The ***Electranet***

Executive Summary

The *Electranet* Argument

If:
- The global middle class is going to double in the next 20-30 years; or
- The world needs to contain the growth of GHG and other harmful emissions; or
- The U.S. must reduce its dependence on the crude oil complex;

Then: The combustion of fossil fuels must, and can be, dramatically and rapidly reduced,
- On a relative basis, for each unit of work accomplished; and
- On a total, absolute basis.

And if this reduction in fossil fuel combustion must not constrain global economic growth, **then**, the developing and industrialized world must:
- Become dramatically more efficient in the use of each unit of energy (Btu); and
- Add significant new, non-fossil fuel energy sources such as nuclear, clean coal, biofuels, solar and wind.

And If:
- Next generation nuclear, clean coal and efficient biofuels technologies will not be commercially available for another 10-15 years; and
- “Green design,” which minimizes energy usage for new structures, does not address the existing infrastructure,

Then *the best, most realistic, pro-growth, existing infrastructure, short lead-time solutions to reduce the combustion of fossil fuels and the resulting emissions are:*

- More efficient use of each Btu through smart energy consumption.

- Rapid integration of distributed renewable resources and high-efficiency, distributed conventional energy supply.

If the US needs to quickly reduce electric grid brownouts and blackouts to support the growing digital economy,

Then smart energy consumption and integration of distributed stationary and mobile energy sources becomes even more important.

The solution is the *Electranet*.

The *Electranet*

The Emerging *Electranet*

The *Electranet*:

- Applies embedded sensing and computing where stationary and mobile energy is consumed.
- Networks together points of consumption and distributed supply through ubiquitous wired and wireless connectivity, information and control systems.
- Uses price to clear this newly integrated stationary and transportation energy market.

The *Electranet* will:

- Dramatically increase both total energy efficiency and facility electric reliability.
- Recognize the energy consumer as the locus of competition and leverage by enabling and empowering customer choice.
- Facilitate rapid integration and monetization of renewable and high efficiency resources using the Electranet.
- Transform the world's petroleum based energy economy to an integrated electrical-based energy economy.

Since the enabling technologies are available today, the *Electranet* is a bridge to long-term, non-petroleum, clean supply and design solutions.

The *Electranet* Network

Every point of energy consumption, stationary or mobile, as well as distributed, small-scale energy storage, conversion and supply will become a *smart node* on the emerging *Electranet*. These *smart nodes*, numbering many orders of magnitude greater than currently exist, will all be connected and tied to the broader energy grid. Metcalf's law states the power of the *Electranet* expands geometrically, enabling revolutionary developments in the way all forms of energy are stored, distributed, and consumed. The *Electranet* will enable:

1. **A step increase in total Btu market efficiency and a corresponding step decrease in fossil fuel consumption and resulting combustion process GHGs.** The Electranet creates these efficiency gains by:
   a. Allowing <u>demand</u> to continuously answer price, thus avoiding the use of inefficient, high-emissions electric generation units.
   b. Arbitraging supply and demand between stationary energy and transportation fuels grids. This arbitrage occurs at energy conversion, transport and storage devices through the energy network and managed by the information network.

2. **Increased localized and total electric grid reliability** through increased cross-grid buffering capacity, elimination of single points of failure and elastic demand in response to price and grid distress signals. The *Electranet*, unlike the previous

supply side-solutions, is a much more robust, targeted and efficient form of reliability.

a. The *Electranet* uses the total energy market supply and incremental electric demand reduction to provide a buffer to compensate for the non-storable nature of electricity.
b. Energy conversion and storage devices are available to provide local power when coupled with the proper control systems when grid electricity is not available.

3. **The partial or full shift of our transportation infrastructure from petroleum to electricity end consumption**, thus transferring:
   a. GHG emissions where they can best be regulated and controlled on the electric grid.
   b. Transportation fuels from petroleum to domestic sources of energy.

4. **The exponential growth of decentralized, distributed, renewable and high-efficiency conventional energy supply,** through:
   a. Accurate valuation and monetization.
   b. Aggregation of distributed assets and their integration into the electric grid.
   c. Creation of energy storage to store wind energy when electric demand is not sufficient.

Why Now?

The emergence of the *Electranet* has just started and is being driven forward by:

- Increasing capabilities of *Electranet* enabling technologies at now competitive price points.
- Demand for short-lead time electric grid reliability solutions.
- Growing awareness that the cleanest unit of energy is the one not used.
- Favorable political and regulatory environment.

Pervasive *Electranet* Trends

***Electranet* Demand Trends.** Demand for innovative solutions to the global energy and environmental challenges are being driven by the following trends:

1. Rapidly increasing demand for higher quality and availability electricity to power our digital economy as the electrical grid is becoming more and more stressed.
2. Increasing premium of fixed-price contracts relative to the average real-time electricity prices as:
   a. Peaking electrical generating capacity becomes scarcer in most regions in the country, especially in major metropolitan areas.
   b. Natural gas pipelines move from single-price, day-ahead prices to time of use rates.

⇒ <u>This increase in premium is forcing many Fortune 500 companies to shift to real-time pricing, in both regulated and deregulated markets to "self-manage" their peak load.</u>

3. Growing awareness of the environmentally damaging effects of combustion process emissions and an increasing ability to monetize improvements through marketing, government incentives and global financial emissions markets.
4. Increasing number of electrical disruption events as the transmission and distribution grid ages and throughput increases; also, increased threat of terrorist activity on a grid with many "single points of failure."
5. Declining G-8 oil and natural gas reserves and increasing global demand, thus raising the US dependence on highly unstable regions of the world for replacement supply.
6. Exponential growth of our world's population over the last century (1.65 billion to 6 billion), the emerging middle class of this population explosion and the ever more finite nature of our world's natural resources against this backdrop.

***Electranet* Enabling Trends**. The *Electranet* solves problems now, not ten years on, by applying existing technology and proven network concepts to the existing total energy grid. The global *Electranet* opportunity is enabled and driven by the convergence of the following powerful and pervasive long-term trends:

1. Electricity providers replacing analog energy meters (which only measure energy used over time) with smart, digital, real-time meters (which measure the amount of energy used at each point in time) and passing actual prices through to many classes of customers.
2. Billion dollar utility budgets committed to making demand elastic.
3. Federal Energy Policy Act 2005 mandating electric *time of use rates* availability by Feb 2007.
4. Incentives and/or penalties designed to price in environmental externalities, especially carbon emissions, such as the pending California Global Warming Solutions Act of 2006.
5. Exponential growth of wireless broadband throughput.
6. The emergence of standards for:
   a. Low power, low data sensor and control mesh networks (IEEE 802.15.14).
   b. Interconnecting small, distributed electrical generation to the distribution grid **and** market structures which allow electric load to participate on an equal footing with supply.
7. Increasing capital flows into large-scale renewable energy to generate electricity.
8. Embedded computing migrating down to the household appliance level.
9. Emerging battery and energy storage technologies and models, both real and synthetic.
10. The evolution of hybrid gasoline/electric technologies in the transportation sector, and the very recent announcement of development of plug-in hybrid technologies by Toyota and GM
11. Internet enabled markets, the "eBay" effect, and the increasing expectation of market clearing prices for an unlimited variety of products and commodities.

Energy Fundamentals

Status Quo looking forward:

Energy: Exponential Increases in Demand, Linear increase in Supply.
Environment: Exponential Increases in Demand, No increase in Supply.

Global Trends

Global Population

- There are 6.5 billion people in the world; that is a ~2x increase in the last 40 years.
- Most projections add another 2-3 billion in the next 20-30 years.
- ~80% of the world's current population is not in the middle class.
- It is highly likely that ½ of the world's current underclass, the product of the population explosion, will enter the middle class over that same time period as we add another 1/3 to our total global population**.**
  - ⇒ <u>That would amount to a 3x increase in the total middle class population from today's level in the next 20-30 years, before ever assimilating the population growth from today's starting point.</u>

Global Energy Consumption

1. The U.S. has 5% of the world's population and consumes 25% of its energy.
2. Although ½ the per capita consumption, the EU and Japan consume another 25% of the world's energy.
3. In total, the U.S., EU and Japan together comprise ~14% of the world's population (880MM/6500MM) and consume 50% of its energy!!!

Fossil Fuel Energy Supply

- Fossil Fuels currently account for ~90% of the worlds total energy consumption; 40% petroleum-based, 24% coal, 22% natural gas and 4% other.
- At current consumption rates, before ever adding the emerging global middle class, most sources predict crude oil production will peak sometime in the next 5-25 years. That relative peak will be accelerated forward as global demand increases.
  - ⇒ <u>It is literally impossible for the emerging global middle class to consume energy at the current per capita rate of the three largest economies.</u>
  - ⇒ <u>The world must fundamentally change the way natural resources are used, especially fossil fuel energy and air.</u>

The Next Constraint

The vast majority of Greenhouse Gas (GHG) emissions (>80% in the U.S., Fig 1) results from fossil fuel combustion to produce energy for stationary and transportation uses.

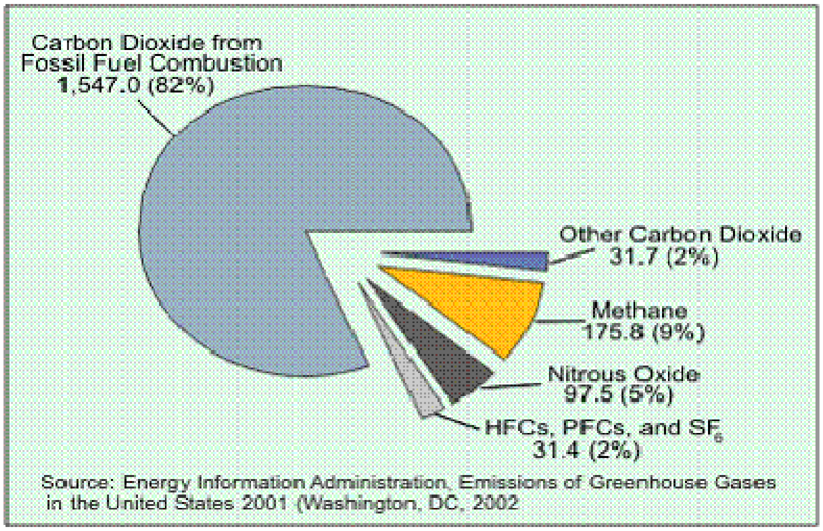

Fig 1 - U.S. Emissions of Greenhouse Gases

There is a growing scientific consensus that greenhouse gases, primarily CO2 produced from the fossil fuel combustion process, are causing a warming of global temperatures that could potentially lead to catastrophic results.

Regardless of cause and effect, the body of evidence is now overwhelming that there is a strong correlation between atmospheric CO2 levels and average global temperature.

⇒ The world is not in a position to absorb linearly increasing emissions from the industrialized world, much less the exponential step change resulting from the combustion of fossil fuels the emerging global middle class will require.

U.S. Electricity

Supply

Electricity cannot be stored; Supply must equal demand instantaneously.

- Baseload: Continuously run. Nuclear, coal, hydro, natural gas (NG).
- Intermediate: Run ~2/3 of the time. NG
- Peaking: Run for short periods of time. NG, Diesel.

Peaking Capacity Economics

- Because peaking generation runs much less than baseload, owners have opted for lower fixed-cost units that maximize return on investment. These units have higher variable costs, lower efficiency and higher emissions than baseload generation.

- The owner of peaking generation must receive a higher imputed variable price for each hour to cover both fixed and variable costs. This could be received on either a variable basis or as a fixed payment from the grid operator.
- Because of this dynamic, and baseload generation diversity, variable cost of electricity production can vary by approximately 2 orders of magnitude from $5 to $500. For a given increase in demand, the change of the cost of production increases at an increasing rate which tends towards a vertical line in scarcity. {Fig 2}

Current Peaking Capacity Shortage

- Because of recent electricity price controls, very few peak power plants have been added to the supply base.
- At the same time and because of their much lower variable costs, developers built baseload plants to answer peaking capacity needs, but stopped short of building to the actual peak demand levels
- This has resulted in degraded electric grid reliability, even as huge surpluses of generation capacity have been available during most of the day.

The Energy Clearinghouse. The electric grid has largely been then clearinghouse for the energy market, ex-transportation, and the primary 'green' energy distribution grid.

Demand

- Demand has been effectively inelastic in the past, largely due to lack of price transparency, storage, enabling technologies capabilities and policy.
- Demand varies greatly within a day, largely due to space conditioning and business load. http://capabilities.itron.com/eshapes/EShapes.cfm
- Baseload demand (peak demand very close to the average) as a percent of total system demand continues to decline as many continuous process industries are outsourced to cheaper manufacturing regions.
- Peaking demand (peak demand is much higher than the average) continues to increase with the growth of two primary sources of peak demand:
  - Residential housing build-out.
  - Continued shift to a service economy.
- The cost of interruption of a specific electricity process varies two orders of magnitude from $100 to $10,000.
  - Electricity reliability is materially degraded when the market price is above willing sellers and below willing buyers and the market remains unfilled.

Market Fundamentals

Cost, Price, underlying fuel consumption and emissions vary exponentially within a day for a given change in electric load. {Fig 3}

- All Kilowatts are NOT created equal.
- Being ok on average doesn't work for a non-storable commodity.

The use of supply to answer inelastic demand of non-storable electricity has resulted in:

⇒ Higher costs, emissions and fuel consumption per a unit of electricity produced.

⇒ Degraded reliability.

⇒ Large spare capacity currently available during non-peak hours.

Average pricing of electricity to the end consumer has resulted in:

⇒ Complacency and "sloppiness" resulting inefficiencies in the consumption of electricity, relative to its actual value.

⇒ Higher electricity costs to the end consumer, as electricity providers embed large risk premiums to manage peak capacity volatility.

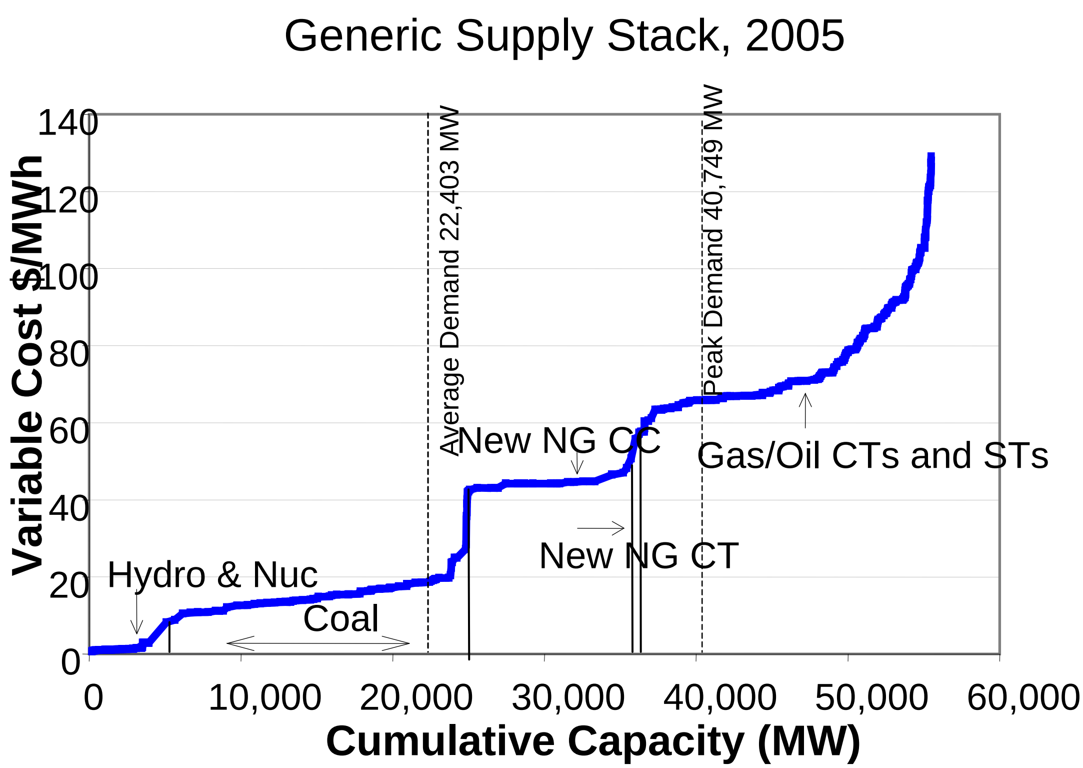

Fig 2 – Generic Regional Supply Stack

CC: Combined Cycle; CT: Combustion Turbine; ST: Steam Turbine

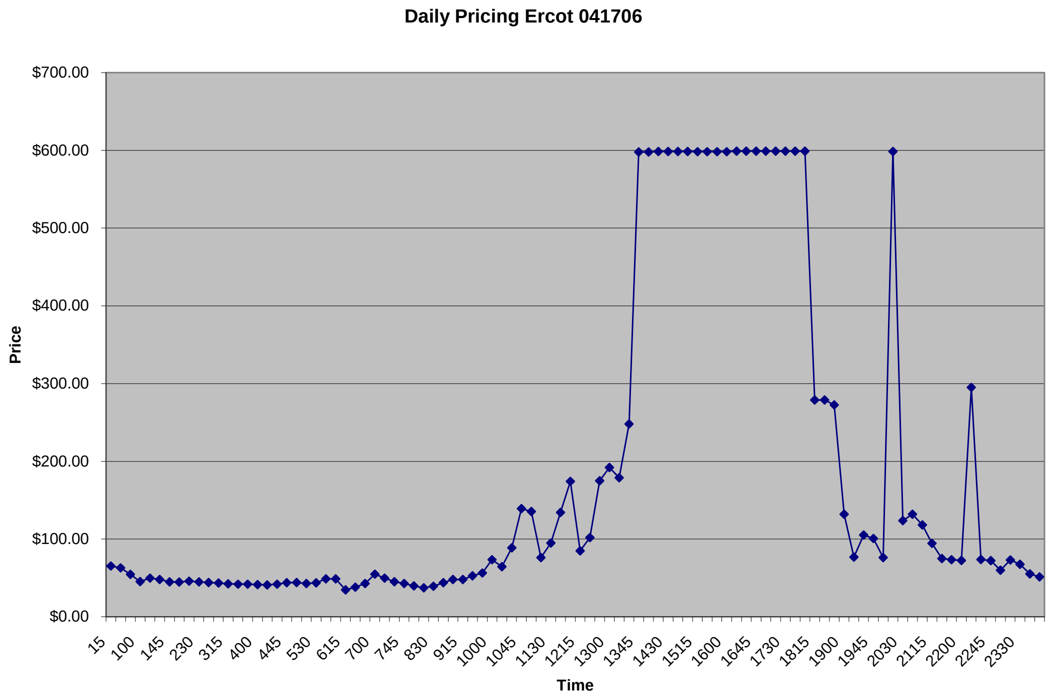

Fig 3 – Source ERCOT Balancing Energy Market Data April 17, 2006

U.S. Petroleum

Supply

- Global crude and refined product supply is struggling to keep up with global demand growth, even before supply interruption risk is considered.
- Supply interruption risk continues to grow as these crude supplies continue to shift from the industrialized world to unstable regions at an increasing pace.
- From the U.S. Energy Information Agency, the top six sources of U.S. oil imports**,** Canada, Mexico, Saudi Arabia, Venezuela, Nigeria and Iraq account for 65.1 percent of all foreign crude reaching our shores and 38.9 percent of total domestic consumption. Of these four, Saudi Arabia, Venezuela, Nigeria and Iraq provide 38.2 percent of oil imports and 22.6 percent of total consumption. For a variety of reasons, none of the four can be considered a reliable source of supply.
- The U.S. has become dependent on crude and product imports for almost 75% of its total demand.
- “Oil Nationalism,” especially in Latin America, is impeding private sector investment in oil and gas production as the risk of nationalization increases.

Demand

- Transportation fuel demand in the developing world, especially Asia, is increasing exponentially with linear changes in median income. This is primarily due to the “peak of the bell curve” in population moving towards income levels where cars are feasible.

- Crude oil in the U.S. is effectively a transportation fuel feedstock. Although globally crude oil is used as a feedstock for heating and electric generation, incremental crude oil demand is almost entirely devoted to transportation in the U.S.

Market Fundamentals

- As domestic and G8 oil and natural gas production declines and energy consumption increases, U.S. national security and economic well being is becoming increasingly dependent on petroleum imports from the most unstable regions in the world.
  - ⇒ <u>The U.S. will face increasingly competitive pressures from the developing world for each barrel of crude and gallon of gasoline it imports from highly volatile regions.</u>
- Reducing dependence on crude oil is a transportation challenge and requires increasing vehicle efficiency and shifting transportation from petroleum fuel to alternatives such as ethanol and electricity.

U.S. Total Energy Market Fundamentals

Electric Peak Capacity Shortage

- Building new conventional electric generation supply to answer the peak capacity shortfall is much less attractive than in the past, given the difficulty in building peaking generation in major metropolitan areas, where it is needed, due to:
  - o NIMBY.
  - o Environmental considerations.
- Peaking generation built away from the load is subject to transmission and distribution risk. Increasingly, this peak capacity shortage is being managed by passing risk through to the consumer.
  - ⇒ <u>Many electricity providers are starting to mandate smart meters and passing actual, real-time prices through for large segments of the load they serve to more efficiently manage peak capacity shortages.</u>

Electric Off-Peak Capacity Surplus and Transportation Fuels Shortage

- Only limited linkages exist between crude oil (transportation) and stationary energy grids.
- Huge disparities routinely exist between the energy content of electricity and petroleum.
  - o From April through August 2006, gas at the pump averaged ~ $3.00, but electricity equivalent gas is less than $1.00. {Appendix 1}
  - ⇒ <u>Linkages between the petroleum and electricity grids could create tremendous total Btu market efficiencies, resulting in reduced crude oil consumption, lower total emissions and greater electric grid reliability.</u>

⇒ There is more than adequate electricity supply available during off-peak periods to shift major parts of the transportation sector from petroleum to electricity, especially as new renewable generation is brought online.

Energy Customers and Risk

More and more electricity providers are transferring price risk to the end consumer. Final consumption is being linked with the true cost of electricity at an increasing rate as shown by:

- The Federal Energy Policy Act of 2005 which mandates electric *time of use rates* will be made available by Feb 2007.
- Electric providers, regulated and de-regulated, aggressively pursuing market-based solutions to peak capacity shortages that became obvious in the summer of 2006.

Due to the increasing peak capacity short in most regions in the country, the premium of fixed price electricity contracts, where the utility bears the risk, compared to real-time pricing, where the customer bears the risk, continues to increase.

- This is forcing many large, influential companies to demand real-time pricing to "self-manage" their peak load.

Consumption and cost can be controlled through creative, technological solutions when the correct pricing information is available.

- Our "eBay world" is ready to use price to establish value in electricity.
- History has shown there is no more effective way to efficiently allocate resources than a functioning, competitive market; command and control, socialistic systems always create higher prices and shortages.
- Functioning markets require competition between supply and demand to find the most efficient answer to price.

⇒ Exposure to actual electricity prices, real-time, will create competition and drive demand for solutions. This is the trend, and it is accelerating; massive innovation will be unleashed to fix a broken system.

Electranet Technology Groups

Technology groups, and associated firms, include, but are not limited to, the following:

The Network

1. Information Networks

- Low-power, low-data Sensor and Control Networks
- Radio Chipsets
- Device Vendors
- Integrators

2. **Energy Networks**
   - Digital Electrical Monitoring and Controls
   - Solid state switching
   - Power conditioning
   - Advanced Energy Metering

3. **Facility Broadband over Powerline (BPL):** the nexus of information and energy networks

4. **Software**
   - Distributed supply and demand: Information Aggregation and Control
   - Electric Grid Integration

The Nodes

1. **Energy and Power Storage**
   - Chemical (Battery, Flow batteries)
   - Capacitors
   - Thermal
   - Kinetic (Flywheel)

2. **Electrical to Kinetic Energy Conversion**
   - Motor/Generator (Plug-In Hybrids)
   - Digital controls & motor/generators
   - Regenerative Braking
   - Hybrid System Integrators

3. **Service Providers**
   - Electricity Demand Response
   - Electricity Baseload Efficiency
   - Energy Physical and Financial Risk Management

4. **Distributed Energy**
   - High-efficiency Conventional Electric Generation
   - Solar Electric Generation**:** Photovoltaic panels, films and surfaces; thermal

Appendix 1 – Electric Grid Gasoline

Price. Using the Prius{which can be scaled to larger cars without materially affecting ratios below}:

- 10 kwh charge overnight gets ~45 miles during the day.
- 45 miles avoids buying 1 gal of gasoline.
- 1 kwh off-peak, very, very conservatively costs 5cents/kwh, retail
- 10 kwh off-peak*5 cents/kwh = $0.50
- 1 gal of gasoline costs $3.00 retail
- <u>10 kwh displaces 1 gal, therefore arb is $3.00-0.50=$2.50.</u>

Off-peak Capacity Required. Estimate that the average U.S. car would use 20 kwh, or twice as much as the Prius. If half the fleet was converted, then the total consumption would be as follows:

- 200,000,000 cars in the U.S.
- ½ * 200,000,000 = 100,000,000
- 20 kwh*100,000,000 cars*1 MWh/1000kwh = 2,000,000 MWh
- 8 hr charge time, therefore 2,000,000 Mwh/8 hr = 250,000 MW of capacity needed off-peak
- Average MW needed in U.S. in 2004 was ~450,000 MW.
- Peak capacity available in was 960,000
- <u>250,000 MW off-peak is available.</u>

Unleaded Gas Demand displaced.

- 100,000,000 cars displacing ~2 gal/day = 200,000,000 gal/day displaced.
- Current U.S. consumptions: 9.5 mm/bbl/day*42 gal/bbl = 400,000,000 bbl/day.
- <u>**½ of current U.S. gasoline consumption can be displaced by the grid.**</u>

Contact Information

Enchanted Rock, Ltd.

3027 Marina Bay Dr
League City, TX 77573
Thomas McAndrew
tmcandrew@erockhold.com