

Energy Trends & the Return on Investment of Solar Hydronic Heating

"I'd put my money on the sun and solar energy."

—Thomas Edison

March 1936



Christian O'Mara

March 23, 2006

Brown University

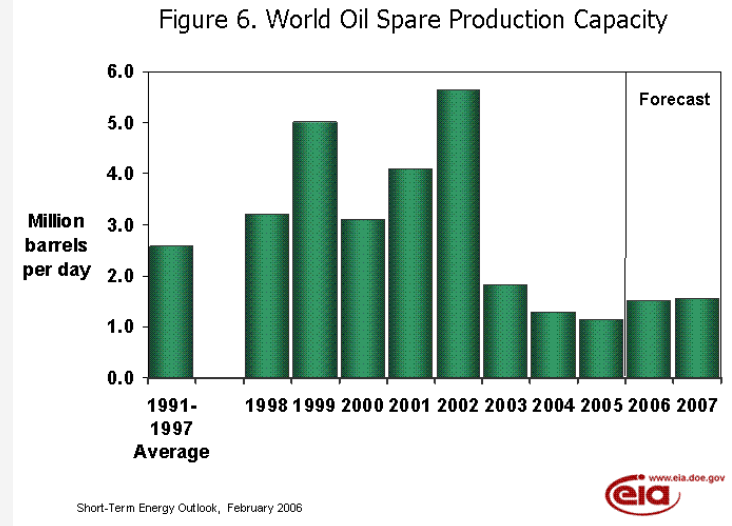
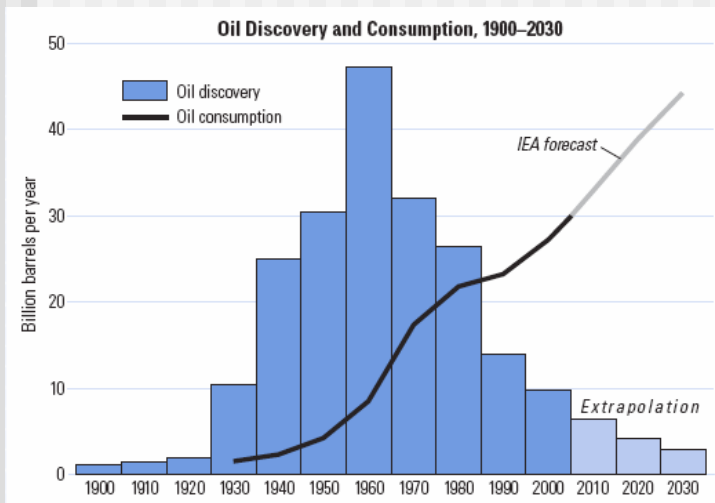
Center for Environmental Studies

Discussion Topics

- Energy Trends
- Solar Decathlon
- Solar Hydronic Heating
- Mashapaug Installation Analysis
- Implications

Conventional Crude Oil Supplies

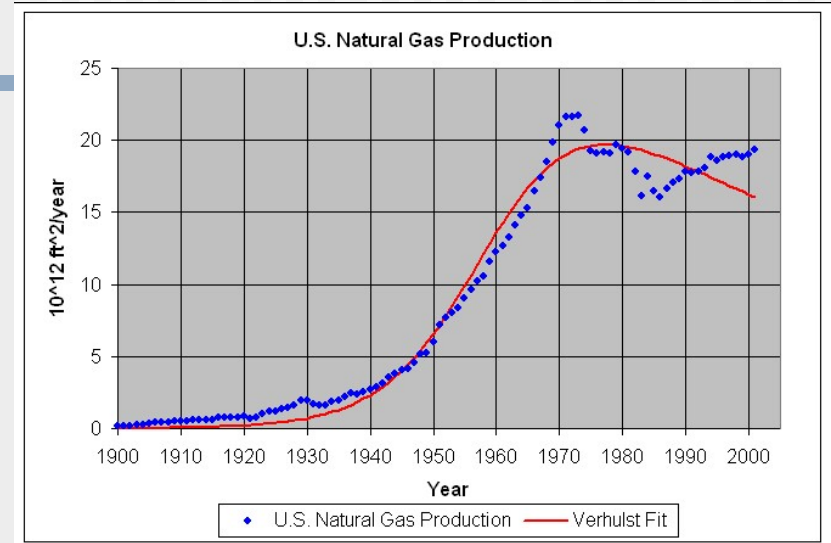
- 2005 Oil Consumption: 86 mbd
- 95% Current Supply Conventional Crude
- Estimated 2025 Consumption: 120 mbd*
- Chevron: “33/48 Largest Producers in Decline,” “125 yrs 1st trillion barrels 30 yrs next”
- ExxonMobil: “Meet Demand with Increased Fuel Efficiency,” “Discovery Peaked 1964”
- World Spare Capacity: Saudi Arabia 1.5 mbd*



*Data Source: EIA

Natural Gas Supplies

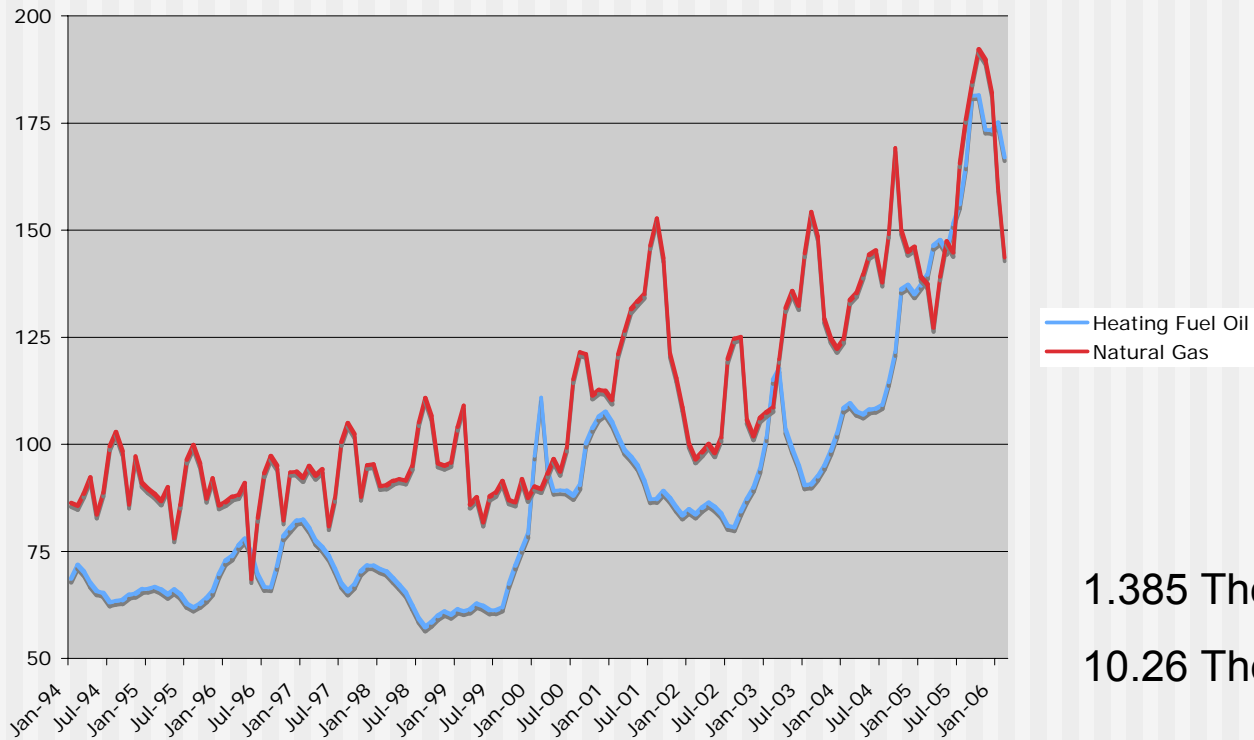
- Regional Market; Pipeline Supply
- US Production Peaked 1971
- 2005 US Consumption = 22.3 Tcf, 19% imports*
- 80% of imports from Canada*, 3.4 Tcf
- 2002 Canada produced 6.6 Tcf with 56.1 in proven reserves*
- Now in Decline, Current Production Levels Deplete Reserves 8.6 yrs
- US Consumption 2025 to be 31.4 Tcf, Canadian Imports 2.6 Tcf
- LNG import capacity of 5.8 Tcf by 2025 according to EIA



Data Source: EIA

Local Energy Costs

New England Natural Gas & Heating Fuel Prices

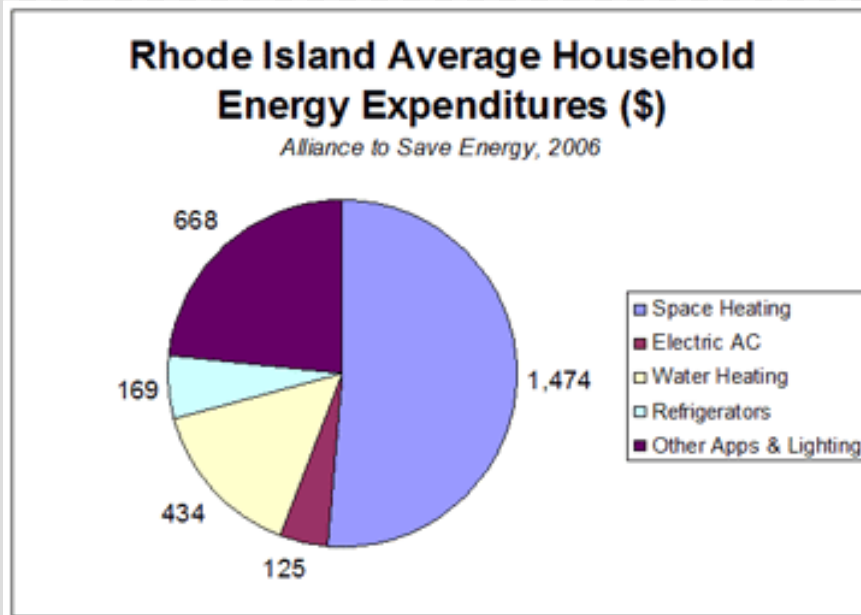


Data Source: Energy Information Agency (eia.doe.gov)

1.385 Therms/Gal Heating Fuel

10.26 Therms/Mcf Natural Gas

Energy Consumption Splits



- US Buildings
 - 54% Natural Gas
 - 8% Oil
- Heating: 39.1%
- Hot Water: 12.9%

Solar Decathlon 2005

National Mall, Washington D.C.

- DOE Competition
- Zero-Energy Homes
- 18 Universities
- Innovative Design & Technology
- 7 Days; 10 Contests

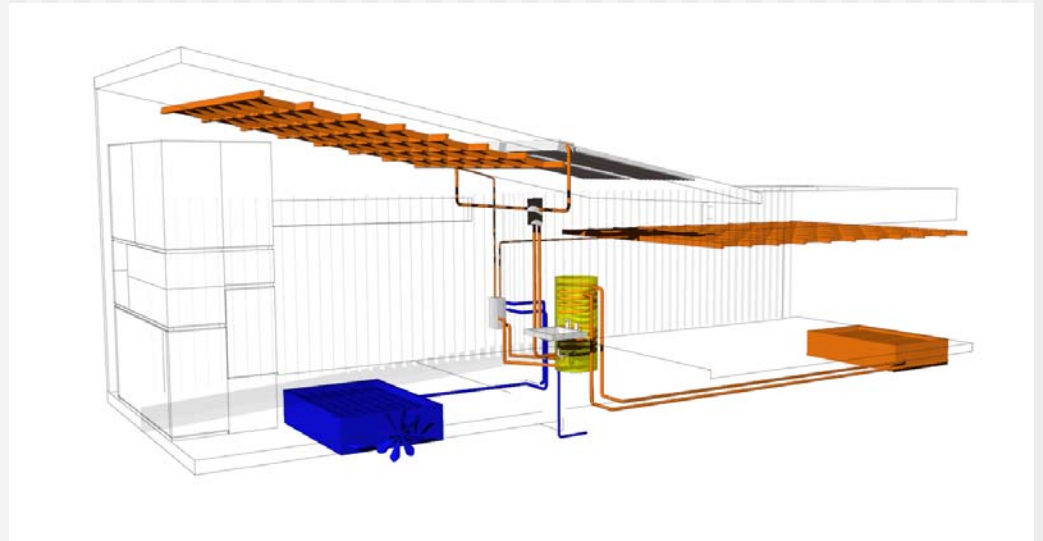


RISD Solar



RISD Solar Heating & Cooling Design

- Solar Collectors
- Thermal Energy Storage
- Hydronic Radiant Heating & Cooling



Solar Evacuated Tube Collectors

- Thermo-siphon cycle
- Vacuum Sealed
- Cold Weather Climates



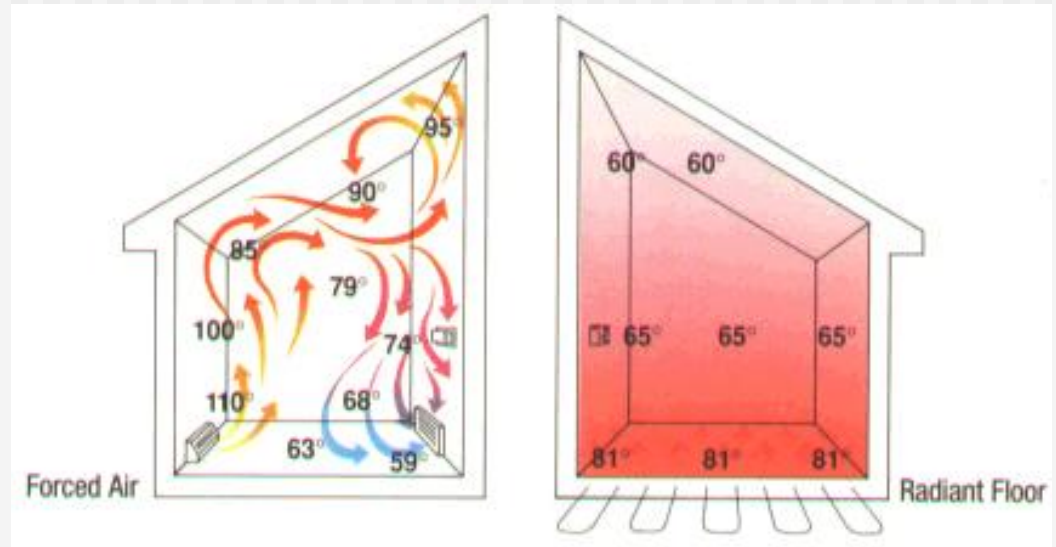
Thermal Energy Storage

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

- Latent Heat Storage
- 1/10th Volume of Water
- Non-Toxic
- Commercially Available

Hydronic Radiant Heating

- Thermal Comfort
- Indoor Air Quality
- Energy Efficiency
- Cost Competitive
- Solar Thermal Applicable



Solar Heating Workshop



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Art Evans
Sustainable Renewable Energy,
Hesperia, CO

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- Potential Applications?
- NESEA Conference
- System Analysis Method

Thesis Question

What is the Payback of Installing the
Solar Hydronic Heating System at
1 Mashapaug Providence, RI?

Assumptions:

1. New Development Designed with Natural Gas Heating
2. \$1.82 per Therm, December, 2005*

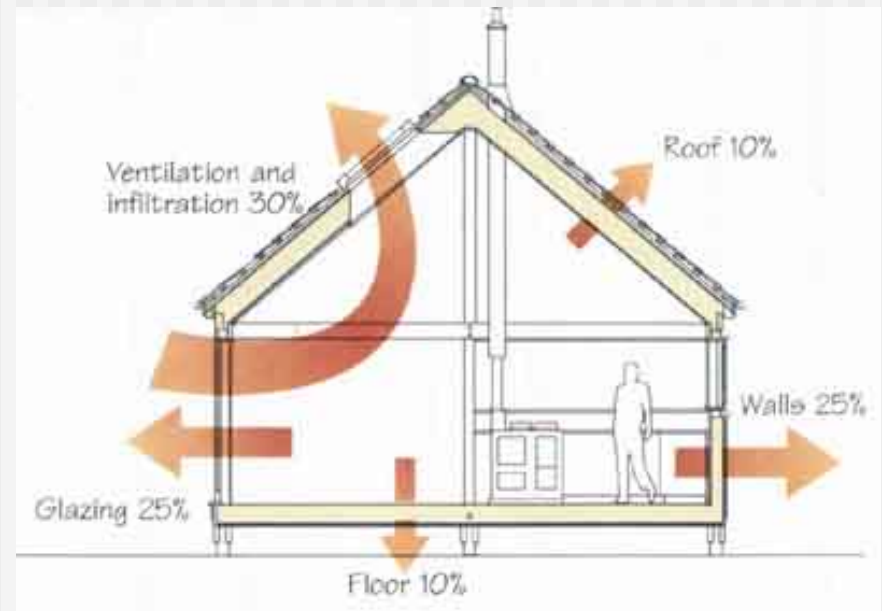
Proposed Site: 1 Mashapaug

- EPA Brownfield
- Old Mill Redevelopment
- Low-Income Veteran Housing
- Flat Roof Southern Exposure
- ASHRAE Insulation Standards



Building Heat Loss

- Heat Loss Outflow
- Heat Load Inflow
- Maintain Temperature
- Larger “Engine”



Mashapaug Heat Loss Factors

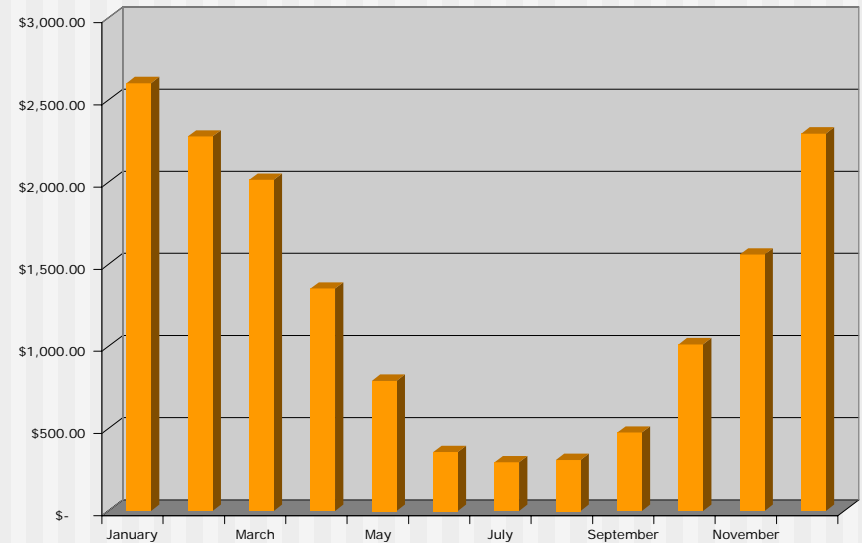
- Average Monthly Outside Temperature*
 - Providence, RI January: 28°F
- Average Monthly Heating Degree Days*
 - Deviation of Outside Temperature 1°F from 68°F Room Temperature
 - Providence, RI January: 1,150
- Heat Loss Degree Day
 - Mashapaug: 88,224 BTUs / Day / 1°F ΔT

Mashapaug Heat Load

- Monthly Space Heating Load
 - Mashapaug January: 101,457,600 BTUs / Month
- Monthly Hot Water Load
 - Mashapaug: 12,994,800 BTUs / Month
- Monthly Total Heat Load
 - Mashapaug January: 114,452,400 BTUs / Month

Mashapaug Average Energy Costs

- Heating & Hot Water
- \$1.82 per Therm Natural Gas*
- Avg New Boiler Efficiency: 80%**
- Annual Energy Costs: \$15,353.29



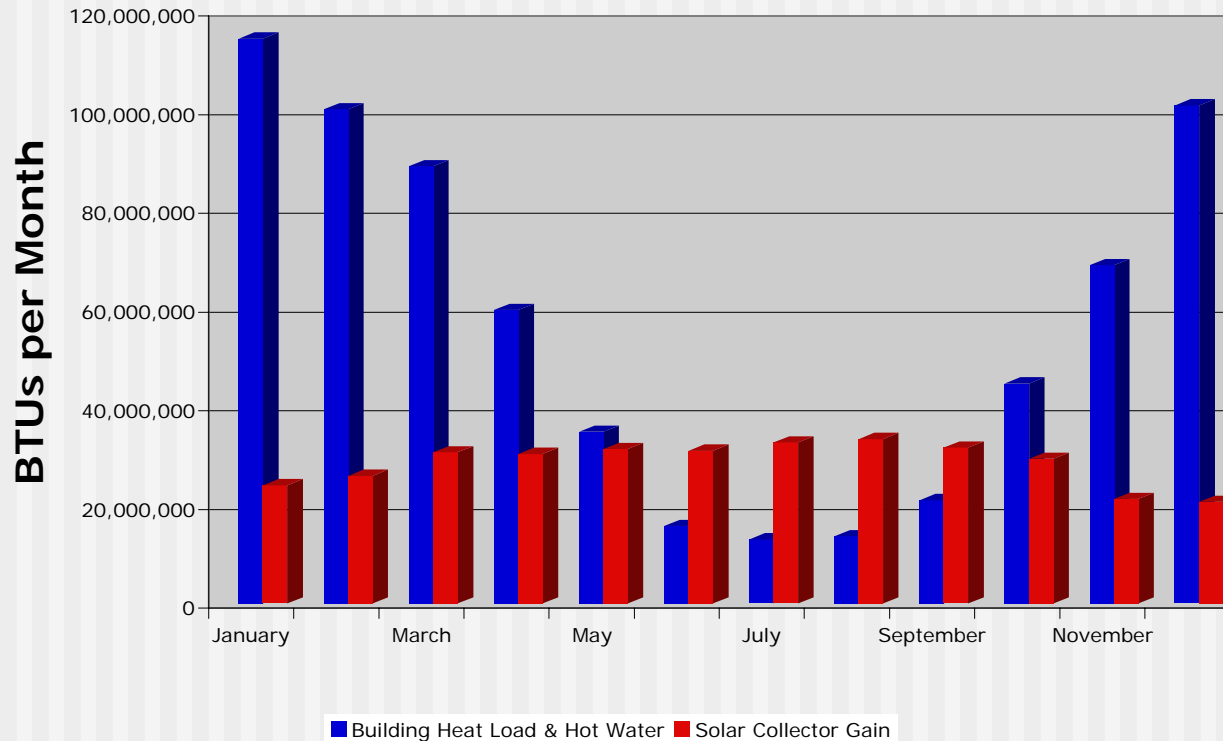
Data Source: *EIA **EERE

Solar Collector Gain Factors

- Average Monthly Solar Radiation*
 - Providence, RI March: 1458 BTU / ft² / day
- Solar Collector Array Aperture
 - Mashapaug: 968.8 ft²
- Average Solar Collector Efficiency
 - Sunda Seido: 70%
- Average Monthly Solar Collector Gain
 - Mashapaug March: 30,651,475 BTUs / Month

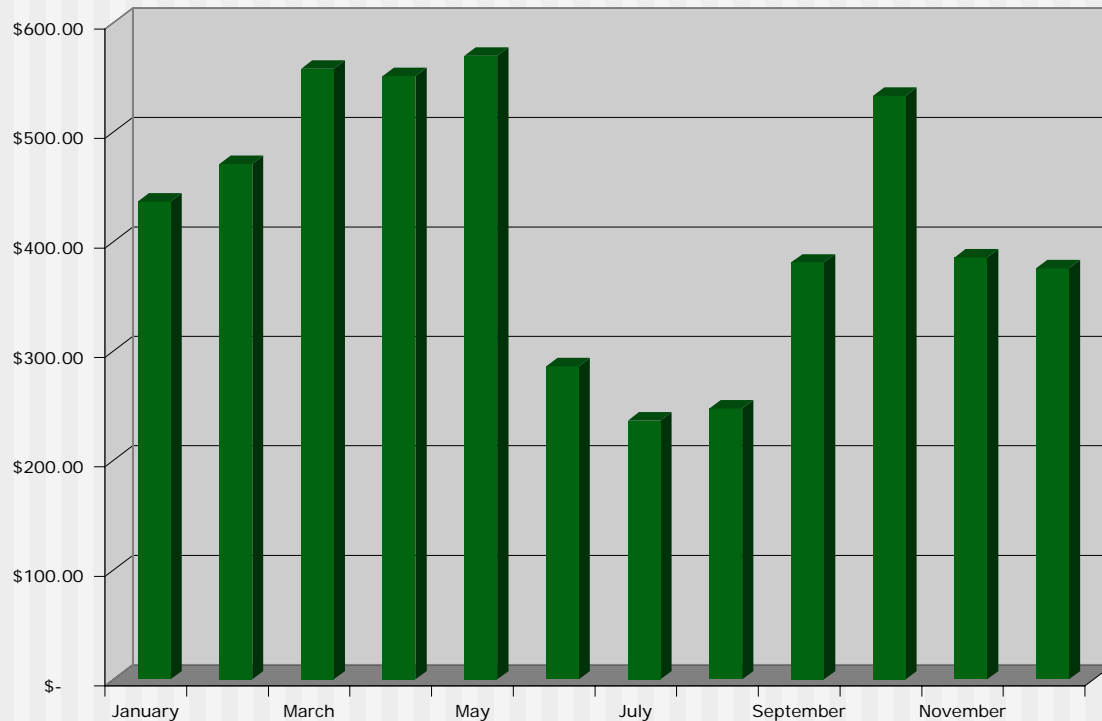
* Data Source: NREL

Mashapaug's Thermal Energy Gains & Loads



Average Solar Savings BTUs: 39%

Estimated Heating & Hot Water Energy Savings



- \$1.82 per Therm Natural Gas*
- Estimated Annual Energy Savings: \$5,032.86

Data Source: *EIA

Solar Material Costs

- 400 Evacuated Solar Tubes Collectors
 - 25 Sunda Seido 5/16
 - \$31,266 Phoenix Energy Supply (Auburn, NY)
- PCM Thermal Energy Storage
 - 490 ft³, Plus Ice E58, Phase Change 136°F
 - 2,500,000 BTU Storage Capacity
 - \$39,000 EPS Ltd. (Yaxley, UK)

Solar Material Costs

- Thermal Energy Storage Container
 - \$2,000 EPS Ltd. (Yaxley, UK)
- Solar - Radiant & DHW Tie-In
 - \$5,000
- **Solar Material Costs: \$77,266**

Solar Installation Costs

- Solar Collector Flat Roof Installation
 - 2 man hrs per collector unit, 25 units
 - \$50 per hour skilled work
 - \$2,500

- PCM Installation
 - 10 man hrs
 - \$100 per hour skilled work
 - \$1,000

Solar Installation Costs

- Solar - Radiant & DHW Installation
 - 50 man hrs
 - \$100 per skilled work
 - \$5,000
- **Solar Installation: \$8,500**
- **Solar Material: \$77,266**
- **Total Solar System Costs: \$85,766**

Federal Government Tax Credit

- Commercial Apartment Building Installation
- 2006-2007
- 30% of all system components
- Transfer Tax Credit

Payback Period

- Total Solar System Cost: \$85,766
- 30% Federal Tax Credit: \$25,730
- Net Solar Cost: \$60,036
- Annual Energy Savings: \$5,033

- Simple Payback: 11.9 years

So What?

- Advanced Energy Initiative
 - Reduce Oil & Gas Dependency
 - Realistic Economical Approach
- Policy: Tax Credit Extension, Dedicated Loans
 - Industry Growth
 - Economies of Scale
 - LIHEAP

Acknowledgements

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- *Family & Friends*