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TEXAS GULF COAST CHAPTER

COLLECTION Series guides are aimed at all those involved in the process of procurement, design and construction of the green built environment in the Texas Gulf Coast Area. They shoud stimulate fundamental change in green practices by providing information on particular technologies and practices, showcasing LEED awarded examples in the region and providing specific guidance of practices in relation to the LEED rating system.

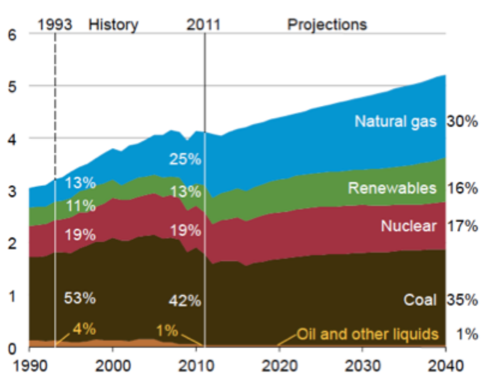
SOLAR ENERGY IN HOUSTON ON-SITE GENERATION IN LEED BUILDINGS

This guide focuses on the integration of Solar PV mounted and Thin Film systems to generate electricity, as the most widely spread renewable energy technologies used in buildings and neighborhoods. Solar energy systems can help a building become self-sufficient, zero-energy structures with superior energy efficient performance levels. Many installed examples exist across Europe, Japan, California and New York among other places, testifying to the benefits of grid parity, self-sufficiency, and clean energy consumption. Such systems have yet to be utilized to their full potential in Texas, the state with the 6th highest energy consumption per capita in the country and where sunshine is abundant enough to supply this energy demand several times.(2)

GREEN ENERGY BACKGROUND

Over the past 30 years, a raising concern about the avid depletion of natural resources in a fast developing world has been driving the question towards whether societies are able to sustain development and provide the adequate supplies of energy in a clean, safe and sustainable manner.

As a result, renewable energy production has experience a steady growth in U.S. over the past decade as a clean alternative harnessed from inexhaustible natural resources. From emerging technologies, renewable energy has become part of the mainstream energy supply to power a sustainable future. Today it contributes 13% to the total Electricity Generation in the nation. (1)



Electricity generation by fuel, 1990-2040 (trillion kilowatthours per year). Taken from U.S. Energy Information Administration, 2013.

Solar Energy in Houston

The history of PV mounted systems in Houston has been closely related to the USGBC since 2007, thanks to the first LEED certified home in the city. The Ronn Residence was part of the LEED pilot program for homes. Designed by Kathleen Reardon, and built by Michael and Tommy Strong, the home features a solar electric system and solar hot water heater installed by John Miggins of Harvest Solar. The Houston Renewable Energy Group (HREG) organized the first annual Houston Solar Tour in 2004 as part of the American Solar Energy Society (ASES) national solar tour, to raise awareness for renewable energy. The tour has highlighted LEED projects every year since 2006. In 2008 Houston was named a United States Department of Energy (DOE) Solar American City, as a result the city joined forces with the Houston Advanced Research Center (HARC) and Sandia National Laboratory, to implement the Solar Houston initiative. The Solar Houston Advisory Council was subsequently formed from a broad cross-section of businesses, government, educational institutions and non-profit organizations, USGBC among them, to produce the Solar Houston Plan. The plan identifies barriers and opportunities for the deployment of solar technologies and delivers the strategy to encourage the adaptation of this technology in Houston (4).

Today, the deployment of solar in Houston offers a much more mature market, with a range of local financial incentives, easy permitting process and state legislation that sets the technology as a viable and competitive solution in the energy market. The growth of available products has lowered technology prices and the option to sell excess power to the grid offers financial tools particularly favourable for residential, institutional and educational sectors. However, barriers such as intermitency of available solar resources, technology efficiency and the maintenance to cost energy ratio have prevented accelerated growth in commercial and industrial sectors. These sectors have preferred to purchase green energy alternatives as a cost effective option to off set CO_2 emissions.

HOUSTON'S SOLAR WEB RESOURCES

www.solarhoustontx.org
Created by HARC an excellent source of background information, and detail guidance for residential projects.

www.*houstonrenewableenergy.org*
HREG website is an educational portal on renewable energy technologies and community outreach in Houston.

www.dsireusa.org/solar/
DSIRE Solar Portal Texas, Database of Incentives for Renewables and Efficiency, first source of information for federal and State financial incentives.

http://www.codegreenhouston.org
Green Building Resource Center website is a gubermental portal with general information and links on solar technologies.

LEED GOLD HOME CASE STUDY

4119 Underwood, Houston TX
2.3 kW Solar Electric System,

The Newsham Bogler residence was designed as a LEED project from the start. It's smaller, more energy efficient, made from environmentally preferable products and it's designed to conserve water. Towards the end of construction, the team realized that a Gold level rating would be possible with the addition of solar panels. The house had been designed for future solar panels so they were easy to add.

As part of the LEED process this home has been energy rated by a trained HERS(5) rater. By using the plans of the home and then verifying with testing, a HERS rater analyzes the future energy usage of a home. The solar panels on this project will be making about 20% of the home's electricity, giving them an excellent HERS energy score of 39. (If you are living in an older home – your rating could very well be over 100.)

A small array of panels was always part of the project's goals and building design. The solar installer designed the system, and the LEED rater confirmed the additional points that the panels contribute to the LEED score. Finally the homeowner approved the additional cost of the system. Oliver Bogler comments: "Adding solar panels that allow us to generate 20% of the power needed was attractive to us economically, as well as allowing us to support the consumer segment of the sustainable energy industry." Please visit the owner's blog at www.leedhouse.info to learn more.

PROJECT TEAM

Homeowners
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Architect
RD Architecture, LLC
Kathleen Reardon, AIA LEED AP
Susannah Devine, LEED AP Homes
Builder
Michael and Tommy Strong
Solar Installer
APS Alternative Power Solutions
LEED Rater
Blue Gill Energy Management,
Clayton Farmer, HERS, LEED AP.
Landscaper
Wildflower Landscape Design, Jackie Barry

Solar Energy Systems and Efficiencies

Efficiencies vary according to the type of technology chosen and its integration with a building's design (6).

There are two types of technologies driving efficiencies:

Conversion Efficiency is primarily dominated by the crystalline technologies (c-Si) that excel at converting light into power. c-Si technology consists of silicon mineral. It is hard with a diamond cubic molecular lattice that provides superior conduction with an average conversion efficiency of up to 24%. Its hard nature, however, limits design possibilities as it can only be produced as a rigid wafer.

- **Mono-crystalline** – features pure, natural silicon. Unfortunately, pure silicon is rare in nature, therefore it translates to a high price point in the marketplace.

- **Poly-crystalline** – this synthetically produced version, features various isotopes with varying degrees of half-lives to compensate for the mono-crystalline's high conversion efficiency. at a relatively lower cost.

Applications:

Photovoltaic systems (i.e. solar panels). These first generation systems consist of individual panels with rigid crystalline wafers aligned on a substrate and bordered with metal. The panels are tiltable, replaceable and mounted either on the ground or roof in a southern direction. The use of c-Si based solar panels or modules is appropriate when site conditions permit the optimum solar exposure. Periodic adjustment is necessary for optimized performance and for the panels to face due south continuously. At minimum, these should be adjusted twice a year at the winter and summer solstices, tilting +15˚ and -15˚ relative to the horizontal ground, respectively, for maximum sunlight exposure, or ideally four times a year at the solstices and spring and autumn equinoxes. The panels can be connected to an automated sun tracking system to increase exposure and thus performance.

Absorption Efficiency is dominated by photovoltaic thin films consisting of combined non-crystalline technologies (CIS/CIGS, a-Si, and CdTe) that excel at absorbing light in all forms.

- **CIS/CIGS (copper-indium-selenium and copper-indium-gallium-selenium)** – Unlike silicon, the minerals are pliable and readily available either in pure or blended states with a remarkable long lifespan (7). Produced in a lab, the copper provides for a high conduction and even temperature distribution, while the other minerals offer superior light absorption, resulting in high absorption efficiencies that compensate for the relatively lower conversion efficiency.

- **a-Si** – This is an amorphous silicon with a dense but imperfect molecular lattice structure. It is a synthetic solution with low production costs. Like the CIS/CIGS technologies, it has a high absorption efficiency, performs well in ambient and low light conditions and tolerates high temperatures. Its economic price point makes this an attractive solution when an entire building is considered for power generation.

Applications:

Thin Film photovoltaics are found as integrated solutions in glass, polymers and commercial-grade fabric, usually laminated and implemented in curtain walls, ventilated façades, canopies, brise soleils, and tiles. Their sensitivity to all light sources (ambient, sunshine, artificial) enables these systems to operate efficiently in any direction, regardless of sun exposure. The thin film's pliability and thin profile make it versatile and usable on many more surfaces, having greater opportunities for building power generation, design flexibility and next generation photovoltaics.

	Conversion Efficiency		Absorption Efficiency	
PV system	Mono Si	Poly Si	CIS/CIGS	a-Si
Energy Output per sq ft	11 - 16.5 watts	11 - 16.5 watts	8 - 12 watts	6 watts
Efficiency Rate %	24.7	14 - 19	19.9	4.5 - 8
Heat Tolerance	low		high	
Shade Tolerance	low		high	
Drawbacks	*High price point* *Shade intolerance* *Heat intolerance* *Periodic cleaning* *Periodic adjustment* *Limited design flexibility*		*Lower conversion efficiency* *Historical data unavailable in the USA* *Few U.S. manufacturers* *Requires large surfaces* *Efficiencies may drop due to surrounding light conditions.* *Color, pattern and transparency affect efficiencies.*	

Recently awarded LEED Gold, Houston's Permitting Center, displays an on-site renewable energy system of new 107 kW Solar Electric System and 6 kWs of Wind Turbines in real time.

Connections

The decision either to connect or not to a local grid depends on different factors:

- *Solar energy storage is still in development*
- *Resource intermittency due to weather makes the system unstable*
- *As backup in the event of failure or maintenance to provide additional security.*
- *The option to sell additional excess energy (net metering)*
- *Solar energy systems can assist the city grid's demand response program objectives and relieve peak pressure during times of stress or extreme weather events*

On the other hand, when carbon neutrality is decided then a stand-alone arrangement for total self-consumption is favored.

Such solar energy systems are designed to deliberately generate sufficient power to sustain a building's energy needs throughout the year, and the following must be considered:

A comprehensive building energy simulation analysis is necessary to understand the building's projected energy performance, expected energy load and weatherization.

A Building Management System (BMS) is required to:

- *Monitor system performance*
- *Provide power output data in real time*
- *Correlate the sun's movement for optimization with solar tracker systems*
- *Generate reports*

Economics

A system's payback depends on multiple factors, namely the cost of technology at the time of purchase, system/building location, finance options, eligible incentives, local energy tariff rates and installation rates. Given this, the following is a ballpark guide for determining payback periods.

	Technology	
	c-Si	Thin Film
Embodied Energy Payback	1 to 4 years	≤ 1 year
Return On Invesment (ROI) *	25% annually 4 to 7 years	25% annually 4 to 7 years
System Lifespan	25 to 30 years	25 to 30 years

* ROI timeframe is subject to change according to incentives employed at the time of system installation

SCHOOL CASE STUDY
WILSON ELEMETARY SCHOOL HISD

2100 Yupon Street, Houston, TX 77006

9.36 kW Solar Electric System, 39 Conergy solar modules

The system installed by Akary Energy, contributes to the district's 20% reduction goal by supplying solar power to the school building and is estimated to generate 5% of the school's consumption. The installation was possible thanks to a grant from the Green Mountain Energy Sun Club and system will be inter-connected to the school, providing a slight off-set in the power required from the grid. The panels are part of a interactive solar education kiosk that has the aim to use the system as a teaching tool for teachers and students. This system will provide a variety of information on system performance, energy saving tips and carbon reduction equivalents. Also, the system can be monitored on a school-specific web site. (9)

COMMERCIAL SECTOR

Research has shown that net zero commercial building solar installations in hot and humid weather conditions are likely effective for buildings between two or three floors high, providing the entire building footprint is used (8). While conditions in Houston are ideal for solar panels on low rise commercial buildings, residential solar installations are more prevalent. Commercial energy use is significantly greater than the residential sector, but the incorporation of renewable energy in commercial buildings has been relatively minimal. Initial investment, financial plans and local tax incentives affect the viability of commercial installations at the moment. Additional research and education is needed to encourage investment.

Some barriers facing the commercial sector are:
- Few available financial incentives or leasing plans from energy companies.
- Variable solar energy market.
- Local legislation needs to develop further local tax incentives and streamline permitting.
- Solar installation prices still high compared to local energy tariffs.
- Additional operation and maintenance costs.
- Net metering is currently designed for residential, nevertheless there may be a potential for certain commercial units to serve the city in events of stress. Further research is needed in this area.

While energy efficient design is the background goal to be considered, LEED Commercial buildings in the city likely prefer to opt for green energy purchase agreements to off set carbon emissions in addition to their energy baseline model.

Under the present conditions, the choice to go solar is mainly linked to the level of corporate commitment to sustainability missions and particular corporate goals to be energy independent ie, IKEA, (815 Kw array provides 35% of store's energy consumption).

SOLAR ENERGY ON -SITE GENERATION ACROSS LEED

Prerequisite/Credits Impacted		H	NC	SCHOOLS	CI	HC	ND	EBOM	CS	Max. Points Contribution as a Result of Renewable Energy Generation
		Points Available per Credit								
EAp2	Minimum Energy Performance (1)	N/A	Prerequisite	Prerequisite	Prerequisite	Prerequisite			PR	No points, but may contribute towards demonstrating prerequisite compliance (min 10% energy cost improvement)
								PR		No points, but may contribute towards demonstrating prerequisite compliance (minimum ENERGY STAR score of 69)
EAc1	Optimize Energy Performance (1)		19	19						Depends on overall energy cost improvement of project and specific contribution made by renewable energy. Points thresholds are 1pt - 12%, and an additional point for every addition 2% threshold achieved up to 48%.
						24				Depends on overall energy cost improvement of project and specific contribution made by renewable energy. Points thresholds are 1pt - 12%, and and slightly more than one additonal point on average for every addition 2% threshold achieved up to 48%.
								18		Depends on overall energy cost improvement of project and specific contribution made by renewable energy. Points thresholds are 1pt - ENERGY STAR Performance Rating of 71, and an additional point for slightly less than one additonal unit increase in rating on average us to 18pts - rating of 95
									21	Depends on overall energy cost improvement of project and specific contribution made by renewable energy. Points thresholds are 3pts - 12%, and an additional point for every addition 2% threshold achieved up to 48%.
EAc1.2	Optimize Energy Performance (1)	34								Depends on overall Home Energy Rating System (HERS) rating of project and specific contribution made by renewable energy. Points are based off of rating and climate zone. A 0 HERS rating is equivalent to a net-zero energy home and earns 34 points.
EAc1.3	Optimize Energy Performance - HVAC (2)				10					Depends on amount overall energy cost improvement of project and specific contribution made by renewable energy. Points thresholds are 5pts - 15%, 10pts - 30% energy cost improvement
EAc2	On site Renewable Energy		7	7						7 - points awarded based on offsetting 1,3,5,7,9,11, or 13% of project's annual energy costs
						8				8 - points awarded based on offsetting 1,3,10,20,30, or 40% (1,2,5,6,7,8 pts respectively) of project's annual energy costs
									4	4 points earned for offsetting 1% of project's annual energy costs
EAc4	On site Renewable Energy							6		6 - points awarded based on offsetting 3,4.5,6,7.5,9, or 12% of project's annual energy consumption
EAc10	Renewable Energy	10								Points are not available for projects that pursue points via EAc1.2 and vice versa. One point earned for every 3% of the annual reference electrical load that is met by the system.
GIBp2	Minimum Building Energy Efficiency						PR			No points, but may contribute towards demonstrating prerequisite compliance (min 10% energy cost improvement)
GIBc2	Building Energy Efficiency						2			Depends on amount overall energy cost improvement of project and specific contribution made by renewable energy. Points thresholds are 1pt - 18%, 2pts - 26% energy cost improvement
GIBc11	On site Renewable Energy Sources						3			3 - points awarded based on offsetting 5, 12.5, or 20% of project's annual energy costs
GIBc12	District Heating and Cooling						2			2 - system may be used at district heating and/or cooling plant to increase energy efficiency of plant and make eligible for credit
ID	Innovation in Design	N/A	2	2		2			2	Achieve exemplary performance in an existing LEED credit. An exemplary performance point may be earned for achieving the next incremental percentage threshold of an existing credit (i.e., EAc2 -15%, EAc1 - 50%)
								2		Achieve exemplary performance in an existing LEED credit. An exemplary performance point may be earned for achieving the next incremental percentage threshold of an existing credit (i.e., EAc4 -13.5%, EAc1 - ENERGY STAR score of 97)
RP	Regional Priority	N/A	1	1		1			1	1 RP credit is earned if one point in EAc2 is earned
							1			1 RP credit is earned if one point in GIBc12 are earned
								1		1 RP credit is earned if one point in EAc4 is earned

All LEED rating systems have 100 base points; Innovation and Design and Regional Priority Credits (excluding Homes) provide Opportunities for up to 10 bonus points

(1) Table inputs based on 100% new construction projects for NC/CS/Schools/Heathcare/Retail/NC. Renovated buildings have slightly different point thresholds associated with them pertaining to EAp2 and EAc1

(2) Energy modeling path must be pursued to gain credit from renewable energy systems within EAc1.3 in CI/CI-Retail.

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(3) Solar Houston Tour, reference guide 2012.

(4) Houston Advance Research Centre, Solar Houston Initiative Plan.

(5) HERS stands for Home Energy Rating System.

(6) National Renewable Energy Laboratory (http://www.nrel.gov) – technology and R&D updates.

(7) In the order of $1x10^{14}$ half-life years.

(8) Duncan, P. et others, *How High Can You Go?* ASHRAE Journal, September 2009.

(9) Solar Houston Tour, reference guide 2012