Massachusetts Maritime Academy

Wind Turbine Project

Presented by: Paul O'Keefe, Kathleen Driscoll
Contributions by: Rich Phelan, Dave Beck

Wind Turbine at MMA

- Environmentally responsible
- No polluting emissions.
- Reduce emissions from existing power producers.
- Great student training in the greatest power growth market.
- Stabilize and reduce power cost.

The Team

- Mass Maritime Academy
- Division of Capital Asset Management
- Massachusetts Technology Collaborative
- UMASS Renewable Energy Research Lab

Project Design Team

- Jay Cashman, Inc. – General Contractor
- Energy Management, Inc. – Management Support
- ESS Group – Permitting (NOI and FAA)
- Solar Design – BOP Electrical Design
- LeMessurier Consultants – Foundation Design

Project Key Dates

- **Preliminary Technical Feasibility Study** by Sally Wright, PE - 21 May 2004
- DCAM Issues RFP in February 2005
- JCI Submitted Proposal March 9, 2005
- DCAM Awarded Contract July 2005
- Submitted Interconnect Application –Aug. 2005
- Order of Conditions Obtained Fall 2005
- Construction March and April 2006

Technical Feasibility Study

- UMASS RERL, Sally Wright
- Annual average wind speeds 6-6.5 m/s @ 50m using True Wind Map, local data
- Fall zone 1.5 x the blade tip height
- Setback from residences 3.0 x the hub height (rule of thumb) 492 ft. for V-47

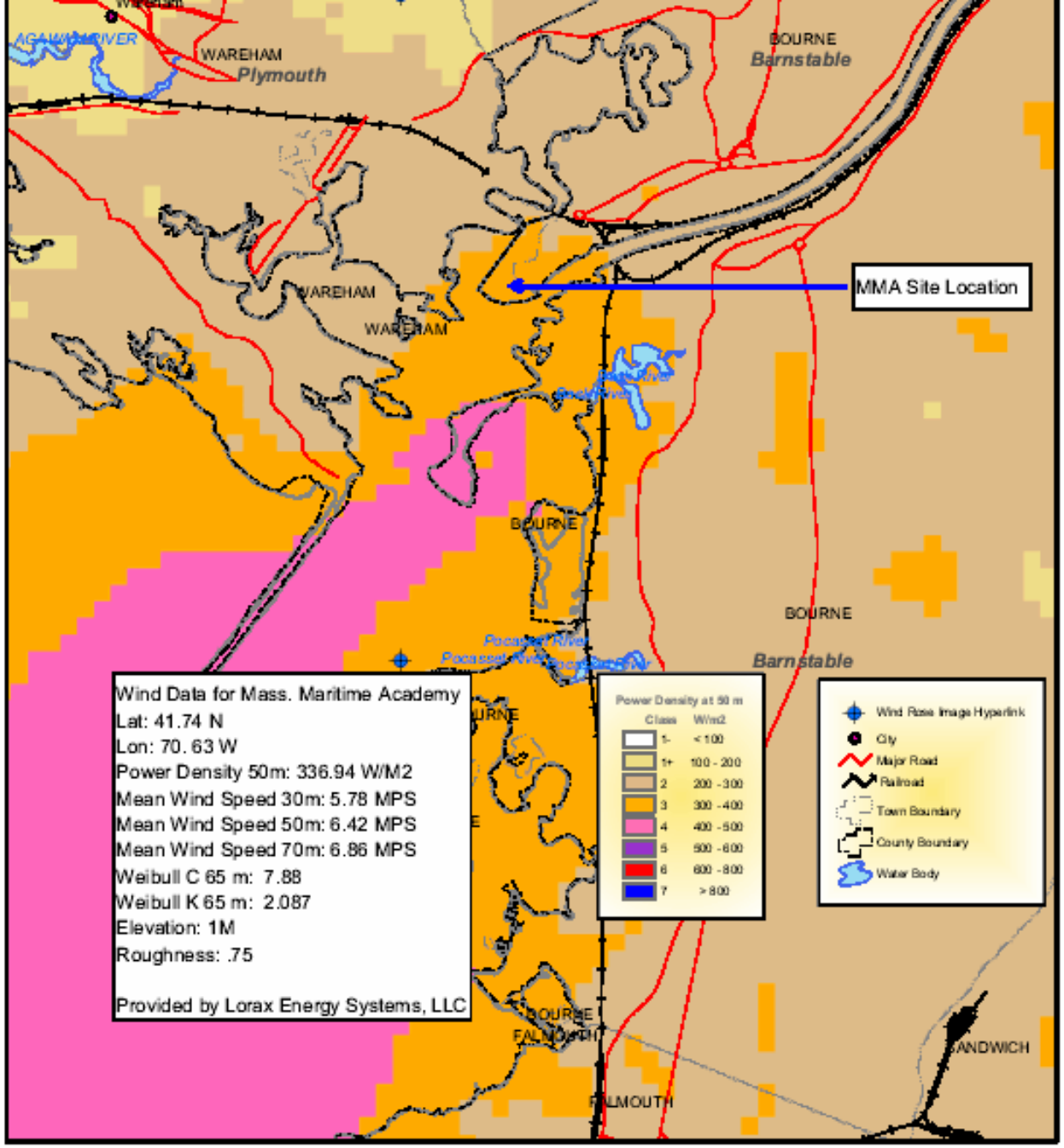
Turbine Manuf.	Model	Rated Power	Diameter		Hub Height *		Blade Tip Height	3 x Hub height
		kW	m	ft	m	ft	ft	ft
Vestas	V47	660	47	154	50	164	241	492
	V80	1,800	80	262	70	230	361	689
General Electric	GE 1.5SL	1,500	77	253	80	262	389	787
	GE 1.5SL	1,500	77	253	60	197	323	591
Fuhrlander	FL 100	100	21	69	35	115	149	344
	FL 250	250	30	97	42	138	186	413

	m	ft.
Hub Height	50	164
Blade Sweep	47	154
Blade Tip Height	73.5	241
1.5 X Tip Height	110.25	361.5
3 X Hub Height	150	492

V47-660 kW

Pitch regulated wind turbine with OptiTip® and OptiSlip®

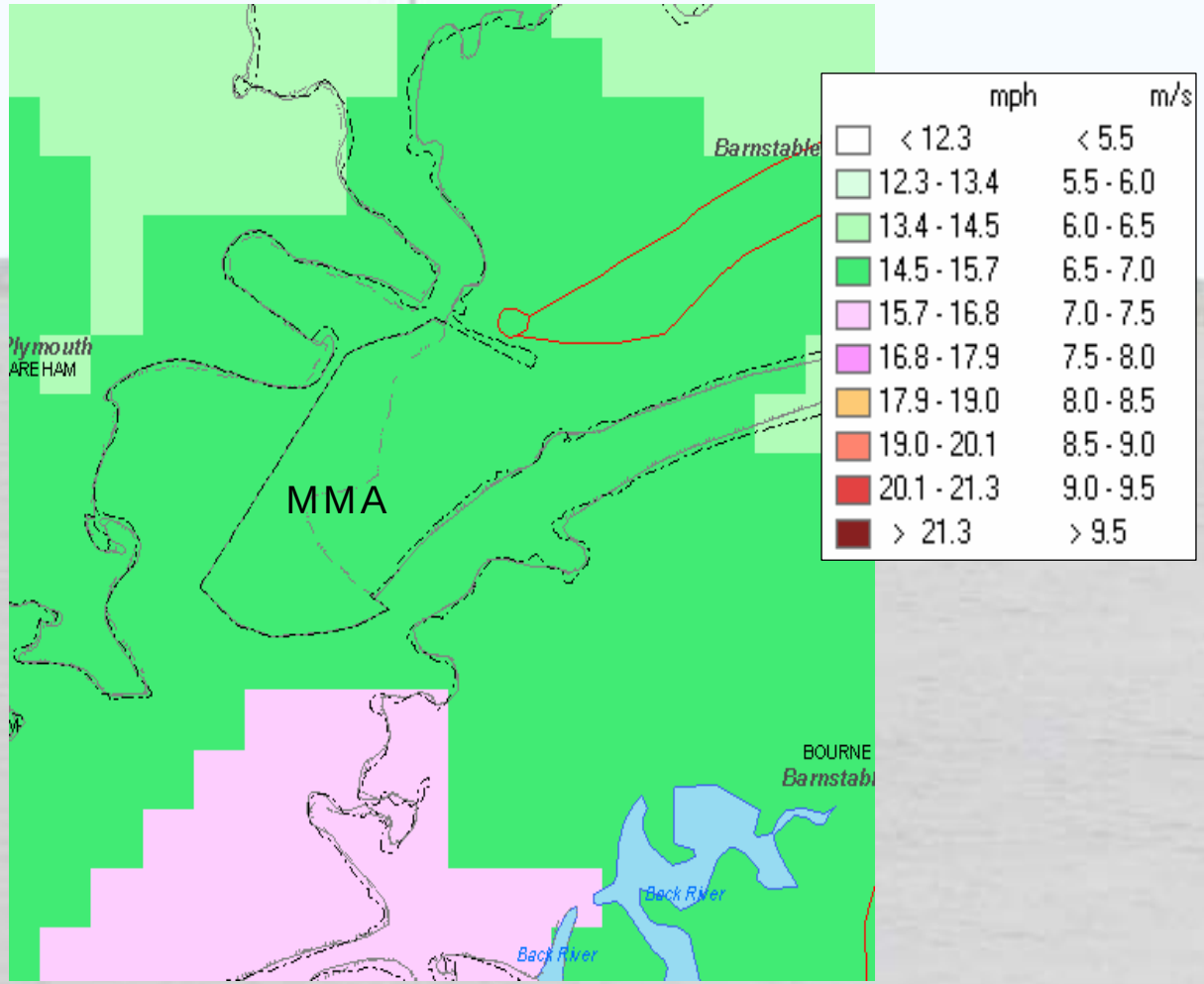
Vestas



Wind Resource of New England

0 0.25 0.5 1 1.5 2 Miles

N



Massachusetts Maritime Academy, Annual Average Wind Speed at 70 m

From TrueWind Solutions New England Wind Map http://truewind.teamcamelot.com/ne/

ESS Group, Inc.
Engineers
Scientists
Consultants

MASSACHUSETTS MARITIME ACADEMY
Bourne, Massachusetts

Scale: 1" = 500'

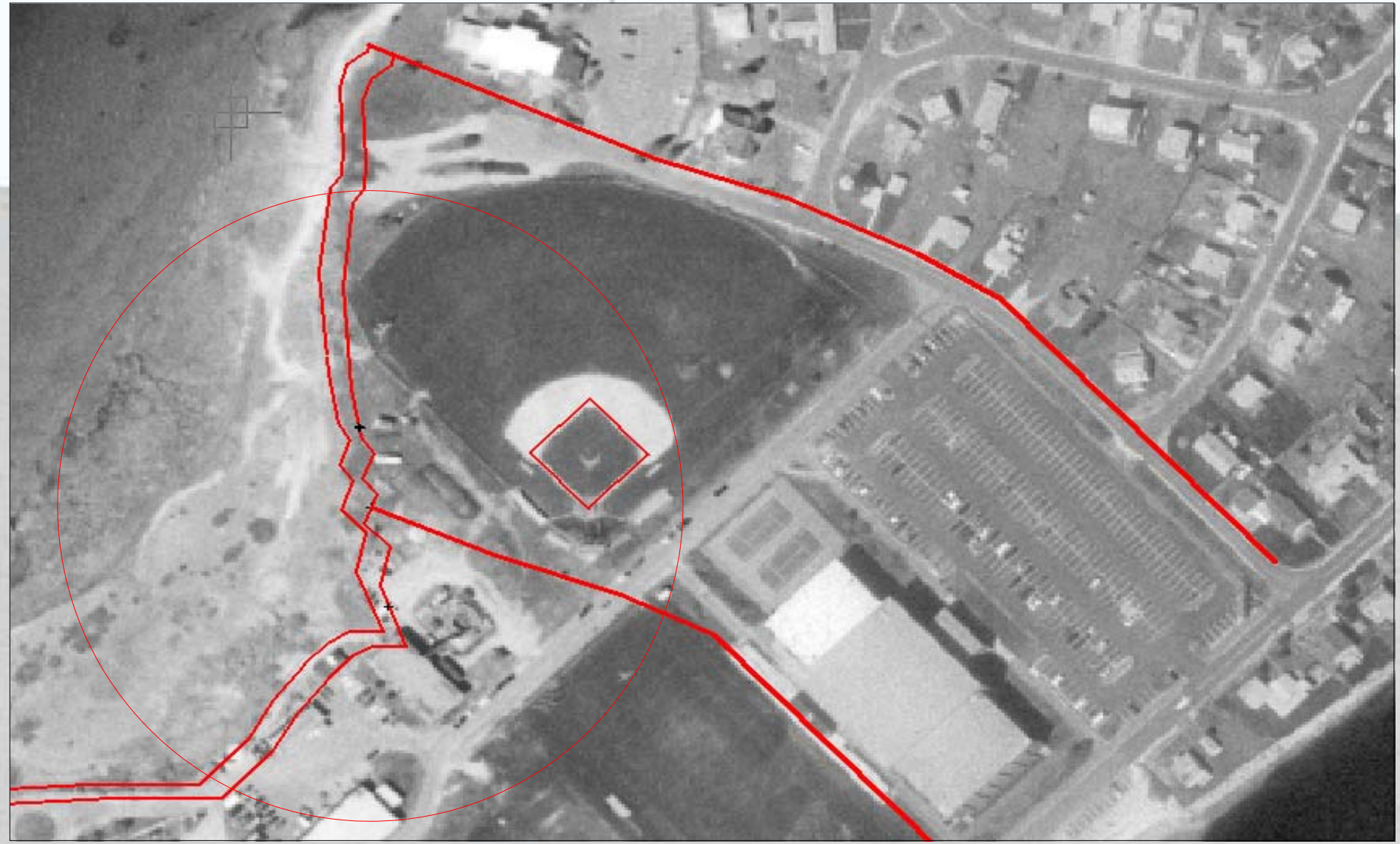
Source: 1) MassGIS, Half-Meter Color Orthos, 2001
3) ESS, Simulation Locations (GPS), 2005

LEGEND
Turbine Location
Visual Simulation Location

Turbine Simulation
Site Locus

Figure\1

Upper red line delineates 3X hub height



Fall zone within circular area

Permitting

- ESS Group reviewed potential environmental impacts
- Notice of Intent Filing required with the Bourne Conservation Commission
- FAA Notice of Proposed Construction required for structures over 200 feet
- State facility not subject to local bylaws
- Built to Mass. State Building Code

Permitting

Other analysis identified

- Noise Analysis, DEP guideline no more than 10 dB rise from minimum ambient noise level
- Visual Simulations show turbine installation from two vantage points
- Avian Impact Analysis
- Post construction avian study by MMA

Avian Mortality at the MMA

"Avian mortality associated with the wind turbine is comparable to mortality at larger wind farms when fatalities are considered on a per turbine basis. We estimated that the MMA wind turbine was responsible for causing 2.15 avian fatalities/year. Elsewhere, most avian mortality rates range between 0.01 and 7.5 fatalities/turbine/year (Erickson 2001, Erickson 2004)."

COHASSET NARROWS BRIDGE – Existing view from Cohasset Narrows Bridge looking south

COHASSET NARROWS BRIDGE – Proposed view from Cohasset Narrows Bridge looking south

ESS Group Inc.
Engineers
Scientists
Consultants

MASSACHUSETTS MARITIME ACADEMY
Bourne, Massachusetts

Source: ESS, Original photograph taken 8/4/05 – 2:35 PM

Turbine Simulation (Cohasset Narrows Bridge) Viewpoint 1

Figure 2

FISHERMAN'S COVE ROAD – Existing view from 16 Fisherman's Cove Road looking east

FISHERMAN'S COVE ROAD – Proposed view from 16 Fisherman's Cove Road looking east

ESS Group Inc.
Engineers
Scientists
Consultants

MASSACHUSETTS MARITIME ACADEMY
Bourne, Massachusetts

Source: ESS, Original photograph taken 8/4/05 – 1:30 PM

Turbine Simulation (Fisherman's Cove Road) Viewpoint 2

Figure 3

Electrical Interconnection

- Standards for Interconnection of Distributed Generation MDTE tariff
- Expedited/Standard Process Application fee $3 per kw….$1980
- NSTAR Impact Study….fee $7250 additional protection needed $55,376
- Suspension Fee…$5775
- Execute Interim Interconnection Agreement
- Execute Power Purchase Agreement

Local Outreach

- Front page articles in a major and local newspapers
- Discussion on local radio show
- Discussion with Town of Bourne Selectman
- Newspaper and radio exposure yielded no negative calls to MMA

Potential Problems

- NIMBY
- Aviary
- FAA Obstruction Lighting

Project Cost and Savings

- Estimated turbine output 1,461,746 kwh or 28% of FY 05 campus consumption of 5,196,600 kwh
- 2007 production 1,057,848 kwh @ 98%
- First year avoided cost of $169,255 @ .16/kwh
- Value of RECs = $60,249 @$57/mwh
- 2007 savings = $229,504
- 22,920 kwh exported@.07=$1,574

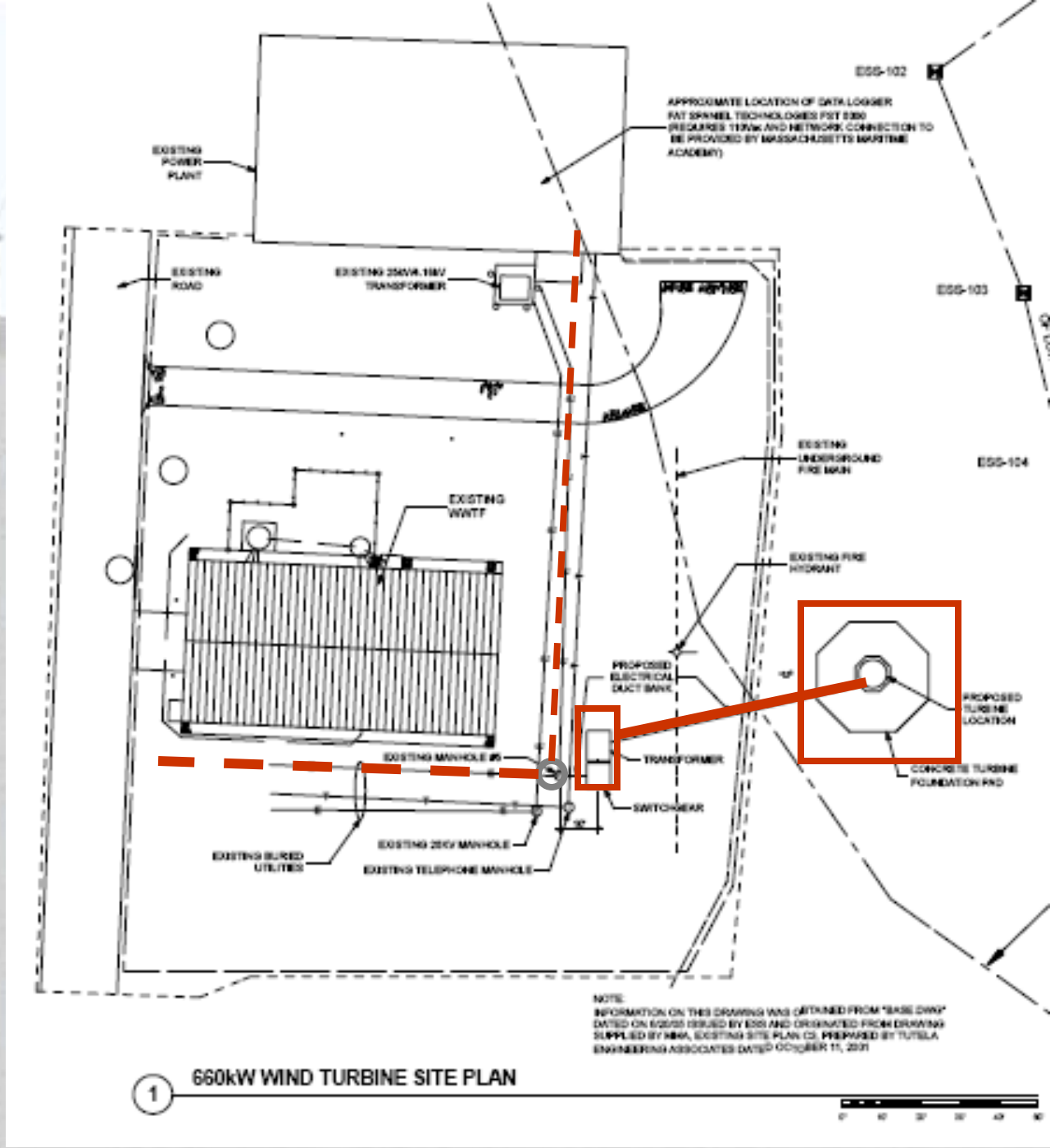
Project Cost and Savings

- Total Project Cost = $1,469,371
- MTC Grant $500,000
- Simple payback $969,371/$229,254=4.2yr
- Lifetime production = 2,107,608 kwh= $337217 savings to 8/25/08
- Avoided 2,475,000 lbs. green house gases

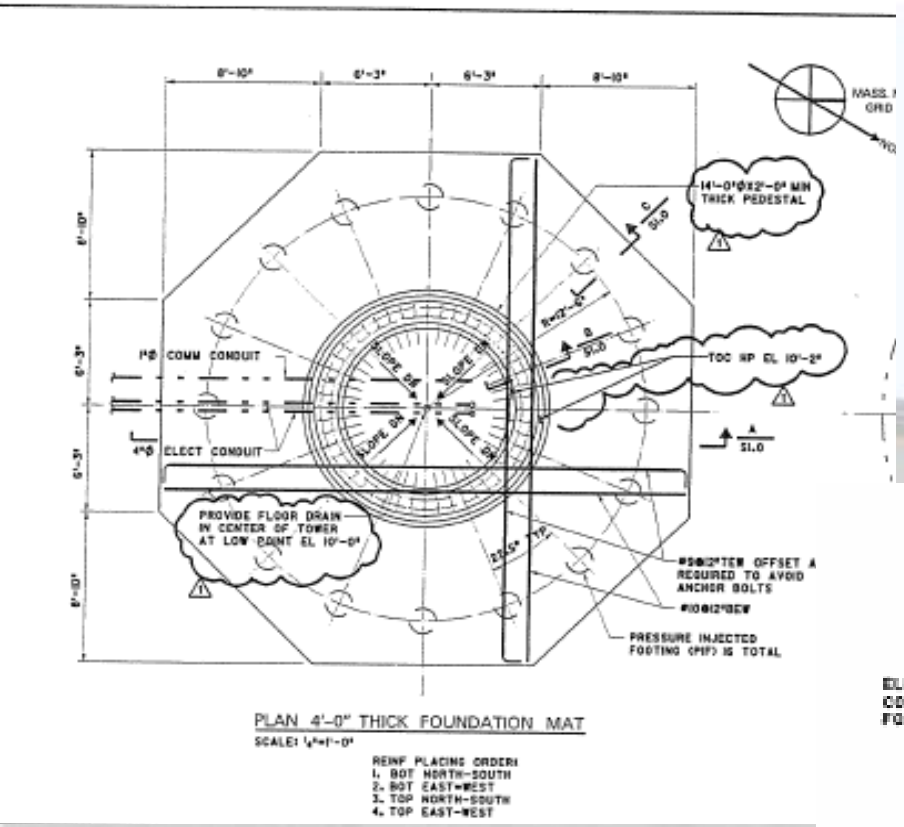
MONTHLY PRODUCTION

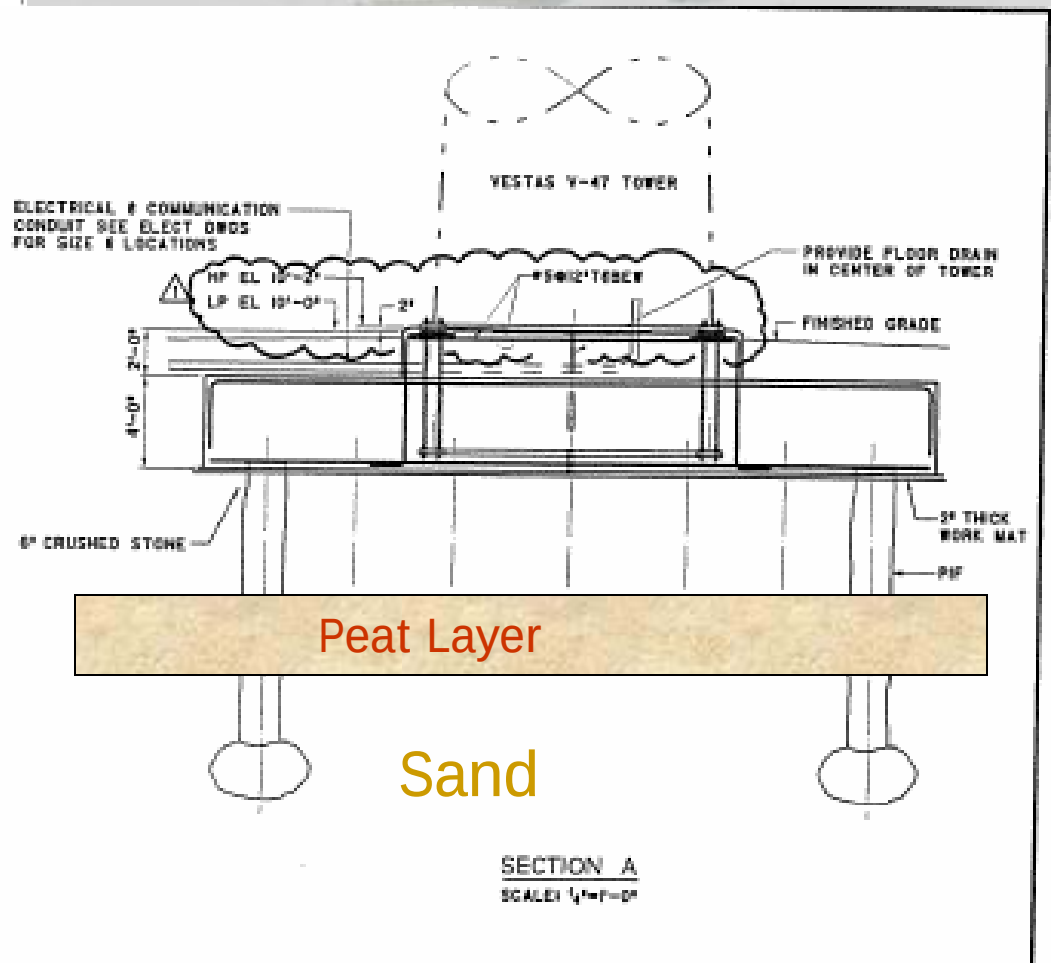
Month	Hours	kwhrs	**Capacity Factor**
Oct-06	744	100810.08	0.2053
Nov-06	715	67002.32	0.1420
Dec-06	734	91382.2	0.1886
Jan-07	696	113392.44	0.2468
Feb-07	664	104021.68	0.2374
Mar-07	697	138444.04	0.3010
Apr-07	663	94587.08	0.2162
May-07	737	84072.24	0.1728
Jun-07	712	86185.4	0.1834
Jul-07	735	67112.92	0.1383
Aug-07	741	55835.92	0.1142
Sep-07	720	68016.48	0.1431
Oct-07	742	72317.28	0.1477
Nov-07	728	95129.44	0.1980
Dec-07	711	78732.92	0.1678
2007 Total	**8546**	**1057847.84**	**0.1889**

BOP Electrical Design



WTG Foundation Design





- 16 PIFs (50 tons/20 tons)
- 30'x30'x 4' Base Mat
- 14' Dia. X 2' Pedestal
- 96 Anchor Bolts

Site Work and Foundation Installation

- Install Erosion Controls
- Install 16 Pressure Injected Footings (PIFs)
- Foundation Excavation
- Mud Mat and Remove PIF Concrete
- Install Base Mat Rebars, Anchors and Conduits
- Install Foundation Pedestal
- Install Buried Conduits
- Backfill Operations

Site Prior to Construction

Installation of 16 PIFs

Excavation Around PIFs

PIFs and Mud Mat

Bottom Steel and 96 Anchor Bolts

Rebars, Anchor Bolts and Conduits

Base Mat Concrete (110 CY)

Conduits at Manholes (EMH#5)

Conduits to Electric Equipment

Pedestal Forms

V47 Components

Tower From North Dakota

- Bottom Tower Section
- Top Tower Section

Parts From Italy

- Nacelle
- Parts Container - Hub, Nose Cone, Controller
- Blades Container

Nacelle Arrives at Site

Tower Sections Arrive

Base Section Making Turn Into Site

Electrical Preparation Work

Lifting Base Section

Swinging Base Section

Tower Rigging

Setting Tower Base Section

Rotor Assembly on Ball Field

- Offload Blades from Shipping Container
- Set-up Elephants Foot on Ball Field
- Set Hub and Fiberglass Cone
- Install Three Blades

Setting Hub on Elephant's Foot

Blade Pitch Linkage

Setting Nose Cone on Hub

Install First Blade

Bolting Blade to Hub

Tie-Down of Blades

Install Blades onto Hub

Completed Rotor

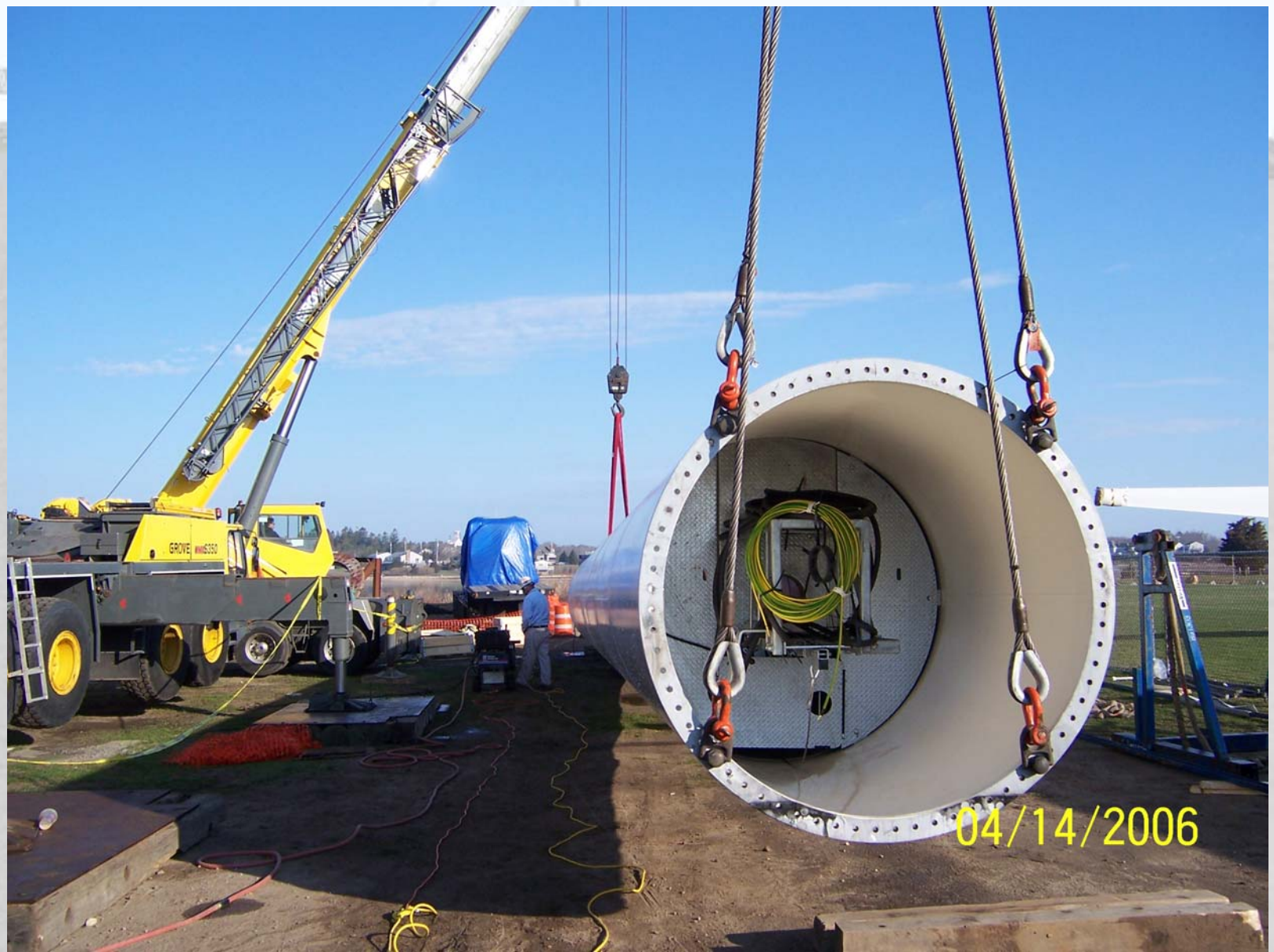
Rotor Tied Down and Ready for Lifting

Install Top Section, Nacelle and Rotor (Friday April 14th)

- Install Cables in Top Tower Section
- Install FFA Lights and Wind Instruments on Nacelle
- Lift, Set and Bolt Top Tower Section
- Lift, Set and Bolt Nacelle
- Lift and install Rotor onto Nacelle

Rigging Tower Top Section

Lifting Top Tower Section



Up Righting Top Section

Installing Top Section onto Tower Base Section

Nacelle FAA Lights and Wind Vanes

Nacelle Ready for Lifting

Lifting Nacelle From Transport

Lifting the Nacelle

Setting Nacelle on Tower

Rotor Lift Rigging

Lifting Rotor from the Horizontal

Rotor Raised to Vertical

Rotor Hub

MMA
04/14/2006

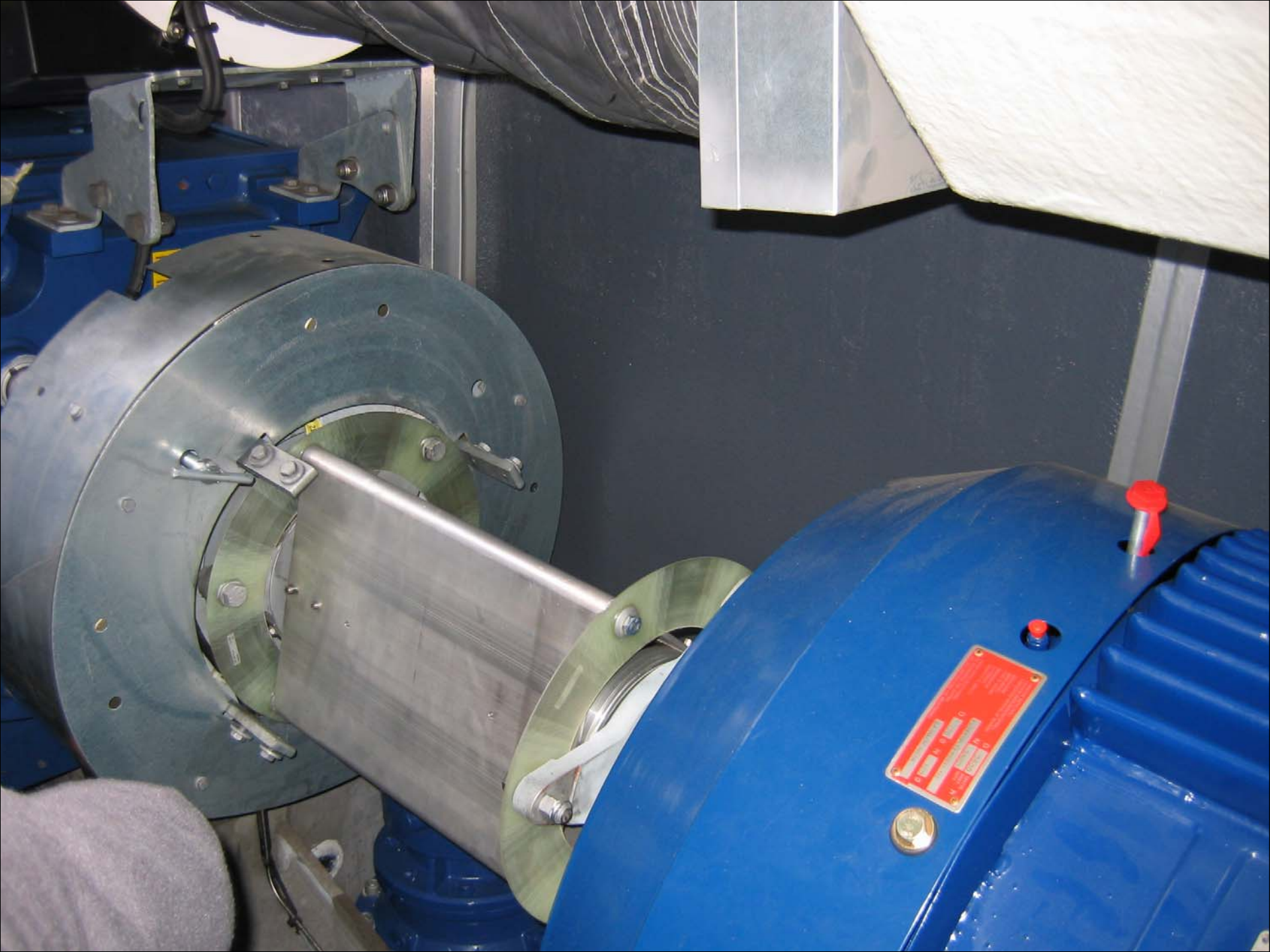
MMA
CASHMAN

MMA

Construction Schedule Summary

- March 15th – Start PIFs
- March 28th – Place Base Foundation
- April 10th – Nacelle Arrives at Site
- April 12th – Install Tower Base Section
- April 14th – Install Top, Nacelle and Rotor
- April 15th – WTG Electrical Hookup
- May 27th – Nstar Installs Recloser
- June – WTG Commissioning

CT 3357
Off
Power
On
Turn Power Off before Module exchang
Error -
5V DC -
Internal
CT 3514
Optical Serial Port
CT3503
CT 3220
Analog Input
CT 3181
Empty
CT 3133
DC Input
CT 3218
Serial
RxD
TxD
Counter
CT 3153
DC Output
CT 3220
Analog Input
cotas
CT 3232
Analog Output
CT 3133
DC Input
CT 3364
Error
24V DC
External Power
Vestas
PTS 5
VAS/RC
701290



MMA Sustainable Initiatives

- ENERGY STAR BUILDING PARTNER
- 660 KW Wind Turbine
- LEED Gold Certification in new dormitory
- 10 KW VAWT *(proposed)*
- 81 KW Photovoltaic Solar Panels
- 195 KW CHP Microturbines in Dormitories
- 62 Solar Lights under construction
- Single Stream Recycling
- Energy Conservation
- Water Conservation
- Green Programs *(Cleaning, Landscaping, Purchases)*
- Energy/Sustainability Committee
- Solar Thermal for pool heating (future)

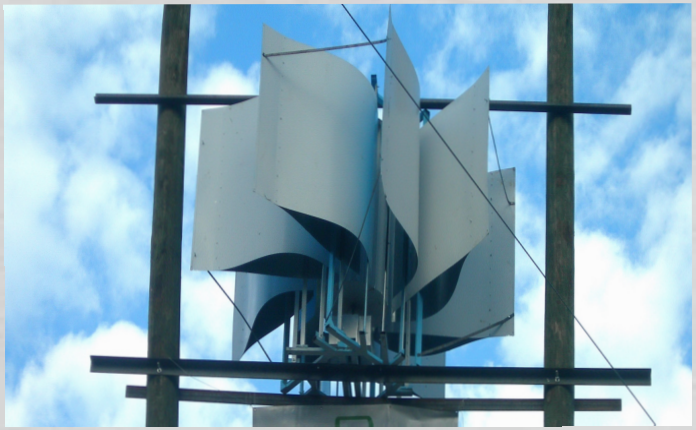
Turning Mill Energy, LLC

- Headquartered in Sandwich, MA
- Manufacturing facilities in Franklin, MA
- One of the founders is an MMA graduate
- Management lives on Cape Cod

- Vertical Axis Wind Turbine
- Version I - 10KWh unit
- Expected to reach capacity in winds of 15 MPH – cut in speed at 2 mph
- Roof top mounted design

10 KWh VAWT

- Turbine Dimensions
  - 6’X3’
- Wind deflectors
  - 4’X10’
- Weight
  - 375 lbs
- Patent Pending Permanent Magnet Generator Design
- Designed and Rated to withstand 150 mph winds



Partnership with MMA

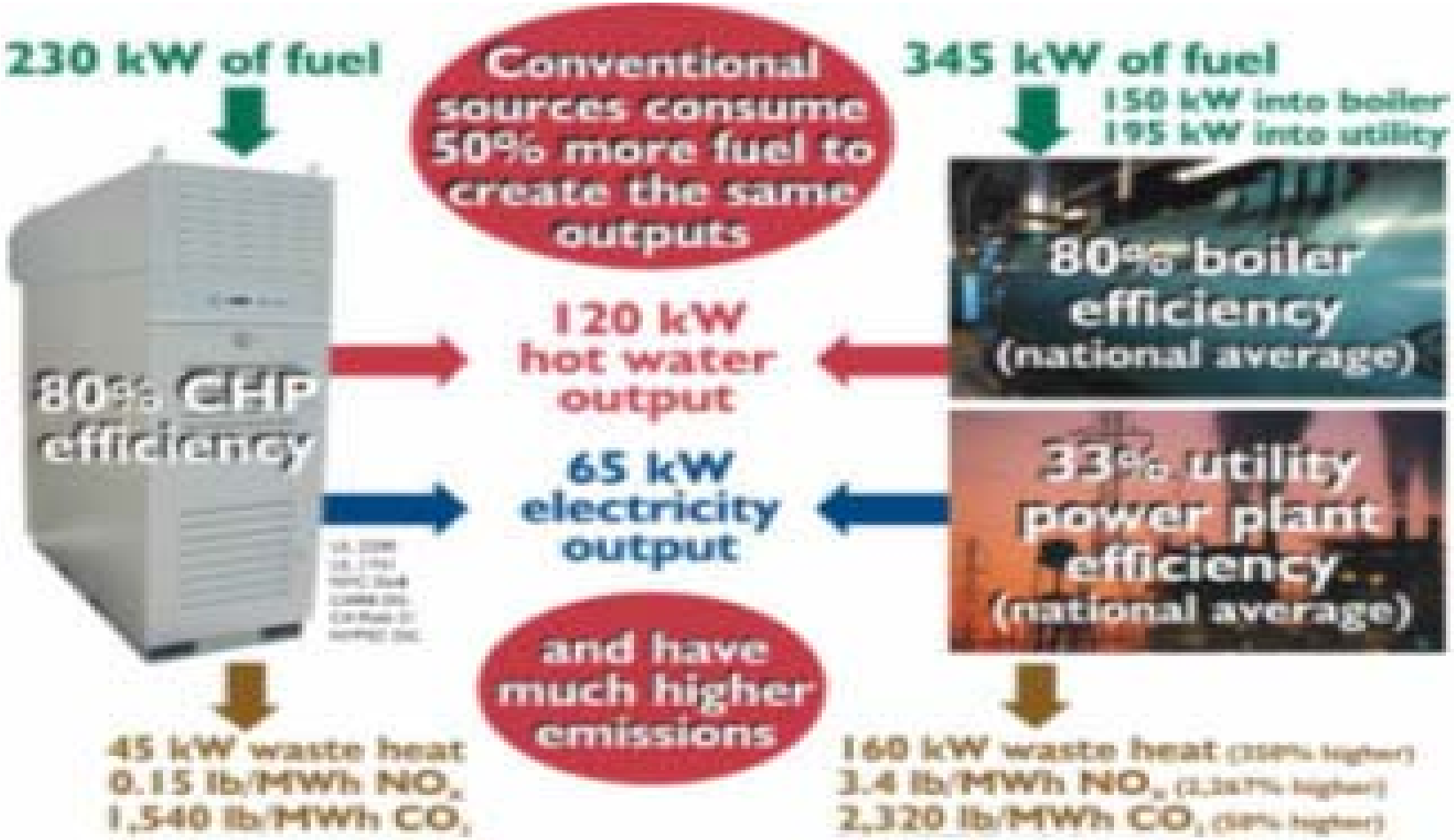
- TME requires a testing environment to prove out system throughout the year
  - MMA provides Real-Time-Data
    - Excellent year-round weather, wind and corrosion conditions
    - TME can use to make design and functional improvements to the system
  - System needs grid connection
    - Allows TME to be registered with the state and provide accessibility to the MTC Rebate Program
      - MMA gets the power and the REC's
- Resources
  - MMA has existing infrastructure and experience with renewables
  - MMA has an engineering program which TME can leverage
  - MMA is a very short distance from TME offices and resources
  - MMA buildings mirror TME's target market; commercial buildings

Solar Panels

- 450 Evergreen panels
- Operating since November 16, 2007
- Part of dorm LEED construction process
- Expected to generate 85,000 kilowatt hours a year using PV Watts
- Energy is converted using an inverter
  - Statistics @ www.maritime.edu

Photovoltaic Cells and Panel

Capstone C65-ICHP



Capstone website

- http://www.capstoneturbine.com/prodsol/solutions/chp.asp

Energy Efficiency

- Computerized Energy Management System
- Variable speed motors
- Roof top energy recovery ventilators
- Occupancy sensors
- Vending misers
- Compact fluorescent light bulbs, fluorescent lamps
- Refrigeration compressor smart controls

Water Conservation

- Installed waterless urinals, low-flow toilets and shower fixtures in dorms
- Installation of artificial athletic field
- Use of well water (non-potable) for baseball field irrigation
- Wastewater treatment plant built to treat effluent before discharge into canal
  - Future consideration for irrigation

Recycling

- Single Stream Recycling
  - Process to collect all recyclable items in one container:
    - All cardboard, paper and paper products
    - All plastics marked with recycling logo
    - Metal, aluminum and glass containers
  - Dormitory Competition
    - Winning team receives prizes and awards
    - Participation in Recyclemania ’09
- Annual Move-out Collection Program
  - Prevent improper disposal of electronics, furniture, and large items

Green Programs

- Green Cleaning
  - Purchase and use of Green Seal certified products.
  - Maintainers trained in green cleaning programs.
- Green Landscaping
  - Draught resistant plants
  - Native species
  - No chemical pesticides
- Green Purchasing
  - Environmentally Preferable Purchasing
  - Recommends recycled and ecologically safe products

Other Efforts

- Executive Order 484
  - Reduce energy and water demands
    - 20% energy reduction by 2012
    - 10% potable water reduction by 2012
  - Install renewable energy resources
    - 15% of electricity by 2012
  - 25% GHG emission reduction by 2020
  - Purchase Energy Star appliances
  - Utilize 3% biodiesel
  - LEED plus construction on all buildings
- Demand Response & Forward Capacity Market
- Solar Powered Trash Compactor
- Paperless File System
- Sustainability Committee

Goals and Initiatives

- **Solar powered lighting system across campus**
- **LEED (Leadership in Energy and Environmental Design) standards for all construction projects**
- **Campus Energy Decentralization Program**
  - **Reduce energy and fuel consumption 20%-30%**
- **Signatory of American College and University Presidents Climate Commitment**
- **Retro-commissioning for campus buildings**
- **Biofuel processing for marine and diesel equipment**
- **Strive for zero net energy building for new library to include geothermal**
- **Investigate tidal energy application**

MMA Solar Lighting Project

(Areas for solar lighting in marked in orange below)

MMA Solar Lighting Project

- *62 Systems*
  - *Street (Basic)*
  - *Parking (Shoe Box)*
  - *Pathway (Decorative Flare)*

- *Offsetting…*
  - *~20,000 kWhr/yr*
  - *~36,000 lbs of green-house gases*
  - *~ 1 mile of re-wiring*

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MMA Solar Lighting Project

- *Improved Lighting Characteristics*
  - *Improved Spectrum*
  - *Improved Uniformity*
- *Enhanced Safety*
  - *Improved visual acuity*
  - *Lights on during power outages*
- *Reduced Operation Costs*
  - *No electric bills*
  - *50,000 hour lamps*
  - *25 year solar panels*

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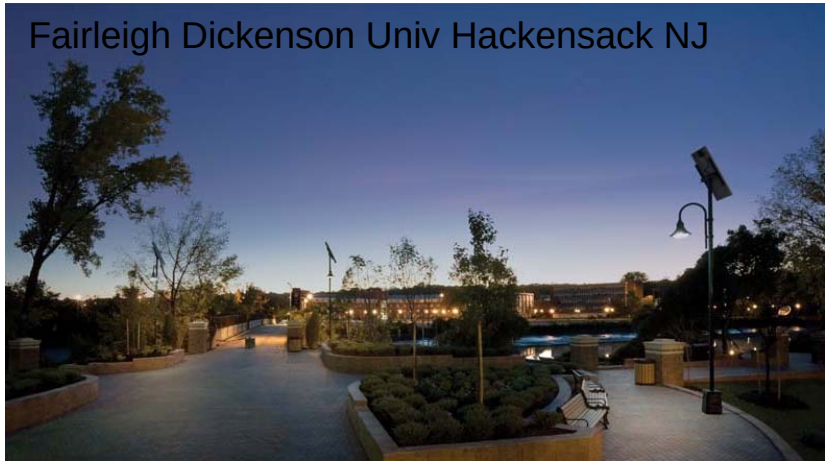
MMA has good company



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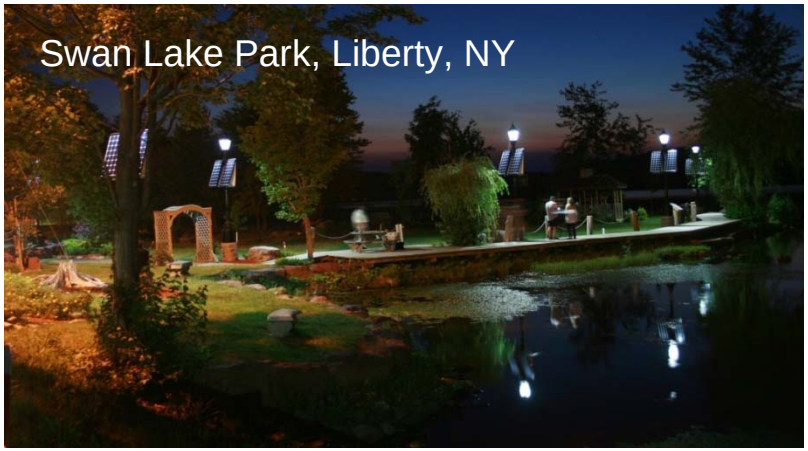
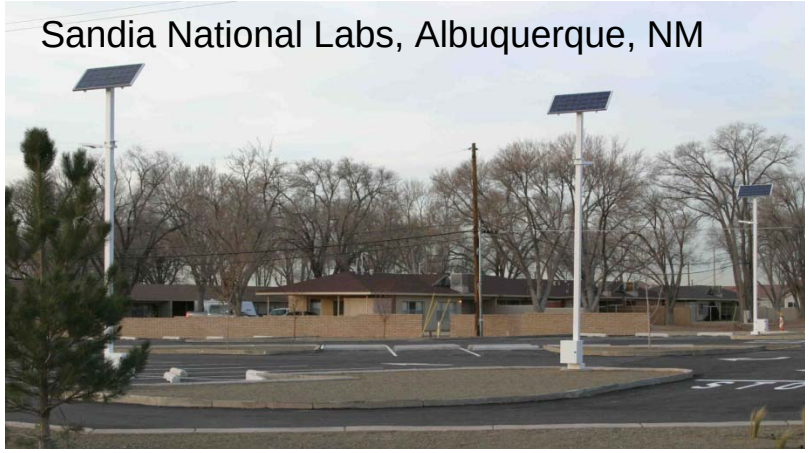
More Installations





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Solar Lighting

- *The Promise of Solar Lighting is <u>effective lighting anywhere and anytime</u>, making public areas <u>safer</u>, creating more <u>usable outdoor space</u>, <u>protecting the environment</u> and <u>saving energy & installation dollars</u>.*

- Reliability	- Control
- Quality Lighting	- Aesthetics

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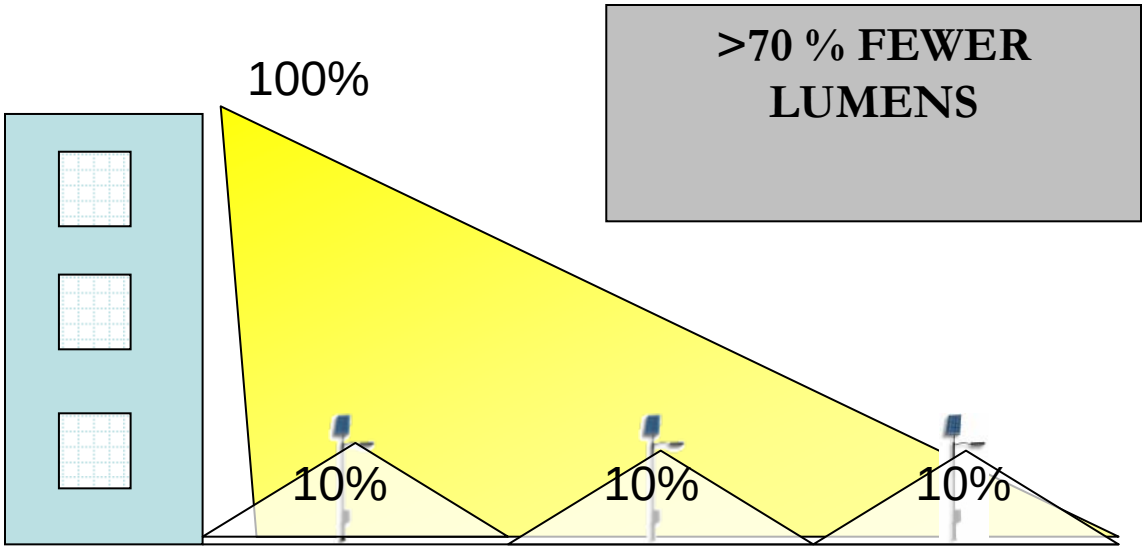
Distributed Lighting Saves More Energy than just a more efficient light bulb.



Bringing light to where its needed and not to places where its not needed (even unwelcome)

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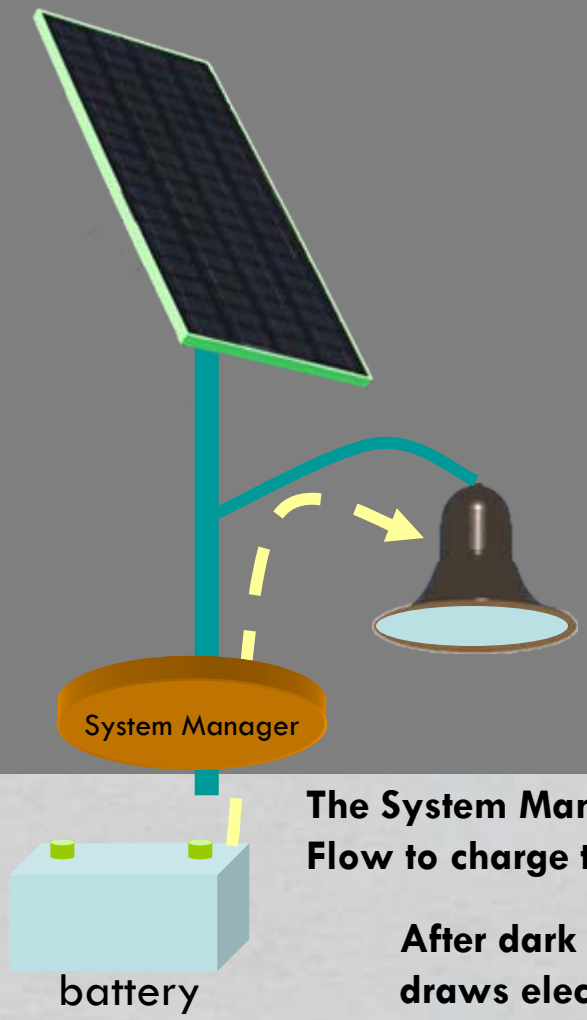
During daylight hours sunshine on the solar panel creates electricity

THE BASICS OF HOW IT WORKS

As the sun goes down, the panel stops generating electricity



The System Manger Controls Current Flow to charge the battery

After dark the system manager draws electricity stored in the battery to power the light

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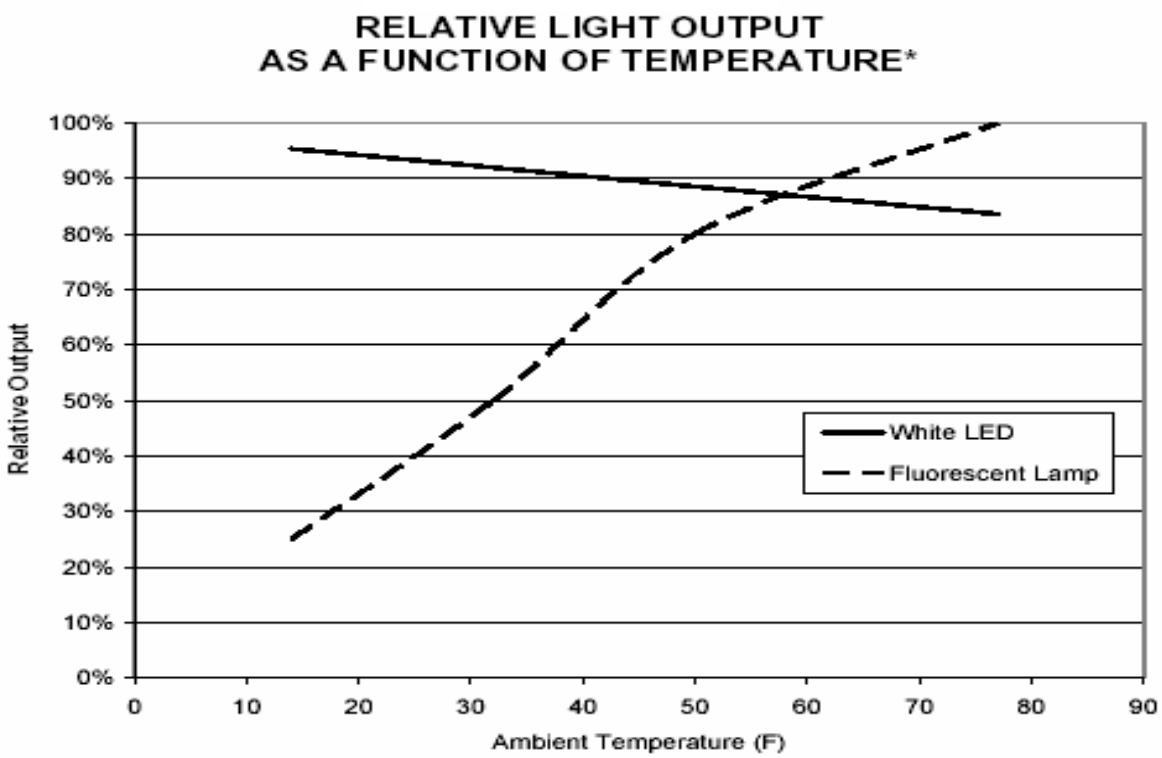
Real LED Advantages:

More Efficient in Colder Temperature



Source: Strategies Unlimited

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Real LED Advantages:

Color Temp for Better Visual Acuity

- "Spectrally Enhanced"

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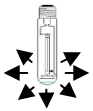
Real LED Advantages:

More Foot-Candles

- Lamp Utilization

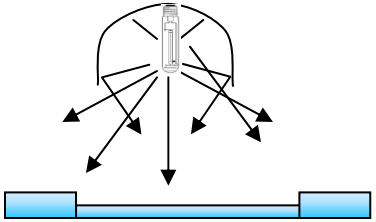
HID: 100 lm/W



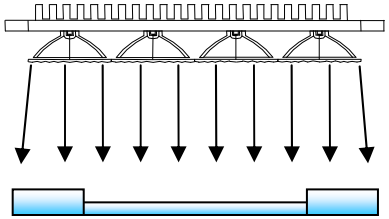
LED: 80 lm/W

Source: Lumiled Devices

40% Utilization Efficiency



Lighting efficiency 40 lm/W



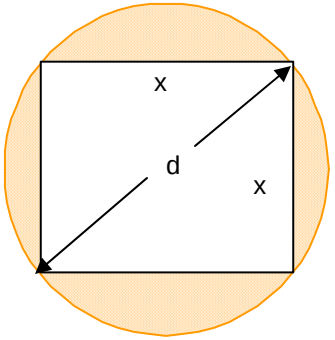
Lighting efficiency 64 lm/W

80% Utilization Efficiency

- Light Placement

Up to 57 % FEWER LUMENS

% excess light = (¶/2-1)=57%



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