

Solar Architecture in Minnesota: Toward Zero Energy Housing



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Acknowledgements: Sarah Nettleton Architects, Minnesota Science Museum, the Weidt Group, Keegan Furfaro, Peter Kerze, and Kerry Haglund.

National Efforts renewable Minnesota



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ZERO ENERGY HOMES PROJECT

Powering the Future with Today's Homes

Home Page

Overview/Definition

- ZEH Impact Study
- 7 Steps to a ZEH

ZEH Demos/Articles

- Tucson, AZ
 - Video
 - Housing Results
- Calicut, WI
- Red Ar, MI
- Energy Features
- Sponsors

ZEH Marketing

- Appraisal Issues
- Selling the ZEH
- ZEH Presentations

Imagine a home that is not only energy-efficient, but also produces its own power. Just like a typical home, a Zero Energy Home (ZEH) is connected to, and uses energy from, the local electric utility.

But unlike typical homes, at times the ZEH makes enough power to send some back to the utility. Annually, a ZEH energy to offset the purchased from the utility in a net-zero annual.

The national Zero Energy Home projects have been supported in part by the Department of Energy's Building America Program.

First ZEH at Arroyo Park del Sur



Moving Toward Zero Energy Homes

The U.S. Department of Energy's Zero Energy Homes research initiative is providing a new concept to homebuilders across the United States. A Zero Energy Home (ZEH) combines state-of-the-art, energy-efficient construction and appliances with commercially available renewable energy systems such as solar water heating and solar electricity. This combination can result in net zero energy consumption from the utility provider. Zero Energy Homes are connected to the utility grid but can be designed and constructed to produce as much energy as they consume annually.

The Net-Zero Energy Home Powering Canadian Homes Through Energy Efficiency, Supply & Innovation

Workshop on Maximizing Energy Efficiency and Renewable Energy in BC
March 23, 2006



“A Zero Energy home combines renewable energy technologies with advanced energy-efficient construction...Because the home produces *about* as much energy as it consumes during a year, it is considered to achieve ‘net zero’ energy consumption.” - DOE

State Efforts renewable Minnesota

Solar Minnesota, Minnesota Million Solar Roofs Initiative



Solar Minnesota

Welcome to Solar Minnesota!

Solar Minnesota is an part of the Million Solar Roofs Initiative (MSRI). Announced in June 1997, Million Solar Roofs (MSRI) is an initiative to install solar energy systems on one million U.S. buildings by 2010. The initiative includes two types of solar technology: solar electric systems that produce electricity from sunlight and solar thermal systems that produce heat for domestic hot water, space heating, or heating swimming pools.

Community Solar
Community solar energy projects are defined by the involvement of the local or regional community in planning, organizing, funding, installing (portions), and/or enjoying a solar energy system. Community solar is about neighbors, customers, and members coming together to make a local solar energy system a reality. The exact definition isn't as important as involving people outside of just the property owner. [more info](#)

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Calculators
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MREA Information



Midwest Renewable Energy Association



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MREA Information

General Information on MREA

Our Mission

The Midwest Renewable Energy Association (MREA) promotes renewable energy, energy efficiency, and sustainable living through education and demonstration.

Our Structure

The MREA is a non-profit 501(C)3 tax exempt organization. The organization was incorporated in March of 1990 in the state of Wisconsin. Donations to the MREA are tax deductible.

Our Activities




MINNESOTA DEPARTMENT OF COMMERCE

Home Page of the 520 Renewable Energy Society



Minnesota
Office of
Environmental
Assistance



MINNESOTA RENEWABLE ENERGY SOCIETY

Making lasting friendships with our environment.



[Home Page](#)

[MRES Annual
Membership
Meeting December
8, 2005](#)

[Revised By-Laws](#)

[BOD Nomination Form](#)

[BOD Job Description](#)

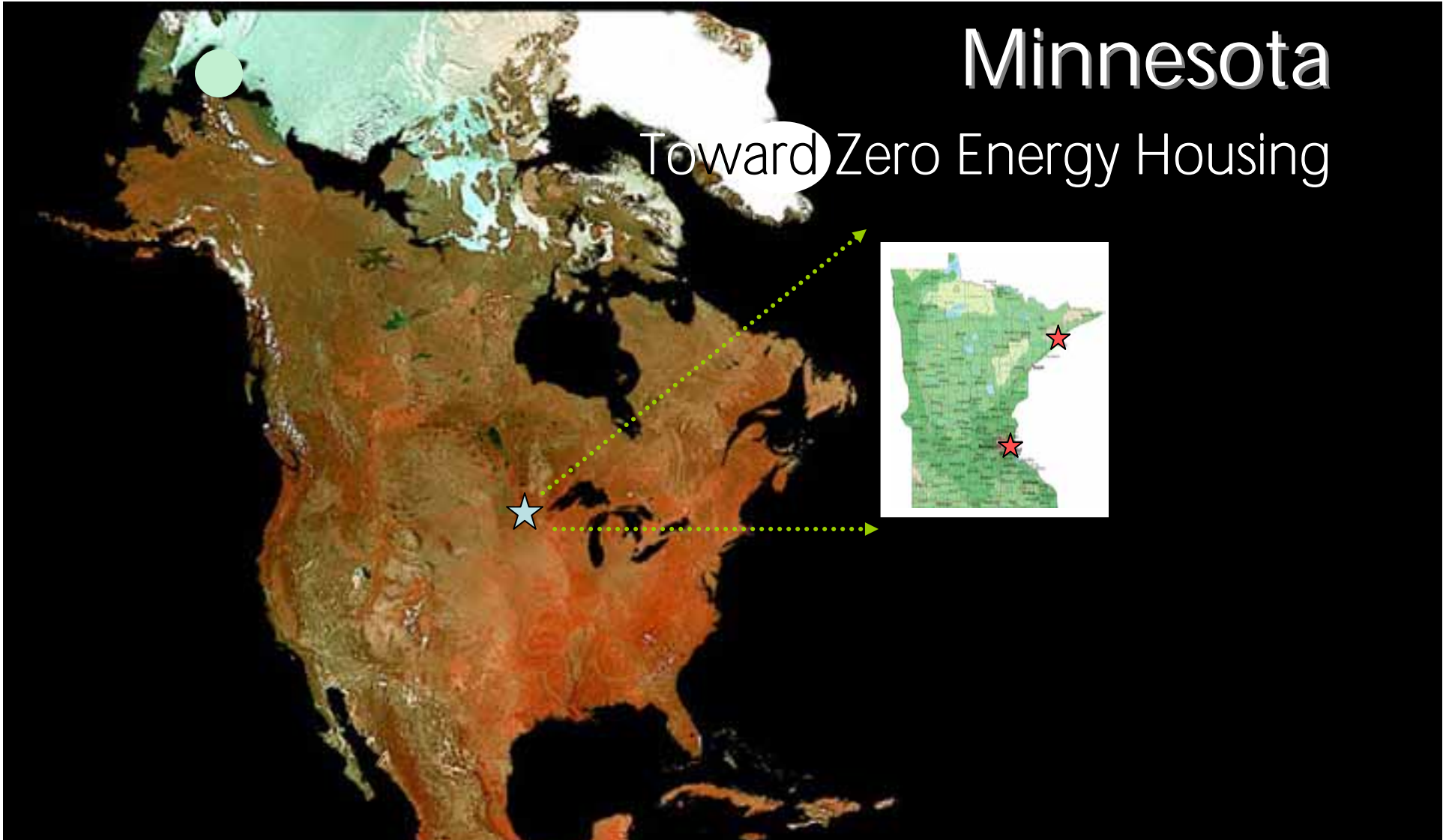
Minnesota Renewable Energy Society

Click on the links at the left side of this web page for the information about the MRES Annual Membership Meeting
December 8, 2005

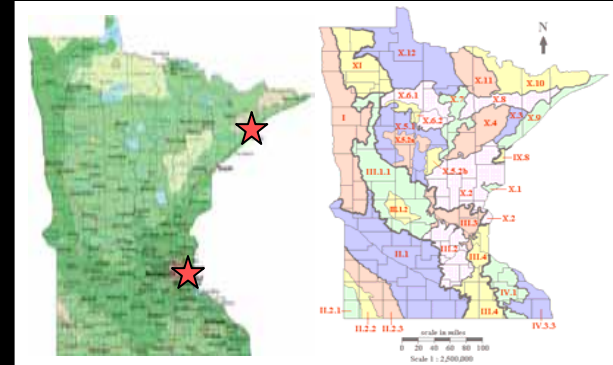
Throughout the year, the Minnesota Renewable Energy Society presents the following.

Minnesota

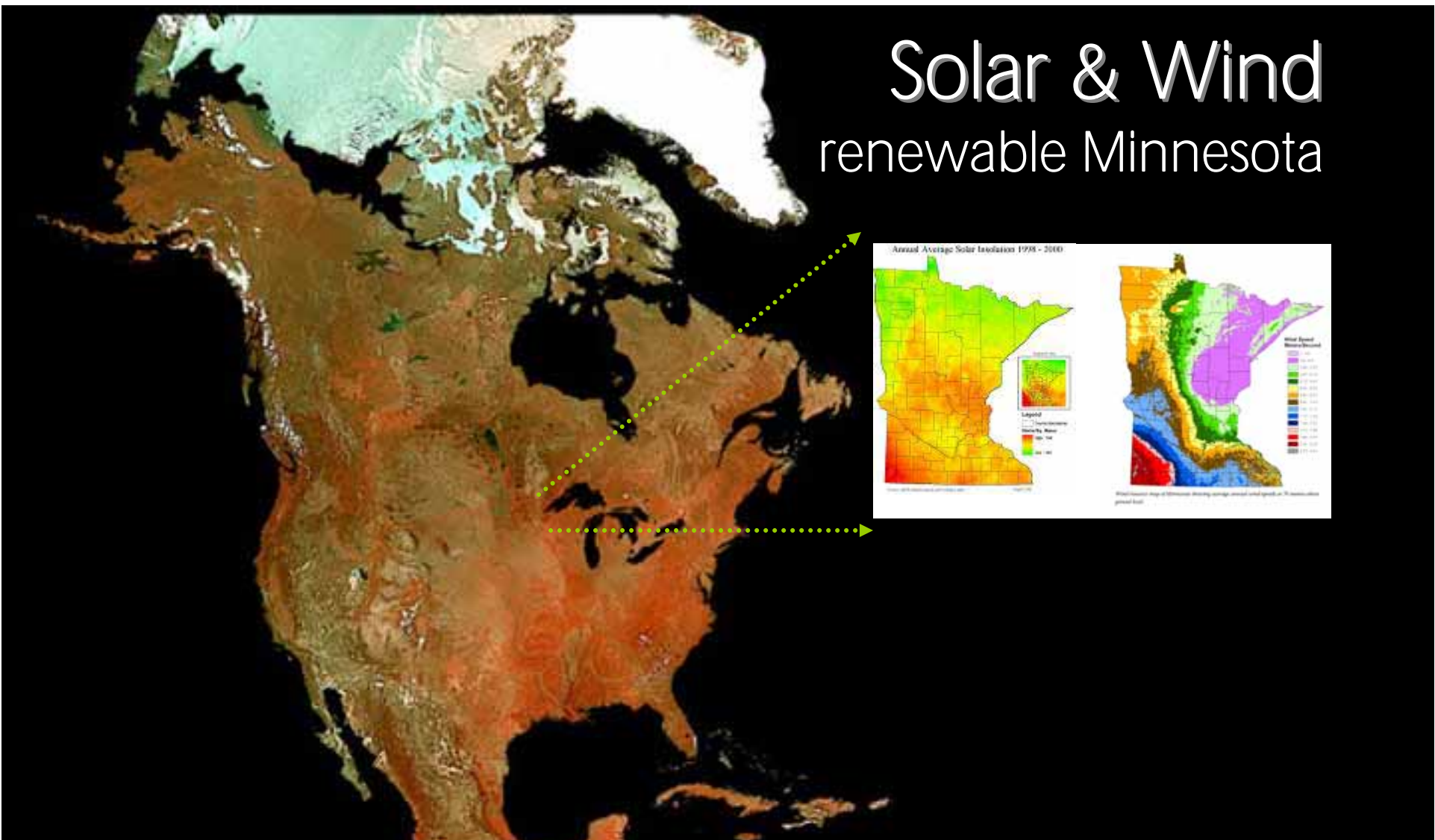
Toward Zero Energy Housing



Ecosystems renewable Minnesota



Solar & Wind renewable Minnesota



Energy Trends renewable Minnesota

Figure 1: Energy End Use in Minnesota, 2001

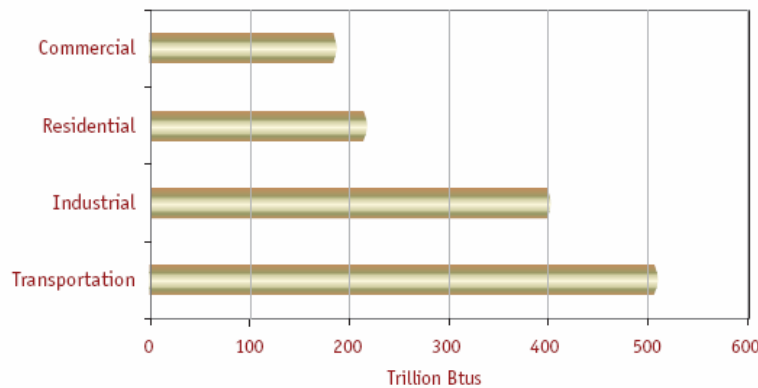


Figure 2: Electric Consumption in Minnesota by Customer Class, 1970–2002

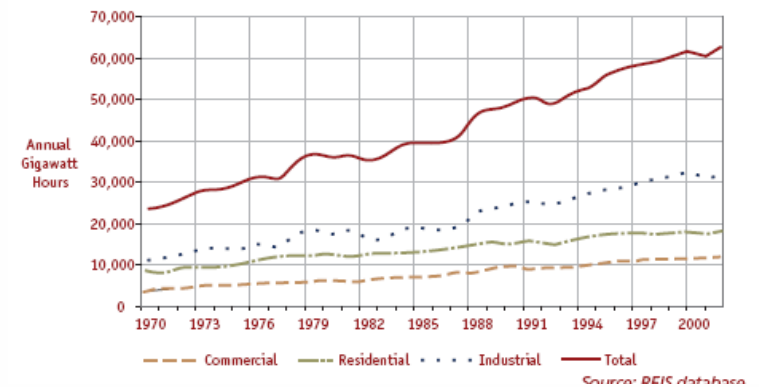
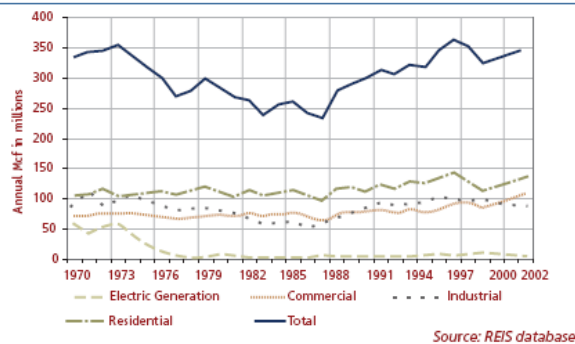
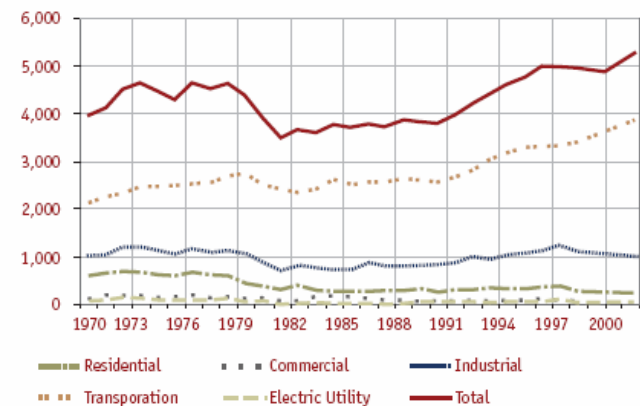


Figure 4: Natural Gas Consumption in Minnesota by Customer Class, 1970–1998



Source: REIS database and EIA.⁴⁴

Figure 6: Petroleum Products Consumption in Minnesota by Customer Class, 1970–2002 (millions of gallons annually)



Note: Figure 4 shows a total consumption of 333.53 Bcf in 2002. However, "deliveries to transportation," "Company Use" and "Unaccounted For" categories account for the difference of approximately 63.73 Bcf in 2002.

Energy Costs renewable Minnesota

Figure 10: 2002 Minnesota Electric Prices Relative to Prices in Other States (¢/kWh)

	Residential Customers	Commercial Customers	Industrial Customers
Minnesota Price	7.49¢	5.88¢	4.19¢
Minnesota Rank*	21st	12th	18th
Average U.S. Price	8.46¢	7.86¢	4.88¢
Highest Price	15.63¢	14.11¢	11.24¢
Lowest Price	5.65¢	5.30¢	3.09¢

* The rank is from the lowest cost state to the highest cost state. For example, a rank of 24 means that 23 other states have lower costs.

Source: EIA-Electric Sales and Revenue 2002

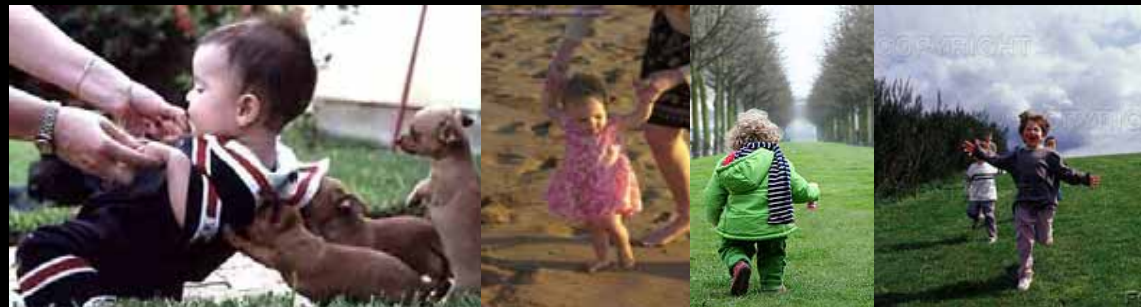
Figure 12: 2002 Minnesota Natural Gas Prices Relative to Prices in Other States

	(Dollars per Thousand Cubic-Feet)		
	Residential Customers	Commercial Customers	Industrial Customers
Minnesota price	\$6.41	\$5.21	\$3.95
Minnesota rank	10th	7th	8th
Average U.S. price	\$7.90	\$6.52	\$3.85
Highest price	\$23.62	\$17.74	\$10.05
Lowest Price	\$4.41	\$3.48	\$1.62

Source: EIA, Natural Gas Monthly January 2003

ZEH in Minnesota

it's like learning to walk

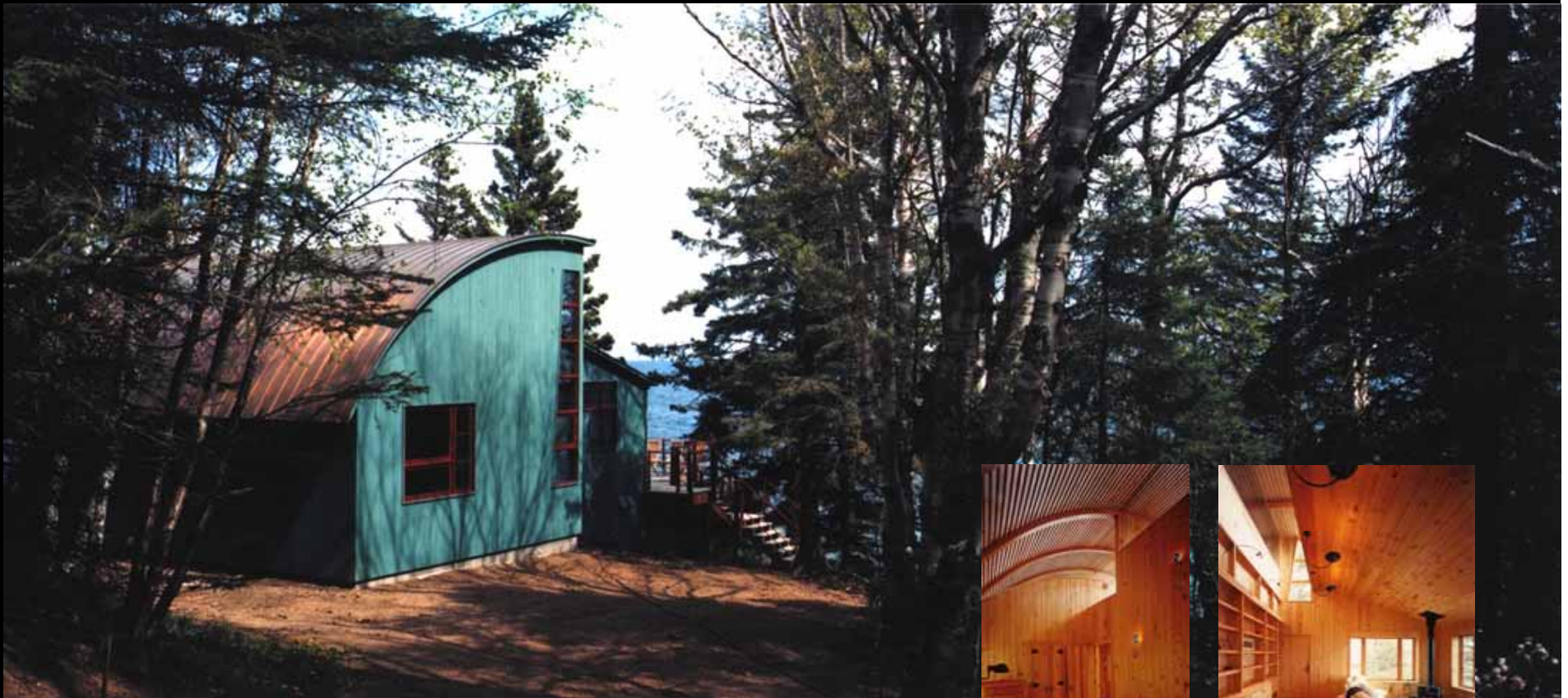


www.afunworld.cm and Flickr



Tofte Cabin

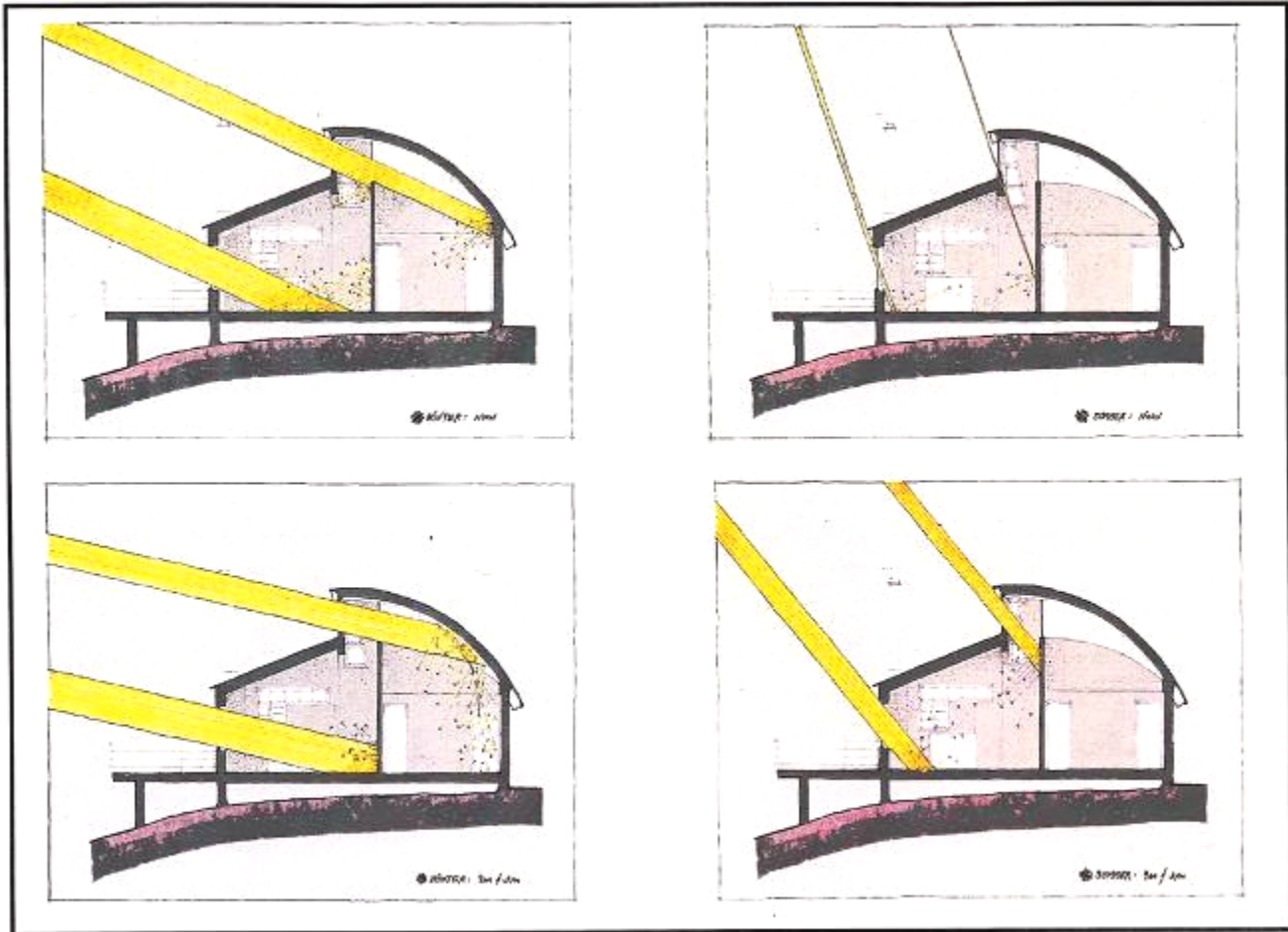
Tofte, MN
Sarah Nettleton Architects



Tofte Photos: Peter Kerze;
Drawings: SNA; Graphs: Kerry Haglund

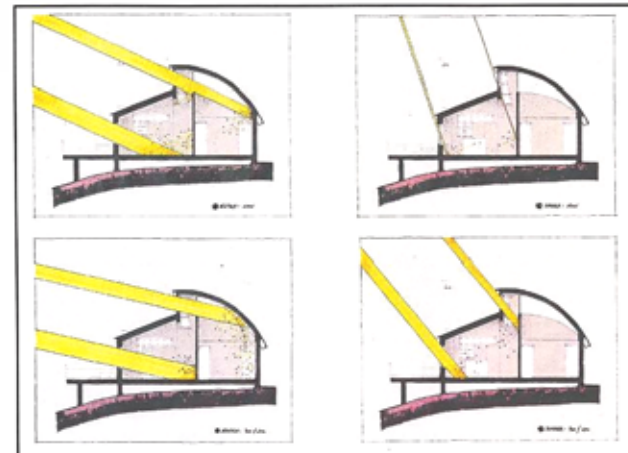
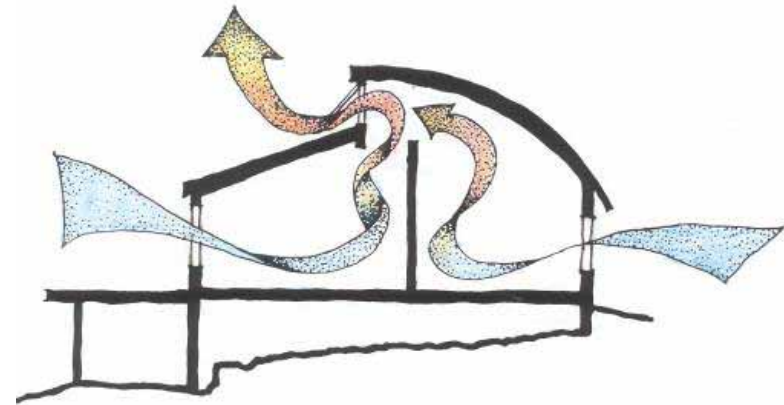


- Programming
- Small footprint
- Architectural strategies
- Finishes and materials



Sarah Nettleton ARCHITECTS Ltd.
Architecture & Garden Design
4159 Grand Ave. South, Minneapolis, Minnesota 55409

TOFTE CABIN
Tofte, MN



Sarah Nettleton ARCHITECTS Ltd.
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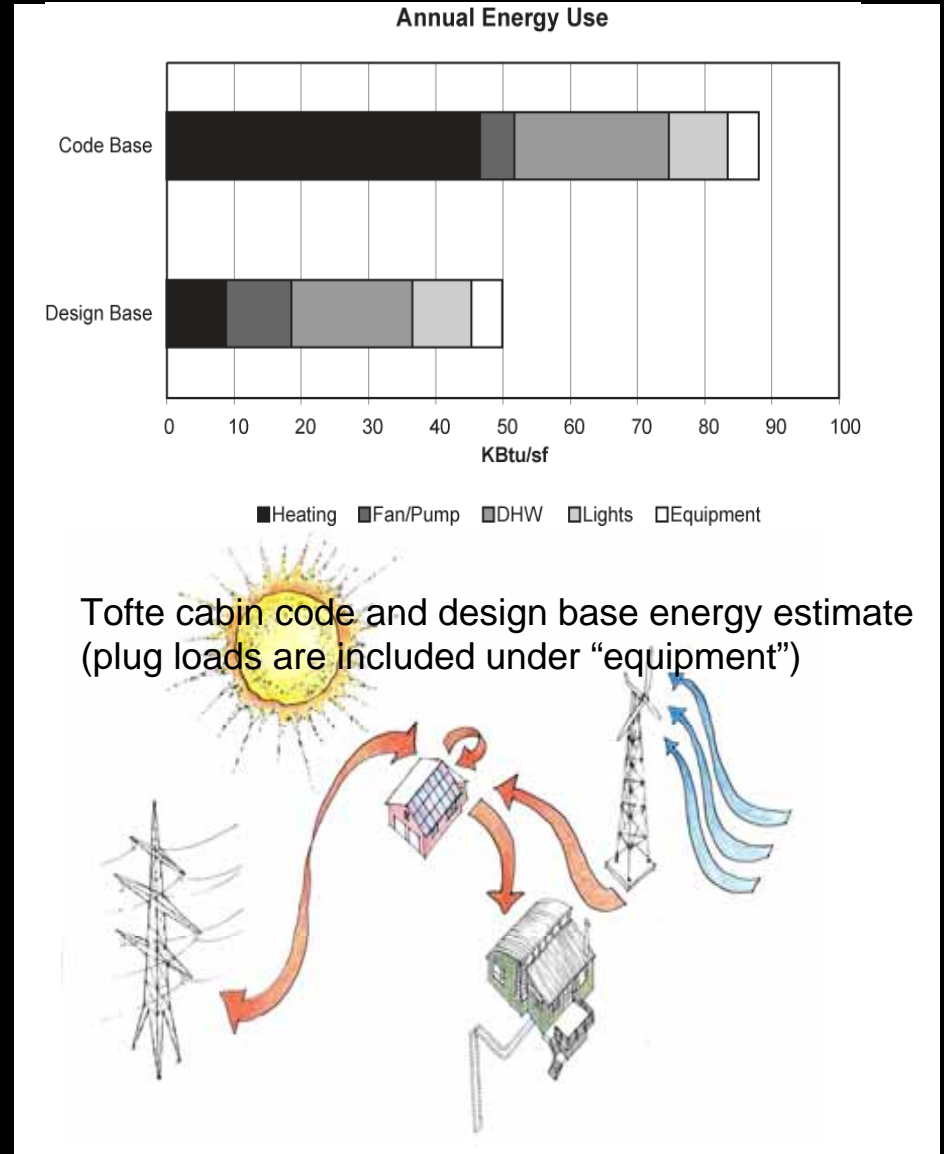
TOFTE CABIN
Tofte, MN

•Optimize daylighting, passive solar, natural ventilation

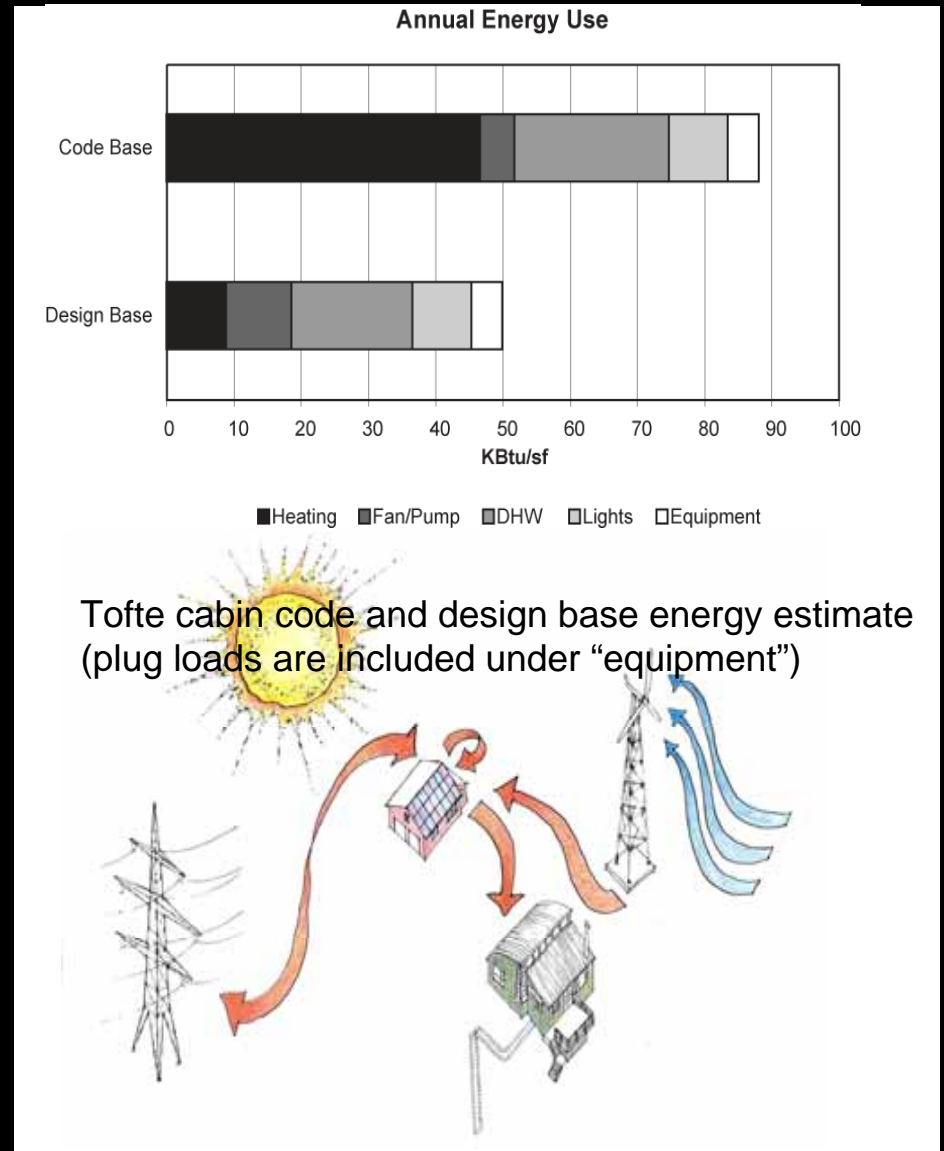
- Site
- Section
- Daylight
- Thermal mass
- Conservation and refrigerator



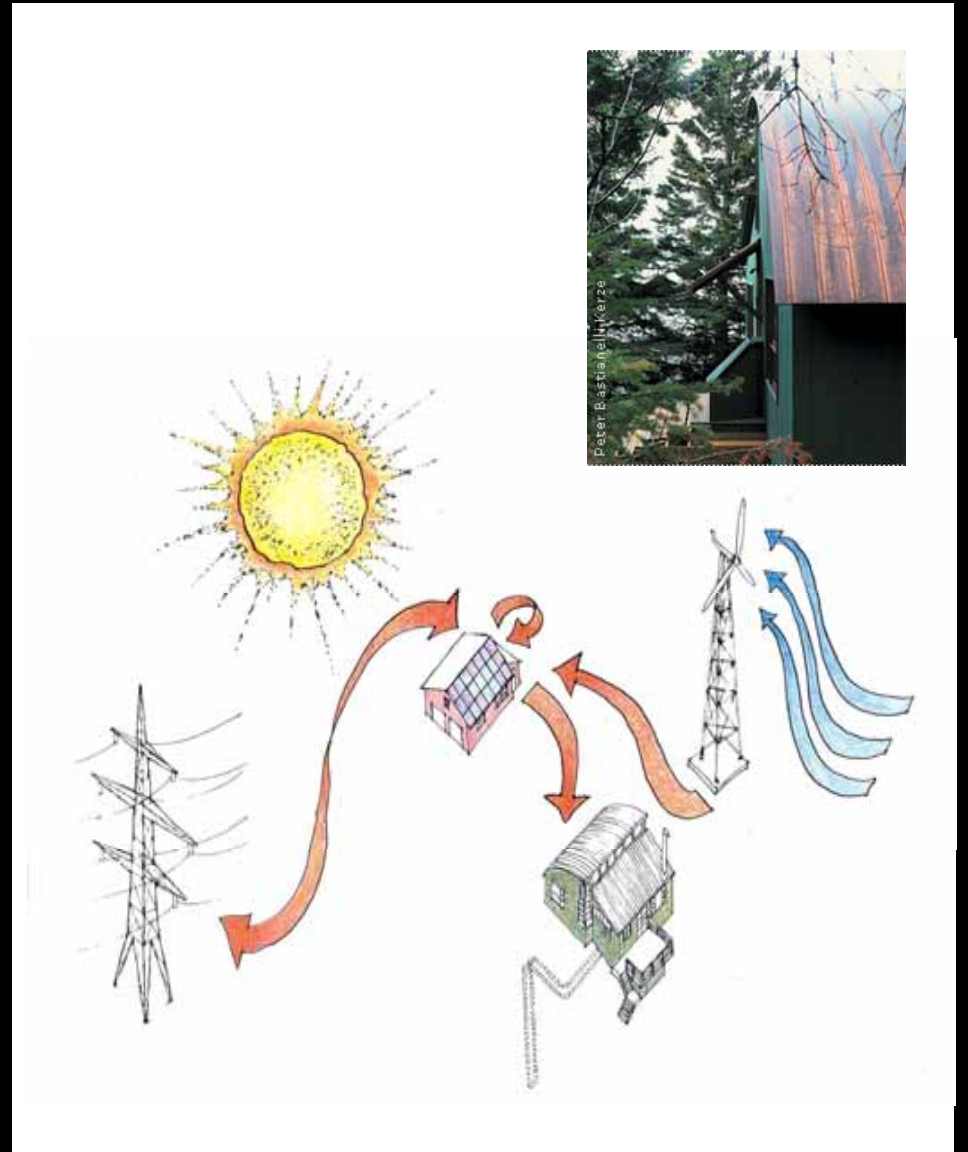
•Insulation levels are comparable to a code base of U-value 0.034 for the roof, 0.052 for the walls, 0.10 for the foundation, and 0.37 for the windows.



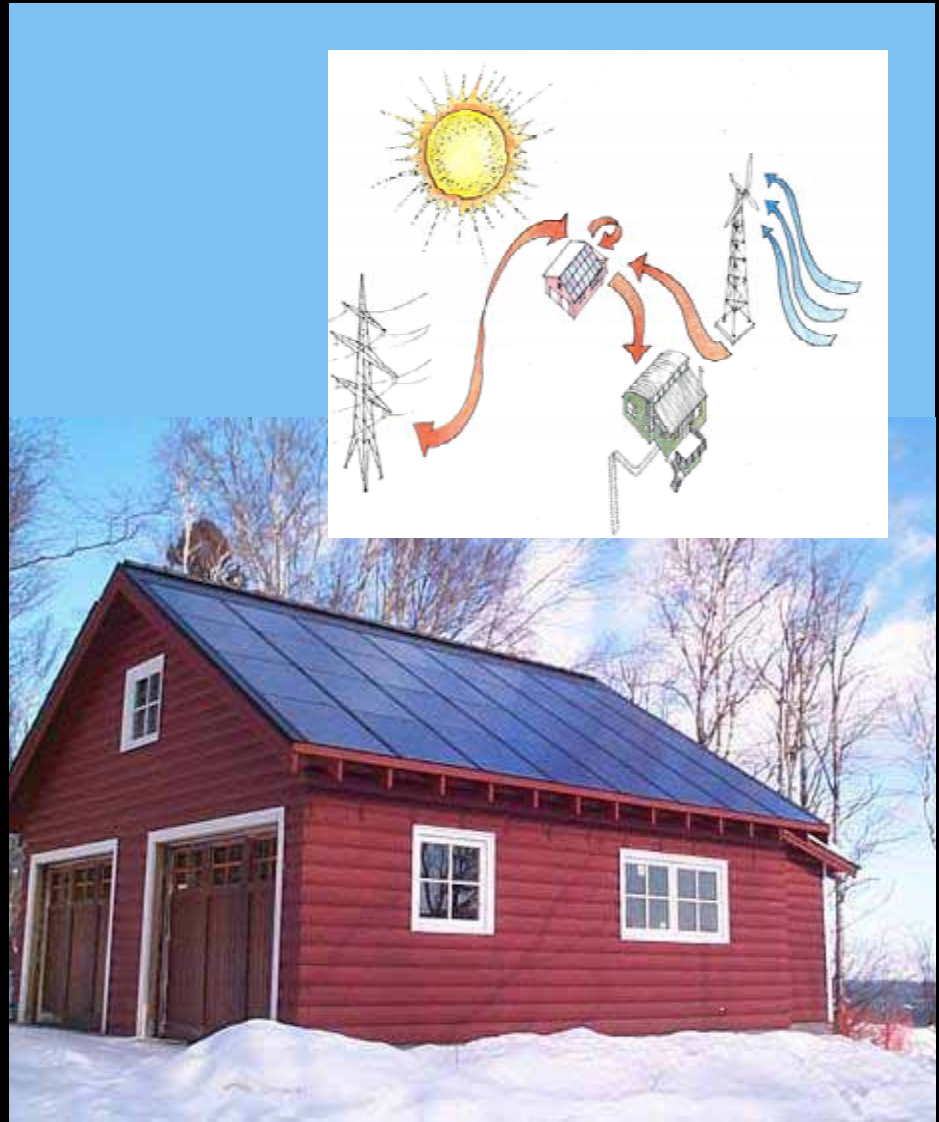
- Ground source heat pump
- Heat recovery ventilator
- High performance appliances and washer/dryer



- Post-construction energy model estimated total building loads at 11,000 kWh/yr; 43% less than an equivalent ASHRAE 90.1 1999 building, or 49.95 KBtu/sf/yr versus 88.13 KBtu/sf/yr
- Space heating reduced by 80% from code - additional 20% reduction from domestic hot water



Combined peak kW rating for the wind and PV: 11.2 kW



Tofte Cabin

Tofte, MN
Sarah Nettleton Architects



Tofte Photos: Peter Kerze;
Drawings: SNA; Graphs: Kerry Haglund



Science House

Minnesota Science Museum, St. Paul, MN

Barbour LaDoucer et al



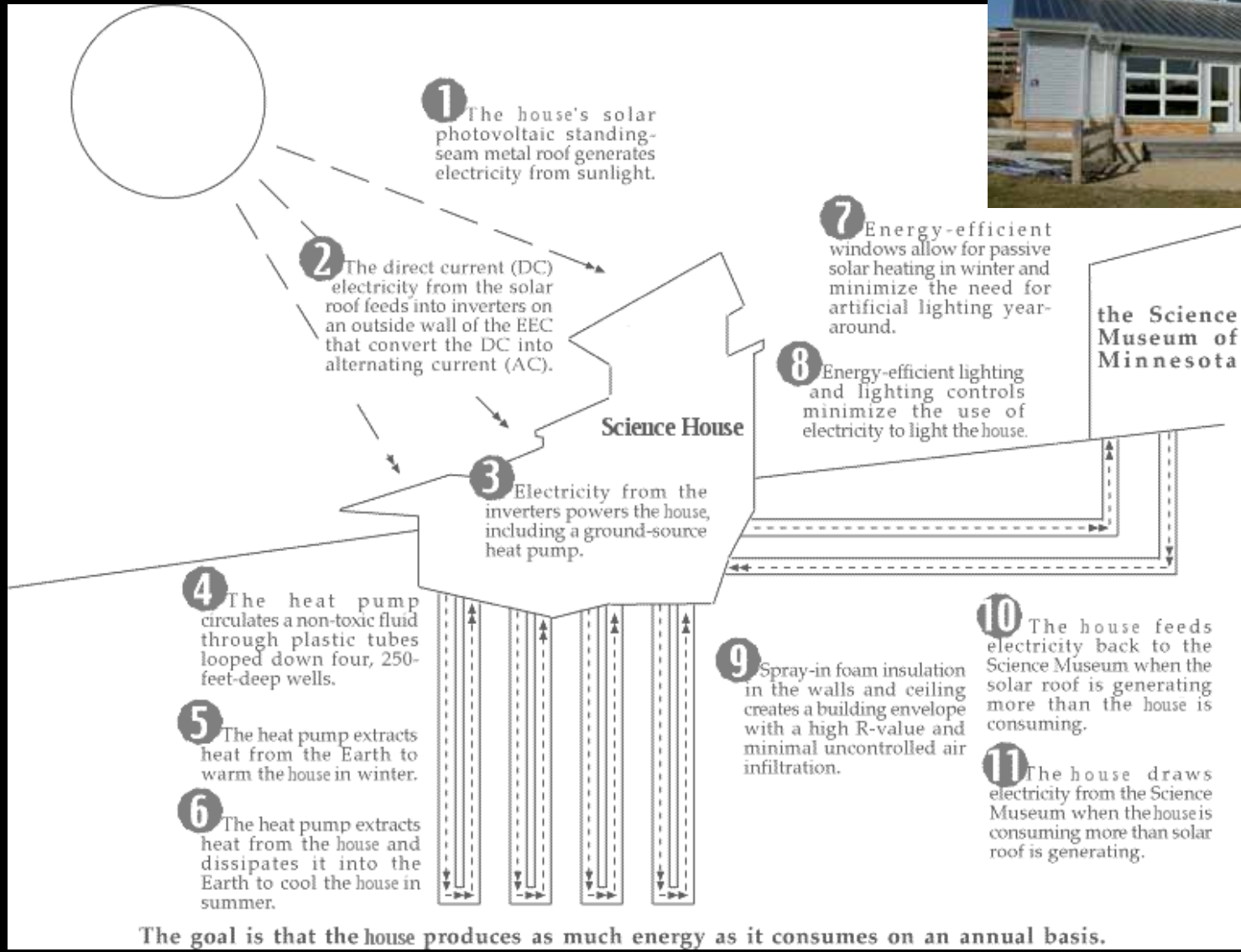
Science House Photos: MSM & Keegan Furfaro

Drawings: MSM; Graphs: Kerry Haglund



- Programming
- Daylighting, passive heating, natural ventilation
- Efficient equipment and systems
- Occupancy patterns

- PV roof
- Construction
- Combined strategies

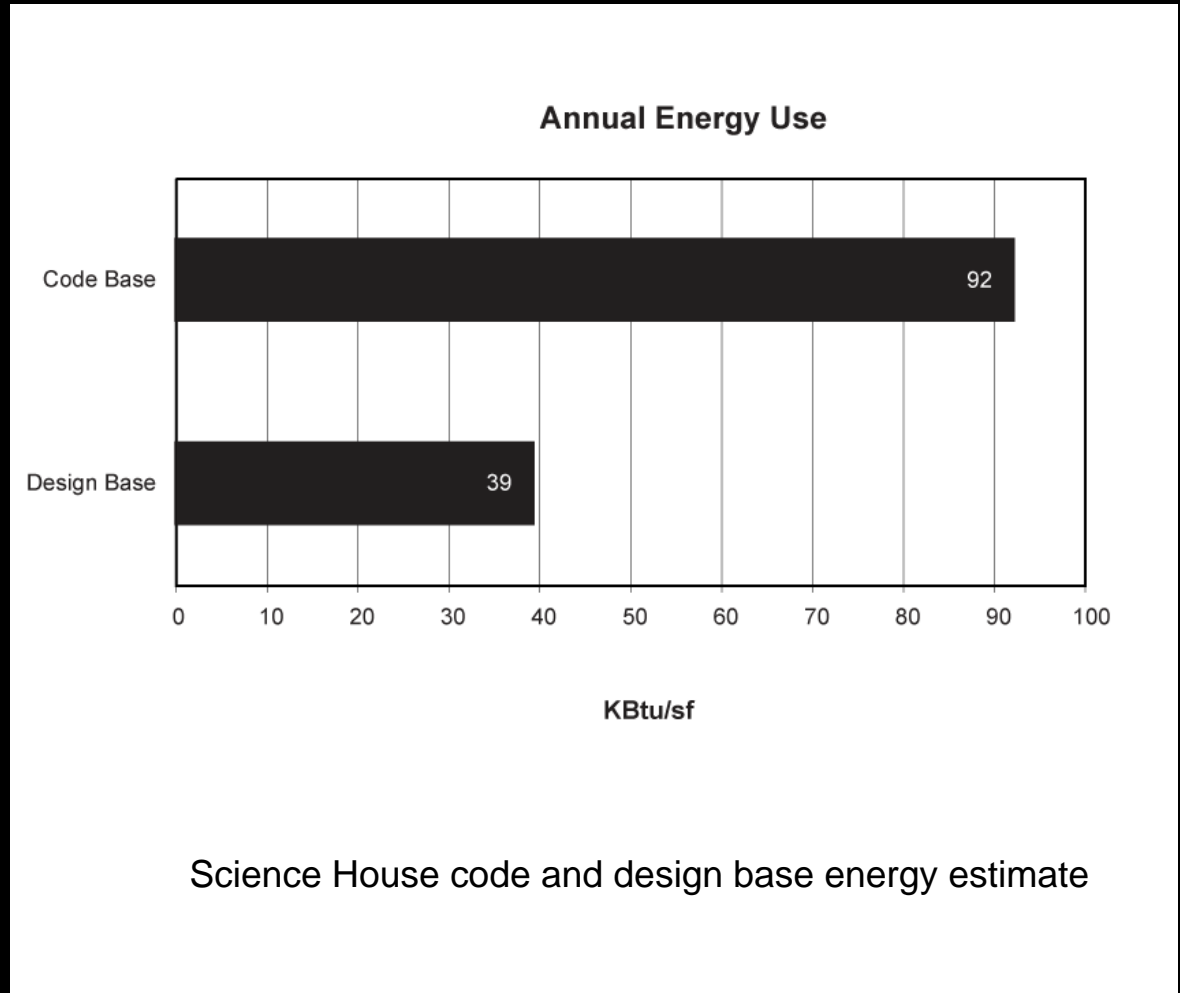


•Insulation values are comparable to a code base U-value of 0.045 for the roof, 0.091 for the walls, and 0.62 for the windows

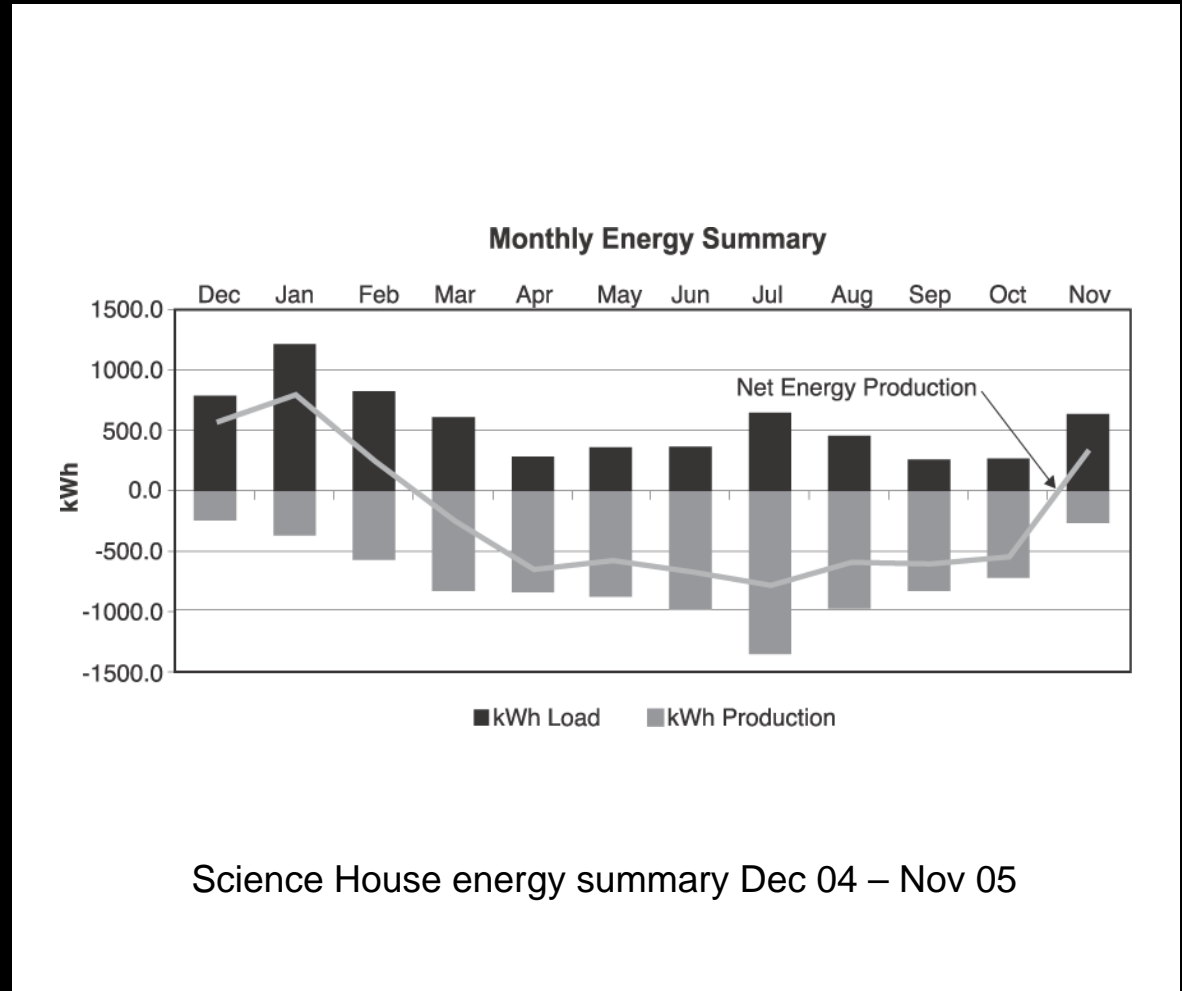
- Occupancy
- Appliance loads
- Systems



- ground source heat pump
- energy recovery ventilator
- occupancy and daylight sensors

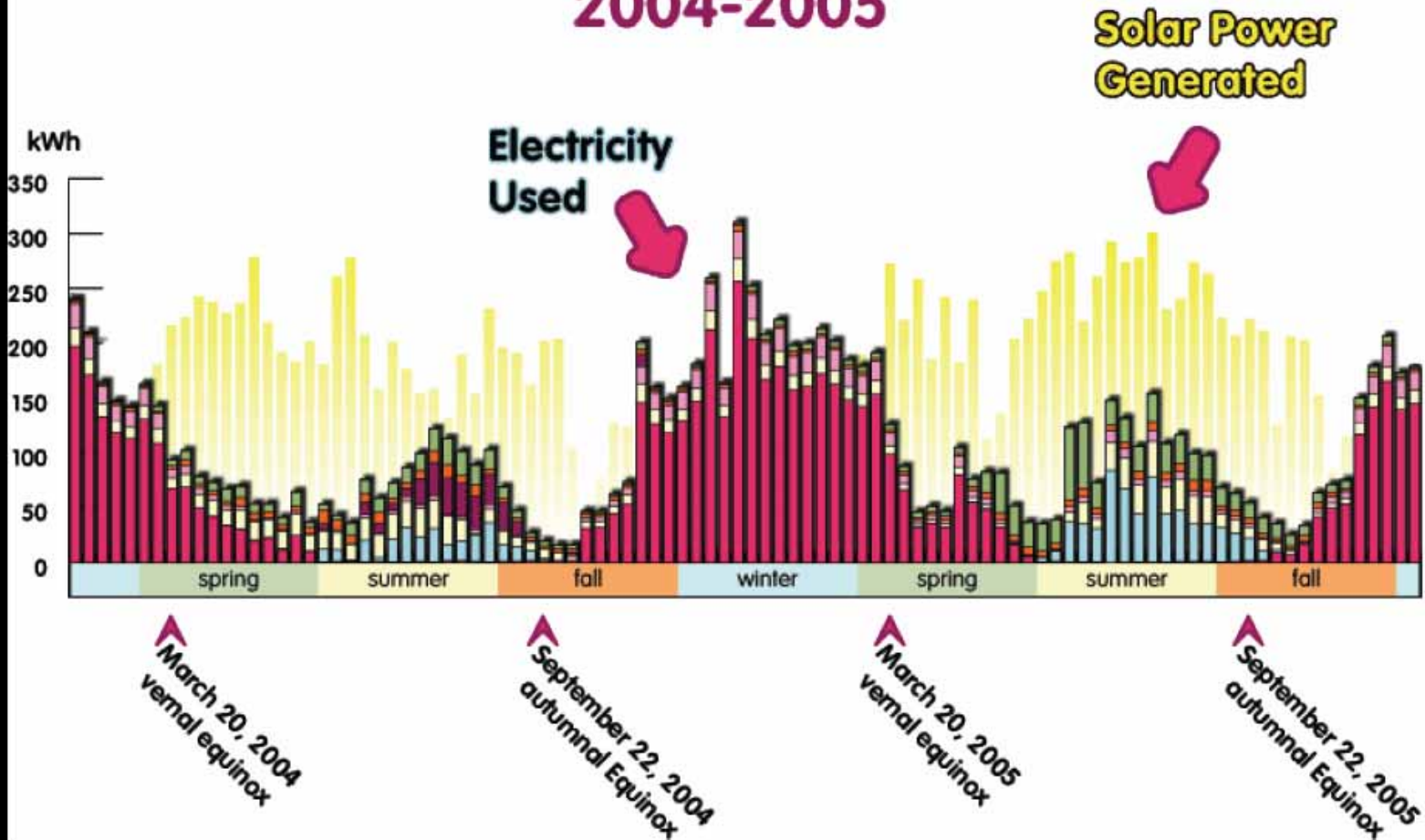


- Design energy target for the project at 10,000 kWh/yr
- Code base model of the project predicted consumption at 92 KBtu/sf annually equal to 25,720 kWh
- 60% reduction in estimated energy use over code



- December 2004 thru November 2005 total energy use was 6,451 kWh
- The energy produced by the PV was 9,172 kWh, net surplus of 2,721 kWh

Science House Energy Usage 2004-2005



Minnesota Science Museum

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- The energy produced by the PV was 9,172 kWh, net surplus of 2,721 kWh

Science House

Minnesota Science Museum, St. Paul, MN

Barbour LaDoucer et al



Solar Architecture in Minnesota: Toward Zero Energy Housing

CONCLUSIONS

1. Achieving zero energy
2. Process and methods
3. Monitoring and commissioning
4. Costs
5. Installations, operations, & maintenance
6. Design excellence



Solar Architecture in Minnesota: Toward Zero Energy Housing

CONCLUSIONS

1. Achieving zero energy
 - Good design and conservation
 - Building massing and envelope
 - Efficient equipment and appliances
- Off-the-shelf renewable technologies; coupled with passive systems
 - Steep learning curve



Solar Architecture in Minnesota: Toward Zero Energy Housing

CONCLUSIONS

2. Process and Methods

- Early collaboration
 - Programming
- Design and technological integration



Solar Architecture in Minnesota: Toward Zero Energy Housing

CONCLUSIONS

3. Monitoring and Commissioning

- On-going monitoring: seasonal patterns
 - System tuning and problems
 - Activity shifts
 - Financial challenges



Solar Architecture in Minnesota: Toward Zero Energy Housing

CONCLUSIONS

4. Costs

- Tofte: not available; Science House: \$981,247; PV: \$62,000
 - Exceptional budgets vs. everyday budgets
 - Financial support; incentives



Solar Architecture in Minnesota: Toward Zero Energy Housing

CONCLUSIONS

5. Installation, Operations, and Maintenance

- Emerging industry
- Limited expertise
- New partnerships
- Training and education



Solar Architecture in Minnesota: Toward Zero Energy Housing

CONCLUSIONS

6. Design Excellence

- Integrated design
- Design performance and design quality
 - Aesthetics and human experience



ZEH in Minnesota

it's like learning to walk



www.afunworld.cm and Flickr

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Minnesota

Toward Zero Energy Housing

ZEH Strategies

- (1) Set project and energy goals
- (2) Minimize loads
- (3) Meet energy loads
- (4) Use appropriate energy and fuel sources
- (5) Monitor the project



Climate Change renewable Minnesota

[playing with fire] climate change in minnesota

[third edition]
foreword by Paul Douglas

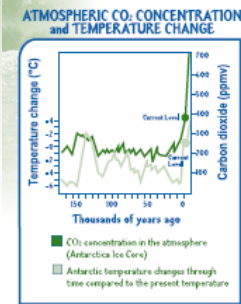
- agriculture 
- forests 
- lakes and streams 
- wetlands and prairies 
- more prosperity, less pollution 
- new energy for a new era 
- policies for a clean future 
- a time for leadership 

ME3
MINNESOTANS FOR AN
ENERGY-EFFICIENT ECONOMY



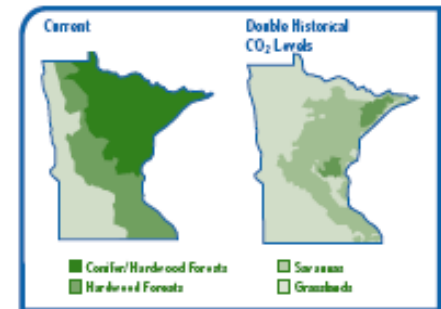
Trends and Forecasts

- Since preindustrial times, atmospheric CO₂ concentrations have increased 31 percent.
- Average global temperature increased more than 1°F in the twentieth century.
- The U.N. Intergovernmental Panel on Climate Change projects that temperatures could rise from 2-10°F by 2100. Northern latitudes like Minnesota would be at the high end of the range.

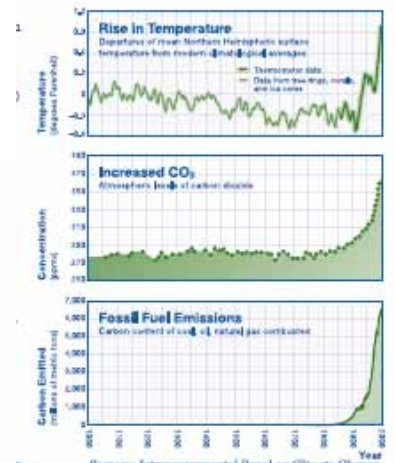


Source: White House Office of Science and Technology Policy

SIMULATED VEGETATION CHANGE CAUSED BY CLIMATE CHANGE



The scenario shows what Minnesota might look like if average temperatures rise 10°F and precipitation increases 13 percent at double historical CO₂ levels. This is one of several scenarios created by bioclimatologist Ronald P. Nelson of the U.S.D.A. Forest Service.



Sources: Intergovernmental Panel on Climate Change and U.S. Department of Transportation.

ME3: Fresh Energy