



Nuclear Power, Solar, Wind, and Other Renewable Energy Sources: The Need for Infrastructure Investment

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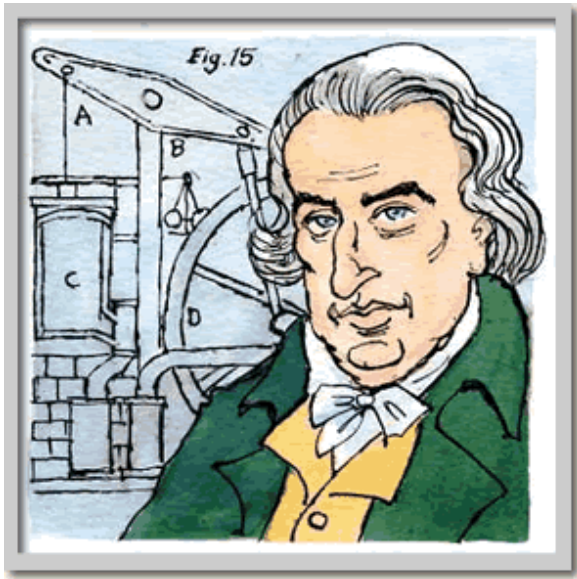
POPULATION=ENERGY DEMAND

- WOOD – Cooking, Heating, Pottery, Metallurgy – Charcoal
- HUMAN POWER – Pyramids
- ANIMAL POWER – Horses, Oxen
- WATER POWER – MILLS
- WIND POWER - MILLS

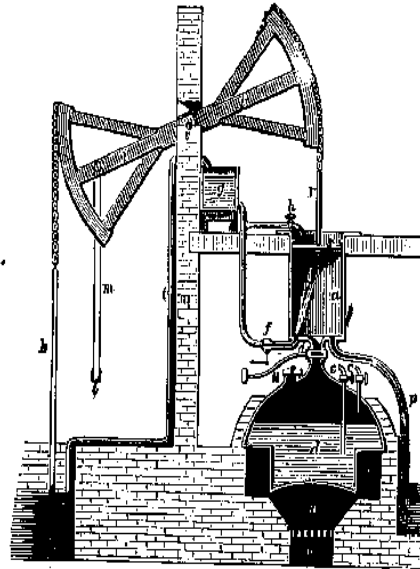
- THEN CAME THE STEAM ENGINE

STEAM ENGINE

- James Watt ---- Watt is unit of Power

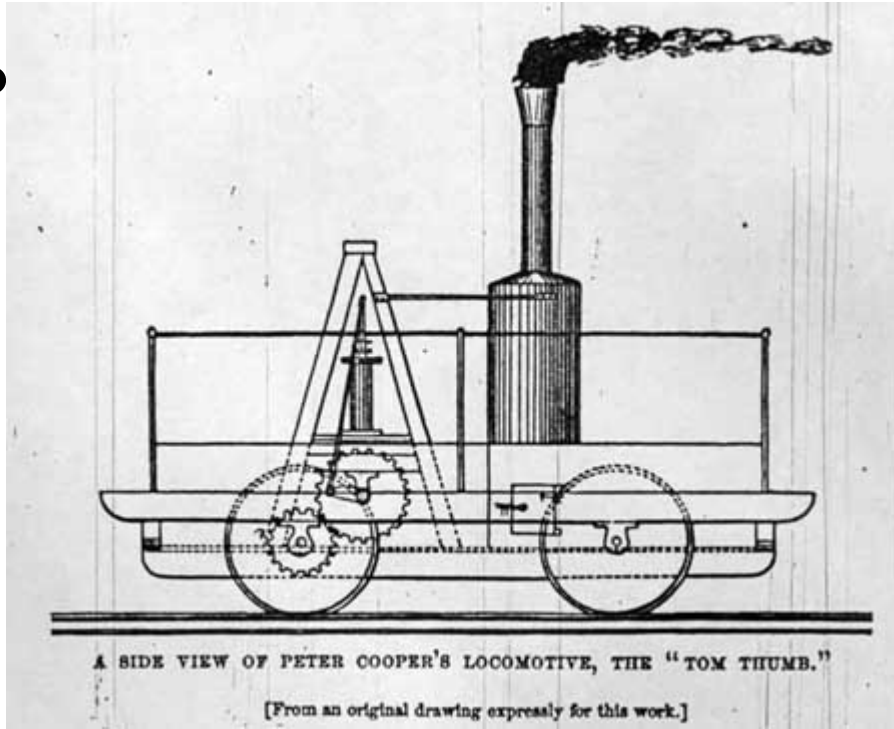


1712, Thomas Newcomen



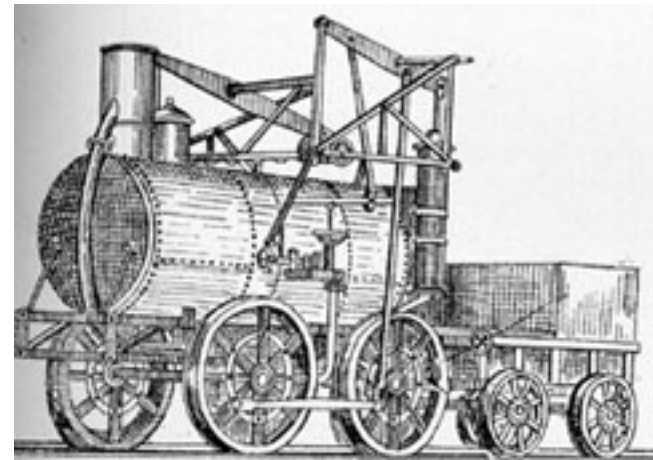
1769 Watt Improves Engine

Steam Powered Locomotives



Early 1800s

WOOD FIRED STEAM ENGINES




JOINING OF CONTINENTAL RAILROAD – May 10, 1869



Coal Fired Steam Engines...

Heating Values of Carbon Fuels



		Heating value	
Fuel		kJ/g	Btu/lb _{mass}
Wood		17	7700
Soft coal		23	10000
Hard coal		35	15000
Fuel oil, gasoline		44	19000
Natural gas		54	23000
Hydrogen		143	61000

Source: Elementary principles of chemical processes

Table 15-1

Wood 17.5-18.3 –
12% moisture

Gasoline, Kerosene
41-48

Methane – 55.6

Propane 50.3

N-Butane- 49.5

Wood, Coal, Gasoline, Natural Gas – MIXTURES.. So they
Vary in Heating Content!

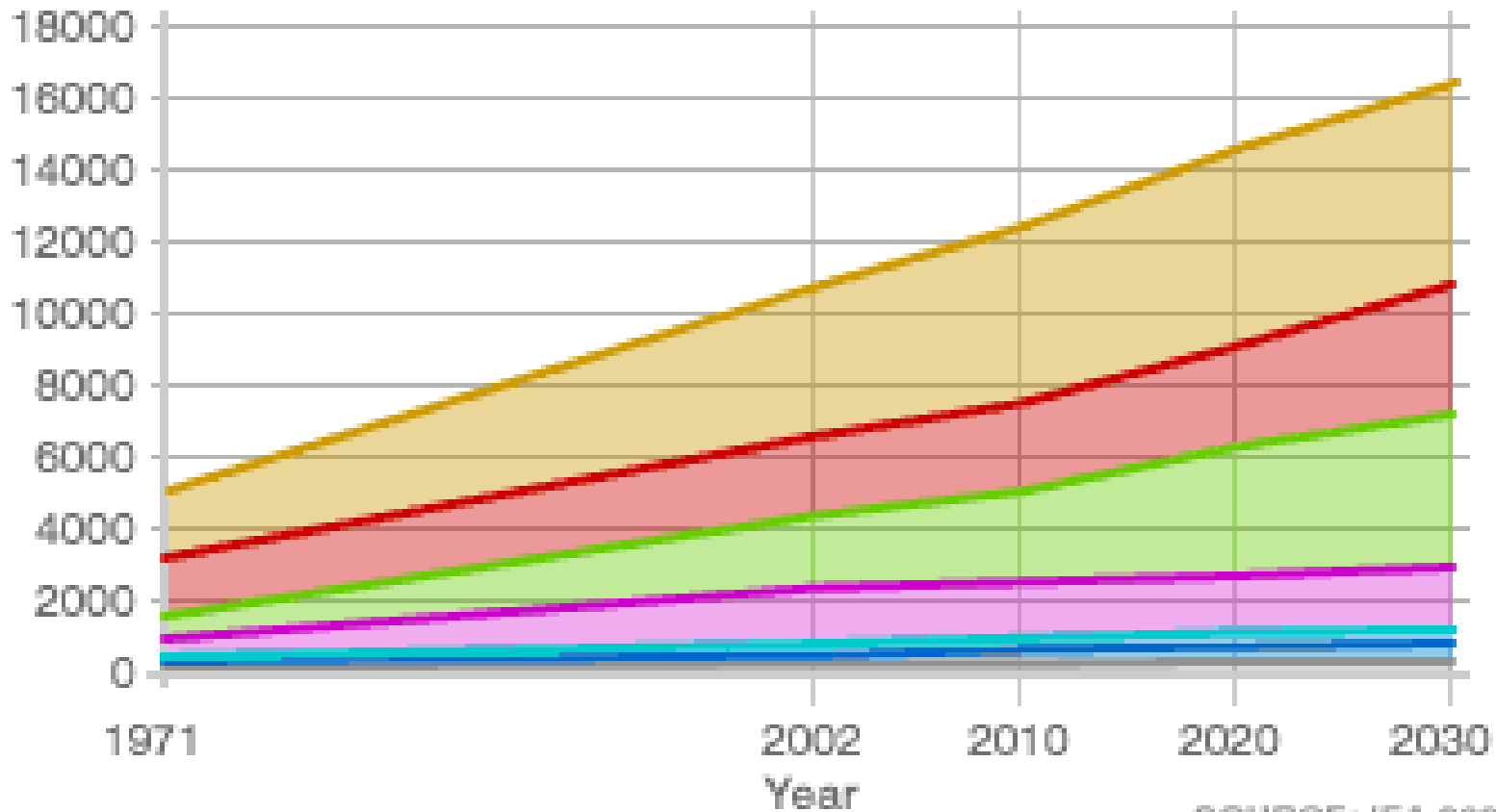
No such thing as perpetual motion

- Friction and other Heat Loss – its substantial. Look at your Motor Vehicles
Chemical Energy ends up as HEAT..
Engine exhaust losses, engine heating,
etc. - only about 25% of energy is useful
work!

World primary energy demand

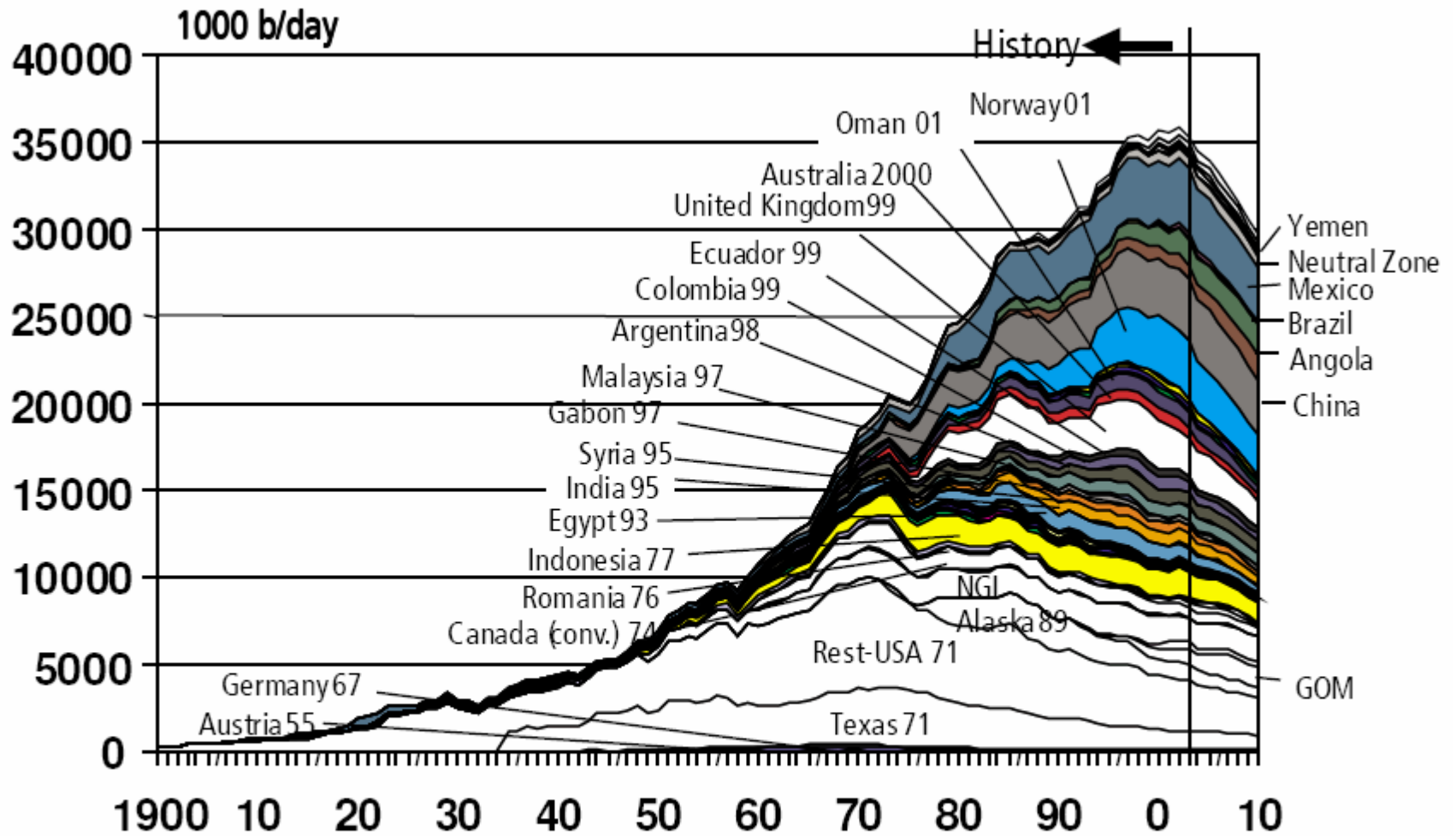
Million tonnes oil equiv.

- Coal
- Gas
- Hydro
- Others
- Oil
- Nuclear
- Biomass



SOURCE: IEA 2004

OIL PRODUCTION IS DROPPING OFF.. Price vs Demand.. \$\$\$\$

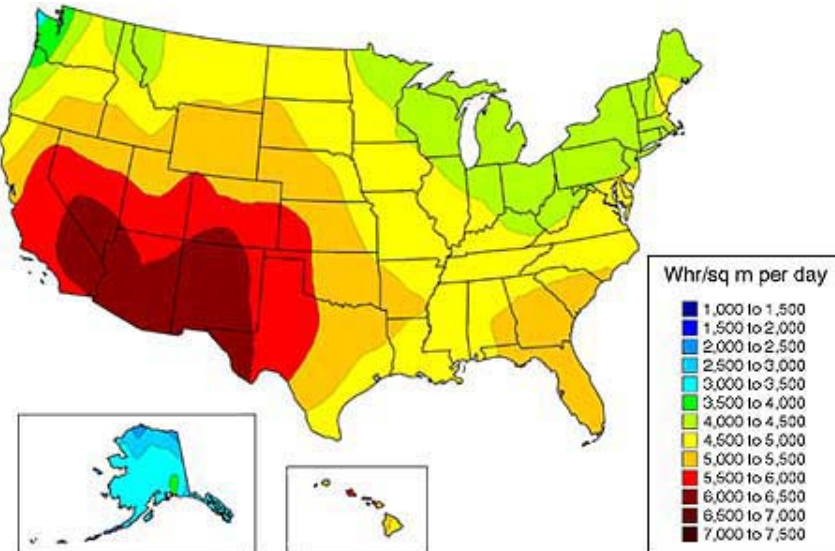


Source: Industry database, 2003 (IHS 2003)
 OGI, 9 Feb 2004 (Jan-Nov 2003)

Various Scenarios

- Use Tar Sands and Oil Shale
- Take Coal and Make Synthetic Petroleum
- Use more Coal..
- Natural Gas – similar problem as Oil
- Make Syn-Methane from Coal – requires lots o Water.
- Nuclear Energy – “Regulations” – Started Strong – 107 Nuclear Plants leads the world.. But no new ones since 1978
Were Behind World Development
France – Sweden – Japan - Germany

Solar Energy

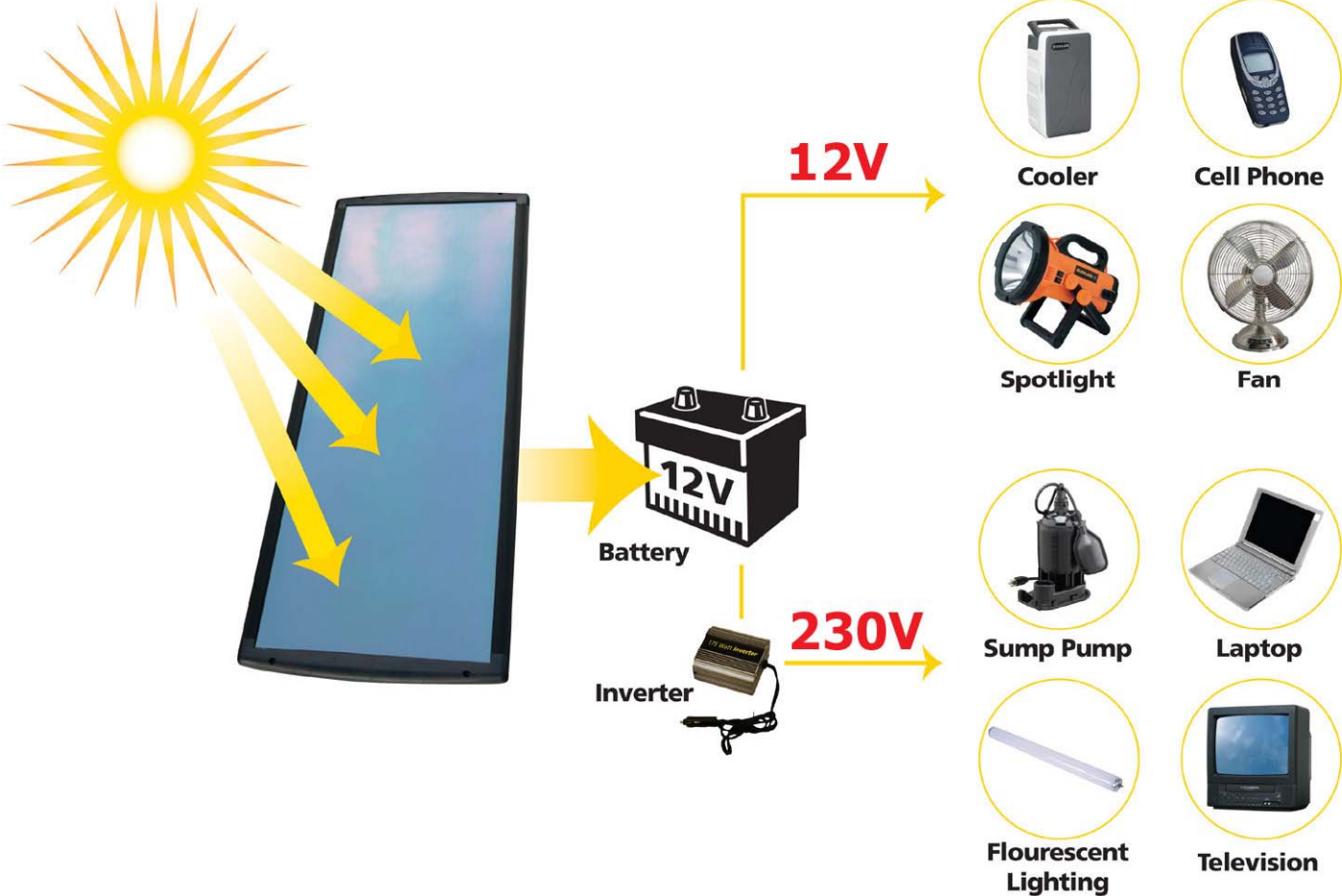


Solar resource for a flat-plate collector

Southwest and Southern U.S.
Solar may Start to Play Role

Better Batteries..Storage...Night

How Solar Works



Drawbacks

- Solar Panels – Mirrors, etc. Require Smelters to process materials – Mirrors or panels susceptible to dirt and dust.
- Processes are still in need of improvement

Biomass – Chemically Trapped Solar Energy

- Photosynthesis.. Need water and nutrients and carbon dioxide. CAN LEAD TO WATER QUALITY PROBLEMS DUE TO FERTILIZER and PESTICIDE USE.
- Air pollutants effect uptake by plants
- Ozone, NO₂, SO₂, etc. cause reduction in photosynthesis and plant damage and senescence – Ethylene
- SUSTAINABLE? – Frost, Flood, drought, etc. with changing climate makes that difficult to predict.. One year bumper crop.. Next year loss.

Sugar Cane vs Corn

- High Sugar Content.. More ETOH
 - Search for Enzymes.. Break down cellulose – Switchgrass, Rice Straw
- Biomaterials may be workable for materials we currently make from petroleum.. Plastics, synthetic cloths, etc.

TRADE OFF --- Food for Fuel?

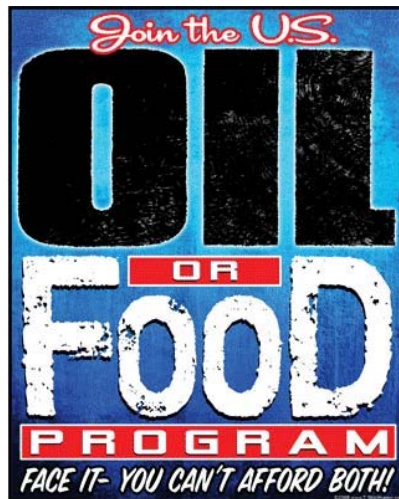
Ocean Currents. Tides. Wind. Geothermal. Hydroelectric

- Local generation. i.e. near hot spots – Iceland.. Now using energy to make Aluminum there
- Need Energy Storage.. Also need to couple with low loss power transmission to make larger scale use..
- Super Conductors
- HOT DRY ROCK.. Deep holes –
- Water limiting factor

Hydrogen

- It's stored electrons.. Hard to contain.
- Reactive
- Good for quick use in Fuel Cell Technology
- NOTE FUEL CELLS are fairly clean.
- BURNING Hydrogen in Air will produce NO_x

GAS PRICES – Forcing Change



CHANGES...

- **GM closing production at 4 truck plants; mulling options for Hummer brand - update 1 6/3/2008**
- **SUVs on road to nowhere** But not dead yet, concludes analyst - Nicolas Van Praet, Financial Post 6/3/08
- **Ford fightback halted by shunned SUVs and pick-ups** Andrew Clark in New York, The Guardian, UK

Electric Cars



Atera – 120 miles range

Hybrid – 300 mpg

- Good Idea..

But if everyone decided tomorrow to buy and use electric vehicle..

NOT ENOUGH ENERGY TO CHARGE THEM....

Need to plan AHEAD...

RELYING ON THE MARKET DOES HAVE ITS DISADVANTAGES – WHEN IT COMES TO INFRASTRUCTURE INVESTMENTS..

Also...

- Need to consider.. Electric car – Good..
- BUT IT Needs electricity
- If you get it from COAL.. More CO₂, SO₂, NO_x, etc.- NOT SO GOOD..
- Nuclear Power?
- Solar, Hydro, Wind, - Power transmission lines?

- LOTS TO DO AND CONSIDER

- INFRASTRUCTURE CHANGES TAKE TIME!