



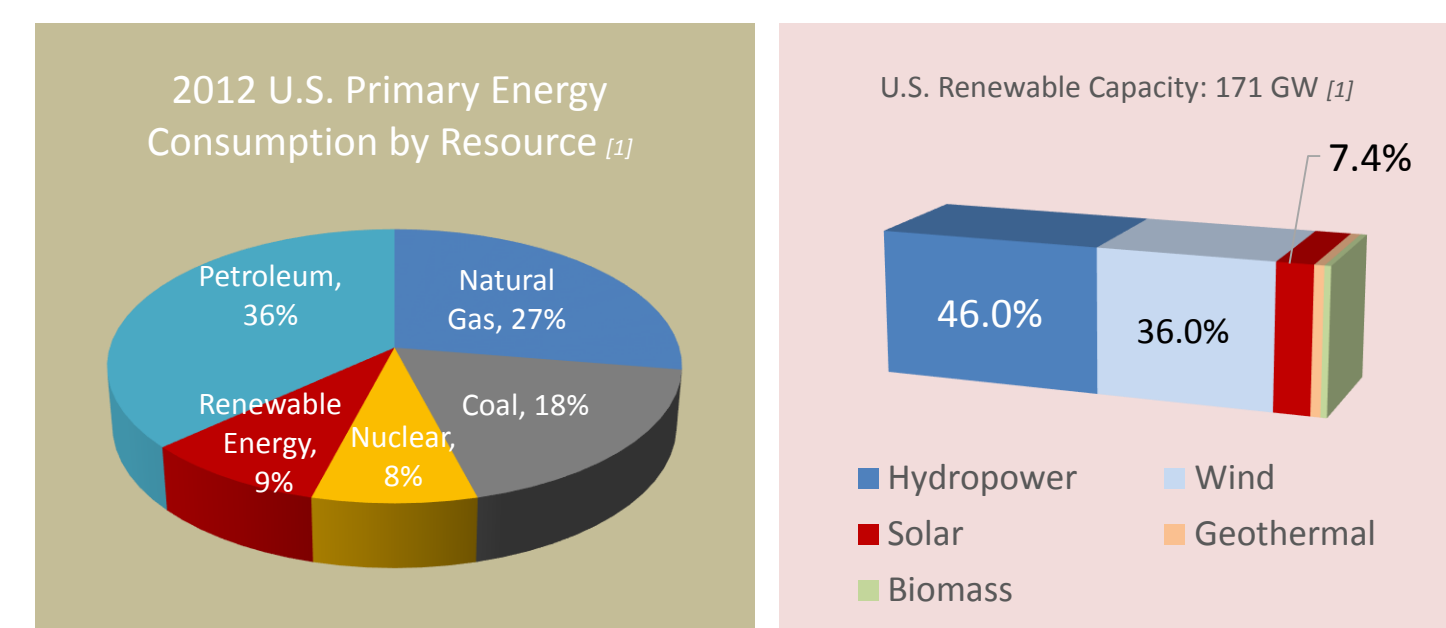
Economic Feasibility Study of Photovoltaic System in UNH Campus

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Introduction

As the use and the demand for the energy continue to grow quickly, fossil and nuclear fuel are becoming increasingly limited. Needs for development of alternative energy has been emerging and the study on the potential of solar power system has been very promising. The demand for the use of solar energy will constantly increase since the solar energy can be operated for an indefinite period of time without wearing out unlike other natural resources such as petroleum, coal, and natural gas. Therefore, the sun is the most dependable source of energy for the future, and the solar energy can reduce carbon footprint and electricity bill significantly.

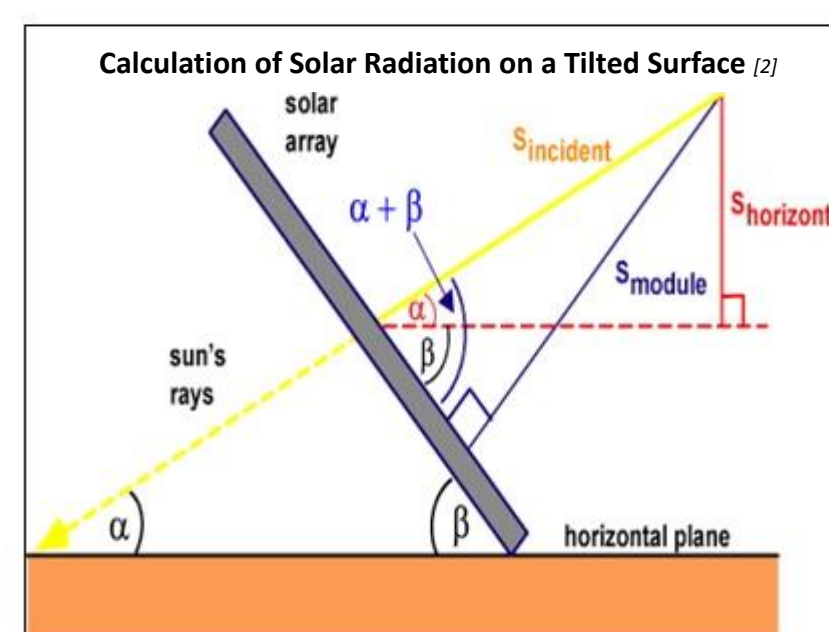
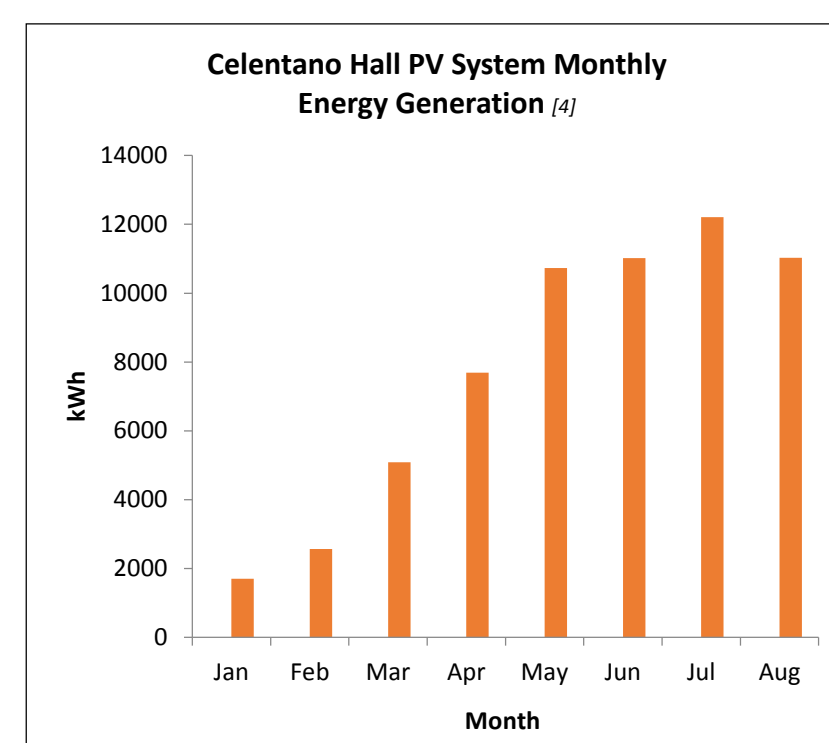


This study focused on the economic feasibility of installing photovoltaic systems in the University of New Haven campus. The result of this study will be used to analyze and further develop the feasibility study of PV systems for other universities in New England (NE), which share similar characteristics of climate and economic factors. The electricity price in Connecticut is currently 4th highest in the nation [1], and electricity demand in NE region has been continuously increasing. This suggests that the prosperity of PV systems in the region and development of precise models for economic analysis are urgent.

Feasibility Study

- Location Feasibility
 - 4.35 kWh/m²/day of solar radiation [2]
- Celentano Hall PV System Cost Analysis
 - 1,200 ~ 1,500 kWh electricity generation capacity [1]
- Technical Factors
 - Useable Roof Area
- Economic Factors (Incentives)- \$ 27 Million fund supported by government [3]
 - ZREC
 - MACRS
 - TAX Exemption

Celentano Hall PV System Financial Analysis



No. of Solar Panels	228 panels	Calculated Array Size DC	67.21	Estimated Loan Payment	
System Size	67.26 DC Kw	Calculated Array Size AC	933.65	Utility or Local Rebate	
1st Year kWh Solar Production	81847 kWh / year	Module Efficiency %	13.89%	Loan Term in Years	
Estimated Installation Price	\$ 288,500.00	Turn Key		Loan Amount	
Estimated O & M	\$ 10.00 per kw per year	Annual Module Degradation	-0.50%	Estimated ZREC Reward	\$ 0.148 per kWh
Potential 15 yr Inverter Repl	\$ - estimate	Discount & Interest Rate	5% Estimated	ZREC Reward Escalator	0.50% per year
		Estimated Inflation Rate	3% per year	ZREC Term	15 years
Annual Electric Cost Escalation	3.50% per year	Estimated Insurance	0.17%	Local Incentive	
Estimated Current kWh Rate	\$ 0.17 kWh	Marginal Tax Rate	38% Estimated	Annual Consumption	
Yearly Electricity Usage	1,222,800 kWh	Tax Credits	30% on Installation	Estimated Property Tax	

Year	Estimated Installation Cost and Maintenance after Warranty	Estimated Annual electricity cost	Estimated kWh Solar Production	Estimated Electrical Cost Savings	Estimated Zero Emissions Renewable Energy Credit (ZREC)	Estimated Property Taxes	Estimated Federal Tax Credit	Estimated Insurance	Estimated Annual Effective Cash Flow	Estimated Cumulative Cash Flow
1	\$ (288,500)	\$ 0.17	81,847	\$ 13,914	\$ 12,113	Exempt	N/A	\$ (490)	\$ (262,963.10)	\$ (262,963.10)
2	\$ (673)	\$ 0.18	81,438	\$ 14,329	\$ 12,053	Exempt	N/A	\$ (505)	\$ 25,204	\$ (237,759.10)
10	\$ (852)	\$ 0.23	78,237	\$ 18,127	\$ 11,579	Exempt	N/A	\$ (640)	\$ 28,214	\$ (23,131.59)
11	\$ (878)	\$ 0.24	77,846	\$ 18,667	\$ 11,521	Exempt	N/A	\$ (659)	\$ 28,652	\$ 5,520.33
20	\$ (1,145)	\$ 0.33	74,412	\$ 24,320	\$ -	Exempt	N/A	\$ (860)	\$ 22,315	\$ 230,113.69
25	\$ (1,327)	\$ 0.39	72,570	\$ 28,169	\$ -	Exempt	N/A	\$ (997)	\$ 25,845	\$ 352,069.76
30	\$ (1,614)		2,285,427	\$ 660,090	\$ 175,477			\$ (1,118)	\$ 493,319	

Results

No	Building	Area (m ²)	Estimated No. of Solar Modules	Cash Flow After 25 yrs (\$)
1	Arbeiter Maenner Chor	248	26	\$ 94,736.98
2	Bartels Hall	475	50	\$ 100,319.14
3	Beckerman Rec. Center	3755	392	\$ 627,855.41
4	Bergami Hall	1196	125	\$ 194,407.48
5	Bethel Hall	929	97	\$ 141,080.22
6	Bixler Hall	1048	109	\$ 173,981.99
7	Bookstore/Security	702	73	\$ 117,164.04
8	Botwinik Hall	1428	149	\$ 238,933.74
9	Buckman Hall	1570	164	\$ 258,540.87
10	Celentano Hall	2186	226	\$ 352,069.81
11	Charger Gymnasium	1651	172	\$ 273,014.52
12	Charger Plaza	795	83	\$ 134,966.76

No	Building	Area (m ²)	Estimated No. of Solar Modules	Cash Flow After 25 yrs (\$)
13	Dental Center	805	84	\$ 137,081.31
14	Dodds Hall	2133	223	\$ 349,039.88
15	Dun, Shef, Winch Halls	3601	376	\$ 603,139.80
16	Echlin Hall	897	94	\$ 144,779.68
17	Forest Hills Apt	2916	304	\$ 496,371.12
18	Gate House	289	30	\$ 48,665.56
19	Henry C. Lee Institute	389	41	\$ 61,761.62
20	Kaplan Hall	668	70	\$ 110,857.90
21	Maxcy Hall	900	94	\$ 141,446.28
22	Peterson Library	1380	144	\$ 223,323.80
23	Ruden Street Apt	606	63	\$ 102,420.74
24	S. Campus Hall	306	32	\$ 50,605.18
25	Subway Building	275	29	\$ 47,499.92
	Total	30172	3147	\$ 5,224,063.75

PV System Output Estimation

Solar Energy Generation [1]

$$E = A * r * H * PR$$

- E = Energy (kWh)
- A = Total Solar Panel Area (m²)
- R = Solar Panel Yield (%)
- H = Annual Average Solar Radiation on Tilted Panels
- PR = Performance Ratio, Coefficient for Losses (Default = 0.75)

Conclusions

- 25 out of 30 UNH Buildings are feasible for PV System
- Most of buildings qualifying for ZREC and other incentives
- Most of buildings with qualifying ZREC incentives will start generating positive cash flow within 11 years
- Average annual electricity saving from Campus wide PV System : \$ 210 K

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- Louis C. Annino Jr., Associate Vice President

References

- [1] Renewable Energy Data Book 2013. National Renewable Energy Laboratory (NREL). Web. 5 June 2015. <http://www.nrel.gov/>.
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- [3] Annino, Louis C., Jr. "PV Systems on the UNH Buildings." Personal Interview. 28 Jan. 2015.
- [4] Chris Lotspeich, "PV System on Celentano Hall." Personal Interview. 22 July. 2015.