Economic Analysis of the Tucson/Pima County Net-Zero Energy Building Code

---

Net-zero energy building and a positive cash flow on day 1

December 1, 2011

Tucson/Pima County

Net Zero Energy Code

X:_Shared Data\Green Building Programs\Zero Net Energy Code Grant\Deliverables\Final Report\Net-Zero-Code-Economic-Benefits-Report.doc

Executive Summary

If you can not measure it, you can not improve it.
-- *Lord Kelvin 1824-1907*

The Net-Zero Energy Building Code project was sponsored by the City of Tucson Office of Conservation and Sustainable Development. Pima County Development Services, Building Safety and Sustainability was the principle research group with assistance from the University of Arizona College of Architecture and Landscape Architecture and Tucson Water. The goal of the project was to develop a building code that will provide a prescriptive set of rules for designing a building that generates as much energy as it uses. Through the course of the research four key concepts were developed:

1) The development of a primary metric called Energy Use Intensity (EUI) to measure the predicted and actual energy use. This is analogous to miles per gallon for a car. The current practice for energy efficient buildings is to define them as a percent better than a bench mark. However, this does not measure the energy use and therefore does not provide information needed to size on-site energy production. Therefore a primary metric of energy use intensity (EUI) is required. This metric is 1000 Btu per square foot per year or kBtu/sf/yr.
2) The embedded energy to deliver water to the building must be offset by on-site energy production to achieve net-zero status.
3) Net-zero potential is defined by the ability of the building to generate on-site energy with the energy producing area limited to the building roof (and covered parking in commercial buildings). This requires that buildings be energy efficient which in turn decreases the amount of peak power capacity required by the utility.
4) The net-zero certification will be issued after one year of performance demonstrates net-zero achievement.

The Net-Zero Energy Code has a prescriptive residential section and a prescriptive commercial section covering apartments, office and retail. These building types represent approximately 30% of total energy use in the metro area. The Net-Zero Energy Code also has a performance section for both residential and commercial that will allow buildings that can not use the prescriptive path to achieve a net-zero certification by using energy modeling software.

This report on the economic benefits of Net-Zero is one of the final reports of the project. This report introduces the concept of "nega-watt" as a way to compare the cost of building energy efficiency improvements to the cost of PV power and utility supplied power. The report also provides a methodology to determine when the cost of a nega-watt exceeds the cost of electricity produced by PV, thereby creating the tipping-point where further energy efficiency improvements are not financially beneficial and funds should be diverted to the purchase of PV.

The key conclusions and recommendations of the Economic Benefits report are:

Conclusions:

- Nega-watts cost less than the cost of utility purchased power. In many cases nega-watts cost less than the cost of incentivized photovoltaic (PV) power.
- Cash flow positive: The decrease in monthly utility bills is larger than the increase in monthly amortized cost due to the energy efficiency improvements and PV power resulting in net positive cash flow to the building owner in the residential and apartment prototypes. The office and retail are not cash flow positive due to the high cost of efficient commercial air conditioning (HVAC).

Recommendations

- Provide incentives to jump-start the market: reward early adopters, bridge the small cash flow gap in energy efficiency improvement cash flow. Market the program to create demand for the benefits of net-zero.
- Close the gap on long term financing. *Cash flow positive* is dependent on the inclusion of energy efficiency measures and PV into the initial financing for the construction. Existing loan products exist, e.g., EEM and 203(K) loans, but investor banks have been reluctant to purchase these mortgages due to perceived additional risk.

INTRODUCTION

Project Summary: The Tucson/Pima County Net-Zero Energy Building Code was a joint effort of City of Tucson, Office of Conservation and Sustainable Development, Pima County Development Services Building Safety and Sustainability, and the University of Arizona, College of Architecture and Landscape Architecture (House Energy Doctor). The purpose of the project was to lay a path toward reducing greenhouse gas emissions associated with building energy consumption through a comprehensive approach of adopting future energy codes based on the most cost effective methodologies for reducing energy and water use in the desert southwest. The goal of the project was to develop a building code that will provide a prescriptive set of rules for designing a building that generates as much energy as it uses.

Why a net-zero energy code? According to Pima Association of Governments residential energy use is 25% and Commercial Energy use is 20% of Tucson total energy use. When combined, these building energy uses are the largest consumers of energy in our community[1]. To reduce the need for energy imports, additional peak generation capacity, green house gas emissions and to provide residents and business with additional income, it is in the best interest of the community to reduce the energy consumed by buildings.

Net-zero definition: In a report prepared by the National Renewable Energy laboratory (NREL) there are four definitions of net-zero.[2] The NREL definition used by the Tucson/Pima County Net-Zero Energy Code is:

> "Net-Zero Site Energy: A site [net-zero energy building] produces at least as much energy as it uses in a year when accounted for at the site." In addition, for the purposed of the Net-Zero Energy Code, the embedded energy in water used at the site must be accounted for at the site.

Research outline:

1) Determine prototype buildings that are representative of the majority of the current market. As noted above, the residential sector is the largest building segment of energy use in Tucson, within the commercial sector; national statistics indicate that office and retail are the two largest energy users accounting for 1/3 of commercial use[3]. Taken together residential, office and retail use account for 30% of total energy use in metro area. The research for the Net-Zero Code focused on these building types.
2) Perform energy modeling on the prototype buildings to determine baseline energy use, energy efficiency improvements, and target Energy Use Intensity (EUI)[4].
3) Determine the economic feasibility of net-zero. The subject of this report.

The Net-Zero Energy Code is a planning tool: The Net-Zero Energy Code is both a path for compliance with the requirements of the International Energy Conservation Code and a planning tool to assist designers and architects in achieving the goal of net-zero. Often, when planning a building, the costs are tracked "per square foot". Many people in the construction industry have rules of thumb regarding cost per square foot for various building elements, interior finishes, etc. The Net-Zero Energy Code requirements and factors as well as the outputs of the various calculators are similarly presented in value per square foot to assist in planning. The preferred planning method is to use an energy modeling tool during the design process. However, the use of energy modeling tools is not yet common. The prescriptive path of the Net-Zero Code can be used for early planning and design prior to energy modeling.

---

[1] Pima Association of Governments. "Tucson Region Greenhouse Gas Emissions Inventory." City Of Tucson, n.d. Web. 20 July 2011. http://www.tucsonaz.gov/ocsd/docs/CMS1_035279.pdf; slide 8. The other areas of use are: Transportation – 34%, Industrial, 18% and Waste 3%.

[2] Torcellini, P.. "Zero Energy Buildings: a Critical Look at the Definition." National Renewable Energy Laboratory, June 2006. Web. 15 July 2011. <http://www.nrel.gov/docs/fy06osti/39833.pdf>.

[3] "Energy Use by Building Type." *Sustainability - High Performance Buildings*. N.p., n.d. Web. 20 July 2011. <http://buildinginformationmanagement.wordpress.com/2010/02/12/energy-use-by-building-type/>.

[4] Energy Use Intensity: the total site building energy use divided by the building area; see the net-zero code for a complete definition at http://www.pimaxpress.com/Documents/Green/Net-Zero-Energy-Code-Public-Draft.pdf

A key concept of the Net-Zero Energy Code is the use of Energy Use Intensity[5] (EUI) as a primary metric for determining energy performance. Many building energy performance metrics are secondary metrics. For example it is common to say that a building is 15% better than a code baseline building. The '15% better' is a secondary metric. It tells you nothing about the actual energy use, unless you know the energy use of the code baseline building. EUI is a primary metric and is measured in 1000 Btu per square foot per year (kBtu/sf/yr). With this information it is possible to estimate utility bills and the amount of solar photovoltaic (PV) required to be net-zero. The concept of EUI is not new. The American Society of Heating Refrigeration and Air conditioning Engineers (ASHRAE) standard 100-2006R[5] established EUI targets for all building types in all climate zones. But the application of EUI in a building code is new.

1) STATEMENT OF PROBLEM

Is it possible to build a Net-Zero Energy Building and have a positive cash flow on day one?

Building a net-zero energy building is like any construction project and needs to balance four overall factors: size, quality, time and budget. In the case of a net-zero energy building the quality of the building envelope and systems are enhanced. Many people refer to a net-zero building as a high performance building. High performance suggests enhanced quality which may increase the cost. Conventionally, when quality increases the cost, the building size is reduced so that the construction budget is not increased. This conventional approach does not take into account the cost to finance the energy efficiency improvements and the photovoltaic system and the utility bill savings. In the case of the net-zero energy building, the question becomes:

> *If the energy efficiency improvements and photovoltaic panel are financed as part of the construction, will the utility bill savings result in a positive cash flow on day 1?*

A second question is:

> *What is the "tipping point" whereby energy efficiency improvements cost more than a photovoltaic system?*

The following factors will be considered in this report:

a) First cost of energy efficiency improvements, incentives
b) Amortized cost of energy efficiency improvements
c) Incentives
d) Energy saved over the life of the energy efficiency improvement: a "nega-watt"
e) Cost of saved energy or "nega-watt"
f) First cost of solar systems, incentives
g) Amortized cost of solar systems
h) Cost of energy produced by the solar system; PVwatt
i) Utility bill savings
j) Analysis of the nega-watt tipping point.

2) ECONOMIC ANALYSIS

a) First Cost of Energy Efficiency Improvements, incentives.

The first step in determining the first cost of energy efficiency improvements is to establish the baseline from which to measure any cost increases. Tucson and Pima County have adopted the 2006 International Energy

[5] "ASHRAE Standard 100-2006, Energy Efficiency in Existing Buildings." *Public Review Draft Standards*. ASHRAE, 25 Apr. 2011. Web. 22 Aug. 2011. <https://osr.ashrae.org/Public%20Review%20Draft%20Standards%20Lib/Std-100-2006R-APR1-Draft_2011-04-11_v4.pdf>.

Conservation Code (IECC). This code prescribes minimum quality construction requirements and equipment requirements as reflected in a baseline building.

The second step is to determine the improvements to the baseline building. The Tucson/Pima County Net-Zero Energy Building Code describes higher levels of quality to the building envelope and systems to improve energy efficiency. These systems are readily available, but may cost more than the minimum building code allowable quality for three reasons: 1) the system is inherently better quality and/or additional quantity, 2) it is not common practice therefore builders will increase cost to cover perceived risk, and 3) there is no economy of scale for production that results from common use. For example, the 2006 IECC requires a minimum of R13 insulation in walls. The Tucson/Pima County Net-Zero Energy Building Code requires wall insulation of R30. This example includes all three of the above reasons: 1) there is additional insulation material required, 2) the installation techniques are not widely known and 3) there is low demand for the higher quality insulation material required.

The final step is to determine the incremental cost increase due to the higher level of quality. This final step is highly variable because building components interact with building systems and a component increase in one area may result in a consequent cost reduction in another area. An example of this is that increasing the solar heat gain coefficient (SHGC) of windows will result in a smaller air conditioner and smaller electrical service to the air conditioner. The glass costs extra, the air conditioner costs less, the smaller electrical service costs less.

Experienced green builders were asked to review the improvements to the building envelope and systems and estimate associated additional cost to a minimum code compliant building. The estimated first cost increase for the net-zero prototypes were as follows:

Residential[6]	$5.50 to $8.50	per square foot more than a code minimum building.
Apartment:[7]	$7.00 to $12.00	per square foot more than a code minimum building.
Office	$16.00 to $21.00	per square foot more than a code minimum building.
Retail	$20.00 to $25.00	per square foot more than a code minimum building.

Other organizations have researched the cost for energy efficient upgrades: The Southwest Energy Efficiency Project (SWEEP) reported in November of 2007 that the estimated cost for home in phoenix to achieve a 50% savings on energy use compared to a code home was $15,210[8]. In an abstract of this report, SWEEP says that, “The initial cost of construction of a highly efficient home that includes renewable energy system (PV and solar thermal hot water is 6 to 8% more than a typical home (before incentives), but the net cost of ownership is lower because of reduced utility bills.”[9] The SWEEP analysis is used as a case study in the Nega-watt calculator (see section 5 of this report). The City of Austin Net Zero Task Force reports that their amendments to the 2006 IECC save 11% over the baseline code and cost $1,167 with an annual utility bill savings of $228[10]. The Building Codes Assistance Project (BCAP) study estimates that the cost achieve 2009 IECC requirements, which is 15% better than 2006 IECC is $0.24 per square foot[11]

---

[6] The residential estimate of additional cost was provided by the Southern Arizona Home Builders Association Green-build Council. This is a group of home builders with experience in construction high performance, beyond code homes.

[7] The commercial estimate of additional cost was provided by Sundt Construction Inc, Tucson office. Sundt is experienced in building high performance commercial buildings with LEED certification. See appendix 2 for the detailed estimates by building strategy.

[8] Dunn, Steve. "High Performance Homes in the Southwest." *High Performance Homes In The Southwest*. SWEEP, Oct. 2007. Web. 22 Aug. 2011. <http://www.swenergy.org/publications/hph/>.; pg ES-8

[9] Dunn, Stephen. "High Performance Homes in the Southwest." *UC Davis Energy Efficiency Center*. University Of California Davis, June 2008. Web. 02 Aug. 2011. <http://eec.ucdavis.edu/ACEEE/2008/data/papers/2_19.pdf>. Pg 4

[10] "Austin Net Zero Task Force Report." *Www.ci.austin.tx.us*. City Of Austin, Texas, 5 Sept. 2007. Web. 22 Aug. 2011. <http://www.ci.austin.tx.us/council_meetings/wams_item_attach.cfm?recordID=7329>.

[11] Paquette, Zachary. "Incremental Construction Cost Analysis for New Homes." *Bcap-ocean.org*. Building Codes Assistance Project, June 2011. Web. 2 Aug. 2011. <http://bcap-ocean.org/sites/default/files/resources/Cost%20Increment%20Project-FINAL_0.pdf>.

Research on the added cost for energy efficiency measures in commercial buildings is not as prevalent as for residential buildings. Recently the Rocky Mountain Institute held a round table discussion and published a white paper on the issues surrounding financing of energy efficiency retrofits in commercial buildings.[12]

While the purpose of this section is to focus on the estimated first cost, it is useful to note that a process called integrated design can potentially mitigate all of the additional first costs. As noted above with the example of SHGC and air conditioning, energy improvements in one system can improve another system. A process called integrated design[13] has been developed to take advantage of all of the savings possible. See the John Wesley Miller case study in the appendix 1 of this report for an example that documents the integrated design process. Many builders, included Pepper Viner Homes of Tucson, have found that through integrated design, there is little or no overall first cost increase when increasing the energy efficiency of a building[14].

b) Amortized cost of Energy Efficiency Improvements

Amortization refers to the paying off of a debt in regular installments over a period time. A long term loan with the construction cost amortized is the common way to finance the construction of buildings. Energy efficiency improvements are often considered as first cost of construction without regard to the fact that they reduce the energy costs over time. If the costs of the energy improvements are amortized there will be an increase in loan payment. There will also be a decrease in monthly energy bills.

In the mid-1990s the Federal Housing Administration (FHA) realized that amortized energy efficiency measures would result in mortgage payments that increased less than energy bills decreased. Overall the home owner paid less every month for the combined mortgage and energy payments. Based on this home owner benefit, the FHA developed the energy efficient mortgage (EEM)[15]. Research on commercial sector projects shows a similar result: energy efficiency does not reduce the return on investment and in fact may increase the return on investment[16].

The Net-Zero Energy Code financial model includes the cost of energy efficiency improvements and the cost of PV and solar hot water in the long term financing for the building. For this report the assumptions for amortization are: Thirty year term; 5.5% fixed interest rate. (The nega-watt calculator described later in Section 5 provides a tool to change the financial assumptions.)

c) Incentives

Incentives are available for both commercial and residential new construction projects and renovations. Residential incentives include energy efficiency incentives from Tucson Electric Power (TEP) to offset a portion of the first cost increase for energy efficiency improvements. For example, the total cost of construction for the energy efficiency improvements, including solar hot water, for the residential prototype 2,395 square foot house used in the net-zero code energy modeling is estimated to be $25,000. The TEP incentive for this house is $2,500[17]. Therefore the net cost of construction improvements after incentives is $22,500.

For commercial projects, the 179D tax deduction can result in a tax deduction of up to $1.80 per square foot for new and renovation projects that are 50% more efficient than ASHRAE 90.1-2001. The net zero code is approximately 60% better. In the case of the 50,000 square foot office prototype the cost of construction for the energy efficiency improvements is $800,000. $90,000 of this cost can be recovered as a tax deduction. Designers can claim the tax deductions if there project owner can not, for example public schools, public universities and government buildings of all kinds.

---

[12] "Financing Deep Energy Retrofits." Sustainable Realestate Solutions, 17 May 2011. Web. 22 Aug. 2011. <http://www.srmnetwork.com/wp-content/uploads/Whitepaper_Financing_Energy_Retrofits_RMI_05-17-2011.pdf>.

[13] For further information in integrated design with a residential focus see: http://www.greenbuildingadvisor.com/green-basics/integrated-design; for a commercial focus see: http://www.wbdg.org/design/engage_process.php

[14] Barna, Richard. Pepper Viner Homes; personal communication, August 22, 2011

[15] For more information on EEM see http://portal.hud.gov/hudportal/HUD?src=/program_offices/housing/sfh/eem/eemhome

[16] See the work of Professor Gary Pivo, professor at the University of Arizona: http://www.u.arizona.edu/~gpivo/

[17] Hogan, Dan. Tucson Electric Power Residential Account Manger, personal communication; August 15, 2011

Additional incentives are available for PV systems, solar thermal systems. These incentives are listed at the Database of State Incentives for Renewable and Efficiency (DSIRE)

d) Energy saved over the life of the improvement: a "nega-watt"

An energy efficiency improvement to a building translates into less energy use compared to a baseline building. This energy savings has value and can be converted to an equivalent "cost" per kilo-watt-hour (kWh). Using energy modeling, the energy saved per year by an energy efficiency improvement can be determined and the total energy savings over the life of the improvement can be calculated. This energy saved is called a "nega-watt."[18] The Net-Zero Energy Code uses the unit "kNWh" to represent 1000 watt hours saved. The prototype home used in the Net-Zero Energy Code will save 371,027 kNWh over thirty years. This is energy that the home owner does not have to pay for. The on-line nega-watt calculator calculates the energy savings for the apartment, office and retail prototypes.

e) Cost of a "nega-watt"

The cost of a "nega-watt" is based on the amount of energy saved and the first cost of the energy efficiency improvements. Using the case of the prototype home used for energy modeling in the Net-Zero Energy Code, the first cost of construction is discussed in Section 3 (a) above. The nega-watts, or energy saved is discussed in Section 3 (c) above. The cost per kNWh is calculated as follows:

	Net Cost of Construction / total nega-watts		=	cost of nega-watt
For the minimum cost case:	$12,500	/ 418,000 kNWh	=	$0.02986/kNWh,
		or about 3.0 cents per nega-kilowatt		
For the maximum cost case:	$22,500	/ 371,027 kNWh	=	$0.04897/kNWh,
		or about 4.9 cents per nega-kilowatt		

This can be directly compared to a kWh purchased from the utility, or that produced by a photovoltaic system. Using Tucson Electric Power's residential rate 1, the cost of purchased power for the prototype home is 11 cents per kWh [19]– more than twice the cost of a nega-watt. The cost of PV power is 7 cents per kWh in the current market with current incentives[20]. The additional benefit of nega-watts is the reduced photovoltaic system size required to achieve net-zero, thus reducing the first cost of the solar system.

f) First cost of solar systems, incentives

The first cost of photovoltaic systems is easily established since it represents a stand alone system that does not interact with other systems in the building. As of July 2011, the first cost for the installation of photovoltaic systems in the Tucson market is $5.50 per kW DC[20].

The first cost of solar hot water systems (sometimes called domestic hot water systems) is similarly easy to determine. However converting the installed cost to cost per unit of energy delivered depends on two variables:

i) The efficiency of the solar thermal devise in converting solar energy to thermal energy which is more variable than in photovoltaic systems, and

ii) Will all the stored thermal energy be used? For example, a small household with limited hot water needs may not be able to use all the energy produced. Further, if the residents typically shower in the morning, there will be storage losses and potentially the need for supplemental heat. One strategy to counter this

---

[18] "Rocky Mountain Institute: Amory & Hunter Lovins." *Green Univeristy*. Green Univeristy, LLC, n.d. Web. 21 July 2011. <http://www.greenuniversity.net/Ideas_to_Change_the_World/Lovins.htm>.

[19] The TEP rate R-1 has summer and winter block rates. The 11.1 cent rate is calculated based on the energy use of the prototype home and the R-1 rate. NREL PV watts cites 10 cents, the site www.solar-estimate.org uses 11 cents

[20] Current installed cost, conservative estimate is $5.50 per DC watt, Marc Romito, TEP, personal communication 7/6/11. Current TEP rebate is $1.75 per DC watt.

shortcoming is to use a new technology for electric water heaters called a heat pump water heater[21] and install additional PV which, when not used, returns power to the grid.

For the purposes of the Net-Zero Energy Code; the cost of solar thermal is included in the cost of energy efficiency improvements and included in the cost per nega-watt calculation. However it is useful to calculate the nega-watts separately from the energy efficiency improvements to illustrate that solar hot water is our most valuable energy resource in the metro region. The net cost of solar thermal after federal tax and utility incentives (the state tax credit is applied to the cost of the PV system in this calculation.) is estimated to be $3,100[22].

The cost of the nega-watts from the solar hot water system is calculated as follows:

Energy saved for the prototype house =

Energy Factor Saved in kWh/sf/yr * Size of Home * 20 year useful like of system = total Energy Saved
2.057 kWh/sf/yr * 2,395 sf * 20 yr = 98,000 kNWh

Cost for the solar nega-watts =
Net Cost of Construction / total nega-watts = cost of nega-watt
$3,100[22] / 98,609 kNWh = $0.003147/kNWh,
or about 3.1 cents per kilowatt (or nega-kilowatt).

When compared to the cost of the energy efficiency nega-watts for the various prototype buildings and the cost of PV watts, solar hot water is the most cost effective way to reduce energy use. It is for this reason that solar hot water is a mandatory requirement of the Net-Zero Energy Code
Incentives are available from TEP to offset the first cost of PV and solar hot water systems. These incentives are included in this financial analysis. The nega-watt calculator described later in Section 3 provides a tool to change the utility incentive assumptions.

g) Amortized cost of solar systems

Commonly, the cost of PV and Solar hot water are considered a first cost or expense. However, similar to the cost of amortized energy efficiency improvements discussed in Section 3 (b) above, if the cost of solar systems are amortized there will be an increase in loan payment and a decrease in monthly energy bills.

Therefore solar systems are not an expense, but an income generator. The Net-Zero Energy Code financial model assumes cost of the solar system is part of the construction project that included the energy efficiency improvements and any other construction. This construction is to be financed as described in the Section 3 (b) above.

h) Cost of energy produced by the solar system: PVwatt

It is possible to calculate the cost of energy produced by photovoltaic systems. This report uses the term “PV Watt” to describe energy produced by PV. These costs can then be compared to the cost of a nega-watt and to the purchase price of electricity. PV watts are expressed either as direct current (DC) or alternating current (AC). Photovoltaic panels produce DC power and PV systems are typically sized in DC kilowatts. A 5 kW system is a photovoltaic system that produces 5 kW DC at peak production. The unit PVkW (DC) is used to describe the energy produced by the PV system. Buildings use alternating current (AC) and an inverter is required to convert the PV panel output to AC. The unit PVkW(AC) is used to describe the converted energy used by the building. The calculation for the cost of the PV watts for the prototype home and the net-zero prescriptive path follows.

---

[21] Wilson, Alex. "Heat Pump Water Heater." *Green Building Advisor.com*. N.p., 13 Oct. . Web. 21 July 2011. <http://www.greenbuildingadvisor.com/blogs/dept/energy-solutions/heat-pump-water-heaters>.
[22] The net cost, after incentives for an 80 gallon tank with 1 4x10 collector per Danielle Kontovas at Technicions for Sustainbility, August 24, 2011 <Solar hot water budget number.msg>

(The nega-watt calculator described in Section 3 below provides a spreadsheet tool for the following calculations):

The size of the PV system on the prototype house is 12.38 PVkW(DC)

Based on a 20 year life, the total kWh(AC) power production is calculated as follows:

PV System size in kW(DC) * kWh(AC)/yr/kW(DC) * 20 years = Total kWh(AC) for the life of the system
12.28 kW(DC) * 1,644[23] * 20 = 403,736 kWh(AC)

The cost of the PV system is calculated as follows:

(PV System size in kW(DC) * $5.50/kW(DC)) - Incentives = Net System Cost
(12.28 kW(DC) * $5.50/kW(DC)) - $38,988 = $28,547

The cost of PV kWh(AC), to compare to the cost of a nega-watt or utility purchased power is calculated as follows:

Net System[24] Cost / Total kWh(AC) = cost per PV kWh(AC)
$28,547 / 403,736 = $0.0707 PVkWh(AC)

The cost of a PV kWh(AC) is 7.1 cents, which compares to 6 cents for a kNWh and 11 cents for a utility purchased kWh.

i) Utility Bill Savings

To determine the monthly cash flow, the cost to purchase grid supplied power must be considered. TEP rates have fixed monthly charges and block rates with the cost of electricity increasing based on how much is used. In addition, there are rates for winter use and summer use. Based on the Energy Use Intensity of a building, the average TEP rate per kWh can be calculated. The calculation for the prototype home per the prescriptive path using the TEP rate R-1 is 11.544 cents per kWh. This rate is used to calculate the utility bill savings from nega-watts and PV Watts.

j) Nega-watt – PVwatt "tipping point"

In the introduction, the following question was posed:

> *What is the "tipping point" whereby energy efficiency improvements cost more than a photovoltaic system?*

There are two factors to consider. 1) When a nega-watt costs more than a PV watt (AC), then energy efficiency improvements are no longer cost effective, and 2) when the monthly increase in loan payments for the amortized cost of nega-watts is more than utility bill savings from the energy efficiency improvements, nega-watts are no longer cash flow positive. Both of these factors are considered in the analysis in the next section.

3) ANALYSIS OF THE NEGA-WATT TIPPING POINT

A calculator to analyze the cost of nega-watts, PV watts and the associated tipping point has been developed and can be accessed at [insert hyper link – temporary link is www.pimaxpress.com/green]. The inputs for the calculator are show below with the values for the net-zero prototype home and the net-zero prescriptive path: These inputs are variable and multiple scenarios can be calculated by changing the variables.

---

[23]Per NREL PV Watts, accessed through: *In My Backyard*. National Renewable Energy Laboratory, 23 Dec. 2010. Web. 19 Aug. 2011. < http://www.nrel.gov/eis/imby/>.

[24] The cost on inverter replacement in not considered in this analysis.

Inputs to the excel calculator for the minimum cost case:

Total Cost of Construction for Energy Efficiency Improvements	$ 12,000	
Conditioned Floor Area	$ 2,395	sf
Energy Savings from Improvements	17.62	kBtu/sf/yr
Energy Use Intensity (EUI)	29.00	kBtu/sf/yr
Loan period	30	years
Interest rate (APR)	5.50%	
Utility Company Energy Efficient Home Incentive	$ 2,500	
Cost of PV DC Watt installed, before incentives	$ 5.50	
Utility Company Credit per DC Watt	$ 1.75	

Using the calculator to analyze the prototype home and the prescriptive path, the results are:

Factor 1) Does the nega-watt cost more than a PV watt?

Cost of kNega-watt (see section 3(d))	$ 0.02986	kNWh
Cost of PV kWh(AC) with incentives	$ 0.07071	kWh(AC)

In the case of the prototype home, the cost of the energy efficiency improvements is much less than the cost of PV, therefore further energy efficiency improvements may be considered. If the cost of a nega-watt exceeded the cost of a PV watt, then in the current market conditions (cost of utility power and incentives for PV) nega-watts are not cost effective.

Factor 2) Are the nega-watts cash flow positive?

Monthly energy savings from Energy Efficiency Improvements	$ 129	
Less the Monthly loan payment increase	$ 71	
Cash flow is positive	$ 58	

In the case of the prototype home, the monthly energy savings is $58 dollar more than the increase in the monthly loan payment. This means that the energy efficiency improvements result in a positive cash flow from day one. For the maximum cost case, the results are a savings of $13 more than the increase in monthly loan payment. Again, cash flow positive from day one.

A further analysis of the cash flow from the PV system indicates that overall the project is cash flow positive:

Monthly energy savings from PV	$ 187	
Less the Monthly loan payment increase	$ 162	
Cash flow is Positive	$ 25	

In the case of the prototype house, the minimum requirements of the Tucson/Pima County Net-Zero Energy Building Code have been met: Energy Use Intensity (EUI) is less than the Energy Budget Factor of 29 kBtu/sf/yr, the PV system limited to the area of the roof and the cash flow is a total of $83 positive on day one.

Commercial projects: Apartment, Office and Retail

The above example is for the residential prototype. In the case of the apartment prototype, the results are similar: nega-watts cost from 3.1 cents to 5.3 cents. This is far less expensive than PV watts or Grid watts. In the case of the office and retail prototype, the cost of nega-watts is considerably more expensive. The cost of nega-watts for the office prototype ranges from 6.7 cents to 8.8 cents. The cost for the retail prototype nega watts ranges from 8.4 cents to 10.4 cents. This is still less that grid power at 11 cents, but only in the case of the minimum cost for offices are nega-watts less than PV watts.

Analysis of the cost estimating data indicates that the cost of high efficiency commercial HVAC is the reason for office and retail nega-watts exceeding the cost of grid power. The price premium for commercial high efficiency HVAC is $8/sf. This compares to the price premium for residential high efficiency HVAC used in both the residential prototype and the apartment prototype which is $0.51/sf. This difference in premium points to the power of consumer awareness. Residential consumers have been made aware of the importance of high efficiency HVAC and manufactures have responded dramatically to this demand with increasingly higher SEER units at lower and lower prices. In the case of commercial buildings, there is no market demand for increased energy efficiency. One reason for this difference between the residential and commercial markets is the split incentive". Split incentives occur when the tenant, and not the property owner, is responsible for paying a property's utility bill. While this contractual setup keeps daily energy use in check, it often hinders long-term investment in energy-efficiency.[25]

4) FACTORS NOT CONSIDERED

The financial analysis in this report leaves out three important variables that actually improve the financial performance of net-zero buildings: 1) the time value of money, 2) the probability of increasing energy costs and 3) the probability of increased building value. Financial calculators are available that take into account these variables. For example, the on-line calculator www.Solar-estimate.org takes into account: utility inflation rate, tax rates and amortization factors. The results of the calculator include return on investment, internal rate of return and net present value. A recent article on BuildingGreen.com states that "…energy savings in all cases provided a higher rate of return, with a higher level of security, than any other secure type of investment."[26]

One final factor not considered: several characteristics of a net-zero building, for example appliance choices and thermostat settings, rely on the occupants to operate the building in an energy conscious manner. A net-zero home requires a net-zero homeowner. If the occupants do not operate the building in this manner, then the energy savings and net-zero benefits do not accrue. Occupant behavior is as important in commercial projects as it is in residential.

5) CONCLUSIONS

This report focuses on the economic benefits of a net-zero building. The benefit of reduced green house gas emissions is discussed in another report. Other benefits, such as increased occupant comfort and productivity increases that have been documented as a result of high performance buildings like net-zero buildings, are not considered in this report.

- Nega-watts cost less than subsidized PV power and less than half the cost of utility purchased power

- Cash flow positive: The monthly utility bill savings is larger than the monthly loan payment increase resulting in net positive cash flow to the building owner Many analyses that take into account the time-value of money and future increases in utility cost indicate that energy efficiency improvements are the best investment a homeowner can make with the added incentive that the "income" is tax free.[27]

- Community benefits:
  - Both nega-watts, solar hot water and PV reduce the need for power generation thereby reducing the dollar flow out of the metro region economy.
  - Nega-watts have the added benefit of reducing the need for peak power.

  Peak power is the amount of power that TEP needs to produce, or purchase, when the demand for electricity is the largest. Peak power in Tucson is in the late afternoon in the summer. PV production peaks in the mid-afternoon. So even in the best case, PV on a building will not offset all building peak power needs. However if the PV production is interrupted it is essential that the building be as energy efficient as possible to minimize the need for peak power generation or purchase. Since an energy efficient building requires less energy overall, the energy required to offset the loss of PV production is less. For example during the

---

[25] "Dealing with the "Split Incentives" Problem." *Technical Assistance Program Blog*. U.S, Department Of Energy, 2 June 2011. Web. 11 Nov. 2011. <http://www.eereblogs.energy.gov/tap/post/Dealing-with-the-e2809cSplit-Incentivese2809d-Problem.aspx>.
[26] Clifton, Ted. "Home Energy Efficiency Pays Dividends." *Green Building Advisor.com*. N.p., 26 July 2011. Web. 02 Aug. 2011. <http://www.greenbuildingadvisor.com/blogs/dept/guest-blogs/home-energy-efficiency-pays-steady-dividends>.

summer monsoon season there are times when the outside temperature is well over 100 degrees creating a peak power demand. As the clouds begin to form they will shade PV systems thereby reducing PV system power out put. TEP will need to produce, or purchase, power to offset the PV production loss. Net-zero buildings with their cap on Energy Use Intensity will reduce the peak load. (Some researchers describe the concept of zero peak[28] as potentially a more important goal than net-zero. In general, zero peak requires a larger PV system and results in the building being a net energy producer. While zero peak has a big benefit vis a vis purchased peak power, current ACC rules that do not allow net-metering, making zero-peak financially unattractive to building owners.)

Reducing peak power puts money back into the local economy. In 2010, TEP spent $169 million to purchase peak power. Little of this money stayed in Tucson's local economy. Net-zero buildings will reduce the need for peak power purchase. If the $169 million had been spent in Tucson, or saved in local banks, the economic impact would have been considerable.

6) POLICY RECOMMENDATIONS:

Provide incentives to jump start the market:

- Reward early adopters: Consider incentives for the first 100 new homes and/or home renovations and the first 20 commercial new and/or renovation projects that include:
  - Building Permit fee reductions at permit issuance
  - Building Permit fee refund if net-zero documentation provided per the code

  Market transformation begins as techniques become familiar and demand for products and services increase. Initially high first costs come down. This has been shown by the green building movement. An incentive for early adopters will help to establish the market and therefore costs lower to where incentives are no longer necessary. The solar industry is an example of this process

- Market the program. Market transformation will occur if building owners demand the benefits of a net-zero building.

- Close the gap on long term financing. *Cash flow positive on day one* is dependent on the inclusion of energy efficiency measures and PV into the initial financing for the construction in both new and renovation work. Loan products exist, e.g., EEM and 203(K) loans, but investor banks have been reluctant to purchase these mortgages due to perceived additional risk[29]

  i) Work with TEP to assist them in there efforts for on-bill financing.
  i) Work with local lenders to create a warehouse fund and/or cover the additional perceived risk. Potential sources of revenue are CREBS, Industrial Development Authority Bonds,
  ii) Work on Property Assessed Clean Energy (PACE) financing enabling legislation.

And finally,

Net-zero buildings = Increased comfort, positive cash flow, no future energy cost worries and community benefit: Why wouldn't you do this?

---

[28] Hammon, Robert W. "Applications for Large Residential Communities: What Is Net-zero Energy?" *EnergyVortex.com*. N.p., n.d. Web. 20 July 2011. <http://www.energyvortex.com/files/netzero.pdf>.
[29] Painter, Eric. Nova Home Loans, personal communication. May 2010.

Appendix 1 : Case Studies

1. John Wesley Miller Armory Park del Sol ZEH2 case study[30]
    a. Background: John Wesley Miller Companies was selected to participate in a demonstration project to design and build four zero energy homes (ZEH) in different climate zones in the country. Ultimately two zero energy homes were built in the Armory Park del Sol subdivision. John Miller has stated in presentations that the he first home, ZEH1, has not proved to be net-zero in operation due to the habits of the occupants. The second home was built with additional energy efficiency measures and a lager PV array to ensure net-zero status. In addition, the owners of ZEH2 are committed to the concept of net-zero. This has resulted in a modeled EUI of 9.7 kBtu/sf/yr and an actual EUI of 13 kBtu/sf/yr. This is less than half of the Net-Zero code maximum of 29 kBtu/sf/yr.

       ZEH1 made extensive use of integrated planning and designing the house as a system. The excerpted table B from the report follows. This table shows how changes in the energy efficiency reduced the size of the required PV system. 31 scenarios were modeled and estimated. Starting with the Amory Park del Sol building standards, a 7.5 KW PV system at and additional cost of 58,500 was required to be net-zero. In the final case, after extensive energy efficiency upgrades, the PV system was 4.0 KW and the total incremental cost was $38,859. The same result, net-zero, for $20,000 less due to integrated design.

    b. First cost of energy efficiency improvements and PV system were: $25,495
    c. Modeled Energy Use intensity 9.7 kBtu/sf/yr; assume energy savings = 2006 IECC base line of 46 – 9.7 = 36.3 kBtu/sf/yr
    d. Actual EUI = 10.5 kBtu/sf/yr; confirming the energy modeling
    e. Per the Nega-watt tipping point calculator and assuming current PV cost of $5.50 per DC watt installed, the tipping point on the ZEH was not exceeded:
    f. Nega-watt = $0.03335
    g. PV kWh = $0.06167 (with an assumed incentive of $2 per watt, actual incentive at the time of construction was approximately $3.50)
    h. Assuming 30 year fixed, 6% financing, the home owners have a positive cash flow of $96 from day one

2. Other case studies will be developed and posted to the Net-Zero Energy web page at [insert final hyper link]

[30] http://www.toolbase.org/PDF/CaseStudies/TucsonZEH1Report.pdf, accessed 7/13/2011

Table 8
Summary of Life Cycle Cost and Incremental Cost for Energy Packages

Option	Description	Initial Efficiency Investment Cost	Energy Use of System (kWh/yr)	Efficiency Invest + Energy LCC	Calc PV Size (kW)	Total PV Size (kW)	PV LCC (Investment minus Energy Production)	Total Life Cycle Cost	Incremental Efficiency Investment Cost	Incremental PV cost	Total Incremental Cost over JWM standard
–	JWM Standard (includes passive SDHW)	$13,637	12376	$33,535	7.40	7.5	$49,004	$82,539	$0	$58,500	$58,500
A	2" Polyiso	$13,832	12119	$33,360	7.24	7.5	$49,004	$82,364	$196	$58,500	$58,696
B	R43 Insulation	$14,152	12303	$33,929	7.35	7.5	$49,004	$82,933	$515	$58,500	$59,015
C	Hi SEER AC&Solar Htg	$20,337	8917	$36,737	5.33	5.5	$35,936	$72,673	$6,700	$40,500	$47,200
D	Hi Eff Appliances	$14,717	11685	$34,117	6.98	7.0	$45,737	$79,853	$1,080	$54,000	$55,080
E	Hi Eff Lighting	$17,005	11180	$34,984	6.68	7.0	$45,737	$80,720	$3,368	$54,000	$57,368
A+B	2" Polyiso+R43 Ceiling	$14,347	12044	$33,751	7.20	7.5	$49,004	$82,755	$711	$58,500	$59,211
A+C	2" Polyiso+Hi SEER AC&Solar Htg	$20,532	8813	$36,778	5.27	5.5	$35,936	$72,714	$6,896	$40,500	$47,396
A+D	2" Polyiso+Hi Eff Appliances	$14,912	11420	$33,930	6.83	7.0	$45,737	$79,667	$1,276	$54,000	$55,276
A+E	2" Polyiso+Hi Eff Lighting	$17,200	10915	$34,797	6.52	6.5	$42,470	$77,267	$3,564	$49,500	$53,064
B+C	R43 Insulation+Hi SEER AC&Solar Htg	$20,532	8876	$36,867	5.31	5.5	$35,936	$72,803	$6,896	$40,500	$47,396
B+D	R43 Insulation+Hi Eff Appliances	$15,232	11608	$34,505	6.94	7.0	$45,737	$80,242	$1,595	$54,000	$55,595
B+E	R43 Insulation+Hi Eff Lighting	$17,520	11106	$35,376	6.64	7.0	$45,737	$81,113	$3,883	$54,000	$57,883
C+D	Hi SEER AC&Solar Htg+Hi Eff Appliances	$21,417	8204	$37,287	4.90	5.0	$32,669	$69,956	$7,780	$36,000	$43,780
C+E	Hi SEER AC&Solar Htg+Hi Eff Lighting	$23,705	7689	$38,140	4.60	4.5	$29,402	$67,542	$10,068	$31,500	$41,568
D+E	Hi Eff Appliances+Hi Eff Lighting	$18,085	10499	$35,579	6.28	6.5	$42,470	$78,049	$4,448	$49,500	$53,948
A+B+C	2" Polyiso+R43 Ceiling+Hi SEER AC&Solar Htg	$21,052	8772	$37,221	5.24	5.5	$35,936	$73,157	$7,415	$40,500	$47,915
A+B+D	2" Polyiso+R43 Ceiling+Hi Eff Appliances	$15,427	11346	$34,323	6.78	7.0	$45,737	$80,059	$1,791	$54,000	$55,791
A+B+E	2" Polyiso+R43Ceiling+Hi Eff Lighting	$17,715	10840	$35,188	6.48	6.5	$42,470	$77,658	$4,079	$49,500	$53,579
A+C+D	2" Polyiso+Hi SEER AC&Solar Htg+Hi Eff Appliances	$21,612	8097	$37,324	4.84	5.0	$32,669	$69,993	$7,976	$36,000	$43,976
A+C+E	2" Polyiso+Hi SEER AC&Solar Htg+Hi Eff Lighting	$23,900	7583	$38,178	4.53	4.5	$29,402	$67,580	$10,264	$31,500	$41,764
A+D+E	2" Polyiso+Hi Eff Appliances+Hi Eff Lighting	$18,280	10226	$35,381	6.11	6.0	$42,470	$77,851	$4,644	$45,000	$49,644
B+C+D	R43 Ceiling+Hi SEER AC&Solar Htg+Hi Eff Appliances	$21,932	8161	$37,723	4.88	5.0	$32,669	$70,392	$8,295	$36,000	$44,295
B+C+E	R43 Ceiling+Hi SEER AC&Solar Htg+Hi Eff Lighting	$24,220	7648	$38,579	4.57	4.5	$29,402	$67,981	$10,583	$31,500	$42,083
B+D+E	R43 Ceiling+Hi SEER AC&Solar Htg+Hi Eff Lighting	$18,600	10423	$35,969	6.23	6.0	$39,203	$75,171	$4,963	$45,000	$49,963
C+D+E	Hi SEER AC&Solar Htg+Hi Eff Appliances+Hi Eff Lighting	$24,785	6979	$38,694	4.17	4.5	$29,402	$68,096	$11,148	$31,500	$42,648
A+B+C+D	2" Polyiso+R43 Ceiling+Hi SEER AC&Solar Htg+Hi Eff Appliances	$22,127	8056	$37,763	4.82	5.0	$32,669	$70,432	$8,491	$36,000	$44,491
A+B+C+E	2" Polyiso+R43 Ceiling+Hi SEER AC&Solar Htg+Hi Eff Lighting	$24,415	7542	$38,617	4.51	4.5	$29,402	$68,019	$10,779	$31,500	$42,279
A+B+D+E	2" Polyiso+R43 Ceiling+Hi Eff Appliances+Hi Eff Lighting	$18,795	10150	$35,771	6.07	6.0	$39,203	$74,974	$5,159	$45,000	$50,159
A+C+D+E	2" Polyiso+Hi SEER AC&Solar Htg+Hi Eff Ltg+Hi Eff Appliances	$24,980	6871	$38,730	4.11	4.0	$26,135	$64,865	$11,344	$27,000	$38,344
B+C+D+E	R43 Ceiling+Hi SEER AC&Solar Htg+Hi Eff Appliances+Hi Eff Ltg	$25,300	6939	$39,134	4.15	4.5	$29,402	$68,537	$11,663	$31,500	$43,163
A+B+C+D+E	2" Polyiso+R43 Ceiling+Hi SEER AC&Solar Htg+Hi Eff Appls+Hi Eff Ltg	$25,495	6830	$39,169	4.08	4.0	$26,135	$65,304	$11,859	$27,000	$38,859

Appendix 2: Commercial Cost Estimating

Sundt Construction Inc, Tucson office provided conceptual cost estimating for the apartment, office and retail prototypes. The tables for each prototype that include a cost for each building strategy in the Net-Zero code follow.

Sundt Final w/o Bonus Strategies

10-Nov-11

Pima County Net Zero Energy Study
Energy Efficiency Premium

Element #	Description	Frame	Thermal Mass	Comments
	Two Story Apartment Building (Residential) **Based on 100 Units at 1,000 GSF/EA = 100K** **Exterior Wall Height to TOP - 24'0"**			
1	Orientation	$ -	$ -	Cost neutral
2	Window Area	$ -	$ -	Cost neutral - for analysis purposes the assumption is made that the SF cost for a solid wall is the same as the window SF cost
3	Roof/Ceiling Insulation	$ 0.50	$ 0.50	Premium of R50 over R30
4	Wall Insulation	$ 0.04	$ 0.04	Premium of R30 over R19
5	Roof Reflection	$ 1.00	$ 1.00	Premium of $2.00/SF of roof area
6	Wall Reflection	$ 0.36	$ 0.36	Allowance premium of $5.00/SF of exterior wall area
7	Window Type Premium for 20% of Area	$ 0.22	$ 0.22	Premium of $15.00/SF of window area based on 20% of exterior wall area for windows
8	Window Shading	$ 0.72	$ 0.72	Premium of $50.00/SF of window area based on 20% of exterior wall area for windows for this feature
9	Infiltration (Air Barrier)	$ 0.01	$ 0.01	Premium based on $0.10/SF applied to the exterior wall surface area.
10	Daylight Sensors	$ -	$ -	Not Included with these costs
11	Interior Light Power Density	$ 0.50	$ 0.50	Allowance of $0.50/SF for this premium
12	Exterior Light Power Density	N/A	N/A	
13	Equipment Power Density	$ 0.50	$ 0.50	Allowance of $0.50/SF for this premium
14	Interior Blinds/Drapes	$ 0.04	$ 0.04	Premium of $3.00/SF of the window area (20% of exterior wall)
15	Thermostat (1/unit)	$ 0.17	$ 0.17	Energy Star qualified programmable thermostat over standard analog
16	HVAC Efficiency	$ 0.51	$ 0.51	16.1 - HVAC operating efficiency of 19.1 over the standard 13; 16.2 -ductwork within the buidling envelope sealed with mastic, not tape; and 16.3 - bathroom and ceiling fans meet Energy Star
17	Exposed Concrete Slab	$ -	$ -	No change - could be premium finishing costs offset by floor covering savings
18	Exterior Thermal Mass Walls	$ -	$ 0.72	Premium of $10.00/SF over entire exterior wall area
19	Night Ventilation	$ -	$ 1.50	Whole house ventilation over having none at al
20	Internal Thermal Storage Capacity	$ -	$ 1.00	Allowance of $1.00/SF for upgrades to base interior $
21	Plumbing	$ 2.22	$ 2.22	21.1 - Solar domestic hot water over standard gas/electric fired water heating system; 21.2 - insulated domestic hot water piping; and 21.3.1 &.2 - most lavatory faucets and shower heads alrready meet the requirement, 21.3.3 - the toilets would be 1.1 low flow compared to 1.6 gal standard); and 21.3.4 - most washing machines already have an Energy Star rating.
22	Economizer	$ -	$ -	N/A
23	VAV	$ -	$ -	N/A
24	Energy Recovery Ventilators	$ -	$ -	N/A
25	Landscaping	$ -	$ -	Should be designed to no change from code
	Subtotal	$ 6.78	$ 10.00	
	Suggested Ranges for Energy Efficiency Premiums			
	Frame: $7.00/SF to $12.00/SF			
	Thermal Mass: $11.00 to $16.00/SF			

10-Nov-11

Pima County Net Zero Energy Study
Energy Efficiency Premium

Element #	Description	Frame	Thermal Mass	Comments
	Two Story Office Building (Commercial) **Based on 25,000 SF / Floor x 2 = 50,000 SF** **Exterior Wall Height to TOP - 28'0"**			
1	Orientation	$ -	$ -	Cost neutral
2	Window Area	$ -	$ -	Cost neutral - for analysis purposes the assumption is made that the SF cost for a solid wall is the same as the window SF cost
3	Roof/Ceiling Insulation (Premium from R30 to R50)	$ 0.50	$ 0.50	Premium of R50 over R30
4	Wall Insulation (Premium from R19 to R30)	$ 0.07	$ 0.07	Premium of R30 over R19
5	Roof Reflection	$ 1.00	$ 1.00	Premium of $2.00/SF of roof area
6	Wall Reflection	$ 0.70	$ 0.70	Allowance premium of $5.00/SF of exterior wall area
7	Window Type Premium for 20% of Area	$ 0.36	$ 0.36	Premium of $15.00/SF of window area based on 20% of exterior wall area for windows
8	Window Shading	$ 1.40	$ 1.40	Premium of $50.00/SF of window area based on 20% of exterior wall area for windows for this feature
9	Infiltration (Air Barrier)	$ 0.01	$ 0.01	Premium based on $0.10/SF applied to the exterior wall surface area.
10	Daylight Sensors	$ 1.00	$ 1.00	Allowance of $1.00/SF for this premium
11	Interior Light Power Density	$ 0.50	$ 0.50	Allowance of $0.50/SF for this premium
12	Exterior Light Power Density	$ -	$ -	Code design should incorporate dark sky provisions
13	Equipment Power Density	$ 0.50	$ 0.50	Allowance of $0.50/SF for this premium
14	Interior Blinds/Drapes	$ 0.08	$ 0.08	Premium of $3.00/SF of the window area (20% of exterior wall)
15	HVAC Systems Controls	$ 0.26	$ 0.26	
16	HVAC Efficiency	$ 8.01	$ 8.01	16.1 - This high efficiency is hard to obtain in a commercial application. This will require a chilled water system, not roof mounted DX air handlers; 16.2 - duct sealing; and 16.3 - bathroom and ceiling fans already meet the Energy Star rating.
17	Exposed Concrete Slab	$ -	$ -	No change - could be premium finishing costs offset by floor covering savings
18	Exterior Thermal Mass Walls	$ -	$ 1.40	Premium of $10.00/SF over entire exterior wall area
19	Night Ventilation	$ -	$ 0.80	Whole building ventilation based on utilizing an economizer
20	Internal Thermal Storage Capacity	$ -	$ 1.00	Allowance of $1.00/SF for upgrades to base interior S
21	Plumbing	$ 1.14	$ 1.14	21.1 - Solar; 21.2 - insulating the piping; 22.3.1 & .2 - most lavatory and shower heads already meet the requirement; 21.3.3 - 1.1 gal low flow toilets in lieu of standard 1.6 gal; and 21.3.4 - washing machines - N/A
22	Economizer	$ -	$ -	See item 19 above
23	VAV systems	$ -	$ 6.50	Based on 100 zones at 5,000 SF/Zone
24	Energy Recovery Ventilators	$ -	$ 1.36	Small unit for exhaust only
25	Landscaping	$ -	$ -	Should be designed to no change from code
	Subtotal	$ 15.54	$ 18.74	Not includeing bonus measures 22- 25
	Suggested Ranges for Energy Efficiency Premiums			
	Frame: $16.00 to $21.00/SF			
	Thermal Mass: $19.00 to $24.00/SF			

10-Nov-11

Pima County Net Zero Energy Study
Energy Efficiency Premium

Element #	Description	Frame		Thermal Mass		Comments
	Two Story Office Building (Commercial) **Based on 25,000 SF / Floor x 2 = 50,000 SF** **Exterior Wall Height to TOP - 28'0"**					
1	Orientation	$	-	$	-	Cost neutral
2	Window Area	$	-	$	-	Cost neutral - for analysis purposes the assumption is made that the SF cost for a solid wall is the same as the window SF cost
3	Roof/Ceiling Insulation (Premium from R30 to R50)	$	0.50	$	0.50	Premium of R50 over R30
4	Wall Insulation (Premium from R19 to R30)	$	0.07	$	0.07	Premium of R30 over R19
5	Roof Reflection	$	1.00	$	1.00	Premium of $2.00/SF of roof area
6	Wall Reflection	$	0.70	$	0.70	Allowance premium of $5.00/SF of exterior wall area
7	Window Type Premium for 20% of Area	$	0.36	$	0.36	Premium of $15.00/SF of window area based on 20% of exterior wall area for windows
8	Window Shading	$	1.40	$	1.40	Premium of $50.00/SF of window area based on 20% of exterior wall area for windows for this feature
9	Infiltration (Air Barrier)	$	0.01	$	0.01	Premium based on $0.10/SF applied to the exterior wall surface area.
10	Daylight Sensors	$	1.00	$	1.00	Allowance of $1.00/SF for this premium
11	Interior Light Power Density	$	0.50	$	0.50	Allowance of $0.50/SF for this premium
12	Exterior Light Power Density	$	-	$	-	Code design should incorporate dark sky provisions
13	Equipment Power Density	$	0.50	$	0.50	Allowance of $0.50/SF for this premium
14	Interior Blinds/Drapes	$	0.08	$	0.08	Premium of $3.00/SF of the window area (20% of exterior wall)
15	HVAC Systems Controls	$	0.26	$	0.26	
16	HVAC Efficiency	$	8.01	$	8.01	16.1 - This high efficiency is hard to obtain in a commercial application. This will require a chilled water system, not roof mounted DX air handlers; 16.2 - duct sealing; and 16.3 - bathroom and ceiling fans already meet the Energy Star rating.
17	Exposed Concrete Slab	$	-	$	-	No change - could be premium finishing costs offset by floor covering savings
18	Exterior Thermal Mass Walls	$	-	$	1.40	Premium of $10.00/SF over entire exterior wall area
19	Night Ventilation	$	-	$	0.80	Whole building ventilation based on utilizing an economizer
20	Internal Thermal Storage Capacity	$	-	$	1.00	Allowance of $1.00/SF for upgrades to base interior $
21	Plumbing	$	1.14	$	1.14	21.1 - Solar; 21.2 - insulating the piping; 22.3.1 & .2 - most lavatory and shower heads already meet the requirement; 21.3.3 - 1.1 gal low flow toilets in lieu of standard 1.6 gal; and 21.3.4 - washing machines - N/A
22	Economizer	$	-	$	-	See item 19 above
23	VAV systems	$	-	$	6.50	Based on 100 zones at 5,000 SF/Zone
24	Energy Recovery Ventilators	$	-	$	1.36	Small unit for exhaust only
25	Landscaping	$	-	$	-	Should be designed to no change from code
	Subtotal	$	15.54	$	18.74	Not includeing bonus measures 22- 25
	Suggested Ranges for Energy Efficiency Premiums					
	Frame: $16.00 to $21.00/SF					
	Thermal Mass: $19.00 to $24.00/SF					