Renewable Energy Options for (Cambridge) Landlords

Photovoltaic (PV)

&

Solar Thermal Technologies

Eric Lorenz, S +H Construction Renewable Energy Division
Overview

- Residential Energy Consumption
- PV Options – solar electricity
- Solar Thermal Options – domestic hot water
- Installer’s Role
- Landlord’s Role
- Tenant’s Role
- Benefits of Renewable Energy
US Energy Consumption by Energy Source

U.S. Energy Consumption by Energy Source, 2009

Total = 94.578 Quadrillion Btu

- Petroleum 37%
- Natural Gas 25%
- Coal 21%
- Nuclear Electric Power 9%
- Renewable Energy 8%

Total = 7.744 Quadrillion Btu

- Hydropower 35%
- Wood 24%
- Biofuels 20%
- Wind 9%
- Biomass waste 6%
- Geothermal 5%
- Solar 1%

Note: Sum of components may not equal 100% due to independent rounding.
Figure 2.5 Household Energy Consumption and Expenditures

Consumption by Energy Source, 2005

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Consumption (Qtr Btu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>4.8</td>
</tr>
<tr>
<td>Electricity</td>
<td>4.4</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>0.9</td>
</tr>
<tr>
<td>LPG</td>
<td>0.5</td>
</tr>
<tr>
<td>Wood</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Expenditures¹, Selected Years, 1978-2005²

<table>
<thead>
<tr>
<th>Year</th>
<th>Expenditures (Billion Dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>55</td>
</tr>
<tr>
<td>1980</td>
<td>63</td>
</tr>
<tr>
<td>1982</td>
<td>76</td>
</tr>
<tr>
<td>1984</td>
<td>83</td>
</tr>
<tr>
<td>1986</td>
<td>87</td>
</tr>
<tr>
<td>1987</td>
<td>97</td>
</tr>
<tr>
<td>1990</td>
<td>110</td>
</tr>
<tr>
<td>1993</td>
<td>124</td>
</tr>
<tr>
<td>1997</td>
<td>136</td>
</tr>
<tr>
<td>2001</td>
<td>160</td>
</tr>
<tr>
<td>2005</td>
<td>201</td>
</tr>
</tbody>
</table>

Consumption¹ by End Use, 2005

<table>
<thead>
<tr>
<th>End Use</th>
<th>Consumption (Qtr Btu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Heating</td>
<td>4.30</td>
</tr>
<tr>
<td>Appliances</td>
<td>3.25</td>
</tr>
<tr>
<td>Water Heating</td>
<td>2.12</td>
</tr>
<tr>
<td>Air Conditioning</td>
<td>0.88</td>
</tr>
</tbody>
</table>

Consumption¹ for Space Heating, 2005

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Consumption (Qtr Btu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>2.95</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>0.75</td>
</tr>
<tr>
<td>Electricity</td>
<td>0.28</td>
</tr>
<tr>
<td>LPG</td>
<td>0.32</td>
</tr>
</tbody>
</table>

¹Does not include wood, which is used for both space heating and ambiance.
²For years not shown, there are no data available.
³Prices are not adjusted for inflation. See "Nominal Dollars" in Glossary.
⁴Distillate fuel oil and kerosene.
⁵Liquefied petroleum gases.
⁶Used for both space heating and ambiance.
Source: Table 2.5.
Practice Energy Conservation First

Before conservation measures
- Grid share: 68%
- 3 kW PV system share: 32%

After 30% reduction in demand
- Grid share: 54%
- 3 kW PV system share: 46%
Solar Energy Potential – Cambridge, MA

Solar Insolation in Cambridge, MA

Average: 3.58 kWh/m2/day
Photovoltaic Systems

- System overview
- System components
- Grid-tied system & installation options
- Integrating PV with rental units
- Installed systems –
  - Energy production
The sun’s energy is converted to usable electricity for our homes.
Parts of the PV Generation System
Grid-Tied PV Systems

- Grid-Tied PV systems: solar electric systems that are interconnected to the electric utility
- Net metering: the net production/consumption of electricity is metered by the utility. Excess electricity fed to the grid is usually credited to the metered account at retail prices.
- If the grid goes down, the PV system shuts down
- Battery backup systems are an option, but will not be covered here
Array Locations and Mounting Methods

– Rooftop, pole or ground mounted arrays
– Fixed vs tracking
Rooftop Options

• Flush mounted – array installed parallel to roof plane
• Tilt mounted – modules tilted to increase overall PV system production
• Fastened vs ballasted racking systems
  – Fastened systems require many roof penetrations
  – Ballasted systems place more dead loads on roofing structures – they are heavy, but no roof penetrations, installed on large commercial flat roofs
Inverter Options

- **Central Inverter**: PV array output circuits meet at a single (or multiple) inverter(s) to convert the DC current to AC current.

- **Micro (distributed) Inverter**: one inverter per module for DC to AC current conversion.

4 micro-inverters to 4 PV modules

1 central-inverter to 4 PV modules
## Central vs Micro

<table>
<thead>
<tr>
<th>Central</th>
<th>Micro</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pros:</strong></td>
<td><strong>Pros:</strong></td>
</tr>
<tr>
<td>• Better suited for larger systems</td>
<td>• Module level MPPT tracking</td>
</tr>
<tr>
<td>• One point of maintenance</td>
<td>• Better array production values when partial shading occurs</td>
</tr>
<tr>
<td></td>
<td>• Allows for multiple azimuth and/or tilt arrays</td>
</tr>
<tr>
<td><strong>Cons:</strong></td>
<td><strong>Cons:</strong></td>
</tr>
<tr>
<td>• Partial shading can have a dramatic affect on array production values</td>
<td>• Maintenance on larger and/or difficult-to-access arrays</td>
</tr>
<tr>
<td>• Do not allow module-direct monitoring</td>
<td></td>
</tr>
</tbody>
</table>
PV Systems for Multi-Unit Buildings

1 Array 2 Inverters, 2 Meters

UNIT 1

UNIT 2

COMMON SPACE

AC Current

UNIT 1

UNIT 2

AC Current
1 Array (20 modules) 20 Inverters, 5 meters
Example SolrenView Monitoring System

**Solar**

**System Info**
- **Location**
- **Monitoring Started**: Fri Aug 21, 2009
- **Installer**: S+H construction inc.

<table>
<thead>
<tr>
<th>Inverter Models</th>
<th>Inverter WAC</th>
<th>Qty.</th>
<th>Total Capacity (WAC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solectria PVI 2500</td>
<td>2500</td>
<td>1</td>
<td>2500</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Solar Modules</th>
<th>Module WDC</th>
<th>Qty.</th>
<th>Total Capacity (WDC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sanyo 200</td>
<td>200</td>
<td>12</td>
<td>2400</td>
</tr>
</tbody>
</table>

**System Status Now**
- **System Status, Inverter-Direct**: Active
- **Energy generated today**: 0 kWh
- **Lifetime energy generated**: 4185 kWh
- **Lifetime CO2 emission offset**: 5231 lbs
- **System AC power now**: 318 W

[Site picture not yet available]

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Solar Thermal Systems

• System overview
• System components
• Integrating Solar Thermal with rental units
• Installed systems –
  • Photos
  • Energy production
Solar Thermal Domestic Hot Water

• Roof or ground mounted collectors warm up a heat transfer fluid (HTF) that warms up a solar water storage tank. The HTF is separated by heat exchangers from the potable water in the tank. Water from the street is diverted through the pre-heat tank then into the regular domestic heater.

• The generic system makes roughly 95+% of the summer load and 35% of the winter load. Plus it provides some backup hot water, more storage, is small, simple, reliable, and inexpensive.

• Rough costs after incentives $5,000 to $8,000.

• Collectors take up between 4’ x 8’ and 10’ x 10’ of roof space.

• Flat panel or evacuated tube collectors? This is an esoteric argument. Both work fine. Your solar guy will undoubtedly have an opinion - let him make the case.
**Solar Thermal Domestic Hot Water ctd**

- Drainback or closed loop? Drainback systems essentially turn off and drain the collectors unless there is sun energy to harvest and somewhere to put it in the house. Great for oversized solar heating systems. More pump energy at start-up, hard to pipe, must use flat plates, might take more space in the mechanical area.

- Closed loop systems are always filled with pressurized fluid. Pump-efficient, compact, easier to pipe, must be able to handle a condition where the collectors stagnate, must use for evacuated tubes.

- Whatever you do make sure the design is warrantied not to blow up if it gets too hot, and that yearly maintenance is not required. Realistically a system should be able to handle power failures, vacations, neglect, etc. and run for a design life of 25 years.

- Avoid systems where the solar loop and primary heater both have coils in a single tank. This harvests much less energy in our climate area.
Active Thermal Space Heating

- Space heating with collectors takes more roof space. Collectors should be tilted steeply for winter gain, and orientation is sensitive.
- Systems that can make a useable amount of heat during the winter need to be designed not to freak out in the summer. There is about a 5.5 to 1.75 seasonal ratio of energy in New England.
- Low-water temperature delivery system can be either independent, or boiler integrated
- Independent panel radiators: independent controls, easy to retrofit, requires tank storage, scalable, adds the expense of another distribution layer.
- Radiant tubes and slabs: independence is possible, thermal mass of a slab can be much of the storage, distribution can also function for passive gain, may be hard to retrofit.
- Boiler integration: the issue is efficient harvest. You do not want the fossil heater working on the solar storage tank or storage mass.
Incentives

- Commonwealth Solar II
- Commonwealth Solar Thermal (Pilot)
- Federal and State tax credits
- State excise, sales and property tax considerations
- Net metering
- Solar Renewable Energy Certificates (SRECs) and the SREC market
- Commercial depreciation MACRS
- Funding Programs
Commonwealth Solar II Rebate

• Residential Rebate
  • System size > 1 kW
  • Rebate capped at 5 kW
  • Base: $0.75/watt installed
  • MA component adder: $0.10/watt
  • Moderate Home Value or Moderate Income adders: $0.85/watt
  • Maximum system size: 10 kW

• Commercial Rebate
  • System size > 1 kW and < 10 kW
  • Rebate capped at 5 kW
  • Base: $0.75/watt installed
  • MA component adder: $0.10/watt
Commonwealth Solar Thermal

- Brand new pilot program for 2011
- Base rebate:
  - $25 per collector * SRCC thermal performance rating of the collectors (kBTU/panel/day for Category C, Mildly Clouy climates)
  - This roughly translates to $450 - $650 for a 4’ x 8’ solar thermal collector
- MA component adder:
  - $200 per system
- Example: Heliodyne GOBI 408 collector – SRCC rating is 23.6 kBTU/panel/day
- Multiply this rating by $25/collector:
  - $25*23.6 = $590 rebate per collector
Federal and State Tax Credits

• Massachusetts State Tax Credit – PV or thermal
  – 15% of installation costs (after any cash rebates)
  – Capped at $1,000
  – Must be installed on an individual’s primary residence

• Federal Tax Credit (Personal or Corporate)
  – 30% of installation costs (after any cash rebates)
  – No maximum
Additional Tax Incentives

• Massachusetts Sales Tax Exemption
  – Massachusetts law exempts from the state's sales tax "equipment directly relating to any solar, windpowered; or heat pump system, which is being utilized as a primary or auxiliary power system for the purpose of heating or otherwise supplying the energy needs of an individual's principal residence in the commonwealth.”

• Massachusetts Property Tax Exemption
  – Massachusetts law provides that solar-energy systems and wind-energy systems used as a primary or auxiliary power system for the purpose of heating or otherwise supplying the energy needs of taxable property are exempt from local property tax for a 20-year period.

• Modified Accelerated Cost Recovery System
  – “eligible property placed in service after September 8, 2010 and before January 1, 2012 qualifies for 100% first-year bonus depreciation.”
Solar Renewable Energy Certificates (SRECs)

• Part of Massachusetts’ Renewable Portfolio Standard
  – requires each regulated electricity supplier/provider serving retail customers in the state* to include in the electricity it sells 15% qualifying renewables by December 31, 2020.

• The sale of SRECs allows electric suppliers to buy these certificates in order to meet their solar RPS requirement.

• One SREC is “minted” for every 1 MWh that a recognized system produces

• System owners are required to report their renewable energy generation on a monthly basis to the Production Tracking System (PTS) overseen by Mass. CEC

• Participation in the SREC market is voluntary and can be done for a maximum period of 10 years

• Aggregation Services are available to manage your SREC portfolio

• Example Income: 5kW system could potentially produce 6.6 MWh of solar energy annually; therefore, 6 SRECs would be “minted” and sold at a price of $510 each resulting in an income of $3,060.
Funding Programs

• Massachusetts HEAT Loan
  – Zero percent financing of $2,000 - $15,000 for a period of up to 7 years
  – Solar Thermal systems and energy efficiency measures

• New Generation Energy Community Solar Lending Program

• Please see the handout from today’s conference for other funding programs
Benefits Specific to Landlords

• Added value to property without increased tax liability
• Property becomes more attractive to renters
• Likelihood of having long-term tenants versus single-lease tenants:
  – A more stable source of rent income
  – Long-term tenants tend to take better care of property
  – Happier tenants send rent checks on time
• Broader reduction in carbon footprint
• Reduced operating cost
The Integrator’s Job

• Design the system
  • Site feasibility: electric service, roof condition structure and size, access, shading, utility usage
  • Insolation study
  • Engineering - 1-Line and piping diagrams
  • Energy audit

• Demonstrate feasibility
  • Energy generation estimate and/or financial payback modeling
  • Com Solar application sets the bar
  • NGRID asks for RETScreen for solar thermal - estimated use

• Get an interconnection agreement and process the Commonwealth Solar rebate application for PV.
• Obtain electrical, plumbing, mechanical and/or building permits
  • Code compliance - grounding and warning labels
• Turnkey contract and insurance
S+H Construction Solar Electric Financial Model

Address

<table>
<thead>
<tr>
<th>Project Cost</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>System size in watts DC</td>
<td>3,600</td>
</tr>
<tr>
<td>Base system cost</td>
<td>$31,088.88</td>
</tr>
<tr>
<td>Projected Commonwealth Solar rebate</td>
<td>$3,600.00</td>
</tr>
<tr>
<td>Invoice cost</td>
<td>$27,488.88</td>
</tr>
<tr>
<td>Projected tax credits and REC value</td>
<td>$9,915.81</td>
</tr>
<tr>
<td>Net system cost</td>
<td>$17,573.07</td>
</tr>
</tbody>
</table>

Equipment

<table>
<thead>
<tr>
<th>Panels</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Canadian Solar CSP6</td>
<td>200</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th># of panels</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inverter</td>
<td>Enphase M200</td>
</tr>
<tr>
<td>Rack</td>
<td>Unirac flush mount</td>
</tr>
<tr>
<td></td>
<td>color matched to panels</td>
</tr>
</tbody>
</table>

Project Production

| Estimated first year production in kWh | 3,802 |
| Value of solar energy harvested in the first year | $684.36 |
| Value of solar energy harvested over project life | $45,828.89 |
| Pre-purchased solar electricity per kWh rate | $0.18 |
| Projected solar fraction | 14% |

Carbon Savings

| Pounds of carbon saved in the first year | 5,703 |
| Pounds saved over the project lifetime | 150,529 |

Cash Flow

![Cash Flow Chart](#)
Last Words - all this available roof space and no solar

Approximately 2,650,000 kWh per year
(370,400kWh converted PV power)
Thank You!

Eric Lorenz, Project Manager
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