PERFORMANCE EVALUATIONS OF PROTOTYPE HOUSES: MINIMUM 40% SAVINGS LEVEL

TASK ORDER **KAAX-3-33412-03**

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ASTROPOWER

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Task 3.B.1 PERFORMANCE EVALUATIONS OF PROTOTYPE HOUSES: MINIMUM 40% SAVINGS LEVEL

Richard Schingler, a homebuilder in the San Joaquin Valley planned to build his new residence in Stockton, California. He came to ConSol for Title 24 Energy documentations as part of the city submittal requirements. Mr. Schingler expressed interests in energy efficiency measures and consulted with ConSol. ConSol provided Mr. Schingler the Title 24 documentations with minimum energy efficiency features necessay to acquire a building permit. ConSol then met with Mr. Schingler and explained the Building America Program (BAP). Inspired in learning about BAP, Mr. Schingler asked ConSol to further analyze his residence and recommend energy upgrades to meet, or exceed, the 40% goal of BAP. He wanted to build the most energy efficient home possible without excessive increases in cost. The process of analysis, presentation, consideration of alternative combinations of energy features took numerous steps, or stages in decision making. For each stage, energy features, associated costs and benefits were reviewed and analyzed with Mr. Schingler.

This report presents these stages of decision making and evaluation of tradeoffs considered in this process. It also presents the resulting 43% more energy efficient home which is under construction at the time of this report.

Description:

The new Schingler home being analyzed and reported here is a two story slab on grade detached home with a detached Casita (detached, 241 sq.ft. “grand parents apartment”), located in Stockton in San Joaquin County, California. This location has 2,806 heating degree days (HDD) and 1,529 cooling degree days (CDD). The house has a combined floor area of 3,553 sq.ft. and 21.4% of the floor area in glazing (760 sq.ft.).

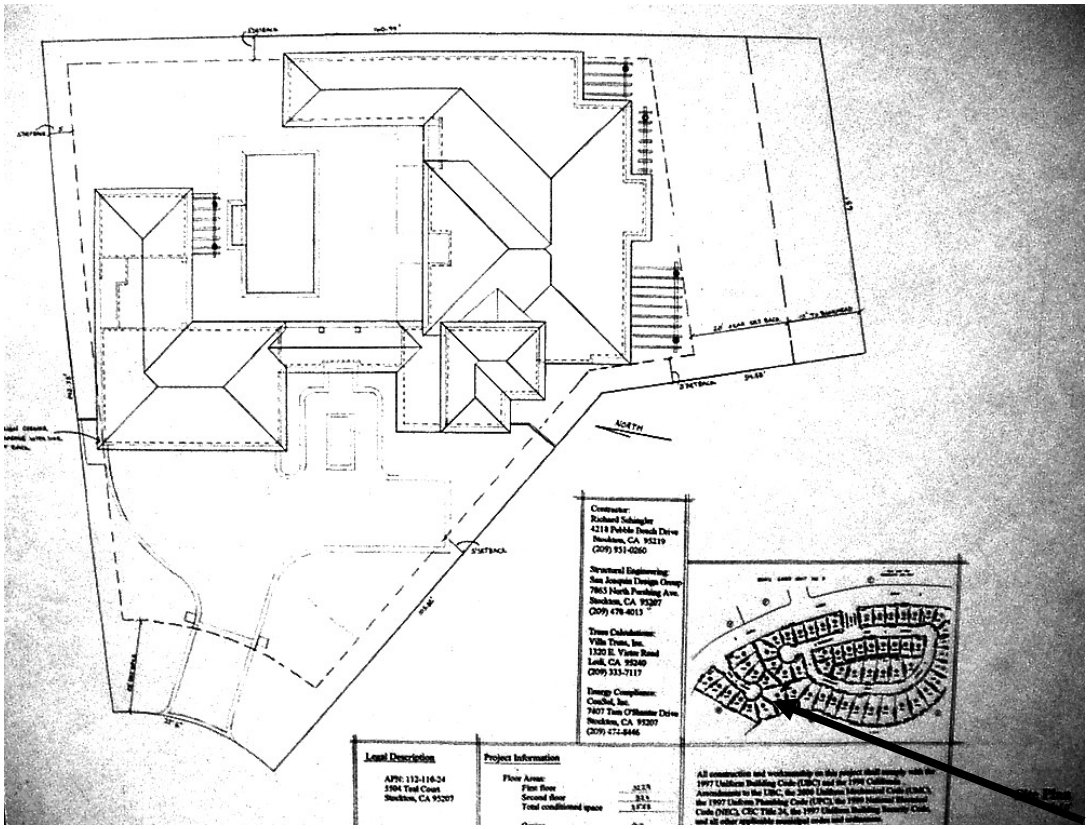

Fig. 1 Site Plan and Roof Plan.

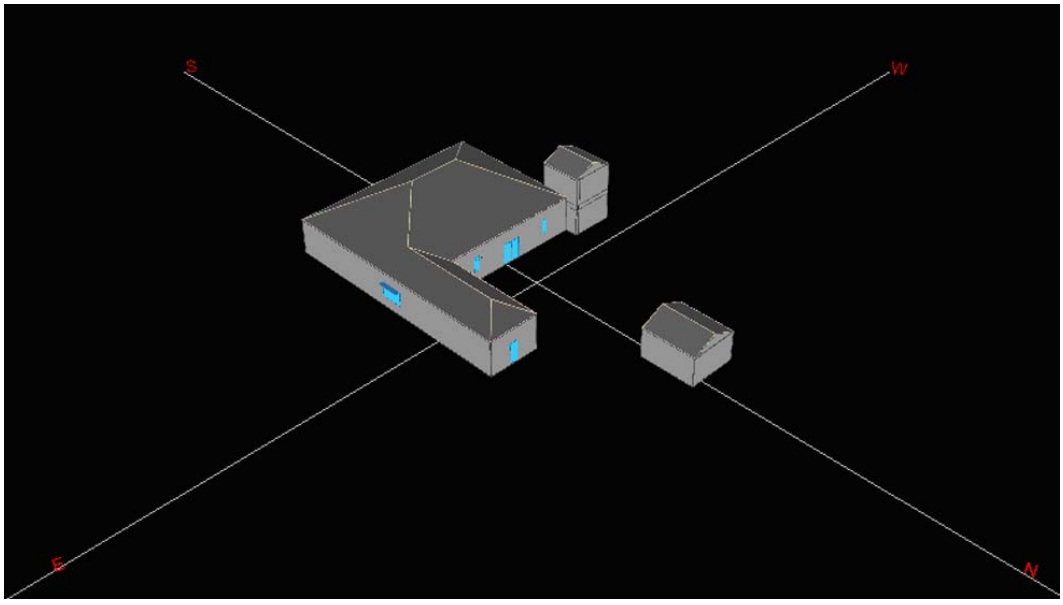

Fig. 2 Three Dimensional Representation of Schingler Home.

See Appendix A for floor plans, elevations and sections.

Richard Schingler typically builds 3 or 4 large homes per year and he plans to work with ConSol to build a BAP home in the Parade of Homes in Tracy, CA in 2004, in addition to the home discussed in this report.

Stage 1:

ConSol simulated the BAP prototype house based on the current BAP reference house which had the following characteristics:

1. Ceiling R-value = 30
2. Frame wall U-value = 0.082
3. Specific Leakage Area (SLA) = 0.00048 (used 4.8 for software simplicity)
4. Fenestration and opaque door U-factor = 0.60 and SHGC = 0.40
5. HVAC: 2-78% AFUE heating and 2-10.0 SEER cooling
6. Duct Insulation = R-5
7. 2-40 gallon gas water heater w/ 36,000 Btu/hr and Energy Factor (EF) = 0.54
8. Lighting Usage based on Navigant 2002 used in Building America's benchmark is Total annual lighting use = (Finish Floor Area * 0.8 + 455) kWh/yr. Garage lighting =100 kWh/yr and exterior lighting = 250 kWh/yr. ([3553 sf. * 0.8 + 455] kWh/yr + 100 kWh/yr + 250 kWh/yr = 3647 kWh/yr)

ConSol then simulated this plan with features to achieve at least the 40% energy savings level and told Mr. Schingler that a typical BAP home needs to have the following minimum characteristics and that the energy savings would result from:

1. Tightly sealed ducts
2. Engineered Heating Ventilating and Air Conditioning (HVAC) systems
3. Reduced air leakage through tighter envelope
4. Improved low emissivity (low-E) windows
5. Super-efficient water heater, and pipe insulation on all hot-water trunk-lines
6. Improved lighting to Compact Fluorescent Lamps (CFLs)
7. Installation of gas-dryer stub

Mr. Schingler agreed to build with the above minimums and would upgrade features to meet the 40% energy savings level as per BAP if needed. Please reference Appendix B - Option 1 for a detailed list of features for this and other options.

ConSol then faxed and called Mr. Schingler about the features on Option 1 and asked him for approval. Mr. Schingler responded by asking ConSol to remove the 1 inch EPS foam and upgrade other energy features to compensate. He reported, in his experience, that many homebuyers do not like 1 inch foam wall construction due to stories they have heard or read from other parts of the country about mold problems with exterior foam. He feared it might not be a good feature to market if he wants to sell the house in the future. ConSol informed Mr. Schingler of the benefits of the 1 inch foam including energy savings and that production home builders in hot-dry climate regions build with the 1 inch foam wall construction (1-Coat Stucco System) with no mold problems. In

ConSol's analyses, the 1 inch foam is approximately a 3.00 kBtu/sf-yr energy savings, which is equivalent of upgrading an air conditioner from SEER 10 to SEER 14 (approximately $600.00). Mr. Schingler requested that ConSol simulate another run without using 1-Coat Stucco System, rather 3-Coat Stucco System. Mr. Schingler wanted to know what features would be close to the cost effectiveness of the 1 inch foam.

Stage 2:

Option 2 was developed and achieving 44.6% in energy savings. This option excluded the 1 inch foam and increased the energy performance of other features. ConSol reviewed the option with the client and informed him of the upgraded features. Specific changes include the insulation in the attic was increased to a much higher level and all windows had to have better window U-factors and Solar Heat Gain Coefficients (SHGC). (Reference Appendix B - Option 2 for details of all energy features for this and other options.) The client was interested in exploring the features of this option and agreed to obtain cost estimates from his subcontractors and suppliers. He asked ConSol to recommend a window product which would meet the specifications called for in this option. ConSol explained that these window U-factors and SHGC can be achieved with wood frame windows with spectrally selective glass. ConSol recommended a few alternative window manufacturers including Andersen wood frame windows with spectrally selective glass all which meet the specifications required in this option. The client responded that Andersen windows are very expensive and their window sizes are usually custom made and may not match his plan set. He declined to use Andersen windows. After a few days of reviewing the mechanical information with his HVAC contractor, Mr. Schingler told ConSol that the high efficiencies of the both the heating and cooling systems in this option are too expensive and asked ConSol to develop another option reducing the HVAC efficiencies in meeting the BAP goal.

In comparing Option 1 and Option 2, ConSol explained to Mr. Schingler that building without the 1-inch EPS foam costs would increase about $1,130.00 just on roof and wall insulation upgrades. In addition improved windows would also increase costs substantially. As a result, Schingler asked ConSol to develop additional options which follow.

Stage 3:

ConSol developed and analyzed Option 3. This option achieved 41.7% in energy savings. ConSol switched out the high efficiency windows of Option 2, replacing them with the original window product (Milgard vinyl frame windows with spectrally selective glass) and lowered the HVAC efficiencies from 95% to 90% AFUE for the furnace and dropped the SEERs from 16.0 (main house) and 12.0 (Casita) to 14.0 (main house) and 10.0 (Casita). ConSol also introduced the Night Breeze System to the client and explained the benefits and costs of the system to the builder client. The Night Breeze System is a product developed by Davis Energy Group in Davis, California using the California Energy Commission's (CEC) Public Interest Energy Research (PIER) funding. This system acts as an economizer for residential homes (please see details at Appendix B –

Option 3). It pulls in cooler air from outside at night and use it as space cooling when the outside temperatures are 5 degrees cooler, or more, than the inside temperature of the house. In this application, the Night Breeze System also is integrated with a tankless water heater and hydronic fancoil to also provide space heating. Based on past research and monitored results, the Night Breeze System could save a home as much as 50% in annual air conditioning (cooling) energy use in this same climate region (see http://www.davisenergy.com/nb_page.htm). ConSol directed the client to read and contact Davis Energy Group directly about the Night Breeze System. ConSol highly recommended this system because of its performance, the cost effectiveness of the system and because Stockton is directly east of the Sacramento-San Joaquin Delta. (The Delta is located at the confluence of the Sacramento and San Joaquin Rivers before they flow into the San Francisco Bay). Typically during summer afternoons and nights, on-shore winds blow from the Pacific Ocean across the Delta delivering cool air to the hot valleys that the Night Breeze System utilizes to cool the homes. ConSol claimed 25% annual energy savings in cooling to be conservative. For example, the annual cooling budget for this house using Micropas simulated to be 2.48 kBtu/sf-yr, 25% reduction of this budget would be 1.86 kBtu/sf-yr (see details on Appendix B – Option 3).

Stage 4:

ConSol also developed Option 4 which resulted in 47.4% in energy savings (see Appendix B – Option 4). This option incorporated the latest innovative wall assembly, T-Mass, by Dow Chemical which has an R-value of R-28 (U-value = 0.036). This is a concrete wall assembly with 2 inch concrete, 2-4 inch polyisocyanurate and 4 inch concrete (going from outside to intside). This wall product can be poured-in-place or pre-manufactured and trucked to the site. With this product the exterior walls can be assembled on site in 2-3 days for a house of this size and complexity. Mr. Schingler liked the idea of the thick thermal mass, huge energy savings and the time saving, but he declined to build with T-Mass. The incremental cost of the T-Mass alone compared to a typical framed wall construction was approximately $5,161.00, which was too expensive for Mr. Schingler.

It is interesting to note that while Mr. Schingler declined the use of T-Mass for this project he wants to investigate using it in another high exposure house he plans to build in the City of Tracy's (CA) Parade of Homes in 2004. This project is in the early stages of design at the time of this report.

Stage 5:

After considering various alternatives, Mr. Schingler reiterated his desire to reduce costs and features as much as possible and still meet the 40% energy savings of BAP. He also changed his mind and asked that 1 inch EPS be reintroduced into the project as had been originally recommended. The resulting Option 5 is listed below:

1. The 1 inch EPS foam in the wall system (1-Coat Stucco System)
2. The Night Breeze System by Davis Energy Group
3. The tankless water heater (in conjunction with the Night Breeze System to use as space heating (Hydronic system) for the main house. A 30 gallon gas water heater would be used for the detached Casita.
4. HVAC to be 80% AFUE (Furnace) / 12 SEER with TXV for the main house and 7.0 HSPF (Heatpump) / 12 SEER for the Casita.
5. Using Milgard vinyl frame with spectrally selective glass.

Analysis of Option 5 indicates that it achieves 41% energy savings. ConSol reviewed the costs and benefits of this option with Mr. Schingler and he agreed to building with these features (please reference Appendix B - Option 5).

In terms of the tankless water heater, Mr. Schingler was referred by his plumber to use the Takagi TK-2 with an Energy Factor (EF) of 0.84. However, ConSol was concerned about the hot water output of this system since it would also be used for space heating. Davis Energy Group had mentioned that their Night Breeze System would draw about 5 gallons per minute (gpm) of hot water for space heating. With this, ConSol was concerned that the tankless water heater could only provide 6.9 gpm and might not have sufficient hot water when other appliances (washer and dish washer) and faucets are running at the same time when the space heater is on. ConSol had asked that Davis Energy Group to design and install a relay/switch to automatically make hot water through faucets, showers and appliances the first priority. Space heating would be shut off if the total draw from other appliances, faucets and showers are running when there is not enough hot water for space heating. ConSol then also researched and recommended another tankless water heater product, Rinnai. Rinnai has a product called the Continuum 2520 FFU that can put out 8.5 gpm so that the client would never run out of hot water or would never experience cold water in the shower in a worst case scenario. After having researching and informing Mr. Schingler of this issue, Mr. Schingler appreciated the concern and told ConSol that this residence was only going to be occupied by him and his wife. Running out of hot water would not be an issue and there would likely be a time when all the appliances, faucets, showers and space heating would be running at the same time. However, he would like to install the relay/switch with the Night Breeze System to automatically make space heating the 2nd priority.

Stage 6:

ConSol's mechanical engineer met with Mr. Schingler to discuss the design details of incorporating an engineered HVAC system with the Night Breeze System. In addition, ConSol also worked closely with Davis Energy group to resolve any issues that might occur in the design stage. Mr. Schingler reviewed the mechanical layout and HVAC designs and approved them. The plans were then sent to Davis Energy Group for review and for the addition of the Night Breeze System's components. Davis Energy Group also simulated the Night Breeze System as it is specifically designed for this house using DOE 2.1 software. Through this analysis they determined energy savings for space cooling is 40%. ConSol claimed 40%. In working with Davis Energy group, ConSol also made sure

that Mr. Schingler was able to purchase the right components and integrate his HVAC system with the Night Breeze System and that no components were missing.

Stage 7:

ConSol revised the reference house with the latest BAP benchmark version 3.1 after receiving it and it has the following characteristics (see also Appendix B – Option 6):

Base Case House Characteristics (Stockton, California with 2806 HDD)
The base case house meets the latest BAP Benchmark Version 3.1 and has the following characteristics:

1. Ceiling U-value = 0.036
2. Frame wall U-value = 0.076
3. Air Change per Hour (ACH) = 0.43
4. Fenestration and opaque door U-value = 0.688 and SHGC = 0.581
5. HVAC: 78% AFUE heating & 10.0 SEER (main house) and 6.8 HSPF heating & 10.0 SEER (Casita)
6. Duct Insulation = R-5.00
7. Two 40 gallon gas water heater w/ 36,000 Btu/hr and Energy Factor (EF) = 0.54
8. Lighting Usage based on Navigant 2002 used in Building America's benchmark. Total annual lighting use = (Finish Floor Area * 0.8 + 455) kWh/yr. Garage lighting =100 kWh/yr and exterior lighting = 250 kWh/yr. ([3553 sf. * 0.8 + 455] kWh/yr + 100 kWh/yr + 250 kWh/yr **=** 3647 kWh/yr)

This is the latest option with the most recent BAP benchmark reference home requirements and latest energy savings. With the new reference house requirements, this house now achieves 43% in energy savings.

Prototype Case House Characteristics and Results:

B. 43% Prototype BAP House Characteristics: To achieve 43% energy savings below the base case house, this Prototype BAP House requires the following advanced systems:

1. **R-38 attic insulation (U-value = 0.031)** – higher insulation levels reduce heat gain in summer and reduce heat loss in winter.

2. **Radiant Barrier** – to reduce solar gain and keep attic cool

3. **R-13+1" EPS foam (2x4 portions, U-value = 0.067) and R-19+1" EPS foam (2x6 portions, U-value = 0.054) wall insulation**. **These U-values reflect the 25% framing factor.**

4. **0.36 ACH or Low air infiltration rate**
   Tight building envelope to help minimize outside/inside air from entering/exiting the home. With lower infiltration of unconditioned air and exfiltration of conditioned air, less conditioning is required, making the home more efficient. . Homes with low air infiltration/exfiltration are often quieter and cleaner.

5. **Dual pane non-metal frame windows with spectrally selective glass with U- factor and Solar Heat Gain Coefficient no greater than the following:**

	U-value	Solar Heat Gain Coefficient (SHGC)
Slider	= 0.38	0.29
Single Hung	= 0.39	0.29
Fixed	= 0.35	0.30
Sliding Patio Dr.	= 0.34	0.31
Casement	= 0.36	0.26
French Dr.	= 0.30	0.33

   These types of glazing help increase the comfort level of the home by reducing solar insolation into the house. In summer, spectrally selective glass lets in visible sunlight while blocking 80% of both the infrared and ultraviolet solar energy that drives up cooling costs and degrades curtains, window treatments, carpeting and furnishings. In winter, these glazing products offer reduced heating costs by reflecting room-side radiant heat back into the room[1]. In hot climates this type of glazing typically enables builders to reduce the size of air conditioners and decrease other building energy related features.

6. **Engineered System with Heating Ventilating and Air Conditioning (HVAC) efficiencies of: 83.9% for furnace / 12.0 SEER for AC with thermal expansion valve (TXV) in conjunction with the Night Breeze System developed by Davis Energy Group – (Hydronic space heating system for the main house) & 7.0 HSPF / 12 SEER (Casita)** - Licensed mechanical engineers size and select HVAC systems, design duct sizes and register locations. The final product of these engineered systems will have properly sized and balanced HVAC systems with correct duct sizes and placement of registers to assure that conditioned air will be evenly distributed throughout the whole house. They will also provide improved efficiency and comfort. The TXV is a metering device for refrigerant flow into the

[1] Supplemental Catalogue for Cardinal IG: LoE^2 Glass Products "The Choice for Year-Round Energy Savings and Comfort"

evaporator of an air conditioner. A TXV improves efficiency and mitigates the effect of a system with improper refrigerant charge. This home incorporates Hydronic space heating using the Night Breeze System with the tankless water heater. In addition, the Night Breeze System acts as an economizer pulling in cooler outside air to cool the house when the outside air temperature is 5 degrees cooler than the inside air temperature. Simulations using the DOE 2.1E software by Davis Energy Group using Night Breeze System in homes in similar climate regions have an annual cooling savings of 40%. ConSol claims 40% reduction in cooling reduction. (See brochures on the Night Breeze System at http://www.davisenergy.com/nb_page.htm .)

7. **R-4.2 insulation with Tight duct and ACCA Manual D design by a licensed mechanical engineer (ducts to be buried in insulation).**
Duct leakage can have a significant impact on HVAC performance, household infiltration/exfiltration rates, moisture levels in the house, water heater and furnace safety, and overall occupant comfort. A tight duct system is one that does not leak more than 6% of the fan airflow. Excessive air leakages in duct systems make HVAC systems work harder, using more time and energy to cool or heat the home due to insufficient air delivery. This results in higher energy bills and less comfort for homeowners/occupants, which often triggers callbacks. Duct leakage typically occurs at:
   - Poorly fitted and improperly sealed joints and seams in the ductwork
   - Disconnected and partially disconnected boot connections
   - Holes in the ducts
   - Use of improperly sealed building cavities for supply and return ducts
   - Poor connections between room registers and register boots
   - Poorly fitted air handler doors, filter doors and air handler cabinets

   Tight duct systems increase forced air distribution efficiency, resulting in improved comfort and lower utility bills for homeowners. According to data found in CARB Newsletter, link: http://www.carb-swa.com/PDF%, ducts with R-4.2 insulation buried in attic insulation have equivalent of R-values of an R-13. All ducts should be fully buried in insulation to achieve this level.

8. **One Tankless water heater w/ a minimum Energy Factor (EF) of 0.84 at main house and one 30 gallon gas water heater w/ an EF of 0.57 at Casita. R-4 insulation on all trunk lines of both hot water tanks. This includes any hot water lines located in concrete slabs or underground** - A tankless water heater has high efficiencies. Hot water is heated upon demand and has no storage tank. Tankless water heater is also used in conjunction with the Night Breeze System as space heating (Hydronic fancoil heating system).

9. **All-fluorescent lighting** – The wide variety of improved quality, more efficient lighting that are on the market today warrant more careful lighting design. Lighting plans are recommended and fluorescent lamps used wherever possible.

Where possible, in compact-fluorescent fixtures use bayonet-mount fluorescent; where this is not possible, medium-base CFLs are permitted. Minimum recommended downlight specifications of fluorescent lamps should be 2700K in color temperature, 26 watts and 1300 lumens. Vanity lighting requirements may vary.

Calculations for lighting energy usage in Prototype BAP House:
Lighting plan for this house shows
- 9 permanent fluorescent fixtures (estimated at 100 W each)
- 65 indoor/outdoor medium-base incandescent fixtures (at 100 W each)

74 total

Yearly lighting kWh/yr savings: for BAP Benchmark House
9 * 100 W = 900 W
65 * 100 W = 6,500 W
Total = 7,400 W

[7400 * 1kW / 1000 W] * X hours * 365 Days = 3647 kWh

Hours = 1.35, and so 7,400 watt operating at an average 1.35 hours/day at 365 days/year = 7,400 W*1kW/1000W*1.35 hours/day*365 days/year = 3647 kWh/yr

43% BAP Prototype House - Switching to CFLs:
9 * 26 W = 234 W
65 * 26 W = 1690 W
Total = 1,924 W

1,924 watt operating at an average 1.35 hours/day at 365 days/year = 1,924 W*1kW/1000W*1.35 hours/day*365 days/year = 948 kWh/yr

Total kWh/yr savings = [[3647 kWh/yr – 948 kWh/yr] / 3647 kWh/yr] * 100 = 74%

Percent savings when switching from incandescent to compact fluorescent lamps (CFLs) = 74%.

10. **Gas dryer stub** – provided to encourage the use of gas dryers which are less expensive to operate than electric.

Approach to achieve 43% energy savings in the BAP Prototype House.
(See Appendix B - Option 6)

Base Case / Building America benchmark energy uses are derived as follows:
Heating (from Micropas simulation) = 30.32 kBtu/sf-yr

Therms = [30.32 kBtu/sf-yr * 3553 sf] = 107,727 kBtu/yr

Cooling (from Micropas simulation) = 13.33 kBtu/sf-yr
kWh = [13.33 kBtu/sf-yr * 3553 sf] = 47,361 kBtu/yr

Water Heating (from Micropas simulation) = 10.14 kBtu/sf-yr
Therms = [10.14 kBtu/sf-yr * 3553 sf] = 36,027 kBtu/yr

Lighting = 37,342 kBtu/yr

Other Uses/Appliances/Plug Loads = 87,838 kBtu/yr

Total = 316,296 kBtu/yr

43% BAP Prototype House Energy uses are derived as follows:
Heating (from Micropas simulation) = 14.60 kBtu/sf-yr
Therms = [14.60 kBtu/sf-yr * 3553 sf] = 51,874 kBtu/yr

Cooling (from Micropas simulation) = 1.68 kBtu/sf-yr
kWh = [1.68 kBtu/sf-yr * 3553 sf] = 5,969 kBtu/yr

Water Heating (from Micropas simulation) = 6.90 kBtu/sf-yr
Therms = [6.90 kBtu/sf-yr * 3553 sf] = 24,516 kBtu/yr

Lighting = 9,707 kBtu/yr

Other Uses/Appliances/Plug Loads = 86,765 kBtu/yr

Total = 178,831 kBtu/yr

Overall, the total energy savings is: [[316,296 kBtu/yr – 178,831 kBtu/yr] / 316,296 kBtu/yr] *100= 43% Energy Savings

The annual kBtu/year reduced from the benchmark base case house to the Prototype BAP House is from 316,296 kBtu/year to 178,831 kBtu/year source energy. In San Joaquin County, California, the price of gas/therm is approximately $1.00 and the price of electricity/kWh is approximately $0.15. The projected utility bill per year for this base case house is $3,928.98. With the upgrades for the 42% Prototype BAP House, the annual bill is estimated to be $2,186.99, which is an approximate savings of $1,741 or 43%.

Enhancing the building features in making this home reach the 43% energy savings level will cost approximately $6,480.00, including savings from HVAC downsizing. The simple payback is estimate to be 3.7 years. The unit costs, on page 1 of Appendix B - Option 6, are from medium to large production home building companies.

Installation of Insulation

An aspect of quality construction is the proper installation of insulation, which provides an additional energy savings compared to typical (base-case) construction. Recent and past research in California and by ORNL have shown that quality insulation installation can result in heating and cooling savings of 10% or more. This savings can be achieved, as reported by the California Institute for Energy Efficiency (CIEE), by following a protocol called "Quality Installation of Insulation"[2]. The purpose of envelope insulation is to provide a continuous thermal barrier to minimize heat flow through walls, ceilings and floors. Insulation serves to keep a home comfortable and reduce costs for heating and cooling. The home will not be as comfortable and energy costs will be increased if insufficient insulation is installed, or if it is installed incorrectly. Examples of incorrect installations are compressed areas of insulation or gaps in the insulation. With a little additional care insulation can easily be installed correctly.

The above studies have found that over one-third of new homes have lower levels of insulation installed than specified and an additional one-fifth of the homes have serious installation problems that will result in significantly decreased effectiveness of the insulation. For example, thermal shorts and insulation flaws can degrade an R-19 stud wall to as low as R-11. Installation problems include insulation installed with rounded shoulders, compressed around electrical wiring, voids, and with the facing stapled to the inside of the stud[3]. In addition, virtually all of the new production homes studied were found to have numerous insulation installation defects that reduce the performance of the insulation well below its rated R-value. In addition to causing unnecessary energy losses and comfort problems for occupants, these installation shortcomings can lead to defect litigation.

Builders can minimize energy losses, prevent litigations and add 10% or more in energy savings using quality installation of insulation verified through 3rd party inspections. This savings is sufficiently well established that the California Energy Commission provides a Title 24 credit for following the installation protocols and using 3rd party inspections. For this credit, inspections of installation of insulation must be done by a California Energy Commission certified Home Energy Efficiency Rating System (C-HERS) raters. Raters provide a second set of eyes to help identify specific areas where improvements can be made while at the location. (*Inspections and diagnostics give subcontractors immediate feedback enabling them to take corrective action and to learn how to routinely perform improved quality construction. Raters can also conduct other tests for Title 24 compliance credit such as tightness of the building shell and the HVAC ducts. Raters' tests and inspections are essential to certify that homes are compliant with building codes or other energy efficient program requirements. Inspections and diagnostics serve as quality control to ensure that contractors maintain high quality construction practices*

[2] Protocols for Energy Efficient Residential Building Envelopes, CIEE Project Report, January 1999, Robert W. Hammon, Ph.D.

[3] Energy Design Update, September 1999

and assure the builders and homebuyers get a well made home. These procedures should also decrease construction costs by decreasing callbacks).

BIRA did not take this 10% for quality installation of insulation. However, procedures in the protocol should be followed to achieve maximum energy savings.

Conclusion:

ConSol has achieved in promoting the Building America Program energy efficiency measures to Mr. Schingler. It was a long but productive process in trying to achieve the 43% energy savings level. Every step of each option was carefully reviewed and analyzed both by ConSol and the client to make sure it was cost effective. ConSol also worked well in conjunction with Davis Energy Group and other trades in the planning and design stage to resolve any issues that occurred. Mr. Schingler started construction already and is looking forward towards living in a Building America Program energy efficient home. He also intends to work with ConSol to design and construct other BAP homes.

Appendix A Schingler Home Plans

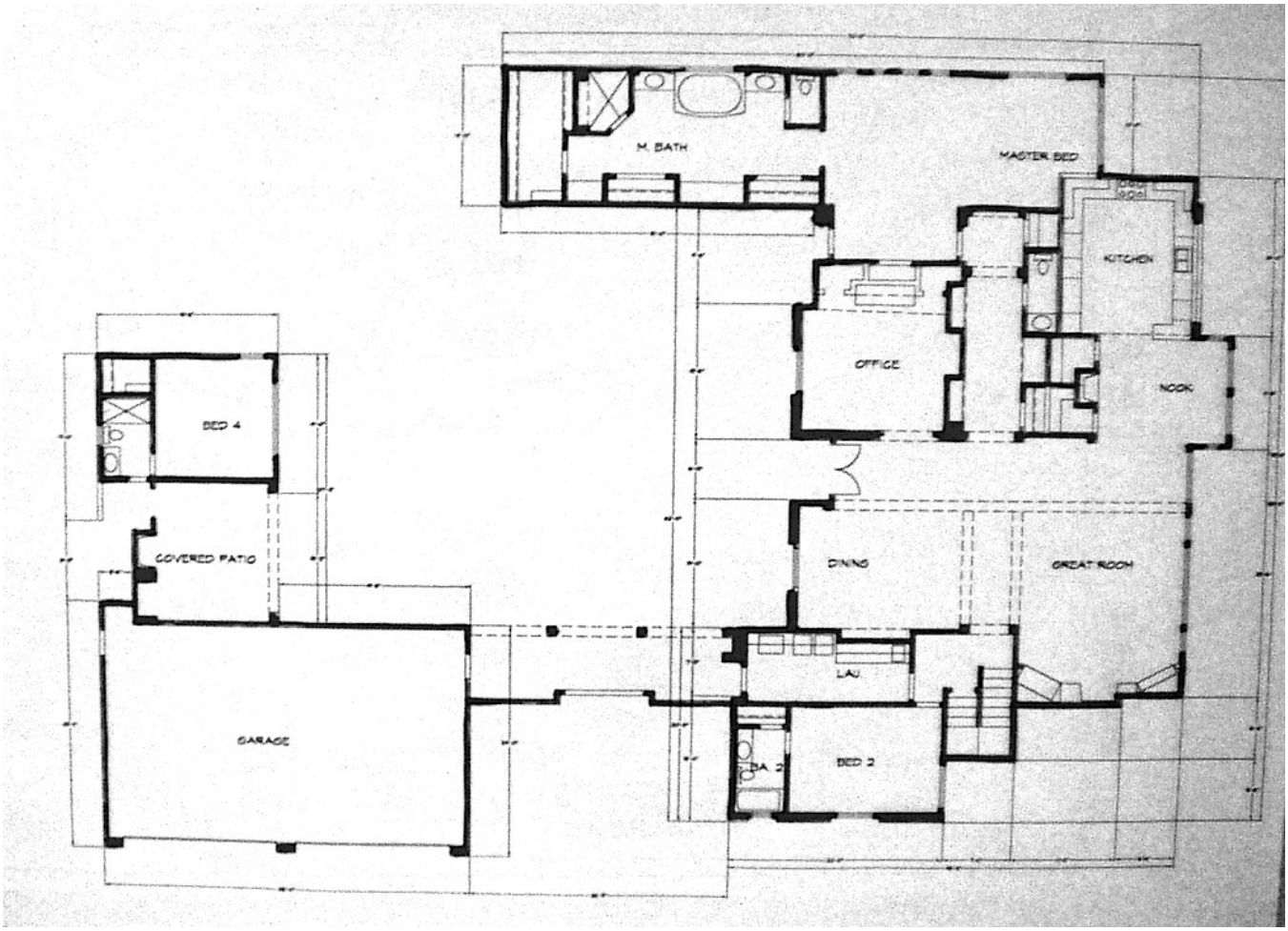

Fig. 3 Schingler Home First Floor Plan.

Appendix A-Schingler Home, Plans, Elevations & Sections

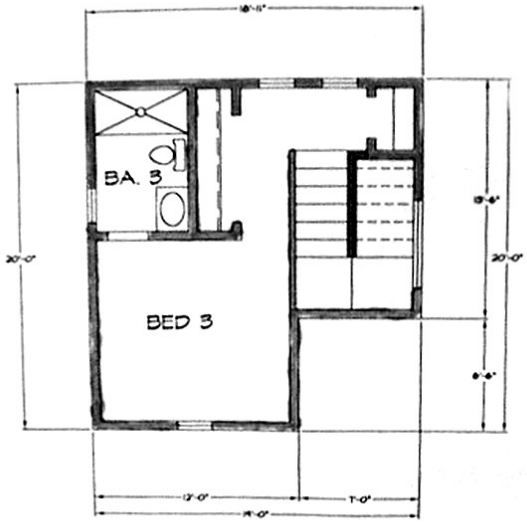

Fig. 4. Schingler Home Second Floor Plan.

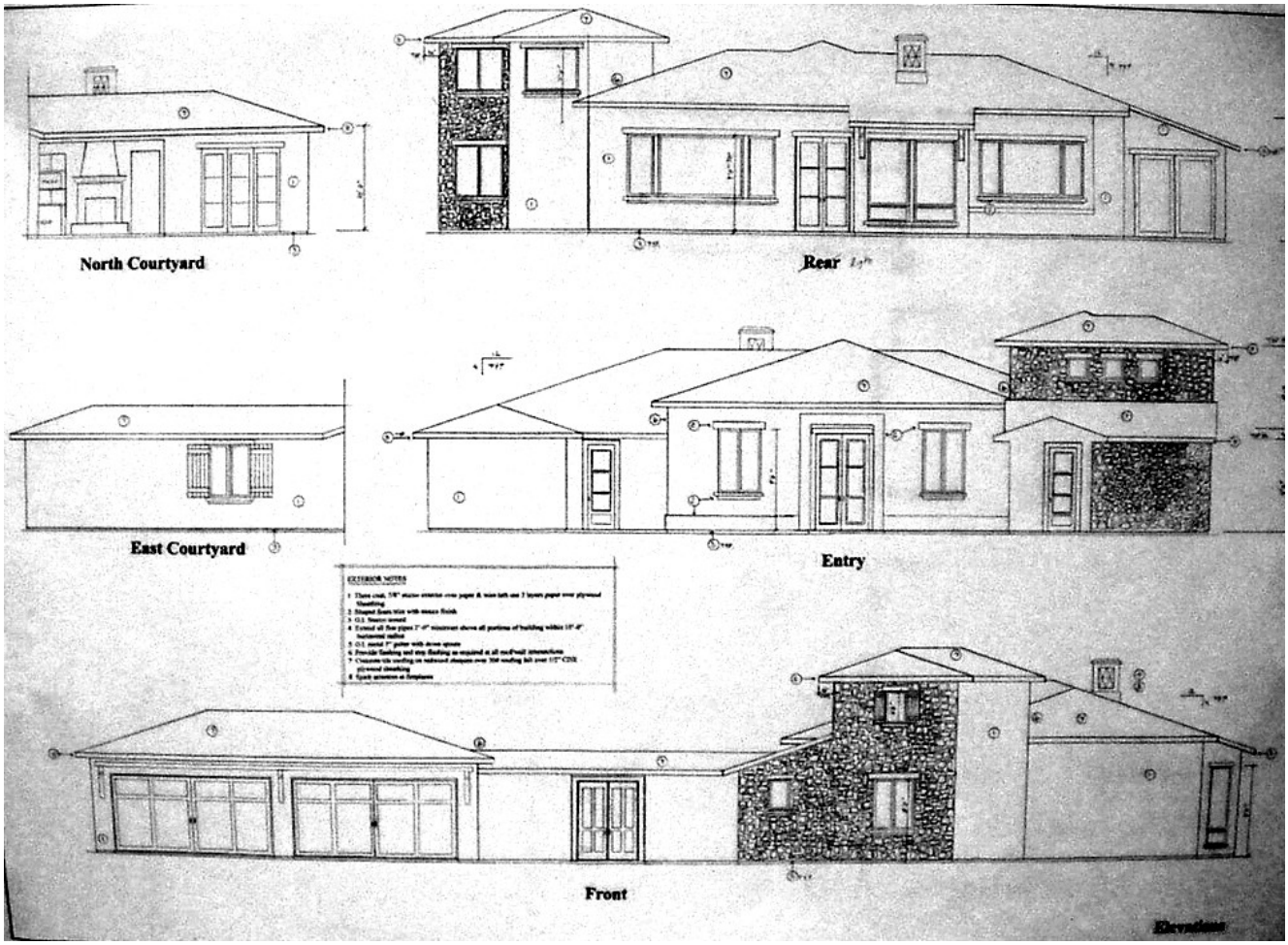

Fig. 5 Schingler Home Elevations 1

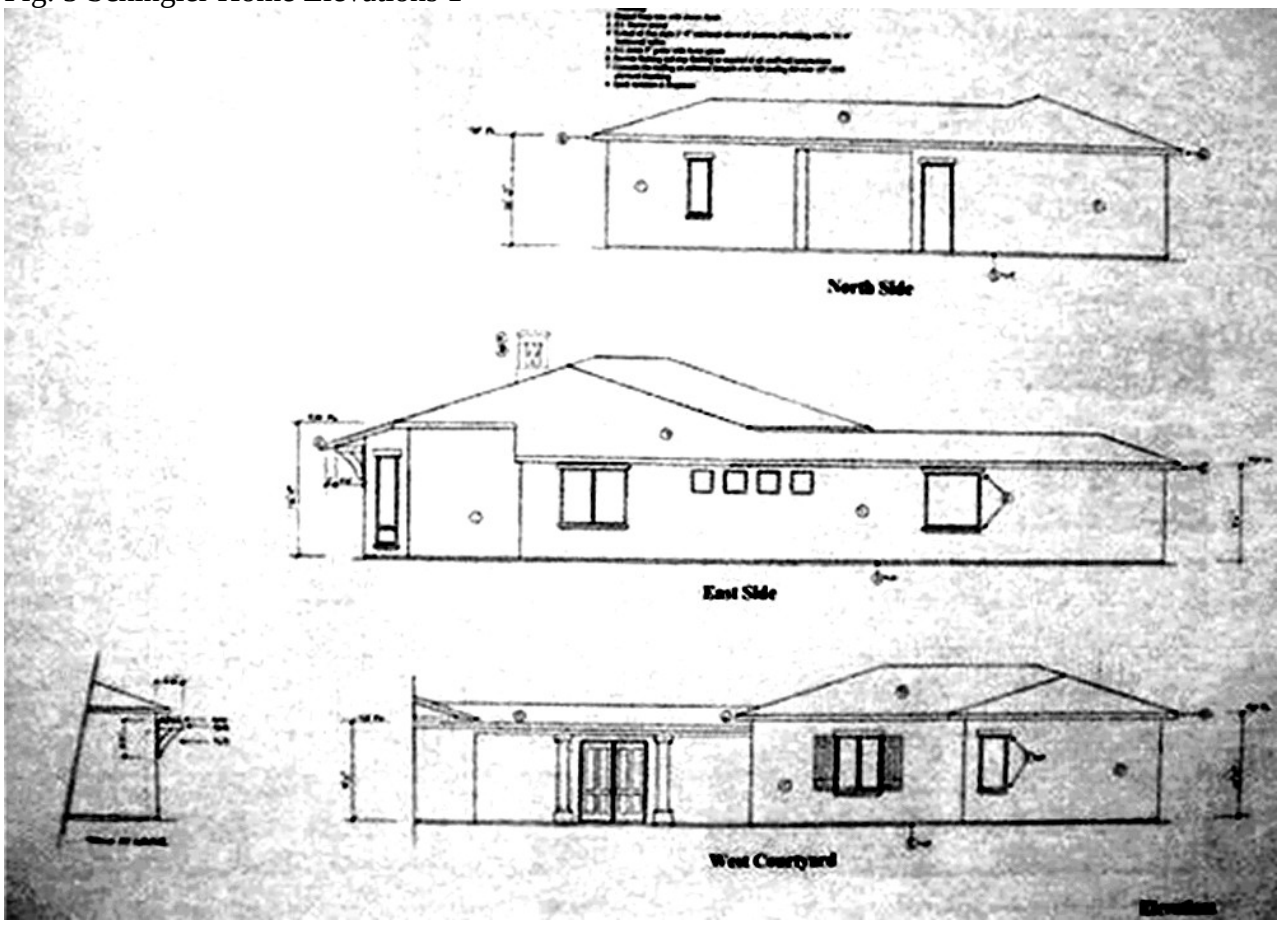

Fig. 6 Schingler Home Elevations 2.

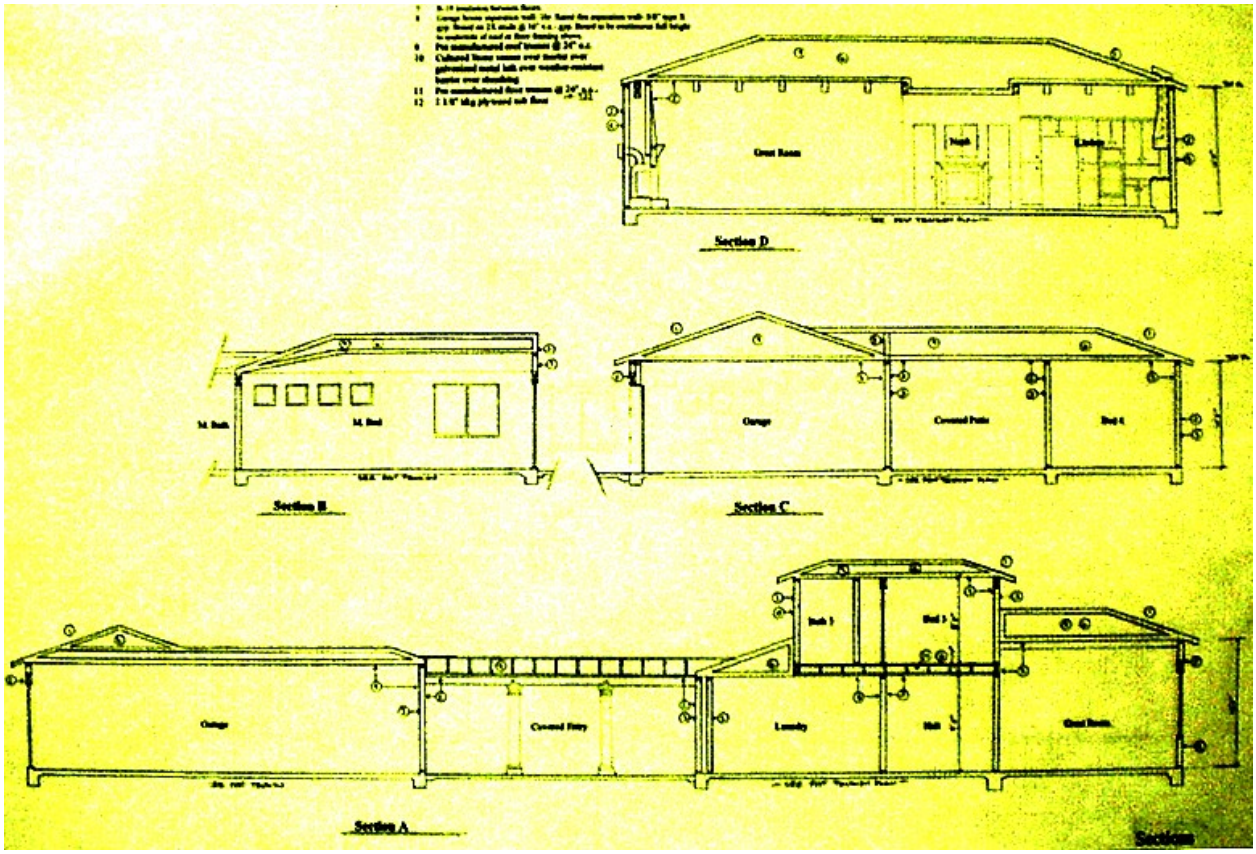

Fig. 7 Schingler Home Sections.

Appendix B – Schingler Home Energy Analyses, Options 1 – 6.

Option 1
Schingler Residence **(w/ 1 inch EPS Foam)**
Floor Area = **3,553** **Sqft**
Stockton, CA

Energy and Cost Analysis for Base Case and BA Prototype Houses

	Base Case / BA Benchmark House (kBtu/sf-yr)	Base Case / BA Benchmark House (kBtu/yr)	Prototype House - 40% Energy Savings Features (kBtu/sf-yr)	Prototype House - 40% Energy Savings Features (kBtu/yr)	Reduction in Energy Use (kBtu/yr)	Estimated Incr. Cost: Base to Prototype House (40% Energy Savings Level)
Heating	31.52	111,991	14.29	50,772		
Cooling	9.74	34,606	1.79	6,360		
Water Heating	10.14	36,027	4.81	17,090		
Total	51.40	**182624**	20.89	**74222**	**59.4%**	
Lighting		37,342		9,707		
Total (Heat, Cool, WH and Lighting)		**219,966**		**83,929**	**62%**	
Other Uses		87,838		86,765		
Total (Heat, Cool, WH, Lighting & Other Uses)		**307,804**		**170,694**	**45%**	
Site Generation (2kW PV)				-		
Overall Total Energy Savings		**307,804**		**170,694**	**44.5%**	
ENVELOPE: (Insulation U-Values or R-Values)						
Roof (attic)	R-30		**38 (U-value = 0.025)**			$517
Roof (at furnace)	R-30		**19 (U-value = 0.047)**			
Wall (2x4 Exterior)	U-value = 0.082		**13+1 inch EPS (U-value = 0.067)**	**(25% Framing factor)**		$300
Wall (2x6 Exterior)	U-value = 0.082		**19+1 inch EPS (U-value = 0.054)**	**(25% Framing factor)**		$300
Wall (Kneewall)	U-value = 0.082		**13 (U-value = 0.102)**	**(25% Framing factor)**		
Floor (above garage)	N/A		N/A			
Floor (cantilever)	N/A		N/A			
Attic Radiant Barrier	No		**Yes**			$588
Low Air Infiltration	No		**Yes, SLA less than 3.5**			
GLAZING:						
U-Factor			**Milgard Vinyl Frame Windows w/ Spectrally Selective Glass**			
Slider (horz)*	0.60		**0.38**			$950
Slider (vert)*	0.60		**0.39**			(For total glass
Fixed*	0.60		**0.35**			in the house)
Patio*	0.60		**0.34**			
Casement / Awning*	0.60		**0.36**			
French Doors*	0.60		**0.35**			
SHGC						
Slider (horz)*	0.40		**0.29**			
Slider (vert)*	0.40		**0.29**			
Fixed*	0.40		**0.30**			
Patio*	0.40		**0.31**			
Casement / Awning*	0.40		**0.26**			
French Doors*	0.40		**0.35**			
HVAC SYSTEM:						
Furnace: AFUE (Main House) / HSPF (Casita)	0.78 (AFUE) / 6.8 (HSPF)		**0.95 (AFUE - Main House) / 8.0 (HSPF - Casita)**			$750
A/C: SEER	10 SEER		**16.0 (Main House) / 12.0 (Casita)**			$1,300
Duct Insulation / Location	5.00		**13.0 (buried in insulation)**			$150
Duct Testing	No		**Yes**			
ACCA Manual D	No		**Yes**			
WATER HEATING:						
Water Heater Size	40 gal		**Tankless**			$1,000
Energy Factor	0.54		**0.84**			
Distribution Type	Standard		**Pipe Insulation**			$75
External Wrap	R-12		**None**			
Solar Credit	None		None			
3rd Party Inspections and Testing (In ComfortWise Program)						$440
Gas dryer stub						$75
Fluorescent lighting (screw-in lamps)						$60
Total Estimated Incremental Cost						$6,505

Option 1

Comparison of Total Energy Use

	Base Case / BA Benchmark House			**BA Prototype House** - 40% Energy Savings (Upgraded Features, Fluorescent, Gas Dryer Stub & Tankless Hot Water)		
	\		Dollars	Energy Use		Dollars
	Therms	kWh	$	Therms	kWh	$
Energy Code Related						
Space Heating	1120		$ 1,119.91	508		$ 507.72
Space Cooling		3,380	$ 506.98		621	$ 93.17
Water Heating	360		$ 360.27	171		$ 170.90
Other Uses						
cooking	78		$ 78.00	78		$ 78.00
dishwasher		240	$ 36.00		240	$ 36.00
electric or gas dryer		974	$ 146.10	89		$ 89.00
refrigerator		669	$ 100.35		669	$ 100.35
Miscellaneous (Appliances + Plug)		5,934	$ 890.10		5,934	$ 890.10
Lighting		3,647	$ 547.05		948	$ 142.20
reduce kWh by solar contribution		n/a	n/a		-	$ -
Total use	1558	14,844	$ 3,784.76	846	8,412	2,107.44

Total Annual Energy Use		307,804	kBtu/yr		170,694	kBtu/yr
Reduction in Energy Use			100%	46%	43%	44%
Total for Column in kBtu/yr	155,818	151,986		84,562	86,132	

Total kBtu/yr for BA Benchmark House	307,804	kBtu/yr
Total kBtu/yr for Prototype House	170,694	kBtu/yr
Percent End Use Energy Savings	**44.5%**	

Estimated Montly Energy Bill			$ 315.40	/mo	$ 175.62	/mo
Reduction in Energy Cost					56%	

price of gas/therm	$1.00
price of electricity/kWh	$0.15

Option 2
Schingler Residence
Floor Area = 3,553 Sqft
Stockton, CA

Energy and Cost Analysis for Base Case and BA Prototype Houses

	Base Case / BA Benchmark House (kBtu/sf-yr)	Base Case / BA Benchmark House (kBtu/yr)	Prototype House - 40% Energy Savings Features (kBtu/sf-yr)	Prototype House - 40% Energy Savings Features (kBtu/yr)	Reduction in Energy Use (kBtu/yr)	Estimated Incr. Cost: Base to Prototype House (40% Energy Savings Level)
Heating	31.52	111,991	14.34	50,950		
Cooling	9.74	34,606	1.72	6,111		
Water Heating	10.14	36,027	4.81	17,090		
Total	51.40	**182624**	20.87	**74151**	**59.4%**	
Lighting		37,342		9,707		
Total (Heat, Cool, WH and Lighting)		**219,966**		**83,858**	**62%**	
Other Uses		87,838		86,765		
Total (Heat, Cool, WH, Lighting & Other Uses)		**307,804**		**170,623**	**45%**	
Site Generation (2kW PV)				-		
Overall Total Energy Savings		**307,804**		**170,623**	**44.6%**	
ENVELOPE: (Insulation U-Values or R-Values)						
Roof (attic)	R-30		**49 (U-value = 0.019)**			$840
Roof (at furnace)	R-30		**19 (U-value = 0.047)**			
Wall (2x4 Exterior)	U-value = 0.082		**15 (U-value = 0.091)**	**(25% Framing factor)**		$1,407
Wall (2x6 Exterior)	U-value = 0.082		**21 (U-value = 0.066)**	**(25% Framing factor)**		
Wall (Kneewall)	U-value = 0.082		**15 (U-value = 0.091)**	**(25% Framing factor)**		
Floor (above garage)	N/A		N/A			
Floor (cantilever)	N/A		N/A			
Attic Radiant Barrier	No		**Yes**			$588
Low Air Infiltration	No		**Yes, SLA = 3.1**			
GLAZING:						
U-Factor			**Dual Pane Non-Metal Frame Windows w/ Spectrally Selective Glass**			
Slider (horz)*	0.60		**0.29**			$950
Slider (vert)*	0.60		**0.29**			(For total glass
Fixed*	0.60		**0.29**			in the house)
Patio*	0.60		**0.29**			
Casement / Awning*	0.60		**0.29**			
French Doors*	0.60		**0.29**			
SHGC						
Slider (horz)*	0.40		**0.26**			
Slider (vert)*	0.40		**0.26**			
Fixed*	0.40		**0.26**			
Patio*	0.40		**0.26**			
Casement / Awning*	0.40		**0.26**			
French Doors*	0.40		**0.26**			
HVAC SYSTEM:						
Furnace: AFUE (Main House) / HSPF (Casita)	0.78 (AFUE) / 6.8 (HSPF)		**0.95 (AFUE - Main House) / 8.0 (HSPF - Casita)**			$750
A/C: SEER	10 SEER		**16.0 (Main House) / 12.0 (Casita)**			$1,300
Duct Insulation / Location	5.00		**13 (buried in insulation)**			$150
Duct Testing	No		**Yes**			
ACCA Manual D	No		**Yes**			
WATER HEATING:						
Water Heater Size	40 gal		**Tankless**			$1,000
Energy Factor	0.54		**0.84**			
Distribution Type	Standard		**Pipe Insulation**			$75
External Wrap	R-12		**None**			
Solar Credit	None		None			
3rd Party Inspections and Testing (In ComfortWise Program)						$440
Gas dryer stub						$75
Fluorescent lighting (screw-in lamps)						$60
Total Estimated Incremental Cost						$7,634

Option 2

Comparison of Total Energy Use

	Base Case / BA Benchmark House			**BA Prototype House** - 40% Energy Savings (Upgraded Features, Fluorescent, Gas Dryer Stub % Tankless Hot Water)		
	\		Dollars	Energy Use		Dollars
	Therms	kWh	$	Therms	kWh	$
Energy Code Related						
Space Heating	1120		$ 1,119.91	510		$ 509.50
Space Cooling		3,380	$ 506.98		597	$ 89.53
Water Heating	360		$ 360.27	171		$ 170.90
Other Uses						
cooking	78		$ 78.00	78		$ 78.00
dishwasher		240	$ 36.00		240	$ 36.00
electric or gas dryer		974	$ 146.10	89		$ 89.00
refrigerator		669	$ 100.35		669	$ 100.35
Miscellaneous (Appliances + Plug)		5,934	$ 890.10		5,934	$ 890.10
Lighting		3,647	$ 547.05		948	$ 142.20
reduce kWh by solar contribution		n/a	n/a			
Total use	1558	14,844	$ 3,784.76	847	8,388	2,105.58

Total Annual Energy Use		307,804	kBtu/yr		170,623	kBtu/yr
Reduction in Energy Use			100%	46%	43%	44%
Total for Column in kBtu/yr	155,818	151,986		84,740	85,883	
Total kBtu/yr for BA Benchmark House	307,804	kBtu/yr				
Total kBtu/yr for Prototype House	170,623	kBtu/yr				
Percent End Use Energy Savings	**44.6%**					
Estimated Montly Energy Bill			$ 315.40 /mo			$ 175.46 /mo
Reduction in Energy Cost						56%
price of gas/therm	$1.00					
price of electricity/kWh	$0.15					

Option 3
Schingler Residence w/ Night Breeze System
Floor Area = 3,553 Sqft
Stockton, CA

Cooling budget is 2.48 and 25% reduction of this is 1.86

Energy and Cost Analysis for Base Case and BA Prototype Houses

	Base Case / BA Benchmark House (kBtu/sf-yr)	Base Case / BA Benchmark House (kBtu/yr)	Prototype House - 40% Energy Savings Features (kBtu/sf-yr)	Prototype House - 40% Energy Savings Features (kBtu/yr)	Reduction in Energy Use (kBtu/yr)	Estimated Incr. Cost: Base to Prototype House (40% Energy Savings Level)	
Heating	31.52	111,991	16.60	58,980			
Cooling	9.74	34,606	1.86	6,609			
Water Heating	10.14	36,027	4.93	17,516			
Total	51.40	**182624**	23.39	**83105**	**54.5%**		
Lighting		37,342		9,707			
Total (Heat, Cool, WH and Lighting)		**219,966**		**92,811**	**58%**		
Other Uses		87,838		86,765			
Total (Heat, Cool, WH, Lighting & Other Uses)		**307,804**		**179,577**	**42%**		
Site Generation (2kW PV)				-			
Overall Total Energy Savings		**307,804**		**179,577**	**41.7%**		
ENVELOPE: (Insulation U-Values or R-Values)							
Roof (attic)	R-30		**38 (U-value = 0.025)**			$517	
Roof (at furnace)	R-30		**19 (U-value = 0.047)**				
Wall (2x4 Exterior)	U-value = 0.082		**15 (U-value = 0.091)**	**(25% Framing factor)**		$1,407	
Wall (2x6 Exterior)	U-value = 0.082		**21 (U-value = 0.066)**	**(25% Framing factor)**		(Total wall insulation)	
Wall (Kneewall)	U-value = 0.082		**15 (U-value = 0.091)**	**(25% Framing factor)**			
Floor (above garage)	N/A		N/A				
Floor (cantilever)	N/A		N/A				
Attic Radiant Barrier	No		**Yes**			$588	
Low Air Infiltration	No		**Yes, SLA = 3.5**				
GLAZING:							
U-Factor			**Dual Pane Non-Metal Frame Windows w/ Spectrally Selective Glass**				
Slider (horz)*	0.60		**0.38**			$950	
Slider (vert)*	0.60		**0.39**			(For total glass	
Fixed*	0.60		**0.35**			in the house)	
Patio*	0.60		**0.34**				
Casement / Awning*	0.60		**0.36**				
French Doors*	0.60		**0.35**				
SHGC							
Slider (horz)*	0.40		**0.29**				
Slider (vert)*	0.40		**0.29**				
Fixed*	0.40		**0.30**				
Patio*	0.40		**0.31**				
Casement / Awning*	0.40		**0.26**				
French Doors*	0.40		**0.35**				
HVAC SYSTEM:							
Furnace: AFUE (Main House) / HSPF (Casita)	0.78 (AFUE) / 6.8 (HSPF)		**0.90 (AFUE - Main House) / 6.8 (HSPF - Casita)**			$1,800	(Night Breeze System)
A/C: SEER	10 SEER		**14.0 (Main House) / 10.0 (Casita)**			$675	
Duct Insulation / Location	5.00		**13 (buried in insulation)**			$150	
Duct Testing	No		**Yes**				
ACCA Manual D	No		**Yes**				
WATER HEATING:							
Water Heater Size	40 gal		**Tankless**			$1,000	
Energy Factor	0.54		**0.82**				
Distribution Type	Standard		**Pipe Insulation**			$75	
External Wrap	R-12		**None**				
Solar Credit	None		None				
3rd Party Inspections and Testing (In ComfortWise Program)						$440	
Gas dryer stub						$75	
Fluorescent lighting (screw-in lamps)						$60	
Total Estimated Incremental Cost						$7,736	

Option 3

Comparison of Total Energy Use

	Base Case / BA Benchmark House			**BA Prototype House** - 40% Energy Savings (Upgraded Features, Fluorescent, Gas Dryer Stub & Tankless Hot Water)		
	\		Dollars	Energy Use		Dollars
	Therms	kWh	$	Therms	kWh	$
Energy Code Related						
Space Heating	1120		$ 1,119.91	590		$ 589.80
Space Cooling		3,380	$ 506.98		645	$ 96.81
Water Heating	360		$ 360.27	175		$ 175.16
Other Uses						
cooking	78		$ 78.00	78		$ 78.00
dishwasher		240	$ 36.00		240	$ 36.00
electric or gas dryer		974	$ 146.10	89		$ 89.00
refrigerator		669	$ 100.35		669	$ 100.35
Miscellaneous (Appliances + Plug)		5,934	$ 890.10		5,934	$ 890.10
Lighting		3,647	$ 547.05		948	$ 142.20
reduce kWh by solar contribution		n/a	n/a		-	$ -
Total use	1558	14,844	$ 3,784.76	932	8,436	2,197.43

Total Annual Energy Use		307,804	kBtu/yr		179,577	kBtu/yr	
Reduction in Energy Use			100%	40%	43%		42%
Total for Column in kBtu/yr	155,818	151,986		93,196	86,381		
Total kBtu/yr for BA Benchmark House	307,804	kBtu/yr					
Total kBtu/yr for Prototype House	179,577	kBtu/yr					
Percent End Use Energy Savings	**41.7%**						
Estimated Montly Energy Bill			$ 315.40	/mo		$ 183.12	/mo
Reduction in Energy Cost						58%	
price of gas/therm	$1.00						
price of electricity/kWh	$0.15						

Option 4
Schingler Residence w/ Night Breeze System and T-Mass Walls
Floor Area = 3,553 Sqft
Stockton, CA

Energy and Cost Analysis for Base Case and BA Prototype Houses

	Base Case / BA Benchmark House (kBtu/sf-yr)	Base Case / BA Benchmark House (kBtu/yr)	Prototype House - 40% Energy Savings Features (kBtu/sf-yr)	Prototype House - 40% Energy Savings Features (kBtu/yr)	Reduction in Energy Use (kBtu/yr)	Estimated Incr. Cost: Base to Prototype House (40% Energy Savings Level)	
Heating	31.52	111,991	13.48	47,894			
Cooling	9.74	34,606	0.00	-			
Water Heating	10.14	36,027	4.93	17,516			
Total	51.40	**182624**	18.41	**65411**	**64.2%**		
Lighting		37,342		9,707			
Total (Heat, Cool, WH and Lighting)		**219,966**		**75,117**	**66%**		
Other Uses		87,838		86,765			
Total (Heat, Cool, WH, Lighting & Other Uses)		**307,804**		**161,883**	**47%**		
Site Generation (2kW PV)				-			
Overall Total Energy Savings		**307,804**		**161,883**	**47.4%**		
ENVELOPE: (Insulation U-Values or R-Values)							
Roof (attic)	R-30		**38 (U-value = 0.025)**			$517	
Roof (at furnace)	R-30		**19 (U-value = 0.047)**				
Wall (2x4 Exterior)	U-value = 0.082		**28 (U-value = 0.036)**			$30,720	
Wall (2x6 Exterior)	U-value = 0.082		**28 (U-value = 0.036)**			(Total wall cost)	
Wall (Kneewall)	U-value = 0.082		**15 (U-value = 0.091)**	**(25% Framing factor)**			
Floor (above garage)	N/A		N/A				
Floor (cantilever)	N/A		N/A				
Attic Radiant Barrier	No		**Yes**			$588	
Low Air Infiltration	No		**Yes, SLA = 3.5**				
GLAZING:							
U-Factor			**Dual Pane Non-Metal Frame Windows w/ Spectrally Selective Glass**				
Slider (horz)*	0.60		**0.38**			$950	
Slider (vert)*	0.60		**0.39**			(For total glass	
Fixed*	0.60		**0.35**			in the house)	
Patio*	0.60		**0.34**				
Casement / Awning*	0.60		**0.36**				
French Doors*	0.60		**0.35**				
SHGC							
Slider (horz)*	0.40		**0.29**				
Slider (vert)*	0.40		**0.29**				
Fixed*	0.40		**0.30**				
Patio*	0.40		**0.31**				
Casement / Awning*	0.40		**0.26**				
French Doors*	0.40		**0.35**				
HVAC SYSTEM:							
Furnace: AFUE (Main House) / HSPF (Casita)	0.78 (AFUE) / 6.8 (HSPF)		**0.90 (AFUE - Main House) / 6.8 (HSPF - Casita)**			$1,800	(Night Breeze System)
A/C: SEER	10 SEER		**14.0 (Main House) / 10.0 (Casita)**			$675	
Duct Insulation / Location	5.00		**13 (buried in insulation)**			$150	
Duct Testing	No		**Yes**				
ACCA Manual D	No		**Yes**				
WATER HEATING:							
Water Heater Size	40 gal		**Tankless**			$1,000	
Energy Factor	0.54		**0.82**				
Distribution Type	Standard		**Pipe Insulation**			$75	
External Wrap	R-12		**None**				
Solar Credit	None		None				
3rd Party Inspections and Testing (In ComfortWise Program)						$440	
Gas dryer stub						$75	
Fluorescent lighting (screw-in lamps)						$60	
Total Estimated Incremental Cost						$37,050	
Typical Cost for Framed Wall Construction						$25,559	
					Net Cost	**$11,491**	

Option 4

Comparison of Total Energy Use

	Base Case / BA Benchmark House			**BA Prototype House** - 40% Energy Savings (Upgraded Features, Fluorescent, Gas Dryer Stub & Tankless Hot Water)		
	\		Dollars	Energy Use		Dollars
	Therms	kWh	$	Therms	kWh	$
Energy Code Related						
Space Heating	1120		$ 1,119.91	479		$ 478.94
Space Cooling		3,380	$ 506.98		-	$ -
Water Heating	360		$ 360.27	175		$ 175.16
Other Uses						
cooking	78		$ 78.00	78		$ 78.00
dishwasher		240	$ 36.00		240	$ 36.00
electric or gas dryer		974	$ 146.10	89		$ 89.00
refrigerator		669	$ 100.35		669	$ 100.35
Miscellaneous (Appliances + Plug)		5,934	$ 890.10		5,934	$ 890.10
Lighting		3,647	$ 547.05		948	$ 142.20
reduce kWh by solar contribution		n/a	n/a		-	$ -
Total use	1558	14,844	$ 3,784.76	821	7,791	1,989.76

Total Annual Energy Use		307,804	kBtu/yr		161,883	kBtu/yr
Reduction in Energy Use			100%	47%	48%	47%
Total for Column in kBtu/yr	155,818	151,986		82,111	79,772	
Total kBtu/yr for BA Benchmark House	307,804	kBtu/yr				
Total kBtu/yr for Prototype House	161,883	kBtu/yr				
Percent End Use Energy Savings	**47.41**					
Estimated Montly Energy Bill			$ 315.40 /mo			$ 165.81 /mo
Reduction in Energy Cost						53%
price of gas/therm	$1.00					
price of electricity/kWh	$0.15					

Option 5
Schingler Residence (w/ Night Breeze System and 1 inch EPS Foam)
Floor Area = 3,553 Sqft
Stockton, CA

Energy and Cost Analysis for Base Case and BA Prototype Houses

Original Cooling Budget is 2.80, 25% reduction is 2.10

	Base Case / BA Benchmark House (kBtu/sf-yr)	Base Case / BA Benchmark House (kBtu/yr)	Prototype House - 40% Energy Savings Features (kBtu/sf-yr)	Prototype House - 40% Energy Savings Features (kBtu/yr)	Reduction in Energy Use (kBtu/yr)	Estimated Incr. Cost: Base to Prototype House (40% Energy Savings Level)
Heating	31.52	111,991	15.17	53,899		
Cooling	9.74	34,606	2.10	7,461		
Water Heating	10.14	36,027	6.90	24,516		
Total	51.40	**182624**	24.17	**85876**	**53.0%**	
Lighting		37,342		9,707		
Total (Heat, Cool, WH and Lighting)		**219,966**		**95,583**	**57%**	
Other Uses		87,838		86,765		
Total (Heat, Cool, WH, Lighting & Other Uses)		**307,804**		**182,348**	**41%**	
Site Generation (2kW PV)				-		
Overall Total Energy Savings		**307,804**		**182,348**	**41%**	

ENVELOPE: (Insulation U-Values or R-Values)					
Roof (attic)	R-30	**38 (U-value = 0.025)**			$517
Roof (at furnace)	R-30	**19 (U-value = 0.047)**			
Wall (2x4 Exterior)	U-value = 0.082	**13+1 inch EPS (U-value = 0.067)**	**(25% Framing factor)**		$300
Wall (2x6 Exterior)	U-value = 0.082	**19+1 inch EPS (U-value = 0.054)**	**(25% Framing factor)**		$300
Wall (Kneewall)	U-value = 0.082	**13 (U-value = 0.102)**	**(25% Framing factor)**		
Floor (above garage)	N/A	N/A			
Floor (cantilever)	N/A	N/A			
Attic Radiant Barrier	No	**Yes**			$588
Low Air Infiltration	No	**Yes, SLA = 3.1**			
GLAZING:					
U-Factor		**Milgard Vinyl Frame Windows w/ Spectrally Selective Glass**			
Slider (horz)*	0.60	**0.38**			$950
Slider (vert)*	0.60	**0.39**			(For total glass
Fixed*	0.60	**0.35**			in the house)
Patio*	0.60	**0.34**			
Casement / Awning*	0.60	**0.36**			
French Doors (Pozzi)	0.60	**0.30**			
French Doors*	0.60	**0.35**			
SHGC					
Slider (horz)*	0.40	**0.29**			
Slider (vert)*	0.40	**0.29**			
Fixed*	0.40	**0.30**			
Patio*	0.40	**0.31**			
Casement / Awning*	0.40	**0.26**			
French Doors (Pozzi)	0.40	**0.33**			
French Doors*	0.40	**0.35**			
HVAC SYSTEM:					
Furnace: AFUE (Main House) / HSPF (Casita)	0.78 (AFUE) / 6.8 (HSPF)	**0.80 (AFUE - Main House) / 7.0 (HSPF - Casita)**			$1,800 (Night Breeze System)
A/C: SEER (Main and Casita)	10 SEER	**12.0 (Main House) / 12.0 (Casita)**			$675
Duct Insulation / Location	5.00	**13.0 (buried in insulation)**			$150
Duct Testing	No	**Yes**			
ACCA Manual D	No	**Yes**			
WATER HEATING:					
Water Heater Size	2 (40) gal	**1 (Tankless System) / 1 (30 Gal - Gas)**			$1,000
Energy Factor	0.54	**0.84 (Tankless) / 0.57 (30 Gal)**			
Distribution Type	Standard	**Pipe Insulation (both DHW systems)**			$150
External Wrap	R-12	**R-12 External Wrap on the 30 Gallon only**			
Solar Credit	None	None			
3rd Party Inspections and Testing (In ComfortWise Program)		**Yes**			$440
Gas dryer stub		**Yes**			$75
Fluorescent lighting (screw-in lamps)		**Yes, all downlights**			$60
Total Estimated Incremental Cost					$7,005

Option 5

Comparison of Total Energy Use

	Base Case / BA Benchmark House			**BA Prototype House** - 40% Energy Savings (Upgraded Features, Fluorescent, Gas Dryer Stub and Tankless Hot Water)		
	\		Dollars	Energy Use		Dollars
	Therms	kWh	$	Therms	kWh	$
Energy Code Related						
Space Heating	1120		$ 1,119.91	539		$ 538.99
Space Cooling		3,380	$ 506.98		729	$ 109.31
Water Heating	360		$ 360.27	245		$ 245.16
Other Uses						
cooking	78		$ 78.00	78		$ 78.00
dishwasher		240	$ 36.00		240	$ 36.00
electric or gas dryer		974	$ 146.10	89		$ 89.00
refrigerator		669	$ 100.35		669	$ 100.35
Miscellaneous (Appliances + Plug)		5,934	$ 890.10		5,934	$ 890.10
Lighting		3,647	$ 547.05		948	$ 142.20
reduce kWh by solar contribution		n/a	n/a		-	$ -
Total use	1558	14,844	$ 3,784.76	951	8,520	2,229.10

Total Annual Energy Use		307,804	kBtu/yr		182,348	kBtu/yr
Reduction in Energy Use			100%	39%	43%	41%
Total for Column in kBtu/yr	155,818	151,986		95,115	87,233	
Total kBtu/yr for BA Benchmark House	307,804	kBtu/yr				
Total kBtu/yr for Prototype House	182,348	kBtu/yr				
Percent End Use Energy Savings	**40.8%**					
Estimated Montly Energy Bill			$ 315.40 /mo			$ 185.76 /mo
Reduction in Energy Cost						59%
price of gas/therm	$1.00					
price of electricity/kWh	$0.15					

Option 6
Schingler Residence (w/ Night Breeze System and 1 inch EPS Foam)
Floor Area = 3,553 Sqft
Stockton, CA

Energy and Cost Analysis for Base Case and BA Prototype Houses

Original Cooling Budget is 2.80, 40% reduction is 1.68

	Base Case / BA Benchmark House (kBtu/sf-yr)	Base Case / BA Benchmark House (kBtu/yr)	Prototype House - 40% Energy Savings Features (kBtu/sf-yr)	Prototype House - 40% Energy Savings Features (kBtu/yr)	Reduction in Energy Use (kBtu/yr)	Estimated Incr. Cost: Base to Prototype House (40% Energy Savings Level)	
Heating	30.32	107,727	14.60	51,874			
Cooling	13.33	47,361	1.68	5,969			
Water Heating	10.14	36,027	6.90	24,516			
Total	53.79	**191116**	23.18	**82359**	**56.9%**		
Lighting		37,342		9,707			
Total (Heat, Cool, WH and Lighting)		**228,458**		**92,065**	**60%**		
Other Uses		87,838		86,765			
Total (Heat, Cool, WH, Lighting & Other Uses)		**316,296**		**178,831**	**43%**		
Site Generation (2kW PV)				-			
Overall Total Energy Savings		**316,296**		**178,831**	**43%**		
ENVELOPE: (Insulation U-Values or R-Values)							
Roof (attic)	R-30		**38 (U-value = 0.025)**			$517	
Roof (at furnace)	R-30		**19 (U-value = 0.047)**				
Wall (2x4 Exterior)	U-value = 0.076		**13+1 inch EPS (U-value = 0.067)**	**(25% Framing factor)**		$300	
Wall (2x6 Exterior)	U-value = 0.076		**19+1 inch EPS (U-value = 0.054)**	**(25% Framing factor)**		$300	
Wall (Kneewall)	U-value = 0.076		**13 (U-value = 0.102)**	**(25% Framing factor)**			
Floor (above garage)	N/A		N/A				
Floor (cantilever)	N/A		N/A				
Attic Radiant Barrier	No		**Yes**			$588	
Low Air Infiltration	ACH = 0.43		**Yes; ACH = 0.36**				
GLAZING:							
U-Factor			**Milgard Vinyl Frame Windows w/ Spectrally Selective Glass**				
Slider (horz)*	0.688		**0.38**			$950	
Slider (vert)*	0.688		**0.39**			(For total glass	
Fixed*	0.688		**0.35**			in the house)	
Patio*	0.688		**0.34**				
Casement / Awning*	0.688		**0.36**				
French Doors (Pozzi)	0.688		**0.30**				
French Doors*	0.688		**0.35**				
SHGC							
Slider (horz)*	0.581		**0.29**				
Slider (vert)*	0.581		**0.29**				
Fixed*	0.581		**0.30**				
Patio*	0.581		**0.31**				
Casement / Awning*	0.581		**0.26**				
French Doors (Pozzi)	0.581		**0.33**				
French Doors*	0.581		**0.35**				
HVAC SYSTEM:							
Furnace: AFUE (Main House) / HSPF (Casita)	0.78 (AFUE) / 6.8 (HSPF)		**0.839 (AFUE - Main House) / 7.0 (HSPF - Casita)**			$1,800	(Night Breeze System)
A/C: SEER (Main and Casita)	10 SEER		**12.0 (Main House) / 12.0 (Casita)**			$675	
Duct Insulation / Location	5.00		**R-4.2 (buried in insulation, R-13 Equivalent)**			$150	
Duct Testing	No		**Yes**				
ACCA Manual D	No		**Yes**				
WATER HEATING:							
Water Heater Size	2 (40) gal		**1 (Tankless System) / 1 (30 Gal - Gas)**			$1,000	
Energy Factor	0.54		**0.84 (Tankless) / 0.57 (30 Gal)**				
Distribution Type	Standard		**Pipe Insulation (both DHW systems)**			$150	
External Wrap	R-12		**R-12 External Wrap on the 30 Gallon only**				
Solar Credit	None		None				
3rd Party Inspections and Testing (In ComfortWise Program)			**Yes**			$440	
Gas dryer stub			**Yes**			$75	
Fluorescent lighting (screw-in lamps)			**Yes, all downlights**			$60	
Total Estimated Incremental Cost						$7,005	

Option 6

Comparison of Total Energy Use

	Base Case / BA Benchmark House			**BA Prototype House** - 40% Energy Savings (Upgraded Features, Fluorescent, Gas Dryer Stub and Tankless Hot Water)		
	\		Dollars	Energy Use		Dollars
	Therms	kWh	$	Therms	kWh	$
Energy Code Related						
Space Heating	1077		$ 1,077.27	519		$ 518.74
Space Cooling		4,626	$ 693.84		583	$ 87.45
Water Heating	360		$ 360.27	245		$ 245.16
Other Uses						
cooking	78		$ 78.00	78		$ 78.00
dishwasher		240	$ 36.00		240	$ 36.00
electric or gas dryer		974	$ 146.10	89		$ 89.00
refrigerator		669	$ 100.35		669	$ 100.35
Miscellaneous (Appliances + Plug)		5,934	$ 890.10		5,934	$ 890.10
Lighting		3,647	$ 547.05		948	$ 142.20
reduce kWh by solar contribution		n/a	n/a		-	$ -
Total use	1516	16,090	$ 3,928.98	931	8,374	2,186.99

Total Annual Energy Use		316,296	kBtu/yr		178,831	kBtu/yr
Reduction in Energy Use			100%	39%	48%	44%
Total for Column in kBtu/yr	151,554	164,741		93,090	85,741	
Total kBtu/yr for BA Benchmark House	316,296	kBtu/yr				
Total kBtu/yr for Prototype House	178,831	kBtu/yr				
Percent End Use Energy Savings	**43%**					
Estimated Montly Energy Bill			$ 327.42 /mo			$ 182.25 /mo
Reduction in Energy Cost						56%
price of gas/therm	$1.00					
price of electricity/kWh	$0.15					