The Zero Energy Suburb
(Sprawl is Beautiful?)

In October of 2007, I attended the annual U.S. convention of the Association for the Study of Peak Oil and Gas (ASPO) in Houston. This is the premier group of social and environmental activists, academics, oil industry professionals, and end-of-the-world enthusiasts who are grappling with the ominous dilemma of how the world will cope with the imminent crisis of Peak Oil. Peak Oil advocates believe that as world oil and fossil fuel demand exceeds supply, fuel costs will soar and availability will dwindle. (The peak price of $145 per barrel in July 2008 will be a bargain.) They believe that industrial countries unprepared for a transition will face a more-or-less permanent economic depression as a society founded on cheap oil and energy for its agricultural production, transportation, buildings, and industrial feedstocks loses its base.

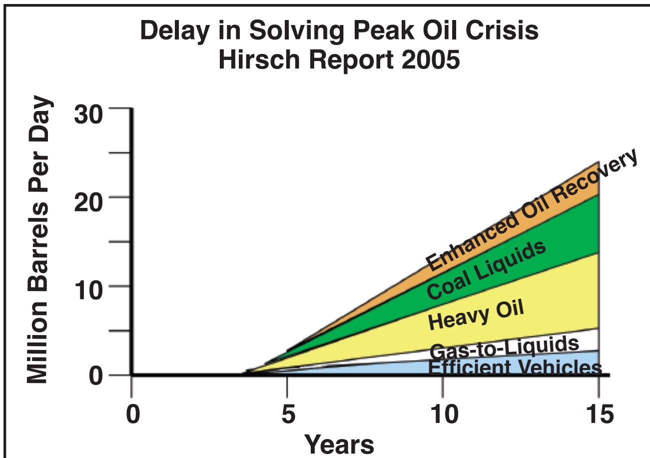
That is the tame version. In the worst-case scenarios, wars over energy resources become commonplace. Domestic crime and poverty overwhelm the social system to the point society cannot function. When this happens, democratic government will cease. With increasing poverty and decreasing standard of living, more death and disease is inevitable. Societies dependent on cheap energy could totally collapse. The classic movie "Mad Max" is frequently referred to as one distopian example of the future.

While some of the ASPO convention attendees viewed the situation as a crisis to contain, the mood on the first day of the conference was so somber that one might have viewed it as a convention for manic depressives. Indeed, a noticeable faction of Peak Oil devotees are identified as "doomers" or "Peak Oil Fundamentalists" who believe that there is no way to pull society back from its inevitable crash and die-off. It might have been advisable for the conference organizers to have a psychiatrist on the floor to console those prone to suicide.

The ASPO presentations methodically attempted to show how fixed or dwindling oil and energy reserves could not keep up with demand in industrial and industrializing nations. Not only was oil production said to be at or near peak, but oil use was increasing in oil-*producing* countries to the point where even major oil-exporting nations would have no export capacity at all in the next 10-20 years. Industrial countries such as China and India were fueling another huge segment of the increase, not only driving up demand and costs of oil, but also natural gas, coal, and all manner of metals. Even coal, which is generally thought to be the most abundant fossil fuel, was believed under certain scenarios to peak at or before the year 2030.

There were a number of presentations about alternatives: renewable energy, efficient vehicles, and electric transit. But most were viewed through the lens that these could only cushion the blows – that the world could never go back to the old models. A case in point was a speech by a representative from Toyota, crowing about the virtues of the Prius as a gas-saving alternative. He was verbally assailed by ASPO founding member James Kunstler (author of *The Long Emergency*), who decried the hapless speaker for perpetuating "the myth of a car-dependent lifestyle!"

Speaking to this point more analytically was Robert Hirsch, a Houston-based energy consultant with decades of experience in the oil and energy industries. Among his many accomplishments, he is the author of a seminal report on Peak Oil for the U.S. Department of Energy in 2005.(1) Key to his report is the belief that it takes decades for an industrial society to completely adapt to new technologies. The average life of a car in the U.S. is 17 years. The average life of a power plant can exceed 40 years. Producing biofuels or synthetic fuels in sufficient quantities (assuming you believe they are real alternatives) will take many years to ramp up.



Robert Hirsch has astutely pointed out that it takes many years to transition to new technology. In this example, it would take up to 15 years to displace 25 million barrels a day of oil (less than 30% of world oil use in 2008).

Look at the powerful Prius, launched in the year 2001. It is renowned as the most efficient commercial auto in the U.S. It saves 45% on fuel compared to minimum American vehicle requirements in 2010.(2) It can be reconfigured with more (still expensive) batteries into a Plug-In Hybrid that can achieve more than 100 mpg. In the span of nine years, it has achieved sales of 1.2 million cars! Impressive, until you consider there are over 862 million automobiles in the world, that each one can last almost 20 years, and that the auto fleet grows by 22 million vehicles each year.(3)

The prevailing attitude at the ASPO conference was in many ways absolutist. Many there felt there was no technological way to escape the consequences of diminishing oil supplies, and we should start planning for the worst.

It Hits You Where You Live

One of the predictions of Peak Oil doomers is "The End of Suburbia."**(4)** This threat is also the title of a one-hour documentary that splices interviews with writers and activists with facts and figures on the wasted energy and resources from a prodigal suburban lifestyle. The pointed documentary, satirically laced with 1950s TV ads depicting the good life, predicts the decay and probable elimination of suburbs and their lifestyle. It predicts that their former inhabitants will no longer be able to afford the fuel to travel there, and the permanent depression set about by expensive oil robs suburbanites of their money to pay for the homes themselves. (And at that point, you can forget all about the Malls.)

There are many apt and accurate criticisms of the suburban lifestyle on environmental, economic, and social grounds.

Environmentally, suburbs are enormous consumers of energy, and thus major sources of air pollution and global warming. Commuting has increased the number of miles traveled per person by 173% between 1970-2007, causing a 94% increase in oil used for transportation.**(5)** Homes can be miles from essential destinations such as grocery stores, schools, and workplaces. Many suburbs lack the most rudimentary bus service, and in some areas, cycling and walking are inconvenient or even dangerous. Even ignoring transportation energy, new houses themselves consume more energy because they are 45% larger than they were in 1973.**(6)** Land formerly used by wildlife, or for recreation and agriculture has been permanently converted.

The low-density suburban form itself uses more resources, as more structural materials for streets, water, and electric service must be provided per mile. And less city services such as fire and police protection can be provided per capita for money spent, meaning higher costs for public safety.

Then there is the real concern of the social structure that it creates. Suburbs can be socially isolating because there is often little common ground. Parks, schools, and other common destination points can be miles away. Suburbs can breed conformity. There are often draconian subdivision rules governing the minimum size of homes (which can increase energy use), the exterior color a home, the landscape in the front yard, and even if clotheslines or solar panels can be installed.

Suburbs also frequently segregate occupants by class and even race. The most original analysis of suburbs I have seen suggests that they were originally the U.S. version of Apartheid, as white Americans attempted to flee the central cities on federally subsidized highways to live away from other races. Some older subdivisions literally prohibit certain races from living in them through deed restrictions, though these have long since been invalidated by legal rulings. Today, it is more complicated, and class has replaced race as a motive.

But say what you want about suburbia, the majority of people in our cities and urbanized areas live in it, or in areas that were once considered suburbs until new suburbs grew around them.

I got tired of listening to the doomers at the ASPO conference who said that there was no technifix that could work and we would have to "power down" or face chaos.

In many ways, the critics are correct. Rising population levels and lifestyle expectations for these populations are straining past the earth's ability to support them.

Even if there was no energy problem, there will be world shortages of water, prime agricultural land, metals, and conventional building materials. And Hirsch is right, an orderly transition usually takes longer than we really have to deal with the dilemas of Peak Oil, global warming, and other environmental and resource problems. I really do not want to get into the position of defending the continued abuse of the planet. But should we abandon the vast investments in resources we have now?

So the ASPO conference inspired me to consider the questions about how realistic alternatives are. Is there such a thing as a "zero energy suburb" with technologies that exist *today*? And what will it cost right *now*, not 5 to 20 years when we anticipate that the cost will come down through economies of scale (assuming we are still around)?

The answer, in sum, is that a zero energy suburb can be built today, with current technology, for a moderate increase in monthly payments and few adjustments in lifestyle. Of course, this considers only the two largest components, the house and car. Other large energy and material consumers, including roads, food, and consumer goods, are also in play. I will save them for other articles, though there is something to be said for living simply. Money *can* buy you comfort and a modicum of security. It cannot, by itself, make life worthwhile.

What Zero Looks Like

The classic definition of a *net zero energy building* is a structure that saves most of its expected energy use by employing energy saving design and the most energy-efficient equipment. The balance is provided by onsite renewable energy. A building receiving renewable energy without storage will use back-up power from conventional utilities when renewable energy is not available. But by definition, the renewable energy provided will be enough to offset the back-up power on an annual basis. This is not altogether different than conventional electric systems, which also use back-up power, albeit at a lower overall percentage.

The model new home for this was 1,800 square feet. Advanced efficient equipment in this analysis includes geothermal heat pumps, zoned duct work (that directs conditioned air to occupied parts of the building), air ducts that are located inside the home's thermal envelope, efficient gas water heaters and appliances, fluorescent or compact fluorescent lamps, radiant-barrier roofs, increased insulation levels, and advanced window glazing.

In most U.S. climates, the most advanced forms of small-scale, onsite power are photovoltaic solar cells (PVs) and solar water heaters. Interestingly, much of the solar energy from this analysis is used to provide for non-essential plug loads: televisions, phones, computers, video game stations, electric dog petters, etc. (America's love of gadgets is un-

A Zero Energy Capable Home saves the majority of the energy normally used in a conventional home with energy-efficient design and equipment, and provides the balance with onsite renewable energy. This model home exhibits strategies to achieve zero energy: A) Foam insulation applied to underside of roof deck – this turns the attic into a conditioned space so ductwork can run through it without losing heating or cooling to a cold or hot attic; B) Ductwork is sealed, insulated, and on the inside of house or in insulated attic; C) High-efficiency HVAC unit is on the inside of house or in insulated attic; D) Energy Star™ appliances; E) Insulated doors; F) Windows with low Solar Heat Gain Coefficient and U-value; G) High R-value wall insulation; H) Ceiling fans in major rooms; I) Compact fluorescent lamps that save 75% of lighting energy; J) Solar photovoltaics; K) Solar water heater that saves 70-80% of water heating energy in Texas.

bounded.) The zero energy home model includes adequate energy to meet these electric needs. If these were removed, however, the economic costs would be much lower.

The extra cost of a zero energy home is about $40,000; 72% of this is for the solar systems. This may seem high until you consider the alternative: buying and fueling a power plant. In this model financing scenario, Austin's municipal utility, Austin Energy, finances the entire cost, and is paid back on a monthly basis instead of a utility bill. Utility profit is included in this bill at the same rate of return as a conventional power plant. Annual maintenance is also included. The high first costs of installation are mitigated in the following ways.

1. The utility uses its low cost of capital for financing;
2. Municipal utility equipment is exempt from property taxes;
3. The geothermal heat pump lasts twice as long as a conventional heating and air conditioning unit;
4. The solar cells are awarded a "value of solar" price that is higher than average electricity because PVs are displacing the highest cost summer peak power and preventing costly environmental damage.**(7)** This is not a rebate or tax credit, as it is cost justified because peak electricity costs more to produce than baseload power.
5. There are minor savings from other features associated with energy-efficient equipment, such as longer lasting light bulbs, and washing machines that use less water.

The technology of electric transportation is nothing new, and is discussed in detail in the section on alternative transportation. The fundamental variables for someone wishing to convert from a conventional vehicle or buy a new alternative vehicle are the first costs, the range per charge, the battery life and replacement costs, operation and maintenance costs, and the type of electricity used for supply (renewable or fossil fuel).

The additional upfront cost of two zero energy cars is estimated to be $62,000 more than two gasoline cars. The electric vehicle premium is the cost of batteries, or about $33,000 for two cars with a 100-mile range and a 20-year life. The PVs to power these cars will cost about $29,000. This will seem high until you consider the alternative: buying a share of an oil field and refinery.

The Cost of Zero

Buildings and vehicles are the two pillars of suburban energy use, but they are very different financially. Buildings are often financed for 30 years, can last 100 years, and usually appreciate in value. Vehicles are generally financed for 5-7 years, last an average of 17 years, and depreciate in value.

There are hundreds of different scenarios that can play out over the next 20 years (the length of this analysis) in terms of technology and pricing for the Zero Energy Suburb. This article analyzed four.**(8)** All of them estimate maintenance savings for electric vehicles and zero energy homes, as well as savings for energy costs.

SCENARIO 1:
1) utility financed PVs at $6,000 per KW (DC);
2) privately financed cars for 7 yrs. at 5% interest;
3) battery replacement in year 11, 7 yrs. at 5% interest;
4) no extra value for solar energy;
5) *no price increase in gasoline ($2.50/gallon), electricity (9.5¢/kwh), and natural gas ($9/MCF).*
6) no adjustment for inflation.

RESULTS: In this most conservative scenario, the increased annual cost will be $5,383 in nominal (2010) dollars per year. This would be the equivalent of adding $116 to the monthly cost of utilities, and an additional $11.52 per gallon to the stated cost of gasoline.

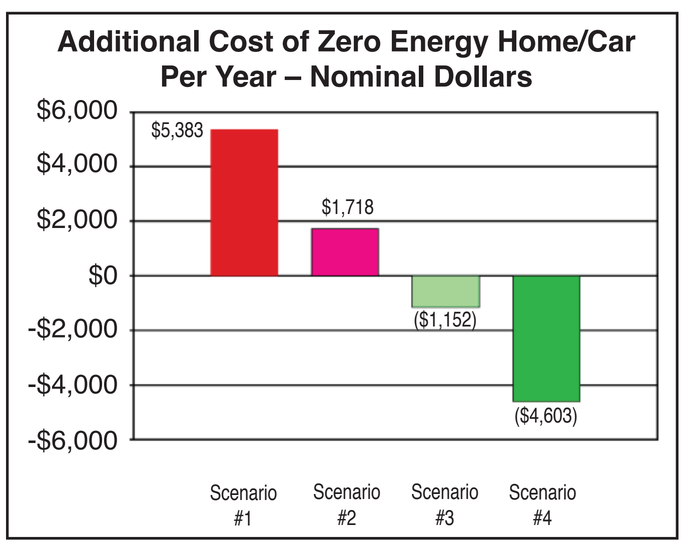
These higher costs will be an impediment for a certain percentage of people trying to qualify for or make payments on a home or stay within their family budgets. The extra $5,383 would be the equivalent of raising the average mortgage payment in Austin about 26% over the cost of the median-priced home sold in Austin in 2009. However, these estimates are meant to show that one does not have to be extravagantly wealthy to afford this extra cost.

SCENARIO 2 – Based on Scenario 1 with:
1) the value of solar rewarded (15.9¢/kwh);
2) gasoline costs go up 5% per year above inflation, and electricity and natural gas costs go up 2% per year above inflation rate.

RESULTS: The additional annual cost is only $1,718. About 64% of this decrease is due to the value of solar. The additional monthly energy cost for a zero energy home is roughly $6 per month more for the average Austin residence, and gasoline costs are $4.75 above the stated price.

SCENARIO 3 – Based on Scenario 2 with:
1) geo heat pump costs down due to volume purchase, and ducts in conditioned space at no increased cost;
2) gasoline prices at $4 per gallon (their record high in 2008) and increased at 5% per year due to excessive world demand and lack of new supplies;
3) replacement battery costs reduced by half.

RESULTS: If gasoline prices rise (a likely possibility), and battery costs fall in 10 years (also likely), the balance would



be a $1,152 decrease in annual costs. A homeowner would see a $8 monthly decrease in utilities, and the equivalent of a $3.06 per gallon reduction below the stated cost of gasoline.

SCENARIO 4 – Based on Scenario 3 with:
1) PV costs reduced by 1/3 to $4,000 per KW (DC);
2) battery costs reduced by half to $8,500;
3) no battery replacement needed over the life of the vehicle (claims some manufacturers make today).

RESULTS: There would be an annual decrease of $4,603. A homeowner would see monthly utility bills decrease by $64, and the equivalent of a $11.05 per gallon decrease in the stated cost of gasoline.

Zero in the Real World

While the theory and numbers are fairly accurate, there are several complications to this virtuous goal.

1. Diminishing Returns for Each Dollar Invested – It is more cost-effective to spend about $156 on high-quality compact fluorescent lamps than it is to buy a $11,000 geothermal heat pump, and more cost effective to buy a geothermal heat pump than buy a solar cell array. New homes generally use less energy than the *average* home of the same size because many of these "cream-skimming" measures are already required by the Austin building code. However, if you view this as a package, it would make economic sense compared to an *average* Austin home.

2. Retrofits – The same Zero strategy can be used on any type of building, new or existing. However, retrofit costs are almost always higher than installing energy saving measures in a new structure.

3. Lack of Solar Access – Many Austin homes have too much tree shade to generate enough solar energy to meet all their needs. Purchasing centralized renewable electricity through Austin's GreenChoice™ program can be done to compensate. *This would lower the cost of Scenario 1 dramatically in the short term because centralized renewables are currently much less expensive than onsite PVs*.

4. Car Range – About 14% of the mileage used in an average vehicle is used for trips longer than the 100-mile range that will limit many electric vehicles manufactured in the near future. While electric vehicles have enough range for a typical suburban lifestyle, a rented or second (conventional) vehicle may be needed for long excursions. Depending on developments, battery swap depots and fast charging stations may be in place for long-distance driving a decade from now, but not today. Using a conventional vehicle for long ranges could add fossil fuel emissions, as well as several hundred dollars to the annual cost of a vehicle.

Range reduction might occur due to accessory uses such as air conditioning and headlights. Battery wear from repeated complete discharges can also shorten range over time, sometimes by 2% a year. However, large reductions may be avoided in many cases because drivers will recharge batteries before they are fully depleted, ensuring longer life and range.

To estimate the financial impacts, electric vehicle costs were increased by 25% to account for range reduction possibilities. This increased the yearly cost over a thousand dollars to $6,702 in Scenario 1 (expensive, not outrageous), and lowered savings a few hundred dollars to $4,273 in Scenario 4.

Behind The Numbers: The Activist As Enabler

The statistics and analysis in this story were meant to demonstrate that a zero energy home and car are already technologically possible, that they are not outrageously expensive, and that they are within striking distance of being affordable to large numbers of people. Some of these numbers are speculative, though many are conservative estimates. They will undoubtably change in future analyses. But no matter how many times I qualify them, no matter how many times I attempt to place them in context, they will be deliberately misread by people with different worldviews.

Diesel Diehards will not give up their Hummers until their steering wheels are pried from their cold dead hands. They believe that there are no resource limitations; a few even believe global warming is a conspiracy invented by environmentalists to facilitate a world government (watch out for black helicopters).

Some Peak Oil Fundamentalists will argue that my analysis might be faulty when the fact is they *want* them to be faulty. To some of them, Peak Oil is a symptom of overall resource waste, personal greed, and societal dysfunction. To perpetuate the suburban dream is anathema to them. If by some miracle a perpetual motion machine appeared at Walmart next week on sale for $99, they would find some reason to decry it.

In my more cynical moments, I view activists as enablers. Similar to the enabler of an alcoholic that saves the derelict from themselves, activists keep trying to pull society back from the brink of its own self destruction. Sometimes the activists fail, but other times they meet with temporary success, only to have society go off on another bender of dangerous behavior.

If we can create the Zero Energy Suburb in time to stop the worst ravages of Peak Oil and climate change, what is to stop even more suburbs from being built on farmland and wildlife habitat? What is to stop the houses from being twice as big, or driving the electric cars run on clean solar energy to the North Pole for weekend excursions? Is there something so hardwired in human genetic make-up that we feel compelled to constantly tempt fate and live beyond our means?

A glaring example of resistance to change is the dismal failure of the global warming summit in Copenhagen in early 2010. It has been said the nation states are monsters. Imagine having 192 of them in a room together supposedly working on the long-term sustainability of the planet. No legally binding agreement, or hint of such an agreement in the future, emerged, while the Danish police had a field day harassing grassroots protestors. Too often large countries whose economies were locked into production or consumption of fossil fuels blocked a meaningful outcome.

While I have great admiration for the committed people working at the world level to create some remedy for this impending disaster, people at the local level generally feel disengaged and skeptical of any world accord on climate change. Creating the financing and infrastructure for a zero energy lifestyle is something that does not have to wait for worldwide agreement. And if this strategy can lower the cost of the installed technologies, it increases the chances of a global agreement on global warming ever being forged.

People and societies are slow to change (willingly, at least). If there is any way to avert climate change, peak oil, resource wars, and the death and miseries that will accompany them, technifixes are one essential strategy that cannot be ignored. Even prehistoric hunter and gatherer societies had primitive tools.

S. David Freeman, a nationally-known energy expert, once expressed the paradox of making environmental protection affordable when the dangers of conventional energy use were not in the market price. "In net-present value economics, the human race isn't worth saving." It is possible the Zero Energy Suburb could help change this.

DOCUMENTATION

1 Hirsch, Robert, et. al, Peaking of World Oil Production: Impacts, Mitigation, and Risk Management (Washington, DC: U.S. Department of Energy, February 2005).

2 U.S. Department of Transportation, *Automotive Fuel Economy Program, Annual Update, Calendar Year 2003* (Washington, DC: U.S. Department of Transportation, November 2004).

3 Number of vehicles and vehicle increase between 2000-2005 from Wright, John, Ed., The New York Times Almanac 2009 (New York, NY: Penguin, 2008), p. 423.

4 See summary at endofsuburbia.com

5 Federal Highway Administration, *Highway Statistics*, volumes 1971-2007.

6 U.S. Census Bureau, "Characteristics of New Housing, Median and Average Square Feet of Floor Area in New One-Family Houses Completed by Location," accessed December 19, 2009.

7 Clean Power Research, L.L.C., *The Value of Distributed Photovoltaics to Austin Energy and the City of Austin*, Austin Energy, March 17, 2006, and "Distributed Solar PV Value for Austin Energy Update," September 16, 2008, for year 2008.

8 Assumptions for Zero Energy Analysis:

Interest rates are 5% for the house and car; loan terms are 7 years for car and 25 years for house. New car batteries are financed at 5% for 7 years. Utility profit and bad debt estimated at 10.1%.

Lighting energy assumes 90% of consumption is incandescent lamps coverted to CFLs with 67% savings. Consumption from 2 studies:
Navigant Consulting Inc., *Volume I: National Lighting Inventory and Energy Consumption Estimate*, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, September 2002.
U.S. Department of Energy, Energy Information Administration, *Residential Lighting: Use and Potential Savings*, September 1996, p. 35.
Lamp cost is $4 each; lamp replacement cost included in maintenance savings.

Electronics consumption from Roth, Kurt, and Kurtis McKenney, Energy Consumption by Consumer Electronics in U.S. Residences, Consumer Electronics Association, January 2007.

Appliance consumption from: Energy Star appliance estimates; Energy Information Administration, Residential Energy Conservation Survey 2001 (cooking and tools); Energy Gauge, Version 2.8 (ceiling fans).
Gas Range energy from U.S. Dept. of Energy, Energy Efficiency and Renewable Energy, *Building Technologies Program, Technical Support Document Energy Conservation Standards for Consumer Products Cooking Products* (Washington, DC: U.S. Dept. of Energy, June 20, 2008), Chapter 4. Online at https://www1.eere.energy.gov/buildings/appliance_standards/residential/cooking_products_0998_r.html
Efficient appliance incremental costs and life from U.S. Dept. of Energy, "Program Planning Spreadsheet," EERE State Activities and Partnerships, Technical Assistance. Refrigerator: $31/12 years; clothes washer: $258/12 years; dishwasher: $12/10 years; gas water heater: $70/20 years (used as solar back-up only).
Savings from appliance replacements for new HVAC unit ($3,600 at 13th year) and water heater ($700 at 13th year).

Heating and cooling energy derived from Energy Gauge, Version 2.8. HVAC energy-saving measures include:
Windows: U-Value 0.4; SHGC 0.2 – $3 per square feet X 180 square feet
Air Infiltration: 0.5 Air changes per hour – $225 for duct and infiltration tests
Ducts: in interior space – ranges from $0 to 800
Duct zones (two): $1,200 for estimated 20% heating/cooling savings
Ceiling Insulation: R-38 (code requirement)
Wall Insulation: increase from code to R-15 – $305
Radiant Barrier – $0-125
Ceiling Fans: 6

Geothermal Heat Pump: 2-tons, 18.5 EER; 5.6 COP – $11,000/$9,850 with volume discount; $3,600 is deducted for the cost of a standard unit; same amount is deducted for replacement unit.

Water heating based on 20 gallons a day per person and 50 degree delta between water temperature and hot water temperature, with back-up tank Energy Factor of 0.62. Solar water heating reduces annual use 75%.

Miles per vehicle (12,100) from 10-year average (1998-2007) of annual *Highway Statistics* reports, Federal Highway Administration.
Breakdown of number of miles traveled per day per vehicles from U.S. Department of Transportation, Federal Highway Administration, "2001 National Household Travel Survey" (Washington, DC: U.S. Department of Transportation, 2001). Information by Susan Liss, National Personal Transportation Survey Program Manager, on September 25, 2008.
Increased cost of electric vehicle estimated at cost of batteries, which is currently about $500/kwh of storage per cycle.
Vehicle efficiency: 3 miles/kwh for electric cars and 30 mpg for gas powered cars.
Car maintenance schedule from Nissan 2010 Service and Maintenance Guide. Service costs from Austin area auto dealers and mechanics.

Photovoltaic energy from PV Watts Web site (pvwatts.org) for Austin Texas at 0.82 conversion rate and 210˚ azimuth to synchronize production with Austin peak demand.
PV output deterioration estimated at 0.5% per year.
PV costs include one replacement inverter in 13th year at cost of $1,500.

Natural gas savings per household estimated from average gas use per Texas Gas Service residential customer from 2000-2008 from Texas Railroad Commission, *Gas Utilities Annual Statistical Reports*, Tables 1A and 1B and U.S. Dept. of Energy, Energy Information Administration, "Natural Gas Prices," for average of City Gate costs for 2005-2009 in Texas, adjusted for Texas Gas Service delivery rate, franchise fee (5%), and taxes (1%).
Electric use per conventional Austin home from analysis by John Trowbridge, engineer at Austin Energy Conservation Services, for energy use per square foot in Austin single family homes, on March 15, 2010, adjusted for size of home.
Average residential electric costs from Austin Energy for calendar year 2008, adjusted to remove monthly service fees.

Natural gas distribution system loss of 2%. Electric Transmission and distribution loss of 7.5%. Power plant lifetime output degradation estimated at 2..3%. Heat rate of 9,810 btus per kwh from Austin Energy, *Open Meetings/Open Records Resolution Annual Report 2009*, p. 1.

Home maintenance savings: Water savings from efficient washing machine and dishwasher from Energy Star, multiplied X 2010 Austin water and wastewater rate of $10.35/thousand gallons.
Detergent savings for clothes washers from lifecycle analysis by Northwest Power and Conservation Council, online at www.nwcouncil.org/rtf/supportingdata/EStarAppluse.xls. Lamp savings estimated at 9 times the cost of an incandescent bulb, adjusted for consumption.