Economic Analysis of the UD Eco-house: A New Era of UD Housing

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Executive Summary

The following document presents the cost-benefit analysis of the UD Eco-house within the constraint of designing a Net-Zero energy residence. For economic analysis, a 35 year house lifetime and a 5% university discount rate were used.

Traditional New Five-Person Student Residences

- First cost $225,000
- 2004 unit energy costs were $0.088/kWh and $9.40/mmBtu
- 2006 total energy cost of $1,800 and $1,909
- Between 1995 and 2005, energy cost escalation averaged 1.9% per year
- Future energy cost escalation rates bracketed between 1% and 4% per year
- Present value lifetime energy cost between $33,443 and $54,333
- Present value of owning and energy costs over lifetime $258,443 and $279,333
- Annualized owning and energy costs between $15,784 and $17,059

Eco-house

- Net-metering results in $0.088/kWh purchase cost and $0.053/kWh sell price
- 2006 total energy cost of $24 and $25
- Present value lifetime energy cost between $446 and $712
- Additional first cost "break-even" expenditure between $32,997 and $53,621
- Estimated total additional first cost **$49,647**
- Present value of owning and energy costs over lifetime $275,103 and $275,369
- Annualized owning and energy costs between $16,805 and $16,821

Results

- At 1% fuel escalation rate, Eco-house costs about $1,000 per year more than traditional house. At 4% fuel escalation rate, Eco-house saves about $200 per year over traditional house.
- Thus, the Eco-house may be the most cost effective type of student housing.

Introduction

The University of Dayton has expressed interest in building a student residence that demonstrates the commitment of the University and student body to working towards a sustainable economic and environmental future. An important aspect of sustainability is to provide today's needs without compromising the ability of future generations to meet their needs. Today, over 90% of all end-use energy is derived from non-renewable fossil fuels which are being rapidly exhausted at today's high levels of demand. Further, carbon dioxide emissions from fossil fuel combustion are the leading contributor to global warming. Moreover, the competition for remaining fossil fuel reserves causes international tensions and hampers efforts for international development based on humanitarian needs. Thus, any effort toward sustainability must include renewable and greenhouse-gas neutral energy sources.

Toward this end, UD students, with the guidance of faculty, have begun designing a net-zero energy student residence called the Eco House. A central idea behind the Eco House is to generate the same amount of energy that the house consumes on a net annual basis. To achieve this, the house will be designed to incorporate advanced energy-efficient building components, appliances, mechanical and electrical systems. The house will also use solar thermal and solar photovoltaic collectors to convert solar energy into useful heat and electricity. If successful, the house will serve as an example of the university's commitment to a sustainable future, hands-on student learning, and a living learning community that extends beyond the classroom.

Within the primary constraint of net-zero energy, we seek to design the Eco House to be as economical as possible. In addition, we seek to use this experience to provide guidance for the design of future eco-houses and typical student housing. This report documents our preliminary analysis of the economics of building and operating the Eco-House.

Typical New Student Residence

Owning Cost

In 2005, a typical new 5-student house costs $225,000 fully-furnished with appliances, painting and carpeting. To finance the house, the University of Dayton typically borrows $225,000 at a 5% interest rate over a 20 year period. The economic lifetime of the house is 35 years.

Energy Cost

The largest single operating cost associate with student housing is the cost of energy. In baseline, newly constructed 5-person UD housing, energy consumption is about 13,455 kWh and 61.2 mmBtu annually. In 2004, the costs of electricity and natural gas in the Dayton area were $0.088 per kWh and $9.40 per mmBtu. The annual costs of electricity and natural gas were $1,190 and $575 respectively. In 2004, the cost of electricity and natural gas for a typical 5-person student house was $1,765.

US Energy Cost Escalation

Electricity

The average annual price of electricity for residential use in the US between 1992 and 2004 has been recorded by the Energy Information Administration (EIA) and is reported in the Annual Energy Outlook 2005. The prices have been adjusted for inflation and are displayed in real 2000 US dollars.

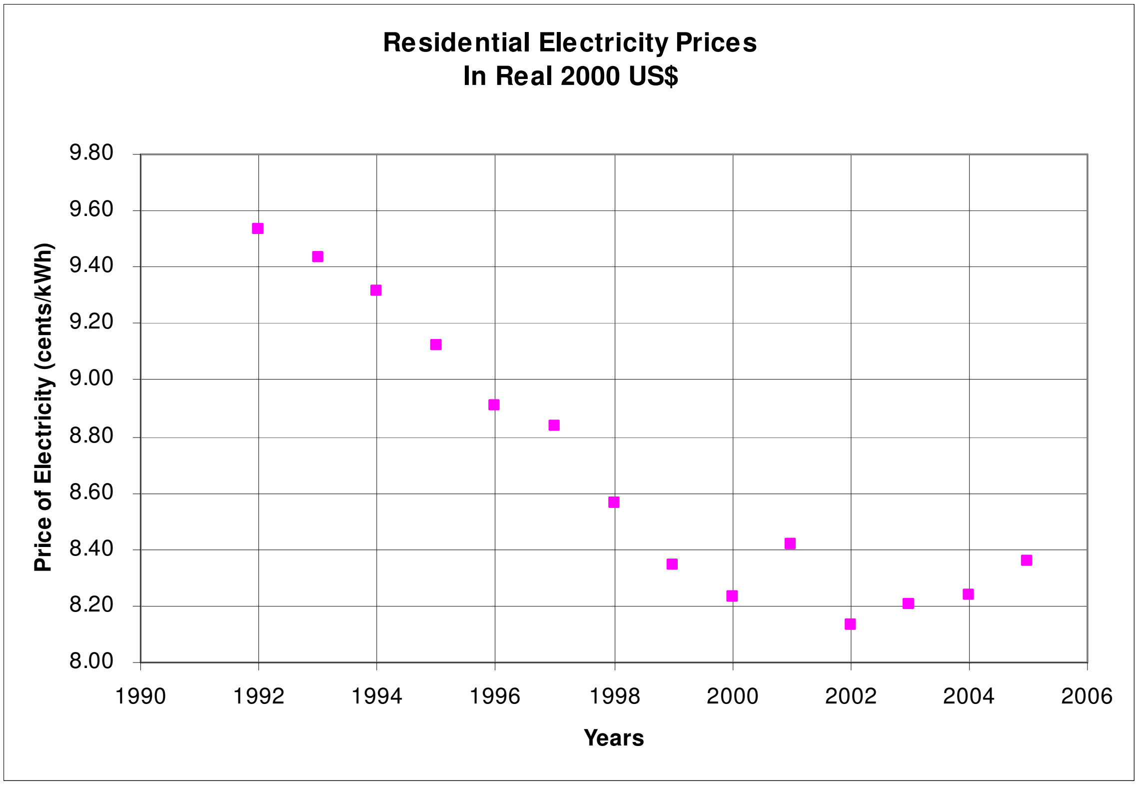


Figure X: Residential Electricity Prices in Real 2000 US$

Between 1992 and 2004, electricity prices have decreased at a rate of 1.21% per year. Electricity prices declined primarily between 1992 and 2002. In 2002, prices began increasing, indicating that most of the price decrease occurred 1992 and 2002. Between 2002 and 2004, electricity prices have increased at a rate of 0.66% annually.

Natural Gas

The average annual price of natural gas for residential use between 1992 and 2004 has been recorded by the Energy Information Administration (EIA) and is displayed in the Annual Energy Outlook 2005. The prices have been adjusted for inflation and are displayed in real 2000 US dollars.

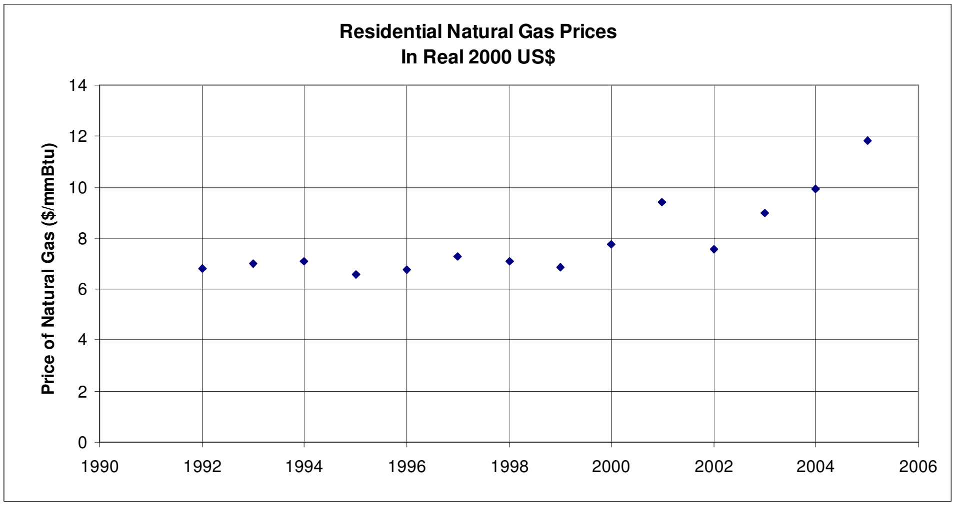


Figure X: Residential Natural Gas Prices in Real 2000 US$

Between 1992 and 2004, natural gas prices have increased at a rate of 3.2% per year. However, natural gas prices remained flat between 1992 and 1999, indicating that most of the price increase has occurred from between 2000 and 2004. During these years, natural gas prices have increased at a rate of 6.3% annually. The EIA predicted in the beginning of 2005 that the average cost of natural gas would rise to $13.03 per mmBtu in 2005, however, prices are likely to rise even higher than that. Even using the EIA estimate of $13.03 per mmBtu would result in natural gas fuel escalation rates of 4.4% and 8.8% since 1992 and 2000, respectively.

Weighted National Escalation Rate

Over the long term, between 1992 and 2005, electricity and natural gas price escalation rates have been -1.0% and 4.2% respectively. Since 2002, electricity price escalation has been 0.93% annually. And since 2000, natural gas price escalation has been 8.8% annually. In 2004, electricity and natural gas were 67% and 33% of all energy costs. Thus, between 1992-2005, the weighted national energy escalation rate was:

-1.21% x 67% + 3.17% x 33% = 0.22%

Between 2002 and 2005, the weighted national energy escalation rate has been:

0.66% x 67% + 6.2% x 33% = 2.50%

Local Energy Cost Escalation

DPL reports that at least 95% of its electrical power is produced from coal-fired power plants. We believe that future electricity cost escalation will be caused by increasing concerns about the carbon dioxide emissions from coal fired power plants, and the requirement that DPL and other utilities diversify their generation capacity.

Despite aggressive drilling in the Rocky Mountain West, virtually no study projects that domestic gas production will increase substantially in the coming years, even as demand will continue to rise. In the long term, the U.S. will build ports to import LPG from Africa. However, we believe that natural gas prices will continue to increase in the future.

Electricity

In order to better predict the energy cost escalation, we examine local historical energy costs. The costs were adjusted with the implicit price deflator to reflect their Real Cost in 2000 US Dollars (EIA Annual Energy Review 2004). Historical electricity prices from the Dayton area were obtained from actual bills for a resident of Dayton (Kissock Utility Data). Readings were taken from the same time of year to minimize seasonal fluctuations in energy prices. Adjusted to 2000 dollars, the price of electricity in September of 1995 was \$0.101 per kWh. The price of electricity in September, 2005 was \$0.093 per kWh. Thus, using the equation for exponential growth:

$F = P \times (1 + e)^n$

Where
P = present value = \$0.101
F = future value = \$0.093
n = years of growth = 10
e = rate of growth

e = (\$0.101 / \$0.093) ^ (1/10) – 1 = -.0116

Thus, between 1995 and 2005, electricity prices have decreased at a rate of 1.16% annually in the Dayton area.

Natural Gas

In order to better predict the energy cost escalation, we examine local historical energy costs. The costs were adjusted with the implicit price deflator to reflect their Real Cost in 2000 US Dollars (EIA Annual Energy Review 2004). Historical natural gas prices from the Dayton area were obtained from actual bills for a Dayton resident (Kissock Utility Data). Readings were taken from the same time of year to minimize seasonal fluctuations in energy prices. Natural gas data points were obtained for winter months due to the fact that the majority of natural gas use occurs during these months. Adjusted to 2000 dollars, the price of natural gas in January, 1996 was \$0.44 per ccf. The price of natural gas in January, 2005 was \$1.03 per ccf. Thus, using the equation for exponential growth:

$F = P \times (1 + e)^n$

Where
P = present value = \$0.44
F = future value = \$1.03
n = years of growth = 9
e = rate of growth

e = (\$1.03 / \$0.44) ^ (1/9) – 1 = 0.0797

Thus, between 1996 and 2005, natural gas prices have increased at a rate of 7.97% annually in the Dayton area.

Weighted Local Escalation Rate

Between 1995 and 2005, local electricity and natural gas price escalation rates have been -1.16% and 7.97% respectively. In 2004, electricity and natural gas were 67% and 33% of all energy costs. Thus, locally, between 1995 and 2005, the energy escalation rate was:

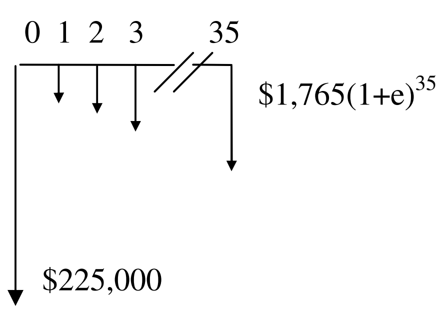
$$-1.16\% \times 67\% + 7.97\% \times 33\% = 1.85\%$$

Since deregulation of electrical utility companies beginning in 2001, a fix has been placed on the residential cost of electricity for the next 5 years (EERE). Beginning in 2006, it is expected that electricity rates will increase in a similar fashion to natural gas prices. We believe that energy costs will increase more than the calculated US average values of 0.22% and 2.5%. Considering the fact that, locally, energy escalation rates have been about 1.85% between 1995 and 2005, we bracket the study with energy escalation rates between 1% and 4% annually over the 35 year economic lifetime of the Eco-house. The magnitude of annual growth rates can be visualized by applying the rule of seventy, which states that the doubling time is approximately equal to the ratio of 70 and the annual rate of increase. Thus, a 1% annual increase corresponds to a doubling of the real cost of energy every 70 years. A 4% increase corresponds to a doubling every 18 years.

In addition, the possibility of increasing energy supply disruptions is very real (EIA Energy Security). Although the economic consequences of supply disruption may be large, they are not considered here.

Present Value of Owning and Energy Costs

A schematic of the owning and energy costs for a typical new residence over the lifetime of the residence is shown below.



The present value of the owning and energy costs, Pown,engy is the sum of the present values of the owning, Pown, and energy, Pengy, costs.

$$Pown = \$225,000$$

Pengy = A x ESPWF(i,e,n) = A $\frac{1}{(i-e)}\left[1-\left(\frac{1+e}{1+i}\right)^{n}\right]$

Pown,engy = Pown + Pengy

where ESPWF(i,e,n) is the escalating series present worth factor.

Assuming the real discount rate of the university is 5% (the value at which money can be obtained) and the economic lifetime of the building is 35 years, the present value of the owing and energy costs is bracketed by the assumptions of real energy cost escalation:

First Year Energy Costs
$A_{2006} = A_{2004} \times (1 + e)^2$

A_{2006} = \$1,765 x $(1 + 0.01)^2$ = \$1,800 at (e = 1%)
A_{2006} = \$1,765 x $(1 + 0.04)^2$ = \$1,909 at (e = 4%)

Lifetime Energy Costs
n = 35 years
i = 5%

Pengy = \$1,800 x 18.6 = \$33,443 at (i = 5%, e = 1%, n = 35 years)
Pengy = \$1,909 x 28.5 = \$54,333 at (i = 5%, e = 4%, n = 35 years)

Pown,engy = \$258,443 at (i = 5%, e = 1%, n = 35 years)
Pown,engy = \$279,333 at (i = 5%, e = 4%, n = 35 years)

Annualized Owning and Energy Costs

The annualized owning and energy costs, Aown,engy, of a typical 5-person student residence over the 35 year lifetime assuming a discount rate of 5% are:

Aown,engy = Pown,engy / SPWF = P $\left[\frac{1-(1+i)^{-n}}{i}\right]$

SPWF = $\left[\frac{1-(1+0.05)^{-35}}{0.05}\right]$ = 16.37

Aown,engy = \$258,443 / 16.37 = \$15,784 at (i = 5%, e = 1%, n = 35 years)
Aown,engy = \$279,333 / 16.37 = \$17,059 at (i = 5%, e = 4%, n = 35 years)

where SPWF(i,n) is the series present worth factor.

Eco House

Annual Energy Costs

Although the Eco House is designed to use no energy on a net basis over the year, the cost of energy for the house will not be zero. This is because the electrical system will be designed to sell electricity back into the electrical grid when the PV system generates more electricity than it needs, and purchase electricity from the grid when the house needs more electricity that the PV system is generating.

Current Ohio Law mandates that electric utilities install a single meter to measure the net amount of electricity used (or generated) by the house each month. However, the law permits utilities to sell electricity for the standard residential rate and purchase electricity for their lowest avoided cost.

Electricity Billing

When billing, the utility generally breaks up the electricity tariff into three components, generation, transmission and distribution. The customer is further billed on additional riders, the excise tax surcharge rider, emission fee recovery rider, universal service fund rider, and the energy efficiency surcharge rider. In order to quickly calculate monthly bills, a customer could break these charges into a monthly service charge, which is typically fixed, and a monthly energy charge, based on the number of kWh consumed. For the detailed rate structure, see the Appendix: Dayton Power and Light Residential Electricity Tariff. The service and electrical energy charges are shown below:

Service
$4.25 per Customer (Customers with monthly energy consumption)

Electrical Energy
$0.08844 per kWh for the first 750 kWh
$0.07780 per kWh for all kWh over 750 kWh

Homes in the student neighborhood never consume more than 750 kWh per month, so the price of electricity remains in the first block, at $0.088 per kWh. Each month the homes are also billed a $4.25 service charge. Since both traditional homes and the Eco-house would be billed the same service charge, it will be ignored in the billing calculation.

Electricity Credits

According to DP&L's net-metering regulations, customers may generate excess electricity by solar, wind, biomass burning, hydro power, or fuel cells. The electricity can be fed into the electrical grid and the customer will be compensated according to their shopping credit tariff. Credits for electricity fed into the grid will be calculated on a net-monthly basis and will appear as credits on the next bill. For residential energy generation, credits will be:

$0.05338 per kWh for first 750 kWh
$0.04332 per kWh for all kWh over 750 kWh

The solar system will never produce more than 750 kWh to sell back to the utility, so the electricity credit will always be $0.05338 per kWh sold. Using current prices and rates, DP&L will sell electricity for about $0.088 per kWh and purchases it for $0.053 per kWh. ESim software (Kissock 1997) was used to estimate the monthly electricity requirements of the Eco-house. Using SolarSim software (Kissock 1997), it is projected that the house will produce excess electricity during summer months and purchase electricity during winter months. The Eco-house electricity requirements are shown in the chart below.

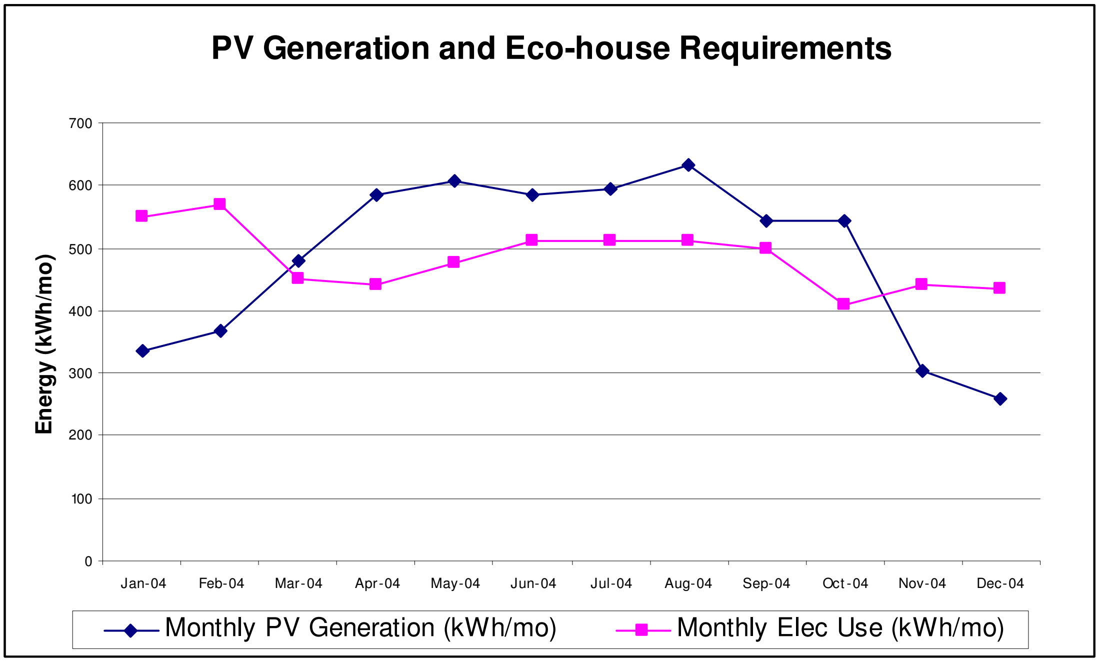


Figure X: Eco-house PV Generation and Electricity Requirements

The electricity produced by the photovoltaic system is presented along with the electricity requirements of the Eco-house in the following table. The monthly electricity charges, credits and annual utility costs are calculated.

Table X: Monthly PV Generation, Electricity Use and Utility Charges

Month	Monthly PV Generation (kWh/mo)	Monthly Elec Use (kWh/mo)	Monthly Elec Purchased (kWh/mo)	Electricity Cost
1/12/2004	336	550	214	$18.83
2/12/2004	369	570	201	$17.71
3/13/2004	481	450	-31	-$1.62
4/13/2004	587	440	-147	-$7.76
5/13/2004	608	475	-133	-$7.04
6/13/2004	585	510	-75	-$3.96
7/13/2004	594	510	-84	-$4.43
8/13/2004	632	510	-122	-$6.49
9/13/2004	542	500	-42	-$2.25
10/13/2004	542	410	-132	-$7.01
11/13/2004	304	440	136	$11.95
12/13/2004	259	435	176	$15.47
Total:		5800	-38.41	$23.40

Lifetime Energy Costs

Thus, we project that the annual energy costs of the UD Eco-house will start at $23.40 per year. The lifetime energy cost of operating the UD Eco-house can be expressed as follows:

$$\text{Pengy} = \text{A x ESPWF(i,e,n)} = \text{A } \frac{1}{(i-e)}\left[1-\left(\frac{1+e}{1+i}\right)^{n}\right]$$

where ESPWF(i,e,n) is the escalating series present worth factor.

Assuming the real discount rate of the university is 5% (the value at which money can be obtained) and the economic lifetime of the building is 35 years, the present value of the owing and energy costs is bracketed by the assumptions of real energy cost escalation:

A2006 = A2004 x (1 + e)2

A_{2006} = \$23.40 x $(1 + 0.01)^2$ = \$24 at (e = 1%)
A_{2006} = \$23.40 x $(1 + 0.04)_2$ = \$25 at (e = 4%)

Pengy = \$24 x 18.57 = \$446 at (i = 5%, e = 1%, n = 35 years)
Pengy = \$25 x 28.46 = \$712 at (i = 5%, e = 4%, n = 35 years)

Based on the preceding analysis, the maximum additional cost first cost to make the EcoHouse cost neutral for the university would be;

A=20
n = 35 years
i = 5%

Padd = Peng,trad – Peng,eco
Padd = $33,443 - $446 = $32,997 at e = 1%
Padd = $54,333 - $712 = $53,621 at e = 4%

Additional Costs of Construction

Additional costs of constructing the UD Eco-house are summarized in the table below. Sources of the costs are presented in Appendix 2: Sources of Cost Estimates. It should be noted that every addition to the Eco-house is not more expensive. Some changes entail elimination of traditional systems, which we have accounted for in the summary table. For example, in the replacement of a traditional furnace and air conditioner, with an air to air heat pump, the costs of the furnace and air conditioner are eliminated. Significant additional costs are solar PV, solar hot water systems, and data monitoring. The predicted net additional cost is $49,657. According to a local engineering firm, Heapy Engineering, the estimated additional cost of Eco-house construction would be $69,340. In the analysis presented below, 12 house components are presented, while 6 are presented by Heapy. In addition, Heapy includes $11,300 for LEED certification, or about 20% of the additional cost. LEED certification is something to be considered but not considered essential to the success of the project. Of the total LEED fees, $3,500 are for certification and the remaining $6,800 are for Heapy engineering. Eliminating LEED certification fees, Heapy's additional costs are about $58,040 or roughly $10,000 more than the estimated additional costs of the analysis presented.

Table X: Summary of Eco-House Net Additional Costs

Components	Baseline	Eco-house	Net Addition	Heapy Engineering Addition
Walls / Roof	$25,200	$31,300	$6,100	$5,040
Windows	$3,684	$4,254	$570	$0
Furnace	$1,978	$0	-$1,978	$0
Air Conditioner	$650	$0	-$650	$0
Heat Pump	$0	$2,775	$2,775	$4,500
Heat Exchanger	$0	$561	$561	$1,500
Hot Water	$480	$3,735	$3,255	$7,000
Clothes Washer/Dryer	$648	$988	$340	$0
Refrigerator	$449	$679	$230	$0
Dish Washer	$279	$780	$501	$0
Solar PV	$0	$34,953	$34,953	$40,000
Data monitoring	$0	$3,000	$3,000	$0
Natural Gas hookup	$3,000	$0	-$3,000	$0
LEED Certificaion				$11,300
Total	$33,368	$83,025	$46,657	$69,340

Present Value of Owning and Energy Costs

The present value of the owning and energy costs, Pown,engy is the sum of the present values of the owning, Pown, and energy, Pengy, costs.

Pown = $225,000 + $49,657 = $274,657

Pengy = $446 at (i = 5%, e = 1%, n = 35 years)
Pengy = $712 at (i = 5%, e = 4%, n = 35 years)

Pown,engy = Pown + Pengy
Pown,engy = $275,103 at (i = 5%, e = 1%, n = 35 years)
Pown,engy = $275,369 at (i = 5%, e = 4%, n = 35 years)

Annualized Owning and Energy Costs

The annualized owning and energy costs, Aown,engy, of a typical 5-person student residence over the 35 year lifetime assuming a discount rate of 5% are:

$$\text{Aown,engy} = \text{Pown,engy} / \text{SPWF} = \text{P}\left[\frac{1-(1+i)^{-n}}{i}\right]$$

where SPWF(i,n) is the series present worth factor.

$$\text{SPWF} = \left[\frac{1-(1+0.05)^{-35}}{0.05}\right] = 16.37$$

Aown,engy = $275,103 / 16.37 = $16,805 at (i = 5%, e = 1%, n = 35 years)
Aown,engy = $275,369 / 16.37 = $16,821 at (i = 5%, e = 4%, n = 35 years)

Economic and Environmental Impact Summary

Based on these estimates, it appears that, in addition to supporting the university's commitment to sustainability and environmental stewardship, the Eco-house would be cost-effective to build and operate over a life-cycle of 35 years. If the Eco-house is operated for more than 35 years, additional energy savings will be accrued. Further, the Eco-house will provide a living-learning community where students will be encouraged to study the effect of technological improvements and occupant behavior on energy consumption.

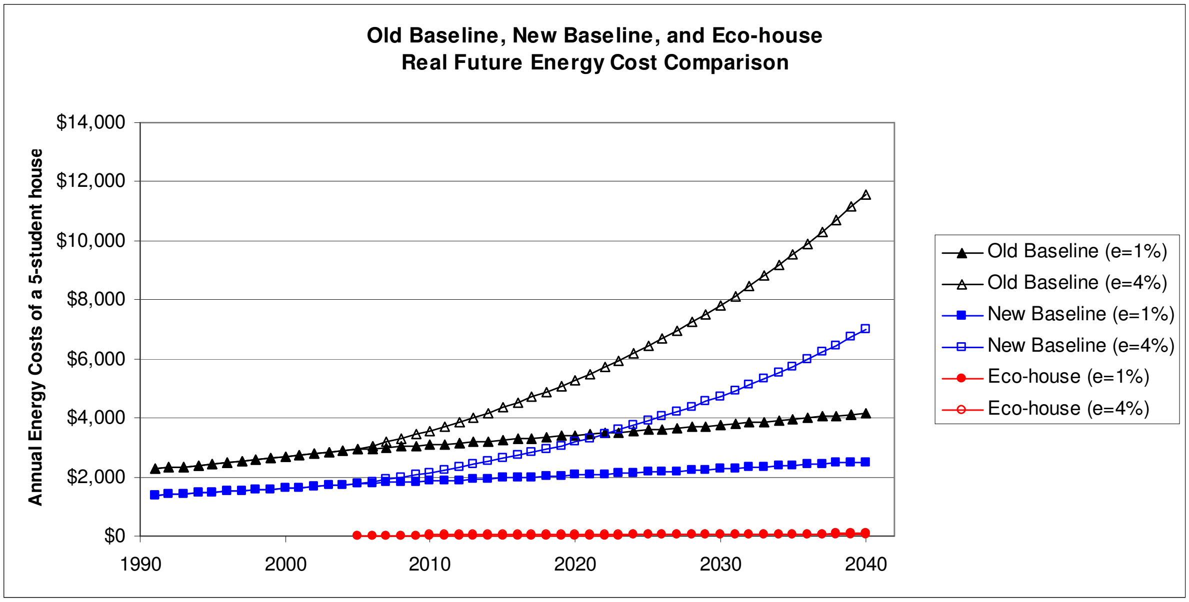


Figure X: Old Baseline, New Baseline, and Eco-house Real Future Energy Cost Comparison

Economic Summary

Annual Mortgage Payments

Annual mortgage payments for owning new construction and the Eco-house are $18,055 and $22,067 on loans of $225,000 and $275,000, respectively. The entire loan is paid over the course of 20 years. Annual mortgage payments for new construction and the Eco-house are plotted in the chart below.

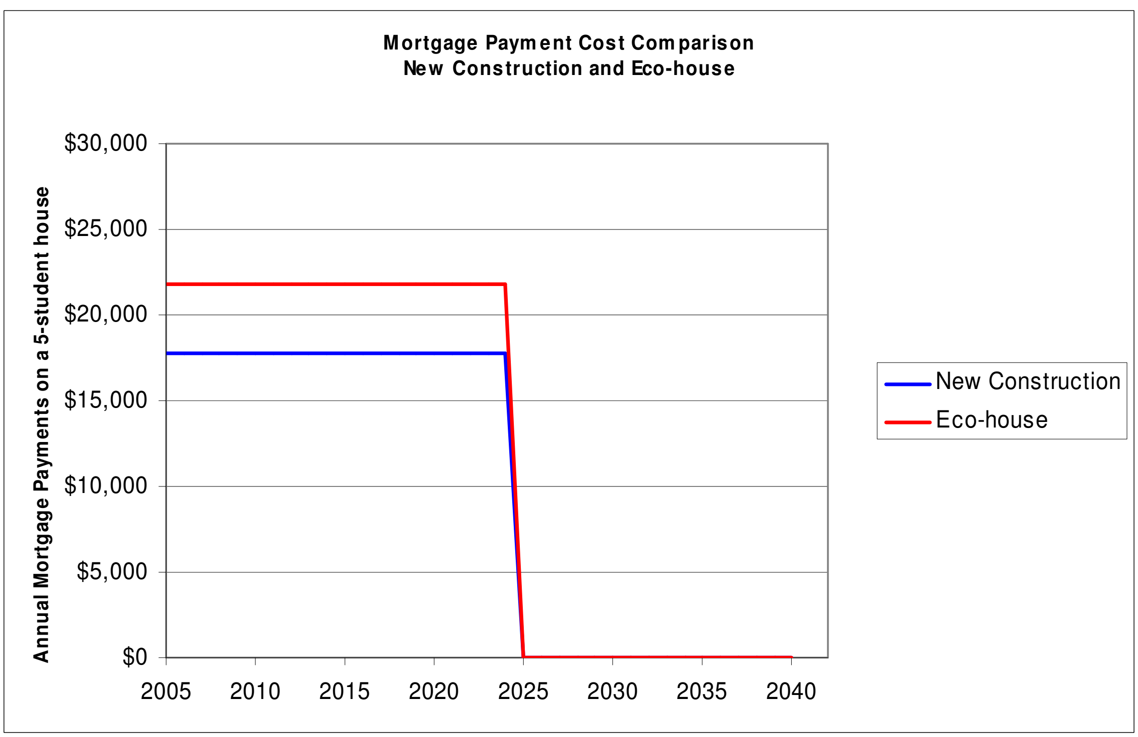


Figure X: Annual Mortgage Payment Comparison of New Construction and Eco-house

Annual Energy Expenditures

Annual energy expenditures for new construction and the Eco-house are displayed in the following two charts. New construction and $1,800 and $1,909, respectively for 1% and 4% fuel escalation rates. Eco-house first year energy costs are $24 and $25 at 1% and 4% fuel escalation rates. The 2004 unit costs were $9.60 per mmBtu of natural gas and $0.088 per kWh of electricity. The two charts assume energy escalation rates of 1% and 4% respectively.

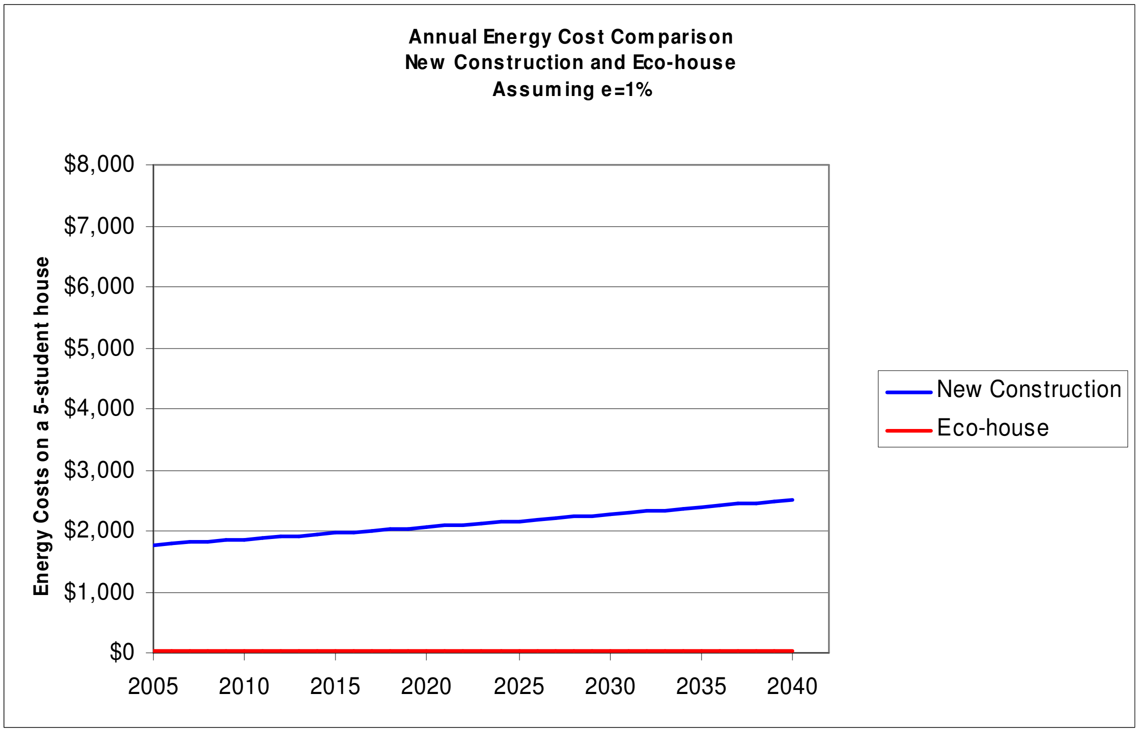


Figure X: Annual Energy Expenditures of New Construction and Eco-house at e=1%

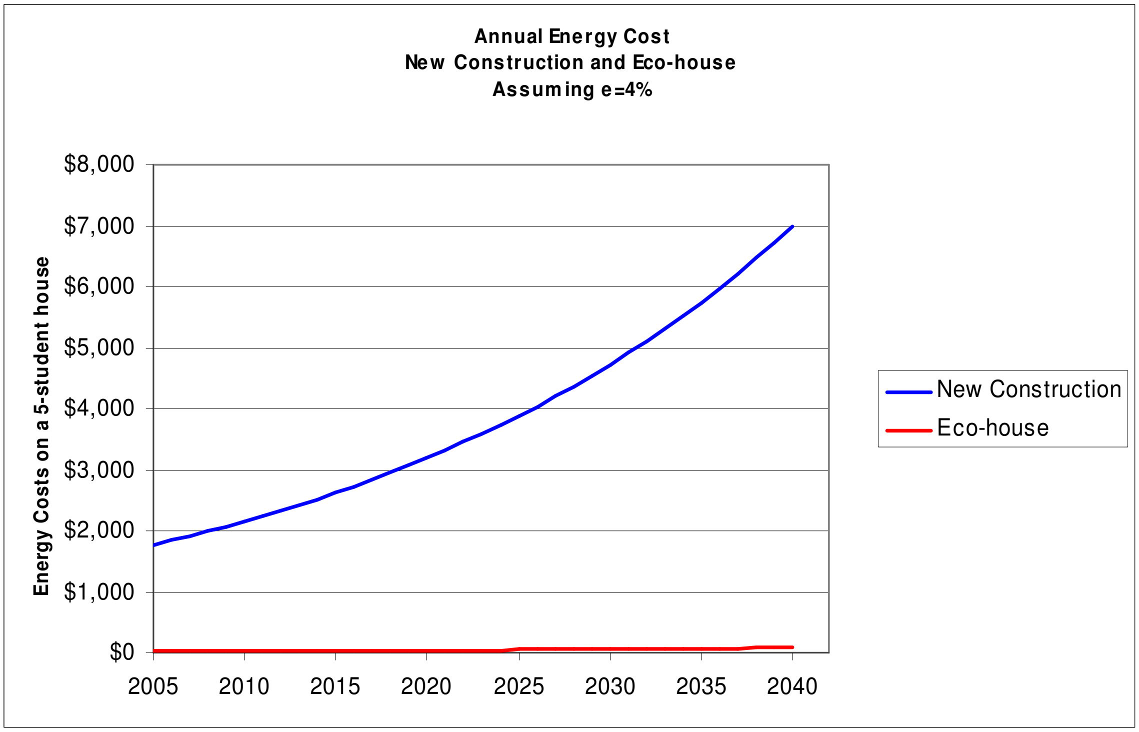


Figure X: Annual Energy Expenditures of New Construction and Eco-house at e=4%

Combined Mortgage and Energy Annual Expenditures

Annual owning and operating costs have been summed and presented in the following two graphs. The graphs indicate the annual mortgage and energy expenditures for the given year for new construction and the Eco-house, assuming energy escalation rates of 1% and 4% annually.

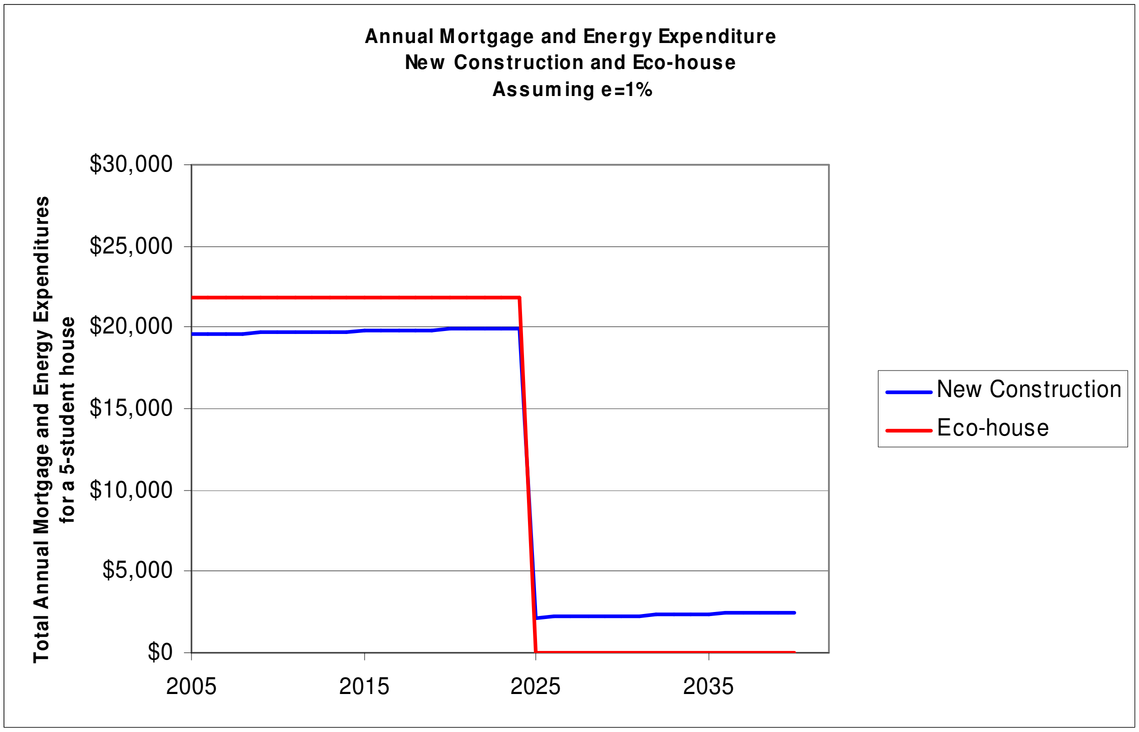


Figure X: Annual Mortgage and Energy Expenditures of New Construction and Eco-house at e=1%

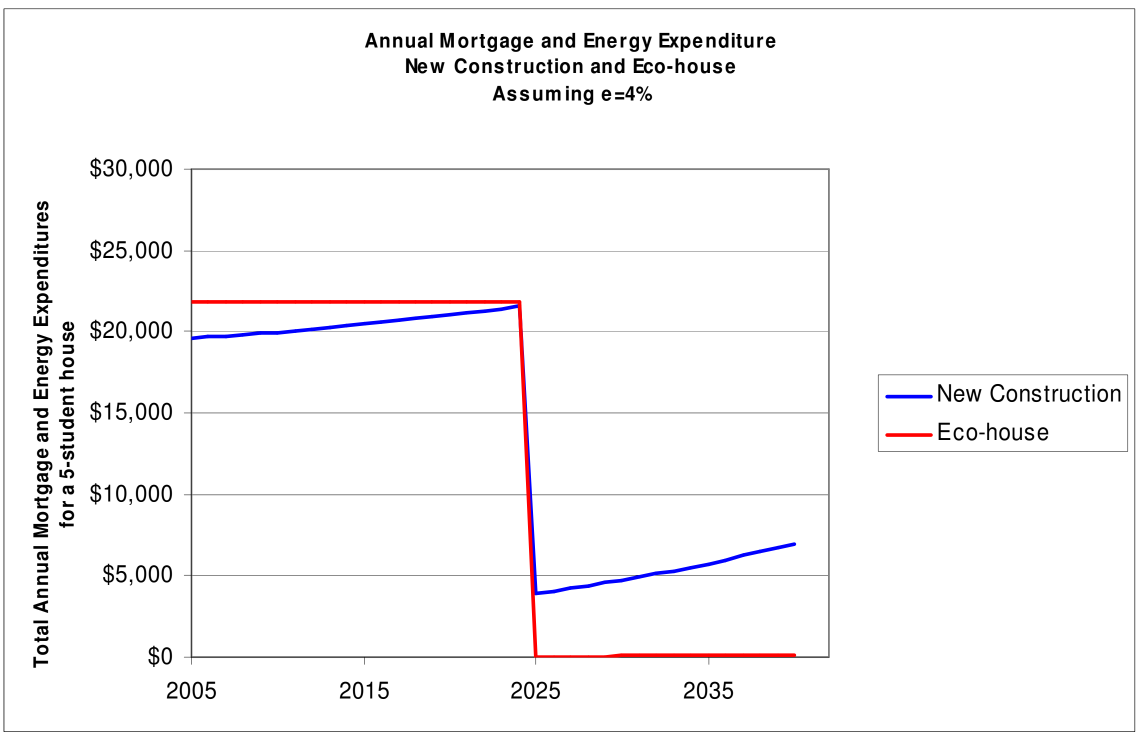


Figure X: Annual Mortgage and Energy Expenditures of New Construction and Eco-house at e=4%

One thing we can observe from these graphs is the degree of variability in the owning and operating cost of new construction and the eco-house. The variable is energy escalation rate, which we vary between 1% and 4%. The cost of operating new construction varies significantly more than the cost of operating the Eco-house. This is seen in the flatness of the annual energy costs for the Eco-house and the steepness of the annual energy costs for new construction. Energy escalation rates are external to the construction of a new home. Rates cannot be fixed, or determined by the university. Thus, energy costs for new construction are subject to a high degree of variability, and potentially harmful effects from energy shortages or simply sharply increasing prices. In purchasing the Eco-house, the university will know what they are purchasing. It is not the gamble on energy prices that typical new construction would be.

Cumulative Present Value Expenditures

The cumulative present value of mortgage and energy expenditures chart is shown below. The charts below sum mortgage payments and energy expenditures, and discount them to their present value. So, to us there are two points of mathematical interest, end points and points of intersection. The end points at year 2040 for each house signify their respective present value life-cycle costs. Points of intersection signify the point at which the Eco-house breaks even with new construction and begins accruing savings.

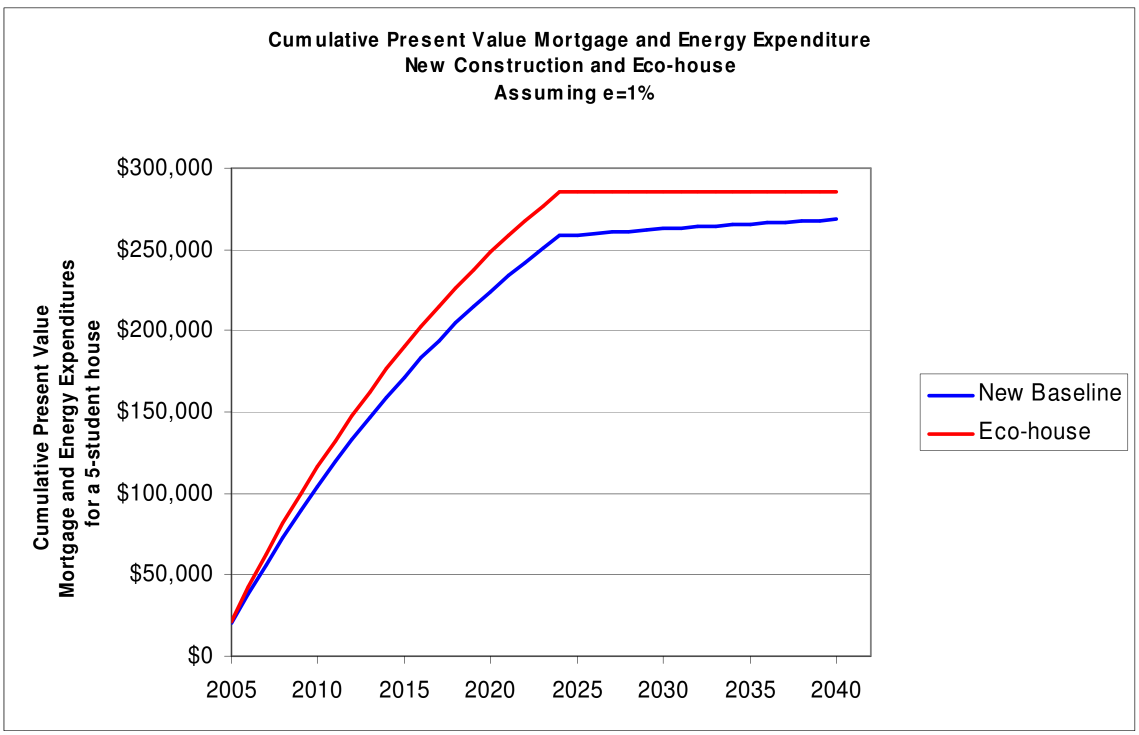


Figure X: Cumulative Present Value Mortgage and Energy Expenditures of New Construction and Eco-house at e=1%

In the case of 1% energy escalation rates, New Construction and the Eco-house have a life-cycle cost of $258,443 and $275,446 respectively.

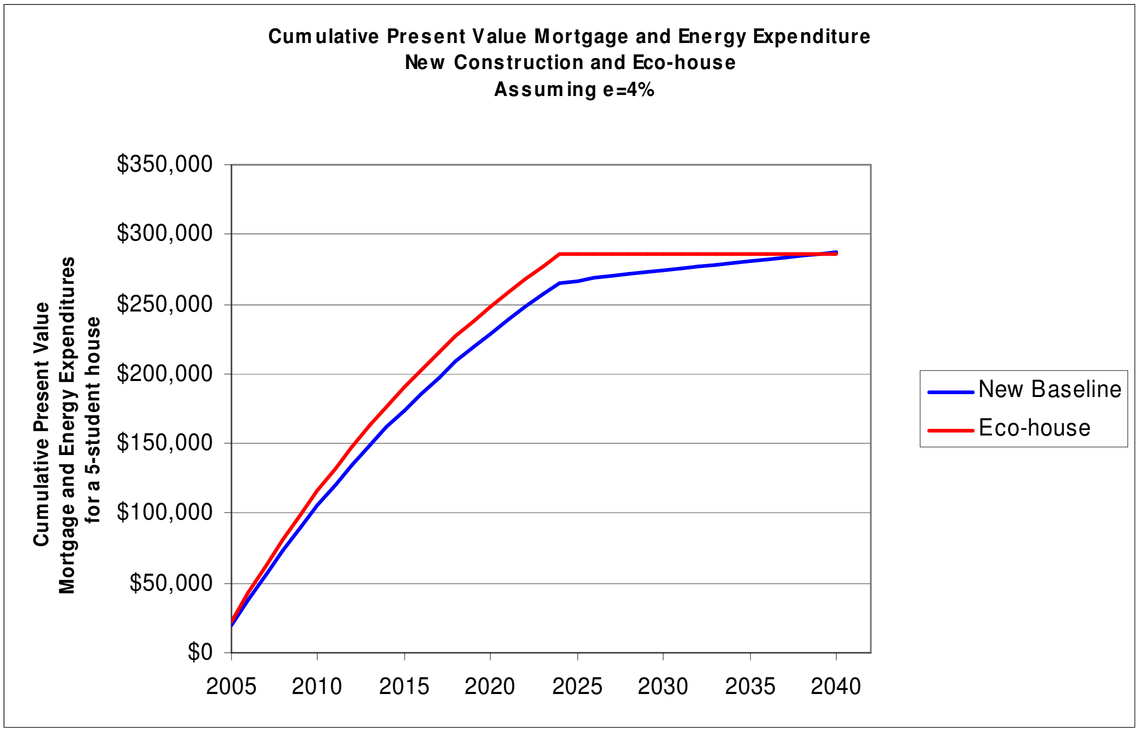


Figure X: Cumulative Present Value Mortgage and Energy Expenditures of New Construction and Eco-house at e=4%

In the case of 4% energy escalation rates, New Construction and the Eco-house have a life-cycle cost of $279,333 and $275,712 respectively. Even though the Eco-house has a lower life-cycle cost than New Construction at a 4% annual energy escalation rate, it is undesirable that the Eco-house only breaks even at the very end of its life time.

Comparison of Typical Residence and Eco-house CO_2 Emissions

The local utility generates about 2.3 lbs CO_2 for each kWh of electricity generated. Assuming 10% excess air, about 113 lbs CO_2 are generated for each mmBtu of natural gas combusted.

Typical Student Residence

61.2 mmBtu x 113 lbs CO_2 / mmBtu = 6,915.6 lbs CO_2
13,455 kWh x 2.3 lbs CO_2 / kWh = 30,946.5 lbs CO_2
Annual CO_2 Emissions = 6,915.6 + 30,946.5 = 37,862 lbs CO_2
Lifetime CO_2 Emissions = 37,862 x 35 = 1,325,170 lbs CO_2

Eco-house

0 mmBtu x 113 lbs CO_2 / mmBtu = 0 lbs CO_2
-38.41 kWh x 2.3 lbs CO_2 / kWh = (-88.3) lbs CO_2
Annual CO_2 Emissions = 0 + (-88.3) = (-88.3) lbs CO_2
Lifetime CO_2 Emissions = (-88.3) x 35 = (-3,091) lbs CO_2

	Typical New Residence	Eco-House
Present Value Lifetime Cost (e=1%)	$258,443	$275,446
Present Value Lifetime Cost (e=4%)	$279,333	$275,712
Annualized Present Value Owning and Energy Costs (e=1%)	$15,784	$16,822
Annualized Present Value Owning and Energy Costs (e=4%)	$17,059	$16,838
Annual Electricity Consumption	13,455 kWh	-38.41 kWh
Annual Natural Gas Consumption	61.2 mmBtu	0 mmBtu
Annual CO_2 Emissions	37,862 lbs CO_2	(-88.3) lbs CO_2
Lifetime CO_2 Emissions	1,325,170 lbs CO_2	(-3,091) lbs CO2

Eco-house Financing Options

Though the current economic analysis suggests that the Eco-house will be net-zero cost over its lifetime, it is recognized that the Eco-house will only break-even at the end of its assumed 35-year life time with energy escalation rates of 4% annually. The Eco-house will not break even in its 35-year life time with energy escalation rates of 1% annually. In order to overcome this drawback of the Eco-house design, rent could be increased to reduce the time to break even.

Assuming energy escalation rates of 1% and 4% annually, the Eco-house would save -$17,003 and $3,621 respectively. A chart, comparing the life-cycle costs of new construction and Eco-house is shown below.

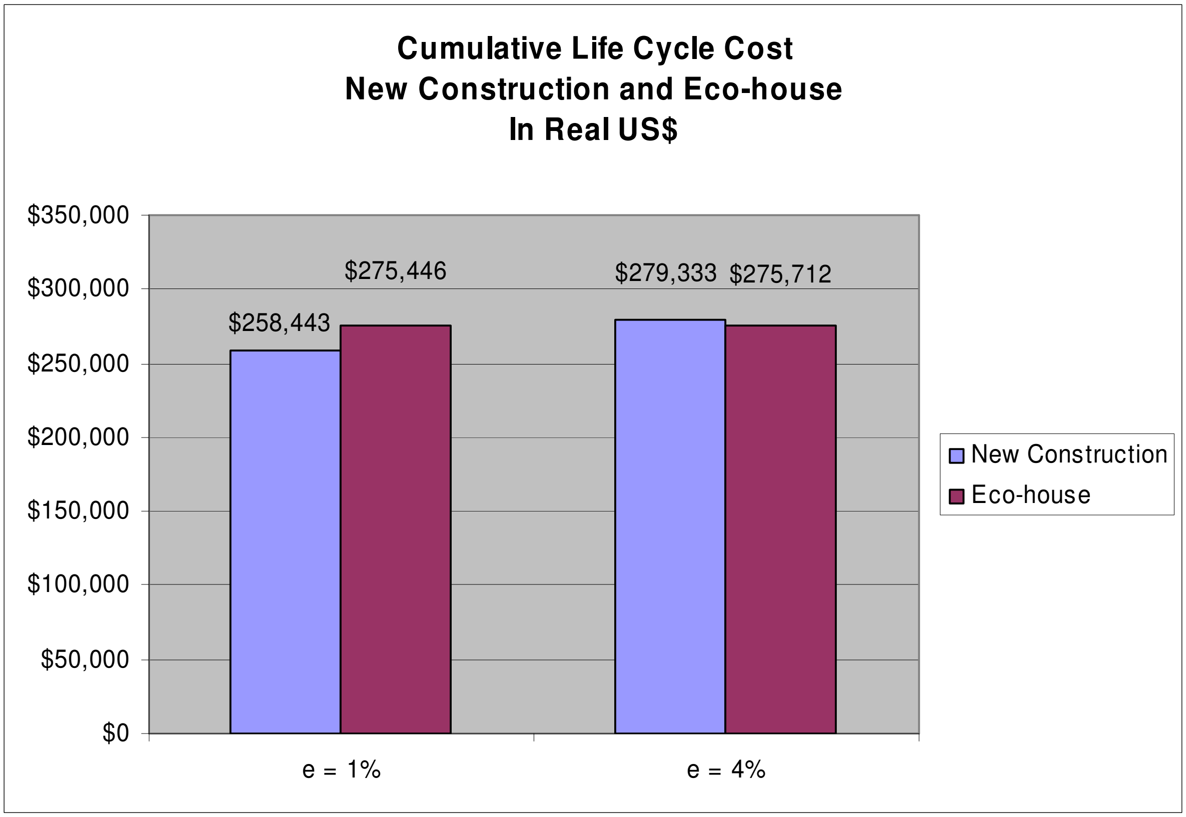


Figure X: Cumulative Life Cycle Cost of New Construction and Eco-house

Increasing Rent

The rent for current new construction is $2,630 per student per semester. And the summer rate is $1,270 per student. It is assumed that the Eco-house will be occupied year round by 5 students, and thus generate:

($2,630 /stud-sem x 2 sem/yr + $1,270 /stud-sum x 1 sum/yr) x 5 stud = $32,650 /yr

If annual rent were increased by $2,210 per year, or a 7% increase, the Eco-house would immediately break even with New Construction. That is, the Eco-house would be immediately generating positive cash-flow for the university. A $2,210 per year increase in rent corresponds to a per student monthly increase of:

$2,210 /yr / (5 students x 12 months/yr) = $37 /month

This sort of increase is similar to the increase in rent from old construction to new construction. The rent for old construction is $2,350 per student per semester and the summer rate is $1,270 per student. Assuming old construction is occupied year round by 5 students, it would generate:

($2,350 /stud-sem x 2 sem/yr + $1,270 /stud-sum x 1 sum/yr) x 5 stud = $29,850 /yr

Annual new construction rates are about 9% greater than old construction rates. It is proposed that the Eco-house rates would be about 7% greater than new construction rates.

The cumulative present value of mortgage, rent and energy expenditures chart is shown below. The charts below sum rent, mortgage payments and energy expenditures, and discount them to their present value. Adding additional rent to the Eco-house budget reduces the net owning and operating expenditures. There are two points of mathematical interest, end points and points of intersection. The end points at year 2040 for each house signify their respective present value life-cycle costs. Points of intersection would signify the points at which the Eco-house breaks even with new construction and begins accruing savings.

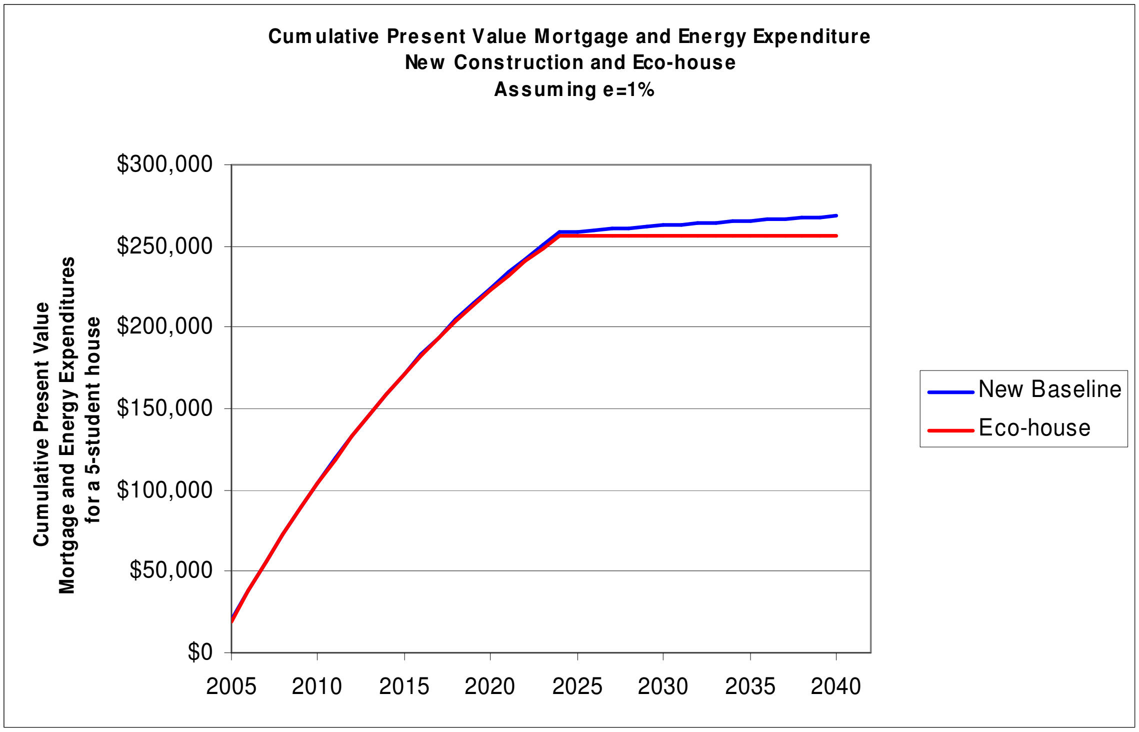


Figure X: Cumulative Life Cycle Cost of New Construction and Eco-house with Rent at e=4%

In the case of 1% energy escalation rates, New Construction and the Eco-house have a life-cycle cost of $258,443 and $248,170 respectively.

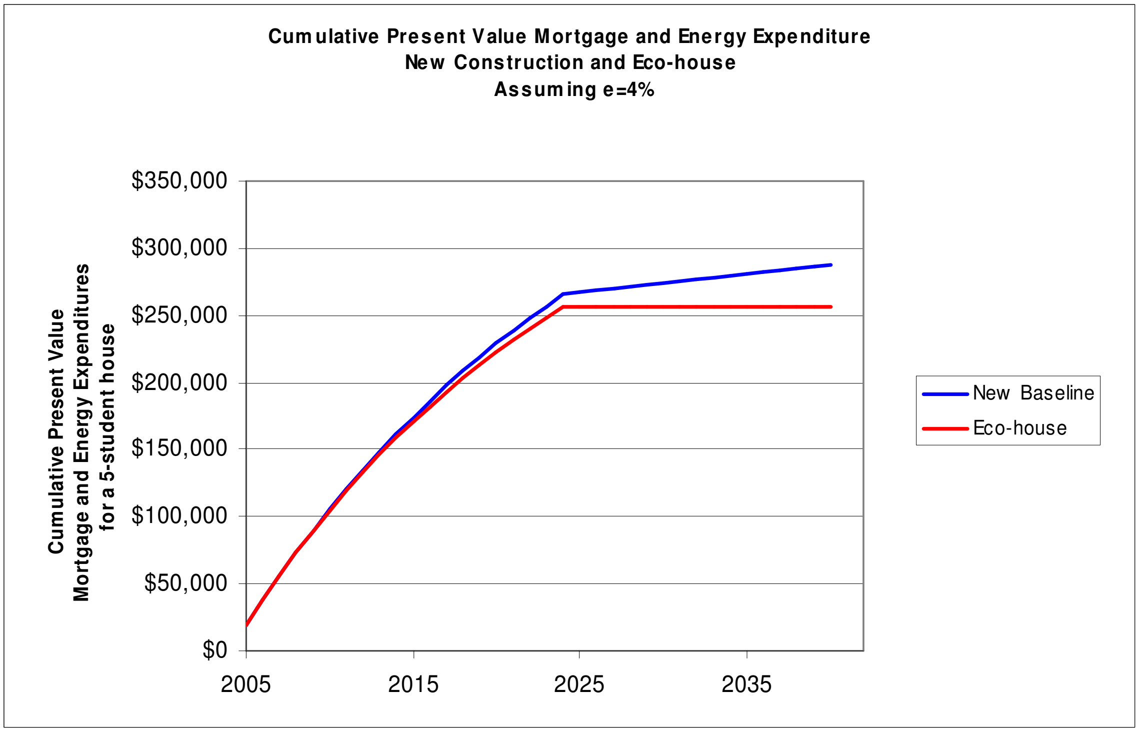


Figure X: Cumulative Life Cycle Cost of New Construction and Eco-house with Rent at e=4%

In the case of 4% energy escalation rates, New Construction and the Eco-house have a life-cycle cost of $279,333 and $248,170 respectively.

With increased rent, the Eco-house breaks even immediately, and would save the university money over its entire lifetime. Assuming energy escalation rates of 1% and 4% annually, the Eco-house would save $10,539 and $31,162 respectively. A chart, showing the life-cycle costs of new construction and Eco-house with increased rent for the Eco-house is shown below.

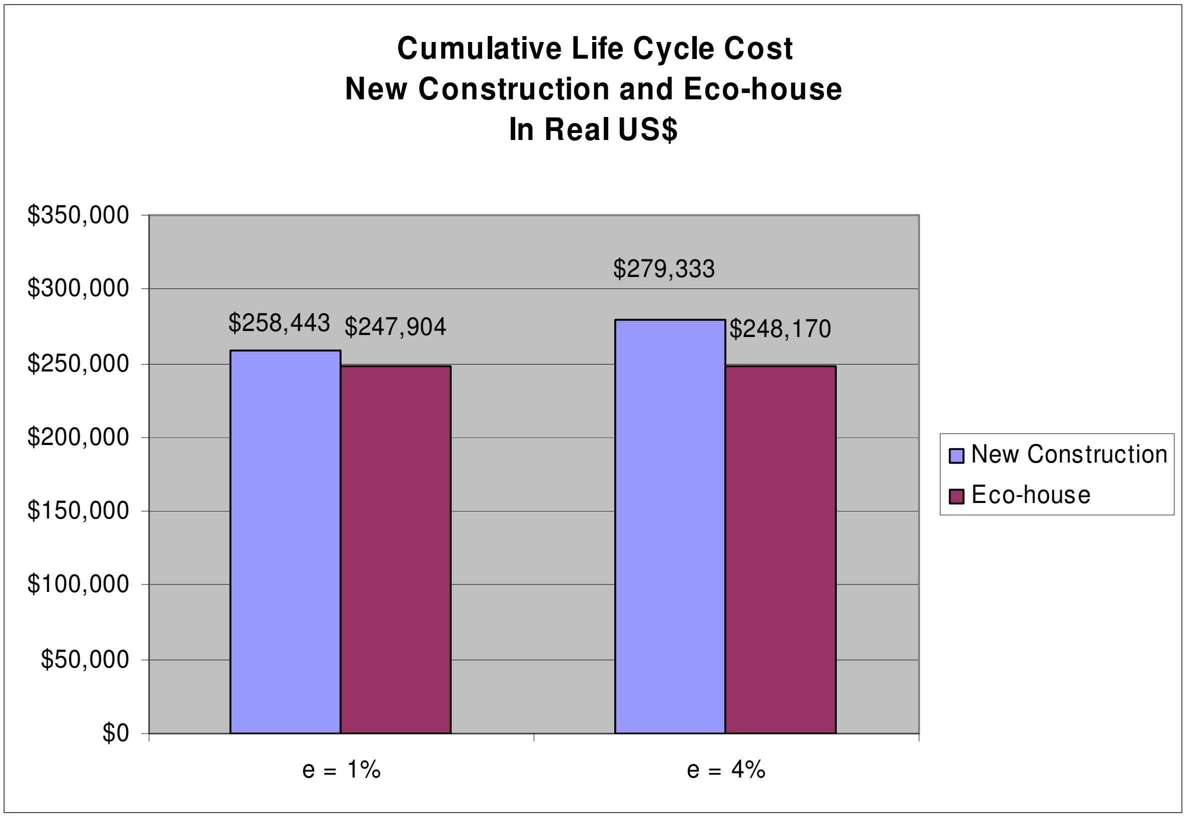


Figure X: Cumulative Life Cycle Cost of New Construction and Eco-house with Rent

The Eco-house would also be a positive contribution to a Marianist university, indicating our commitment to learn, lead, and serve as well as environmental stewardship. The Eco-house would be a selling point for the university and an attraction to new students.

Attraction of New Students

The Eco-house may attract students that would not otherwise attend UD. Consider the economic benefit if the Eco-house attracted 1 new student. Tuition is about $26,000 per year. Over four years this results in $104,000 more revenue to UD. Assuming the marginal cost of services for one additional student is 50% of the total revenue, the net additional revenue to UD is about $52,000. This covers the entire additional cost of the Ecohouse. If the Ecohouse attracts more than one student, then the financial gain to UD increases.

Discussion of House Components

Water Heating:

Baseline Water Heater

Currently installed in newly constructed 5-person homes at UD are AO Smith water heaters model GCV-50. The energy factor for these natural gas water heaters is 0.58 and the average life expectancy of a water heater is about 13 years (Consumer Energy Center). The retail cost of the baseline water heater is about $480.

From our baseline analysis of new 5-person homes at UD where we simulated annual energy use with ESim, we found that natural gas use for these homes is about 28.0 MBtu per year. With an energy factor of 0.58, the needed energy to heat this water is about:

28.0 MBtu/yr x 58% = 16.24 MBtu/yr

Efficient Water Heater

A more efficient water heater that could be installed in newly constructed 5-person homes at UD is the AO Smith water heater model XGV-50. The energy factor for these natural gas water heaters is 0.63 and the average life expectancy of a water heater is about 13. The retail cost of the water heater is about $580.

From our baseline analysis of new 5-person homes at UD where we simulated annual energy use with ESim, the necessary energy is 16.24 MBtu/yr. For the energy efficient water heater, the annual natural gas consumption would be about:

16.24 MBtu/yr / 63% = 25.78 MBtu/yr

Solar Water Heating

From SolarSim simulations, we estimate that a 6 meter squared solar collector system will provide 99% of total hot water requirements for the house. For all practical purposes, we assume the solar collectors will provide all hot water requirements. An online solar water heating system from Solar Roofs was found, including 3 collectors, each sized at 1.71 m^2, shipping and a dedicated PV pump. This system, model number 200153C80EX, costs $2,640. An additional 80 gallon Rheem/Rudd heat exchanger tank, model 81V080HE1 costs $1,095 (Solar Roofs). The total cost of the solar water heating system is about $3,735. According to Avin, a solar water heating system retailer, the lifetime of the solar water heating system would be about 15 years (Avin).

Summary

Inputs	Baseline	Energy Efficient	Solar
Model Number	GCV-50	XGV-50	200153C80EX
Real Discount Rate	0.05	0.05	0.05
Unit Cost of Electricity ($/kWh)	0.08844	0.08844	0.08844
Unit Cost of Natural Gas ($/mmBtu)	13.03	13.03	13.03
Electricity Fuel Escalation Rate	0.0066	0.0066	0.0066
Natural Gas Fuel Escalation Rate	0.063	0.063	0.063
First Cost ($)	480	580	3735
Lifetime (years)	13	13	13
House Lifetime (years)	35	35	35
Annual Electricity Use	0	0	0
Annual Gas Use	28	23.56	0
Calculations			
Annual Electricity Savings (kWh/yr) = E * CE	0	0	0
Annual Gas Savings (mmBtu/yr)	0	4.44	28
Annual Electricity Cost ($/yr)	$0	$0	$0
Annual Natural Gas Cost ($/yr)	$365	$307	$0
Annual Energy Cost ($/yr)	$365	$307	$0
First Year Fuel Cost Savings ($/yr)	$0	$58	$365
Additional First Cost ($)	$0	$100	$3,255
Simple Payback Using First Year Savings (years)	0	1.73	8.92
Simple Payback Including Increase in Fuel Costs (yrs)	0	1.59	6.95
Discount Factor	0.952	0.952	0.952
Net Present Value Total Cost ($)	$5,655	$4,934	$3,735
Net Present Value Total Savings ($)	$0	$721	$1,920
Net Present Value Payback (years)	0.00	1.70	8.41
Return on Investment	0	721%	59%
Internal Rate of Return	#NUM!	60%	7%

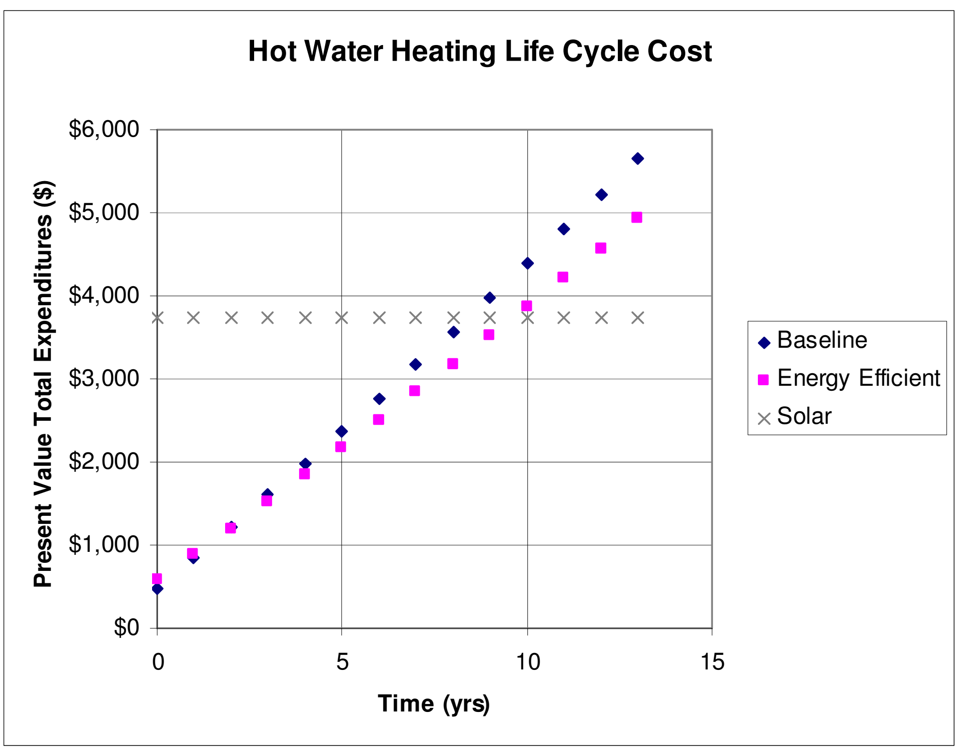


Figure X: Hot Water Heating Life Cycle Cost

Heating and Cooling Supply and Distribution

Baseline Forced Air Heating and Cooling:

Heating:
Currently installed in newly constructed 5-person homes at UD are Carrier forced air furnaces model 58MXA040. The AFUE for these forced air natural gas furnaces is 94.3. According to the Iowa Propane Association (IPA), the average life expectancy of a forced air natural gas furnaces is about 18 years (IPA). The retail cost of the natural gas furnace is about $1,978.

From our baseline analysis of new 5-person homes at UD where we simulated annual energy use with ESim, we found that natural gas use for space conditioning is about 33.2 MBtu per year. With an AFUE of 94.3, the needed energy to condition the building is about:

33.2 MBtu/yr x 94.3% = 31.3 MBtu/yr

Cooling:
Currently installed in newly constructed 5-person homes at UD are Carrier air conditioners, model 38CKC030340. The SEER for these air conditioners is 10.2 and the average life expectancy of an air conditioner is between 12 and 15 years (Center Point). The retail cost of the air conditioner is about $650.

From our baseline analysis of new 5-person homes at UD where we simulated annual energy use with ESim, we found that electricity use for space conditioning is about 2,036 kWh per year. With an SEER of 10.2, the needed energy to condition the building is about:

2,036 kWh/yr x 10 Btu/Wh = 20.36 MBtu/yr

Efficient Forced Air Heating and Cooling:

Heating:
What could be installed in newly constructed 5-person homes at UD are Carrier forced air furnaces model 58MVP06014. The AFUE for these forced air natural gas furnaces is 96.6 and the average life expectancy of a forced air natural gas furnaces is about 18 years. The retail cost of the natural gas furnace is about $2,400 (Carrier).

From our baseline analysis of new 5-person homes at UD where we simulated annual energy use with ESim, we found that natural gas use for space conditioning is about 31.3 MBtu per year. With an AFUE of 94.3, the needed energy to condition the building is about:

31.3 MBtu/yr / 96.6% = 32.4 MBtu/yr

Cooling:

An energy efficient air conditioner, model HSX16-0240 by Lennox could be installed in new 5-person UD residences. The SEER for these air conditioners is 16 and the average life expectancy of an air conditioner is between 12 and 15 years. The retail cost of the air conditioner is about $1850 (Local Installer).

From our baseline analysis of new 5-person homes at UD where we simulated annual energy use with ESim, we found that electricity use for space conditioning is about 2,036 kWh per year. With an SEER of 16, the needed electricity to condition the building is about:

20.36 MBtu/yr / 16 Btu/Wh = 1,272 kWh/yr

Air to Air Heat Pump

A 2-ton air to air heat pump from Lennox HP26-024 costs $1,937 to purchase. The SEER for the heat pump is 14.7 and the HSPF is 8.85 (Lennox). According to Natural Resources Canada (NRC) the average life expectancy of an air to air heat pump is between 15 and 20 years (NRC).

According to a local installer, they could install the HP26-024, air handler, wiring and controls for $3,500 - $3,700. This includes labor. In order to remove labor from this cost, we subtract roughly 25% of the installed cost or:

$3,700 x (1-25%) = $2775

Annual energy use for heating would be about:

31.3 MBtu/yr / 8.85 Btu/kWh = 3,794 kWh/yr

Annual energy use for cooling would be about:

20.36 MBtu/yr / 13.4 Btu/Wh = 1,519 kWh/yr

Summary

Inputs	Baseline	Energy Efficient	Heat Pump
Model Number	Low Efficiency he	Energy Efficient	Heating and Air
Real Discount Rate	0.05	0.05	0.05
Unit Cost of Electricity ($/kWh)	0.08844	0.08844	0.08844
Unit Cost of Natural Gas ($/mmBtu)	9.4	9.4	9.4
Electricity Fuel Escalation Rate	0.0066	0.0066	0.0066
Natural Gas Fuel Escalation Rate	0.063	0.063	0.063
First Cost ($)	2628	4250	2775
Lifetime (years)	20	20	20
House Lifetime (years)	35	35	35
Calculations			
Annual Electricity Use	2036	1272	5313
Annual Gas Use	33.2	32.4	0
Annual Electricity Savings	0	764	-3277
Annual Gas Savings	0	0.8	33.2
Annual Electricity Cost	$180	$112	$470
Annual Natural Gas Cost	$312	$305	$0
Annual Energy Cost	$492	$417	$470
First Year Fuel Cost Savings	$0	$8	$312
Additional First Cost	0	1622	147
Simple Payback Using First Year Savings (years)	0	215.69	0.47
Simple Payback Including Increase in Fuel Costs	0	Not In its Lifetime	2.61
Discount Factor	0.952	0.952	0.952
Net Present Value Total Cost	$8,818	$9,672	$7,378
Net Present Value Total Savings	$0	-$853	$1,441
Net Present Value Payback (years)	0.00	0.00	2.81
Return on Investment	0	-53%	980%
Internal Rate of Return	#NUM!	-10%	46%

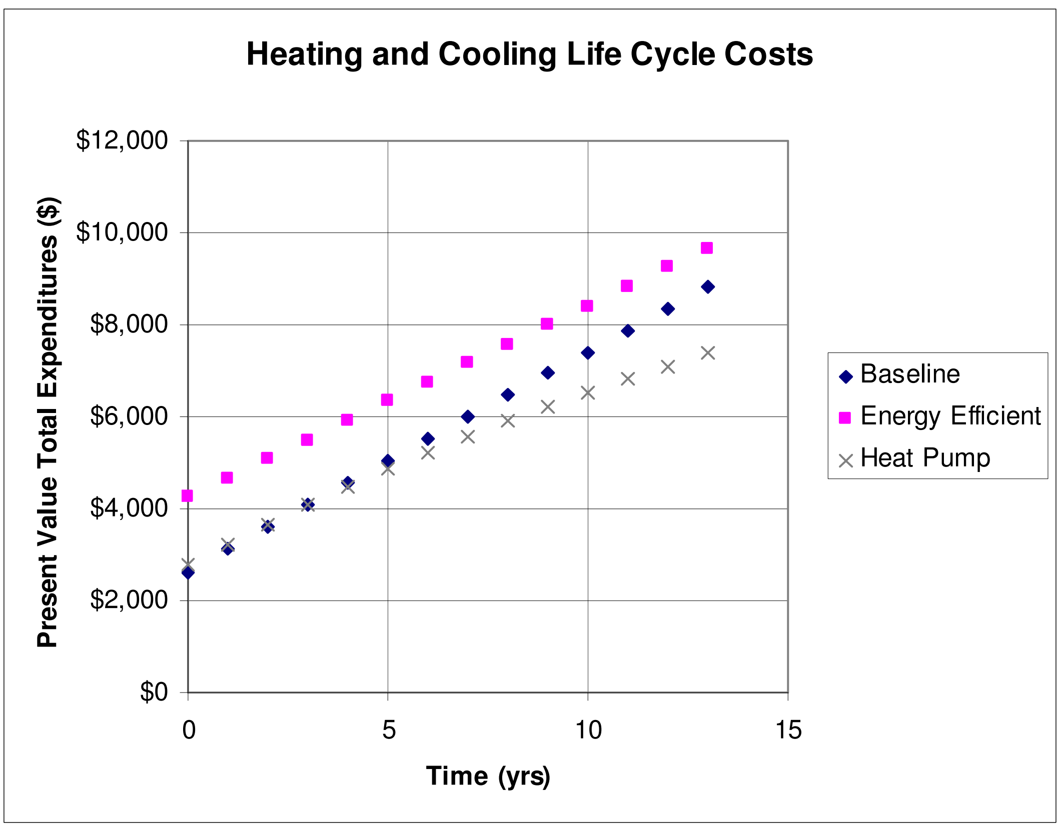


Figure X: Heating and Cooling Life Cycle Analysis

Wall Construction

Baseline

The building practices described below are for the new houses. Walls consist of wood siding, 0.75-inch OSB sheathing, 2" x 4" wood stud frames built 16 inches on center with 4-inch fiberglass batt insulation, and ½-inch drywall on the interior surface. Assuming, winter convection coefficients, the R-value of the walls is about 13 hr-ft2-F/Btu.

According to a builder from RL Fender, with labor, the comparable materials to construct a stick-frame building is about $25,200.

The remaining building characteristics are shown in the following table:

Table X. Summary of Baseline House Characteristics

Awalls (ft2)	2,002
Awindows (ft2)	78
Aceiling (ft2)	938
Number of occupants	5
Conditioned Floor Area (ft2)	1600
Perimeter length (ft)	104
Rwalls (hr-ft2-F/Btu)	13
Rwindows (hr-ft2-F/Btu)	2
SHGC	0.531
Rperimeter_insulation (hr-ft2-F/Btu)	0
Rceiling_roof (hr-ft2-F/Btu)	16
Infiltration (air changes per hour)	0.62
Internal Loads (kWh/mo)	950
Temperature Setbacks	None
Furnace Efficiency	0.8
SEER Air Conditioner (Btu/Wh)	10

Using ESim building energy simulation software (Kissock 1997) and the building characteristics, stated above, annual energy consumption for typical 5-person student residences was simulated. Simulated energy use and actual utility data are presented. The close fit between simulated and actual utility data gives us confidence in the simulated values. Baseline electricity and natural gas use are shown in the figures below.

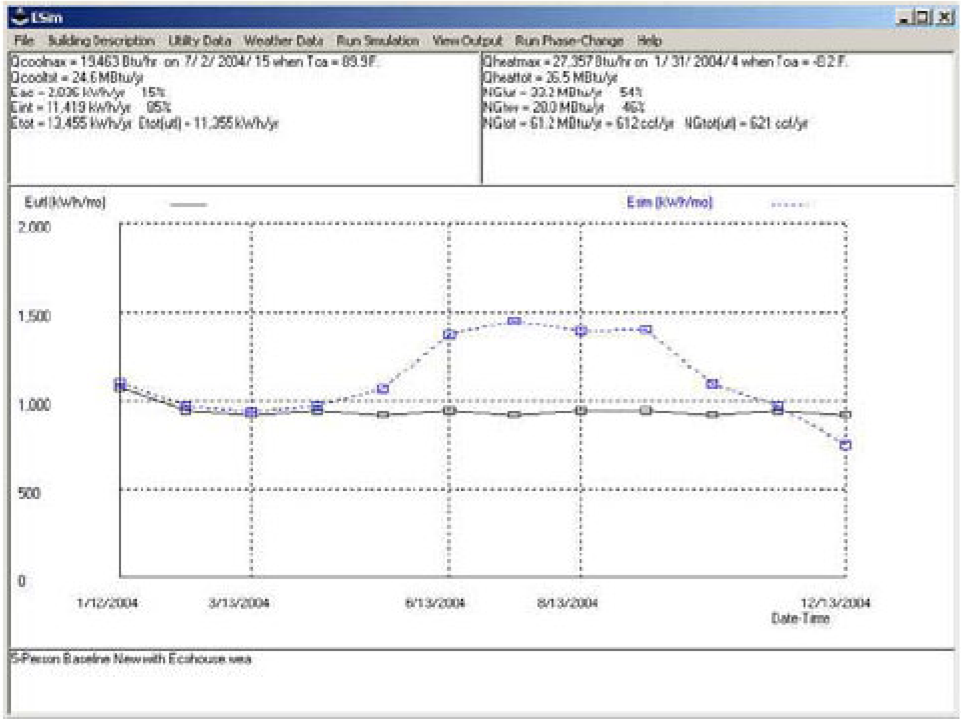


Figure X: Baseline Electricity Use

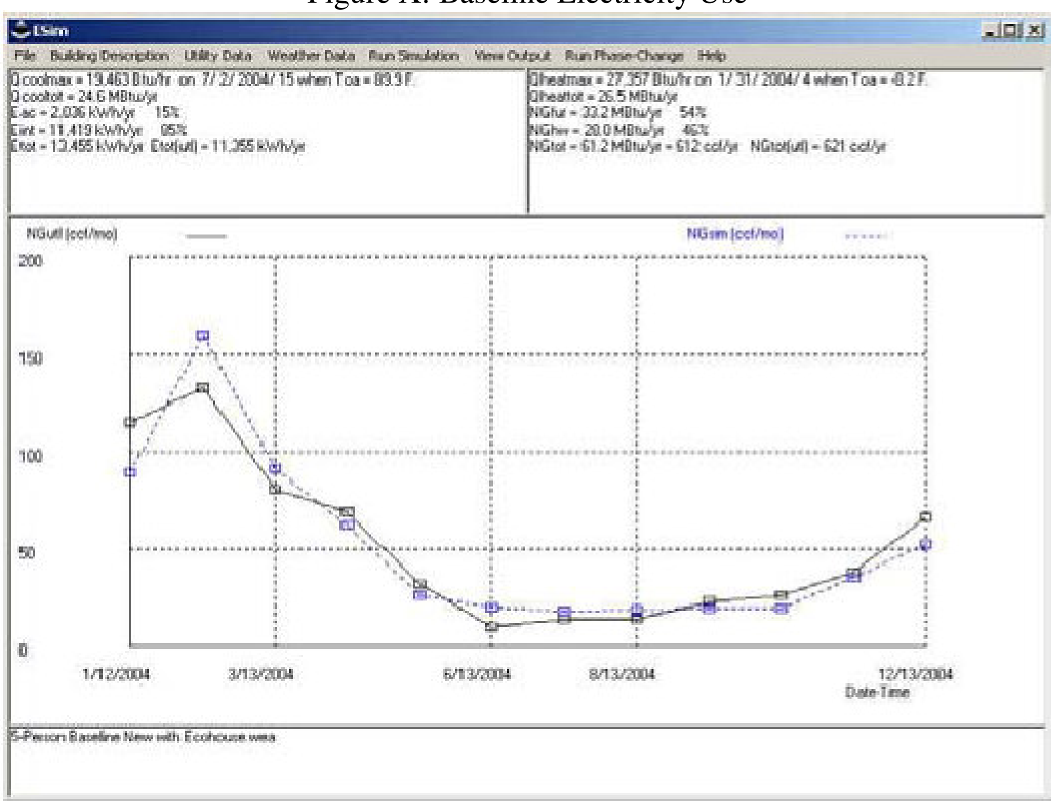


Figure X: Baseline Natural Gas USe

For the current baseline house, annual electricity use for space conditioning is 2,036 kWh/yr and annual natural gas use for heating is 33.2 MBtu/yr.

Low-end SIP

According to Engineered Panel Designs, Inc. low-end SIPs cost about $26,800 in materials. This does not include the cost of labor. For typical construction, framing takes about 2 weeks and costs about $10,000. SIP construction can usually take place in about one seventh of the time. Thus we estimate that labor for SIP construction would be about:

$10,000 x 1/7 = $1,500

Total SIP installation costs would be about:
$26,800 + 1,500 = $28,300

According to ESim simulations, leaving all other building characteristics the same but altering wall and ceiling R-values, the annual electricity use for space conditioning is 2,025 kWh/yr and annual natural gas use for heating is 3.5 MBtu/yr.

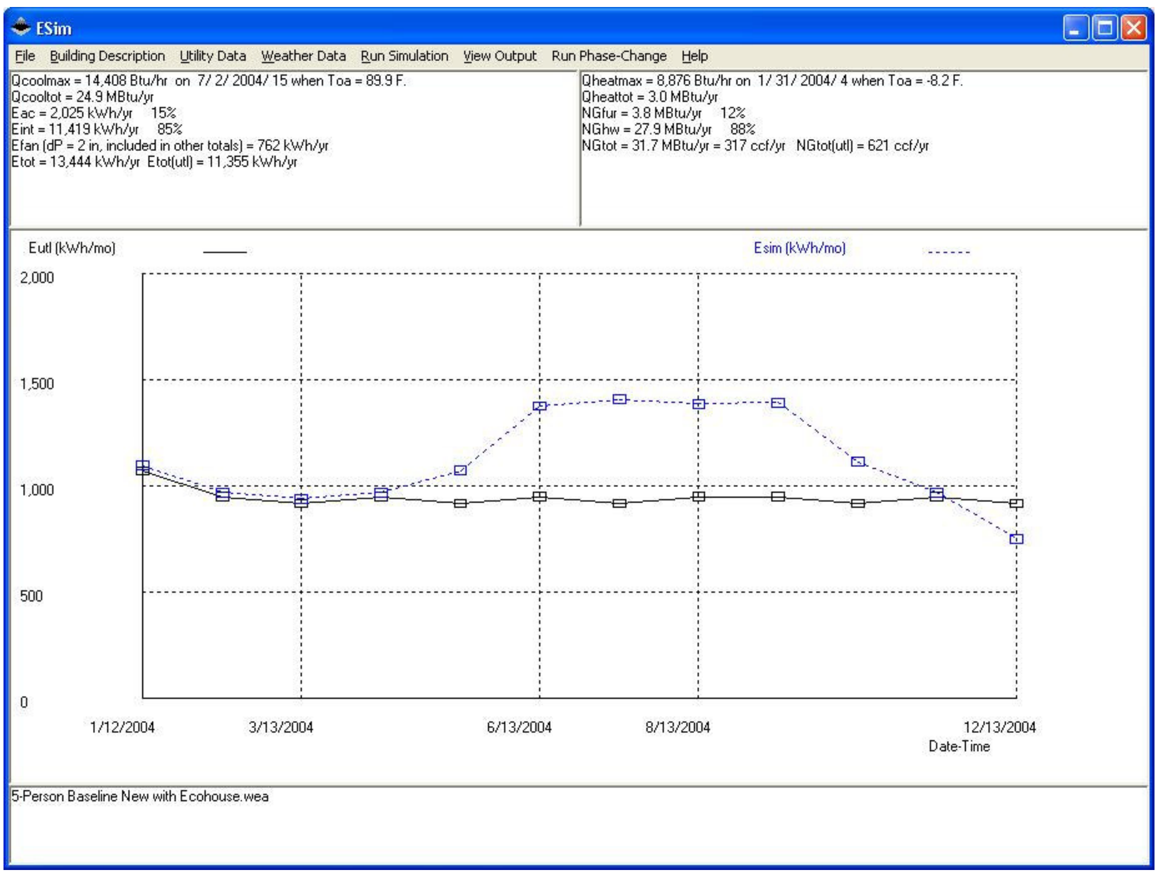


Figure X: Baseline Electricity Use with Low-end SIP

Medium-range SIP

According to Engineered Panel Designs, Inc. medium range SIPs cost about $29,800 in materials. Including the cost of labor calculated above, the total SIP installation costs would be about:
$29,800 + $1,500 = $31,300

According to ESim simulations, leaving all other building characteristics the same but altering wall and ceiling R-values, the annual electricity use for space conditioning is 2,020 kWh/yr and annual natural gas use for heating is 2.3 MBtu/yr.

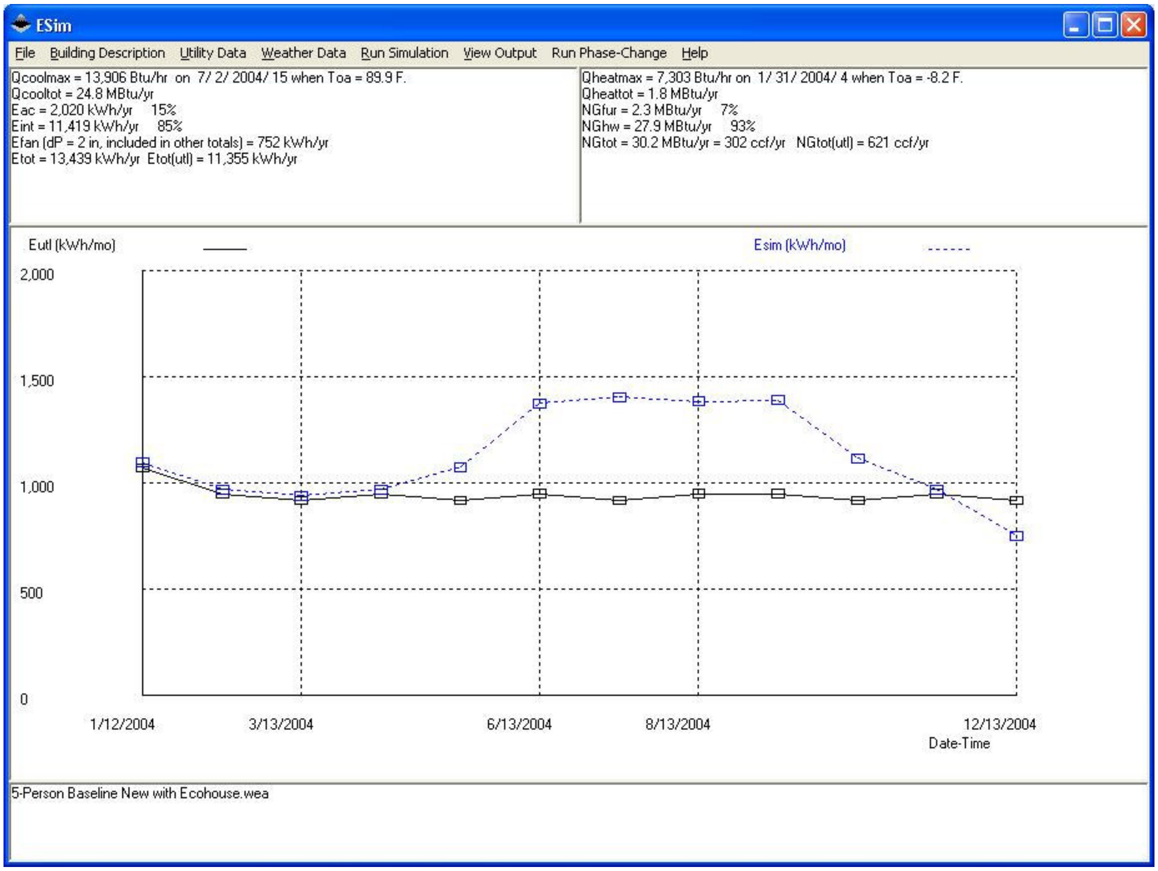


Figure X: Baseline Electricity Use with Medium-range SIP

High-end SIP

According to Engineered Panel Designs, Inc. medium range SIPs cost about $32,800 in materials. Including the cost of labor calculated above, the total SIP installation costs would be about:

$32,800 + $1,500 = $34,300

According to ESim simulations, leaving all other building characteristics the same but altering wall and ceiling R-values, the annual electricity use for space conditioning is 2,016 kWh/yr and annual natural gas use for heating is 1.4 MBtu/yr.

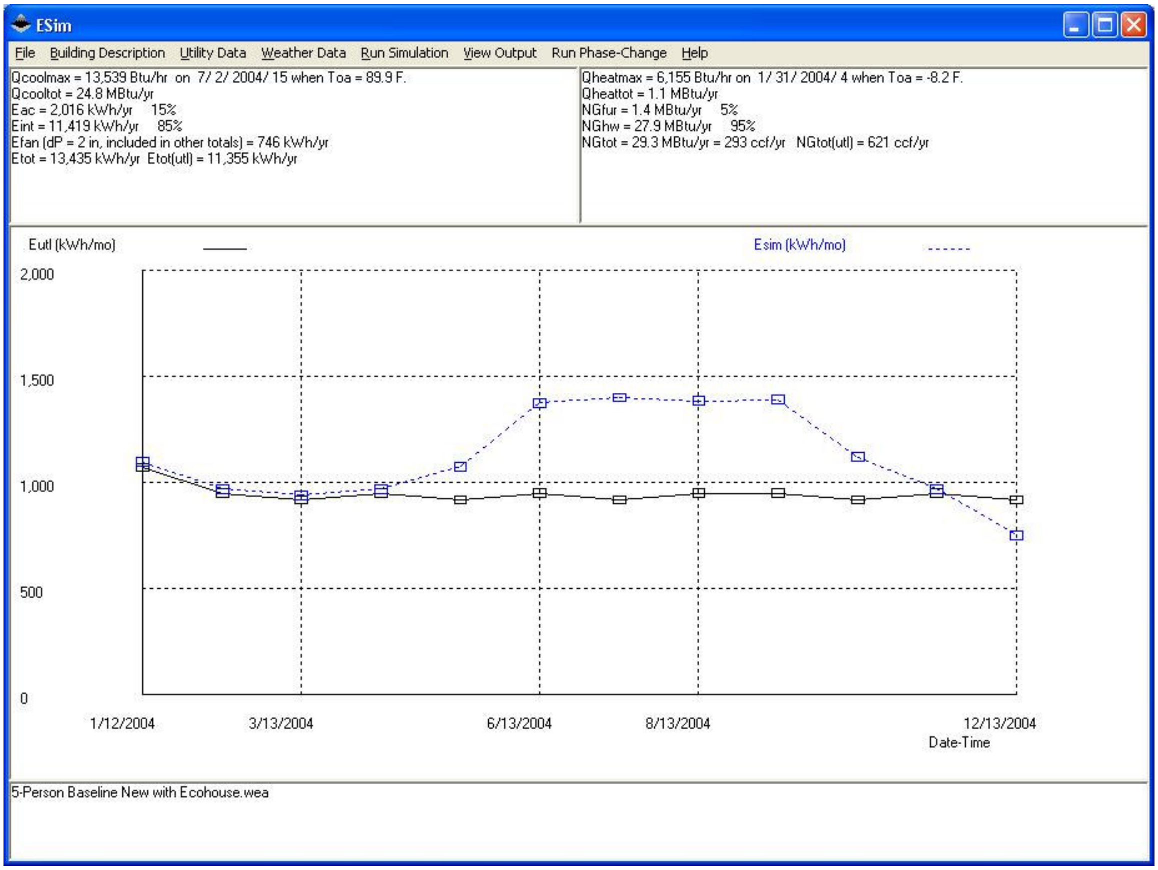


Figure X: Baseline Electricity Use with High-end SIP

Summary

Inputs	Baseline	Low SIP	Mid SIP	High SIP
Model Number	2x6 Constructi	SIP 6"	SIP 8"	SIP 10"
Real Discount Rate	0.05	0.05	0.05	0.05
Unit Cost of Electricity ($/kWh)	0.08844	0.08844	0.08844	0.08844
Unit Cost of Natural Gas ($/mmBtu)	9.4	9.4	9.4	9.4
Electricity Fuel Escalation Rate	0.0066	0.0066	0.0066	0.0066
Natural Gas Fuel Escalation Rate	0.063	0.063	0.063	0.063
First Cost ($)	25200	28300	31300	34300
Lifetime (years)	35	35	35	35
House Lifetime (years)	35	35	35	35
Calculations				
Annual Electricity Use	2036	2025	2020	2016
Annual Gas Use	33.2	3.8	3	1.4
Annual Electricity Savings	0	11	16	20
Annual Gas Savings	0	29.4	30.4	31.8
Annual Electricity Cost	$180	$179	$179	$178
Annual Natural Gas Cost	$312	$36	$26	$13
Annual Energy Cost	$492	$215	$205	$191
First Year Fuel Cost Savings	$0	$277	$287	$301
Additional First Cost	0	3100	6100	9100
Simple Payback Using First Year Savings (years)	0	11.18	21.24	30.26
Simple Payback Including Increase in Fuel Costs	0	8.32	13.35	16.84
Discount Factor	0.952	0.952	0.952	0.952
Net Present Value Total Cost	$42,160	$33,078	$35,656	$38,071
Net Present Value Total Savings	$0	$9,082	$6,503	$4,089
Net Present Value Payback (years)	0.00	10.42	18.80	25.65
Return on Investment	0	293%	107%	45%
Internal Rate of Return	#NUM!	10%	4%	2%

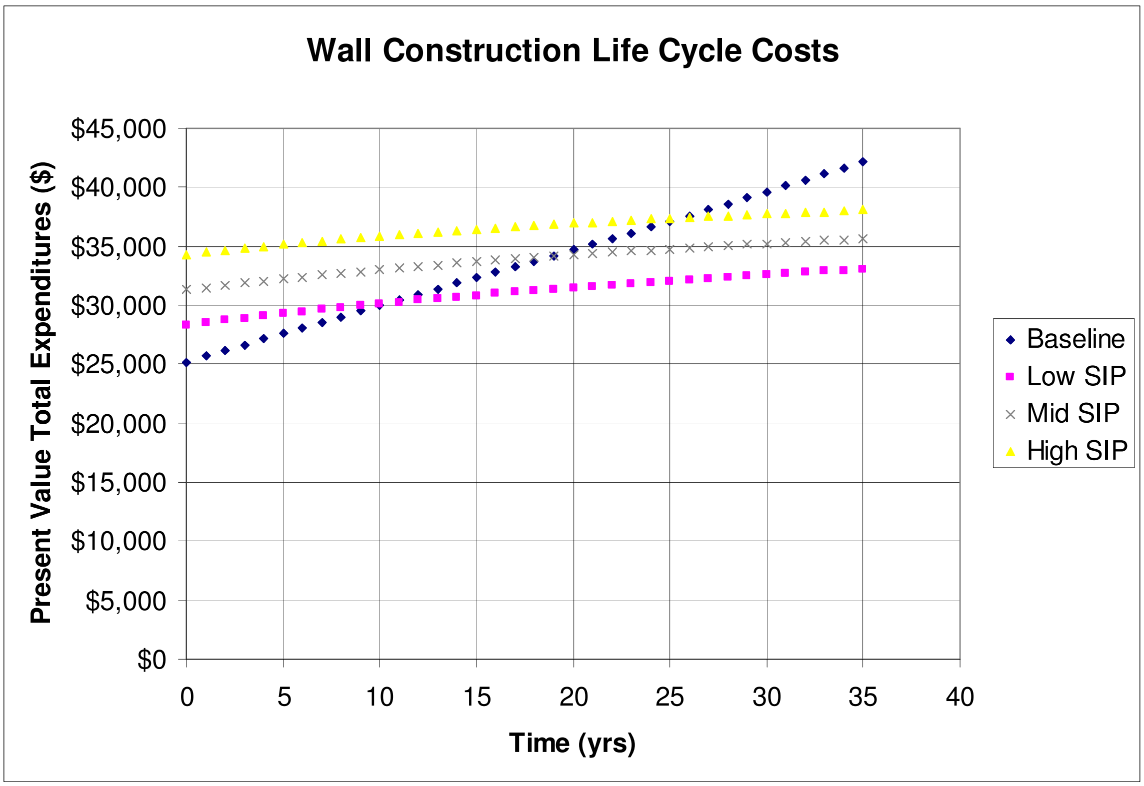


Figure X: Wall Construction Life Cycle Analysis

Appliances

Refrigerator

Currently installed in newly-constructed 5-person houses at the University of Dayton are Frigidaire's FRT18G4A top-freezer. According to the manufacturer, typical energy use is about 479 kWh per year and the initial cost is about $449. Maytag's energy efficient model MTB1895A uses about 409 kWh per year and has an initial cost of $679.

Inputs	Baseline	Energy Efficient
Model Number	FRT18G4A	MTB1895A
Real Discount Rate	0.05	0.05
Unit Cost of Electricity ($/kWh)	0.08844	0.08844
Unit Cost of Natural Gas ($/mmBtu)	9.4	9.4
Electricity Fuel Escalation Rate	0.0066	0.0066
Natural Gas Fuel Escalation Rate	0.063	0.063
First Cost ($)	449	679
Lifetime (years)	13	13
House Lifetime (years)	35	35
Calculations		
Annual Electricity Use	479	409
Annual Gas Use	0	0
Annual Electricity Savings	0	70
Annual Gas Savings	0	0
Annual Electricity Cost	$42	$36
Annual Natural Gas Cost	$0	$0
Annual Energy Cost	$42	$36
First Year Fuel Cost Savings	$0	$6
Additional First Cost	0	230
Simple Payback Using First Year Savings (years)	0	37.15
Simple Payback Including Increase in Fuel Costs	0	Not In its Lifetime
Discount Factor	0.952	0.952
Net Present Value Total Cost	$864	$1,033
Net Present Value Total Savings	$0	-$169
Net Present Value Payback (years)	0.00	0.00
Return on Investment	0	-74%
Internal Rate of Return	#NUM!	#NUM!

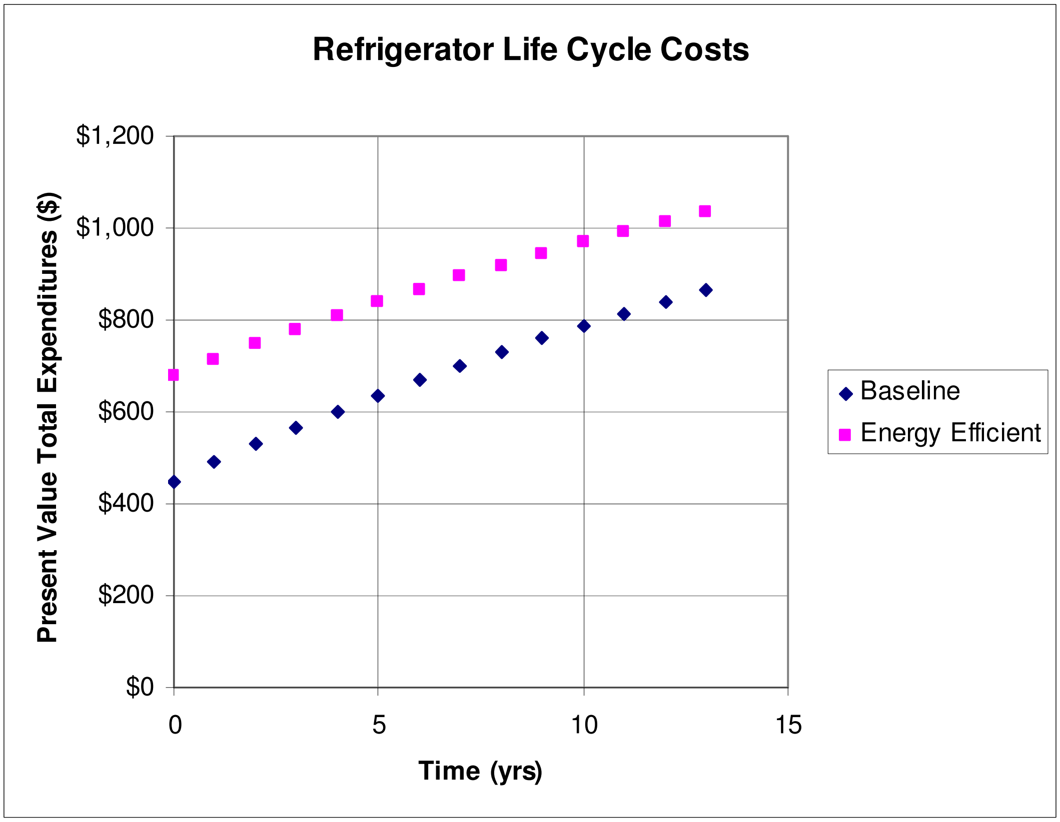


Figure X: Refrigerator Future Value Chart

Dishwasher

Currently installed in newly-constructed 5-person houses at the University of Dayton is Frigidaire's FDB750RC model. According to the manufacturer, typical energy use is about 328 kWh per year and the initial cost is about $279. Asko's energy efficient model D3212 uses about 278 kWh per year and has an initial cost of $780. Asko's more energy efficient model D3432 uses about 231 kWh per year and has an initial cost of $1,100.

Inputs	Baseline	Energy Efficient	Super Efficient
Model Number	FDB750RC	D3212	D3432
Real Discount Rate	0.05	0.05	0.05
Unit Cost of Electricity ($/kWh)	0.08844	0.08844	0.08844
Unit Cost of Natural Gas ($/mmBtu)	9.4	9.4	9.4
Electricity Fuel Escalation Rate	0.0066	0.0066	0.0066
Natural Gas Fuel Escalation Rate	0.063	0.063	0.063
First Cost ($)	279	780	1100
Lifetime (years)	13	13	13
House Lifetime (years)	35	35	35
Calculations			
Annual Electricity Use	328	278	231
Annual Gas Use	0	0	0
Annual Electricity Savings	0	50	97
Annual Gas Savings	0	0	0
Annual Electricity Cost	$29	$25	$20
Annual Natural Gas Cost	$0	$0	$0
Annual Energy Cost	$29	$25	$20
First Year Fuel Cost Savings	$0	$4	$9
Additional First Cost	0	501	821
Simple Payback Using First Year Savings (years)	0	113.30	95.70
Simple Payback Including Increase in Fuel Costs	0	Not In its Lifetime	Not In its Lifetir
Discount Factor	0.952	0.952	0.952
Net Present Value Total Cost	$563	$1,021	$1,300
Net Present Value Total Savings	$0	-$458	-$737
Net Present Value Payback (years)	0.00	0.00	0.00
Return on Investment	0	-91%	-90%
Internal Rate of Return	#NUM!	#DIV/0!	#DIV/0!

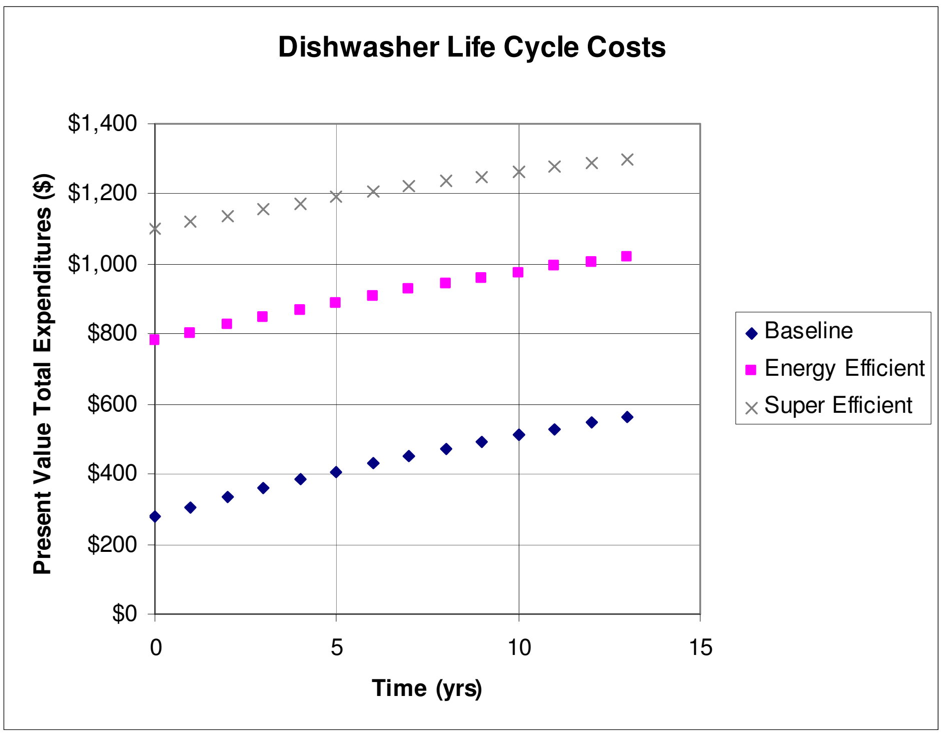


Figure X: Dishwasher Future Value Chart

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http://www.eia.doe.gov/emeu/security/Oil/index.html

IREC Interstate Renewable Energy Commission
http://irecusa.org/connect/statebystate.html?PHPSESSID=b44e22a1c9891eaa6f8eb3cff75c9e45

Info on net-metering rules and interconnection regulations.

DP&L Net Metering Rules
http://www.waytogo.com/cs/csrt/D05.pdf
DP&L Interconnection Rules

DP&L Shopping Credit
http://www.waytogo.com/cs/csrt/G22.pdf

DP&L General Service Residential
http://www.waytogo.com/cs/csrt/G10.pdf

DP&L Residential Transmission Charge
http://www.waytogo.com/cs/csrt/T08.pdf

DP&L Residential Distribution Charge
http://www.waytogo.com/cs/csrt/D17.pdf

Consumer Energy Center
http://www.consumerenergycenter.org/homeandwork/homes/inside/appliances/waterheaters.html

Average water heater life expectancy

Solar Roofs
http://www.solarroofs.com/purchase/sys5.html

Solar water heating system sizes and prices

Avin
http://www.avinsolar.com/swh.htm

Solar water heating system retailer, water heating system life expectancies

IPA – Iowa Propane Association
http://www.iapropane.org/heating.asp

Average life expectancy of natural gas furnaces

NRC - Natural Resources Canada

http://oee.nrcan.gc.ca/publications/infosource/pub/home/heating-heat-pump/asheatpumps.cfm?attr=4
Average life expectancy of air to air heat pumps

Lennox
http://www.lennox.com/pdfs/brochures/Lennox%20HP26%20Heat%20Pump.pdf
HP26-024 heat pump specifications

Center Point Energy
http://mn.centerpointenergy.com/for_your_home/heating_cooling/buying_guide.asp
Average central air conditioner life expectancy

Appendices

Appendix 1: Dayton Power and Light Residential Electricity Tariff

When billing, the utility generally breaks up the electricity tariff into three components, generation, transmission and distribution. The customer is further subjected to additional riders, the excise tax surcharge rider, emission fee recovery rider, universal service fund rider, and the energy efficiency surcharge rider. The charges are as follows:

Generation
$0.05768 per kWh for the first 750 kWh
$0.04704 per kWh for all kWh over 750 kWh

Transmission
$0.00270 per kWh for all kWh

Distribution
$4.25 per Customer (Customers with monthly energy consumption)
$5.00 per Customer (Customers without monthly energy consumption)

$0.02260 per kWh for the first 750 kWh
$0.02260 per kWh for all kWh over 750 kWh

Excise Tax Surcharge Rider
$0.00465 per kWh for the first 2,000 kWh

Emission Fee Recovery Rider
Monthly bills of all retail customers shall be increased by .097%, applied to the following charges:

Distribution
Transmission
Excise Tax Surcharge

Universal Service Fund Rider
$0.0004099 per kWh for the first 833,000 kWh
$0.0004099 per kWh for all kWh over 833,000 kWh

Energy Efficiency Surcharge Rider
$0.0001075/kWh for all kWh

In order to quickly calculate monthly bills, a customer could break these charges into a monthly service charge, which is typically fixed, and a monthly energy charge, based on the number of kWh consumed. The service and electrical energy rates are summarized below:

Service
$4.25 per Customer (Customers with monthly energy consumption)

Electrical Energy
Electrical energy charge has been calculated using the following equation:

Electrical energy charge = Generation + (1 + Emission Fee) x (Transmission + Distribution + Excise Tax) + Universal Service Fund + Energy Efficiency Surcharge

The electrical energy charge is:
$0.08844 per kWh for the first 750 kWh
$0.07780 per kWh for all kWh over 750 kWh

Appendix 2: Sources of Cost Estimates

	Model Number	Price	
Water Heating			
Baseline			
Water Heater	GCV-50	$480	AO Smith
Eco-house			
3 Solar Collectors	200153C80EX	$2,640	http://www.solarroofs.com/purchase/sys5.html
80 gal tank	81V080HE1	$1,095	http://www.solarroofs.com/purchase/sys5.html
Total		$3,735	

	Model Number	Price	
Heating and Cooling			
Baseline			
Furnace	58MXA040	$1,978	Carrier
Air Conditioning	38CKC030340	$650	Carrier
Total		$2,628	
Eco-house			
Air-to-air Heat Pump	HP26-024	$1,937	Local Installer
Air Handler		$838	Local Installer
Total		$2,775	

	Model Number	Price	
Wall Construction			
Baseline			
Labor and Materials for Stick Frame		$25,200	RL Fender
Eco-house			
SIP Materials	8-inch thick wal	$29,800	Engineered Panel Designs
Labor		$1,500	Assuming SIP labor is about 1/7 the labor for a typical house ($10,000)
Total		$31,300	

	Model Number	Price	
Refrigerator			
Baseline			
	FRT18G4A	$449	Frigidaire
Eco-house			
	MTB1895A	$679	Frigidaire

	Model Number	Price	
Dishwasher			
Baseline			
	FDB750RC	$279	Frigidaire
Eco-house			
	D3212	$780	Frigidaire

	Model Number	Price	
Heat Recovery Ventilator			
Baseline			
	None	$0	
Eco-house			
	75 CFM .81 eff	$561	RL Williams

	Model Number	Price	
Solar PV			
Baseline			
	None	$0	
Eco-house			
	4 kW materials	$24,000	MrSolar.com
	4 kW installed	$32,000	Third Sun Installers
25 yr replacement	10000	2953.027717	
Total		$34,953	

	Model Number	Price	
Washer/Dryer			
Baseline			
Washer	FWX833AS1	$329	Frigidaire
Dryer	FER211AS2	$319	Frigidaire
Total		$648	
Eco-house			
Washer	FTF530E	$669	Frigidaire
Dryer	GLER341A	$319	Frigidaire