



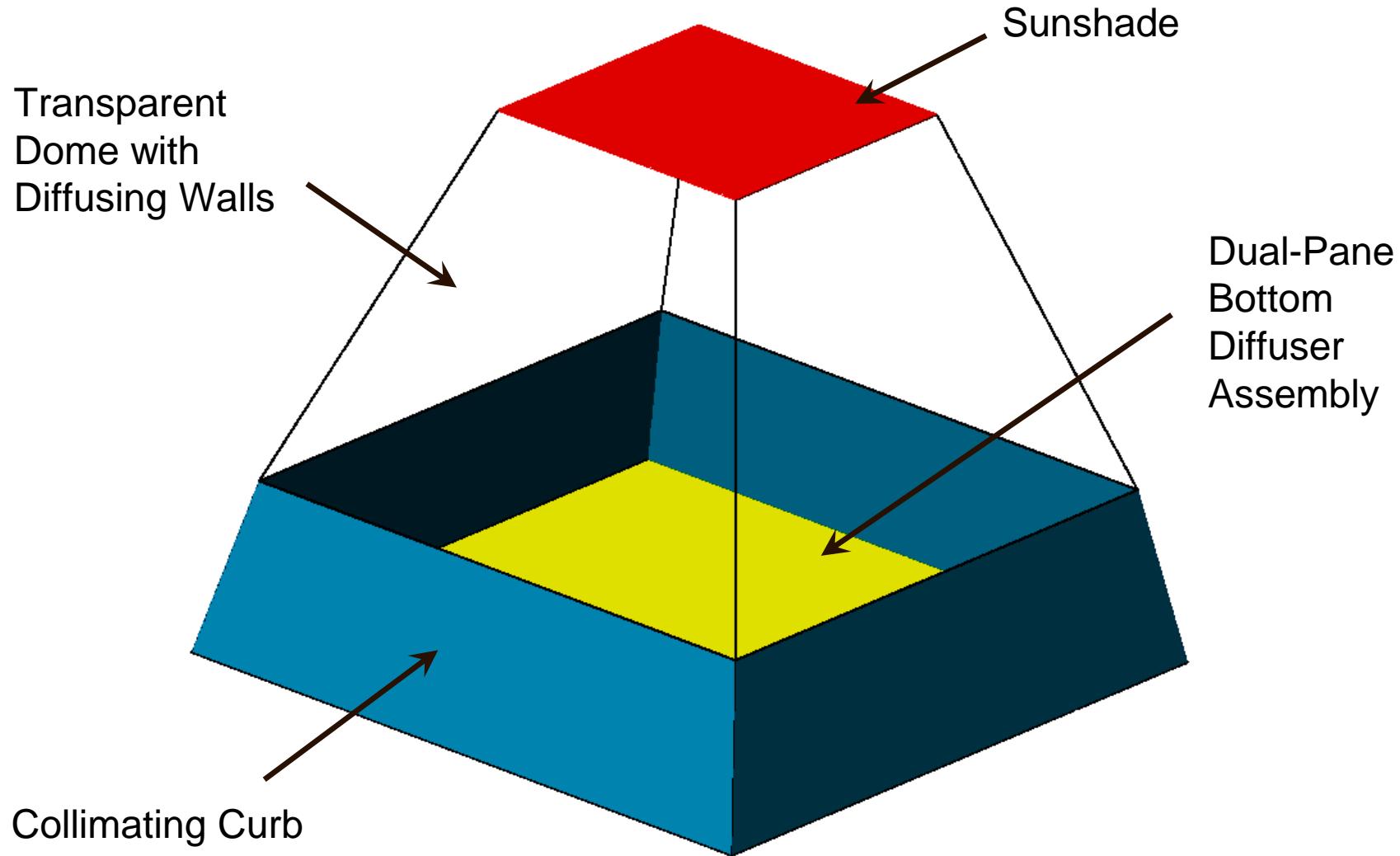
Comparison of Costs of Lighting a Big Box Store Using Rooftop PV+LEDs Versus Using Skylights

***“It’s Cheaper To Use Skylights To Provide Lighting
Than It Is To Use Rooftop PV+LEDs With Subsidies”***

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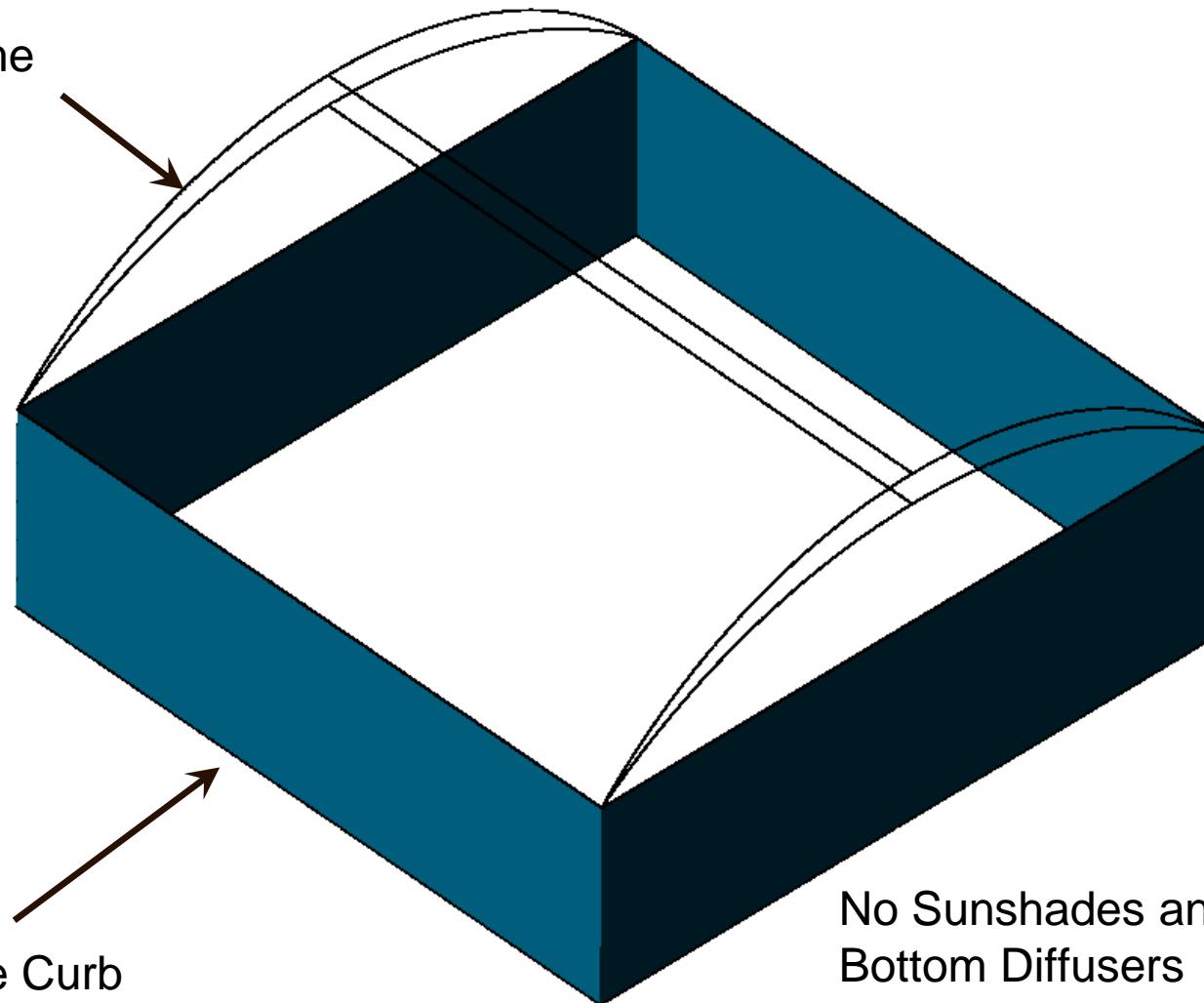
Entech Solar's New Skylight (US Patent #9,416,542)



Conventional Skylight



Double-Arch
Diffusing Dome



Straight White Curb

No Sunshades and No
Bottom Diffusers

Features of Entech skylight



- Goals of skylighting –
 - ◆ maximize the view factor from the dome to the sky
 - ◆ maximize low elevation sunlight collection, extending the hours of daylighting
 - ◆ minimize excess heat collection when the summer sun is overhead
 - ◆ minimize heat transfer losses through the skylight day and night
 - ◆ maximize condensation resistance.
- Tall diffusing sides of skylight collect large amounts of low elevation angle sunlight and scatter some of the low elevation angle light (that would go through clear sides) down into building.
- Transmittance of light through acrylic is low for high incidence angles onto the acrylic. The incidence angle onto the steeply sloping sides is low for low elevation angle sunlight and high for high elevation angle sunlight, thereby maximizing low elevation angle sunlight collection and minimizing excess heat collection around solar noon in summer.

Features of Entech skylight (continued)



- Slanting reflective sides of collimating curb reflect almost all low elevation angle sunlight that hits them and increase its elevation angle, which decreases the incidence angle onto double sheets of acrylic at bottom of curb and increases optical efficiency.
- Double sheets of acrylic at bottom of curb reduce heat transfer losses through the skylight and increase condensation resistance day and night.
- Sunshade blocks high elevation angle sunlight and reduces excess heat collection when the summer sun is overhead, while not reducing view factor from dome to sky much (about 12%) because shade is so far above bottom of dome.

Overview of Costs of Rooftop PV+LEDs Vs Skylights for model Big Box Store in DFW area.



- Pre-subsidy cost per watt of **Rooftop PV**: **\$3.00/watt**
- Post-subsidy cost per watt of **Rooftop PV**: **\$1.29/watt**
- Cost per watt equivalent of **Entech's skylights**: **\$0.88/watt**
- Cost per watt equivalent of **conventional skylights** :**\$1.11/watt**
- Note: The watt equivalent of a skylight is the number of watts of PV required to deliver the same annual dollar value as the skylight (not counting benefits of natural lighting such as enhanced sales and productivity).
- Example: If it takes 1500 watts of PV to deliver the same annual dollar value as one skylight, then the watt equivalent of the skylight is 1500.

Metrics for which these values hold



- All studies have been done on a model store with an illuminated space of 135,000 square feet with a ceiling height of 23' and no drop ceiling. These are all representative values and conditions.
- I don't think the cost per watt equivalents would change for a smaller space.
- For a store with a lower ceiling height, 15' for example, the cost per watt equivalent for the skylights would go up.
- For a store with a drop ceiling, the cost per watt equivalent would go up even more because it would necessary to add a reflective tube between the roof and the ceiling which would add to the cost of the skylights.

Skylights are more efficient than PV and are built with cheaper materials.



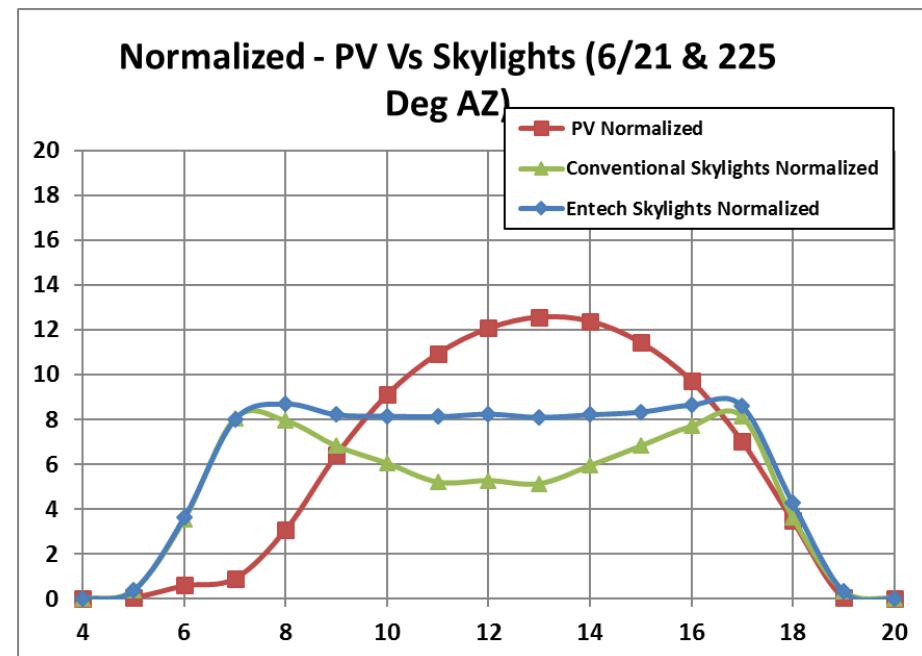
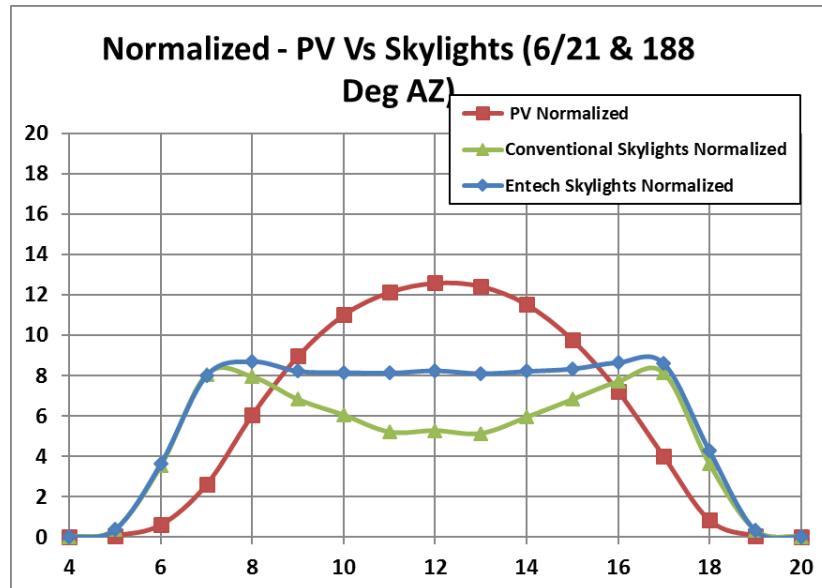
- It is reasonable to expect that skylights would be less expensive for lighting than rooftop PV.
- Rooftop PV is 15-20% efficient.
- A hole in the roof is 100% efficient at delivering light.
- Skylights are built with acrylic and other materials with low costs per square foot.

Demand Reduction



- As the following graphs show, skylights reduce the demand for electricity more in the morning and afternoon than south facing fixed tilt PV.
- If the PV is oriented to the southwest ($AZ=225$ Deg), then PV reduces demand as much in the afternoon as do skylights. However, net energy generation is reduced by about 4% almost canceling the effect of any reduction in demand charges in places that have demand charges.

Energy Savings Graphs for PV, Entech Skylights and Conventional Skylights



Skylights are Better for Building Owners, US Taxpayers, Utilities, Environment Than Rooftop PV



- 1) Cost per watt equivalent to building owners for skylights is less than post-subsidy cost per watt for PV.
- 2) Watt equivalents from skylights cost the US taxpayer less than do watts from PV.
 - a. The cost to the US taxpayer per watt equivalent generated by **Entech's skylights is 12 cents/W.E.** This cost to the taxpayer is a result of depreciating the skylights at 3% per year and taking a tax deduction for the depreciation.
 - b. The cost to the US taxpayer per watt equivalent generated by **conventional skylights is 16 cents/W.E.** (3% depreciation)
 - c. The cost to the US taxpayer per watt of **PV is \$1.71/W!** (30% ITC plus 5 year accelerated depreciation)

Skylights are Better than Rooftop PV(continued)



- 3) Skylights reduce demand more than south-facing PV. This benefits the utilities and also building owners who pay demand charges.
- 4) Skylights take less energy to build per watt equivalent than PV and thus have a quicker energy payback and reduce global warming more than PV. If it takes one year for a skylight to save as much energy as it took to build it and it takes a solar panel two years to save as much energy as it took to build it, then manufacturing and using the skylight has reduced global warming after one year while manufacturing and using the solar panel hasn't reduced global warming until two years have passed.

Opportunities in skylight world



- As we've seen, skylights can out compete rooftop PV even when it gets subsidies.
- However, subsidies tend to drown out technologies that don't get them. Example: I once started to tell someone from a utility in New Jersey about skylights and he said that he wasn't interested in anything that didn't get subsidies.
- There are opportunities to improve the performance of skylights. Because they get less attention, the chances of someone making a breakthrough may be higher than in PV.
- If subsidies for PV go away, then the relative value of skylights will be much higher. I think it's early days in the skylight world.

Background of Entech Solar



- Entech Solar – Entech Solar is a startup company with 3 employees, including the CEO. It consults with Mark O'Neill and Robert Walters, who were founders of the company. It is located in Grapevine, TX. It recently received a patent on the skylight mentioned in this presentation.
- Earlier this year, Dr. Roland Winston and Dr. Lun Jiang reviewed Entech Solar's analytical methods for measuring skylight performance and made critically important corrections and suggestions, which were implemented.

Background



- As a result of donations by the shareholders and by my wife and me, about 50% of Entech Solar's equity is owned or has been pledged to non-profits for veterans and military families. This is a continuation of the effort my wife and I made in 2004-2008 to give back to veterans and military families by donating \$275 million to organizations that supported them. For this, in 2008 we received the Department of Defense's Distinguished Civilian Service Award.
- If Entech is successful, value will be created for all of its shareholders, including non-profits for veterans and military families.

Calculating cost per watt equivalent of skylights



- To calculate out the cost per watt equivalent of skylights you need to know:
 - the annual savings generated by the skylights
 - the total installed cost of the skylights
 - the annual savings generated per watt of rooftop PV.
- Next, I'll describe the different components of the net savings generated by the skylights.

Components of Annual savings generated by skylights (page 1)



- Savings in electricity from turning off the lights
- A store owner will have a targeted illumination level. When the skylights deliver enough sunlight to reach the targeted illumination level, the electric lights are turned off and electricity is saved.
- When the skylights deliver some sunlight but not enough light to reach the targeted foot candle level, the electric lights are dimmed and some electricity is still saved.

Components of annual savings generated by skylights (page 2)



- LED replacement savings
- By permitting the electric lights to be turned off, the interval between replacements of LED fixtures is increased. This saves on materials and labor.
- For example, if a store is open 24 hours per day and the electric lights are on 16 hours per day, the interval between replacements of LED fixtures will be 1.5 times as long as in a store without skylights where the LEDs are on 24 hours per day.

Components of annual savings generated by skylights (page 3)



- Cooling costs and savings on hot days.
- Skylights deliver radiant heat at the same time that they deliver visible light. The radiant heat delivered is called Solar Heat Gain.
- Solar Heat Gain heats up the building and increases air conditioning costs on hot days.
- On the other hand, when the skylights bring in sunlight and the electric lights are turned off, the heat from the electric lights is avoided and this decreases air conditioning costs on hot days.
- Skylights do not insulate the building as well as the roof does. The insulating ability is measured by the U-Factor. Heat leaks into the building on hot days and increases air conditioning costs. These are called U-Factor losses.

Components of annual savings generated by skylights (page 4)

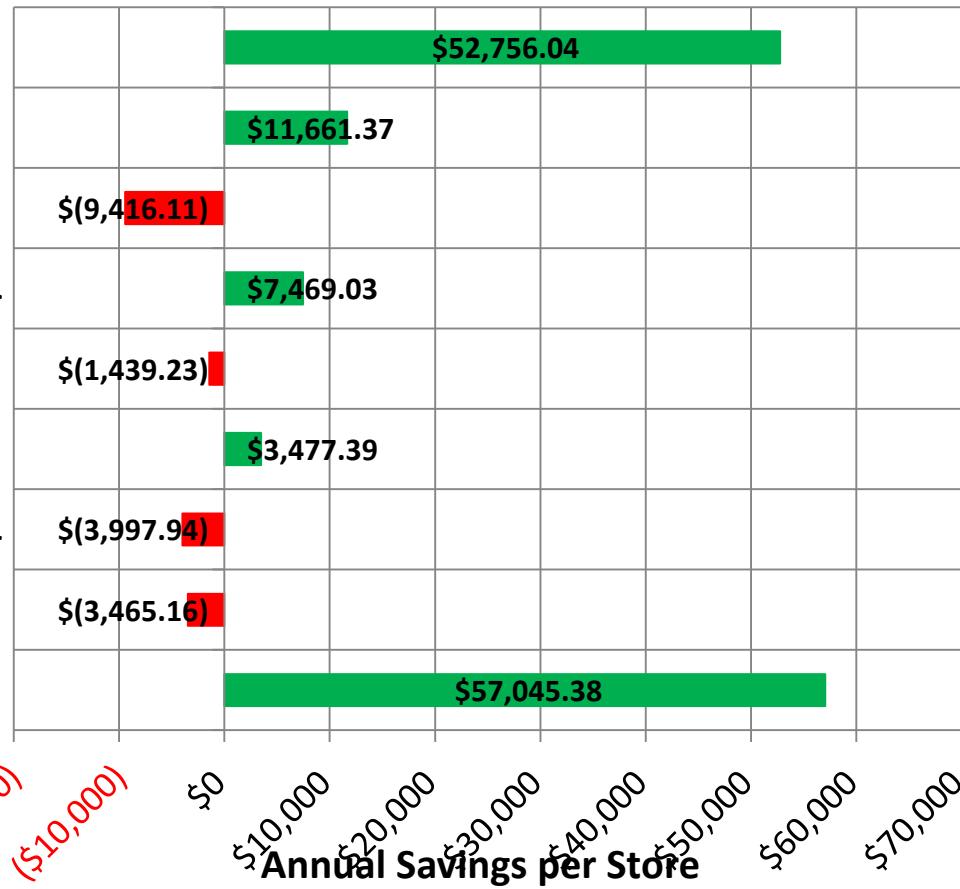


- Heating costs and savings on cold days.
- The Solar Heat Gain heats up the building and reduces the use of natural gas on cold days.
- But when the skylights bring sunlight into the building and the electric lights are turned off, the heat from the electric lights is lost and this cools the building and increases the use of natural gas on cold days.
- U-Factor losses: Heat leaks out of the building through the skylights and this increases the use of natural gas on cold days.

Chart of Annual Savings for 233 Conventional Skylights



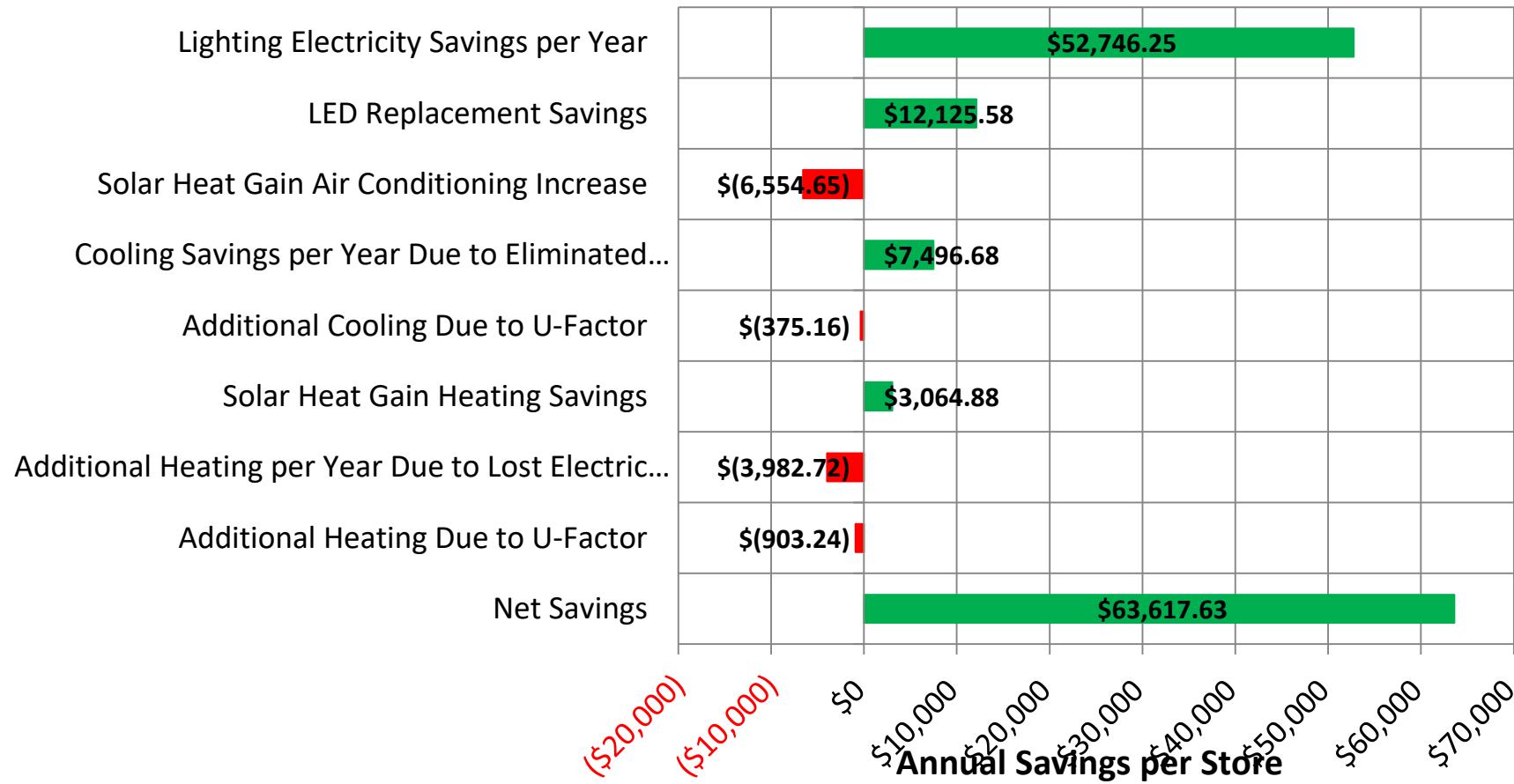
Annual Savings per Store for 233 Conventional Skylights in DFW



Graph of Annual Savings for 173 Entech Skylights



Annual Savings per Store for 173 Entech Skylights in DFW Area



Why Entech skylights have bigger savings than conventional skylights.



- Conventional skylights bring in more Solar Heat Gain than Entech skylights. This causes about \$3000 more in extra cooling costs in the summer.
- Conventional skylights don't insulate as well as Entech skylights. This causes about \$2500 more in heating costs in the winter.
- These two effects constitute the bulk of the difference between the savings of Entech skylights and conventional skylights.

Total Installed Cost of Skylights



- There are two components to the total installed cost of a skylight system.
 - ◆ Cost of the skylights including the cost of all the components and the installation costs and the number of skylights required to meet the targeted foot candle level. Fewer more expensive skylights can cost less than a greater number of less expensive skylights.
 - ◆ Cost of the extra air conditioning (A/C) capacity required to deal with excess heat delivered by skylights on hot days.
 - ▶ A building without skylights will need to have enough air conditioning capacity to cool the building on the hottest days of the year.
 - ▶ A building that has skylights installed will need to add air conditioning capacity if on the hottest days of the year the skylights increase the amount of air conditioning capacity necessary to cool the building.

Total installed costs for Entech skylights



- Each Entech skylight is estimated to cost \$1380. This includes the hardware and the shipping and installation costs.
- It takes 173 Entech skylights to provide adequate illumination in a store. Cost = $\$1380 * 173 = \$238,740$
- 173 Entech skylights require 6 tons of extra A/C at \$1800 per ton (initial cost per ton of A/C plus lifetime maintenance and repair costs). Cost = $\$1800 * 6 = \$10,800$
- At 5% discount rate and 35% corporate tax rate, 3% annual depreciation lowers cost by 15%. 20% margin to Entech increases cost by 20%.
- $.85 * 1.2 * (\$238,700 + \$10,800) = \$254,530$ per store.

Total installed costs for Conventional skylights



- Each conventional skylight is estimated to cost \$1110. This includes the hardware and the shipping and installation costs.
- It takes 233 conventional skylights to provide adequate illumination in a store. Cost = $\$1100 * 233 = \$256,300$.
- 233 Conventional skylights require 46 tons of extra A/C at \$1800 per ton (initial cost per ton of A/C plus lifetime maintenance and repair costs). Cost = $\$1800 * 46 = (\$82,800)$
- At 5% discount rate and 35% corporate tax rate, 3% annual depreciation lower cost by 15%. Margin is already included.
- $.85 * (256,300 + 82,800) = \$288,235$ cost per store.

Why the total installed cost of Entech skylights is lower than for conventional



- Entech skylights cost more but only 173 are required to illuminate a store while 233 conventional skylights are required to do this. This is because the Entech skylights are more optically efficient and deliver more low elevation angle sunlight and more diffuse sunlight (from the entire sky). When the elevation angles are low, usually much of the sunlight is diffuse and it's necessary to collect diffuse light as well as direct low elevation angle light.
- Each Entech skylight brings in less Solar Heat Gain than does each conventional skylight and there are fewer Entech skylights than conventional skylights. This reduces the amount of air conditioning capacity that is needed to cool the building on the hottest days.

Annual savings per watt of PV



- Each watt of fixed tilt PV generates 1.686 kWh per year
- At \$0.13 per kWh, annual savings = \$.22/watt

Cost per watt equivalent for skylights



Watt equivalents (W.E) for Entech skylights:

Annual savings/(PV savings/W) = $63625/.22 = 289,420$ W.E.

Total installed cost = \$254,530

Cost per watt equivalent = $254,530/289,402 = \$.88$

Watt equivalents for conventional skylights:

Annual savings/(PV savings/W) = $56968/.22 = 258,946$ W.E.

Total installed cost = \$288,235

Cost per watt equivalent = $288,235/258,946 = \$ 1.11$

Why Entech skylights have a lower cost per watt equivalent than conventional skylights



- The annual economic savings of the Entech skylights are higher than for conventional skylights.
- The total installed cost of the Entech skylights is lower than for conventional skylights.

Notes on data.



- The characteristics of the output of the skylight (optical efficiency, Solar Heat Gain) have been determined through experiment.
- The U-Factor has been determined by modeling which has been shown to agree well with real world data.
- The optical efficiency and Solar Heat Gain and U-Factor data have been applied to data from NREL's TMY3 data set to calculate annual savings and costs.
- The PV output data was taken from PVsyst.