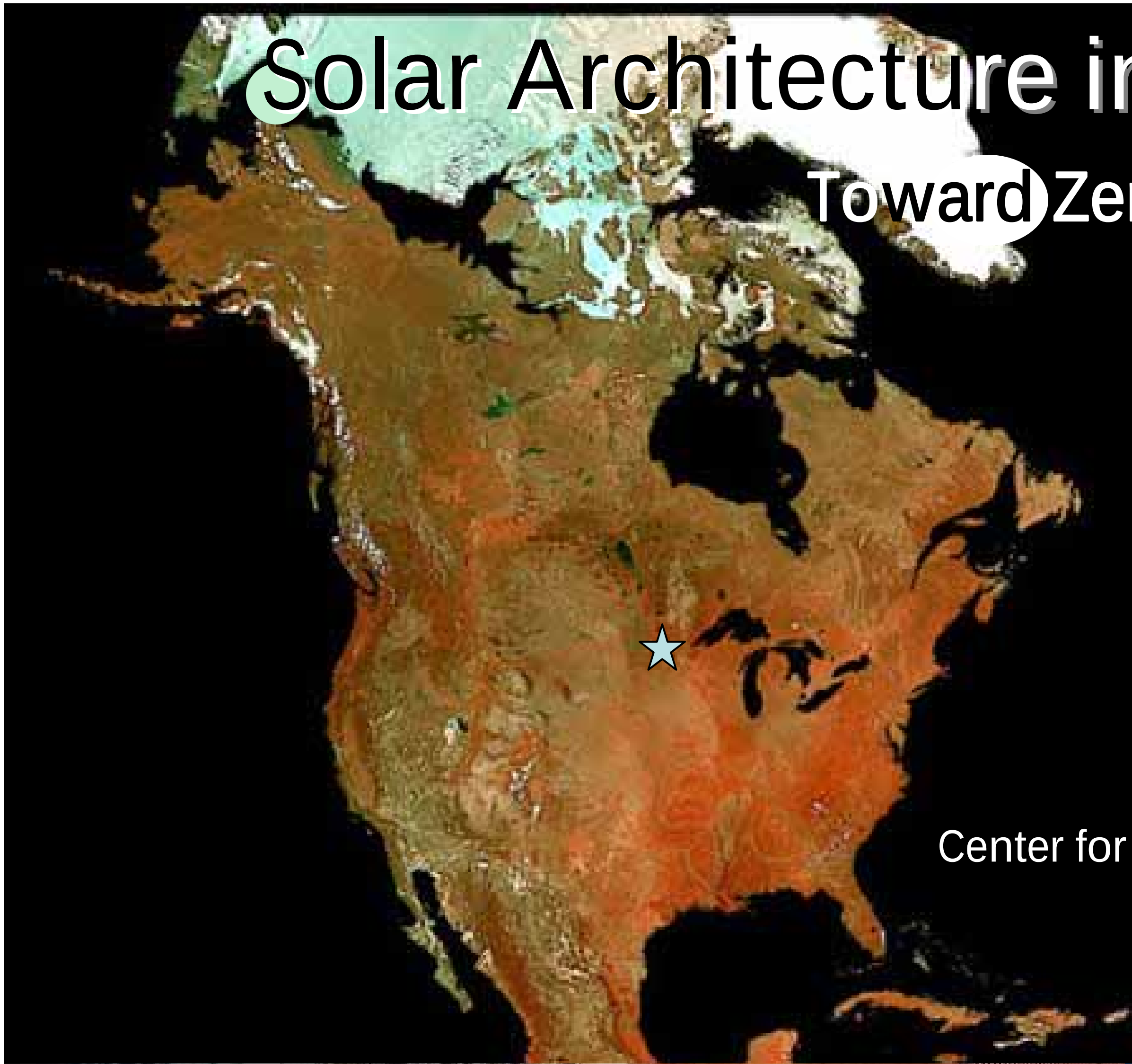
Solar Architecture in Minnesota:

Toward Zero Energy Housing



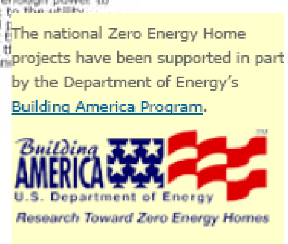
Mary Guzowski
Department of Architecture

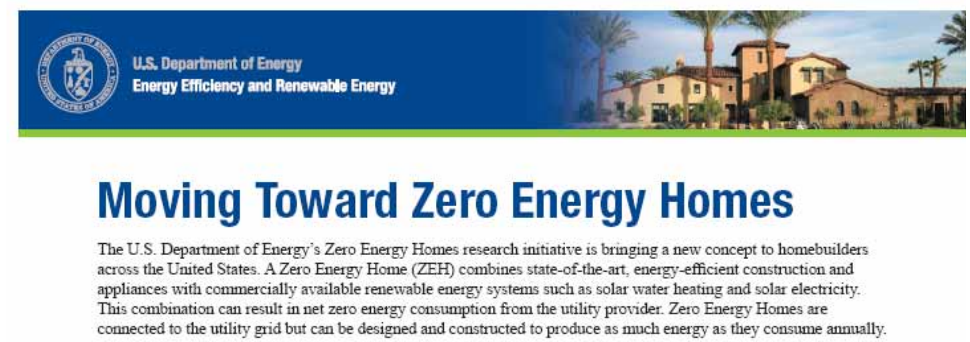
William Weber
Center for Sustainable Building Research

UNIVERSITY OF MINNESOTA

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

National Efforts
renewable Minnesota

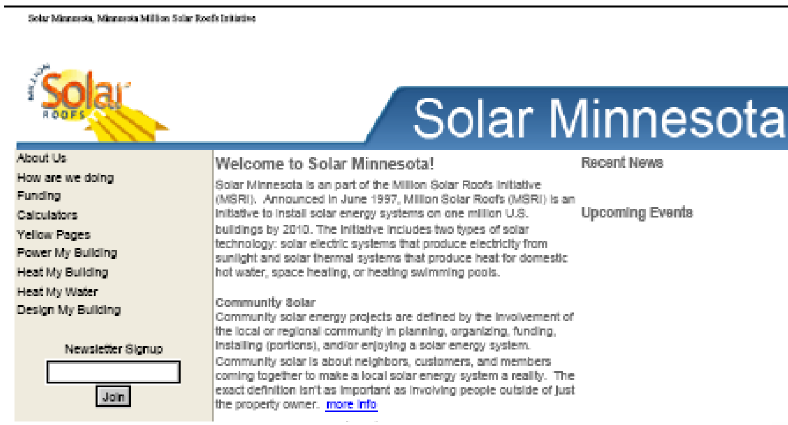




"A Zero Energy home combines renewable energy technologies with advanced energy-efficient construction…Because the home produces *about* as much energy as it consumes during a year, it is considered to achieve 'net zero' energy consumption." - DOE

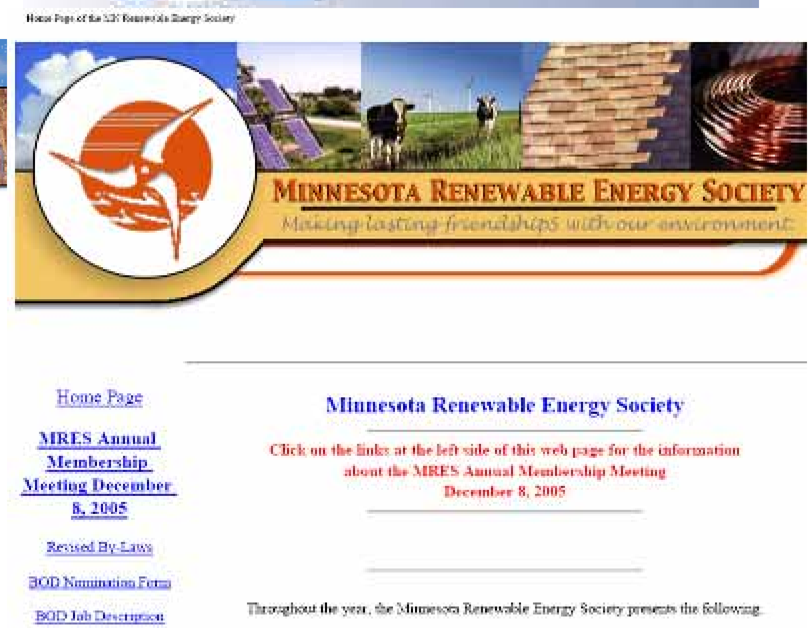
State Efforts

renewable Minnesota



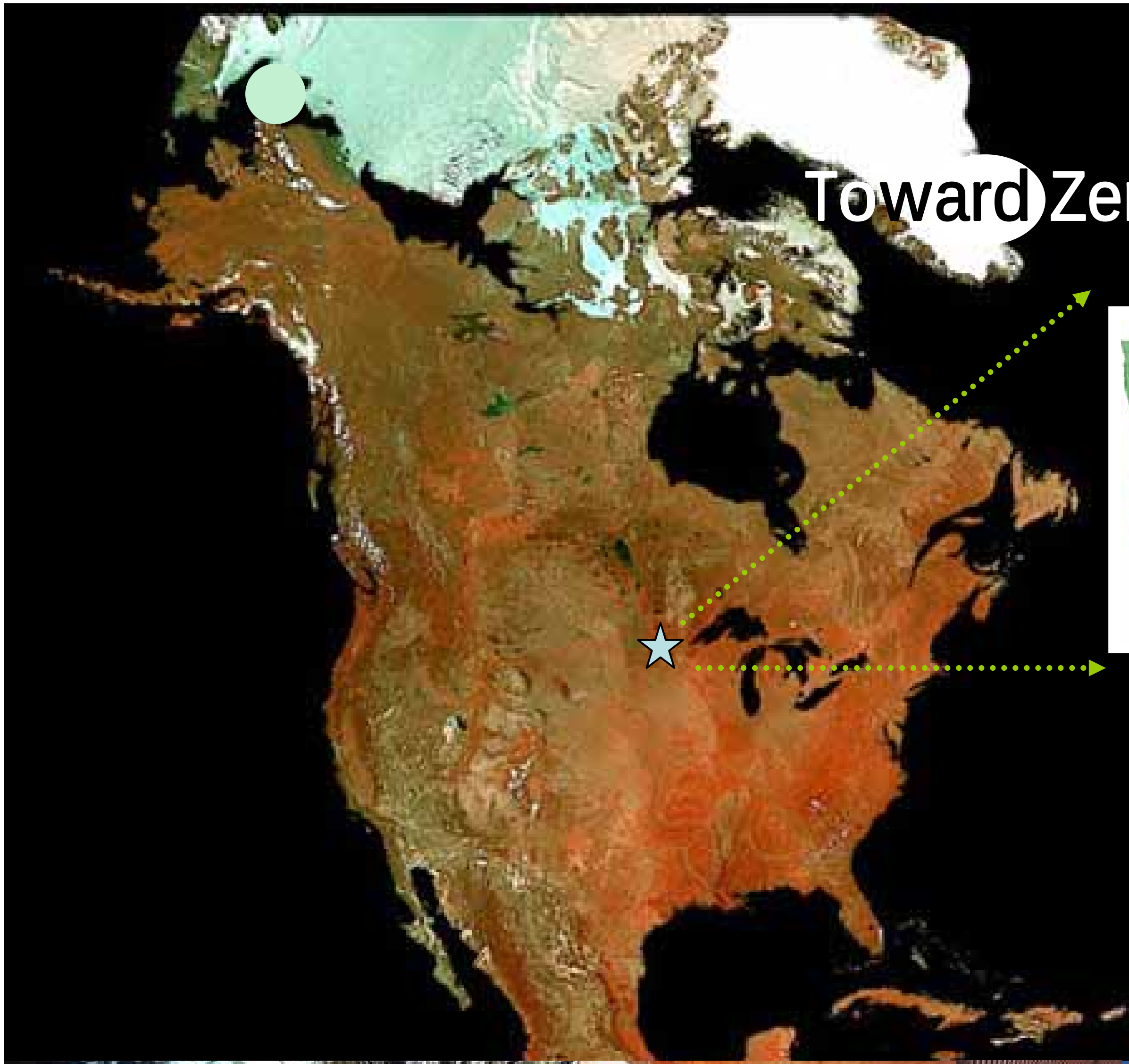
MINNESOTA DEPARTMENT OF COMMERCE

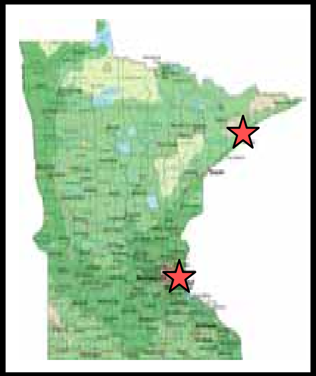
Minnesota Office of Environmental Assistance



Minnesota

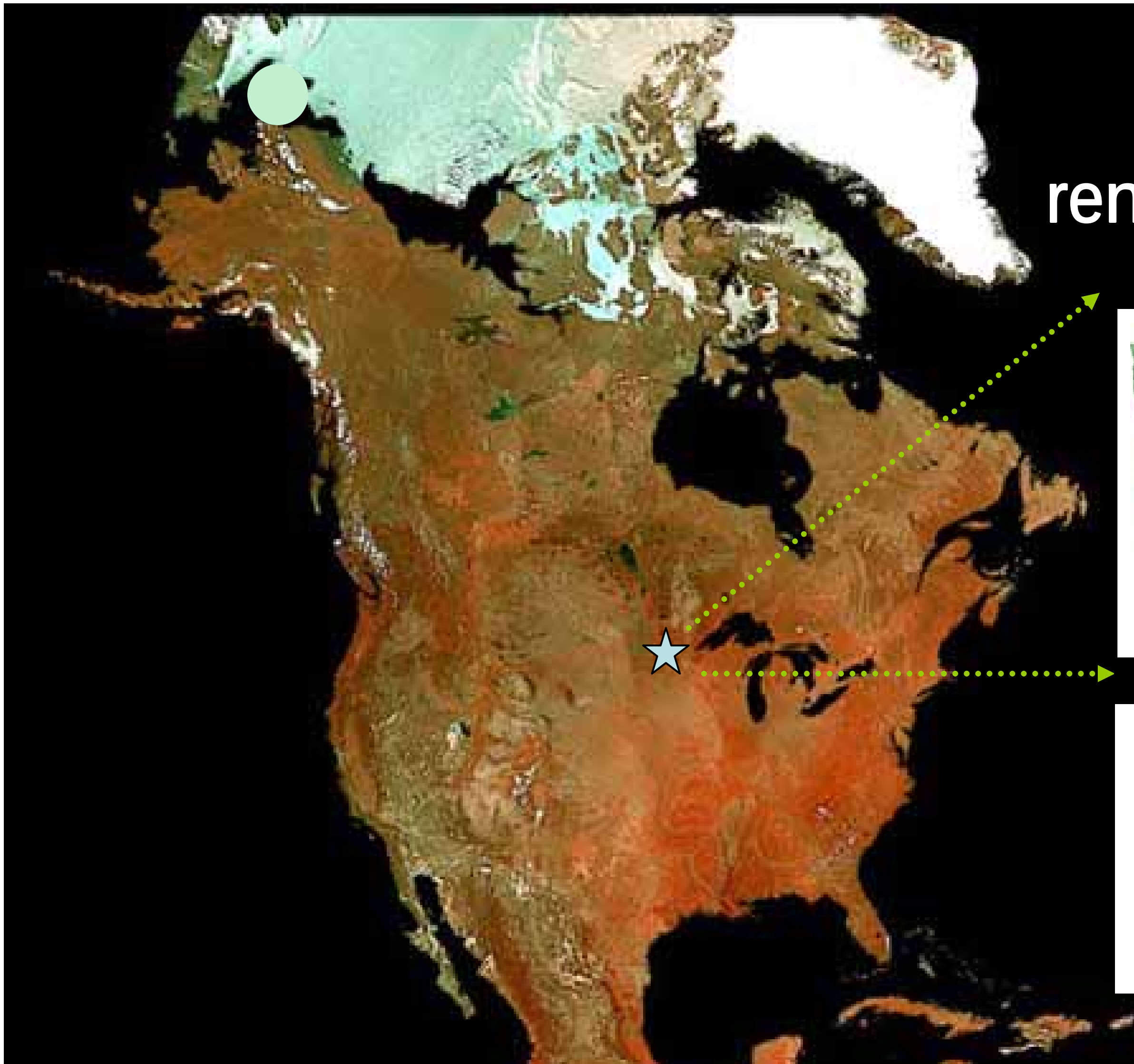
Toward Zero Energy Housing

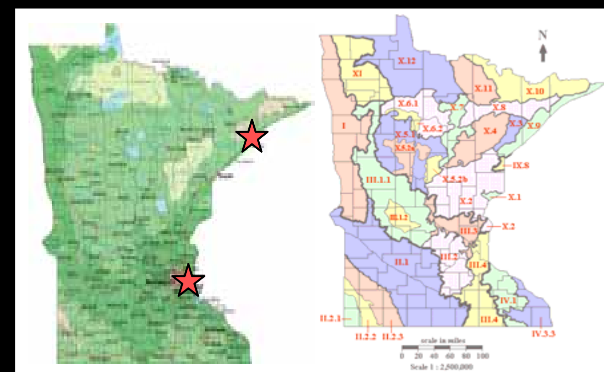




Ecosystems

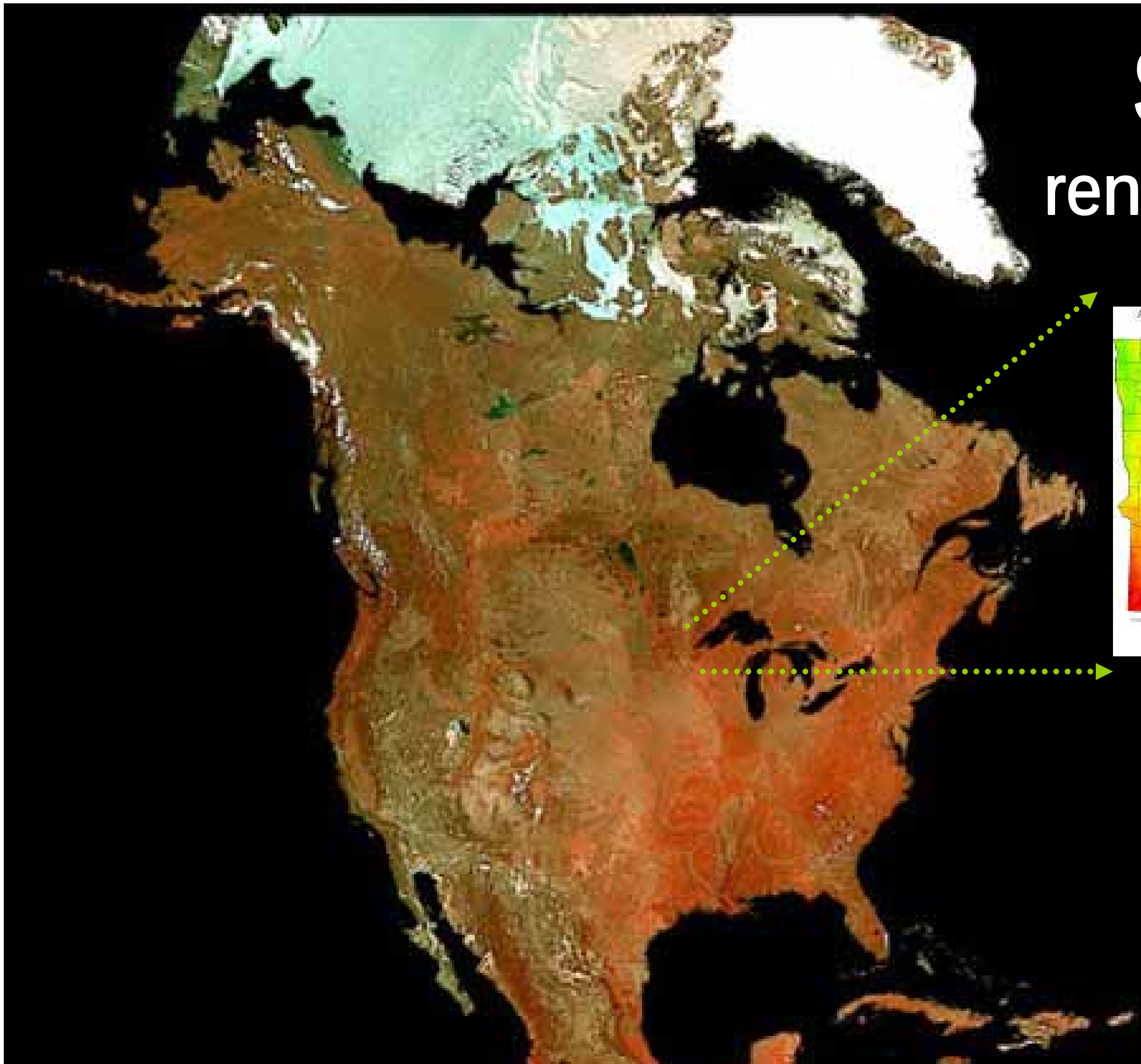
renewable Minnesota

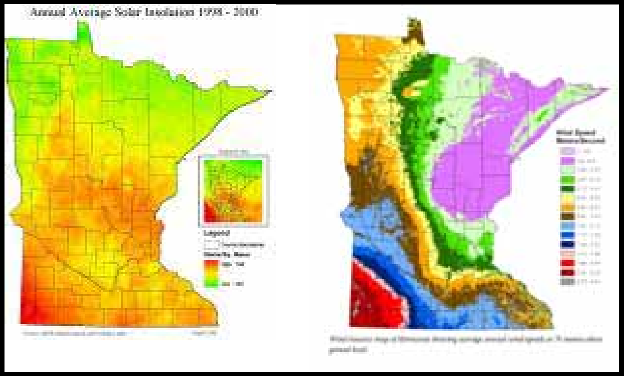




Solar & Wind

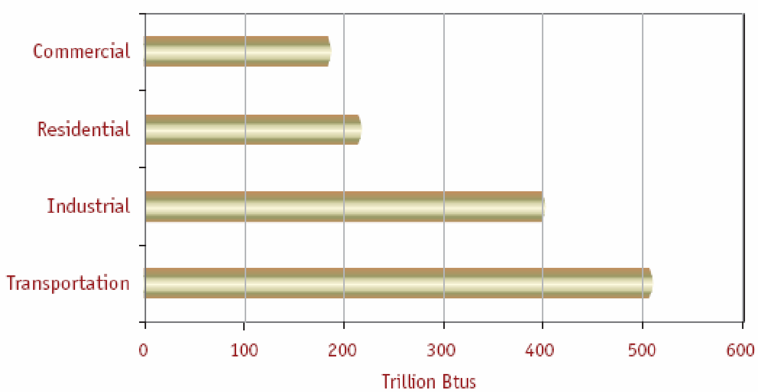
renewable Minnesota





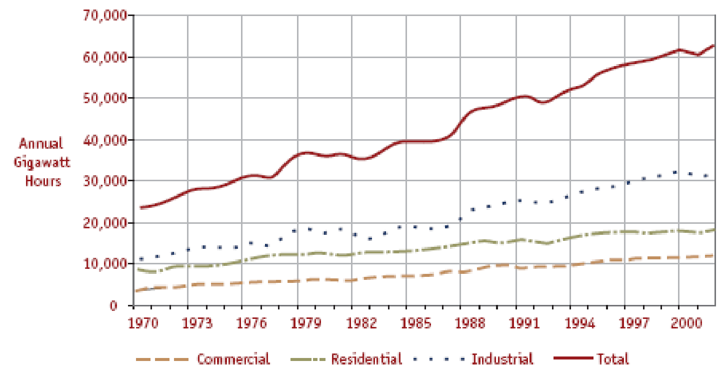
Energy Trends
renewable Minnesota

Figure 1: Energy End Use in Minnesota, 2001



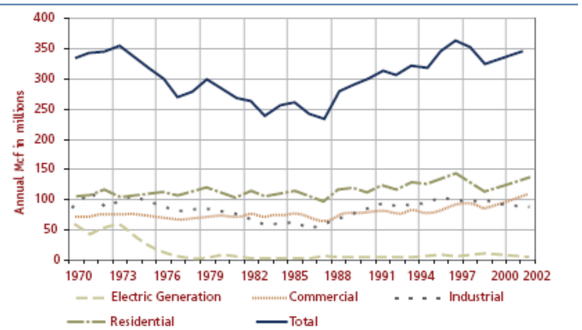
Source: REIS database and EIA.[46]

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



Source: REIS database

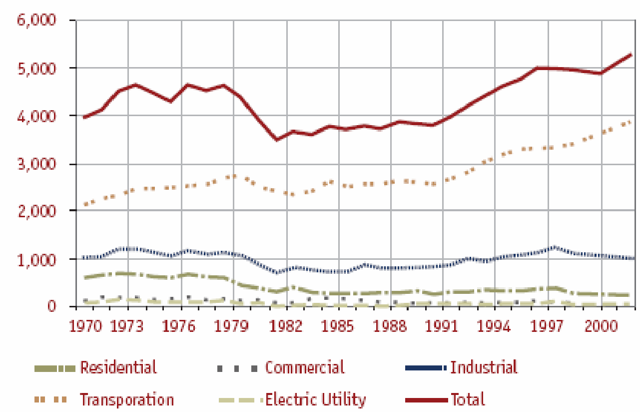
Figure 4: Natural Gas Consumption in Minnesota by Customer Class, 1970–1998



Source: REIS database

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.

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



Source: EIA State Energy Data 2000 Consumption tables at http://www.eia.doc.gov/emeu/states_use_multistate.html

Energy Policy and Conservation Report, MN Department of Commerce, 2004

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 20

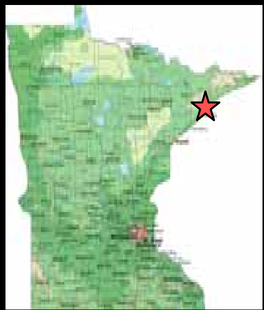
Energy Policy and Conservation Report

MN Department of Commerce, 2004

ZEH in Minnesota

it's like learning to walk

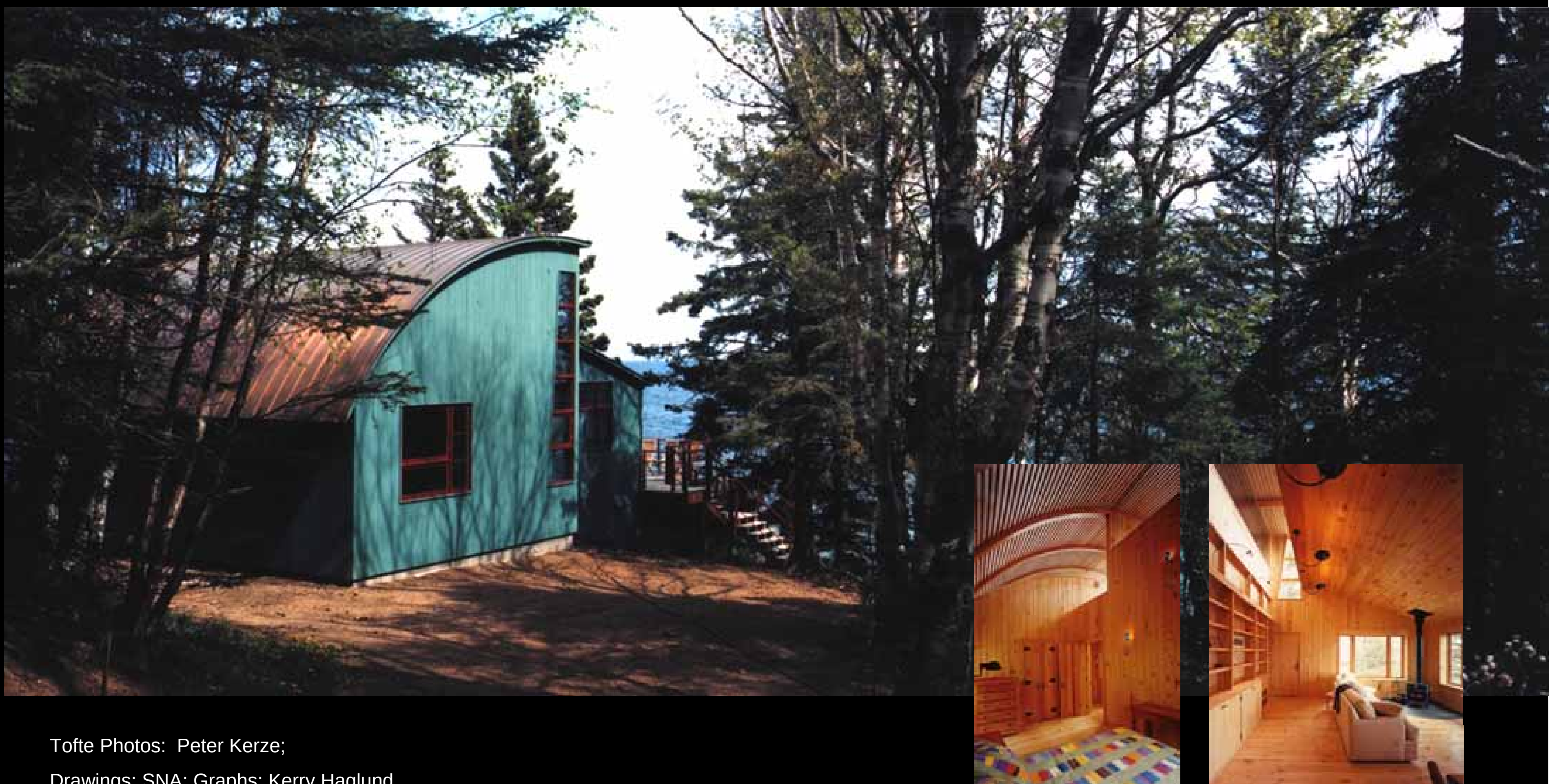
www.afunworld.cm and Flickr



Tofte Cabin

Tofte, MN

Sarah Nettleton Architects

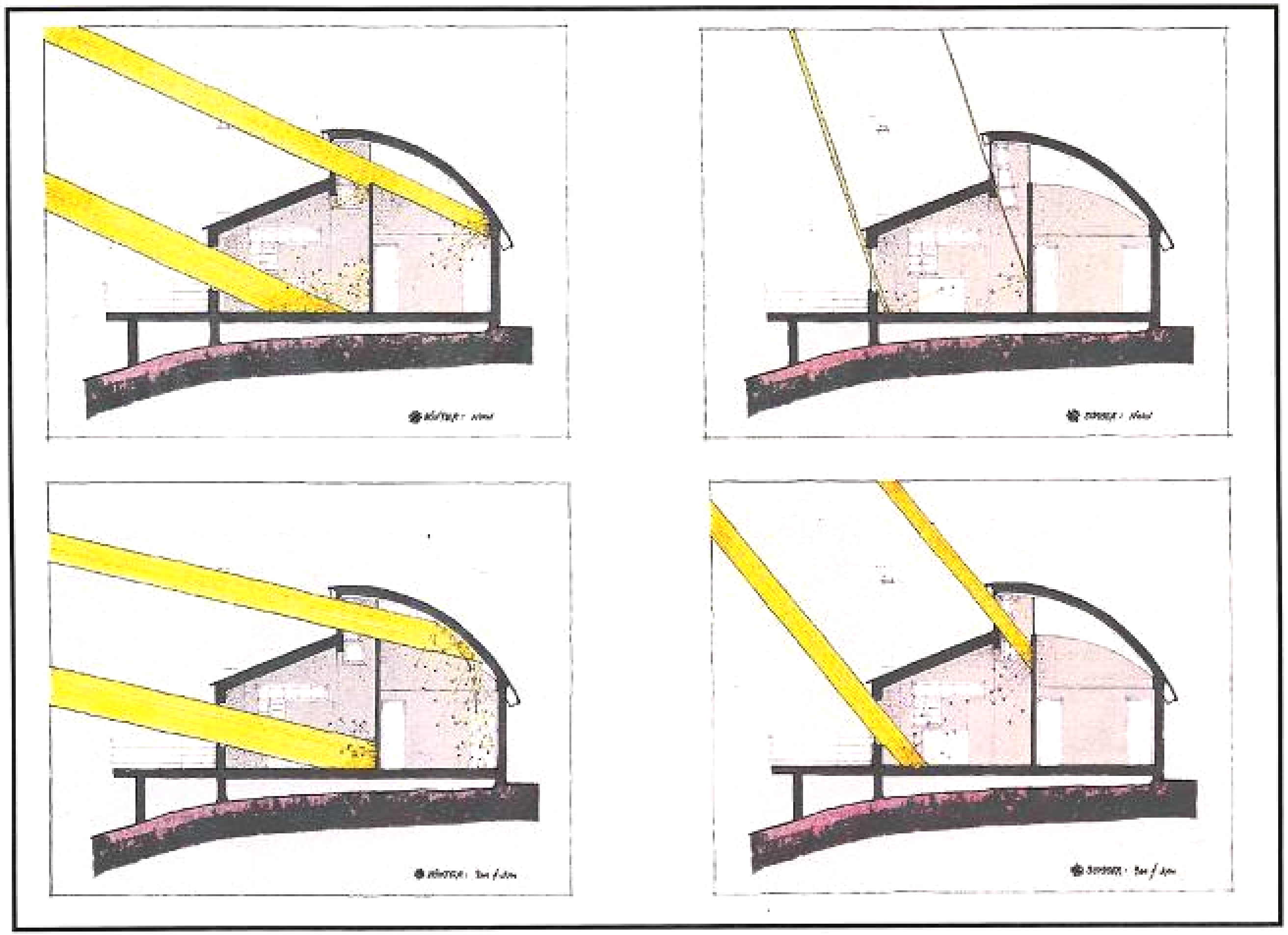


Tofte Photos: Peter Kerze;

Drawings: SNA; Graphs: Kerry Haglund

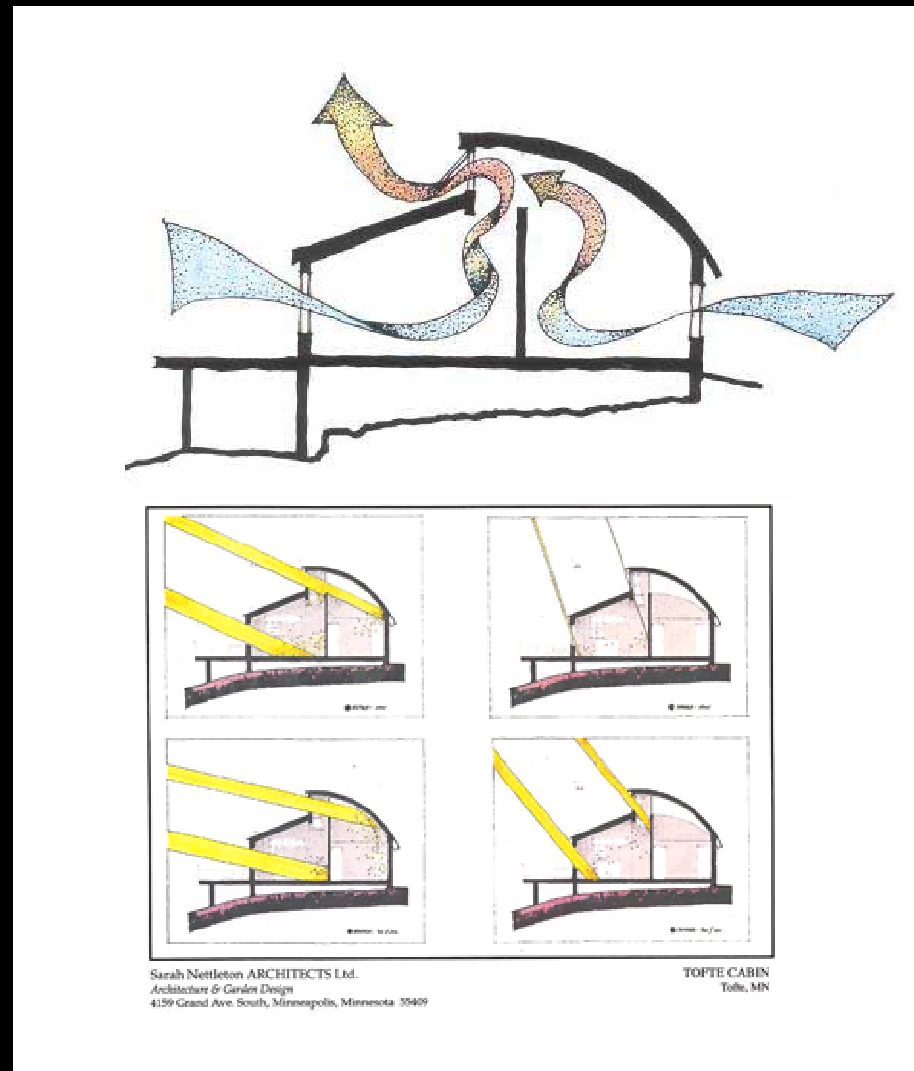
 

- Programming
- Small footprint
- Architectural strategies
- Finishes and materials



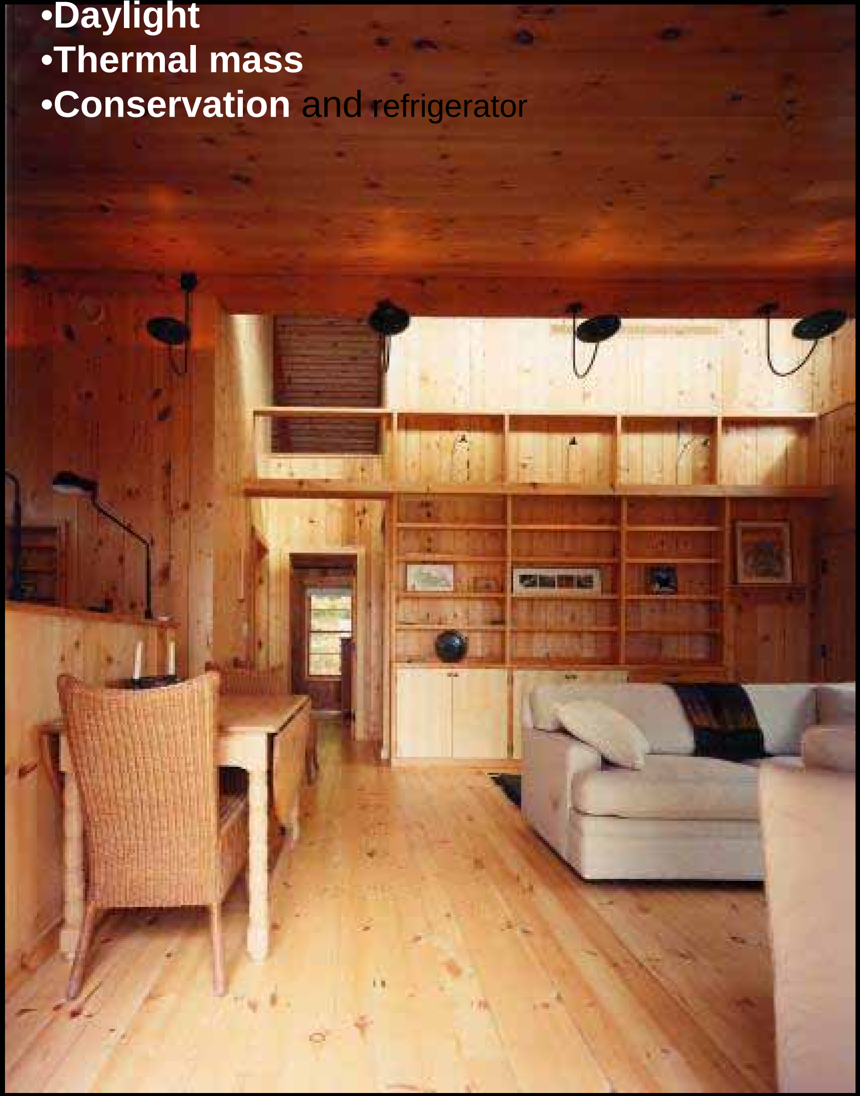
Sarah Nettleton ARCHITECTS Ltd.
Architecture & Garden Design
4159 Grand Ave. South, Minneapolis, Minnesota 55409

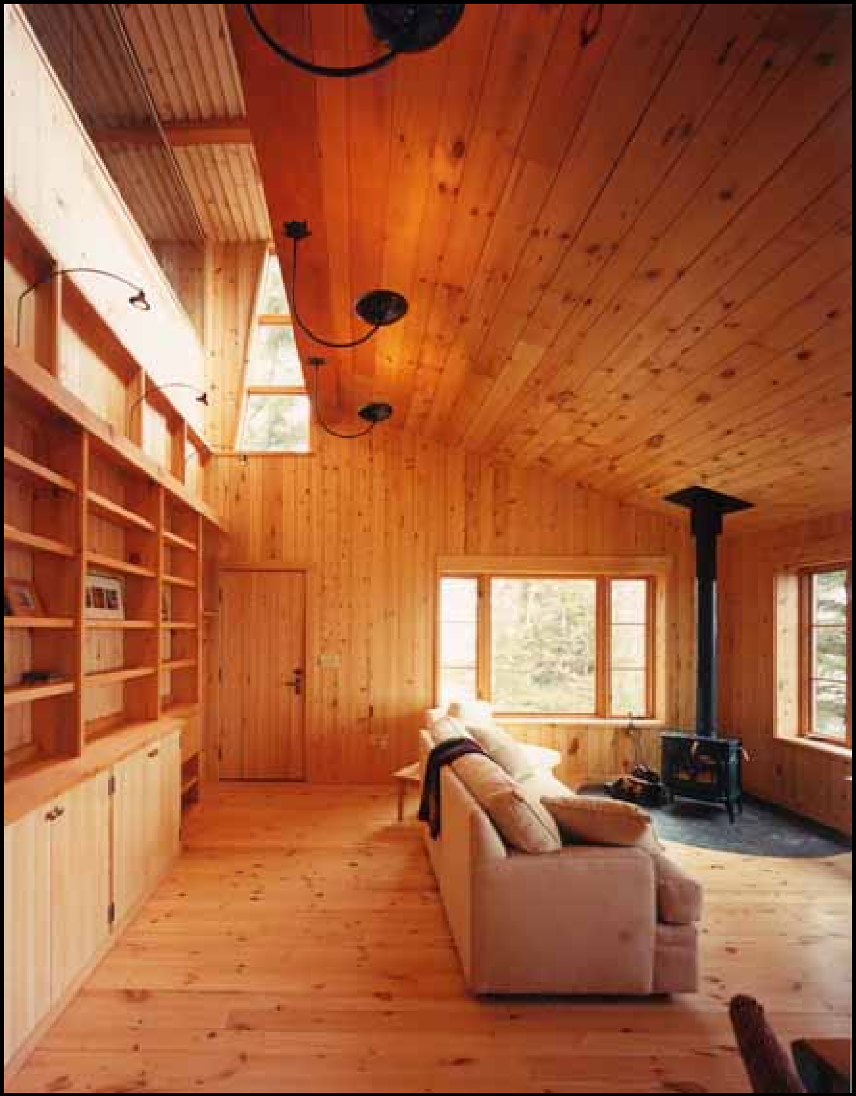
TOFTE CABIN
Tofte, MN



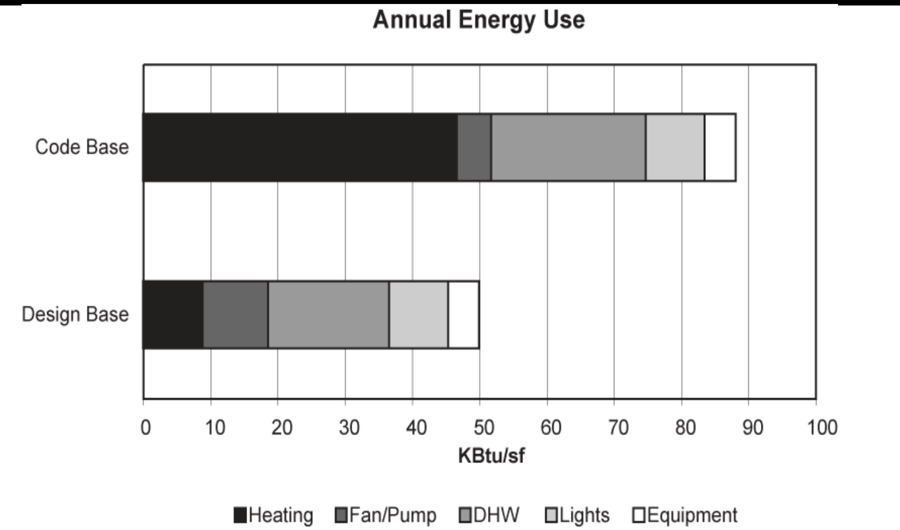
•**Optimize daylighting, passive solar, natural ventilation**

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

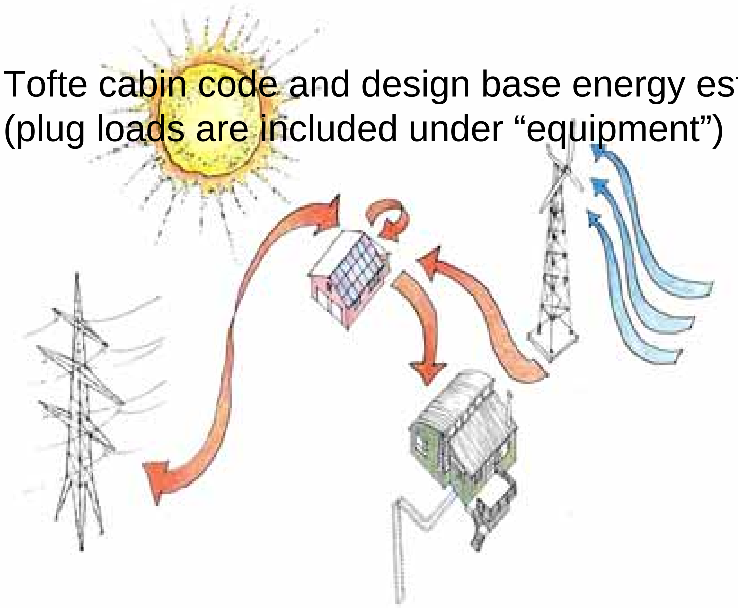




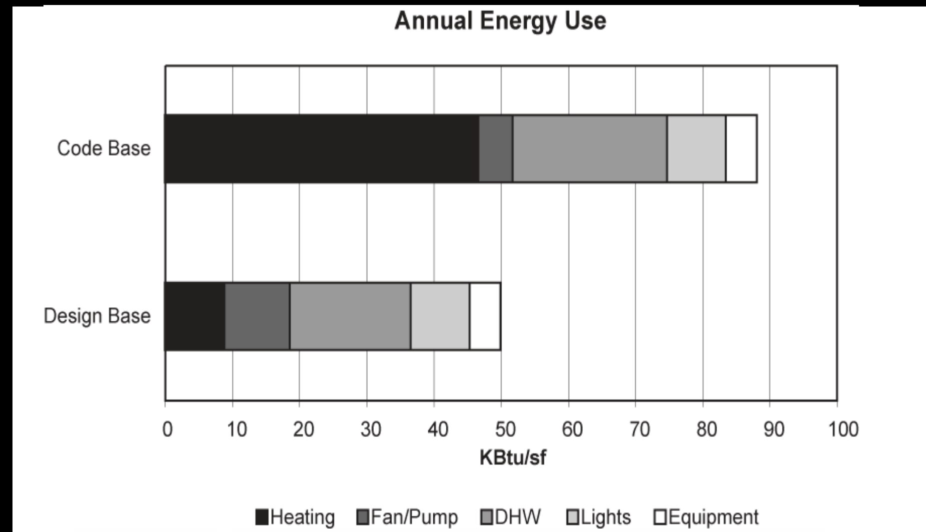
•Insulation levels are comparable to a code base of U-value 0.034 for the roof, 0.052 for the walls, 0.10 for the foundation, and 0.37 for the windows.



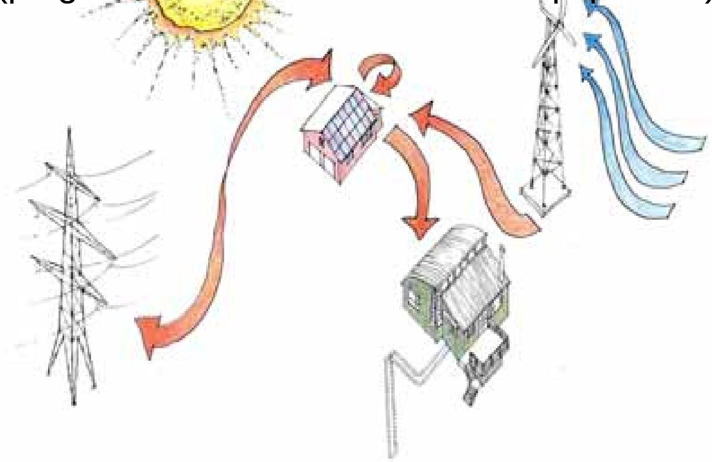
Tofte cabin code and design base energy estimate (plug loads are included under “equipment”)



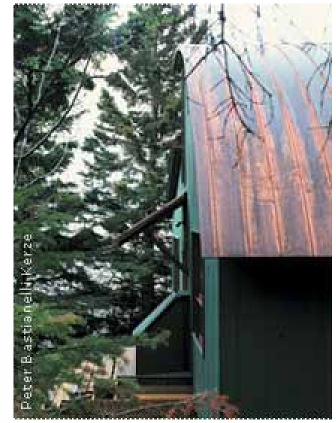
- **Ground source heat pump**
- **Heat recovery ventilator**
- **High performance appliances and washer/dryer**

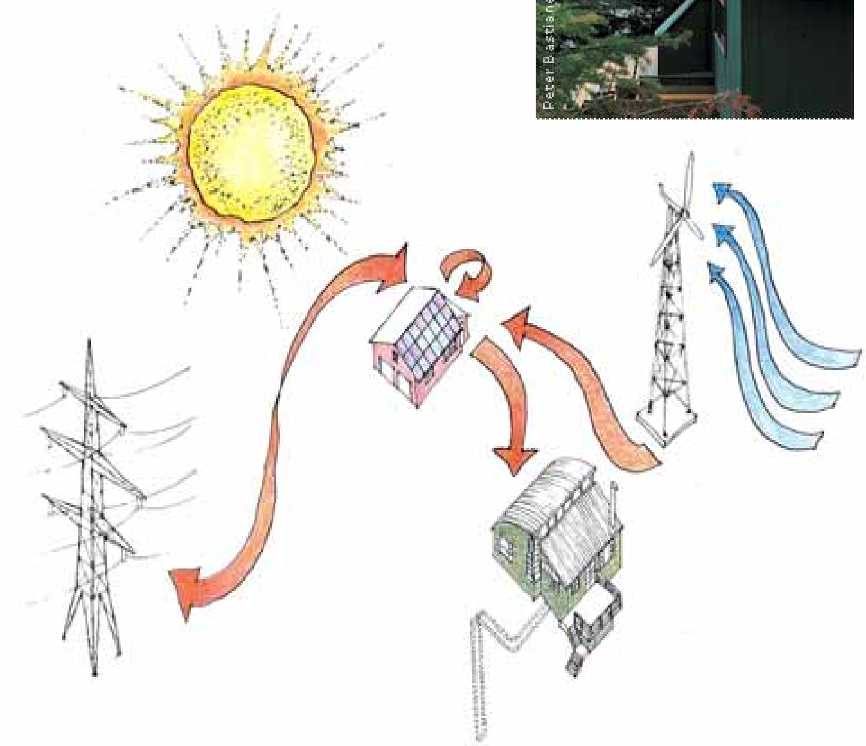


Tofte cabin code and design base energy estimate (plug loads are included under “equipment”)

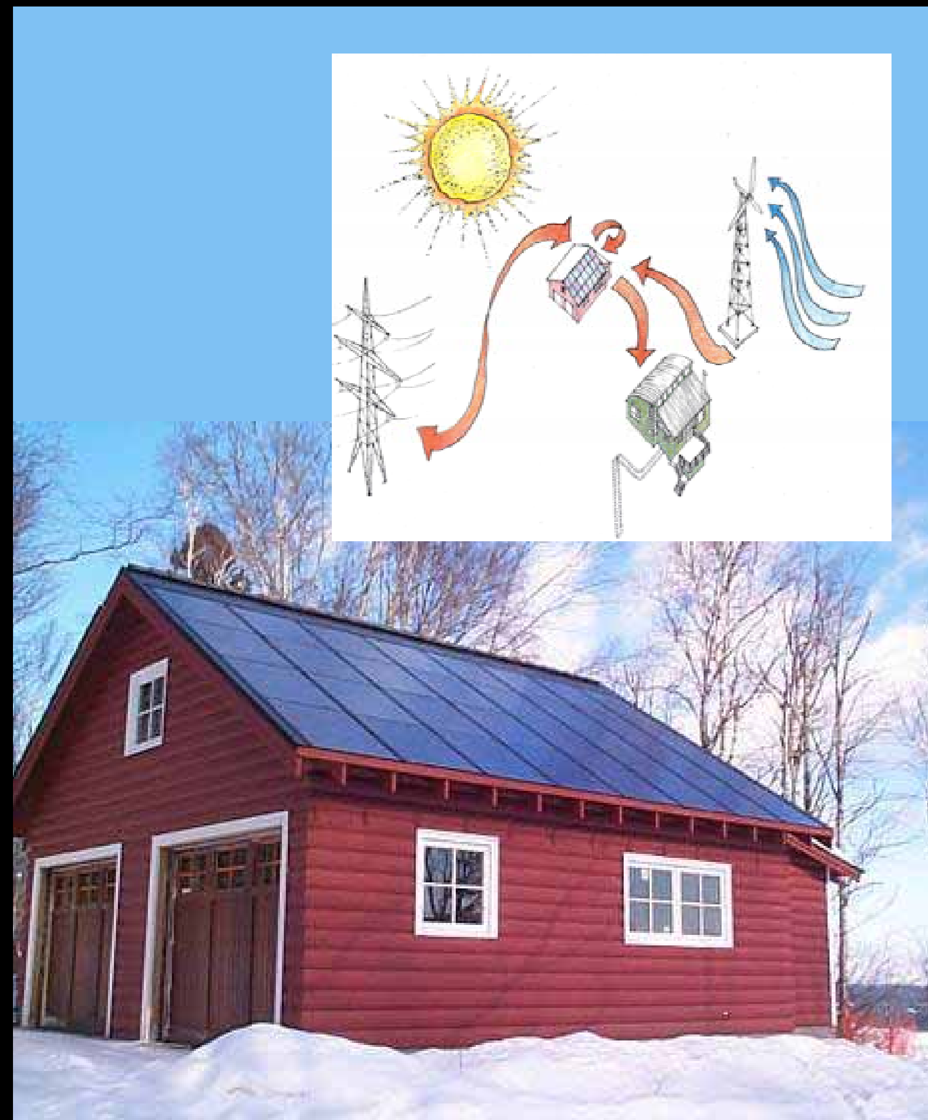


- Post-construction energy model estimated total building loads at 11,000 kWh/yr; 43% less then an equivalent ASHRAE 90.1 1999 building, or 49.95 KBtu/sf/yr verses 88.13 KBtu/sf/yr
- Space heating reduced by 80% from code - additional 20% reduction from domestic hot water





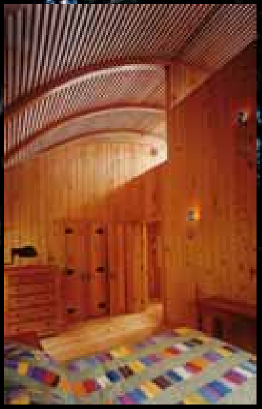
Combined peak kW rating for the wind and PV: 11.2 kW

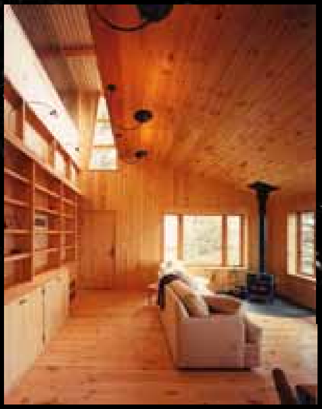


Tofte Cabin

Tofte, MN

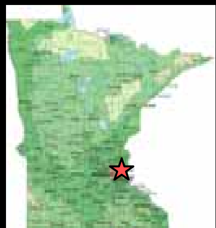
Sarah Nettleton Architects





Tofte Photos: Peter Kerze;

Drawings: SNA; Graphs: Kerry Haglund



Science House

Minnesota Science Museum, St. Paul, MN

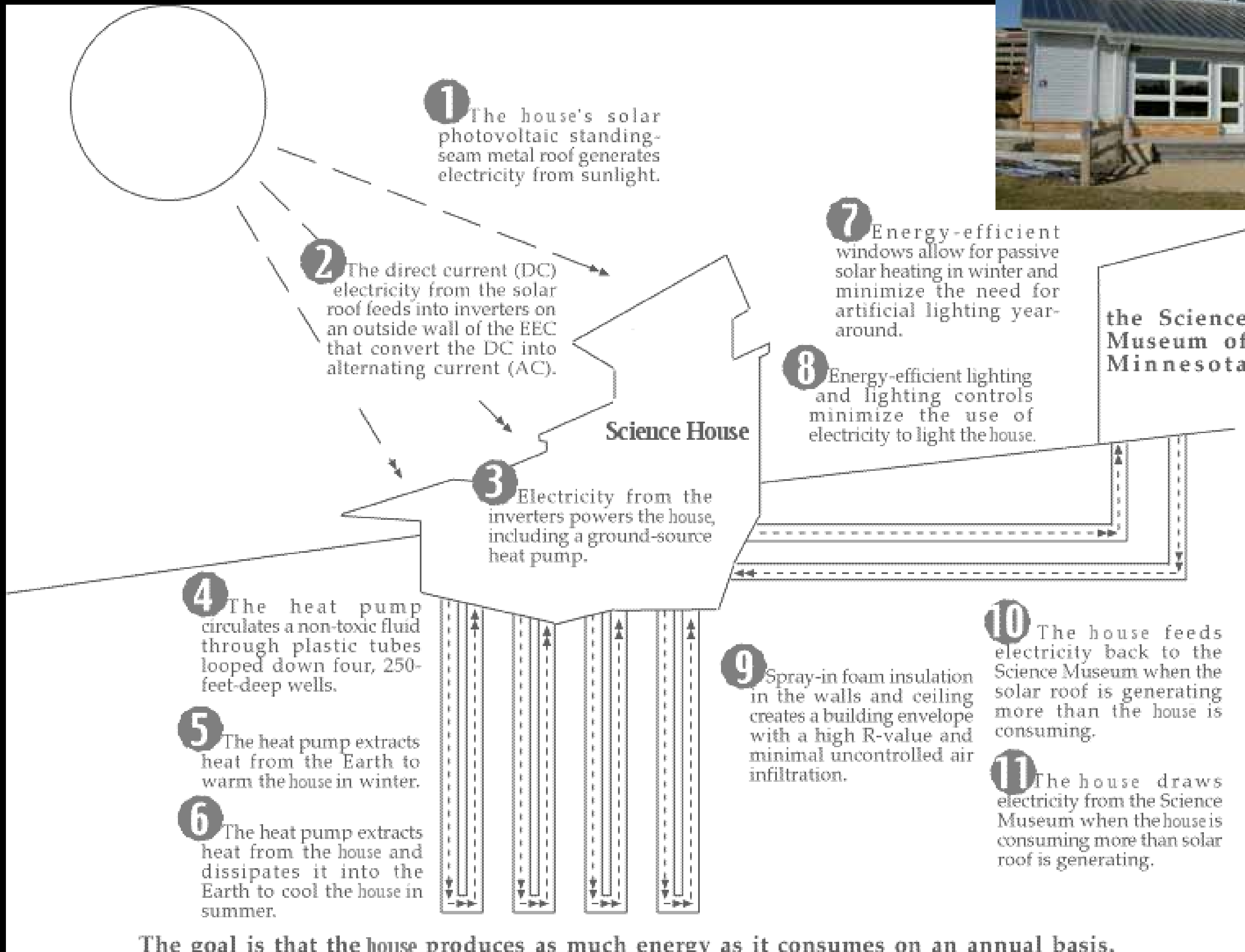
Barbour LaDoucer et al

Science House Photos: MSM & Keegan Furfaro

Drawings: MSM; Graphs: Kerry Haglund

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

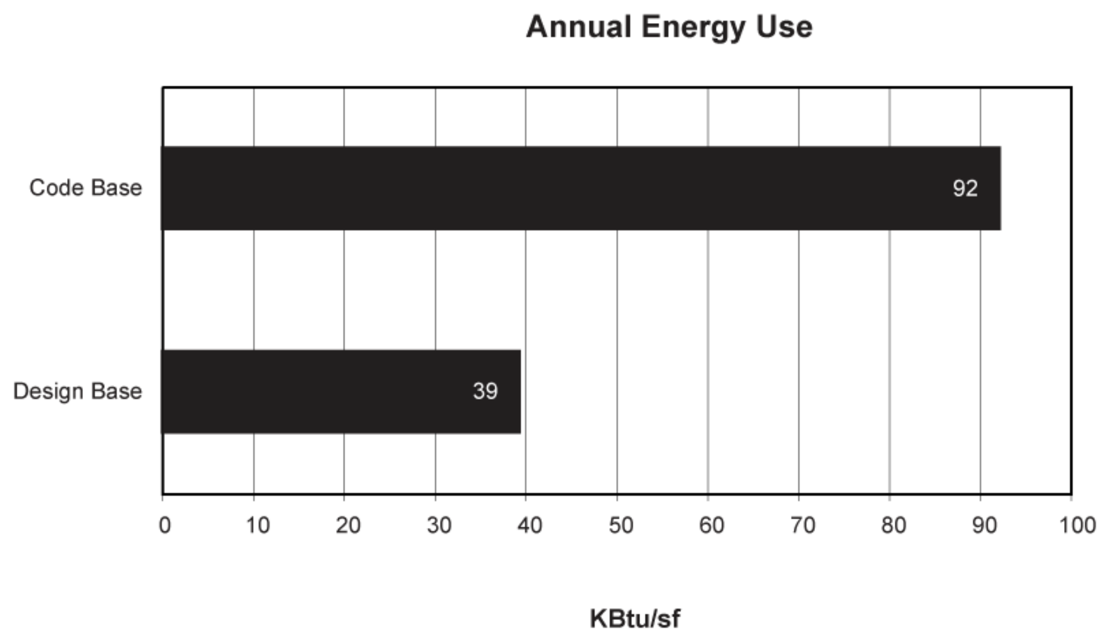
- •PV roof
- •Construction
- •Combined strategies



- •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

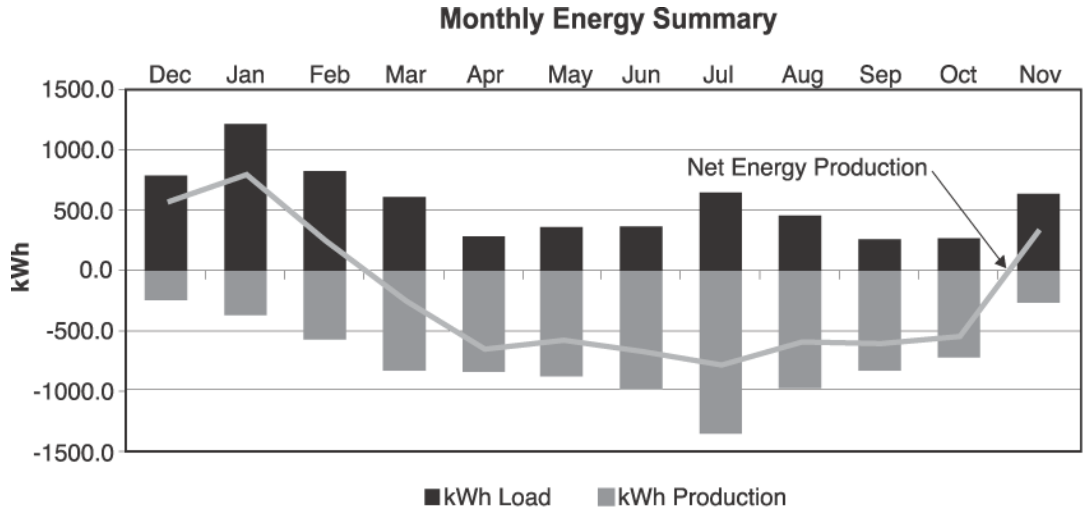
- Occupancy
- Appliance loads
- Systems

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



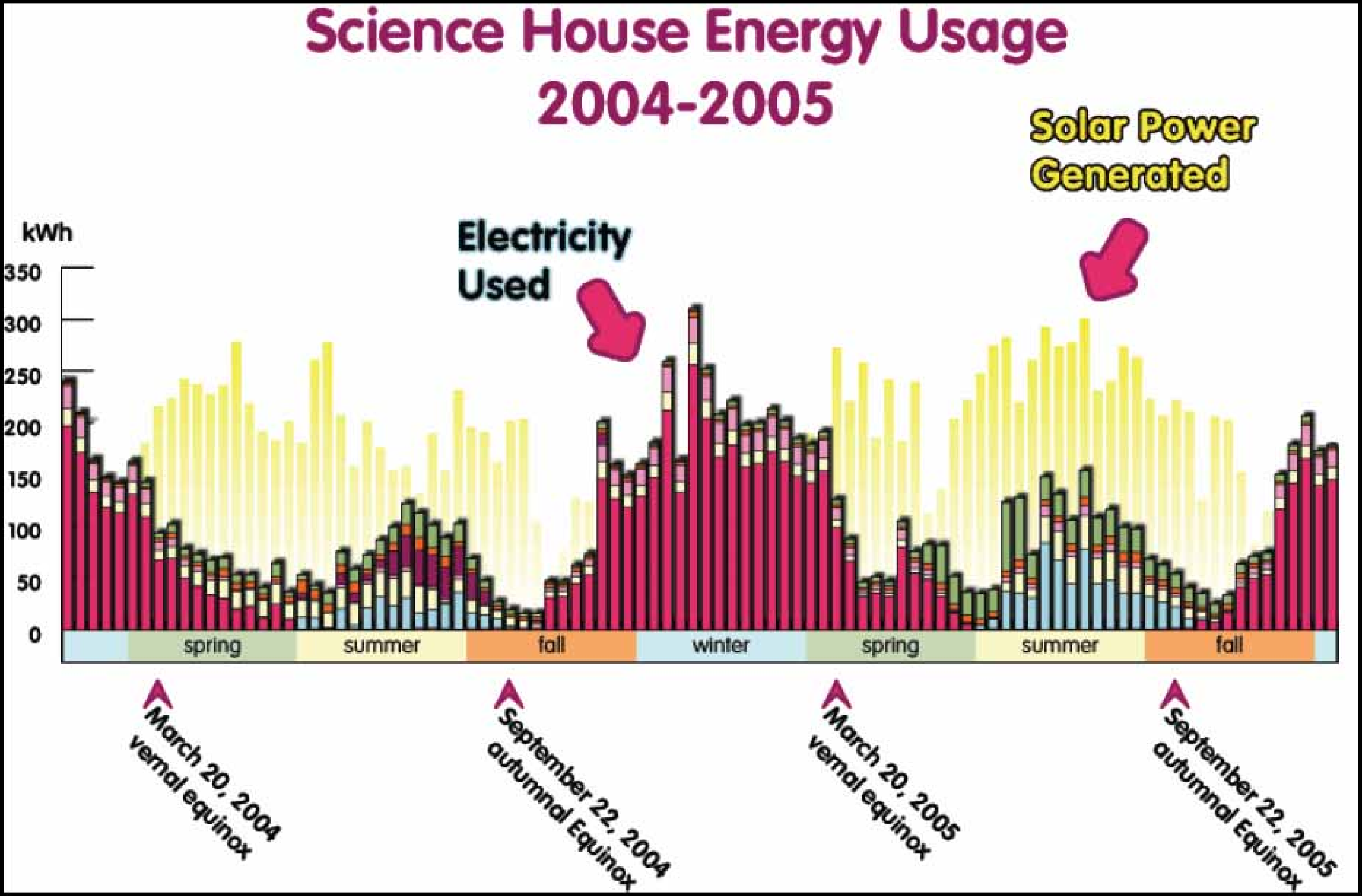
Science House code and design base energy estimate

- **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**



Science House energy summary Dec 04 – Nov 05

- **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**



Minnesota Science Museum

- **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

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

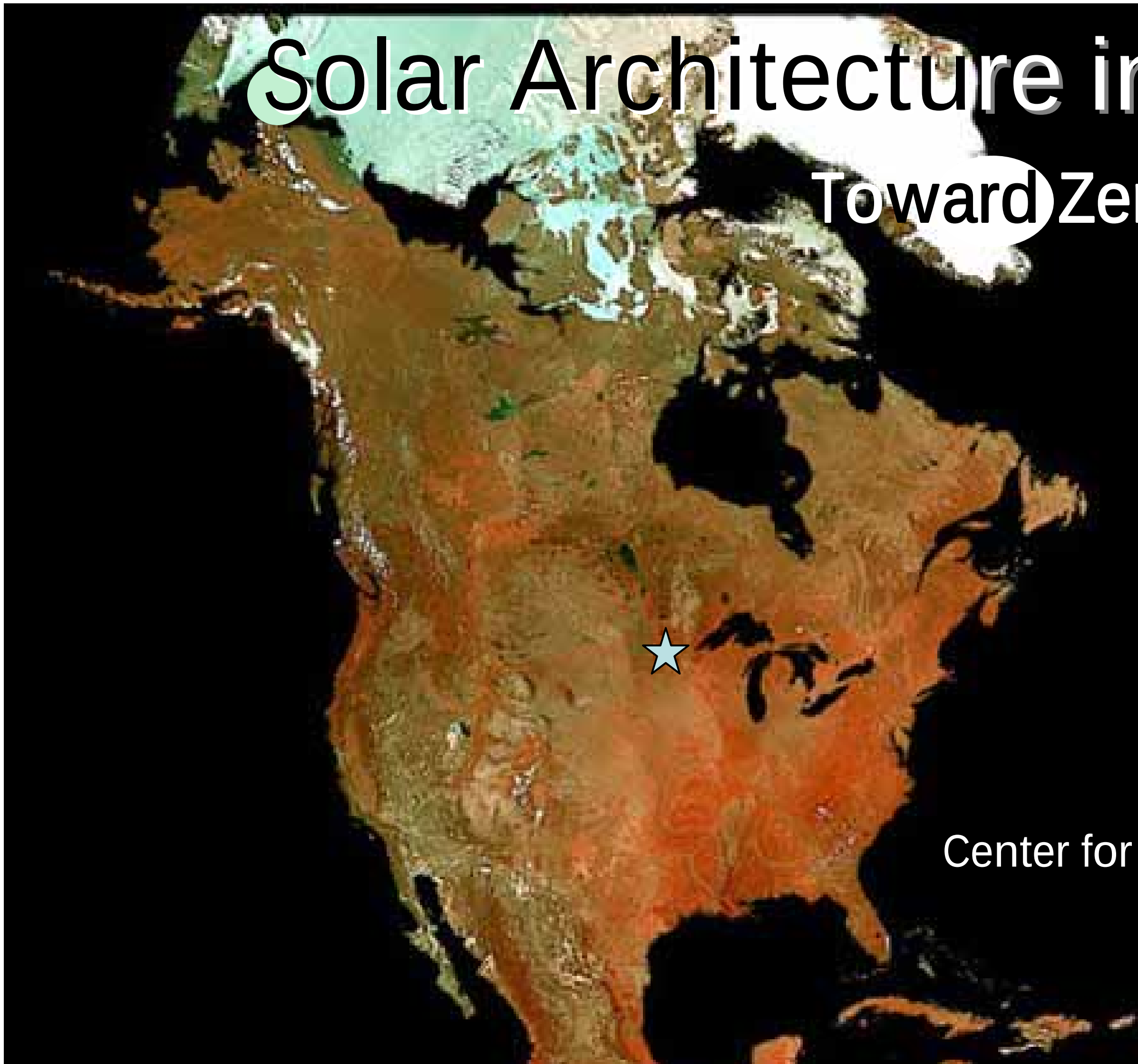
- Integrated design
- Design performance and design quality
- Aesthetics and human experience

ZEH in Minnesota
it's like learning to walk

www.afunworld.cm and Flickr

Solar Architecture in Minnesota:

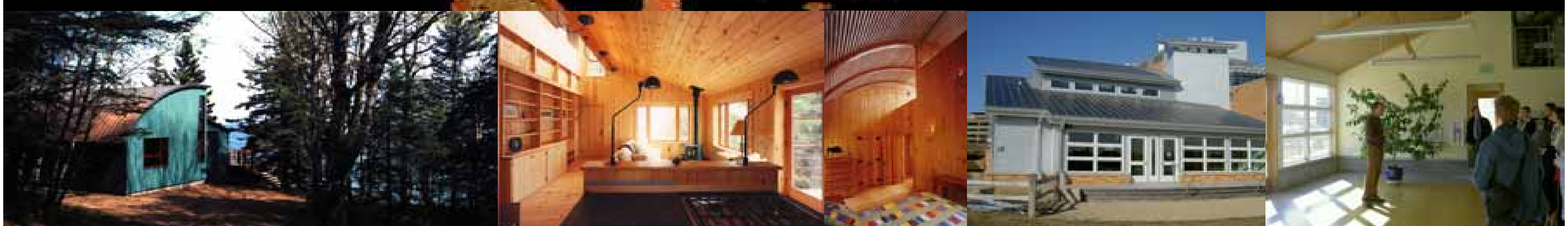
Toward Zero Energy Housing



Mary Guzowski
Department of Architecture

William Weber
Center for Sustainable Building Research

UNIVERSITY OF MINNESOTA

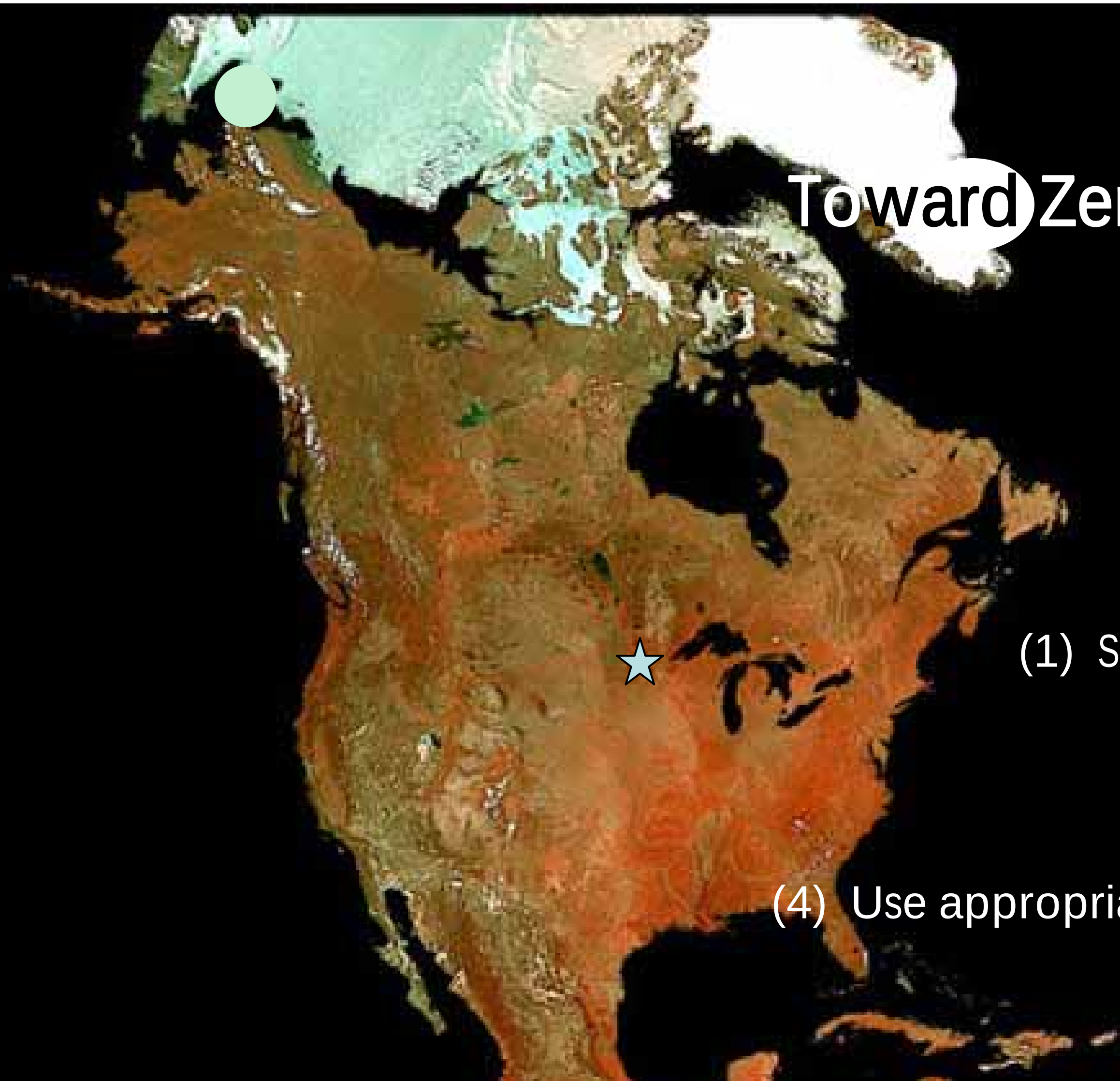


Acknowledgements: Sarah Nettleton Architects, Minnesota Science Museum, the Weidt Group, Keegan Furfaro, Peter Kerze, and Kerry Haglund.

[redacted]

Minnesota

Toward Zero Energy Housing



ZEH Strategies

(1) Set project and energy goals

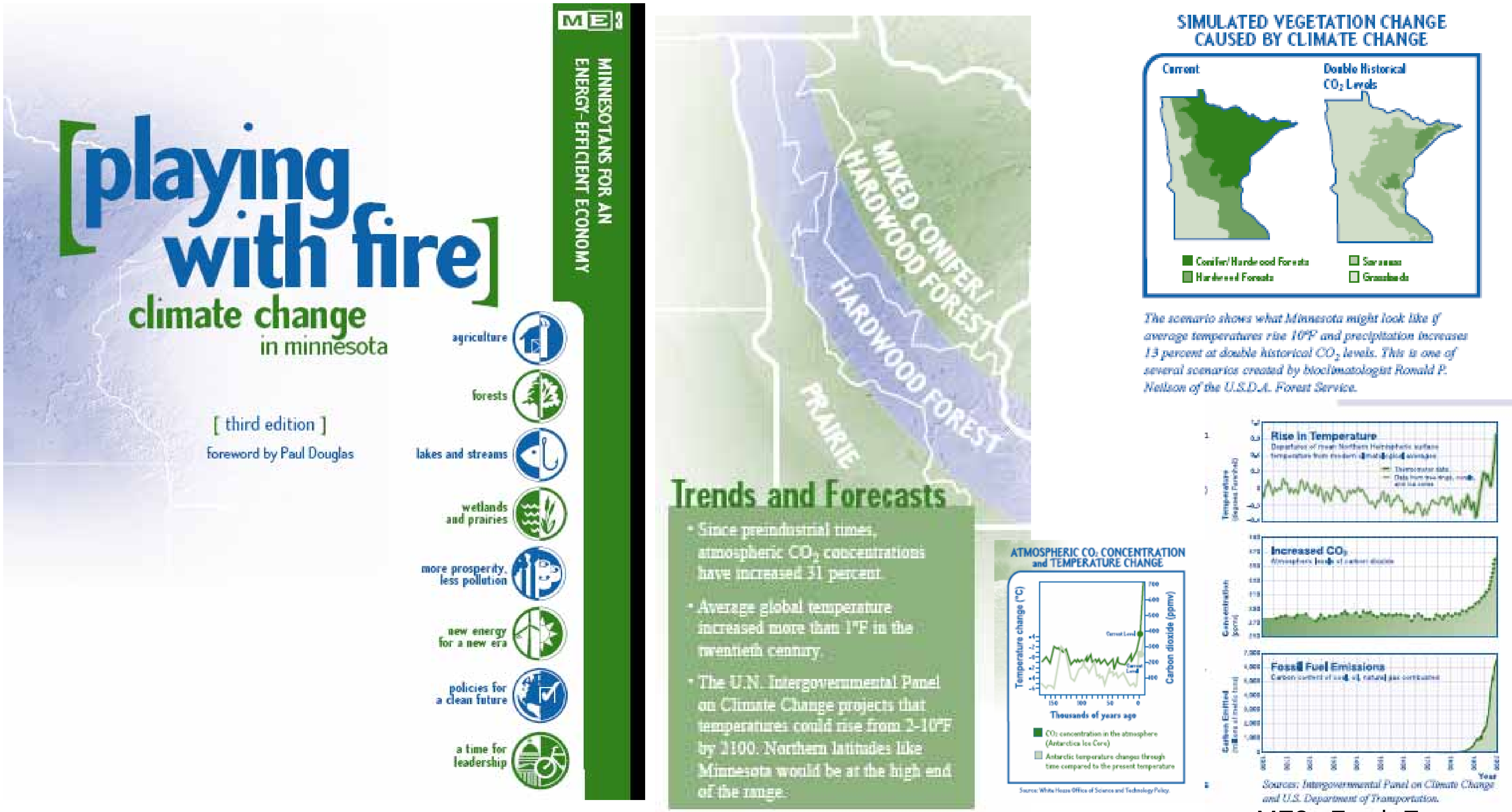
(2) Minimize loads

(3) Meet energy loads

(4) Use appropriate energy and fuel sources

(5) Monitor the project

Climate Change
renewable Minnesota



ME3: Fresh Energy