

# Fuel Sources and Designers

OUR WORLD.  
OUR RESPONSIBILITY.

Can This Profession Be Saved?

Part II: Ethics

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## Review of last lecture:

According to the EPA, the way we produce electricity is the number one cause of air pollution and global warming. In the US, about 60% of our electricity is produced by burning fossil fuels, with the following effects:

- Depletion of natural resources and destruction of natural habitat for ALL humans and animals.
- Compromised public health for ALL humans and animals.
- Increased world conflict due to quests for more natural resources.
- Smog, air pollution, acid rain.
- Global warming.
- Extraordinary use of water in the production process.

Another 22% of our electricity comes from nuclear energy, which leaves a bi-product that future generations will have to deal with and compromises our national security.

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"What you really need is a sea change in public opinion," says McCain. "Global warming has to become a campaign issue, and it never has, either in congressional campaigns or senatorial campaigns or presidential campaigns."

Vs.

the future is what we sell

Snelling Snelling

2015 GULF FRWY. 649-2791

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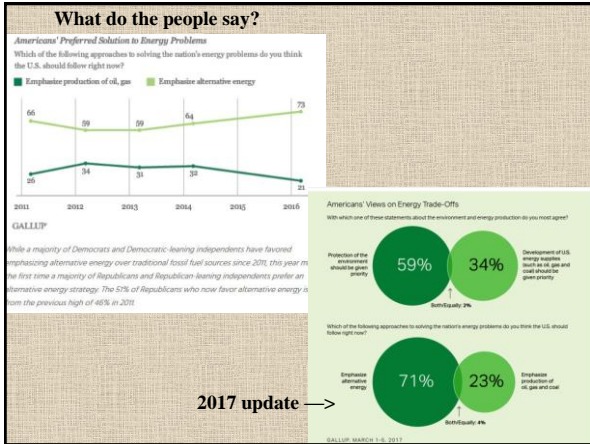
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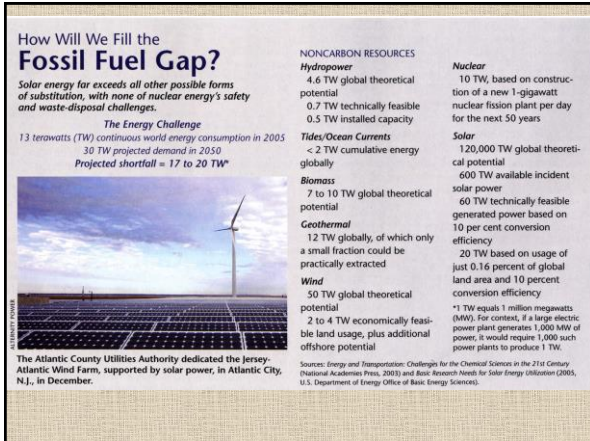
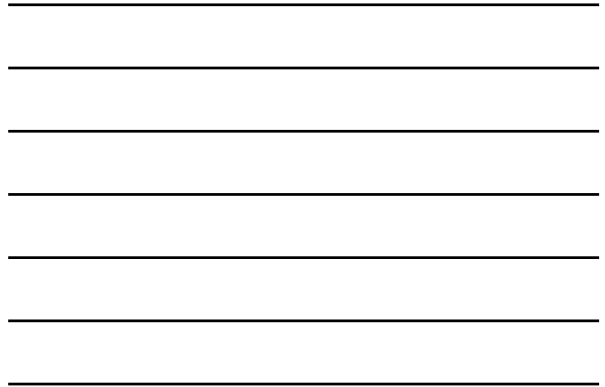
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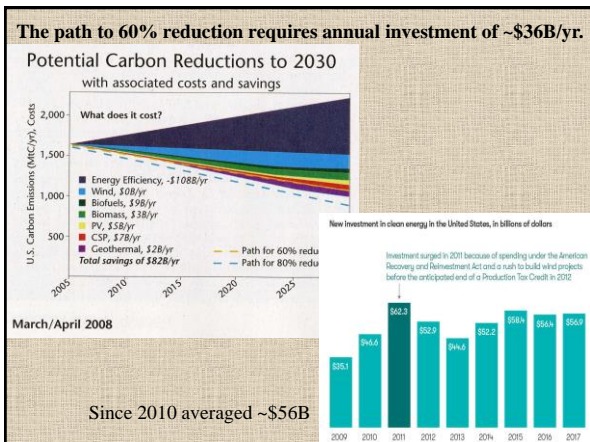
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## New York State as 100% Renewable by 2030

—Stanford Professor Mark Jacobson, 2013

- **40 percent:** Offshore wind (12,770 5-megawatt turbines)
- **10 percent:** Onshore wind (4,020 5-MW turbines)
- **10 percent:** Concentrated solar (387 100-MW CSP plants)
- **10 percent:** Utility-scale solar PV (828 50-MW plants)
- **6 percent:** Residential rooftop PV (5,000,000 5-kW systems)
- **12 percent:** Commercial/government rooftop PV (500,000 100-kW systems)
- **5.5 percent:** Hydro (7 1.3-GW hydroelectric power plants, most of which already exist)
- **5 percent:** Geothermal (36 100-MW plants)
- **1 percent:** Tidal (2,600 1-MW tidal turbines)
- **0.5 percent:** Wave energy (1,910 0.75-MW wave devices)




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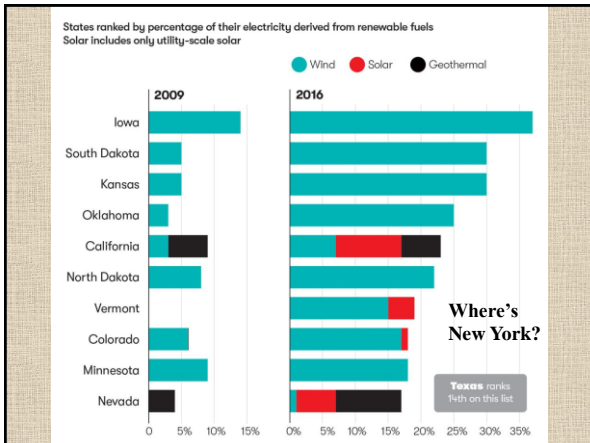
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Alternative energy means jobs for Americans:

# 50,000

Coal-industry employees, 2016

# 102,500

Wind-industry employees, 2016

# 260,000

Solar-industry employees, 2016

# 800

Energy storage, in megawatts, built in the United States in the last five years

**AND**

Energy storage, in megawatts, expected to be added in a single year by 2020

...and storage makes wind and solar ever more effective.

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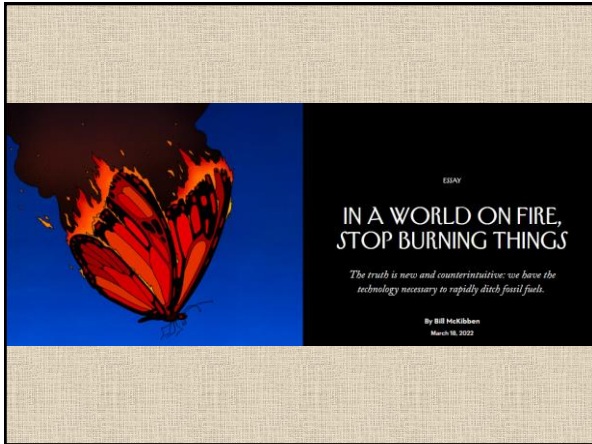
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### Non-Combustion Fuels

	<b>Conservation</b>
	<b>Hydroelectric</b>
	<b>Solar</b>
	<b>Photovoltaic</b>
	<b>Geothermal</b>
	<b>Wind</b>
	<b>Fuel Cells</b>

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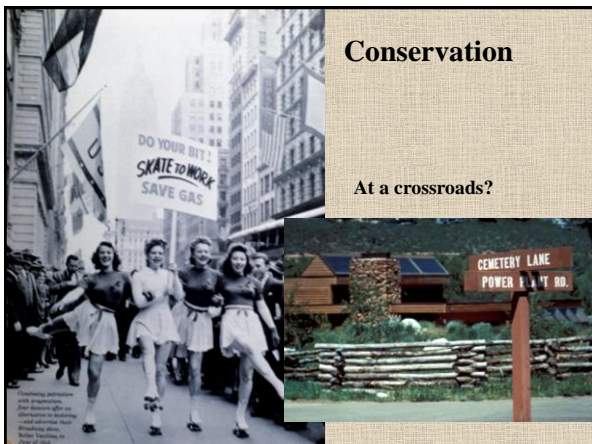
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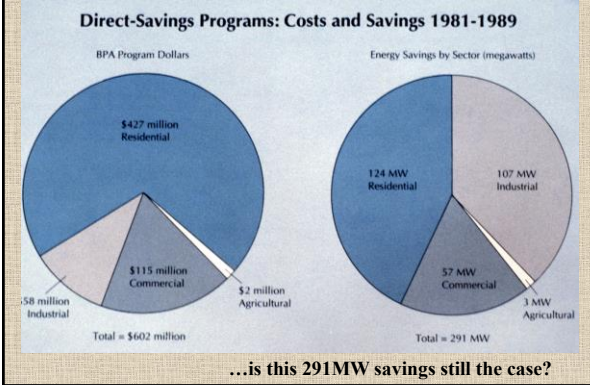
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## Investment in conservation...




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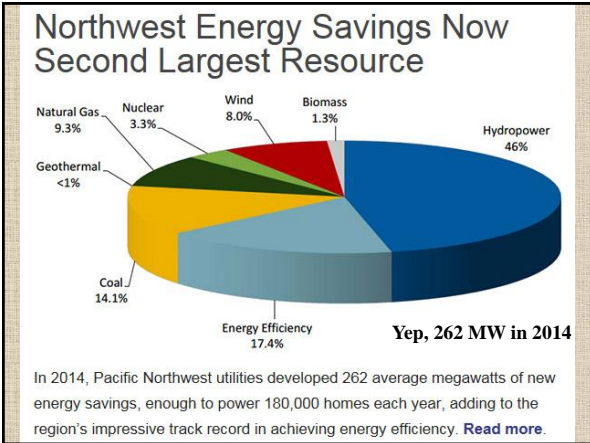
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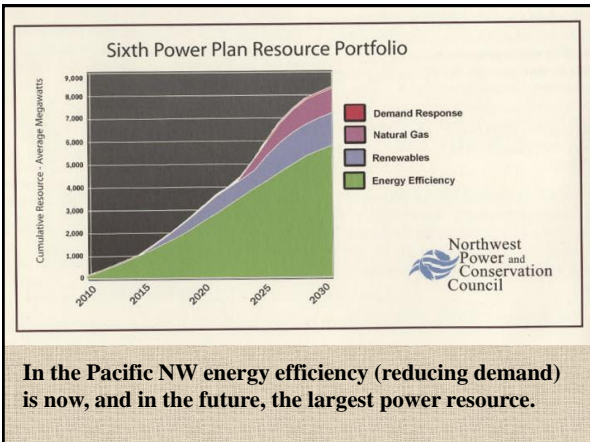
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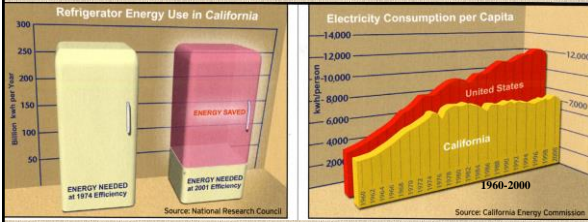
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Practiced most successfully when by...



Code or Crisis

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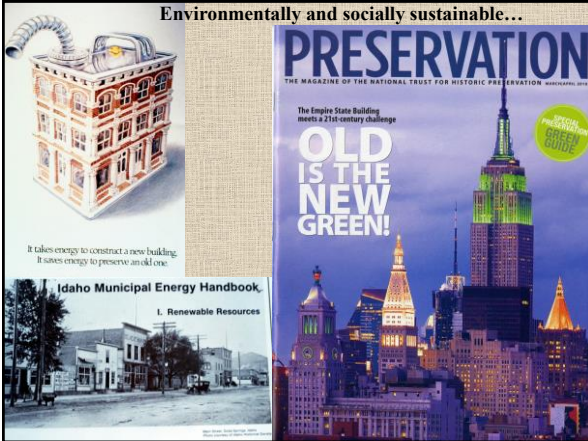
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Environmentally and socially sustainable...



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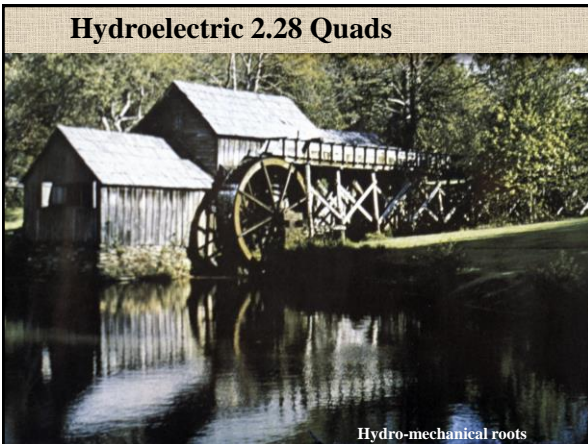
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Hydroelectric 2.28 Quads



Hydro-mechanical roots

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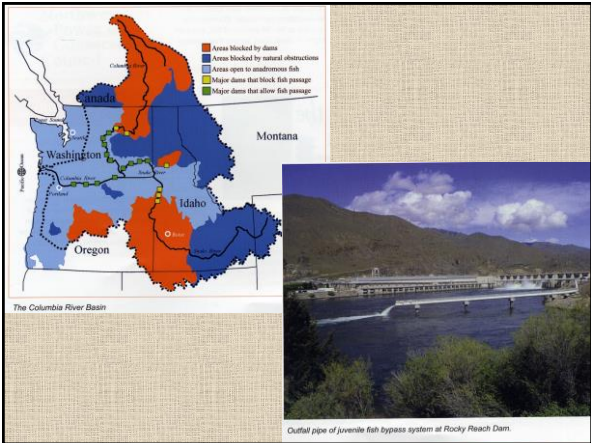
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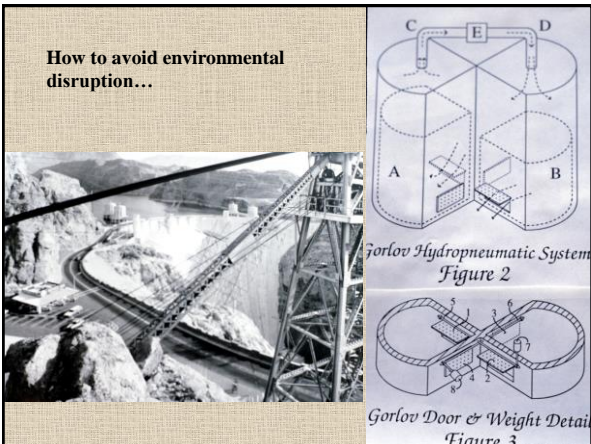
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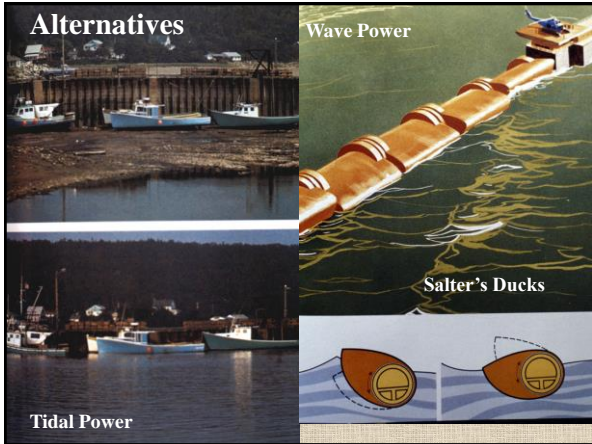
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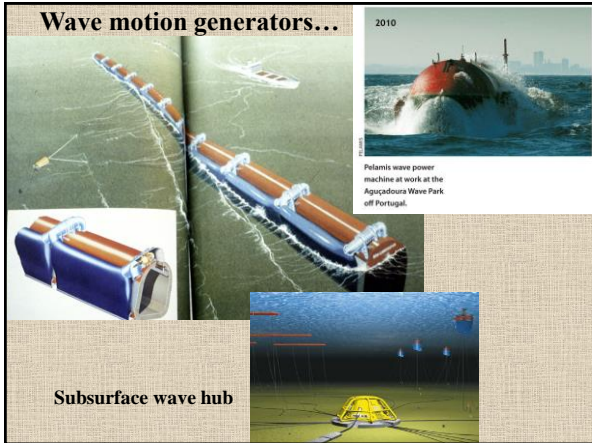
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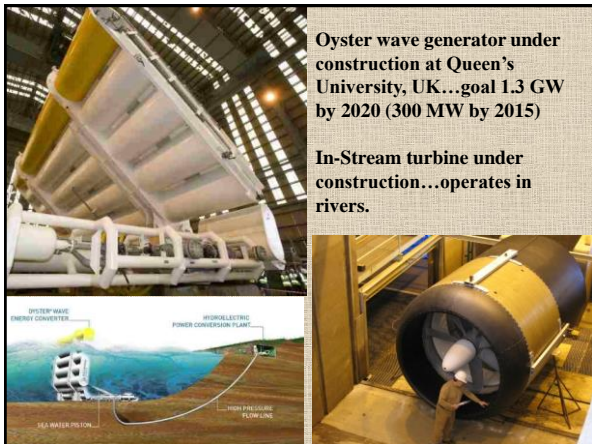
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The energy challenge

## Solar Energy 1.5 Quads

How to harness a plentiful resource?

REFLECTED TO SPACE 35,000

SOLAR RADIATION 178,000

KINETIC ENERGY 300

PHOTO-SYNTHESIS 100

MOON

HEAT FROM EVAPORATION 40,000

TIDES 3

GEOTHERMAL HEAT 30

ABSORBED 120,000

(in terra-watts)

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## Solar Thermal Large Scale (focusing mirror array)

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SOLAR PILOT PLANT PROJECT

A COMPENSATING EFFORT BY THE STATEMENT OF SENATOR  
DOROTHY CALIFORNIA LEGISLATURE LOS ANGELES DEPARTMENT  
OF WATER AND POWER AND THE CALIFORNIA ENERGY COMMISSION

© 2008 Southern California Edison

© 2008 Solar Energy Industries Association

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## Solar Thermal Medium Scale (Stirling engine)

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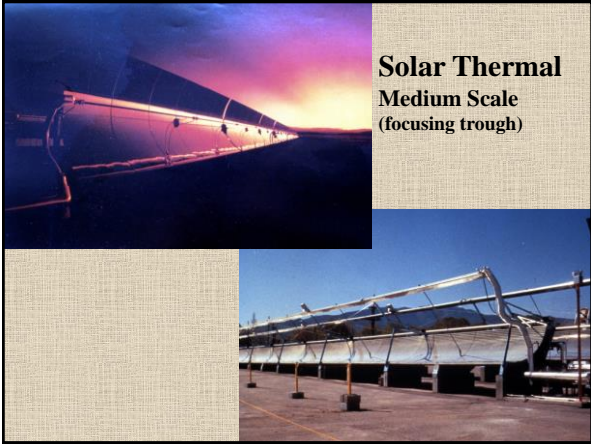
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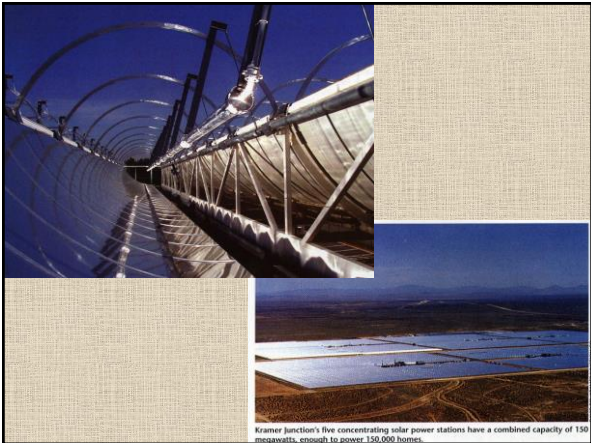
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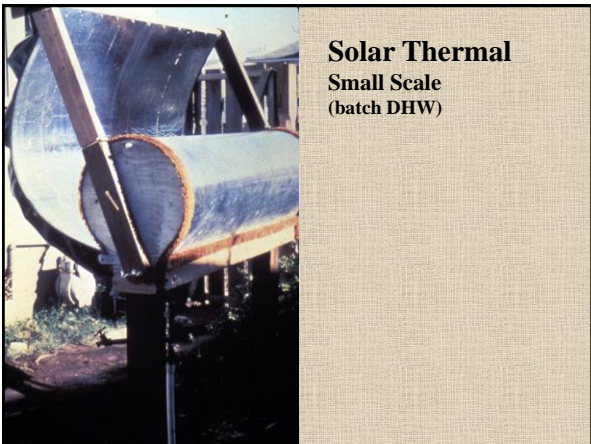
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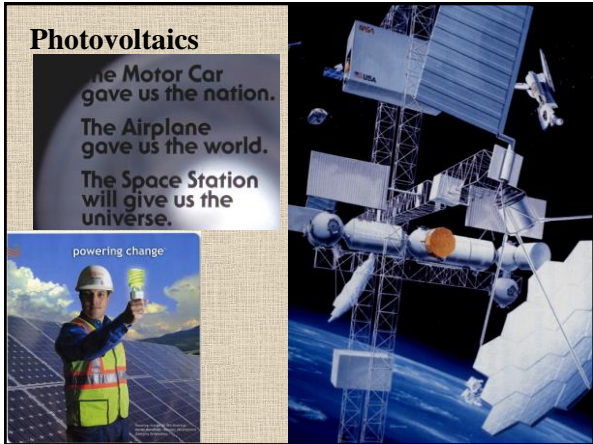
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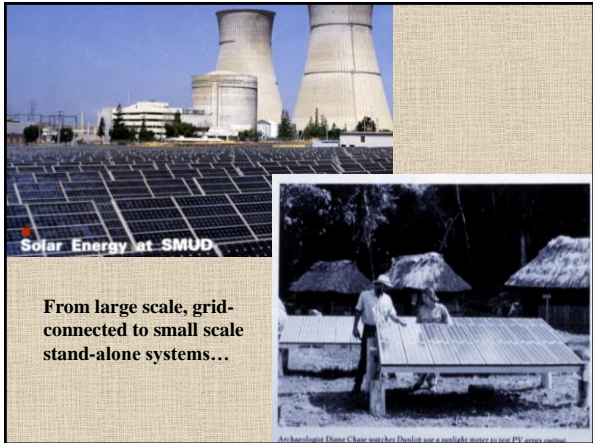
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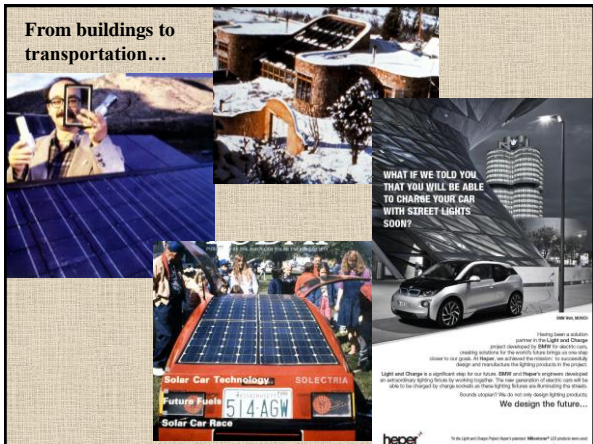
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**We've taken big steps to give you the smallest carbon footprint.**

Our solar panels have the smallest carbon footprint in the industry. There, we've said it. Are we bragging? Maybe a little. But it's a message worth taking aboard — especially in an industry driven by concern for the environment. In fact, our manufacturing methods use less traditional energy to create a product that's not only good for the environment, but that can actually replace traditional energy. Environmentally speaking, it doesn't get much better than that. Learn more about us, our products and our environmental credentials at [www.envertensolar.com](http://www.envertensolar.com).

**high-tech vs. low-tech**

\*Source: Energy Research Foundation of the Netherlands

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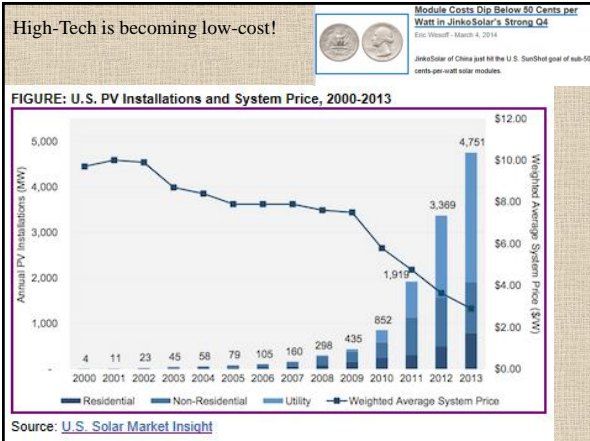
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**The next wave... PV windows!**

Photo by Dennis Schroeder courtesy NREL

Scientists at the U.S. Department of Energy's National Laboratory (NREL) have developed a switchable solar cell that is transparent to tinted in the sunlight, converting the electricity. "There is a fundamental tradeoff between a good solar cell," said NREL scientist Lance Wheeler, "and a good window. Our technology bypasses that. We have a good solar cell when there's sunshine and we have a good window when there's no sunshine." The technology uses perovskites and single-walled carbon nanotubes.

[NREL]

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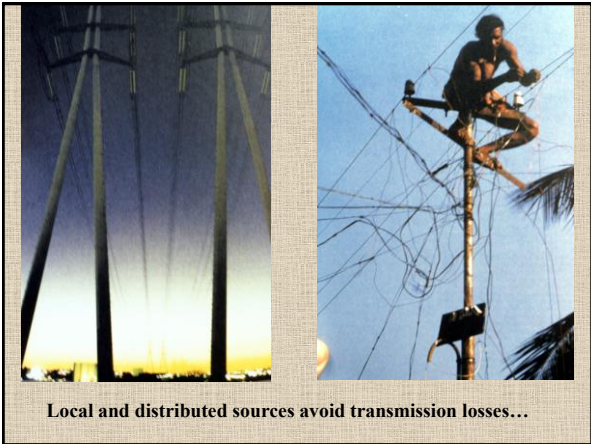
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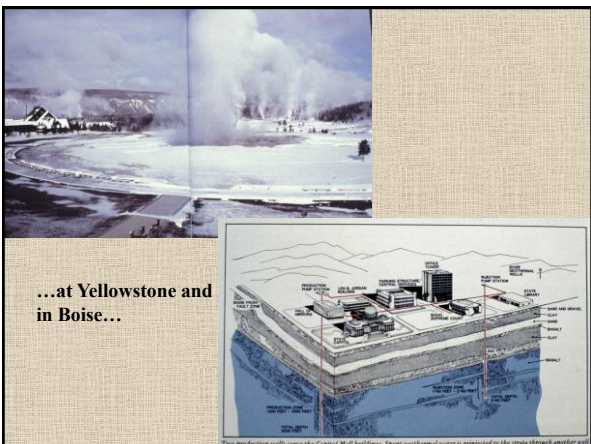
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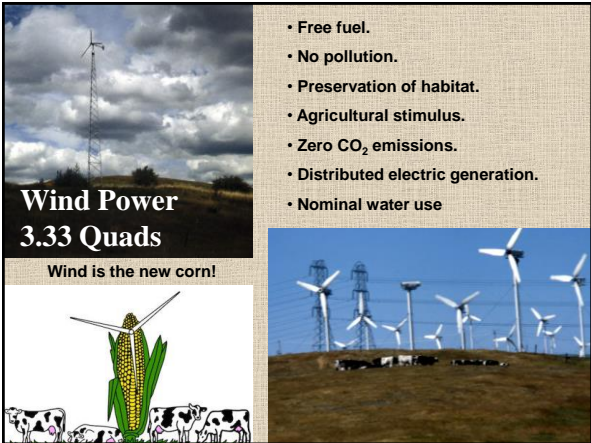
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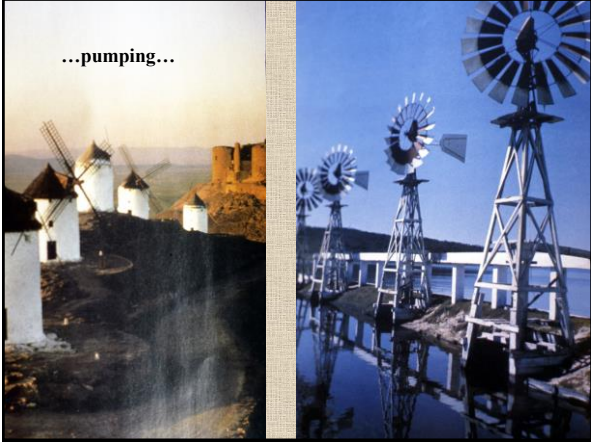
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**IDAHO Currents**  
 In Honor of Live! Live!  
 Vol. 18 Fall 2011  
 Energy and Water News

**Idaho Wind Power Conference**  
 October 22, 2011  
 Boise, Idaho



**It's a new dawn for Idaho wind technology**

**The least expensive and most benign means for new power generation...**



Purchase 5 to 8 blocks and half of your electricity will be from wind power.  
\*2010 average

IDWR and Avista

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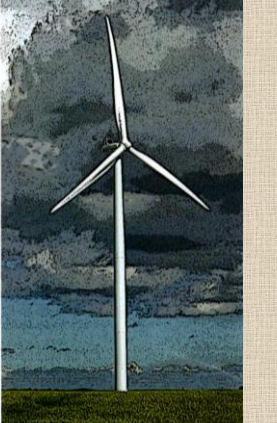
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"The federal tax credit for wind power production is \$19 per megawatt-hour for 10 years, and that makes wind a cost-effective resource compared to other forms of generation."

Jeff King  
 Senior Resource Analyst

NWPPC 2006

**∴ 47% of the new power in the PNW in 2005 was wind.**




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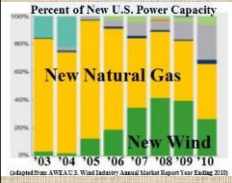
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**...and growth continues in PNW and nationally...**

Percent of New U.S. Power Capacity



**New Natural Gas**

**New Wind**

Adapted from AWEA's Wind Industry Annual Market Report Year Ending 2010

PAGE 2 | SPRING 2011 | nrcouncil.org

2006  
 10 GW of wind facilities contributed 21 percent of the region's capacity growth.

2011  
 16 GW of wind facilities nearly tripled 12 percent of the region's capacity growth.

Comparison of Wind Power Growth in the Pacific Northwest

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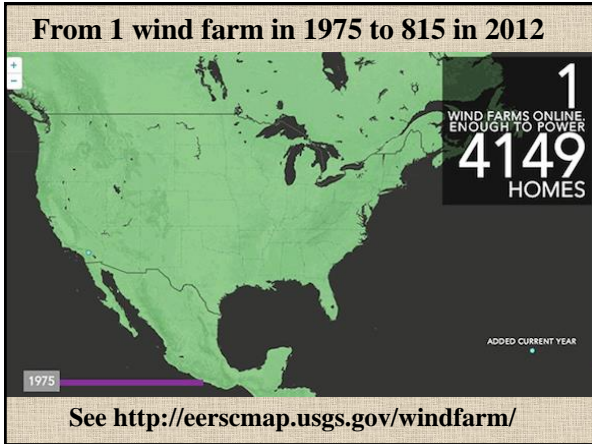
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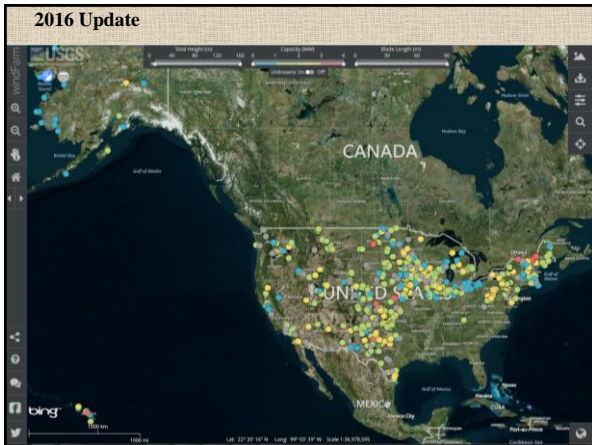
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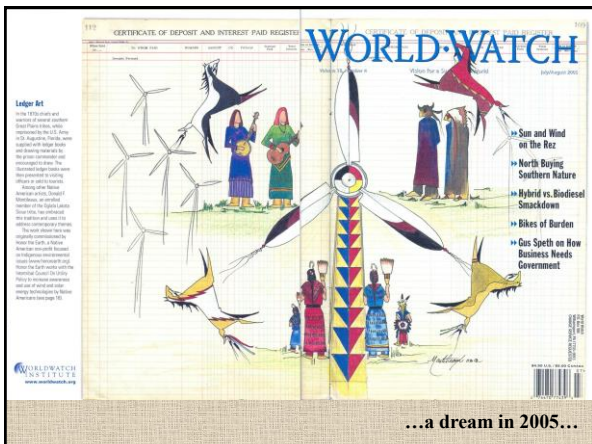
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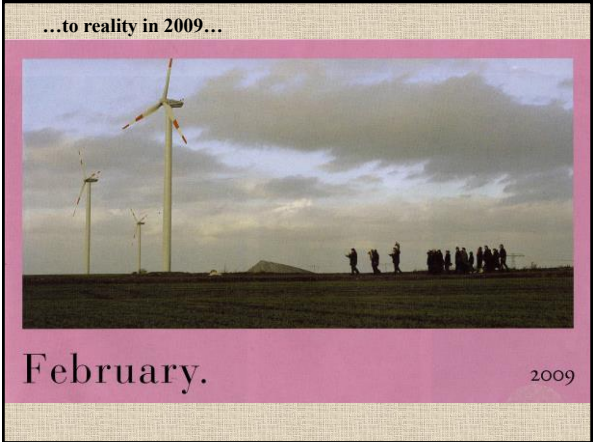
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**Environmentally friendly?**

**The Audubon Society** estimates 10,000 to 40,000 birds are killed annually by wind turbines as compared to:

- 60-80 million due to vehicle collisions,
- 98-980 million due to buildings and windows,
- 174 million due to power lines, and
- 7-50 million due to communications towers.

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**NREL Research Project:**  
Bird detection radar

Field test with Sam Dollar and Houdini in 2015

The ultimate aim is to be able to detect birds soon enough that an alert can be sent to the wind power plant operator in time to shut down the blades.

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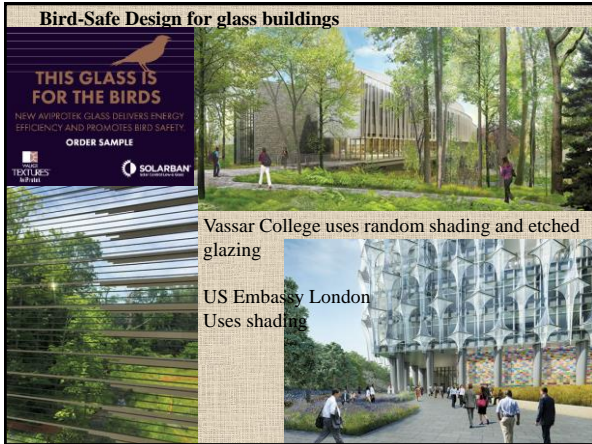
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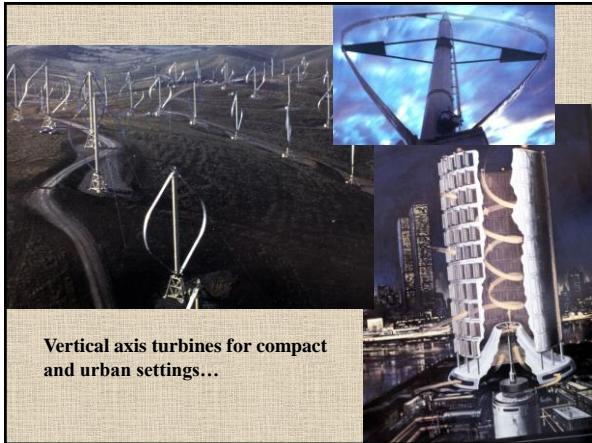
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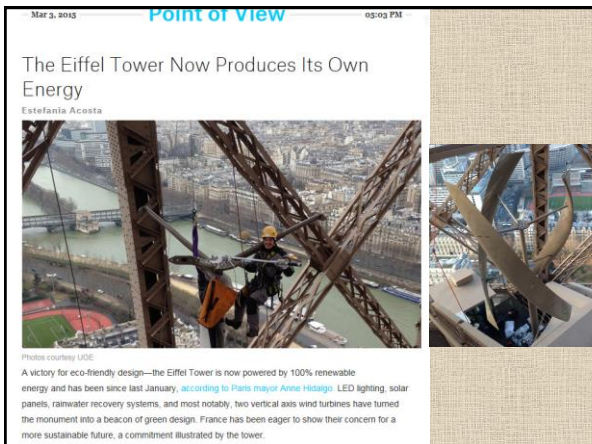
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New age windjammers...



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METROPOLISMAG.COM



Courtesy Elioth + Encore Heureux

"Even if the power is tiny, as soon as you integrate it like that, it creates big, big energy."

—Raphael Ménard, one-third of [this year's Next Generation-winning team](#), on a proposal to integrate wind turbines into existing electrical-transmission towers

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DR. F. DAVID DOTY: FEBRUARY 2, 2011

Guest Post: Kicking Oil Addiction With Windfuels

A startup proposes using off-peak excess wind energy to recycle CO2 into standard transportation fuels.

**2010 = 25 TWh**  
**2011 = 40 TWh**  
**excess off-peak**  
**production in US**

...storage is a problem...



For many years, greentech leaders have been saying renewables are never going to make a major contribution to our energy needs until we have a better method for storing off-peak clean energy. For even longer, environmentalists and national security analysts have been seeking an alternative to fossil oil for our transportation needs. WindFuels, a small company in South Carolina, believes both of these needs can be met simultaneously with a new concept to store excess intermittent clean energy in standard hydrocarbon fuels (gasoline, jet fuel, and diesel) for transportation.

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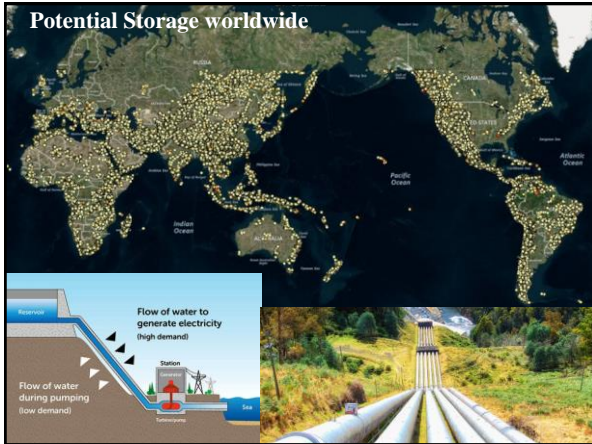
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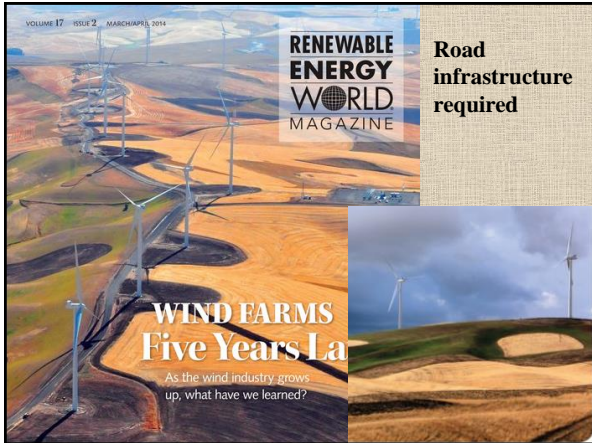
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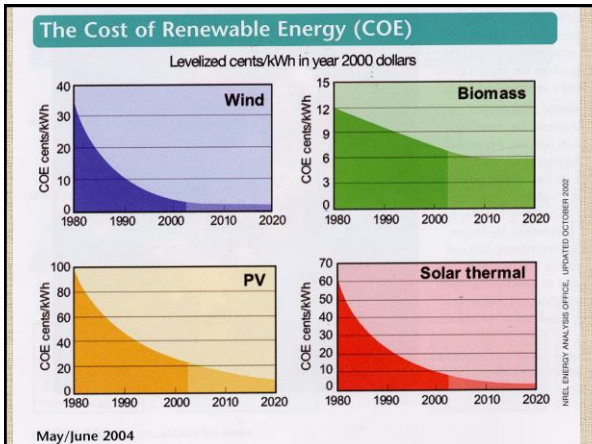
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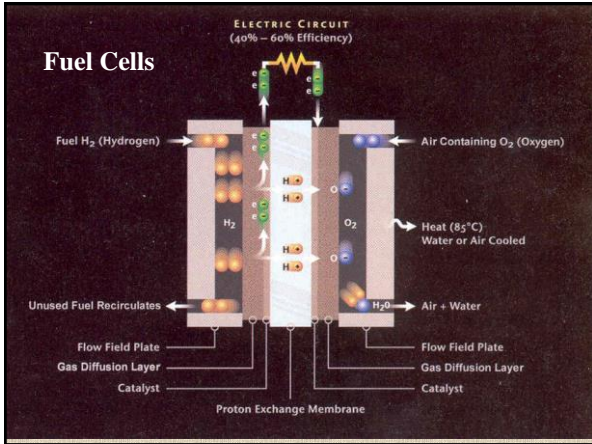
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**Scalable!**  
Can power toys...  
Equipment...

**Hydrogen Fuel Cell SE-8073**  
Electricity from the solar panel is used in the process of electrolysis to split water into hydrogen and oxygen. The hydrogen is used as fuel in the fuel cell. The process that takes place in the fuel cell is the opposite of electrolysis. The hydrogen is combined with oxygen to make water and produce electricity. In this demonstration, the electricity produced by the fuel cell is used to operate a fan. The fuel cell has an efficiency of about 50%.

**Assemble Fuel Cell**  
Fuel Cell 10 Stack  
Hydrogen Fuel Supply  
Solar Cell  
Power Source

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**Can power cities, buildings, or cars...**

**NASA Sustainability Base**

**Barriers**

- Hydrogen fuel
- Costs
- Weight

Figure 1. Fuel cells are starting to impact the transportation industry. They are being used in cars, buses, forklifts, and even airplanes. While it is more efficient and more environmentally friendly means for moving people. The figure shows the placement of a fuel cell (red box) and its supporting system in a car. Photo courtesy of DaimlerChrysler Corporation.

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GreenSage.com e-news Where Every Issue is a Green Issue  
March 2008 Issue  
Providing Wisdom in Building a Sustainable Future

UTC Power FuelCell system

### Whole Foods Powers Store With Fuel Cell

A new Whole Foods Market in Danbury, Connecticut is the first supermarket to generate most of its power on-site with a fuel cell.

"We are always looking to reduce our impact on the environment," said Kathy LaFus, Global Leader, Sustainable Engineering, Maintenance and Energy for Whole Foods Market. "Together with UTC Power and the Connecticut Clean Energy Fund, we've designed a combined cooling, heating and power system for our new Danbury store using a quiet, highly energy-efficient fuel cell that will reduce our carbon footprint dramatically."

The store's fuel cell was eligible for an On-site Renewable Energy grant from the Connecticut Clean Energy Fund (CCEF). The CCEF provides awards and loans in clean energy sources to subsidize energy for the benefit of Connecticut taxpayers. Whole Foods received a \$940,000 grant from the Connecticut Clean Energy Fund to be used toward the purchase of the fuel cell. AP reports.

The new 45,000-square-foot store will generate 50 percent of the electricity and heat and nearly 100 percent of the hot water needed to operate the store from the UTC Power fuel cell.

More than half of the energy potential in traditional power plants is lost to the atmosphere as waste heat or in-line transmission losses. In contrast, the fuel cell system captures its exhaust energy for local cooling and heating. The harnessed exhaust energy at the store will cool refrigeration cases year-round and heat the store in the winter months.

The fuel cell at Whole Foods can provide 200 kilowatts of power in the event of a grid failure, which would allow the supermarket to operate without disruption providing enhanced energy security ensuring a reliable food supply for customers and protect against costly food spoilage if the power grid goes down.

Fuel cells are one of the cleanest and quietest power-generating technologies in the world today. Also highly efficient and virtually pollution-free, fuel cells produce electricity, heat and water electrochemically, meaning there is no combustion.

Whole Foods Market's use of a fuel cell system versus a conventional power plant has carbon dioxide-mitigating benefits equal to planting more than 21 acres of forest, the equivalent of 100,000 trees. The total emissions in hydrogen oxide emissions equal to removing 100 cars from the roadway per year.

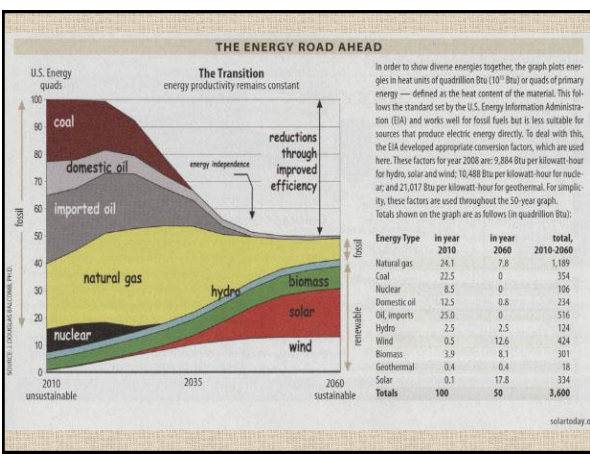



70

### Iceland's Hydrogen Bus




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72





"Mr. Energy, may I be excused?  
My brain is full."

...not until 11:20...

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