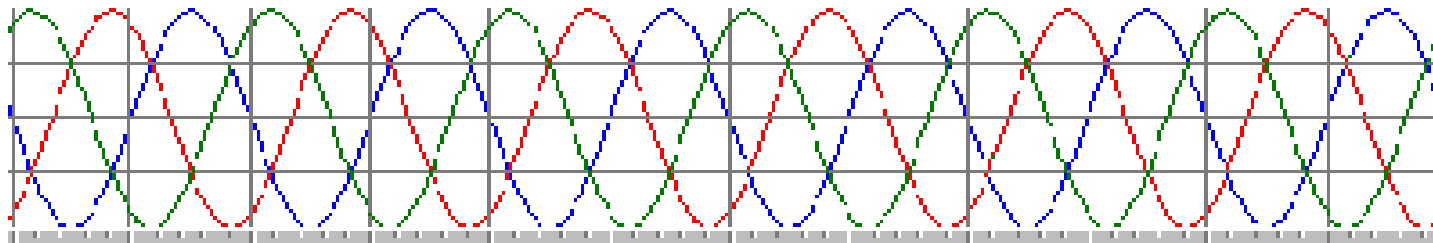


60 cycles per second
170 volts peak, 120 volts rms

Why AC?

- 1) generators produce AC naturally
- 2) distribution depends on transformers, which need AC to operate
- 3) AC to DC conversion is easy (but not DC to AC)

Three phase



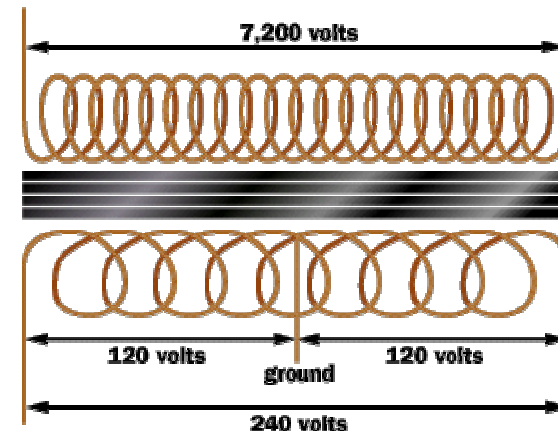
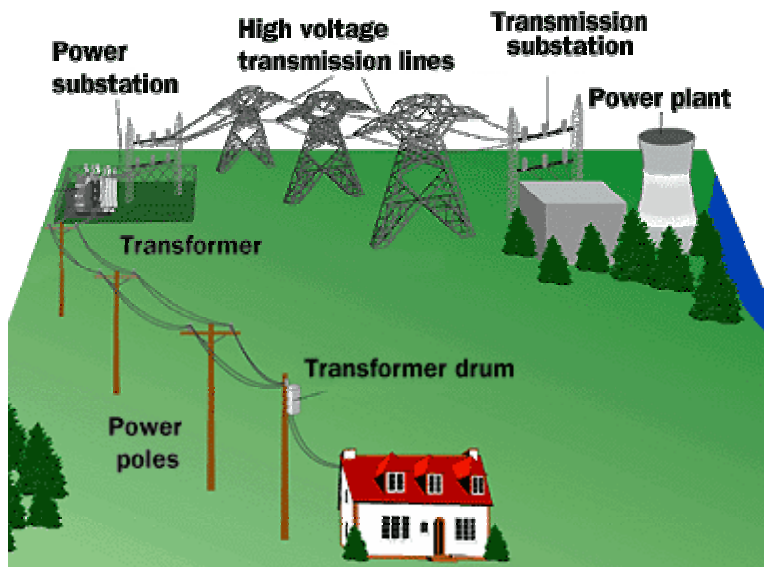
The Electric Grid

US Department of Energy site

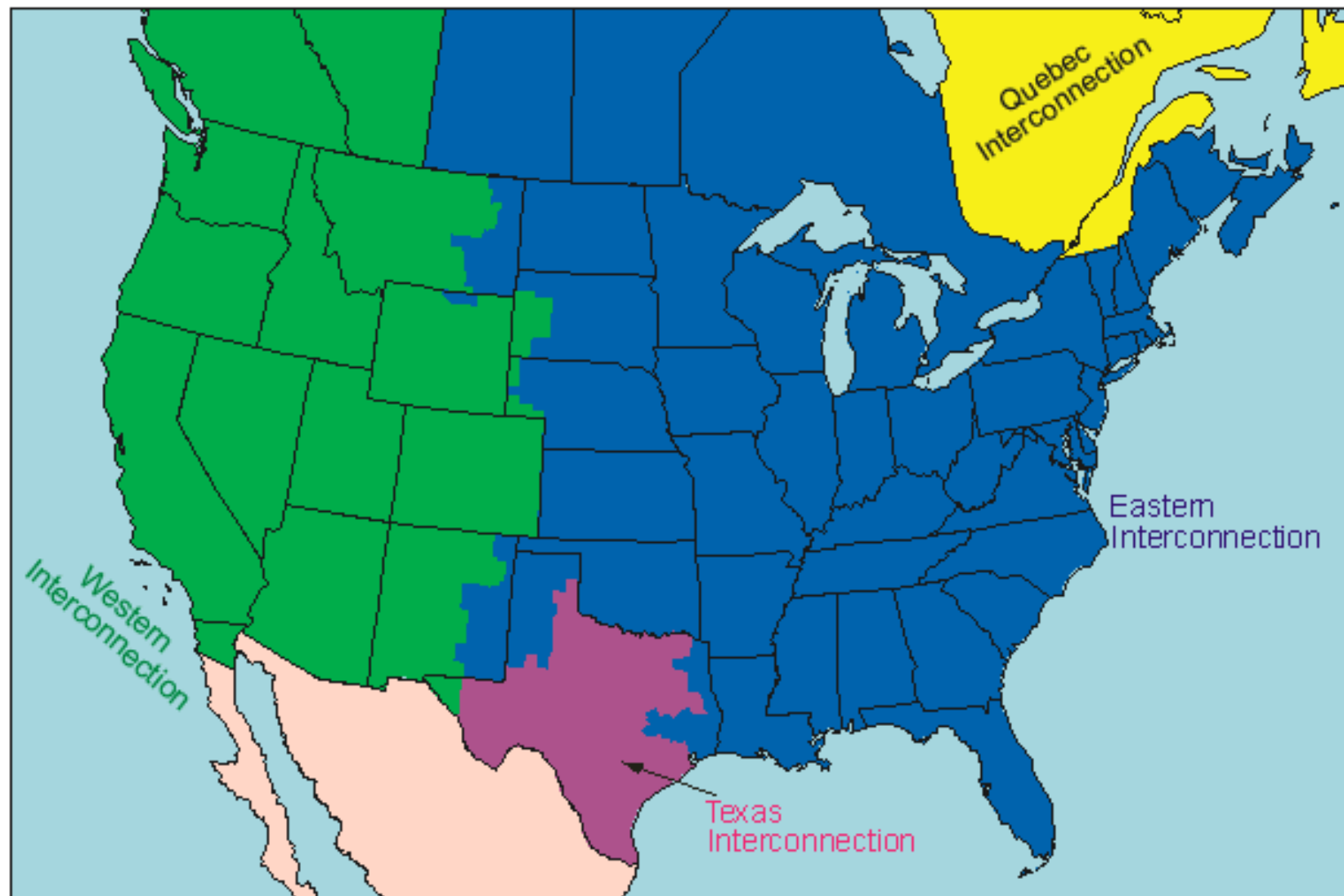
http://www.eere.energy.gov/de/basics/der_basics_egrid.shtml

The grid consists of “centrally” located power plants with two infrastructures:

- High voltage transmission
Transmits electricity hundreds of miles, 155-765 kV
- Low voltage distribution
Distributes to individual customers, 7200 V ---> 120/240 V at your house



Interconnections of the North American Electric Reliability Council in the Contiguous United States, 1998

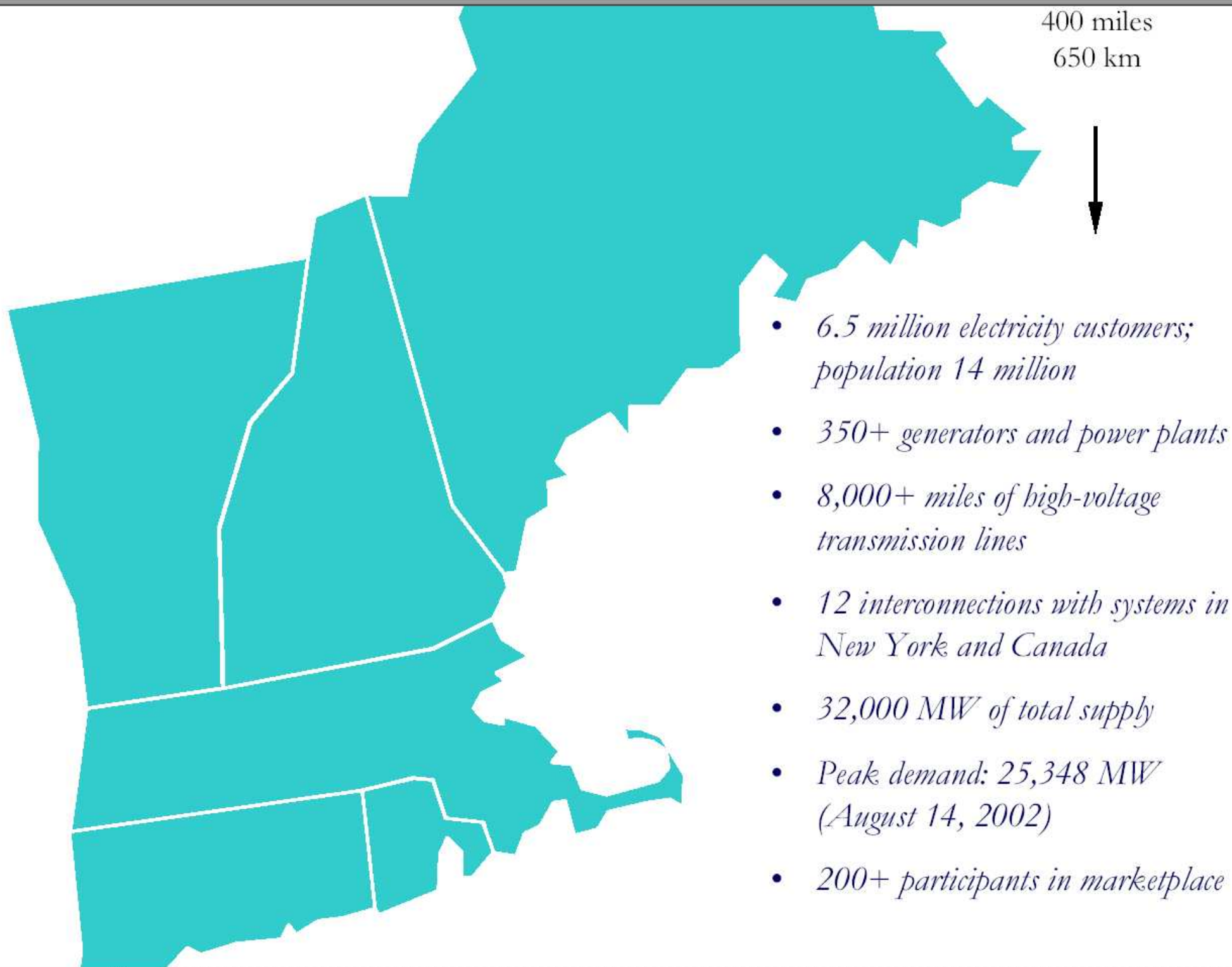


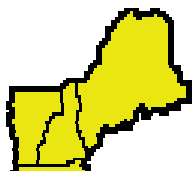


Independent System Operators (ISO) New England



Operates the electric grid and administers the wholesale market.

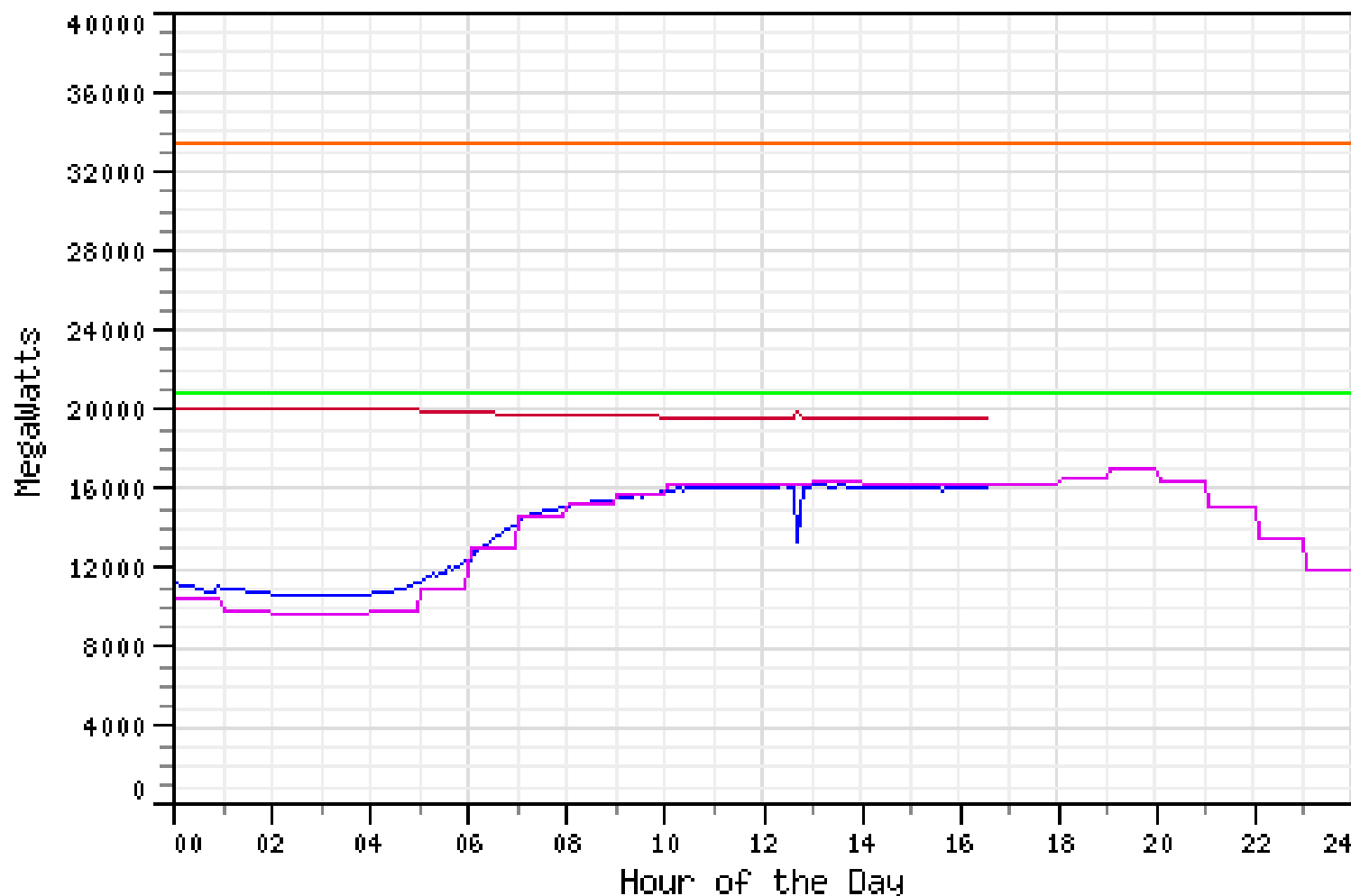
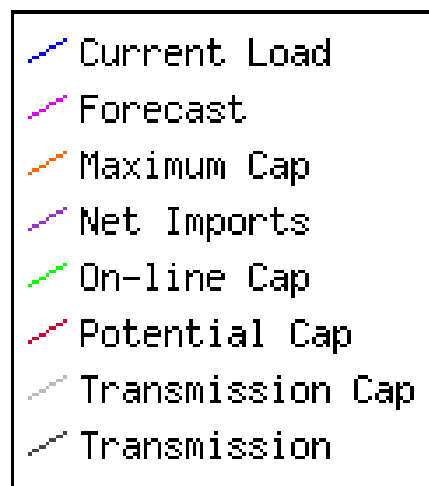




New England Supply & Demand

NE Electricity System Status

Mon. Oct. 4, 2004



<http://currentenergy.lbl.gov/ne/>

Mirant Plant (Sandwich)

About 1100 MW of power (6.5 times Cape Wind)

Burns gas/oil... (has been a huge polluter in the past, burning no. 6 crude oil-- literally the pits from the refinery, containing Vanadium which catalyzes acid rain)

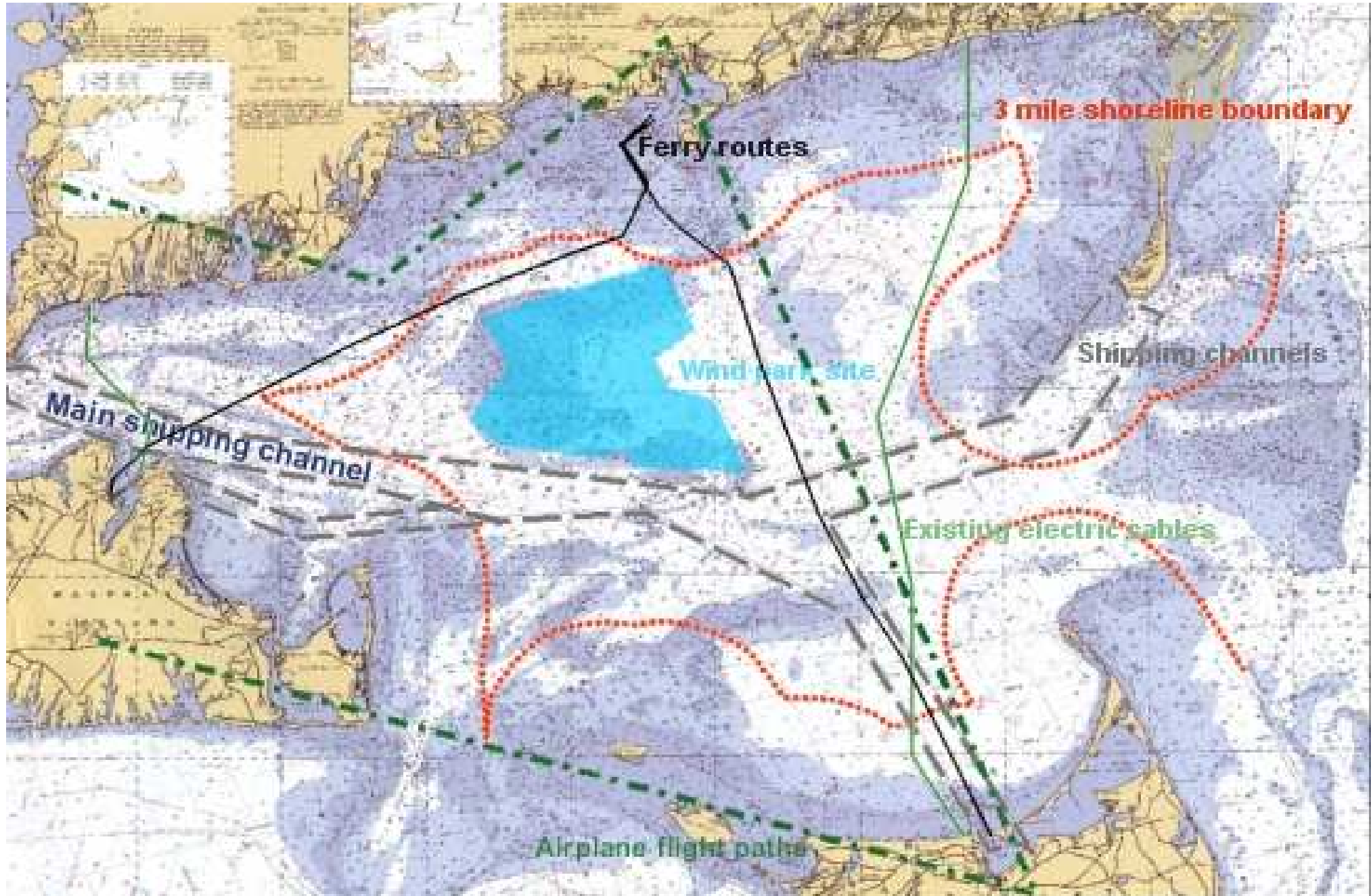
Use of this plant does NOT get reduced by Cape Wind's power output!

“In essence, the power from many power plants is 'pooled' in the transmission system, and each distribution system draws from this pool. This [networked system helps achieve a high reliability for power delivery](#) because any one power plant that shuts down will only constitute a fraction of the power being delivered by the grid.”

“One result of power pooling is that the [electricity drawn off the grid always comes from a diversity of power sources](#), which may include coal, nuclear, natural gas, oil, and renewable energy sources such as hydropower, biomass, wind, and solar power. This is often referred to as "system power" because it is the standard power mixture that supplies the transmission system. There are financial and contractual means of tying an individual generating source, such as a wind farm, with an individual user in a meaningful way, but it is still true that the [electricity one draws from the grid is always system power.](#)”

http://www.eere.energy.gov/de/basics/der_basics_egrid_func.shtml

Project Site: Horseshoe Shoals



Project Timeline

June 2001

Cape Wind introduces plan for 50 turbines in Nantucket Sound

November 2001

Cape Wind files environmental notification with Army Corp for 170 turbines in Nantucket Sound

May 2002

Alliance to Protect Nantucket Sound is formed to oppose project

August 2002

Army Corp grants permit for 197 ft. data tower

January 2003

Cape Wind signs deal with GE for turbines, reducing number to 130

May 2003

Data tower becomes operational

October 2004

Environmental impact report being reviewed by Pentagon



Issues

Visual impact

Avian

Fisheries

Ocean Mammals

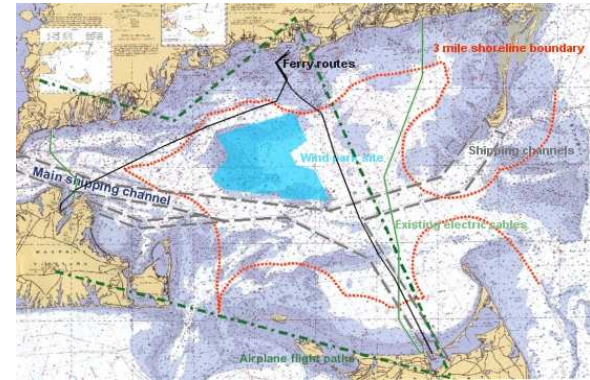
Navigation

Accessibility

Tourism

Cost of electricity

Regulatory process



Visual Impact

On a clear day, the 420 ft structures would be visible at a distance of 25 miles.

At a distance of 5 miles, each structure would subtend an angle of slightly less than one degree. The height of a single structure at this distance may be visualized as the height of your thumbnail when held out at arm's length.

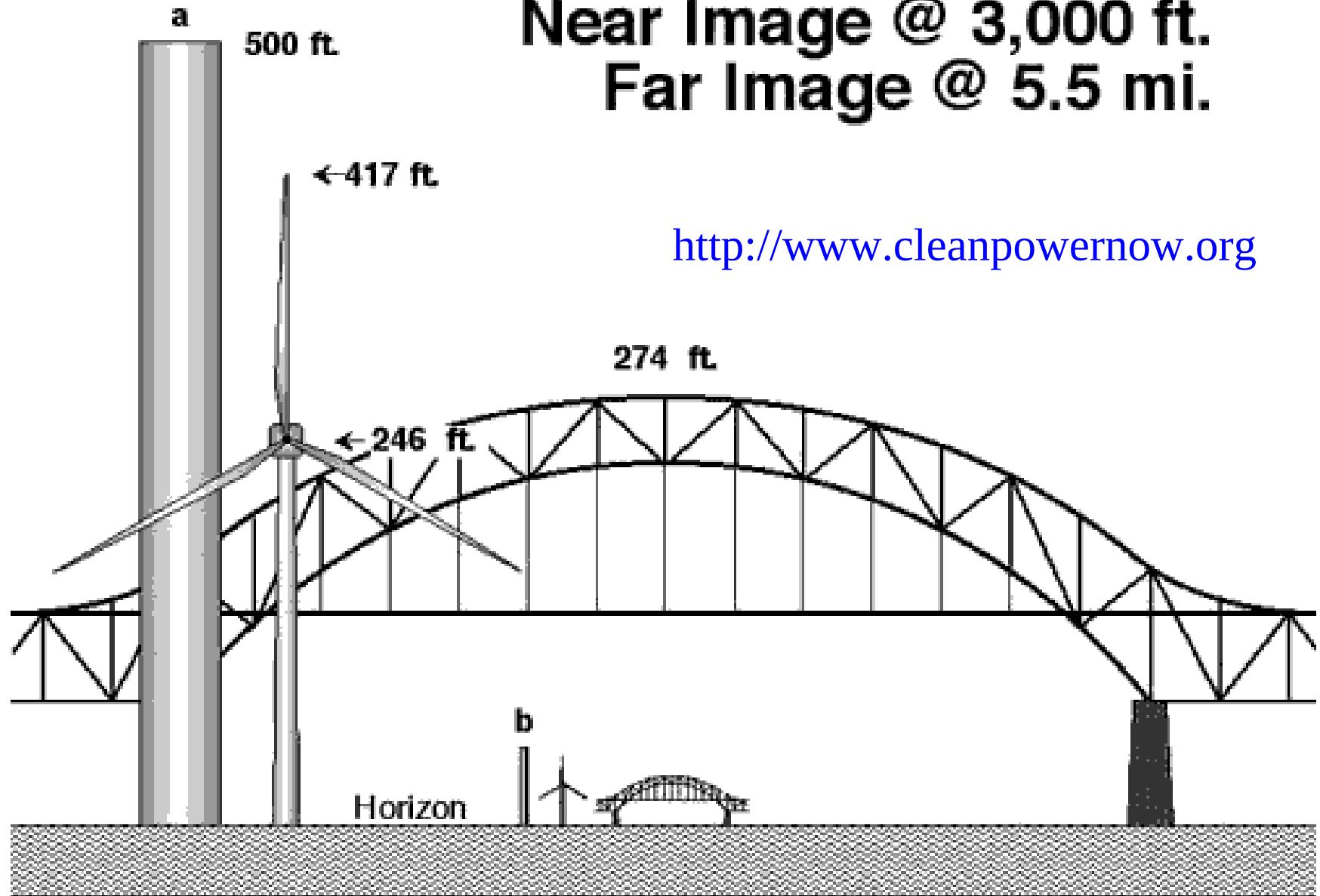
Only 23 buildings in Boston are taller...

Boston Harbor Condominiums: 400 ft

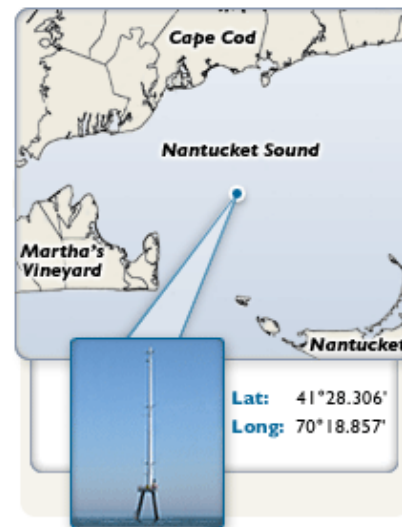


Picture Plane Perspective at 3 feet Near Image @ 3,000 ft. Far Image @ 5.5 mi.

<http://www.cleanpowernow.org>



Data Tower: 197 ft



Current Conditions

Last updated: Mon Oct 4 19:40:04 2004 EDST •

Wind direction*† (WD): 216 deg

Wind speed* (WS): 13 knots

Wind gust* (WG): 15 knots

Barometric pressure** (BP): 1015.0 mb

Air temperature** (AT): 63.1 ° F

**Simulated view from Craigville Beach (6.8 mi)
(source: Cape Wind)**



Avian



Roseate
Tern

Pro

“...extensive avian research is being conducted on Nantucket Sound using high resolution avian radar (below), over-flights, and boat transects. Based upon a preliminary review of existing information and field observations, there will be relatively little change to the avian population as a result of the installation and operation of the wind park.”

“The issue of bird collisions with the turbines has been studied extensively at many wind parks in the US and abroad and no population impacts have been documented.”



Avian Radar

Cape Wind

Con

“This particular project site is an area with one of the highest concentrations of seaducks and terns on the Atlantic seaboard. The shoals at this location provide ample feeding opportunities for birds. The site is also located along a major migratory bird flightway. We do not agree with the ENF's unsupported conclusions that avian risks are small or that bird use in the area is low.”

Mass. Audubon

Fisheries



Mackerel

Pro

“The siting, construction and operations of the wind park are designed to ensure that the wind park co-exists successfully with fish and the fishing industry. The towers will be spaced at least a 1/3 mile to a 1/2 mile apart, allowing most commercial fishing vessels to navigate without obstruction. In fact, some measures may actually increase fisheries yield, benefitting all who depend on these important marine resources.”

Cape Wind

Scup



Con

“The fisheries community that has evolved at Horseshoe Shoals is dependent on the presence of an open, sandy shoal environment and conversion to a habitat dominated by high relief structures could have serious consequences to the functions and values of the area.”

Mass. Marine Fisheries Commission



Winter
Flounder

Ocean Mammals



Gray
Seal

Pro

“Because the wind park uses a negligible fraction of the area of Horseshoe Shoal, the loss of habitat and direct impact to marine mammals and threatened/endangered species will be minimal.”

“The most common ocean mammals in Nantucket Sound are seals. Extensive studies of the Bockstigen wind farm off the shore of Sweden found no adverse impact to the abundant local seal population there.”

Cape Wind

Con

“With respect to the genetic uniqueness of this population, the gray seals' dependence on the waters of Nantucket Sound strongly support protection of these and adjacent waters employing an ecosystem approach to management.”

Review of the State and Federal Marine Protection of the
Biological Resources of Nantucket Sound

Navigation



Pro

“...the turbines will be placed away from any commercial shipping lanes.”

Cape Wind

Con

“We feel strongly that the scope and location of this project will prove to be an additional navigational hazard to commercial and recreational boaters alike.”

Hy-Line Cruises

Not only will ferry traffic and other boat traffic be altered, CCCHFA is concerned that the turbines could become an impediment to Coast Guard search and rescue efforts when lives are on the line.”

Cape Cod Hook Fishermen's Association

Accessibility



Pro

“Cape Wind does not seek exclusive use of Horseshoe Shoal. Access for boaters who use this shallow shoal will not change.”

Cape Wind

Con

“In its application for an Army Corps of Engineers (ACOE) Section 10 permit, the applicants have requested restrictions on other uses of the project area and a mile-wide corridor surrounding the project site.”

Office of Coastal Zone Management, 4/5/02

Tourism

Pro

“The wind park, like so many across the globe, can become a new eco-tourism destination.”

Cape Wind



Con

There are only a handful of offshore wind farms in existence, all in Europe, all considerably smaller than this project. There are land-based parks all over the world and the novelty is nothing new. Because of the clear threat to tourism, no local tourist organizations support this project, though many oppose it.

Alliance to Protect Nantucket Sound



Cost of Electricity



Wind electricity is expensive to produce, about \$ 0.04 per kWh at a high-wind site (low wind sites are considerably more expensive), compared to about \$ 0.03 per kWh for conventional fuels.

A \$28 M per year federal subsidy makes the project financially feasible.
(Note: $\$280 / \$800 = 0.35$)





Regulatory Process

Permitting and review authorities (partial list)

- * US Army Corps of Engineers
- * US Environmental Protection Agency
- * National Marine Fisheries Service
- * US Coast Guard
- * Federal Aviation Administration
- * Massachusetts Executive Office on Environmental Affairs
- * Massachusetts DEP—Division of Wetlands and Waterways
- * Massachusetts Coastal Zone Management
- * Cape Cod Commission



Pro

“...Cape Wind will complete comprehensive environmental studies for federal, state and local agencies, and provide opportunity for public comment.”

Cape Wind

Con

“...does not even begin to address the state interests in the appropriate use of one of the Commonwealth's most precious natural resources”

Congressman Delahunt and AG Reilly, letter to Gov. Romney, 2/26/03

What has NOT been talked about?

If Horseshoe shoals is the only place it makes economic sense to anchor New England's wind power industry, how will it ever be possible to expand beyond 1% of wind power generation in New England?

What are the competitive more cost-effective as less radical means to produce or conserve an equivalent amount of “clean” power?

When there is a wind failure, the only power that can be quickly fired up to support the grid is oil/gas. Ironically, this may actually increase our dependence on the Sandwich Mirant plant (as has been observed in parts of Europe).

THE POLLSTER



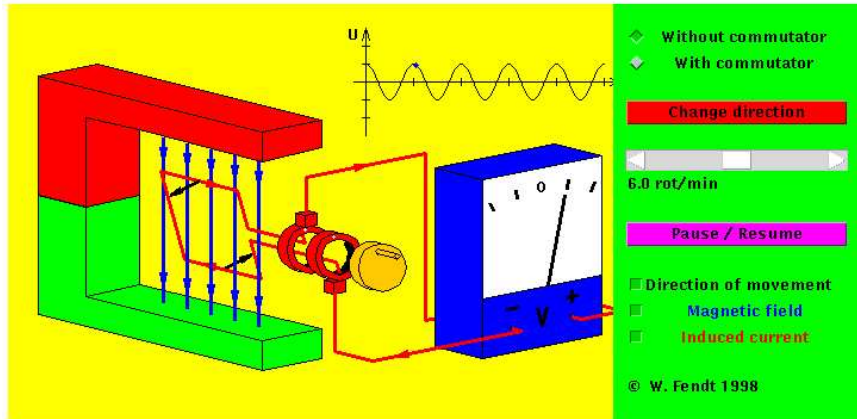
"OUR SURVEYS HAVE INDICATED THAT THERE IS MUCH CAPE-WIDE SUPPORT FOR THE WIND FARMS."

Raison d'etre

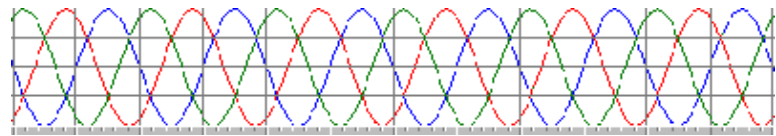
Wind
→



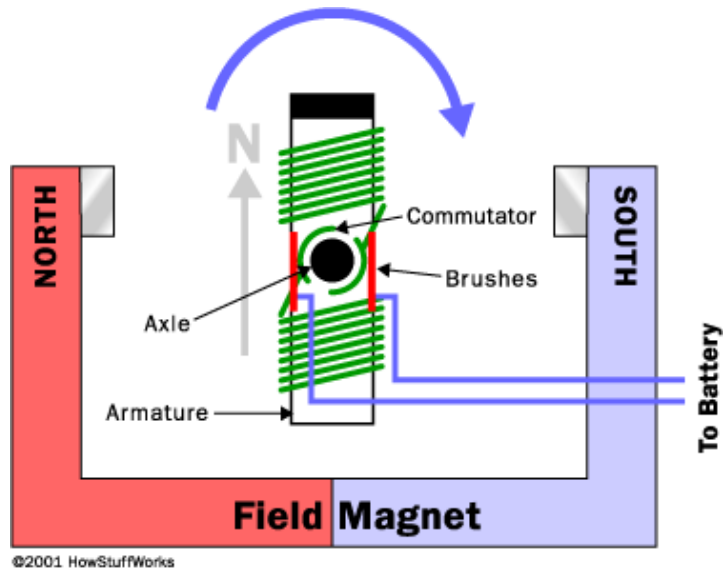
Generator
→



Voltage grid
→



Motor
→



Fan
→



Wind
→

Summary

The wind farm has pitted “environmentalists” against “environmentalists.”



Pro

Renewable energy is politically correct.

It is time NOW to take steps to reduce our dependence on fossil fuels.

Con

A 1% contribution to the New England electric grid, with no plan for expansion, is too little benefit for major industrialization of Nantucket Sound.

Online References



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<http://www.capewind.org>
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- Thomas J. Overbye, “Reengineering the Electric Grid,”
<http://www.americanscientist.org/template/AssetDetail/assetid/1472>
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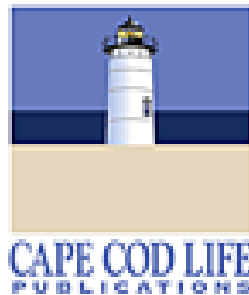
These slides: http://budoe.bu.edu/~rohlf/rohlf_talks.html

Acknowledgements

Thanks to **Arthur Gast** for arranging this invitation...



and to **Brian Shortsleeve** of Cape Cod Life for stimulating my interest in the issues.



(see James W. Rohlf, "The Wind Farm Question,"
Cape Cod Life 2004 Annual Guide)