INFRASTRUCTURE SECTOR REPORT

Session Chairs: George Albercook and Werner Braun
Rapporteur: Diana Stralberg

INTRODUCTION

The Infrastructure breakout group included participants from industry (i.e. chemical manufacturing, automobile and electric utilities), academia (i.e. atmospheric sciences and social sciences), environmental organizations, and Native American groups. The group met four times during the workshop to discuss the potential impacts of climate change and climate variability on various infrastructure components in the Upper Great Lakes region.

The group interpreted infrastructure components to mean primarily fixed, durable goods with long lifetimes that are important in maintaining a functioning society. Other non-fixed distribution networks were also considered. Several infrastructure sectors were identified:

- ***Energy*** **–** including the generation, transmission, and distribution of oil, gas, and electric power
- ***Transportation*** **–** including primary and secondary roads, bridges, rail lines, managed waterways, and airports
- ***Telecommunication*** **–** including cable and satellite transmission of information
- ***Buildings*** **–** including commercial, industrial, and residential structures
- ***Waste management*** **–** including sewer and storm drain systems, landfills, and other disposal facilities
- ***Food*** **–** storage and distribution
- ***Health*** **–** delivery systems

Due to their mobility, motor vehicles, although important to many of the above-listed sectors, were only tangentially considered by this workgroup. It was assumed that climate change impacts related to motor vehicles were adequately addressed by the Industry workgroup.

SIGNIFICANT FINDINGS

The following ideas and themes emerged as significant overall findings of our breakout sessions.

- ***Limits of current infrastructure***. Current infrastructure systems are large, rigid, and largely based on 19th century engineering and scientific understanding. They were constructed under certain assumptions about climate that now appear to be changing. Many of these systems are not designed to withstand extreme events, and their failure or malfunction could actually amplify the impacts of climate change and variability on humans.

- ***Climate extremes.*** In terms of impacts on infrastructure, changes in climate extremes are likely to be more important than changes in climate means.

- ***Inefficiencies.*** Current inefficiencies in energy generation and consumption represent a potential for capturing lost (e.g., waste) heat and alternative forms of generating energy (e.g., water, wind, and solar).

- ***Policy matters.*** Power generation is extremely sensitive to policy changes, especially under deregulation scenarios. Economic incentives can change quickly, and aren't necessarily related to the true costs (i.e. impact) of production.

- ***Small vs. Large.*** Large infrastructure projects, with large capital costs and long payback times, may be a thing of the past. Efficiency and flexibility should be important considerations for new infrastructure projects. Several smaller energy projects (e.g., small hydropower, photovoltaics, and gas turbines) provide more flexibility and adaptability to climate change.

• ***Globalization.*** Increasingly integrated economies, globalization of trade, and deregulation of energy markets may help or hinder our ability to mitigate and adapt to climate change.

• ***"No regrets" strategies.*** The uncertainty and variability of climate change impacts supports the implementation of "no regrets" policies (e.g., increased energy and material efficiency) that make sense under any climate change scenario.

• ***Life-cycle analysis.*** In order to efficiently and effectively achieve reductions in greenhouse gas emissions, life-cycle analyses must be conducted, and produced goods must be reassessed in terms of desired *services* (e.g. warm, well-lit houses), rather than desired *products* (e.g. electricity and gas).

• ***Better metrics.*** Economic indicators must become more sophisticated than Gross Domestic Product (GDP), so that costs may be assigned to environmental degradation, health effects, quality of life, and other values that are not traditionally quantified. Value should be placed on consuming *better* rather than consuming *more*.

THE 4 QUESTIONS

1. What are the current concerns? & 2. How may climate change impact our lives?

The first two questions were addressed simultaneously over two breakout sessions. Current regional concerns were discussed, potential climate change scenarios, direct impacts and indirect impacts, such as policy and market responses to climate change and variability. The direct climate change influences that were considered included increased mean temperatures, increased frequency of temperature extremes, extreme weather events, water level changes, and altered freeze/thaw cycles. The indirect influences that were considered included the effects of energy conservation and efficiency measures, and increased costs and regulations in each of the infrastructure sectors.

For each sector, both the *sensitivity* and *adaptability* of various infrastructure components were considered. Most of the infrastructure sectors were deemed more sensitive to changes in climate *extremes* than to changes in *means*. Although adaptability was considered to be primarily determined by cost, it was concluded that the costs of adaptation depend on the types of policies instituted and how they are implemented (including the rate and predictability of policy changes). It was also acknowledged that public perceptions about climate change maybe just as important as actual changes in determining private and public sector responses and in turn the rate and hence the cost of those changes.

Direct impacts

Energy

• ***Peak Loads.*** Extreme high temperatures create increases in peak power loads. It is expected that climate change will result in more extremely hot days and greater peak loads.

• ***Power line damage.*** Snow, ice, frost, and temperature extremes all place an undue stress on power lines (e.g., the recent ice storm in the northeast). It is expected that climate change will result in greater weather extremes, both warm and cold, which will likely increase damage to power lines.

Transportation

• ***Lake levels.*** Low water levels on the Great Lakes require ships to transport lighter loads or increased dredging of harbors and channels. It is expected that climate change will lead to higher temperatures, increased evaporation, decreased lake levels, and a greater stress on shipping on the Great Lakes.

- ***Road damage.*** Freeze/thaw cycles reek havoc with paved roads, rail lines, and bridges. It is expected that climate change will result in increased interannual variability and greater weather extremes, which will increase the stress on maintaining smoothly paved or railed surfaces.

- ***Erosion and mudslides.*** Heavy precipitation (flash floods) and freeze/thaw cycles accelerate deterioration of roads, rail lines, bridges and lakeshore property. It is expected that climate change will result in increased interannual variability and greater weather extremes, which will increase erosion.

- ***Corrosion.*** Heavy snow events are typically treated with copious amounts of salt that corrode bridges and other elements of the infrastructure. It is expected that climate change will result in decreased snowfall that would decrease salt use and hence corrosion.

- ***Air travel.*** Fog, ice storms, heavy snow, and thunderstorms can all disrupt airline schedules. It is expected that climate change will result in more frequent and more intense weather extremes, which would increase these disruptions.

Telecommunication

- ***Damage.*** Ice storms and other extreme weather events can cause significant damage to power and communication equipment. It is expected that climate change will result in more frequent and more intense weather extremes, which would increase the likelihood of damage.

Buildings

- ***Flooding.*** Existing structures in proximity of flood plains are susceptible to flooding from heavy precipitation events. It is expected that climate change will result in more frequent and more intense weather extremes, which would increase the likelihood of flooding.

- ***Fire.*** Existing structures in proximity of fire-prone areas are susceptible to damage from fires that develop from drought and/or lightning strikes. It is expected that climate change will result in more dry periods followed by more intense convective precipitation events, which may increase the likelihood of lightning strikes and fires.

Waste Management

- ***Sewage.*** Heavy rains can cause overflows of combined storm and sewage drain systems, resulting in releases of untreated sewage into waterways. It is expected that climate change will result in more frequent and more intense heavy precipitation events, which would increase the likelihood of sewage overflows.

- ***Landfill leakage.*** Areas near landfills that are close to the water table are at risk for leaking. It is expected that climate change will result in increased precipitation, which may increase the likelihood of landfill leakage.

Food

- ***Storage and distribution.*** Greater agricultural yields require more storage. It is expected that climate change will result in warmer conditions, which could result in larger harvests and increased problems with storage and distribution of these larger harvests.

- ***Pests.*** Warm conditions tend to support larger (agricultural) pest populations. It is expected that climate change will result in warmer conditions, which could result in larger populations of agricultural pests.

Health

• ***Medical facilities.*** Hot conditions and other extreme conditions are a stress to the medical infrastructure. It is expected that climate change will result in more frequent and more intense heat waves and other weather extremes, along with the possibility of increased vector-borne diseases, which would increase the stress on the existing medical infrastructure.

Indirect impacts

Unlike direct costs, indirect costs are mitigated by societal actions. These include tax and regulatory decisions to deal with both prevention and adaptation. Behaviors like consumption patterns and fears about the future may also have indirect impacts.

Possible consequences of energy conservation and efficiency measures:

• ***Energy taxes.*** Several policy strategies to reduce the amount of CO_2 released into the atmosphere have already been proposed, including taxes on the amount of carbon released.

• ***Increased energy costs related to infrastructure changes.*** Switching to less vulnerable systems or systems that produce less carbon requires the expenditure of money and possibly the retirement of capital equipment before the end of its useful lifetime.

• ***Shifts in economy affecting energy-intensive industries.*** Full-cost accounting, tax shifting, or other methods that attempt to incorporate the impacts of producing a product or service into the price of that product or service will put enormous pressure on energy intensive industries.

• ***Trade-offs between reliable and inexpensive.*** Consumers may be able, as they are now in some pilot programs, to choose less reliable power in return for a lower cost.

• ***Increases in building energy efficient measures.*** Part of a portfolio of energy options may include increased efficiency in the heating, cooling, and lighting of buildings. The payoffs from these types of improvements are equivalent to finding an alternative energy source that releases no CO_2.

• ***Increased localization of energy production.*** Gas turbine and fuel cell technologies both provide cogeneration options. This provides tremendous reduction in the total carbon released.

• ***Pressure to aggregate energy supply/purchase.*** Consumers may form buying cooperatives to make bulk energy purchases.

• ***Selling energy back to the grid.*** Increases in the amount of electricity generated by consumers through alternative energy sources like fuel cells, solar roofs, and combined heat and power will lead to increases in the amount of electricity sold back to the power grid.

Possible consequences of infrastructure adaptations and regulations:

• ***Increased capital investment in new infrastructure:*** It may be necessary to build new infrastructure or to repair existing components more frequently.

• ***Increased inspection and maintenance costs.*** Enforcing regulations and market-driven certifications (e.g. the ISO 9000 standard) cost time and money.

• ***Higher insurance costs / inability to get insurance.*** If climate change is gradual, then it will probably be possible to get insurance to protect property. But if patterns and predictions worsen, then insurance may increase in cost or even cease to be available in some cases.

• ***Decreased convenience and predictability*** (e.g. easily disrupted transportation schedules).

3. What additional information do we need?

Based on questions and uncertainties raised in the previous breakout sessions, the group easily identified several priority data needs, which are summarized below:

• ***Better extreme event data.*** There has been some debate regarding whether the frequency of extreme events has increased recently. A better database and an analysis of that database is needed.

• ***Better accounting.*** The GDP overlooks external costs of environmental degradation, health impacts, etc. Full-cost accounting / credible quantification of externalities are needed to more accurately reflect the impacts of weather and climate on various infrastructure components.

• ***Better documentation.*** Currently there is no consolidated, integrated information on infrastructure characteristics. A systematic, integrated GIS database on infrastructure characteristics is needed.

• ***Better climate models.*** Current climate models are inadequate in terms of their physical parameterizations and resolutions. Some models do not even include the Great Lakes because they are so coarse. Better General Circulation Models (GCMs) and (nested) regional climate models (RCMs) are needed.

• ***Better urban data.*** Much about cities is unknown. For the most part, records of human population, employment, movement of goods, water usage, etc. are of poor quality. Concrete measurements of fundamental human systems and their sustainability are needed.

• ***Better risk analysis.*** Climate change impacts are uncertain, but they are likely to include increased variability in many systems. More in-depth strategic, acute and chronic risk analysis; and sensitivity analysis are needed.

• ***Better understanding of climate interactions.*** Climate change will likely involve synergistic effects, and nonlinear / threshold events. More research on the effects of interacting factors (e.g. UVB, SO_2, ozone, precipitation, nitrogen fertilization, habitat fragmentation) is needed.

• ***Better understanding of the rate of climate change.*** Industry operates with set timelines. The timelines for climate change is not necessarily known, so the timing of appropriate action is hard to gauge. A better understanding of how rapidly climate change will occur is needed.

• ***Better life-cycle analysis.*** The (long-term) impacts of many products and chemicals are unknown. A better understanding of these impacts (e.g., a better life-cycle analysis) is needed.

• ***Better demographic information.*** Population is stratified with respect to infrastructure use and vulnerability to climate change. Better information about infrastructure use by various population segments is needed.

• ***Better cost/benefit analyses.*** There are two types of infrastructure: public and private. More appropriate cost/benefit analyses of the different policy options for each of these types is needed.

4. How do we cope with climate change?

In addressing this question, coping was interpreted to mean prevention and mitigation of climate change, as well as adaptation and response to climate change. With respect to prevention and mitigation, the primary focus was on energy conservation and efficiency measures that may help slow global warming by reducing greenhouse gas emissions. The listings of appropriate adaptations and responses addressed both direct and indirect consequences of climate change. Many of the recommendations for energy conservation and efficiency were technology-based or policy-based.

Technology-Based

• ***Increasing use of cogeneration technologies.*** In cogeneration, electricity and heat are produced in the location where they are needed. Transmission losses are eliminated and heat, which is otherwise wasted, is utilized.

• ***Improved power plant efficiency.*** Cleaner burning coal- and oil-fired power plants will go a long way towards reducing carbon emissions in the region.

• ***Improved vehicle technology.*** More efficient cars, alternate fuel cars, and GPS navigation systems are just some examples of how automobiles can be designed so that less carbon is put into the atmosphere in going from point A to B.

• ***Increased use of mobile energy sources.*** Such energy sources could effectively power transportation vehicles, for example. A fuel cell in a car can be recharged at home during night and at work during the day.

• ***Increased telecommuting.*** Working from home via computer not only saves employees from lengthy commutes, but also saves fuel and reduces carbon emissions.

• ***Technology-assisted home energy audits.*** This could include the use of integrated energy and climate databases to find inefficient homes, as well as technology to find wasted heat energy.

• ***Adopting existing energy technology.*** ***L***ooking to other (e.g. warmer, drier) regions for existing energy-efficient technologies will go a long way towards reducing the amount of carbon that the many coal- and oil-fired power plants in the region now produce.

Policy-Based

• ***Investing in latest technology.*** Investing in "leap frog", rather than incremental technology advances (e.g., much of the world is "leap-frogging" right past land-based telecommunication systems to cellular systems) will be more beneficial in the long run.

• ***Investing in mass transportation.*** Greater use of mass transportation systems – not necessarily conventional public transportation systems like busses, trolleys, and subways; but, on a less massive scale, car sharing, large taxies and public bicycles – will reduce carbon emissions.

• ***Investing in alternate energy.*** Implementing alternate-energy power plants and developing alternate-fuel automobiles are just two examples of how alternative energy use could reduce carbon emissions.

• ***Improved product labeling.*** More stringent labeling requirements and global product standards (e.g., standardized full-cost accounting could lead to labels that include the amount of carbon released by the manufacture of the item) would facilitate full-cost accounting efforts.

• ***More energy conservation incentives.*** Providing rate-based incentives for the public and for industry to shift energy use to off-peak hours would help to alleviate power overloads – especially during heavy-use situations.

• ***More tax incentives.*** Providing incentives in the form of reduced taxes or tax rebates for energy conservation may motivate people to use less energy and to reduce carbon emissions.

The general consensus, however, was that major lifestyle changes and paradigm shifts would be necessary to significantly alter the current global warming trajectory. Some examples included:

• ***Reductions in energy consumption.*** People need to learn how to live using less energy.

• ***Reduced suburban sprawl.*** Changes in human settlement patterns (e.g. densification, cluster development) to retard suburban sprawl could lead to reduced commuting, reduced traffic congestion, and reduced pollution.

• ***Increased use of mass transit.*** Changes in commuting and driving patterns (e.g., greater reliance on public transportation) would lead to fewer driven miles and reduced traffic congestion and pollution.

• ***Better-designed power plants.*** If the energy generation infrastructure were designed to supply the average need, then it might be much more efficient but it would not be able to handle large peak loads.

• ***Better lake-ice forecasts.*** Improved forecasting and monitoring of lake-ice (e.g., sophisticated docks) would allow shipping schedules to be more efficient.

• ***Increased use of high speed rail systems.*** Airports have become increasingly congested. Providing another high-speed alternative will help to reduce the travel burdens from airports.

• ***Switching to electronic communication media.*** Increased use of email and electronic video conferencing, for example, will also help to reduce the burden on the transportation and shipping infrastructure segments.

• ***Interruptible power supplies during peak load hours.*** During peak demand on hot days, customers allow the power company to shut off their air conditioning in return for lower rates.

• ***Separation of storm and sewer systems.*** This separation will help to reduce contamination during heavy rain or melting events.

Some general suggestions for coping with climate change impacts on infrastructure systems included:

• ***Assessing existing (old) infrastructure elements.*** Improved assessment of and attention to old infrastructure elements will help people to decide more carefully whether replacement or repair is a better option.

• ***Increased maintenance of infrastructure systems.*** Better monitoring and maintenance of existing infrastructure elements

Finally, the breakout group recognized that a host of external factors may complicate the implementation of recommended coping strategies. The following key issues should be considered:

• ***Barriers.*** Legislative, regulatory and political barriers impede the implementation of climate change coping strategies. Interest groups and government institutions may be resistant to change.

• ***Scale.*** Other significant barriers to change include the longevity and size of most infrastructure components. The magnitude of investment needed to overcome these barriers is significant.

• ***Interactions.*** In responding to climate change, the interactions between climate change and other human-induced factors, including increases in UVB, sulfur dioxide, nitrogen, ozone, and precipitation, as well as population growth, urbanization and habitat fragmentation, must be considered.

• ***Global scope.*** Due to increasing globalization of economies and markets, climate change impacts of other regions of the U.S., as well as in other countries, will indirectly affect the Upper Great Lakes region. These impacts need additional attention.

• ***Deregulation.*** The deregulation of electric utilities and other energy sectors is already occurring, resulting in greater individual purchasing control but less central control of energy generation, transmission and distribution. It is unclear what interaction will occur between deregulation and climate change.

• ***Better measures***. Our current national accounting system (GDP) does not incorporate the external costs of degrading the environment, human health, quality of life, etc., that are difficult to quantify. More sophisticated economic indicators are needed to provide market incentives for energy conservation.