PV Solar System Installation
Introduction

• Hello, I’m Dave Twellman
• My background is in Chemical Engineering with several years’ “experience” as we say.
• I am a Johnson’s Controls Inc. employee with the good fortune to be working with one of our Environmentally Concerned RTP companies.
• In the Fall of 2007 I was asked to get started on the Engineering Design of a replacement roof for one of their Bldgs. And it was suggested that I look into PV Solar Production Opportunities.
Early Efforts
Building Roof (before)
Design Criteria

• Consult with RTP Architectural Committee
• Area Sizing requirements ~ 1 ft²± is needed for every 7 Watts
• System installed cost ~ $7.00± per Watt
• Plan for Combiner Box(es), Disconnect Switches, Inverter(s) and Meters/Monitors.
• Make sure everything is UL approved for SOLAR
• Will System be fixed, one axis, or two axis?
PV Solar System Selection

I found that there are numerous PV Solar System Manufacturer's and Installer's available and that new ones are coming on line almost daily.

I toiled through proposals from several different supplier/installers with basically two different technologies for the Headquarters' Installation.

I selected UNISOLAR'S Thin Film System

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**Average Daily Solar Radiation Per Month**

**ANNUAL**

**Flat Plate Tilted South at Latitude**

This map shows the general trends in the amount of solar radiation received in the United States and its territories. It is a spatial interpolation of solar radiation values derived from the 1961-1990 National Solar Radiation Data Base (NSRDB). The dots on the map represent the 238 sites of the NSRDB.

Maps of average values are produced by averaging all 30 years of data for each site. Maps of maximum and minimum values are composites of specific months and years for which each site achieved its maximum or minimum amounts of solar radiation.

Though useful for identifying general trends, this map should be used with caution for site-specific resource evaluations because variations in solar radiation not reflected in the maps can exist, introducing uncertainty into resource estimates.

Maps are not drawn to scale.

* NREL

National Renewable Energy Laboratory
Resource Assessment Program

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**Collector Orientation**

Flat-plate collector facing south at fixed tilt equal to the latitude of the site: Capturing the maximum amount of solar radiation throughout the year can be achieved using a tilt angle approximately equal to the site's latitude.
Proposed PV System Performance Calculations

82,280 DC Watts max

\[ \Rightarrow \]
75,000 AC Watts inverter max

\[ \Rightarrow \]
4.4 nominal hours/day

\[ = \]
330,000.00 nominal Wh/day

\[ = \]
0.96 inverter efficiency

\[ = \]
316,800.00 nominal Wh/day

\[ = \]
\( \div 1,000 \text{ Watts/kilowatt} \)

\[ = \]
316.8 nominal kWh/day

\[ = \]
365 days/year

\[ => \]
115,632.00 nominal kWh/year

\[ => \]
0.05 nominal $/kWh cost

\[ => \]
$5,781.60 nominal cost avoidance/year
Building with PV Cells (after)
Combiner Boxes and Disconnects
Design Criteria Cont.

• Don’t forget Maintenance
• Inverter Sizing – come in 30 kW, 75 kW, 100 kW, 200 kW, 500 kW, etc.
• Know your voltage & phase of grid intersect
• Roof Loading don’t forget “lifting load”
• Decide if you are going Off Grid or On Grid
• Is this an Energy Saving, Business Project, or…?
• What is your goal, save money, make money, public relations, community good will, training, etc.
# Proposed PV System Installation Cash Flow Calculations

## Buildings' Proposed Photo Voltaic System

<table>
<thead>
<tr>
<th>Cash Flow Summary</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total System Production Capacity</strong></td>
<td>82,680 Watts (power)</td>
</tr>
<tr>
<td><strong>Nominal Annual System Production Capacity</strong></td>
<td>122,000 kWh/yr (work)</td>
</tr>
</tbody>
</table>

| Proposed Installation Cost of 82,680 Watt PV System | $850,000 |
| Transfer Cost of HQ Roofing Project | $223,000 |
| plus mgmt. & contingency | $120,000 |
| **Total installed costs** | $1,193,000 |

| Federal Income Tax Credit | $357,900 = 30% x $1,113,000 |
| NC State Income Tax Credit | $417,550 = 35% x $1,113,000 |
| **Total Tax Credit Available for Program** | $775,450 |

| Depreciable Basis | $1,014,050 = $1,113,000 - ($333,900/2) |
| **Corporate Federal Income Tax Rate =** | 37.63% |
| **Corporate NC State Income Tax Rate =** | 6.90% |

<table>
<thead>
<tr>
<th>5-year accumulated depreciation schedule</th>
<th>yr1</th>
<th>yr2</th>
<th>yr3</th>
<th>yr4</th>
<th>yr5</th>
<th>yr6</th>
<th>yr7</th>
<th>yr8</th>
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<th>yr10</th>
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<tbody>
<tr>
<td>Depletion</td>
<td>20%</td>
<td>32%</td>
<td>19.20%</td>
<td>11.52%</td>
<td>11.52%</td>
<td>5.76%</td>
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<tr>
<td>Energy Savings/ Purchase Avoidance (kWh)</td>
<td>122,000</td>
<td>122,000</td>
<td>122,000</td>
<td>122,000</td>
<td>122,000</td>
<td>122,000</td>
<td>122,000</td>
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<tr>
<td>cost of energy @ 0.5 x (0.03% annual inflation)</td>
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</table>

| Estimated Energy Savings per year (before taxes) | $6,100 | $6,283 | $6,471 | $6,666 | $6,866 | $7,072 | $7,284 | $7,502 | $7,727 | $7,959 |
| Estimated Energy Savings per year (after taxes) | $6,077 | $6,259 | $6,447 | $6,641 | $6,840 | $7,045 | $7,256 | $7,474 | $7,698 | $7,929 |

| Renewable Energy Credits (REC’s) | 122 (REC/yr) |

| Estimated Value of REC’s (per year) @ $40/REC | $4,880 |

| Tax Savings are based on receipt of depreciation funds that otherwise would have been taxed as income. |

| Cost of money = | 8.00% |

Cost of Money is the interest costs for the future TAX Saving monies that has to be invested in year 1 but for which the return isn't repaid until subsequent years compounded.
Proposed PV System Installation Cash Flow Calculations cont.

Cash Flow and Rate of Return:

<table>
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<tr>
<th>year</th>
<th>Energy Savings less tax effect ($)</th>
<th>Sale of REC's less tax effect ($)</th>
<th>Increased Value of Building ($)</th>
<th>North Carolina Tax Incentive (35%) ($)</th>
<th>Federal Tax Incentive (30%) ($)</th>
<th>Depreciation ($)</th>
<th>FEDERAL Tax Savings (6% @37.63%) ($)</th>
<th>NC STATE Tax Savings (6% @ 8.9%) ($)</th>
<th>Tax Savings Totals ($)</th>
<th>Cost of Money (10%) ($)</th>
<th>Net Depreciation Savings ($)</th>
<th>Net Cash Flow ($)</th>
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<td>$69,969</td>
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Funding cont.

Cumulative Cash Flow

USD $

$1,000,000
($800,000)
($600,000)
($400,000)
($200,000)
$0
$200,000
$400,000
$600,000
$800,000
$1,000,000

Years

Series 1
Reasons for Selection

• Some of my reasons:
• Best Overall Proposal
• Ease of Installation
• Architecturally CLEAN
• Installation by Roofers
• Past Experiences with Installer - a roofing company
PERMITTING

• Who is your current electrical provider:
• What is your provider’s criteria?
• What will your provider bring to the table?
• File for FERC
• File for NCUC
• Apply to Utility Provider
FERC

• FERC Form No. 556
• 18 C.F.R. § 131.80

• CERTIFICATION OF QUALIFYING FACILITY STATUS FOR AN EXISTING OR A PROPOSED SMALL POWER PRODUCTION OR COGENERATION FACILITY
• ETC.
NCUC Filing

- Reports of Construction
- Full Name, Business Address, and Business Telephone Number of Applicant
- COMPANY NAME
- ADDRESS 1
- ADDRESS 2
- Contact – Operator’s Name
- (919) phone #
- Commercial Account
- 

- Individual
- 

- (Business)
- Nature of generating facility including the type and source of its power or fuel
- The generating facility consists of a 75 kilowatt photovoltaic array.
Interconnection Request

- **NORTH CAROLINA**
- **INTERCONNECTION REQUEST**
  - Utility: Duke Energy Carolinas
  - Designated Contact Person: Steve Smith
  - Address: 4412 Hillsboro Rd., Durham, NC 27705
  - Telephone Number: 919 687 3030
  - Fax: E-Mail Address: swsmith@dukeenergy.com
- An Interconnection Request is considered complete when it provides all applicable and correct information required below.

**Preamble and Instructions**
- An Interconnection Customer who requests a North Carolina Utilities Commission jurisdictional interconnection must submit this Interconnection Request by hand delivery, mail, e-mail, or fax to the Utility.
Purchase

• Solicit for proposals
• Obtain funding (see next slide)
• Select Installer/System
• Get Permits and proceed
75kW Inverter
Installation and Commissioning

• Obtain local Building Electrical Permits
• Proceed with installing panels
• Schedule Electrical shutdown for Disconnect Installation
• Install Inverter and Disconnects
• Label, Label, Label, etc.
• Get CofO
• Commission System and ENJOY Clean, Green, Energy
PV System Production

14 September 2010

[Graph showing PV system production from 0 to 60,000 watts over time (PDT)]
Electricity Purchased from Utility

14 September 2010
Buildings’ Utility Energy Usage on a Cloudy Day
Buildings’ Utility Energy Usage on a Sunny Day
Buildings’ 2009 PV Solar Production

Solar PV Production on Headquarters’ Bldg
for year 2009 (kW)
Buildings’ 2009 Utility Energy Consumption

DUKE Energy Consumption by Headquarters’ Bldg for year 2009 (kW)
www.gksolar.com
Future Plans

• Several mega-Watts of opportunity have been identified.
• Currently in Process of installing 240 DC-kW roof top System.
• Currently Progress Energy and DUKE Energy are limiting their involvement
• We have some work to do