EDITOR'S PREFACE

This document constitutes the "PROCEEDINGS" of the International Conference on Cities and Global Change, which took place in Toronto, Canada, June 12-14, 1991. The conference was organized by the CLIMATE INSTITUTE of Washington, D.C., with the support of a number of governments and institutes.

The principal partners were:
- the CITY OF TORONTO
- the ONTARIO MINISTRY of ENERGY
- the CANADIAN CLIMATE CENTRE of ENVIRONMENT CANADA

Financial support was also provided by CONSUMERS' GAS COMPANY. The MUNICIPALITY of METROPOLITAN TORONTO was host to the Conference Banquet. CRAY RESEARCH INC. was the host of a reception at registration June 11.

A number of agencies supported speakers at the Conference. These included the NETHERLANDS CLIMATE PROGRAM and the U.S. DEPARTMENT of ENERGY. The participation of representatives of cities involved in the URBAN CO2 PROJECT of the INTERNATIONAL COUNCIL ON LOCAL ENVIRONMENTAL INITIATIVES, particularly on a number of the panels, was central to the success of the event.

Most of the speakers were kind enough to contribute papers for this document; this is a record of a very large fraction of the presentations and the associated discussion. Readers will recognize that some of the papers are designed to be read to an audience, while others have been modified to offer a more journal-like nature. The questions and their answers have been transcribed from the official audio records of the conference. (Tapes of any or all sessions may be obtained from Audio Archives of Richmond Hill, Canada). Some of the figures in this document do less than justice to those speakers who were unable to procure the originals for me. I sincerely hope that they do not in any way dilute the appreciation of readers for the messages that were so ably presented at the conference.

Additional copies of this document may be obtained from the CLIMATE INSTITUTE, 324 Fourth Street, N.W., Washington 20002-5821, or from the Editor, 15 Emsley Drive, Richmond Hill, Canada L4C 8N2.

The CLIMATE INSTITUTE is an organization with an international Board of Directors, and an even larger international Board of Advisors, dedicated to bridging the gap between science and policy for the greenhouse-gas and stratospheric ozone depletion issues. This conference was only one in a long series dealing with different economic sectors or social structures, and their relationships with global change. The Institute is also playing a large role in informing developing countries about the potential impacts of global change for them. Documents covering previous conferences, and other information about its activities may be obtained from the Institute.

Part 1

KEYNOTE AND DISCUSSION

Planning in a Climate of Uncertainty

by

Barrie Smit
PLANNING IN A CLIMATE OF UNCERTAINTY

Barry Smit
University of Guelph

Climate change is a global issue. Of course, global changes are not new for us. Over the centuries we have witnessed shifts in global populations, world politics and international economics. And there have been broad-scale environmental changes, such as earthquakes, floods and volcanoes, which have greatly influenced our livelihoods. Climate change is distinctive because of three important features. First, it is global in scale; all aspects of the issue from atmospheric physics to the politics of climate transcend national boundaries. Its causes, its effects, and any actions to address the issue involve the entire global community. Second, the physical processes are very slow, relative to economic and political events, and unlike conventional environmental disasters, are difficult to detect. Third, the changes are induced by human activity. They result from our use of the earth’s resources, and are inextricably intertwined with our current way of life.

This connection with human economic activities suggests that we should be able to manage the problem. In practice, the issue is extremely difficult to manage, largely because of the features just noted. Its global and long-term nature mean that it is difficult to identify and understand. Any political action is also confounded both by its long-term and global scope and by its interdependence with activities upon which our life styles are based.

The issue is loaded with uncertainty, from the physical science, through the ecological and economic impacts, to the political implications. This paper aims to provide an overview of the issue as a basis for the deliberations of this conference. It addresses, in turn, the science of the greenhouse effect, its potential socio-economic implications, and the prospects for political action. The paper concludes with some speculation regarding city planning under an uncertain climate.

THE ENHANCED GREENHOUSE EFFECT: THEORY AND EVIDENCE

The heat-trapping ability of the earth’s atmosphere has long been recognized (Figure 1). Certain gases in the atmosphere are transparent to incoming solar energy but absorb some of the infrared radiation subsequently emitted by the earth’s surface. This natural “greenhouse effect” is what makes the earth habitable; without it the earth would be about 35°C colder. What is changing are the atmospheric concentrations of carbon dioxide and other gases which trap more of the terrestrial radiation, essentially enhancing the greenhouse effect, causing temperatures to rise in the lower atmosphere, thereby affecting weather and climate.

This general theory is widely accepted and there is strong
Figure 1: Simplified illustration of the Greenhouse Effect

scientific expectation for unprecedented global warming, but many uncertainties remain. The speed of warming, the effects on other aspects of climate, the regional responses, the ecological consequences, and so on, are not certain, prompting some people to question the legitimacy of the whole idea of an enhanced greenhouse effect.

Debate about the reality of climate change usually relates to several types of evidence. First, is there actually change in the chemical composition of the atmosphere? On this matter there is little contention. Direct measurements of atmospheric gas levels show increasing concentrations of carbon dioxide, methane, CFCs and nitrous oxide (Table 1). There is broad scientific consensus on the sources of these gases, their rates of change, and their roles in enhancing the greenhouse effect (Houghton et al., 1990).

Increases in concentrations of carbon dioxide, the principal greenhouse gas, stem from fossil fuel combustion for transportation, power generation, and industrial, commercial and domestic energy use. The major carbon emitting countries from energy sources are U.S.A., U.S.S.R., and China. In addition, growing trees absorb carbon dioxide from the atmosphere, and represent a carbon “sink”. Deforestation also contributes to

<table>
<thead>
<tr>
<th>Gas</th>
<th>CO₂ Carbon Dioxide</th>
<th>CH₄ Methane</th>
<th>CFC-11 Chlorofluorocarbons</th>
<th>CFC-12 Chlorofluorocarbons</th>
<th>N₂O Nitrous Oxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal Sources</td>
<td>Coal, oil, natural gas; deforestation, ...</td>
<td>Rice, livestock wetlands, ...</td>
<td>Industrial foams, coolants, ...</td>
<td>Fossil fuels, deforestation, fertilizer, ...</td>
<td></td>
</tr>
<tr>
<td>Concentrations</td>
<td>(1800) 280 ppmv, 333 ppmv</td>
<td>(1890) 1.72 ppmv</td>
<td>0 ppmv</td>
<td>0 ppmv</td>
<td>280 ppmv, 310 ppmv</td>
</tr>
</tbody>
</table>
| Annual Increase,  | 0.5% | 0.9% | 4.0% | 4.0% | 0.25%
| Contribution to    | 50-200 yrs | 10 yrs | 65 yrs | 130 yrs | 150 yrs |
| Total Radiative    | 55% | 15% | 24% | 6% |

Table 1: The Principal Greenhouse Gases (Houghton et al., 1990)

increases in carbon dioxide concentrations, accounting for approximately one quarter of CO₂ emissions. Methane is also a naturally occurring gas whose concentrations are increasing from decomposition of organic matter (for example in rice paddies), ruminants (such as cattle), and release during coal, mineral, oil and gas operations. The chlorofluorocarbons (CFCs) are entirely human-made chemicals, used as refrigerants, solvents and blowing agents. They are the most potent greenhouse on a molecule-for-molecule basis, and they pose a threat to the protective layer of ozone in the upper atmosphere.

Given these changes in atmospheric gases, the second issue relates to their implications for the earth’s climate. The principal tools for addressing this question are the GCMs (General Circulation Models or Global Climate Models). These are very sophisticated mathematical representations of the main physical processes relating atmospheric chemistry to global climatic conditions (Schneider, 1969). There are a handful of these coarse-scale computer model in the world, based on slightly different assumptions and run under different sets of conditions. As you might expect, each yields somewhat different results from the others. Notwithstanding these differences, there are major consistencies among the GCM outputs. In particular, all the models show that with increasing concentrations of greenhouse gases, the earth’s temperatures are expected to increase significantly and at unprecedented speed (Houghton et al., 1990).
While the GCMs represent the principal instrument for inferring climate change from the trends in trace gases, some important corroborative evidence also exists. For example, from the Vostock, Antarctic ice cores there is a 160,000 year record of CO₂ concentrations and of global temperatures (Barnola et al. 1987). Over that period there is a very close correlation between CO₂ levels and temperature (Figure 2), just as would be expected from the GCM results. The Vostock data also show that although CO₂ concentrations have varied over 160,000 years, they never remotely approached the levels currently recorded (353 ppmv), nor were past changes as rapid as the increases over the last century.

Predictions of future global temperature vary considerably, particularly because of uncertainty about future levels of GHG emissions, but there is now very strong international scientific consensus that global mean temperatures will increase significantly over the next several decades. Assuming a business-as-usual scenario, warming above pre-industrial temperatures is expected in the order of between 1.5°C and 3°C by the year 2030 (Boughton et al., 1990).

The third issue in the evidence debate relates to actual observed changes in temperature. If gas concentrations have already changed, should it not be possible to identify the corresponding changes in temperature from recent records? Plots of mean global temperature, corrected for measurement anomalies, urban heat effects and so on, indicate a gradual increasing trend over a 100 year period (Figure 3). Over the last century the five warmest

![Figure 2: Global Temperatures and CO₂ Concentrations, 160,000 years, from Vostok Ice Cores (Barnola et al., 1987)](image)

![Figure 3: Global Mean Temperatures, 1861-1989, relative to average for 1951-1980 (Boughton et al., 1990)](image)

years have been in the 1980s. However, these plots also show considerable variation in temperature (and in other climatic attributes) from year to year and from decade to decade. Climate is inherently variable. So while a general upward trend in temperature is expected given the findings of the GCMs, the fact that we may have experienced some particularly hot years recently, by itself, is not proof of anything other than the climatic conditions vary from year to year; by the same token the occurrence of several unusually cool years would not disprove greenhouse warming. The long-term trends in global temperatures are consistent with the expectations from the hard evidence on trace gas concentrations and the knowledge of global climatic responses from GCMs and other analyses.

**IMPACTS**

Regardless of the conclusion you or I might reach regarding the reality of climate change, it is enough of a public concern that there is great interest in the implication of such changes for environments, economies and society generally. The research on impacts has been driven, in large part, by policy makers' needs for information, not just on gas concentrations, nor even on global temperature change, but especially on what these physical changes might mean for economic activities, for regions, for human activity.
A vast array of potential impacts has been identified, some positive and many negative (IPCC, 1990). Several countries have noted how, for illustration only. The expected changes in climate are likely to alter the environmental conditions which define ecosystems, or the areas within which certain species of plants and animals can survive. Quite apart from the purely ecological implications, this has consequences for the spread of diseases such as malaria, and has repercussions for resource-based economic sectors. Of course, there is uncertainty about the ability of natural ecosystems to adapt given the unprecedented speed of climate change.

Changes in precipitation and evaporation will have consequences for hydrologic cycles, for lakes, rivers and groundwater. As an example, under a 'business as-usual' scenario, the Great Lakes are estimated to experience a reduction in net basin water supplies in the order of 20% early in the next century, with major economic implications for shipping, recreation, municipal water supplies, and so on.

One manifestation of climate change is expected to be an increase in the frequency and severity of hot, dry spells. Many aspects of human wellbeing are related to such conditions, including heat-induced deaths and crop failures. Recent experience in such diverse locations as Sudan and California provide indications of what this might mean for resource management, for food production, for living standards, for political stability, and for life itself.

Global warming is also expected to contribute to rises in sea level, via thermal expansion of oceans and glacier ablation (Houghton et al., 1990). The physical effects include coastal inundation, erosion and salt water intrusion. The human impacts for coastal settlements, infrastructure, human health and storm hazards are highlighted by recent events in various parts of the world. Rising sea levels may cause serious inconvenience in London and other places in industrialized economies, but they would be devastating for low-lying regions of the non-industrialized world, such as Bangladesh, the Nile delta and much of Southeast Asia. Further, quite modest rises in sea level threaten the absolute existence of Pacific island nations such as Tuvalu.

Very few regions and very few social and economic sectors are likely to be unaffected by global climate change. It has the potential to affect agriculture, forestry, fisheries, energy production and distribution, transportation, settlement, infrastructure, services, health, and geopolitics. Even areas not directly affected and areas able to adapt to climate changes will still experience impacts via shifts in global food production, trade, energy and water resource demand and supply, population pressures, environmental refugees and political issues.

As with other aspects of the climate change issue, many impacts are uncertain; but there is also broad agreement that the costs of global warming are likely to be high. Certainly, humanity has an impressive ability to adapt to environmental changes. Natural ecosystems and human settlements have evolved and developed under a relatively stable climatic regime. The speed of expected changes may be too fast for biological systems to adjust, and even for human systems to adapt without major disruptions and hardships.

**POLICY RESPONSES**

As global warming and its potential impacts have become widely appreciated, more and more attention has been devoted to their implications for policies of governments. Discussion on policy responses has identified two broad categories of action (Figure 4):

- **Adaptation strategies** deal with actions designed to reduce emissions of greenhouse gases and thereby slow down or stop the associated changes in global climate.
- **Mitigation strategies** are those intended to modify our human activities so that detrimental impacts of climate change (if or when it comes) are minimized and opportunities are maximized.

Let us consider first the prospects for action on limiting emissions. To be effective, action on limitation requires steadily apparent, hence international agreement. In recent years there have been numerous inter-national conventions and pronouncements, allowing the impression that there is widespread commitment to action on limitation of greenhouse gas emissions. In addition to the international efforts, many countries (Canada included) have unilaterally issued statements acknowledging the seriousness of the problem and setting emission reduction targets. Furthermore, impressive lists of policy instruments are being developed and evaluated. These range from legislation and regulation, through pricing and market measures, to planning, technology development and public information.
With all this activity one might conclude that the political commitment is such that it will not be too long before policies are introduced to reduce emissions and stabilize climate. However, the realities of the national and international political-economic situation are such that any significant action on greenhouse gas emissions is a long way off. Among the many hurdles to real action on limitation consider just two, one each in the international and domestic contexts.

One constraint stems from the position of non-industrialized nations. Representatives of countries such as Brazil or China argue that it is the industrialized countries which have made (and continue to make) most use of fossil fuels, and which have contributed most of the greenhouse gas build-up. In fact, their economic development has literally been fuelled by the processes which promote global warming. The developing countries are reluctant to curtail their economic growth to correct a problem brought on largely by other countries who have benefitted from the processes which cause the problem. They reserve their right to exploit forests and burn fossil fuels just as the industrialized nations have done. For many countries today's catastrophes are so pressing that long term climate change is not a priority. For other peoples, such as those in vast areas of the Soviet Union, global warming is seen as beneficial. Now, there are some imaginative attempts to reach international agreement on limitation; for example by offering technology or international transfer payments or debt retirement in exchange for not increasing greenhouse gas emissions or for not cutting rainforest. Despite these efforts, the prospects for effective international action on limitation are extremely uncertain.

There are other constraints on limiting greenhouse gas concentrations. Imagine that an international agreement has been reached or that unilateral a country like Canada commits to reducing gas emissions. Within Canada or U.S.A., what are the political realities of affecting the sort of life style changes necessary to achieve the significant reductions in gas emissions needed to make a difference in global warming? To simply stabilize gas concentrations, massive reductions in fossil fuel use are required; for example reduction in excess of 60% are estimated for CO2 emissions alone (Table 2). Policy instruments to achieve such drastic changes are not readily available - possibilities discussed include fuel taxes to increase prices four or five fold - and are hardly likely to be implemented given current political realities. Whatever the political pronouncements and notwithstanding the goodwill, the prospect of policy to actually reduce emissions significantly in the foreseeable future is very uncertain.

The other type of response is adaptation. It is widely held that even if there was agreement to stabilize trace gas concentrations, the time-lags involved would mean that some global climate change would still occur. Adaptation is seen as needed regardless of action on limitation.

Adaptation strategies can take several forms. The crisis response
CLIMATE CHANGE AND CITIES

Planning under uncertainty is not new for managers of towns and cities. Municipal planners are uncertain about exactly how fast the population will increase, although there are uncertainties about specific locations, public attitudes and technologies dealing with transportation, garbage disposal, and the like. Planning decisions are often controlled by policies of higher levels of government which can also change. The types of uncertainties relating to the climate change issue (physical processes, impacts and policies) are not dissimilar to the uncertainties which are integral to the planning and management of cities.

So, what are some of the aspects of climate change which are particularly relevant to city dwellers and planners? You will address this question throughout the conference. I will simply offer a few possibilities as a starting point.

The potential impacts for low-lying coastal communities include inundation, disruption of sewers and drainage, undermining of structures, increased susceptibility to storms and other hazards, health concerns, forced relocation, and so on. It would seem wise to plan at least for emergency response preparedness, and to consider the appropriateness of land use zoning and codes for new and perhaps even existing buildings and infrastructure. Some situations may warrant consideration of new or upgraded protective structures. Cities like Dhaka, London, Cairo, Miami and many others face these threats under the current climatic regime so the prospect of climatic change really just alters the stakes.

Another potentially sensitive area relates to fresh water. Climate change is expected to result in reduced supplies in many areas, particularly those where water is already a limited resource. Compounding the problem is the likelihood of increased demands for water and degradation of quality through contamination, reduction in irrigation, and so on. The recent experience of Southern California demonstrates the vulnerability of even technologically advanced economies to climate induced problems for water management. Water shortages and the subsequent challenges of distribution, rationing and policing are not peculiar to southern California, but have been experienced in many cities of the world. The prospect of reduced supplies should be recognized in planning for water management, including storage and distribution.

There are many other impacts of climate change pertinent to cities. Heat waves and disease have implications for health care. Urban transportation safety and maintenance are influenced by climatic conditions. It is likely that urban energy demands and supplies will alter with climate change. Pressures in rural areas are likely to increase migrants to urban centres. Refugees from drought or flood prone regions may provide additional challenges to urban planners. For many of these examples, anticipatory planning now may well be worth avoiding the costs sometime in the future.

There is another aspect of climate change which is likely to have significant consequences for urban dwellers and city managers. Quite apart from the effects of climate itself, there are the political ramifications of the issue as a whole. The push for actions which reduce greenhouse gas emissions may well increase, particularly when these actions are consistent with other objectives such as energy efficiency or the reduction of congestion and pollution. A possible outcome is public pressure, and perhaps even regulations or other controls, to modify urban transportation, building design, municipal management, and land use planning.

I am not sure whether we will see a movement towards cities and towns declaring themselves "Greenhouse Free" or "Atmosphere Friendly", but the pressures to plan with such principles in mind may become a significant concern for city managers. If nothing else, the calls for high occupancy vehicle lanes, car pooling incentives, bicycle paths, improved public transit, and urban green spaces are likely to receive a boost from the global warming issue.

I will conclude by returning to the theme of uncertainty. Indeed, there is lot of uncertainty about climate change, its impacts and its policy responses. But this uncertainty is not peculiar to climate nor is it a reason for ignoring the issue or putting it off until there is some indication that there will always be uncertainty here, just as there is in most of the other forces which influence our planning decisions. We are not sure about future population growth, transportation technology, interest rates, energy prices, government policies, and so on and so on. Yet we take planning decisions (individual, corporate, public) with these things in mind all the time.

For the next day or so you will be addressing the challenges of cities in a changing world. I hope this introduction provides some helpful basis for your deliberations. I wish your conference well.

References


Questions for Professor Smit

Jim McCulloch, Conference Director

In your presentation, you mentioned Canada’s “Green Plan”. Could either you or our chairman mention some elements of that plan which bear on this issue, for the benefit of those here not from Canada?

Dr. Dawson

The Canadian Green Plan listened carefully to the Intergovernmental Panel on Climate Change’s Report, and it has adopted what one would call the precautionary principle. That is, it recognizes that there is need to start to take some action, and some action now. It has adopted as its target the concept, as Barry says, of stabilization of CO₂ and other greenhouse gases at 1990 levels by the year 2000.

That is its policy objective. It has adopted within that policy objective action in three areas. The first is action on limitation, and it has announced a series of actions which will lead to a reduction of greenhouse-gas emissions in energy, in methane, in nitrous oxide—those actions will be undertaken by federal government departments, particularly Energy, Mines and Resources. The Green Plan contains actions dealing with energy efficiency—a National Energy Efficiency Act. It deals with the use of alternative sources of energy, sustainable sources one might say. It contains actions by the agricultural sector that would deal with emissions from that sector. It has actions by forestry that will lead to what is called the growth, the reforestation of urban trees. It contains actions by the federal government itself in terms, as our principal colleague said this morning, of getting the federal house in order, ensuring that the federal government buildings are efficient and effective.

It contains a challenge component, a challenge for the provinces to join the federal government in a program. Therefore, there is the movement towards a federal/provincial agreement. It has recognized that, while the federal government can take some role, many of the areas where action is necessary are, in fact, action at the provincial level, action at the municipal level, and action at the individual level.

It has a component of the limitation program that one could call outreach, education—trying to carry the message that it will only deal with this limitation if we all act, and we all act together.

That is the first component.

The second component is one of adaptation, one of trying to improve the resilience of some of our systems to potential changes down the road. Barry picked up on one of the examples used, our federal/provincial flood-plain agreements across the country. There are many such agreements within Canada which contribute to zoning on flood plains. Maybe those should be revisited; maybe we have not used the right flood levels. That is an example of where early policy consideration will be given.

The third area is action to reduce some of the uncertainties, not only in the natural sciences—it is important that we try to reduce those systematically over the next few years. We must also try to reduce some of the socio-economic uncertainties.

So the Green Plan has a three-thrust program domestically, one on limitations, one on adaptation, and one on reducing uncertainties. It has a fourth component, and that is the international component. Clearly, Canada is a small contributor in total, and therefore if it takes action on its own, it does not address the question worldwide. Therefore, we must have international action—it is a global problem which will be resolved only if all countries work together.

Canada is working very hard to develop international agreements that will move towards this goal of, let me call it stabilization. At the same time it is cognizant of the fact that Canada is one of the leading per capita contributors. One could say there are some very good reasons why we might be very high on the list, but it is very important that we recognize the difference between energy efficiency and energy intensity. Maybe someone would like me to pursue that idea.

But we are proposing to get our house in order domestically and that is really what the Green Plan is about. Let us show that we are willing to start to take some action now, irrespective of whether there is an international agreement.

Jim Bruce, Chair, Canadian Climate Program Board

Barry, do you not think you are a little pessimistic on the prospects for international action? At the second World Climate Conference, instead of trying to express the reduction of CO₂ emission by 60% in order to achieve stabilization of atmospheric concentrations at present levels, the Conference formulated that in a slightly different way. They said that if we could reduce CO₂ emissions globally by one percent per year, we can stabilize atmospheric concentrations at somewhat below a doubling of preindustrial levels by the early decades of the next century. So it formulates it in a way that does not make you feel hopeless.

The second reason why I wonder if you aren’t being a bit pessimistic is that many of the actions that need to be taken, or some of the actions that need to be taken, are beneficial in their own right. In other words, energy efficiency and energy conservation, some switching to renewable energy sources, are beneficial to almost all countries whether or not global warming will exist or not. Replantation in a very large way is beneficial in its own right.

Finally, it seems to me that the commitment of 21 countries at the Second World Climate Conference, the western countries, many of them large energy users, to CO₂ emission reductions and other greenhouse gas emission reductions of some kind provides a reasonable kind of base to move forward in an international agreement. That is my optimistic reading, but I would very much
Professor Smit

I am not, by nature, a pessimist. The intent of my presentation was to make it clear for those who believe that any limitation of greenhouse-gas emissions is an easy job, that it is, indeed, not. It is encouraging that there are people with imagination and commitment who are doing things that might make some progress in that direction, but I still believe that it is a long, hard road.

John Gartner

I am not a scientist; I am a practitioner in the urban area. My question really focuses down on a much smaller issue, but one that was pointed out as being very significant in the context of your presentation. This is the relationship between personal transit and the automobile, and the most delinquent substances that you identified. It seems to me that often there is a simplistic solution that is put forward. You actually alluded to the difficulty associated with it, that is, either get rid of it or significantly diminish the use of the automobile, probably the most prized possession aside from property ownership in the most delinquent part of the world, North America. Working in the urban area, I can't get away from trying to confront that issue realistically as opposed to simplistically. I wonder as to what extent is it a scientific community working on alternatives of motive power to that vehicle which I think might be more achievable than the political dilemma created by trying to persuade people to do something that they will probably go to their grave to support.

Professor Smit

I suspect that there are people in the audience who could offer opinions, and more than opinions, on that matter. Certainly, it is true that addressing that issue is not simply a political matter, or a social matter. It is technological; it is a matter of those things together. So, I accept your observation. We were made aware yesterday of some of the technological options apparently that exist now that would make significant improvements in efficiency in automobile use, for example. But, nonetheless, there remain the political and socio-economic impediments to them being adopted. I am not sure to what extent those technological options, if adopted, would address the problem of emissions, but I gather from looking at the program that this will be addressed further in this conference.

Agus Sugandhy, Assistant Minister, Ministry of Population and Environment, Indonesia

Firstly, I would like to congratulate Mr. Smit for his very interesting presentation on the overview of climate change, and secondly I would also like to underline our position of Indonesia as a developing country. Within the uncertainty issue, I guess we are in agreement that we should not take as a reason not to do action. But thirdly, that is very interesting to have your clarification about also the issue at this urban level because at the global, regional and national level to take action especially for a developing country, maybe not for a developed country, it is very; not easy but not too difficult to set up a target for limitation of the greenhouse gases emission and also to adapt for reducing the emission of the carbon dioxide and other greenhouse gases through technology because you have the capability. But in the case of the developing country, what we are facing is to set up the limitation, especially on this urban level. As you mentioned, measurement is inadequate, and also the capabilities and technology. But, we in the developing country, try to reduce the emission, but probably the adaptation is more appropriate. But again, what kind of adaptation we are facing also the limitation of our technology. So I like you to clarify on that kind of action we should be taking. Thank you very much.

Professor Smit

I am not sure of the type of action. What I hear in the international arena is a willingness on the part of some of the industrialized countries to try and reach some kind of agreement which recognizes both the difficulties which many countries would have in achieving any significant limitation of emissions, and also the difficulties that many countries would have in adapting to the kinds of conditions which may be threatening for their people, their economies and their society. But beyond that, I can't help you a great deal. I understand that this is the nature of the political debate; it involves exactly these things, and I suspect there are other people in the room who can offer more specifics than that.

Doug Hayhoe, Executive Director of Energy Educators of Ontario

I am a former physics teacher and scientist, and I was concerned about the same issue as an earlier speaker, the cars. As you mentioned, of all the activities we are engaged in that contribute to global warming, the one single activity which most contributes is driving our automobiles in our industrialized societies. Technological solutions do exist and more are coming out. electric car, the natural gas vehicle, very high efficiency cars which will get twice the mileage of today. In fact, we have them today. We have a turbo-diesel Jetta which probably gets twice or three times the mileage that your car, that the average car, gets. But the problem is that we can't force people, or how can we make people to do that? How can we create the climate in cities for people to go this route. Economic incentives won't do that because the price of fuel a little bit is not going to do that. This is the challenge we are facing. If we are going to encourage other countries such as China to control their greenhouse-gas emissions, what are we doing? We need a qualitative shift, not just a small quantitative shift of our lifestyle, especially in that area. So,
my question is what are the solutions, what are the solutions proposed to encourage us to have a qualitative shift in lifestyle, especially in that area of driving our cars?

Professor Smit

I think the next woman has an answer to that question.

Linda de la Croix, US Department of Energy

I would just like to respond to a small part of his question. One of the things we can do to make this start to happen is what you do in your cities. We fund the Urban Consortium Energy Task Force. One place city government is starting is by buying their fleet of alternative vehicular fuels; that is the way to get the experiment off and running and to start to have a base of orders that go to the companies that produce these vehicles so that there are the numbers there to start production. We also find that city government is a very good place to start with how you deal with the problem of having a network, a way to obtain the fuel for these vehicles. It starts here with cities.

Dr. Dawson

I think I would share that perspective. I would also perhaps say that the role of the educator here is a very critical one. Ultimately we do have to influence the decisions of individuals. It is not simply the role of governments to take action. This issue is unlike many of the other ones we have had; with many of the other atmospheric issues, one could deal with them simply by governments taking action through regulation. Clearly on this, to be effective, we have also to affect the individual decision makers, and I think that cities, in fact, can and are playing a large role in this. The action by Toronto and the action by Vancouver in adopting strategies to start to reduce greenhouse gas-emissions are absolutely vital steps forward. If you take Vancouver, for example, you get a city of that magnitude which represents some sixty percent of the population of the province; you are getting significant steps forward that develop a community for taking action across the country.

Donna Passmore, a member of the Vancouver City Task Force.

What we did was not only develop an education principle in the "Clouds of Change" Report but we also gave guidelines to city planners about redevelopment of the community so it was not so automobile dependent. It does not matter how much we reeducate the public about the need to reduce driving if we continue to plan our cities in such a way that people are required to drive. So government has to be involved and their planners have to be involved in the change.

Anon.

I wanted to ask about general planning guidelines which would take uncertainties into account. For example, the range of warming is expected to be three to nine degrees fahrenheit. Depending on where that happens to fall you get a different level of sea rise. When you go to discuss with urban planners what level of sea rise they should take into account, how do you base that? Do you say "We should look at 'business as usual' scenario" with what is expected there? I had some thoughts on that, but I wondered if you thought they should look at a worst case scenario, or how you would calculate those uncertainties into your formulas.

Professor Smit

I suspect that municipal governments would address that the same way they address any other type of risk. You would assess the probability of certain conditions, along with the cost of the consequences of those, along with costs of doing something about it. It seems to be the same type of logic one uses in making our own investment decisions. A trivial one, when I woke up this morning I had to decide whether it was going to rain or not. I wasn't sure whether it would. Should I take an umbrella - it is a bit of a hassle, it is a cost. What is the consequence of not doing it? For me, not a big deal. For someone else, perhaps the cost would be more. I don't believe that there is a magic algorithm, but those generally seem to be the principles that people consider, and institutions and corporations consider in making their decisions in an uncertain environment. The other observation I would make is that I don't think it is helpful, and it certainly is not possible, to select one sea level and say "This is what it is going to be."

To me that misrepresents our understanding of the issue. It is a fact that there will be variations in these phenomena. It is not just that we don't know. There are a lot of things we don't know and we can reduce our uncertainties. But the phenomena are dealing with are variable by nature over a wide range of time scales. They vary from day-to-day, from month-to-month, from year-to-year, from decade-to-decade, and from century-to-century. So, we are never going to have certainty, but we should be able to reduce the uncertainty significantly from what we have now. So I believe that decision makers, planners for example, have to recognize that there will be those error ranges, and they are not known for sure either. So, I think you are going to have to do what other people have done, and I am sure city planners do every day, recognize the possibility of this; what is the cost of leaving this as a possibility and what is the cost of removing it? I think that what climate change does is really just change the stakes. The sort of decision processes, I suspect, will be similar in this area of adapting. You have a quite different sort of decision process in the area of limitation.
Part 2

NATIONAL ASPECTS

Impact of Climate Change on the Urban Environment of the UK
by
John Page and Martin Parry

Prevention of Climate Change: Approaches at City Level in the Netherlands
by
Tjeerd Deelstra

A Partnership Between Countries and Cities on the Issue of Climate Change - with Special Reference to the Netherlands
by
Joyeeta Gupta

JOHN PAGE

Dr. Page became in November of 1990 the Initiating Director of the Cambridge Interdisciplinary Research Centre. For 25 years, he had been Professor of Building Science at the University of Sheffield, England, specializing in the relationships between climate and building design, especially solar energy and windflow impacts. On retirement 6 years ago, he worked on a number of projects for UN agencies, and subsequently joined the Centre.

MARTIN PARRY

Professor Parry was Head of the Atmospheric Impacts Research (AIR) Group at the University of Birmingham (UK). In October, 1991, the AIR Group moved to Oxford University. Professor Parry is well known for his leadership of a major project at the International Institute for Applied Statistical Analysis (Vienna) on the impact globally of climate change on agriculture.

TJEERD DEELSTRA

Dr. Deelstra is currently working on a study "Climate Change: Prevention Urban Actions" commissioned by the Directorate General for the Environment of the Netherlands. Until 1989, he taught Urban Environmental Management at Delft University of Technology, and continues to do so at the Public Health Institute of Valencia. He is founder and first Director of the International Institute for the Urban Environment.

JOYEETA GUPTA

Ms. Gupta currently works with the Climate Division of the Netherlands' Ministry of Environment and gives a lecture series at the Institute of Social Studies in the Netherlands. After Studying Economics and Law in India, and earning an LLM from Harvard Law School, she worked for a number of non-governmental organizations in India, the USA and the Netherlands.
CO₂ production by human society is primarily related to the use of fossil energy, we see a different world pattern. In Figure 2, the world population in different categories is set down across the bottom. I am sure the data are already out of date, but they are from the Brundtland Report.

Figure 2: Energy consumption per capita, 1984 (data source Brundtland Report (1)).

The vertical scale is world energy consumption per capita. On the left is the energy consumption per capita in the low income group countries. On the right the corresponding figures for the industrialised market economies and Eastern Europe are given. We get the total world energy consumption by integrating the area under each one of the boxes. Now you can see better the global climate change disparities with which we are actually dealing, when we consider the man-made generation of carbon dioxide on earth. Any one country has to exist under the impact of the integrated effect of all other countries. We are talking about CO₂ in one world.

We also need to consider the availability of land per head of population. Figure 3 shows the gross cropped area per capita, again based on the Brundtland report. In North America, agricultural land is relatively plentiful. In Europe, the cropped land availability per head is low, like the Far East. As the population expands, the cropped land available per head, of course,
Figure 3: Gross cropped area per capita (data source Brundtland Report (11)).

Cities are formed out of their regions. In making comparisons between cities in different countries, we have therefore to recognise that there are different underlying factors at work in different parts of the world. I come from a country which is relatively densely occupied with a modest rate of population expansion and a relatively high per capita energy consumption. The energy consumption on transport is tending to rise, in contrast with energy consumption in other sectors. Private transport continues to expand, putting pressure on public transport. In a sense the UK is a deurbanizing economy in contrast to much of the developing world.

In considering the environmental future of specific cities, we have to think simultaneously in terms of a number of spatial and timescales. Figure 4 sets these out diagrammatically. Spatially we have to think locally, and we also have to think within our national structures. At the larger spatial scale, in Europe very importantly at the moment, we have to think in terms of the emergent community structures which now are so important to us in terms of environmental regulation. Finally we have the issues of global environment. Working on the problems of cities actually involves thinking about all these spatial scales. There are issues of time as well. One is looking for solutions that are acceptable the development of environmental policies for now, that are also appropriate in the middle term, and that finally are sustainable in the long term. You have to take all these basic issues on board, if you are thinking about cities and environment.

The main reason I think that I was asked to give this talk was that I was a member of a team in the United Kingdom set up by our Department of Environment called the Climate Change Impacts Review Group (CCIG). This group was chaired by somebody who is much better known in global change climatology than I am, namely, Martin Parry, who is the joint author of this paper. We discussed the key issues
together before I prepared this contribution. When we both started
to work on the Report for the UK Department of the Environment
(CCI) Review Group, he and I both worked in different places to where we
work now. I was working out of my attic in Sheffield as a retired
Professor, where I worked for five years on developing country
problems, going out of the attic, of course, quite often. Martin
Parry was in the Department of Geography in Birmingham, running
in charge of the Atmospheric Impacts Research (AIR) Group there.
As things have evolved, Martin Parry has the key Oxford University
post dealing with the impacts of climate change. He also has the
corresponding Cambridge University post dealing with the initiation
of a new inter-disciplinary environmental centre, so we have become
friendly rivals and collaborators in the UK's two oldest
Universities.

The interim report of the UK Climatic Change Impacts Review group
was published this year. Our group was set up in a great
hurry because our previous Prime Minister, Mrs Thatcher, was very
teen to make an impact on the World Climate conference. Her
Minister of the Environment too wanted some information with which
to go to Geneva for that meeting. The UK Climatic Change Impacts
Review Group was a team assembled on a sectorial basis. I, for
example, brought particular experience of the construction
industry. Martin Parry was the Chairman. He brought especially
experience of agricultural climate change impact analysis. We were
given rather closely defined terms of reference. You may find these
unattractive, but we were told to write an interim report on
potential climatic impacts on the UK economy on a strictly
business-as-usual climatic scenario basis. Our terms of reference,
therefore, to receive a factual report on UK climatic change,
which gave forecasts, or rather scenarios - we were not allowed to
use the word forecast, but I am not quite sure that the difference is
for the years 2010, 2030 and 2050, and then to comment objectively on the expected UK impacts in different sectors.

were not allowed to challenge those scenarios based on a business-
as-usual carbon dioxide and other greenhouse-gas enhancement
assumptions. We were simply required to examine what impacts we
thought the estimated climatic changes would make on the economies
of the UK economy which were our individual speciality, though the
whole group commented on each individual chapter. We had mainly to
regret the absence of sectorial impacts were indicated, looking at
the economy on a sector by sector basis. We were not considered
a suitable committee to look properly at the consequence
intersectoral policies needed. This work involved interferential
considerations of society; Government considered that it was
business to look at that part of the problem as a subsequent task.
We, therefore, could not go down that particular line. Nor were we
to address the problems of limitation of climatic change, so
altering the business-as-usual approach on a different basis.
Nevertheless, I think, by starting in this limited way on an
interim report, simply looking at the basic issues posed by the
effects of business-as-usual climate change, quite a lot of value
emerged.

To summarize, we had business-as-usual. We had a team of
volunteers about fifteen strong. We received our climate forecast
from the University of East Anglia and we were told, "no argument
with that". In our team we had experts on soils, natural
environment, agriculture, ariculture and horticulture, forestry,
coastal regions, water industry, minerals extraction,
manufacturing, construction, transport, financial sector
-especially insurance), recreation and tourism. One of the issues
in which our Department of the Environment was particularly
interested, was the achievement of a better considered view of the
key economic consequences of climate change within the internal UK
economy. Once armed with this information, however, it would be
a much better case, with which to argue with the Treasury,
the finance of the future research needed and the investment
required to counter the predicted impacts of climatic
change. If you cannot put any financial numbers on the costs of
potential climatic change impacts, then you are up against all the
classical problems of Treasury resistance to investment in
research, and in the development of preventative measures.

I will now deal with the climatic scenarios, which were provided
for us, mentioning what they contained and what, in my opinion,
they didn't contain. Basically we had three time scales - 2010,
2030 and 2050. We had a winter seasonal forecast and a summer
seasonal forecast. A summary of the data is found in Table 1
(overleaf).

In winter, the temperature increase forecast for 2050 in the south
of the UK is about 2.1°C and in the north about 3.5°C. In summer,
the increase is smaller, 0.8°C and 1.4°C in the south and 2.3°C in the
north. In winter, precipitation is up just a bit. In summer we
have a "don't know" rainfall change situation; some models say more
rainfall and some less rainfall. Estimating seasonal changes, of course.
I was working with experts, the scenario came out with the concept of a
rise of +22 cm in the year 2030, and +30 cm in the year 2050.
These are more modest than some figures being passed around, but these
are the figures to which we were told to work. It was not
our task to be critical of climatic forecasting.

Well, once you start to attempt impact assessment using GCM data,
you begin to find there are lots of "no data" areas. If
you are trying to do detailed impact studies, you may require data
which the models have in them implicitly which the modellers don't
communicate to you. Alternatively the models may not produce the
relevant data at all. I went to talk to the Atmospheric
Environment Centre here in Canada on Tuesday and I found that the
Canadian circulation model output issued for regional climate
impact studies, made public data estimates for variables like
wind which were not presented at all in our UK forecasts.

Wind. In the UK, is a terribly important topic. Our climate is
dominated by strong winds from various directions, most of the year
around. Cloud is another important topic on which we were given no
scenario information, as well as solar radiation, UV radiation, net
radiation and wind interactions with seas (storm surge prediction with rising sea level). So when you get down to
the task of assessing impacts from the factual point of view, the "no information" areas concerning climate change are very large indeed. If you deal with engineering, as I do personally, the factor that worries you stiff professionally is the question as to whether or not one has made reasonable estimates concerning extremes of weather. Unfortunately, having only mean climatic values concerning the future does not enable one to answer many of the fundamental engineering risk questions. A very important current issue is can GCM modellers provide a better understanding of what is going to happen with extremes? There is a lot of vague talk about what might happen but there is very little modelling information about what might happen quantitatively. Certainly in the UK, and I don't think the situation is unique to our country, we have identified the critical need for more effective interaction between those capable of using climatic data for impact modelling, based on information from the output side of GCMs, and those who actually are capable of producing the appropriate data from GCMs themselves, so that impact study groups get more appropriate data for their future impact studies.

Two months ago, we had a meeting, at the UK Hadley Centre for Climate Prediction and Research Modelling at Bracknell, between the impact research community and the GCM data producers. We are beginning, as a user community in the UK, to put more pressure on the GCM community to persuade them to give more thought to the provision of the data that we really need in order to look at impacts in a more serious way.

There are also additional important problems resulting from erratic popular imagery concerning the nature of climatic change. Misunderstandings can arise from the presentation of partial climatic scenarios. For example, the sort of thing that one often finds in discussion in the popular mind, also in the policy mind I suspect as well, is the belief that, if our southern UK mean temperatures go up to become, say, equivalent to the current mean temperatures in the middle of France, the sunshine hours will automatically go up, and the winter solar radiation will become more intense. The UK is located at a very high latitude. Whatever climatic change takes place, we will still be anchored between latitudes 52° and 60° north which, in Canadian terms is somewhere around the latitude of Hudson Bay. The Gulf Stream really is significant in its impacts. Toronto is about the same latitude as Rome. Cloud may well increase with the additional winter rainfall, so it is likely we will still have a miserable amount of winter sunshine. We will still be short of UV radiation in the winter. There is a tendency at the moment to make a rather uncritical, medical assessment of the impact of UV and see changes in UV just of concern as a cause of potentially increased skin cancer. However, from the point of view of health, especially in high latitudes, winter UV radiation is quite important. If you live in a high latitude climate, you can be UV deficient for some six or seven months of the year. Furthermore the increase of tropospheric ozone resulting from low level reactions in the atmosphere has to be appraised, as well as the impacts of CFC's in the reduction of stratospheric ozone. As it is quite possible that winter cloud

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**Table 1:** The estimated effects of a 4.5°C increase in mean temperatures on annual energy costs in existing buildings and annual carbon dioxide production from buildings in the UK. Source: (Milbank, 1989), with interpolated preliminary scenario estimates for the smaller temperature rises predicted for 2010, 2030 and 2050, estimated by J K Page.

<table>
<thead>
<tr>
<th>MILLBANK DATA</th>
<th>Value (£M) per year</th>
<th>Million tonnes of CO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Housing:</strong> Heating fuels</td>
<td>1,200 saving</td>
<td>27 saving</td>
</tr>
<tr>
<td>Non domestic: Heating fuels</td>
<td>1,200 saving</td>
<td>25 saving</td>
</tr>
<tr>
<td>Refrigeration</td>
<td>150 increase</td>
<td>3.5 increase</td>
</tr>
<tr>
<td>Balance</td>
<td>2,250 saving</td>
<td>46.5 saving</td>
</tr>
<tr>
<td>Percentage change</td>
<td>15% saving</td>
<td>15% saving</td>
</tr>
<tr>
<td>Saving per degree rise</td>
<td>3.3% saving</td>
<td>3.3% saving</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>SCENARIO ESTIMATES</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
</tr>
<tr>
<td>N Scotland: +1.1°C</td>
</tr>
<tr>
<td>S England: +0.8°C</td>
</tr>
<tr>
<td>Assumed weighted mean: +0.85°C</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>2030</td>
</tr>
<tr>
<td>N Scotland: +2.6°C</td>
</tr>
<tr>
<td>S England: +1.6°C</td>
</tr>
<tr>
<td>Assumed weighted mean: +1.8°C</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>2050</td>
</tr>
<tr>
<td>N Scotland: +3.9°C</td>
</tr>
<tr>
<td>S England: +2.3°C</td>
</tr>
<tr>
<td>Assumed weighted mean: +2.6°C</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Note: Milbank’s values are indicative, being based on preliminary studies. A Business-As-Usual scenario for insulation standards was assumed. A 1°C change in average temperature in the UK is roughly equivalent to a 10% reduction in energy consumption in centrally heated domestic dwellings, which currently form about 70% of the UK domestic stock. For non-domestic use, the relationships are more complicated. Page has interpolated from Milbank’s values weighting S England as S and N Scotland as 1. In view of the present small impact of refrigeration in the totals, no special adjustments were made for this.
might increase, and our solar and UV radiation might go down, it could well be that, instead of the imagined basking in the UK under a sun equivalent to the Mediterranean as the consequence of climatic change, we will find ourselves sitting under clouds in a warmer temperature with more days of rain. We simply don't know, but I should point out how easily the imagination, fired by statements about air temperature rise, tends to proceed to guess so many other climatic variables, for example the perception of hot sunny cloudless days occurring in succession in large numbers. Climate change may not go in that direction at all.

Well, let us now come to cities. A large number of UK cities have maritime origins. We once ran an empire based on trade. That evolved into a Commonwealth. Sea trade was always very important to the UK. Many of our large cities are consequently located on estuaries. Much of our heavy industry is also located on estuaries. For example, we have our oil imports coming that route. Many other materials, like iron ore, enter through the estuaries. Estuaries are important sources of water for cooling; our basic energy production facilities and chemical production facilities are very much centred on estuaries. Historically, of course, the estuary offered a convenient path through which to dispose of industrial toxic wastes and other unpleasant materials. The estuaries in our economy also play a very key role in conserving biodiversity. For example, there is a very large number of migratory birds moving around in spring and autumn. The estuaries are also important bird overwintering grounds with mild winter conditions, compared with mainland Europe. The estuaries also provide key facilities for recreation and tourism. The impacts of climate change, combined with changes in sea level, on biodiversity needs careful assessment. The estuaries form part of the urban areas of the cities that stand on or close to them. I will list some of the major UK cities which have estuarial locations. The largest city is of course London, but one must add Hull, Teesside, Newcastle, Edinburgh, Southampton, Bristol, Cardiff, Liverpool, Aberdeen and Glasgow. These city regions probably contain at least half our population. So the study of impacts of climate change on estuaries and estuarial land use is obviously particularly important to us. The situation for estuarial locations in the UK has a lot of similarity, in fact, with the presentation on Istanbul, Turkey, given yesterday. In estuaries, the interaction between the landward river hydrology and sea-level rise has to be assessed.

In urbanism, furthermore, we have to remember we are not dealing just with the land surface. We have got to look at the below-ground impacts, because what we build sits on support systems called foundations located below ground. Water supply, drainage, electricity supplies, gas supplies and telecommunications interlace with foundations in the ground under cities. The two-dimensional surface world is not the world in which cities are constructed. So, in trying to deal with climate and cities, we have to relate the complex impacts of macro-climate three dimensionally to local climate, and then proceed on to the systematic formation of desired micro-climates.

Basically, we should be trying to do three things. Firstly we should aim to maximise the use of climate as a resource, both now and in the future, and secondly to minimise climate as a hazard (Page 19). These are important local aims. The third fundamental aim is to minimise the factors leading to adverse climate change at the global level. Thus we have three major climatic tasks to address in looking at the city planning problem. Furthermore, it is a three dimensional problem.

Figure 5 illustrates the vertical structure of the climatological problems faced.

![Vertical structure of the climatological domain of urbanism](image)

On the surface we have our vegetation and our trees. The tree roots go down into the soil. The soil provides a supporting structure which may be very influenced by water. The trees draw on the water resource and this affects the state of ground. This water extraction may cause vertical soil movements. Further below, we have the deeper geology. In many situations, for example in London, we have an underground water resource below, with a water table whose height varies in position dependent on the balance between supply and extraction. Climatic change can influence the balance between the inputs to such underground aquifers and the water extracts from them. In London, the water table is actually rising very fast at the moment. Historically, industry has pumped a lot of water out below London. This produced a big drop in the
water table. This pumping has been drastically reduced as industries have moved out from the city. Currently the water table is rising slightly, i.e. by something like one metre a year. This change is producing some very significant foundation problems in the city of London. This is a local change simply due to local planning decisions.

Let us now consider what climate models actually predict. Let us start with the meteorologist as he stands by his Stevenson Screen. We are asking, "Where is this system going in the future?". In an important sense, you can think of GCM climatic predictions as "white-box" predictions; the model is trying to predict what one might measure in the future in this white box called a Stevenson Screen, or whatever screen type you use. So basically we are forecasting the future using data from the existing climate measurement system. We are trying to speculate where that system might arrive statistically. If we start to deal with cities, we have to put three-dimensional objects on the surface. These have connections with the ground (foundations), and they have upward connections to the atmosphere above. Buildings are major perturbers of the urban boundary layer. So, once again, I must stress we are dealing very much with a three-dimensional system and not simply with a horizontal, two-dimensional system. Therefore, if we are going to ask how climate change impacts on cities, we have to ask the questions below ground and above ground, and not just at screen level. This is quite a difficult issue to deal with quantitatively.

Furthermore, the city, as we have seen in several papers presented at this Conference (for example, Mexico City and Istanbul) cannot flourish without considerable inputs of resource from outside. We have our mass flows inwards of water, food and goods. We have our energy flows which may be piped or bulk-delivered. We have our information flows which may be paper-based or may be electronically based. Finally, we have our people flows achieved through a mix of public and private transport. In an important sense, one of the things we are doing in city planning is designing the partitioning of the inputs to which the laws of conservation of energy and mass must apply. Useful products and services may still result in putting unwanted by-products into the atmosphere, onto the land resource, and into the hydrosphere. For example, when we work on water policy within the city, we are essentially trying to work out how we are going to attribute the water to these three sectors without encountering excessive pollution in doing it. Useful climatic natural-resource inputs into the city itself may occur. An analysis of the climate resources within the city, which can be harnessed, is desirable; for example, there is a need to study effective use of solar energy. There is also the rainfall resource falling within the city. We can use such internal resources well (for example to nourish sheltering urban trees), or we can drain most of it away very quickly and make it unavailable to the city landscape. In the final analysis, it is the combination of the water resource within the city and the water resource outside the city which is important.

Obviously, when we start to look at sustainable futures, we have to look to wind and solar resources. There are a lot of important planning issues concerning whether these future activities are placed outside the city or located within it. I think the dense structure of the city means that, if we are to use renewable energy seriously, such natural resource supplies will have to be drawn from land located mainly outside the city; there are too many practical difficulties to achieve workable solutions in high density situations, and low density cities are not acceptable on transportation energy conservation grounds.

This concludes my comments on the basic problems of climate change and city design. I shall now present some of the Figures from the UK Department of Environment report, "The Potential Effects of Climate Change in the United Kingdom". These will perhaps enable me to reinforce some of the above points and make them a little bit clearer.

Figure 6 shows the seasonal mean temperature change scenarios for 2010, 2030, and 2050 that we were asked to adopt.
between 50° North and 60° North. If you live in Canada, just work out where 60° North is on the surface of Canada. Then you will realise that the UK is anchored very far North and kept warm by the Gulf Stream. Of course, if that current did not arrive, we really would be in trouble. In the summer season, the North/South gradient of estimated temperature change is very small.

There are very long records of meteorological phenomena in the UK. Figure 7 shows the distribution of summer precipitation for England and Wales for a long period 1873-1987. Naturally, we have had some very dry years and we have had some very wet years. But in statistical terms, it is not currently possible to detect changes in the UK climates, even though there is quite a lot of human feeling that the climate has changed.

![Figure 7: Summer precipitation for England and Wales based on the period 1873-1987](image)

![Figure 8: Central England summer mean temperature: (a) based on the period 1660-1989; (b) shifts in the probability distribution for 2010, 2030 and 2050.](image)

Shaded areas in figure 8 denote changes in approximate exceedance probabilities for reference hot summer of 1976. It gives the Central England summer mean temperatures for the period 1660 to 1989. Last year, 1990, was very warm. It is different so far this year. Because it has been so cold this year, people have stopped believing that global warming has arrived, as they did last year, but that is the way it goes. The mean summer temperature in Central England is 15.3°C. It was very cold in 1895 and 1907. We had an exceptionally hot summer in 1976. We have a very long statistical record which we can use for study.

One of the predictive approaches one can use in looking at the impacts of climate change using mean climatic data is to assume that the standard deviation remains the same and the distribution curve is Gaussian, but this has its dangers. The new distributions can be estimated by altering the mean to match the scenario values. These assumptions are not necessarily true, and the distribution may not be normal. Accepting the limitations of such assumptions, one can work out the temperatures that will occur, say, with a probability of being exceeded in one summer in ten years, or once in a thousand years or once in five years. Refer Figure 8b. The big shift that will be experienced, of course, with global warming, will be the increased frequency of occurrence of very hot summers. This has a lot of implications for the design of buildings to counter better the effects of hot weather. It is an area that currently is very poorly thought through. Most of my life has been spent on work concerning the prediction of the impacts of outdoor climate on the indoor environment. Overheated buildings are not only very common in the Tropics, but are also found frequently in higher latitudes. Basically, developed countries have produced a very energy-extravagant ozone-destructive way of coping with hot weather in buildings and cars, called air conditioning. So it is implicit in counteracting global change that we really do think much more radically about the summer design of buildings. Much more systematic scientific thought needs to be given to designing buildings to make them comfortable in summer without air conditioning. There is a vast, long standing world tradition showing how to do this. This tradition is, by and large, totally ignored by modern architecture and modern engineering. We have a lot to learn from history on how to make buildings comfortable in summer, using without air conditioning.

Let us now turn to the winter situation in the UK. Figure 9 shows the Central England winter mean temperature for the period 1851-1989. In winter, the UK gets quite a lot of benefit from global warming, because we live in a slightly cold and miserable climate.

![Figure 9: Central England winter mean temperature (a) based on the period 1851-1989; (b) shifts in the probability distribution for 2010, 2030 and 2050 according to average warming scenarios.](image)
Shaded areas in figure 9 indicate changes in exceedance probabilities for the reference winter, 1989.

If we look at heating, we get benefits because the forecasts show a reduction in the number of degree days. There are quite significant savings on the heating bills that would occur were global warming to take place as Table 2 shows. In housing, the Building Research Establishment, working with a 4.5°C increase, estimated something like £1.2 billion pounds annual saving on heating fuels for houses, with about the same for non-domestic buildings, and an increase of £150 million on refrigeration, giving a net balance of over £2 billion from global warming, representing a 15% saving, or a saving per degree of 3.3%.  

Table 2: Key features of the climatic change scenario used for the UK impact studies. Source Reference 2.

*The mean global surface air temperature in about 2030 is estimated to be 0.7°C higher than at present, with a best estimate of 1.4°C, in 2050.

*In the summer season in the UK, the climate models indicate that temperature changes should be comparable to the global mean and spatially uniform over the UK and most of Europe.

*In the winter season the UK will experience enhanced warming with increasing temperature change along a southwest gradient. By the year 2030, winters in the UK could be approximately 1.5°C warmer than at present (2°C in 2050).

*Precipitation in the UK is most likely to increase in winter. The best estimate is that, on average, winter precipitation will be 5% higher in 2030 (8% in 2050).

*As regards changes in summer precipitation, model results differ in direction as well as amounts. The best estimate is probably no change, but with a range of uncertainty of ±1% in 2030 (±1% in 2050). Even so, it is likely there would be greater evaporation in the warmer climate and thus drier soils.

So we are talking about a £2 billion annual saving on indoor climate control due to climate change. There must be similar phenomena in Canada in the winter season; offsetting it, of course, is the penalty you pay in the summer.

So a whole number of benefits emerge. This question of benefits is very important. It allows us to ask ourselves, "Should the UK not be in the game of actually encouraging global climatic change to make our economy stronger?" Well, the answer is, of course, we live in one world, and when you examine how many people in the world live in the overheated situation as opposed to the number of people who live in the underheated situation, in addition to all the other problems implicit in climatic change, you immediately begin to see that the problem of being too hot is much more common than the problem of being too cold, as Figure 10 shows. If you take the temperature of Calcutta up by 3°C, it has a very significant effect on human beings and their health; in fact, heat damage to people is often much more significant than cold. So we have to ask ourselves whether any UK benefit would be achieved at the expense of billions of other people in the world. We have to recognize that the heating savings are a windfall which is associated with an undesirable world phenomenon. But, either way, you see that we have to take the summer overheating as a very serious problem and design our buildings appropriately.

In Canada, the form of the built urban environment is strongly structured through the climate being much too cold for outdoor comfort for a significant proportion of the year. This has led to the development of the indoor climate of the shopping mall. In

![Population](https://via.placeholder.com/150)

Figure 10: The concentration of population per 3°F temperature interval plotted against annual mean temperature (data source McKay and Allsopp, 1980)

many parts of the UK, we tend to be rather cool in summer. At least in Canada you have fairly warm weather on the lakes in summer; we can't even count on that. As a consequence, I find many developed countries in Europe have the belief that the overheated building problem is not very important.

Another benefit of global warming for the UK will be that the amount of snow that we get will go down, so the impact of snow on transportation systems will decrease. Snow clearing costs will fall and construction will be less affected by cold weather.

Now we must turn to sea level rise. Figure 11 provides three estimates of sea level rise up to the year 2050 in the UK, a mean estimate and upper and lower limits. (These model results are based on a "business-as-usual" scenario, are courtesy of S.C.B. Raper,
a return period of once in a thousand years. If you bring your sea level up by 0.6 metres, your return period is reduced to once in a hundred years. So sea-level rise affects engineering risks very considerably. If we have to heighten the barrage, we not only have to raise the level of the barrage itself but we have to build up the sea-wall defences all around right out to the main sea because the barrage is only part of a system; we have an estuarian river which is controlled by a banking system. Sea-level rise is particularly important because so much vital UK industry is located on low-lying estuarial ground.

How do we address the engineering issues implicit in climate change? You can look at various trends. You can play safe and use the most pessimistic forecasts. One can compare past trends with the future forecasts. I think that, from the engineering point of view, one has to actually ask a lot of "What If?" questions and, as it were, search around the problem and look at a range of climatic scenarios, not just a single scenario, because the answer is not a mechanistic one. The answers coming from climatology are indicative. Therefore we have to take engineering risk as a serious subject. Figure 13 shows the trend in high water level at London Bridge in the Thames. You can see a steady rise over the period from 1791 to 1953.

Forecasting estuarian storm surges is a very specialised area but
implicit in it is the need for a whole re-examination of our coastal defence systems. In Eastern England we have a very large area of low lying ground which includes lat Anglia where I now live temporarily. There is a lot of very important policy issues. Do we defend existing sea coastlines? Do we retreat from existing sea coastlines? If we pursue one policy we can eliminate much of the biodiversity, south coast marshes and estuarial birdlife by removing habitats. We may preserve certain existing housing communities from sea level rise at enormous economic cost. Alternatively we allow the coastline to retreat back by allowing the marshes to move inwards and move the people. We may or may not defend agricultural land. These very important policies have to be sorted out at a government level. Their resolution involves interactions between local government, central government, agriculture, industry and the water authorities, in particular. But speaking generally, one of the things I think we discovered for ourselves - scientific committees normally discover things for themselves - that many climate change impacts were expressed through climatic impacts on soils. The impact of climatic change on soils needs to be studied, because the water and carbon cycles are so critical. If you change temperatures by a very modest amount, you change the evaporation significantly and so change the water balance of the soil. If you change the water balance of the soil, you change your agricultural economy. The demand for irrigation increases. With lower river flows, you alter the nitrate-pollution risks of the water courses. You may cause other phenomena like increased summer/winter soil movements. Such movements are very important in clay soil areas in the UK.

Recently, the South East of England has encountered a very large amount of damage due to movement of foundations on shrinkable clay soils. The cost of this is quite significant to the economy. Basically speaking, the summer soil moisture deficit gets greater as one moves southwards, and the damage also increases. East Anglia is the UK area where the general problems linked with water are most acute. Rapid development is taking place in this region. It is the area where much of our irrigated agriculture is located. Cambridge seems to have a hose-pipe ban which starts in March every year and finishes in November. We are already quite short of water and water supplies.

So we are up against key planning issues. Do we transport water? How do we do so? Do we restrict development? Should agricultural water supplies be reduced? Thus, already, even in the UK, we are up against water shortage problems. Climate change could make this situation worse.

A very important topic in recent years in the UK has been the issue of rising storm-damage insurance claims. Insurance claims, especially those related to construction, have climbed very strongly. Figure 14 shows some data from the UK insurance industry. It shows the logarithmic relationship between the maximum gusts in a storm where claims are made and the percentage of the total value insured on which they have to meet claims. Once winds go up to 45 metres per second, companies begin to get quite a significant set of claims against the total property insurance. When you look at 0.4%, it may not sound very much until you start to value the buildings in a city like London. It turns out to be a very large sum. So insurance is very important. The insurance industry is becoming increasingly concerned about the risks implicit in climate change. Figure 15 shows the cost at 1987 values of storm damage and other winter weather (cold weather) in the UK. We have had some very bad storms recently. So one of the issues that is quite important is the potential impact of climate change on insurance. How are we going to cope with increased risks? One response, of course, is to make sure that our structures are not already suitable, to make the necessary adaptations, but GCMs are remarkably vague on the question of extremes and storms. In this section of our report, we knew we had totally inadequate data on which to make any firm statements or recommendations, but the short-term experience is that insurance is already becoming more costly. There is a lot of work now to be done in trying to inter-relate our classical understanding of the microclimates of our cities to the predicted macrorclimate changes. We must try to structure our knowledge by bringing together our classical climatological knowledge with the new GCM-based knowledge that is emerging. Statistical techniques and modelling are going to become very important. The interlinking be-tween the GCM modellers and the urban impact community becomes important because we have got to put together our historic knowledge with our future predictions to try
to make our cities: first of all safer; secondly, to make our cities more pleasant; thirdly, to make our cities more energy sensible; and, fourthly, to make our cities less globally impacting.

Acknowledgements:

The following figures are reproduced from the UK Department of the Environment Report, The Potential Effects of Climate Change in the United Kingdom, with the permission of the UK Department of the Environment: Figures 6, 7, 8, 9, 11, 14 and 15, also Table 2.

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PREVENTION OF CLIMATE CHANGE: APPROACHES AT THE CITY LEVEL IN THE NETHERLANDS

by Tjeerd Deelstra

Greenhouse Gasses Emitted in the Netherlands: Policies for Reduction

Present situation in the Netherlands

The Netherlands is a densely populated and economically highly developed country. The population density is 470 people per km² and the gross income per capita is 12,600 Dfl. More than 80% of the Dutch population lives in cities. The volume of greenhouse gases emitted per inhabitant is of the highest in the world. This can be illustrated by the emissions of CO₂ on a world scale that averages 1.2 tonnes CO₂ per person per year, in comparison with an estimated 3.5 tonnes per person per year in the Netherlands (figures from draft Memorandum on Climate Change, May 1991, ref. 1).

These figures compel a reduction in greenhouse gases emitted.

The necessity of lowering the emissions of greenhouse gases is of extra importance to the Netherlands due to the fact that Netherlands is a low-lying country which is directly threatened by the consequences of climate change through greenhouse gas emissions. CO₂ is a major contributor, but it is not the only greenhouse gas which is emitted. The other gases are: CH₄, N₂O, N₂O, CO, and VOC. The contributions of the different gases to climate change cannot be specified with certainty. According to estimates of the National Institute for Public Health and the Environment of the Netherlands (RIVM), the present amount of CO₂ emissions contributing to climate change ranges between 44% and 62%. Other gases are also supposed to contribute within specific ranges (Figure 1). The numbers in figure one are obtained by multiplying two factors: the total emission of the gas and its global warming potential (GWP). CO₂ has a GWP of 1 (by definition).

The greenhouse gases come from different sectors of the Dutch community. The three main gases, together totaling 70% (lowest estimation) or 85% (highest estimation) of all greenhouse gas emissions, can be divided into various sectors (Figures 2 and 3).

Reduction targets

Targets for reductions of emissions of greenhouse gases have been specified in various national policy documents. Explicit targets have been formulated for CO₂ and CPC’s. Policy targets for other greenhouse gases are not explicitly formulated, but are incorporated in other environmental programmes.

Restrictions on the emission of CO₂ have been specified in the National Energy Saving Memorandum of 1990 (ref. 2). Different
sectors within the community, such as the electricity generating sector, housing and traffic, must all be more efficient in energy use and conserve more fuel in order to attain the goal set for the year 2000. The National Environment Policy Plan Plus of 1990 ——

Figure 1. Contributions of different gasses to climate change according to low and high estimations. (Source: RIVM 1991, in: Ministerie van VROM, 1991)

Figure 2. Sectoral contribution of CO₂, CFC's, CH₄ and NOₓ in the Netherlands in general. (Source: RIVM 1991, in: Ministerie van VROM, 1991)
Table 1. Necessary reduction of CO₂ emissions in million tonnes according to National Environment Policy Plan Plus.

The policies regarding the reduction of CFC’s are stated in the CFC Action Programme of the Government of the Netherlands of 1990 (ref. 4). This programme was developed by the Ministry of Housing, Physical Planning and Environment in collaboration with the Ministry of Economic Affairs, the industrial sector and local governments etc. The aim of the Action Programme is to bring the use of CFC’s and halogens to an almost absolute standstill by 1995. The programme proceeds along the lines set in the Protocol of Montreal (September 1987) and the European Community guidelines (1988) for this field.

Restriction on emissions of greenhouse gases other than CO₂ and CFC’s are integrated as part of the policies formulated for, among others, traffic and transport, soil acidification and hydrocarbons. These policies are described in detail in the second Traffic and Transport Structure Scheme of 1990 (ref. 5), the Acidification Abatement Plan of 1989 (ref. 6) and the Project Hydrocarbons 2000 (stated in 1989, ref. 7).

According to the Traffic and Transport Structure Scheme, the quantity of NOₓ and hydrocarbons emitted by car traffic should be 75% lower in 2010 than in 1986. The Acidification Report also sets targets for NOₓ as well as VOC. The report states that NOₓ in 1994 should be 20% lower than in 1980, and in 2000, 50% lower than in 1980. VOC should be 30% lower in 1994 than in 1980, and in 2000, 60% lower than in 1980.

Policies for CH₄ emissions are being researched.

When all targets for reduction of emissions as stated in the various national policy documents are taken into consideration, it is apparent that policies do exist for the majority of greenhouse gases, even though the policies may not explicitly aim at prevention of climate change but are directed at other environmental goals.
Sectors in cities

The sectors in urban regions which are most responsible for the increase in concentrations of greenhouse gasses are mentioned below, together with the different causes.

**Industry:** Through combustion of fossil fuels and other processes the greenhouse gasses CO$_2$, NO$_x$, CO, are VOC are emitted into the atmosphere. CPC’s, used in coolants, solvents and detergents are also released.

**Traffic:** Through combustion of fossil fuels in engines of the various means of transport, the greenhouse gasses CO, NO$_x$, CO, and VOC are emitted into the atmosphere. In this sector CPC’s are present in airconditioning systems and other vehicle components.

**Housing:** The use of natural gas in central heating boilers causes the release of CO$_2$, NO$_x$, CO and VOC. This is primarily the case with boilers which have inefficient combustion. CPC’s in this case, are present in different types of insulation foams and aerosol cans used by members of the household.

**Generation of electricity:** Electricity is generated through heat, gained from the combustion of fossil fuels such as oil, natural gas and coal. The process causes the emission of CO$_2$, NO$_x$, CO and VOC.

**Greenhouse agriculture:** Light and heat are used to increase the productivity of the plants. The warmth is created through the combustion of oil or natural gas, releasing CO$_2$ and other greenhouse gasses into the atmosphere.

**Wastewater treatment plants:** NO$_x$ is a by-product released during the incomplete transformation process from nitrate to nitrogen.

**Waste sites:** Biogas is formed through the anaerobic breakdown process of organic materials which takes place at waste sites. Biogas is mainly composed of CO$_2$ (approx. 40%) and CH$_4$ (approx. 60%), which are major contributors to the greenhouse effect.

The relationship between urban sectors and greenhouse gasses is shown in the following table (table 2). In this table, V stands for a relatively high level of emissions from the sector in relation to the total level of emissions of this gas, W stands for a relatively low level of emissions from the sector in relation to the total level of emissions of this gas, and O stands for very little (or zero) level of emissions from the sector in relation to the total level of emissions of this gas.

<table>
<thead>
<tr>
<th>Industry</th>
<th>CO$_2$</th>
<th>CFC</th>
<th>NO$_x$</th>
<th>N$_2$O</th>
<th>CO</th>
<th>VOC</th>
<th>CH$_4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic</td>
<td>V</td>
<td>V</td>
<td>W</td>
<td>W</td>
<td>V</td>
<td>V</td>
<td>O</td>
</tr>
<tr>
<td>Housing</td>
<td>V</td>
<td>V</td>
<td>W</td>
<td>O</td>
<td>W</td>
<td>W</td>
<td>O</td>
</tr>
<tr>
<td>Electricity generation</td>
<td>V</td>
<td>V</td>
<td>W</td>
<td>O</td>
<td>W</td>
<td>W</td>
<td>O</td>
</tr>
<tr>
<td>Greenhouse agriculture</td>
<td>W</td>
<td>O</td>
<td>W</td>
<td>O</td>
<td>W</td>
<td>W</td>
<td>O</td>
</tr>
<tr>
<td>Waste water treatment plants</td>
<td>W</td>
<td>O</td>
<td>O</td>
<td>W</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Waste sites</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>V</td>
</tr>
</tbody>
</table>

Table 2. Relation between urban sectors and greenhouse gasses

A new policy area: the city

The high density of people and activities in urban areas creates both opportunities and restrictions for the reduction of greenhouse gas emissions.

Densely populated urban areas require a vast input of flows such as water, materials and energy. These supplies are necessary for living, working and recreation in the city. Outputs of cities are products and services, but also wastes in the form of solid, liquid and gaseous substances. The various flows of waste are equally vast, and energy losses are high.

Environmentally sound urban development requires that cities equally limit the amount of exhaustible resources they use, and reduce waste streams (which effect the quality of life and the climate of the globe).

Among the opportunities open to cities, are the advantages of spatial concentration. Actions directed to inhabitants for the conservation of resources and reduction of emissions, can reach a magnitude of people easily.

For instance, a collecting system for CPC’s from refrigerators set up in a highly populated area will contribute considerably to the reduction of this greenhouse gas.

Further benefits for emission reduction can be provided from the principle of communal use of supplies. The technical and managerial possibilities for communal use within the urban regions are plentiful.

The first area to be mentioned is the communal use of heat. This includes not only district-heating projects, but also the implication of different construction policies - compact urban lay-outs and dense building. Both result in a lowered use of fuel for heating and cooling of homes and offices, etc., and consequently in lower emissions of greenhouse gasses.
A second area for consideration is the communal use of transport. Well known examples are car pooling and public transport. Both lead to a reduced use of fuel, and therefore fewer emissions. A further step is to improve facilities for bicycles (technically as well as environmentally) within the city, making the use of automobiles less necessary. The level of emissions from bicycling is zero.

Last, but not least, are the advantages to be gained from actions taken in the area of gas and electricity services. These communal services can be organized in such ways that resources are conserved and emissions of greenhouse gases are reduced by means of controlled processing and the application of new techniques.

Although cities have great opportunities to contribute to the reduction of greenhouse gases, they also face serious bottlenecks. A major problem is that it is difficult for the inhabitants to perceive the origins of flows to, through, and out of the city. This is because management of the flows is far removed from the user.

People no longer realize, for example, where electricity comes from or how it is produced. Nor do they bother about the exhaustibility of energy sources or their contribution to climate change. After all, they don’t see it happening or feel the direct results. This, in combination with the relatively low costs of supply, leads to careless use of energy and of other flows. Visualizing the flows of supplies on an urban scale, at the neighbourhood level and in the architectural environment, can help people to become conscious of the sources of supplies. As a result, they might make more efficient use of them and take more care.

Energy management, taking the above into consideration, will for example lead to the incorporation of windmills, solar panels, porches and veranda’s in urban design. To make a significant saving, and thereby lower the emission of greenhouse gases, costs must also be made felt to the inhabitants.

To conclude, an urban policy for the prevention of climate change should address three issues:

- how to use the advantages of spatial concentration;
- how to exploit the possibilities of communal use;
- how to make resource management more visible to the senses as well as to the pocket.

Examples of good practice

Introduction

Preventative urban actions in order to reduce the emissions of greenhouse gases are becoming an increased priority on political agendas in the Netherlands. Several projects and policies are described in the following sections. These projects and policies are representative of a wide range of initiatives of a similar kind in the Netherlands. The projects as described in sections below are:

- biogas extraction from waste;
- minimum energy housing;
- reduction of car use.

These three types of projects have the following in common:

- they are all presently in use;
- they take place within urban regions;
- they aim at the prevention of further increase in emission of greenhouse gases, in particular CO₂;
- together, the sectors of which the projects are an example are responsible for approx. 65% of the CO₂ emission from urban regions.

In addition to the more detailed project description in following sections, the environment action plan of the energy distribution sector is presented. As well, an example is given of local policy measures aiming at the reduction of greenhouse gases. This example illustrates which local policy instruments are presently being developed in the Netherlands to prevent climate change.

Biogas extraction from solid waste. A project in Overijssel.

Characteristics

In Overijssel a biogas plant was installed in 1984. The plant extracts biogas, in this particular case from a waste dump, hence it is called waste gas. Gas from waste dumps or land fills contains a mixture of 60% methane and 40% carbon dioxide. The caloric value amounts to 60-65% of that of natural gas, a major fuel used in the Netherlands for heating and cooking etc. (ref. 8).

Calculations have indicated that this plant will be able to produce at a rate of 5 million m³ biogas per year over a period of 10-15 years.

Biogas is formed in waste dumps when the organic material present is decomposed by anaerobic bacteria (which do not need oxygen).

In the Overijssel project extraction is made possible by use of 10 suction pipes placed in the waste dump. After treatment of the biogas in an convertor nearby (where it is compressed, cooled, and dehydrated), the gas is transported through 3.5 km of pipes to the consumer. In the case of this experimental project, the gas is used by a chemical factory. There are two parallel transport pipes in order to deliver sufficient gas, even if problems arise in one pipe. A diagram of the biogas extraction plant can be seen below (figure 4).

At the chemical factory the biogas is used to heat two steam kettles and a central heating boiler. Both kettles and boiler can be fed with biogas as well as natural gas. When first used, the
quality of the biogas was tested regularly in the laboratories of COGAS (the Energy Company of Overijssel). The quality proved to be consistent, and now only random testing takes place. The process of extraction and treatment of biogas is automated and monitored from a distance by on line systems. Eventual problems are instantly reported to COGAS.

The calorie content is measured constantly to enable both the supplier and the consumer to control the cost-effectiveness of the biogas used. A mixed flow of biogas, natural gas and air is electronically controlled to provide optimal combustion.

Investments

The investment for starting up of the biogas installation and all apparatus involved (gas transportation pipes, electricity supplies) amounted to Dfl. 2.5 million. Conversion of the combustion installation and the installing of computer control at the chemical factory costed Dfl. 0.5 million.

Savings

The actual gas delivery in terms of natural gas equivalents in the years 1984 to 1989 is presented in figure 5.

The figures from figure 5 show that the yearly supply of biogas is equal to approx. 2.5 million m³ natural gas.

At the start of the project (beginning of 1984) the price for natural gas was 46.4 cents per m³. If prices had stayed at the same level, then investments for the biogas extraction installation would have been returned within five and a half years.

The combustion installation would have been re-earned within two and a half years. These calculations do not include subsidies. The natural gas price has been reduced, in relation to international fuel policies, to 22 cents, making the period of return approx. nine years.

Greenhouse gas savings are two-fold. First the reduction of CO₂ and CH₄ emissions from the waste dump into the atmosphere, and secondly the reduction in the use of natural gas.

Applications

It is technically possible to extract biogas from waste dumps and deliver the gas to burner installations as used for instance in central heating systems. However, when using biogas in central heating boilers, special caution must be taken because of the possibility of condensation. Due to the present low gas price, the cost-effectiveness of this application is dubious. Cost-effectiveness will of course improve as the price of natural gas increases.

Another possibility on an even smaller scale is the extraction of biogas from fermenting tanks filled with animal manure. In a project in the north of the Netherlands eight cattle breeders fill a small fermenting tank of 210 m³ with 5.2 m³ of manure per day. The specific gas production amounts to 16 m³ gas per m³ manure, which is equal to a biogas production of 29,000 m³ per year. The gas is then delivered to a co-generation system which produces 33,000 kWh of electricity per year (ref. 9).

Small biogas plants, using animal manure could be installed in urban regions bordering on cattle breeding areas. It is possible in such regions to provide a section of the city, or a series of neighbourhoods, with electricity derived from biogas production.

Minimum Energy Housing, project in Schiedam.

Characteristics

In 1979 the municipality of Schiedam decided to change the building regulations for new estate and renovation projects in favour of
energy conservation. The motives behind these energy saving activities were three-fold:

- a saving on fuel in general,
- reduction in air pollution through lower energy use,
- reduction in energy costs.

Of the above-mentioned motives, the first and second have become current topics of interest. The effects of energy-cost reduction are presently less visible than they would have been if energy prices were higher.

In the 10 year period of implementation of the strict local regulations, various projects have been realized in the building and renovation sector in the town of Schiedam (ref. 10). One new estate and one renovation project are described in the following sections.

A new estate

In 1984, in Woudhoek Noord, 184 so-called Minimum Energy Dwellings were built. In this neighbourhood energy conservation has been taken to the extreme in its planning. The complex comprises 76 family houses and 108 apartments. On average the houses have a volume of 200 m³. The different methods of energy saving are very varied and include:

- Use of passive sun energy. The houses are oriented to the south, the main living area being situated on the south-facing side, together with the placing of large windows (south) and small windows (north).
- Use of natural cooling systems; cellar-like cupboards were constructed in the north-facing walls for conservation of food without using fossil energy.
- Use of buffers; porches are placed at front and back doors in order to prevent cold air from entering the house.
- Use of window insulation; shutters on the outside of windows provide better insulation. These shutters can be operated from indoors.
- House insulation; for this, 100mm thick isolation material was placed over the outside walls, the roofs and floors of the houses, achieving an insulation value of 0.15 W/m²K.
- Use of insulated glass; the windows contain 3x double glazing, or double glazing with a special foil over the glass.
- Draft prevention; by means of sealing possible crevices and providing doors and windows with three hinges instead of the usual two.
- Use of economized ventilation systems; a balanced ventilation mechanism wins back the warm air leaving the house by means of a heat exchanger. See figure 6.
- Use of efficient water boilers; a high efficiency boiler with electronic ignition allows heating of water for direct use in kitchen and bathroom and space heating.

Figure 6. The ventilation and heating system installations of the minimum energy house, Schiedam (Source: Municipality Schiedam).

A renovation project

The Hogebanweg complex was built in 1951 and renovated in 1985/1986. The complex consists of 140 three and four room apartments.

The energy saving methods incorporated in the renovation were:

- installation of double glazing,
- insulation of outside walls (from the outside),
- sealing of cracks and crevices by (in addition to other methods) placing synthetic window frames,
- replacing of the conventional heating system with high profit central heating systems. The tenants were able to choose between a personal high efficiency central heating system or a communal heating system.

Savings

In order to calculate savings a number of factors must be considered both in the case of the building of new estates and renovation projects. We will first deal with the estates as built in Schiedam.

The energy use will be compared with relevant reference values. The reference values were developed by the NOVEM, The Netherlands Organization for Energy and Environmental Technology sponsored by the Ministry of Economic Affairs. The reference values for various types of housing are given below.
The average consumption of gas by the 184 "minimal energy dwellings" in Schiedam was about 300 m³ gas/house/year, which means that per house a saving of some 1200 m³ was gained: 80%.
This project is the most energy extensive of its kind. Table 3 gives an overview of this and related projects in Schiedam.

<table>
<thead>
<tr>
<th>Projects and number of houses</th>
<th>Gas use</th>
<th>Reference value</th>
<th>Savings (m³)</th>
<th>Savings per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner city (164)</td>
<td>929</td>
<td>1500</td>
<td>571</td>
<td>217.₧</td>
</tr>
<tr>
<td>GTB-1 (93)</td>
<td>887</td>
<td>1500</td>
<td>613</td>
<td>233.₧</td>
</tr>
<tr>
<td>GTB-2 (293)</td>
<td>683</td>
<td>1500</td>
<td>817</td>
<td>310.₧</td>
</tr>
<tr>
<td>Edisonplein (14)</td>
<td>664</td>
<td>1400</td>
<td>836</td>
<td>317.₧</td>
</tr>
<tr>
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<td>197.₧</td>
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<tr>
<td>ME-dwellings (184)</td>
<td>311</td>
<td>1500</td>
<td>1189</td>
<td>452.₧</td>
</tr>
<tr>
<td>Stationsstraat (82)</td>
<td>897</td>
<td>1400</td>
<td>503</td>
<td>191.₧</td>
</tr>
</tbody>
</table>

(2): according to prices of 1987 - Df 0.38 per m³ excl V.A.T. (20%).

Table 3. Savings of energy for space heating in new estates in Schiedam (Source: Municipal working party Schiedam, 1989).

Table 4 gives an overview of calculated savings in some renovation projects in Schiedam. The table demonstrated that considerable savings have been achieved.

The minimal energy dwellings cost 12 % more than a conventional house. The government of the Netherlands subsidized this project and paid the difference because of its interest in the nature of the research involved. Normally these extra costs would raise rents in the public housing sector by Df 45.- per month. However, the Df 100.- per month saved on heating, is an immediate advantage to the tenants.

Applications

Experiences in Schiedam have shown that it is possible, in the Dutch climate, to lower the energy requirement of new houses by 80 % compared to the 1980 national average. Annual gas consumption for space heating in an average house can be limited considerably with minimal extra cost and little or no technical problems or risks of building technology failure.

As a consequence of the experience gained in the Schiedam project, recent projects realized elsewhere show a similar energy saving at about half the extra investment. In Rotterdam and Amsterdam, the same "minimal energy housing" principles have now been applied to several hundred flats, and these were built within the strict public sector initial cost limits.

Other projects demonstrate that renovation of existing housing areas in the Netherlands in subsidised rent systems can include the achievement of higher standards of comfort as well as lower energy bills. These projects can be and are executed with limited disturbance to the occupants.

Reduction of car use. A project in Delft.

Characteristics.

The aim of traffic planning in the Netherlands is, amongst others, directed towards restriction in the use of the automobile, thus reducing negative impacts on society and the environment. In the late '70's the first national Traffic and Transport Structure Scheme and the Multi-Year Programmes for Personal Transport (1980-1984), gave high priority to the encouragement of bicycle use and the improvement of traffic safety by providing better
facilities for cyclists.

Over ten years ago, the municipality of Delft created a bicycle network plan. This plan was selected by the Minister of Traffic and Public Works in 1980 for project evaluation (ref. 11).

The main characteristic of the Delft bicycle network plan is its hierarchy. It is made up of three networks, each having its own functional and design characteristics - the city level, the district level and the sub district level.

The city level network consists of a grid of cycle paths situated approx. 500 meters apart. The paths run directly through the city, and are connected with the regional bicycle-path system. The network is designed for the purpose of linking intensive flows of cyclists with important urban activity centres: schools, university, stations, office and industry areas, sport and recreation areas. Physical barriers (such as canals and railways) call for expensive infrastructural works to avoid detours.

The district level network has two major functions. It connects the various facilities within the district (schools, shops etc.) and collects and distributes bicycle traffic to and from the city level network. The links at this level are spaced 200 - 300 meters apart. The (bicycle) traffic flows on this network are assumed to be less heavy than at the city level and used for shorter distances. The facilities necessary at this level are relatively simple: separated bicycles lanes, small bridges etc.

The sub district level network connects housing areas to local amenities, catering for short trips. This particular network is often used by children. The sub district level network is a fine grained system with links at 100 meter intervals, with a simple structure and provisions which can also be used by pedestrians.

The entire bicycle network plan includes a multitude and diversity of measures, not only in the area of infrastructure but also with regard to traffic control and traffic regulations.

Savings

Bicycle use

The project's primary goal is to encourage cycling. Investigations demonstrate that bicycle use increased in terms of length and number of trips made, thanks to the implementation of the bicycle network plan.

The distance travelled by bicycle increased by 6 to 8% (depending on type of trip). This figure does not include increases caused by factors other than the bicycle network plan.

The increase in bicycle use can be explained by two major factors which occurred simultaneously. Firstly, more people started bicycling. Secondly, those who already cycled used the bicycle more often and over longer distances. The increased bicycle use is caused by modal changes especially by transfers from former walk and car passenger trips. Public transport suffers no significant losses from the trend towards bicycle use.

Car use

One of the objectives of the bicycle network plan is to reduce car traffic by encouraging cycling. Recent studies (data are still being collected for the evaluation report) have indicated that the number of car trips in the Delft area have not increased as it has in other Dutch towns. A striking factor that came to light is that the number of car trips in the centre even decreased. This may be caused by the attractiveness of the city centre which is of monumental value and has a nice intimate ambiance. Mobility in the city centre is a segment of the travel market in which the bicycle rates more favourably than the car.

Competition between modes

A combination of all the aforementioned improvements and changes to the advantage of the cyclist resulted in a shift of the modal split; the share of the bicycle rose from 40 to 43%. The car and walking mode both remained stable at 26%. The public transport share declined from 6 to 4%. (However the total number of passengers remained the same.)

Comfort and safety

Cycling comfort and safety clearly improved as a result of the implementation of the bicycle network plan. This can be concluded from analysis of the use of the network by cyclists. It was shown that the distance travelled by bike on separate and independant cycle paths increased as well as the total number of bicycle trips on these specific cycle lanes. Bicycle volume at linkages with mixed traffic decreased. That the improvements were appreciated is also reflected in the results of interviews held over the perception of cycling conditions.

Application

Delft can be regarded as a typical, medium sized Dutch town. Delft is often used for statistical research in Dutch marketing polls.

Bicycle use varies distinctly between medium sized towns in the Netherlands (population of 50.000 - 200.000).

The proportion of trips made by bicycle varies actually from 20 - 50 % in these towns.

Based on the Delft project, it can be assumed that 55% is the maximum attainable share of internal trips. This means that possibilities are open in many cities and towns to increase bicycle use. Comparison between Delft and other medium sized cities and towns in the Netherlands, with respect to demographic,
socio-economic and mobility characteristics, justifies the assumption that the results of the network plan are transferable to other cities. Similar effects on bicycle use can be expected if the type of measures taken in Delft are applied in other towns.

Environment Action Plan for the energy distribution sector

In April 1990, the energy distribution sector published a document: "Energy Distribution Policy Plan Plus and the National Energy Saving Memorandum. Plans of individual companies (known as B-MAP's) were put together and are collectively known as the first general Environment Action Plan (A-MAP)."

The measures proposed focus on three target groups:
- households,
- industry and government organizations,
- the energy distribution sector.

A wide selection of possibilities exists for the household target group, including energy saving light bulbs, insulation and high-efficiency central heating boilers. The second target group (industries and government organizations) is expected to make savings through use of better lighting and heating installations. The most important contribution is expected to come from the energy-distribution sector itself. Small and middle-sized decentralized electricity generation through co-generation and wind turbines plays an important role.

The measures are a summary of the total presented by the (approx. 60) different energy-distribution companies in the Netherlands in their B-MAP’s. It is a set of measures which comprises many elements and offers genuine methods of reducing CO₂ emissions. Measures are related to various time spans.

Some projects can be put into practice immediately. These projects are able to contribute to the goals set by the energy-distribution sector for the year 2000. Most projects are stated in the MAP-principles. Other projects are complimentary and should be implemented on the initiative of the energy distribution companies themselves. Long-term measures require careful preparation before they can be realized.

Example of local policies

Local Environment Policy Plan, Municipality of Breda

Local governments of large- and middle-sized municipalities in the Netherlands are now making a start with the programming of local environment actions. Programmes are often restricted to a direct translation of the specifications set by the government. Many times these programmes are limited to the coordination of measures already in existence at the local level. However, some municipalities in the Netherlands take the initiative to develop a new kind of environment programme which incorporate new lines of action.

The programme of the municipality of Breda is an example of such an innovative policy. The Breda plan pays explicit attention to the problem of climate change (ref. 13). Policies are divided into measures to prevent the breakdown of the ozone layer and the increase in the greenhouse effect.

Measures and solutions in this area, as formulated in Breda’s environment action programme, feature:
- the prevention of CFC emissions in building and renovation through application of injunction policies by the municipality (building regulations, building specifications),
- the reduction in CFC emissions through stricter rules for so-called hindrance permits,
- the continuous collection of small chemical waste by means of an "environment box”,
- the introduction of energy saving measures in building projects,
- the introduction of subsidies in order to induce the replacement of ordinary central heating boilers in homes, by high efficiency, low emission boilers,
- the expansion and replacement of the municipal car fleet with energy efficient vehicles,
- the promotion of CO₂ absorption by increasing the number and size of green areas within the municipality and the prevention of use of tropical hardwood in buildings,
- the re-channeling of development aid funds to the advantage of re-forestation projects in the Third World.

The Breda environment programme is a good example of municipal regulations with which environmentally sound behaviour and global awareness in towns and cities can be promoted.

Conclusions and recommendations

Programming for preventative urban actions

For programming of preventative urban actions, an overview of the possibilities open to the various urban sectors is necessary. In this paper, three types of local projects to reduce emission of greenhouse gasses have been discussed. They include technical measures to derive energy from waste dumps, and measures to minimize energy use in housing projects and in the traffic sector. Additional analysis of projects, for instance in industry and greenhouse agriculture in urban fringes, would complement this view.

It was also discussed how policies for energy supply of cities and integrated environmental local policy planning can lead to preventative urban actions. Systematic evaluation of projects,
tested experiments and policies will lead to insights to which approaches are best suited for large scale application. It must be established which projects are profitable and which will show increased cost benefit when applied on a large scale.

The coupling and integration of various isolated measures can lead to optimum solutions. Co-generation is an example. Gaps in the existing field of knowledge must be defined and programs for research and development have to be established. Extensive research will have to determine how much emissions can be prevented by applying the principles offered by projects and policies. The main target of such research will be the determination of a great number of data and conversion factors. These data are necessary for calculating the contribution of, for instance, saved fuel consumption in reduced greenhouse gas emissions.

There are examples in the Netherlands which serve as the first steps to such an approach. For instance, the experiences of the “Costs of Energy Team” (E-team) in the Hague are useful. The municipal energy company of the Hague has created special consultation teams, offering energy saving advice at home for inhabitants. The results of the first three years of the project indicate that Dfl 2.2 million is saved. Converting this energy saving in terms of CO₂ reductions this comes down to 9 million kilo’s to be saved in this five year project (ref. 14).

Future developments.

Energy demands depend strongly on material prosperity, as indicated for instance in the amount of consumer products used, the size of houses, the number of trips made, etc. During the 60's and 70's the material wealth increased considerably in the Netherlands. Nowadays growth of income slows down and in some cases has even decreased. However, since the total number of inhabitants of the Netherlands is expected to rise to 15.7 million in 2010, it is likely that future energy demands will increase.

Will it be possible to reduce consumption of energy per capita through technical, managerial and behavioural changes? As far as the technological possibilities are concerned three options are possible:

- independent technical solutions,
- integrated design solutions,
- application of sustainable energy sources.

The independent technical solutions form a very diverse group. Examples are heat and cold storage in underground aquifers, electric vehicles and fuel cells for space heating purposes, etc. Another group of techniques which will become important are the means to store electricity, such as by the use of fly wheels, batteries and the underground storage of compressed air.

The integrated design solutions are meant to save energy through wise combinations of available techniques. These solutions search for economies of scale and optimal coupling of space arrangement, utilities and technique at the level of buildings, neighbourhoods as well as urban regions. An example at the scale of a building is a banking office in Amsterdam with "the lowest energy consumption in the world". This office building has a special wall construction with 100 mm of insulation, and minimal heat losses through special design features (i.e. wind breaks, offices facing south, windows functioning as solar panels, hot air transport system to the north side of the building, maximal infiltration of daylight, etc.). The average primary energy consumption of the office is 96 kWh/m²/year when waste heat can be delivered to neighbouring shops.

When this is not the case, then energy consumption is 111 kWh/m²/year (ref. 15). In 1979, the average use of energy in a Dutch government building was 500 kWh/m²/year.

Sustainable energy sources are wind and solar energy, energy from waste and water, and the use of the earth's heat. In public discussion two reasons have been brought up against the use of sustainable energy sources:

- generating sustainable energy is not financially profitable
- generating sustainable energy is profitable, but the recovery of investments takes too long and the risks are too high.

However, there are also arguments to promote investments in renewable energy sources:

- The profitability mentioned previously relates to the company economy. But investments in renewable energy sources also have macro economic effects. Examples are a decrease in natural gas sales, smaller import of oil and stimulation of the industry through the development of new technologies for sustainable systems. When balancing the pros and cons, development of renewable systems is economically often advantageous. Governments should search for incentives.
- The profitability is strongly dependent on the price of fossil fuels. It is predicted that prices of oil, gas and coal will rise in the beginning of the next century due to effects of shortage. This means that an increasing number of renewable energy systems will be compatible within 10 years from now.
- Many negative environmental effects will be avoided through the use of sustainable sources. Also local and national economies will be less dependent on other countries. This should be another reason to allow for extra costs to develop these systems.

Conclusion

It can be concluded that it is possible to reduce the emission of...
greenhouse gasses from urban regions. International co-operation, exchange of experiences and transfer of knowledge is essential in the programming of preventative urban actions. The combination of isolated technical devices, in design systems and increased use of sustainable energy sources constitute necessary policy lines. Bottlenecks of an organizational and financial kind are there to overcome.

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A PARTNERSHIP BETWEEN COUNTRIES AND CITIES ON THE ISSUE OF CLIMATE CHANGE
With special reference to the Netherlands
by Joyeeta Gupta

"Water, Water, every where. Nor any drop to drink." -S.T. Coleridge

Introduction

The global climate is changing. This problem, by its very nature, affects each of us, in our respective cities, in our respective countries, whether in the North or in the South. Against this background, it is logical to assume that there is a part that each one of us has to play in addressing the problem.

The problem of climate change calls for more than marginal changes to our lives; it calls for structural changes in our socio-economic systems. It is not enough to switch the heating off an hour before going to bed; it means developing better building designs. It calls not only for changes in economic and political thinking; it calls for the creation of the Living City that is fully aware of both the abiotic and biotic aspects, as well as the cultural aspects of human life within the notion of the responsible nation and the conscious global community.

The issue of climate change has certainly activated the international community. It has to a limited extent influenced national policies and activities, and the influence is continuously growing. However, its impact on the local communities and cities has thus far been negligible except in certain groups such as "The Urban CO2 Project of the International Council for Local Environmental Initiatives", involving eleven cities, and the "Climate Alliance" with members from about 40 cities.

This paper, therefore, makes a case for putting the issue of climate change on the political and economic agenda of cities; in the ultimate analysis, international guidelines and national policy cannot effectively address this issue without the involvement of the cities.

This paper goes further to suggest that cities should, in fact, become partners in the policy making process on this issue. Especially as the policy options before us might require structural changes to our lifestyles, cities will have to take the initiative. Furthermore, cities are an ideal "ecodevice"; they have a local view and they are focused on satisfying the people that live within. They are thus able to counterbalance nearly the macro view of nations with a local perspective.

In order to involve cities as partners and to put the issue of climate change on the civic agenda, this paper begins by using the strongest possible argument - the city will be a victim of climate change. The analysis reveals that the city is its own victim, because the city is a cause of the problem and because the city often increases its own vulnerability to the consequences of global warming. Hence, cities must take action to survive. Action should be taken within the framework of national and global policy. Hence, this paper considers the case study of Dutch national policy. As the macro national and global view needs to be continuously reinforced by local micro views, the city should become involved in the policy-making process. This paper concludes that the city must become a partner in the policy-making process.

This paper moves from the concept of the city as victim to that of the city as actor in addressing the problems of climate change while creating an ecologically-friendly habitat for humans.

The City is its own Victim

The small circle of cause and effect

The city has always been its own victim - sometimes because of isolated actions, frequently because of the urban heat island phenomenon, and now because of global warming.

Isolated Incidents

Incidents recur where actions in cities have unpleasant reactions. By 1962, the withdrawal of oil, gas and water from under Long Beach, California, had led to the sinking of the land by 8.1m thus increasing the risk of flooding. Resource extraction, the construction of coastal defence systems and navigation projects often result in anthropogenic subidence. This adds to the natural tectonic subidence of 1-10 mm per year in coastal areas. In recent years as much as the 295 sq km of London have subsided by 0.3 m. About 121,000 sq km of Houston have subsided by 2.70m. (See Table 1.)

In 1969, an article stated that pollution from factories had lead to a 30-40% increase in rain at La Porte,
Indiana, over the previous fifty years, still weather in Mexico City and Athens has shown the lethal effects of air pollution due to road traffic. In frigid areas, one aircraft while taking off often emits enough vapour to cover the air field with fog.

Isolated actions can thus result, inter alia, in subsidence and can have an impact on the local weather.

**Urban Heat Island**

Spreading cities have replaced green countrysides with concrete and asphalt, thus influencing the thermal properties of the ground surface and the hydrologic factors. Less foliage means less transpiration and precipitation, and that means more radiation reaches the pavement and roads causing greater heat to be absorbed by the ground surface. Concrete structures do not retain moisture and hence there is less evaporation than from moist soil. Further, they conduct and hold heat for longer spells of time. They re-radiate incoming solar heat and the heat from air conditioning back and forth between walls and buildings. These factors delineate an urban heat island.

Cities have higher temperatures, less wind and humidity, more cloudiness and fogs, and the dust around them often forms urban dust domes and plumes.\(^3\) (Table 2)

Cities, by expanding, extracting and developing, marginalise the very natural base that sustained them.\(^4\) This increases their vulnerability to global change.

**The principle of local self government** empowers cities to reduce local vulnerability.

**The expanding circle of cause and effect**

With climate change, the "small circle" of cause and effect has grown to a global scale. It is further complicated by multiple feedback effects such that the causation often cannot be directly linked to the problem. The Intergovernmental Panel on Climate Change predicts that in a "business as usual" scenario, the average rate of global sea-level rise will be about 6 cm per decade over the next century and that the global mean temperatures will rise by about 0.3 degrees Centigrade per decade.\(^7\) It is not clear where the effects will manifest themselves. Activities in one part of the globe may have an impact on the other parts. Global change may manifest itself in rising sea levels, increased frequency and intensity of storms and floods, a movement of the climatic zones with the corresponding ecological zones lagging behind, etc. (see Table 3).

**Sea Level Rise**

Table 4: Cities At Risk

<table>
<thead>
<tr>
<th>City</th>
<th>Risk Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alexandria</td>
<td>High</td>
</tr>
<tr>
<td>Bangkok</td>
<td>Moderate</td>
</tr>
<tr>
<td>Dhaka</td>
<td>Low</td>
</tr>
<tr>
<td>Hamburg</td>
<td>Low</td>
</tr>
<tr>
<td>Leningrad</td>
<td>Low</td>
</tr>
<tr>
<td>Miami Beach</td>
<td>Low</td>
</tr>
<tr>
<td>New Orleans</td>
<td>Low</td>
</tr>
<tr>
<td>Shanghai</td>
<td>Low</td>
</tr>
<tr>
<td>Sydney</td>
<td>Low</td>
</tr>
<tr>
<td>Thessaloniki</td>
<td>Low</td>
</tr>
</tbody>
</table>

Civilization has always flourished near water sources. The relatively stable level of the sea since 1 A.D. has permitted people to concentrate in these areas. In the year 2000, about 80% of the world's population will be in such areas.\(^6\) Alexandria, Bangkok, Dhaka, Hamburg, Leningrad, Miami Beach, New Orleans, Shanghai, Sydney, Thessaloniki are identified as some of the "Cities at Risk." (Table 4) This list grows with the rising sea level. In 1950 about 30% of the global population was urban. The percentage is expected to grow to 60% in 2025.\(^6\) These people will be especially at risk if the sea level rises.

A rising sea level could have severe consequences, such as inundation, beach erosion, flooding, saltwater intrusion, habitat modification, structural damage, etc. (see Table 5). A 1 m sea-level rise could, for example, inundate 12-15% of the arable land in Egypt and 11.5% of Bangladesh. The atolls of Tokelau, Tuvalu, Kiribati, and Marshall could also be at risk.\(^7\) Coastal wetlands and tidal beaches may disappear and a new generation of ecological refugees may arrive at cities thus increasing the burden on cities.

Take the case of Alexandria. Sediment starvation as a result of the Aswan High Dam, subsidence as a result of the extraction of groundwater, and natural beach erosion have made her the most vulnerable to possible sea-level rise. Alexandria may become a peninsula.\(^7\) Ground water extraction makes Bangkok's rate of subsidence one of the highest in the world, thus increasing its vulnerability.

Let us consider the case of the Netherlands. 60 percent of the Netherlands lies below 1 metre above the sea level; 72 percent is actually below sea level and more that 60 percent of the Dutch
population live in areas protected by dikes, dunes and dams. The Netherlands is criss-crossed by canals, lakes and rivers with the sea bordering the land on two sides. Obviously, most of the major Dutch cities are located near the sea, rivers or canals. The cost of protecting the Netherlands from a rising sea level is estimated at a minimum of $0.4 billion to 0.8 billion over the next hundred years.

A study conducted in the Netherlands based on the Dutch experience reveals that, at a minimum, about $40.9 billion will be needed to protect the major urban harbours of the world and $102.7 billion to protect the cities of the world from sea level rise. Table 6 gives a break-down of the costs on a regional basis. These do not include water management costs, costs incurred in the maintenance of ground water levels, etc.

**Weather disasters**

Climate-related disasters, including avalanches, cold waves, cyclones, droughts, earthquakes, floods, heat waves, landslides, storms, typhoons, volcanoes and hurricanes, are expected to increase. One study for San Francisco Bay reveals that a sea level rise of 15 cm can result in the increase of flooding from storms from one century to one per decade.

**Climate Change**

Studies reveal that when “climate warms, it warms more in higher latitudes ... and more in winter.” The changing climate can intensify the urban heat island effect. This may affect the water balance in a city, either resulting in shortages or water logging. Drought may be exacerbated. Hansen et al “foresee drought conditions occurring 5% of the time in the control run (1965 to relatively recently) rising to 10% in the 1990s, about 25% in the 2020s and about 45% in 2050.” Another study indicates that an effective CO2 doubling could cause a water deficiency of 28% to 42% of the planned supply in the Hudson river basin. Changes in ground water levels may cause malfunctions in sewers and tunnels in cities like Liverpool. The changing moisture content of soils may affect their ability to hold the foundations of existing buildings. Further, these changes will affect human health by possibly causing heat stress, increased vector borne diseases, inflammatory and respiratory
diseases, skin cancer, etc. (See Figure 1) These changes will also have impacts on energy demands such as increasing the need for air conditioning coupled with reduced needs for heating, thus changing the seasonal demand for energy. There could be increased needs for irrigation facilities, etc. (See Figure 2). These changes may also cause changes in local air quality (Figure 3).

2.3 The City and Uncertainty

Each city in the world has its own problems and is trying to deal with them, but with climate change, the problems each city faces will change. The uncertainty of the range and intensity of the impacts will confuse city councils about their policy. A check list of the kinds of risks ahead is given below.

Energy supply: By causing a change in energy demand, climate change can either render existing efforts to insulate unnecessary or it may cause an energy deficit. Where efforts are being made to produce energy from renewable sources, the dependence on continued wind or sun shine could be affected.

Water supply: Cities that are in the process of providing a regular and sufficient supply of adequate water may be compelled to draw up new plans and procedures.

Drainage systems: There may be increased stress on sewerage systems as a consequence of the increases in the frequency of storm water surcharging and overflowing.

Waste management: Urgent reexamination of the waste management system may have to be undertaken.

Changes in mode of traffic: Where the focus is on improving the infrastructure for cycling; increased rainfall may imply a shift, from cycling to personal cars or buses. The system of inland waterways could be especially at risk. One study has revealed that a 1m rise in sea level would require an improvement in the drainage system at Miami International Airport costing about $30m.16

Supplies and Consumption patterns: A changing climate implies changes in agricultural patterns which may influence the agriculture-dependant industry and the consumption patterns. Construction materials may turn out to be inadequate when faced with excess heat or rain.

Loss of land: A loss of land to the rising sea and rivers may imply more human pressure on existing cities, thus creating a demand for housing and services.

Health care: There may be an increase in heat stress from heat waves and an increase in respiratory diseases as a consequence of accelerated photochemical reaction rates among chemical pollutants. Global warming may imply the movement of tropical diseases to the North in the Northern Hemisphere and to the South.
in the Southern hemisphere. All this may imply a change in the focus of health care services.

Protection and adaptation to sea-level rise: With sea level rise, the need to protect the coastal areas will become more important. For different cities the implication of sea level rise may be different. All the options before the city and state are expensive. Which option will be the best for every city may be difficult to determine in light of the uncertainty of the specific local impact. Roads and bridges may have to be raised! Plans to develop the sea side may have to be scrapped!

It is difficult enough not knowing whether it will rain when you decide to cycle to work in the morning, but it would be much more difficult if you could not plan your multi-crop farm because of the moving climatic zones. Efforts to cope with the weather will be nothing when compared to the efforts to cope with the uncertainties of climate change.

The city, therefore, has much at stake with the problem of climate change. Hence, the principle of self preservation requires cities to take robust action to protect themselves.

The City as Cause

The city is not only the victim of possible climate change; the city is also the cause of climate change. The sources of greenhouse gases lie largely in human activities in cities. The city, by its very definition, has high concentrations of human populations and activities within its limits, consuming high quantities of energy and generating tonnes of waste. Furthermore, the physical planning of a city has allowed for the development of a variety of structures, processes and services, all implying the use of energy and materials within the city. It has, with development, provided facilities for private means of transport, promoted energy-consuming construction, all of which symbolise the greater prosperity of the city. Tiles, bricks, asphalt and concrete structures cover the living ground to make the city look neat, superimposing a man-made design on the natural environment.

Finally, cities have their own culture, distinct from other cities and rural areas, which create and facilitate multifaceted interactions between people, thus increasing consumption.

These three aspects of life in the city lead to the increased use of energy and transport, and the increased generation of waste. This directly and indirectly contributes to the emission of greenhouse gases, which accumulate in the atmosphere leading to global warming. Such global warming can again have an impact on the city, its structure, its activities and lifestyles.

2.5 Conclusion

The City, thus, is its own victim. In the past, the attitude of national and local policy makers to environmental problems was to try and avoid the issue, by longer chimneys and pipes, by dispersing the emissions, by the transportation of waste and by the conversion of emissions from solid to liquid and gas. Such dispersion of pollutants is no longer justifiable, either in the case air pollution or in the case of global warming.

The solution, therefore, does not lie in breaking the city up into several little villages in the hope of reducing the concentration of people, activities and structures. Cities, through their very nature of concentrating activities and human beings, allow for economies of scale, for reduced energy losses in transportation of materials, gas, electricity and water, for better insulation of houses, for reduced needs of transportation, etc. Cities can develop a viable public transport system. Cities can develop a functional waste management system. Cities have become a fact of life. They also have it within their power to take action.

Liability in causing the problem implies that cities must adopt the principle of responsible action which require them to reduce their greenhouse gas emissions. The theory of risk management requires that cities should adopt the principle of preventative action. The principle of reciprocity requires that cities not only have to take action themselves; they have to invite other cities to take corresponding action as well.

Can the city sit back and say, "Climate change is a global problem and the global and national policy makers have to do something about it."? The answer is, "No!". Global and national policy makers depend on the support of citizens, and if the citizens do not back them, politicians are hardly likely to take an unpopular decision. However, the problem of climate change has reached a stage when, although it is necessary that citizens support national policy, it is not enough. The citizen will have to take action in his own city.

The City and National Policy

The action cities need to take with respect to climate change is, to a limited extent, dependant on global and national research
and policy. A starting point is to know that the Intergovernmental Panel on Climate Change has agreed that the natural greenhouse effect is further enhanced by the uncontrolled anthropogenic emissions of greenhouse gases such as carbon dioxide (CO₂), methane (CH₄), chlorofluorocarbons (CFCs), ozone (O₃) and nitrous oxide (N₂O). Each country and member of the global community has "common but differentially responsible" in dealing with this issue. Finally, as climate change will have global impacts over an undetermined time frame, action should be based on the precautionary principle, according to the Declaration of the Second World Climate Conference.

**National Policy of the Netherlands**

<table>
<thead>
<tr>
<th>National Emissions</th>
<th>CH₄</th>
<th>CFCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>(%)</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td>CO₂</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>N₂O</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

Let us concentrate on the climate policy of the Netherlands. The Netherlands has a gas-by-gas policy which focuses on CO₂ and CFCs because of the relative importance of these two gases in national emissions. (See Table 7). In 1989 annual CO₂ emissions were at 182 million tonnes (Mt) and were projected to increase to 195 Mt by 1994 and to 220 Mt by the turn of the century. National CO₂ emission targets with respect to 1989-90 are (a) stabilisation in 1994-95; and (b) reduction by 3-5 percent in 2000.

**Limitation Policy**

Energy policy is focussed on a fuel switch from coal to gas and renewable energy sources and on improving energy efficiency by 28 per annum until 2000. The energy-producing and distributing sectors work with the national government to develop their own policies. The energy distributing sector has its own plan to prevent more than 10 Mt of CO₂ emissions by the year 2000. This plan aims at promoting energy-saving measures with respect to lighting and heating in industry and households. The annual budget of the National energy policy is estimated at Dfl 647 million.

All provinces and municipalities are expected to help implement the national energy policy. The government will guide and subsidise some of these activities. Furthermore, the Energy Distributing Sector will discuss and implement their plans with city and provincial governments. Some of the Municipalities have already taken the initiative. For example, the Municipality of the Hague established an Energy Team in 1987 which approaches individual residents and importers information related to energy saving. It focuses on people who lack resources to invest in energy-saving technologies.

CO₂ emissions from the traffic sector are projected to grow percent annually in a "business as usual" scenario. The Transport policy aims at stabilising emissions by 1995, reducing emissions by 13 percent in 2000 and by 22 percent in 2010, all with a view to the 2000-2005 time frame. The three-track approach first track aims at decreasing emissions per vehicle by vehicle emission standards for new cars (within the EC co changes in the tax system, for parking rights); second track, efficient cars, are being studied. The second track reduces growth of car use by "pushing" people out of their cars (pulling them into more environmentally friendly transport through fiscal measures. Furthermore, by 1997, all companies employing more than 5000 people will have to prepare transport management plans for their personnel.

The third track is, to a large extent, in the domain of provinces. It influences driver behaviour by: enforcement of parking restrictions; better traffic management low speed zones; enforcement of speed limits; and through circulation schemes. In addition, the government will funding to encourage integrated planning between municipalities and transport companies. As well, physical planning policy discourage the establishment of labour-intensive business locations with poor access to public transport. These apps will be implemented by the Government in conjunction regional and local authorities. Several regions have already drawn up their own traffic plans.

**Waste Management**

Waste Management policy targets reducing annual emissions 5 Mt in 1994-95 and 3.5-4.5 Mt by the year 2000. A proposal new waste policy with respect to CO₂ has been developed possible instrument is to take account of CO₂ and greenhouse gas impact in the Environmental Impact Assessment of, and in licenses issued to, dumping sites, incinerators, other such enterprises.

The Municipality of the Hague is an important body for the execution of management policy. It is entrusted with developing schemes with respect to the separation and collection of different kinds of containers and for the management of waste.

Trees are a carbon sink. Currently, 14% of the Netherlands covered by forests and trees. Several different national plans have been drawn up bringing the total area under trees to 40,000 hectares by the year 2000. In addition, the Netherlands is considering a proposal to ban the imports of timber from forests not managed sustainably.

The Netherlands has prepared a CFC Action Programme operation with the CFC producing sector, with a view to eliminating the consumption and emission of fully halogenated...
The government is currently researching the other greenhouse gases emitted in the Netherlands and new policies may be proposed in the next environmental plan.

The climate policy of the Netherlands fits neatly within the national goal to try and achieve the path of sustainable development within one generation by adopting the principles of closing substance cycles, energy intensification, and improving the quality of goods.

**Adaptation Strategy**

With climate change, "only coastal protection is 'climatically critical' for the Netherlands." The current coastal defense strategy is called "Dynamic Preservation". This allows, to an extent, the natural movement of the coast line to ensure the quality and charm of the natural dune coast, while at the same time protecting the land from flooding. This option is estimated to cost about DJ 80 million per year, on the assumption that the sea-level will rise by 20 cm in the next century. However, the possibility of an accelerated sea-level rise was considered in the decision-making process.

The coastal defense system is based on a system of dunes, dikes and dams. Dunes form 75 percent of this system. The dunes are partially maintained by the dynamic equilibrium of wave action. According to a study of the Tidal Waters Division of the Ministry of Transport, if the sea-level rises by 60 cm during the next century, as predicted by IPCC, this equilibrium will be disturbed and the dunes will be washed away. It is estimated that about DJ 1,000 million would have to be spent on maintaining them.

The water level in the Rhine, Meuse and Scheldt delta is expected to rise faster with a changing climate than is already being experienced. Hence, the dikes on the rivers and in the marshes will have to be reinforced. The reinforcement costs are about DJ 7000 million, which will also threaten the existence of the hoge meadows - the "dunes". The cost of protecting ranges from DJ 1000 to 2000 million. Accelerated sea level rise will pose a threat to the Wadden area, the wetlands in the Northern islands and the mainland. These wetlands support an important natural ecosystem.

Furthermore, the surface and ground waters have to be protected in order to prevent flooding and to ensure the continued supply of potable water. The low lands have to be pumped dry; there have to be flood protection measures; and water discharge areas have to be kept under control. Another DJ 1,000 million will have to be spent on pumping stations and water management facilities. Wind surges and tides are other problems that may have a serious impact on the Netherlands. Adaptation measures will respect for residential and business complexes in flood-prone areas will cost about DJ 2000 million.

The Flood Protection Act, which comes into force in 1992, will require that all dikes and dunes be checked for safety every five years and reinforced according to new requirements. Four policy implementation options are being considered: (a) Abidance, i.e. following current policy and law; (b) Anticipation, i.e. space reservation in physical planning to allow for a future growth of sea defense systems, and capital engineering works should be designed to allow for adaptation to a sea level rise of up to 60 cm in the coming decades; (c) Gradual adaptation, i.e. if a sea defense system needs to be maintained, it is reinforced taking into account a potential 60 cm rise in the sea level; (d) Rigorous adaptation, i.e. adapting to a 65 cm rise in sea level and a 10 percent increase in storms and river discharge per century. Most of the coastal defense systems are managed by water boards and municipal authorities.

Dutch national policy is struggling to cope with the problem of climate change. There are several actions that have been taken, but in light of the research findings of IPCC it is clear that very many more policy measures will have to be taken. Further, it is clear that national policy alone will not result in a change in societal values and attitudes. Can the nation adopt a wait and see attitude with respect to the climate change, or should it be made a priority. It is up to the city, or should it be the city, to encourage local initiatives on the climate change issue? Within the context of a democratic, free society it is necessary that change in beliefs and attitudes is not dictated from above. Any change in attitudes should be voluntarily accepted by citizens as a mature response to a problem. Such a response can be expected when the city and citizens participate in an exchange of ideas about how their lifestyles affect their future. The city will have to be involved on a more active basis.

**The City as Partner**

The concurrent movements of power and macro decision making from the state downwards and micro decisions from the people and cities upwards should be unified into a partnership that optimises the results by matching experiences with necessity, freedom of choice with environmental education and cultural diversity with global requirements. This calls for the principle of partnerships between the city and the state, between one city and another city, and between the city and the global community.

**The city as Environment-Friendly Habitat**

In this age of specialisation, people and policy makers tend to concentrate on their own speciality and weaknesses. In this age of complicated interrelationships between the environment and the economy, between one problem and another, it is often difficult to ascertain how one problem should be solved without, in the process, creating another problem. The city, as a small political
and economic unit, may be the ideal unit for the preparation of an "environment-friendly" habitat that considers not only the issue of climate change but also all other environmental issues.

**Figure 5:** The City as Ecodevice

<table>
<thead>
<tr>
<th>Primary stages:</th>
<th>Secondary stages:</th>
</tr>
</thead>
<tbody>
<tr>
<td>pollution</td>
<td>damage to health</td>
</tr>
<tr>
<td>in</td>
<td>for loss of function</td>
</tr>
<tr>
<td>resource</td>
<td>damage to plants and animals</td>
</tr>
</tbody>
</table>

**The City as Ecodevice**

A recent Dutch report states that a house, a neighbourhood or a city can be seen as a model for an "ecodevice". Through the incoming and outgoing streams of energy and water, etc., people can get a grip on the environmental problem in its primary and secondary stages. This grip gives cities an efficient manner of dealing with the issue.

**The City as Partner with a difference**

The city has its own history and culture. While it can function as an executing body as a partner for national policy, the city is also in the position of translating national goals into local policies that retain its local character and are compatible with its history and traditions.

**The city for its citizens**

The city has a very comfortable local view of issues and is focused on making life for its residents more comfortable. This attribute neatly balances one weakness of national and international policy, the tendency of such policy to be more global in view and to lean towards statistical and technocratic solutions. Both are essential. One should not lose out on a macro perspective while dwelling on local sentimentality; at the same time one must not lose out on local common sense and experience while focussing on a national perspective. One must not miss the wood for the trees and vice versa.

The city provides the scope for continuously fine-tuning its existing organism and metabolism to provide an eco-friendly ideal, a habitat for humans in harmony with nature. The principle of involving cities as partners should be considered for adoption.

**The City as Policy Maker**

Cities need to develop their own limitation policy to reduce emissions of greenhouse gases and their own adaptation policy to prepare for the inevitable effects of climate change. This section considers some of the possibilities before them. There is no dearth of ideas when it comes to energy efficient solutions for cities. Cities have to concentrate on improving physical planning, reducing car use, reducing the use of water and energy, reducing waste, and optimising building construction.

Cities could concentrate, on the one hand, on improving the public transport systems and the cycle paths, while on the other hand making driving less attractive for citizens. This will provide more areas for "greening" the city, while reducing energy consumption. Cities could encourage citizens to separate their waste and put the separated wastes into different receptacles. In some cities in the Netherlands, not only paper, glass, chemical waste and batteries are separated but also, organic waste. The focus should be on the three R's: Reduce, Reuse, Recycle. Where there is waste that is being incinerated, cities could explore the possibilities of generating energy from waste. District heating is an attractive option that cities could consider.

As a first step, short term solutions, like improving the insulation of houses and improving the techniques of warming houses, could be adopted. These, along with the promotion of a conservative approach to energy consumption, are a necessary but may not be a sufficient approach to the problem. Nevertheless all cities must make a list of such ideas and try to implement them.

Meanwhile, it would be useful to dwell on long term structural changes. Research is being undertaken in the Netherlands and elsewhere on environmentally friendly housing materials and designs. Asbestos has long been blacklisted, CPCs are now the focus of attention, and soon it may be the turn of cement (a product with a high CO₂ factor). Materials should be studied in terms of their lifecycles from the point of extraction to the point of reuse or disposal - transport, conversion into product, transport, building, housing, renovation, transport to decommissioning site. In all these processes, there is considerable use of energy and generation of wastes. All these could imply that a return to traditional materials may be what is required. According to a recent report, housing should be "build on the environment"; it should reduce the need for raw materials, it should use durable materials on a preferential basis, and should use non-traditional materials in as optimal a manner as possible. This is, in fact, not a new idea at all. It is one of the oldest ideas possible going back in history. Architectural forms have, since time immemorial, depended on the climate and the natural surroundings. Eskimos build igloos, rural Africans thatched wooden houses, rural Indians mud houses, and rural Thais houses on stilts. Even Frank Lloyd Wright advocated blending nature with construction. Thus, in flat prairies, long, low lying, flat houses should be constructed with gentle sloping roofs so that snow would cover them.

Simple design improvement can also yield results. One possibility
is insulating roofs by growing grass and other low-maintenance vegetation on them. In addition to reducing energy needs, green roofs can retain moisture for a longer period of time and, hence, a) the diameter of drainage pipes can be reduced thus saving materials, b) there is a reduction of the volume of water that needs to be purified and c) the house might even fit in nicely with the landscape. Further, by increasing local moisture content, it improves the microclimate of the region. By growing plants against the walls, there is reduced wind and rain pressure on houses, diminished possibilities for frost damage, greater insulation, more possibilities for birds to build their nests, and protection against graffiti, in addition to improving the look of the house. Energy-conserving, environmentally friendly houses are currently being built in the project ECOLONIA in the Netherlands.

Ironically enough, sometimes measures to improve the quality of life can lead to greater problems. One study reveals that, after traffic-related measures were implemented in Rijswijk and Eindhoven (traffic lights, speed breaks), the average speed of traffic decreased by 40% and 22% respectively. However, the CO emissions almost doubled as a consequence in Rijswijk.41

A preliminary report42 of the Ministry of Environment considers designing neighbourhoods in such a manner so as to encourage the use of public transport, and discourage the use of cars, thus improving the local air quality and safety, as well as reducing energy consumption. Other criteria include other environmental considerations (noise, etc.), mobility, costs, social planning aspects, housing and management. The report develops on an existing neighbourhood. The first step towards a “car poor” neighbourhood is good access to public transport. The next step is to withdraw the road. As the big-roads in an area, parking and driving become less attractive to the resident. In the last step, the worked-out plan is optimised.

The starting point of the research is to reduce the percentage of “normal” auto use per adult from 37% to 3.7%. The purpose is to create a neighbourhood where only 10% of the residents use cars, and to concentrate them in specific areas. The car-poor neighbourhood has about 3800 fewer cars than the basic plan; hence there would be about 60 million fewer kilometres driven and about 349 million tons less of CO emitted per year.

It is possible that, with more compact physical planning, “green” roofs and houses, reduced needs for roads and parking more space will become available for growing trees, shrubs and flowers, thus increasing the sinks for carbon while improving the look of the neighbourhood.

The Durable City

In the Netherlands, there is growing interest and debate on the subject of city ecology. Some ecologists state that the ideal is when the city becomes a part of nature and where nature is part of the city, i.e., coexistence of human beings with other organisms. The Platform Stadssecologie in the Netherlands is working on this and other related concepts.

The ABC of city ecology could be defined as taking account of the Abiotic field, the Biotic field and the Cultural field. The Responsible City is aware of the streams in the Abiotic field - energy, water, products and materials - and its strategy is conservation, reuse, renewable resources, responsibility with incoming and outgoing streams. The Living City is aware of growth in terms of the Biotic field with the biotope; the Participating City is the closest to a human habitat.43 Failure of Information and lack of systems thinking, market failure and intervention failure are four areas in which the city must improve.44

The Surviving City

However “durable” a city becomes, it may be forced to take adaptation measures in response to sea level rise. The three options as pointed out by IPCC are a) Retreat, b) Accommodation and c) Protection. Retreat requires the inland movement of people, activities and structures. Accommodation requires no immediate action; people just wait and see. Protection requires the building of dikes, dams and dams to flood the coastal regions. According to a statistic presented to IPCC, about $1551 million will have to be spent to protect the low lying coastal regions in the Netherlands, $510M to protect the cities, $1130M to protect the harbours and $ 1013M to recover the area from the sea, implying a per capita cost of $289M. According to Delft Hydraulics Institute, about 33% of the total costs of protecting the coastlines of the world will have to be spent on defending city waterfronts and ports.

Considering the large amounts of money necessary, it is clear that cities will have to give this problem more thought. But there are creative solutions that go beyond the building of dams and dikes. In the past, people have learned to live with the environmental circumstances. "Traditional architectural forms in Venice, Thailand and other parts of the world both embrace and celebrate water, its power and its danger. Therefore cities have to learn new versions of traditional wisdom."45 In the Netherlands, the concepts of "building on nature" "dynamic preservation" and "building with nature" are gaining currency. The principle "building with nature" is used quite often in Dutch coastal defence policy. "Solid stone or concrete bulwarks against the sea are no longer of prime importance, but instead use is made of the various forces acting on the mobile loose sand material, while creating a flexible new dynamic coast.46 In the Netherlands we are working towards developing an integrated coastal policy for South Holland. As can be seen from the accompanying table, the policy concentrates on integration, delegating authority to the local bodies. Cities elsewhere in the world may have to take the initiative to request their
Local Environmental Initiatives (ICLEI). All these activities reveal that cities are beginning to see the importance of putting climate change on their agenda. It is necessary that more cities become involved and that nations invite them to take a more active role.

The Changing City as Victor

The days when city policy was based on domestic needs and local supplies must belong to the past. With communications breaking barriers, with the acknowledgement of the 70’s that we share "one earth", with the recognition in the 90’s that we live in the same "greenhouse", it is clear that city policy must have a basis in global cooperation.

The principle of local self governance empowers cities to take action to reduce their own vulnerability to global change. The principle of self preservation demands that cities protect themselves. The principle of reciprocity requires cities to oblige each other to take action to reduce greenhouse gas emissions. The principle of liability obliges the city to take responsibility. The principle of risk management requires cities to take preventative action. Further, as cities are ideal political, social and economic units with a micro-perspective, governments and international institutions should call on them to become partners in action. Global change justifies the need for the Changing City which, while allowing for conscious decision making, comes up with creative responses compatible with its historical inheritance, natural surroundings, traditions and culture.

The future city must be modern enough to have low fuel consumption, must be based on the principles of integrated life-cycle management, energy extensification and enhancement of quality, and must be a eco-friendly habitat. But, there cannot be just one vision of a future city, for we cannot, in considering environmental prosperity and a green national income, lose out on cultural and natural diversity. There must be many visions of a future city, each attuned with the needs and desires of people in different parts of the world. But although our visions of the future city may be different, they should all spring from a common global environmental perspective, in tune with a changing world. As Spirn, author of "The Granite Garden" puts it, "Our visions must not be comprehensive, but the understanding of the problem must be."

Another initiative involving eleven US, Canadian and European cities is the Urban CO₂ Project of the International Council for


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14. IPCC Working Group 2, Human Settlement; the energy, transport and industrial sectors; human health; air quality, and changes in ultraviolet-B radiation, Climate Change: The IPCC Impact Assessment, IPCC, 1990, 5-1

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17. IPCC Working Group 2, Human Settlement; the energy, transport and industrial sectors; human health; air quality, and changes in ultraviolet-B radiation, Climate Change: The IPCC Impact Assessment, IPCC, 1990, 5-9


30. DBV, Forestry in the Netherlands as a Measure in the Cadre of the Climate/CO2 Problem, Ministry of Housing, Physical Planning and Environment; Ministry of Agriculture and Fisheries, November 1990, pg 3.


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Part 3

GLOBAL CITIES

Climate Change and Istanbul: Some Preliminary Results
by
N. Nushet Dalfes

Megalopolis and Global Change: The Case of Tokyo
by
S. Nishioka, Y. Moriguchi, and S. Yamamura

Urban Climate of Jakarta
by
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Climatic Change and İstanbul: Some Preliminary Results

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Abstract

İstanbul is a large metropolitan area, the most important economic and cultural center of Turkey. This paper gives a first insight to possible impacts global climate change might have on this urban system. A brief introduction to the physical setting and demographics of the city is followed by a glance into GCM results relevant to this corner of the planet. 1990 water crisis is described as an example of the impact of natural resource variability on the livelihood of the city. Sea level rise can be a serious issue for İstanbul. Impacts studies for complex urban systems are prone to uncertainties, in part external to them such as inadequacies of GCM results for the spatial scales in question, but also intrinsic to our understanding of the these human-made systems and their links to their natural “life support systems”.

Introduction

Large urban areas are clearly among the most important contributors to our planet’s atmospheric composition changes. As complex systems very much dependent—though sometimes in a subtle way—on natural “life support systems” of their regions, they will suffer the consequence of global change caused by these atmospheric composition changes. Therefore, considering the steadily increasing number of people living in urban settings, it is imperative to give serious thoughts to the fate of cities under global climate change.

İstanbul is the most important “megapolis” of Turkey. With a population of over 7 million people, it is the center of economic and intellectual activity of the country. Since ancient times, it served as a focal point connecting the East to the West. Even considering the recent developments in the world geopolitics which are redefining at least the east-west, but may be also the north-south dichotomies, it is likely that İstanbul will continue playing a crucial region role.

In this brief article, we will provide some preliminary observations on possible impacts of global climate change on metropolitan İstanbul based on climate data and general circulation model output analyses. We will also attempt to define a research agenda by pointing at directions in which future efforts should be concentrated.

The city: physical setting

Th old city of İstanbul is situated on the western shore of the Bosphorus, a strait about 30 km long connecting the Black Sea with the Sea of Marmara. The present day city is spread out in N-S direction along both shores of the Bosphorus, but mostly in the E-W direction along the Marmara seashore forming a dense, approximately 130 km long urban strip. The northern region, i.e. the shore of the Black Sea, is relatively unpopulated.

The inner city is a predominantly a hilly one: it is said that, like Rome, it is built on seven hills. On the other hand, the metropolitan area has important low lands, such as Büyükçekmece, Küçükçekmece and Terkos coastal lakes. On the western shore, the “modern” and old sections are separated by a narrow estuary, about 7 km deep, which forms an excellent harbor. This is the famous Golden Horn. Due to industrial activities on its shores and discharges brought by streams, this world renown corner of the city is still heavily polluted despite recent cleanup efforts. Relocation of the industry and replacement of the old Galata Bridge which was blocking the water circulation raises hopes for a cleaner Golden Horn.

İstanbul region is served by 5 climate stations. For this study we will use data from only one of them: Göztepe station on the Asiatic part of the city. One does observe slight local climate differences amongst these stations, but for our purposes they are minor. On Figs. 1 and 2 we are displaying long-term mean temperature and precipitation seasonal cycle based on 60 years of observation at the Göztepe site. İstanbul has a temperate climate with non-freezing winters and not-so-hot summers. The region receives yearly an average 680 mm of precipitation; most of it during late fall and winter. Consequently any precipitation anomaly during these seasons affects drastically water resources as it will further be discussed below.
The city: demography

Needless to say the most important factor determining the level of pressure on resources is the population. According to the results of the 1990 census (Anonymous, 1991), Istanbul has 7.4 million inhabitants. This constitutes 13.2% of the population of Turkey (56.5 million). Fig. 3 depicts the evolution of this population in time. Also displayed are current projections to year 2040. By the turn of the century Istanbul will still be the largest city of the country with a population of nearly 10 million people. For the middle of the next century, the mid-range projection is around 15.5 million.

Making population projections is a difficult exercise since the most important contribution to the growth comes from rural immigration. This component has a non-local character and will depend strongly on future industrial and agricultural policies. Therefore, estimation of the fractional population burden that Istanbul will be carrying (see Fig. 4) in the middle of the next century and consequently, of local pressures on any adversely changing/fluctuating natural resource is plagued with uncertainty. Nevertheless, the mid-range projection indicates that the population of Istanbul relative to that of Turkey will stop growing by 2020 and decline thereafter. According this scenario, though Istanbul will be sharing a lesser fraction of the burden, it will be still coping with twice as many inhabitants as today.

Though we will not be elaborating on it, it is also of practical important to predict the distribution of the population across various subsections of this sprawling urban landscape. Land use—and misuse—practices associated with these trends are already threatening important resources bases, for example, city’s watersheds.

What do models say?

General circulation model (GCM) experiment results are natural recourses to those trying to estimate the sign and the rough magnitude of expected changes in a an enhanced greenhouse world.

Among all those problems associated with the modeling of the climate system through GCM’s, the crucial one is the scale mismatch between the model grid size (typically on the order of 5 latitude or longitude degrees) and scales of interest to the impact researcher (10-100 km). Currently GCM research is to a certain extent computer technology limited: any refinement in resolved spatial scales brings important computational burden; limiting therefore, for a given a computational resource allocation, the integration period of “finer” models and consequently climatological meaning of the results.
Fig. 3  Evolution of the population of Turkey and of Istanbul: historical census data and projections to year 2040.

Fig. 4  The ratio of the population of Istanbul to that of Turkey based on historical data and projections.

Currently there are efforts to “refine” GCM results using natural variability based empirical relationships between various scales, but also to verify the quality or the performance of these model experiments in simulated “present-day” climate, for “without validation appropriate to the spatial scale and temporal scales of the impact study, the reliability of the climate change scenarios, and ultimately impact results, is unknown” (Santer and Wigley, 1990).

GCM’s have still serious problems modeling variables such as precipitation amount and intensity, which are of foremost importance as input to any impact study. There again, the problem lies to an important extend in the resolution of scales relevant for phenomena such convective rainfall.

Keeping all these limitations in mind, we will glance at results from various GCM’s to get a rough sense to the extent and sign of the expected climate change in the Istanbul region. For this purpose we will use compiled results from four GCM’s for both “present-day” (the so-called 1xCO2) and enhanced greenhouse conditions (2xCO2). Information about these models is briefly summarize in Table 1. We are considering only two variable: monthly mean surface air temperature (or the equivalent variable, depending on the model vertical grid) and monthly mean precipitation rate (in mm/day).

<table>
<thead>
<tr>
<th>Model</th>
<th>Resolution</th>
<th>Main reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>United Kingdom Meteorological Office UKMO</td>
<td>5.0 x 7.5</td>
<td>Wilson &amp; Mitchell (1987)</td>
</tr>
<tr>
<td>Oregon State University OSU</td>
<td>4.0 x 7.5</td>
<td>Schlesinger &amp; Zhao (1989)</td>
</tr>
<tr>
<td>Geophysical Fluid Dynamics Laboratory GFDL</td>
<td>4.4 x 7.5</td>
<td>Wetherald &amp; Manabe (1987)</td>
</tr>
<tr>
<td>Goddard Institute for Space Studies GISS</td>
<td>7.8 x 10.0</td>
<td>Hansen et al. (1984)</td>
</tr>
</tbody>
</table>

From the compiled GCM experiment results we selected values corresponding to the grid point nearest to Istanbul. These are the best approximations short of any “scale refinement” relation. These values are then compared with long-term means of observed station data on a monthly basis (Figs 5 and 6). For surface air temperature all models do well
Precipitation cycle: Observed vs. GCM control exp.

Fig. 6 A comparison of the observed precipitation cycle in Istanbul with those produced by the GCM's in their so-called control experiments at the nearest grid point.

(i.e. within observed variability bounds, see Fig.1) except GFDL which overshoots the summer months. For precipitation the agreement is mostly qualitative. General seasonal trend is simulated but precipitation rates can be off by a factor of two. UKMO does especially bad and is not displayed here.

The real value of GCM's are as sensitivity analysis tools. On Figs 7 and 8 their sensitivities at the grid point nearest to Istanbul are displayed for doubled CO₂ vs. control experiments along with an average for all four models. Annually averaged temperature change is around 4.5 °C and UKMO and OSU results are bounding the range from high and low ends respectively. Precipitation ratios show qualitative similarity and are pointing toward dryer summers and enhanced spring and fall rainfall.

Based on these pieces of information, one can play the game of "guestimation" of surface temperature and rainfall in Istanbul in an enhanced greenhouse world. Such an approach has no sound theoretical justification and should only be accepted as a scenario building exercise. For the surface air temperature this was done by adding change values from GISS model to the observed seasonal cycle (Fig. 9). For precipitation, the observed cycle is multiplied with the change ratio.

Temperature Change (2xCO₂ - 1xCO₂)

Fig. 7 Sensitivity of the surface air temperature to CO₂ doubling for four GCM along with an average of all four of them for each month.

Relative Change in the Precipitation Seasonal Cycle

Fig. 8 Sensitivity of the daily precipitation rate to CO₂ doubling for four GCM as a ratio of the 2xCO₂ case to 1xCO₂.
GCMs due to lack of accuracy in the simulation of smaller-scale phenomena, but also to the relative shortness of the simulations. Consequently, we obtain at most first and second order moment information about variables we are interested in, but no reliable statistics on extreme events.

One “quick and dirty” way of curing this problem is to build good statistics for observed data and then to translate them into the future. Here we engage in such an exercise: based on observed summer (July and August, hottest months in Istanbul) we would like to estimate future change in the frequency of “very hot” days. Using 15 years of daily July and August temperatures, we estimated a probability density (Fig. 10a) and shifted this density by 5°C based on model simulation results. By inspecting Fig. 10b, one can see that, while today the probability of getting daily temperatures over 30°C is almost nil, in the future we could have up to 8 days out of 61 hotter than 30°C! Of course, one has to caution about the validity of the approach for there is no guarantee that the climate change will manifest itself as a change only in the first order moment (i.e. the mean) and leave untouched the shape of the probability density function.

Extreme climate events are of interest also in that they prepare the scene for other environmental emergencies in the urban setting. The correlation between extreme inversion events and air pollution in Istanbul are daily observation even to the layperson. Especially during the winter Istanbul is a very heavily polluted city mainly due to domestic heating with high-sulfur content, low quality lignite coal extracted from the vicinity of the city. Sulfur dioxide and smoke level are always well above WHO standards (Fig. 11). Conversion to natural gas heating is expected to gradually alleviated the problem. In any case, there is a definite need to investigate consequences of possible changes in the “inversion climate” on the air quality of the city.

**Water resources and crises**

Water is undoubtedly to the natural resource most tightly couple with climate. Any substantial climate fluctuation coupled with poor resource development policies can generate instant crises.

The summer of 1990 was an living ordeal for the inhabitants of Istanbul. Water supply to the city, which has never been adequate in the past, had to be dropped drastically. Whole neighborhoods were out of running water for weeks in a row.

Water has been a problem for the city of Istanbul throughout its history. Even a short tour of the old city will demonstrate the importance accorded by Byzantine and Ottoman
administrations to water infrastructure. Structures like the Valens aqueduct or the famous Underground Cistern are monumental proofs to this awareness.

Unfortunately during republican times, developments in the city's water system was not commensurate neither with the booming population nor with growing industrial demands. Any middle-aged Istanbul inhabitant can recall some form of water rationing.

Precipitation received during the two consecutive rainy seasons of 1989 and 1990 were anomalously low as it can be seen on Fig. 11. This was compounded with the fact that rainfall in the previous years have not well above the average either. The crisis started to be felt by February 1990 and got worse into the summer as it can be seen from the water supply pattern displayed in Fig. 13. The supply levels dropped as much as 50%. Considering that some neighborhoods were already under some sort of water rationing scheme, this resulted in unbearable shortage for a large fraction of the inhabitants.

Responses to this crisis are most instructive. Besides usual accusations between old and new (elected in March 1989) municipal administrators/politicians, a whole variety of "creative" solutions have been proposed. These ranged from bringing water from all the way south of the country to seawater desalination. Needless to say, the actual solution came from a more rational and extensive use locally existing water resources and, most importantly, from the prevention of losses (up to 40%) from a leaky distribution network. It was also essential to balance the demand on water resources between the European and Asiatic sides of the city by interconnecting their distribution networks at many locations. Existing watershed management projects have been accelerated and new ones started. And repair/replacement work on leaky distribution network was accelerated.

Of course, the real relief came with the return of rains in the fall-winter-spring of 1990-91. Dams filled up again and as it can be seen the amount of water delivered to the city returned to almost "normal" levels.

It is hard to judge whether this crisis induced any real awareness among city administrators/policy makers to climate change issues. During the crisis, the media brought up on several occasions the greenhouse issue, but the interest almost completely died out following the return of rains. Whether climate uncertainty will be incorporated into any future resource planning efforts by the City is to be seen.

Fig. 10 Estimating the probability of extreme daily temperature based on observed data and model derived changes in the mean.

Sea level change and İstanbul

As it was already mentioned above, Istanbul is a relatively high city. But this fact does not make it immune from the consequence of a sea level rise. Considering a nominal range of 0.5 to 1 m of the rise by the middle of the next century, one can easily see that many coastal areas and activities can be affected.
Fig. 11 Sulfur dioxide and smoke as measured at a station in Aksaray, a neighborhood of old Istanbul. Note the seasonal character of the time series pointing at domestic heating as the source of the pollution further enhanced by inversion episodes.

As it was already mentioned, the Istanbul metropolitan area has many coastal lakes and most of them are involved in the city water system. Any sea level rise will result in seawater intrusion to those water bodies.

For the last decade, Istanbul has been trying to upgrade its sewage system which is as it is a serious threat to the marine environments of the Bosphorus and the Sea of Marmara. Undoubtedly, sea level rise should be included in the design of sewage discharge outlets.

Sea level rise will surely affect the coast of the famous Golden Horn. If the level change will be moderate (~0.5 m), proper waterfront management projects should be able to cope with the problem though such efforts will surely affect the Golden Horn landscape.

Fig. 12 Precipitation anomalies for Göztepe station. Displayed are normalized deviations from the long-term annual mean.

Fig. 13 Seasonal distribution of the water delivered to the city by İSKİ (Istanbul Water and Sewage Authority) for the last 5 years. 1990 is the major crisis year.
Conclusions

Assessing possible impacts of a future climate change due to enhanced greenhouse effect on an urban system is a difficult exercise. Part of the problem is external to the urban issue: current GCM's can not deliver results with enough spatial resolution and good extreme value statistics as to serve as reliable inputs to any kind of local/regional study. There the future is certainly not bleak: developments in computer technology combined with our improving understanding of key natural processes are promising much more meaningful and useful climate information.

The second aspect of the problem relates to our understanding of these complex systems that modern day megacities are. This human-made systems are usually built in such way to have serious impacts on the very natural systems they will depend on. Vegetational landscapes are drastically changed, watersheds modified, the air polluted. The task of the impacts researcher is to analyze the dynamics of this continually moving system under external boundary condition changes.

Undoubtedly any urban impact study has to include in its base model the already existing decision/response processes/mechanisms in the city in particular and in the country in general. Especially in the developing world, rural exodus and conflicting economic and political interests create such dynamic pressures that long-term planning is seldom considered.

Istanbul is no exception to these remarks. Its is a continuously growing city and this growth is encroaching on its natural resource basis, such as watersheds and recreational open spaces. City politics heavily influenced by land speculation. On the other hand overwhelming rural immigration is changing the cultural fabric of the city so fast as to eliminate any chances of assimilating these people to an “urban” culture.

Nevertheless, there is a tremendous need for proper ground work to be completed before any serious impact questions can be asked. There is an urgent need for reliable hydrological model for Istanbul and its surrounding. Sea level rise studies have to be conducted on reliable land information systems, continuously updated as to reflect the very dynamic nature of the seashore use patterns. And, of course, the impact researcher has to get access to the most recent GCM results, refined through various techniques such as empirical relations or, even better, with imbedded model simulations.

Acknowledgments.

I would like to acknowledge the help of J. Palutikoff and X. Guo from the Climatic Research Unit of the University of East Anglia for providing a regional subset of GCM statistics. I also would like to thank T. Taraçoğlu from the Istanbul Water and Sewage Authority (ISKI) for water supply data and helpful discussions and R. Alev Temel and A. K. Sayers from Boğaziçi University for their assistance in data compilation.

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MEGALOPOLIS AND CLIMATE CHANGE
- THE CASE OF TOKYO

Shuho Nishioka, Tsuchi Moriguchi and Sombo Yamamura

Introduction

In October, 1990, the Council of Ministers for Global Environment Conservation of Government of Japan adopted the "Action Program to Arrest Global Warming" as a guideline for responding to this urgent and crucial human problem.

The program proposes to create an environmentally sound society which poses less burden on the global environment: by widely examining the present socio-economic systems with a view to creating urban structures and transportation systems which are less likely to emit greenhouse gases; by promoting the establishment of environmental ethics; and by fostering a change in life style to one in which consideration is given to the environment.

More than 60% of people in Japan are living in a "Densely Inhabited District" (DID). Urbanization itself brings congestion, slums, inequity and poverty, and is one of the serious human problems in contemporary society. Moreover recent worldwide concern for the global environment is posing another challenge to cities.

Activities carried on in the urban area discharge pollutants through the resource consumption process, and destroy nature. They not only choke up the cities themselves but also strongly affect the surrounding area; through international trade, they propagate environmental impacts worldwide. Besides, the rapid expansion of their area and increasing activities within them create additional vulnerability to natural disasters and global change.

Recent discussions of global environmental issues offer a good opportunity to re-examine the structure of the cities and urban activities in order to respond to environmental concerns. Many cities in Japan have now started to establish their own action program to cope with this urgent problem. They are thinking globally and acting locally, and surely are the dynamos which thrust new conservation policies towards a sustainable world.

This report analyzes some of the relationships between urbanization and the global environment. Using Tokyo as an example, it shows how cities affect, and are affected by, the global environment. It identifies some common problems and countermeasures which could make urban development compatible with conservation of the global environment.

Urbanization and Global Environment

Interaction

Urban areas use land for infrastructure elements, such as roads, ports, mass transit, power and water lines, parks and other essential structures, to sustain human settlement, industrial production and services. Urban activities require massive amounts of energy, water, industrial materials and food. They consume them, and, as a matter of course, discharge or accumulate pollutants and wastes. Accumulation and dispersion of those discharges induce anthropogenic environmental changes such as acid rain, global warming, ozone depletion and reduced air quality.

The flow of resources from outside regions cause environmental disruption in the places where resources are produced and through which they pass.

Meanwhile, cities are affected by natural and anthropogenic global changes, directly by flood, drought and earthquakes, and indirectly through threats to the security of their supplies of, for example, food and energy, as well as to the health and the quality of life of the population. Thus, urban areas and the global environment are interrelated (Fig. 1).

Evaluation

Activity level of the city and its efficiency

We must ask ourselves in what sense urbanization should be criticized. When we take the countryside, in contrast to urban areas, the essential question in the present context is whether the
evaluation

natural & anthropogenic global change

climate
earthquake conflicts

material energy
dependency water food

quality of life productivity

pressure to environment

anthropogenic global change

settlement production infrastructure

pollutant waste acid rain global warming heat island ozone depletion water pollution

urban planning and design individual living style change

Figure 1: Interrelationship between urban areas and global change
activities of the countryside can keep the environment more sound than can those of densely populated areas.

Usually, urbanization is the result of the growth of human economic activities, and thus urbanization is essential to keep the economy vital. So if urban areas are more responsible for the disruption of the global environment, it is not their physical structure but rather the progress of human economic activities that should be blamed. So the first question to ask in evaluating the environmental soundness of an urban area, which we characterize as one with a high population density, is whether population density, itself, creates a closer relationship with the global environment.

The second question is that whether an urban area has some special structural characteristics which are closely related to the global environment. For example: an infrastructure element such as a mass of concrete, may cause some specific effect which can not be seen in the countryside; traffic congestion in and around a city leads to the consumption of much more energy than does smooth driving in the countryside. On the other hand, dense inhabitation and use of mass transit may lead to a net saving of the energy per capita required for transportation. These are examples of structural issues related to dense urban inhabitation.

Clearly, we must carefully discriminate between intrinsic and structural characteristics in evaluating urban areas from an environmental point of view. For instance, a rough estimation of the relationship between scale of cities (population) and their per capita CO_{2} emissions (Fig. 2, Morita and Matsuoka 1991) shows that the major factor is the income level of the country. Among the high income group, there is no clear relation between changing per capita CO_{2} emissions and population increase. In contrast, among cities in developing countries, emissions grow as the scale of the cities goes up. The former suggests there is some scale merit in urbanization, and the latter suggests that there exists a structural inefficiency in the aggregation of human settlement.

Scope of evaluation

The interrelation between city and environment should be evaluated from three points of view (Fig. 1).

Firstly, the strength of the impacts of its existence and activities on the global environment should be evaluated. This can be represented by the area it occupies, the amount of resources it consumes, and the volume of wastes and emissions of harmful substances it discharges. The measuring unit should be on a per capita base in order to clarify the merits and the detrimental aspects of aggregation of human activities.

Secondly, the vulnerability of the city to global change should be estimated. The fragility to earthquake or flood should be noted as an index of vulnerability due to the topographical and geological situation of the city. The dependence for resources on the

outside area is another index of vulnerability of a city, representing a loss of self maneuverability in its resource supply. Today, many cities have abandoned their own resource-production ability and have become a place only for consumption; they depend for essential supplies of elements such as power and water on sources outside of the area, which weakens them in case of disasters.

Thirdly, the environmental quality of its own area should be taken into account. For many citizens, their whole world is their city and its surroundings, in spite of the fact that the global environmental problems are on the table as a hot issue. Urbanization now involves more than half of the world's population, and can not be neglected. Conventional measurements like concentration of pollutants, and indices of quality of life can be used for this purpose.

Sometimes these three objectives require trade-offs. The high quality of urban life is sustained by the abuse of global resources and by sacrifice of the environment in other regions. But we are now getting into the era of a "closed" world and our urban life should be criticized within a framework involving these three viewpoints.

Urban Ecology Indicators

An Urban Ecology Index, made up of a number of indicators, is now being developed to evaluate whether the urban area has sound metabolism or not (Table 1). It includes, among others, indicators of water saving, resource recycling, energy conservation, energy
efficiency, and waste volume; it aims to evaluate how self-dependent is a city, and whether it is recycling wastes and is using energy and other resources effectively (Moriguchi, 1990).

Response

Three kinds of countermeasures can be taken to establish ecologically sound cities (Fig. 1). Firstly, environmental considerations should be included in the planning and construction stages. Expansion of urban area should be controlled under a deliberate design plan and with construction methods that are

<table>
<thead>
<tr>
<th>OBJECT</th>
<th>INDICATOR</th>
<th>MEASURE</th>
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<tbody>
<tr>
<td>soundness in resource usage</td>
<td>water saving</td>
<td>per capita water consumption</td>
</tr>
<tr>
<td>load on environment conservation effort</td>
<td>water recycling</td>
<td>recycle ratio of industrial water</td>
</tr>
<tr>
<td></td>
<td>energy conservation</td>
<td>per capita energy consumption</td>
</tr>
<tr>
<td></td>
<td>load on soil independency</td>
<td>per area fertilizer consumption</td>
</tr>
<tr>
<td></td>
<td>waste treated inside area</td>
<td>waste treated inside area</td>
</tr>
</tbody>
</table>

Table 1 Example of Urban Ecology Indicators (Moriguchi 1990)

compatibility with nature. These should also be taken into account in the re-development of existing urban areas.

The second is controlling urban activities, such as: regulating traffic flow; stimulating the recycling of materials and the wise use of energy; and enacting stringent pollution-emission controls. The third is to promote a change in the life-style of citizens and to stimulate their sense of environmental values. Social education to promote citizen participation is essential for this purpose.

Recently, people became very conscious of environmental issues. An opinion survey by the Japanese Prime Minister’s Office (Public Relations Office, 1990) showed that 60% of people recognize that the global environmental issues are among the most urgent world problems; the same percentage approves making an immediate response, even though there remain some scientific uncertainties in the forecast. Although these opinions are becoming main stream in Japan, to maintain the enthusiasm requires a strong follow-up effort.

Megapolis Tokyo

Overview

About 70% of the land area of Japan is occupied by mountain and/or covered by forest, and Japan uses its small amount of arable land quite intensively. More than 60% of its 120 million population lives in DIDs which occupy only 2% of the total land area. The activities in this small urbanized fraction, which is more than 10 times denser than in other developed countries, pose a heavy load for the environment (Fig. 3). This situation can be illustrated typically by the example of Tokyo Metropolis, the Capital of Japan, which produces nearly $450 billion output annually within its 2,166 km² land area. This exceeds the GDP of Canada ($400 billion/9,976,139 km²) or that of the Netherlands.

A set of indicators can be introduced to characterize the performance of cities - flow/population, flow/area and self-supply flow/total flow - that indicate respectively efficiency of urban activity, amount of environmental load on the area, and self

<table>
<thead>
<tr>
<th>Nominal Gross domestic product (10,000 $/km²)</th>
</tr>
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</table>
| Japan: 10.0% | West Germany: 8.6% | U.K.: 6.3% | France: 4.5% | U.S.A.: 5.5%
| (1,390) | (1,330) | (1,240) | (1,230) |

<table>
<thead>
<tr>
<th>Consumption of primary energy (in terms of oil) (t/km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan: 10.0%</td>
</tr>
<tr>
<td>(1,660)</td>
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<table>
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<tr>
<th>Number of motor vehicles (vehicles/km²)</th>
</tr>
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<tbody>
<tr>
<td>Japan: 10.0%</td>
</tr>
<tr>
<td>(1,490)</td>
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</table>

<table>
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<tr>
<th>Population (persons/km²)</th>
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</thead>
<tbody>
<tr>
<td>Japan: 10.0%</td>
</tr>
<tr>
<td>(1,490)</td>
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</tbody>
</table>

Remarks: 1. Habitable land area was calculated by the National Land Agency using the reference materials of the Japan Real Estate Research Institute. 1990 figures were used for Japan, 1975 for West Germany, 1979 for France, 1977 for England and 1974 for U.S.
2. Nominal GDP is based on OECD materials.
3. Consumption of primary energy is quoted from United Nations: "1982 Energy Statistics Yearbook"
4. Number of motor vehicles represents the total of passenger and commercial vehicles and quoted from IRE: "World Road Statistics 1992"

Figure 3: Economic and social activities per unit of habitable area in major countries (JEA, 1997)

maneuverability (Table 2).

For example, if we note the energy flow into the Tokyo Metropolitan Region, its per capita consumption is less than the national average. This suggests that, in the urban area, the per capita consumption of energy is not necessarily large in comparison with that of countryside. But its energy consumption per unit of area is several times larger than the national average,
which suggest that, in the urban area, the environment is highly pressed by intensive use of energy.

<table>
<thead>
<tr>
<th>resource</th>
<th>efficiency per capita</th>
<th>load on environment per capita</th>
<th>outside dependency</th>
<th>self supply rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>water</td>
<td>Tokyo Av. 165 m³</td>
<td>0.385 Mm³/km²</td>
<td>0.242 (use/fall)</td>
<td>0.065</td>
</tr>
<tr>
<td>electricity</td>
<td>Tokyo Av. 404 l-oil</td>
<td>925 kl-oil/km²</td>
<td>0.037</td>
<td>0.065</td>
</tr>
<tr>
<td>petroleum products</td>
<td>Tokyo Av. 1,804 l-oil</td>
<td>4,127 kl-oil/km²</td>
<td>0.037</td>
<td>0.065</td>
</tr>
<tr>
<td>paper</td>
<td>Tokyo Av. 207.5 kg</td>
<td>481.9 t/km²</td>
<td>0.037</td>
<td>0.065</td>
</tr>
<tr>
<td></td>
<td></td>
<td>184.8</td>
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</tbody>
</table>

Table 2: Average annual resource usage in the Tokyo Metropolitan Region and in Japan

From those figures, we can conclude, as a first step, that the per capita load of Tokyo on the global environment is not necessarily larger than that of other places, but the environment load on Tokyo area itself is very heavy.

Causes of Impact on the Global Environment

As mentioned before, urbanization by itself is an embodiment of economic growth of the region, and as a matter of course, an urban area consumes much more energy and materials than the undeveloped areas as a whole. But there is some scale merit in urbanization, and the activities there may be performed more efficiently than in the country-side. We should be careful to find out what are the fundamental factors of urbanization that press the global environment.

Energy and material conservation

Comparison of CO₂ emission per capita in various cities (Fig. 4) shows a slight reverse correlation with absolute population density, although there is considerable variation reflecting the income level of the country, the industrial structure, and only then the population size or density. Cities in Japan have almost on the same emission level.

Per capita energy and electricity consumption of the Tokyo Metropolitan Region is rather lower than the national average (Table 2). This suggests that the industrial structure of Tokyo tends to be more service oriented, or that the high energy consumption due to high economic activity is compensated by the high efficiency of urban structure. Automobiles which carry one person consume 10 times more energy than railways in Tokyo (five times the national average). (Moriguchi and Nishioka: 1990)

Figure 4: Per capita CO₂ emission (ton C/year, 1985) of cities (Morita and Matsuoka, 1990)

As is the case of energy, per capita water consumption in the Tokyo Metropolitan Region is slightly lower than the national average.

As to the consumption of paper, Tokyo exceeds by a little the national average, but the per capita garbage discharge is far more than that of other cities. One possible explanation is the loss of the citizens’ own land or gardens as a place to handle waste pushes them to discharge their garbage to the municipal collection system. Another explanation is that the information industries, which flock intensively into this area, demand much paper for their offices, even in this “paperless society”.

Heat island

An urban area has its own structural deficiencies that generate excess waste, one example is the heat island phenomenon. Densely aggregated buildings, pavement and high energy consumption have led to the midnight temperature in Tokyo to be some 2-3 Celsius degrees higher than would otherwise be expected (Fig. 5). This temperature increase induces a high electricity demand for air conditioning, and thus creates an additional load on the local environment.

Discharge of pollutants

Urban activities lead to discharges of pollutants to the atmospheric and marine environments, and can cause acid rain problems and chemical pollution. Discharge of NO₂ and SO₂ in Japan are relatively small in comparison with other countries (Fig. 6). No severe local damage due to acid rain has been reported yet.
The Tokyo Ward Area discharged 67,000 tonnes of NOx in 1985, of which mobile sources contributed 74%. Methane emissions from waste treatment in Japan are estimated to be 0.1 - 0.54 Mt/year, and that from sewage treatment is one tenth of that from waste treatment.

Land use change

The Tokyo area, in its expansion process, invaded forest areas (Fig. 7) which had fixed CO₂, and extended into the sea by reclaiming a natural shore line which had the capability of purifying water pollutants. Nearly 90% of the previous seashore of Tokyo Bay has been altered to serve heavy industries (Fig. 8). It eliminated estuaries and natural ecosystems that could have purified the water of the bay. Beaches for bathing and shell-fishing have been nearly lost, in spite of recent efforts to create artificial sand beaches for recreation.

Pavement deprives the soil of its capability to breathe and to support greenery; this decreases the area’s CO₂-absorbing capability.

Vulnerability to Global Change

Tokyo has increased its own vulnerability: by expanding and aggregating its area; by increasing the consumption of energy and material flow; and by constructing dense urban structures.

Vulnerability attributed to its location

Tokyo was established in 1603 by Ieyasu Tokugawa, the founder of

Figure 5: Fluctuation of temperature at Otemachi and Tokorozawa City stations on a typical summer day (JEA, 1989)

Figure 6: Emission of gases (Environmental Indicators, OECD, 1991)
The Tokyo Metropolitan Government has been taking measures to prevent future disasters, such as earthquakes and tsunamis. In 2011, the Great East Japan Earthquake and tsunami caused significant damage and loss of life. The government has been working on improving building codes and infrastructure to better withstand future disasters.

Japan is a country known for its high population density and urbanization. In Tokyo, the residential area is expanding due to population growth and economic development. However, this expansion has also led to increased risk from natural disasters.

The eastern part of the Tokyo Metropolitan Area is located below the Tsugaru Trench, which is prone to tsunami waves during large earthquakes. The Tokyo and tohoku areas are also at risk for large earthquakes, which can cause significant damage to the city and infrastructure.

The government has been working on disaster prevention measures, such as installing tsunami warning systems and improving earthquake-resistant buildings. These efforts are crucial in ensuring the safety of residents in the Tokyo area.
Decrease of self supply

In its process of economic expansion, Tokyo Metropolis has become a city of huge consumption, and has now lost its self supply ability in energy, water and food.

It supplies only 12% of its electricity from its four power plants (Table 3). The remaining part of its power is generated in adjacent prefectures including Fukuoka and Niihata, which are more than 200 km from Tokyo. This gives rise to a self-supply ratio which is far lower than that of other big cities in the world (London 37%, New York 44%).

Figure 10: Potential liquifying area (TMG, 1984)

At the time of the Tokyo Olympic Games in 1964, Tokyo Metropolis began to take some of its water from the Tone river. That was the start of outside supply which now exceeds 60% of its water consumption. The Tokyo Metropolitan Region uses an amount equal to 0.242 of the rainfall on its area. This figure is quite large, compared to the national average of 0.037 (Table 2).

Conversion of agricultural land to residential area has decreased Tokyo's self supplying ability for food, and this trend has been accelerated by the demand for higher quality produce from distant districts. In 1955, 90% of Tokyo's food came from areas less than 200 km from Tokyo, but in 1982 only 40% was supplied from same areas (Fig. 11).

As to the disposal facilities for garbage, most of the burnable waste from the Wards is incinerated at 15 facilities in the area; other waste goes to landfill sites at the sea shore. But the projected life of such sites is now shortening as the volume of waste is increasing at an unexpectedly high rate.

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<tr>
<td>%</td>
<td>23</td>
<td>20</td>
<td>15</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>Peak demand (MW)</td>
<td>8,100</td>
<td>9,400</td>
<td>11,900</td>
<td>15,210</td>
<td>16,210</td>
</tr>
<tr>
<td>Self supply (MW)</td>
<td>1,978</td>
<td>1,878</td>
<td>1,755</td>
<td>1,755</td>
<td>1,429</td>
</tr>
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</table>

Table 3: Self sufficiency of electric power (capacity)

Vulnerability attributed to its urban structure

The pavement of an urban area prevents the penetration of rain water into the ground, and causes a high runoff directly to the river (Fig. 12). This not only prevents the rainwater from adding to the ground water in the area, but causes unexpected floods in low-lying areas. A large part of the urban river bank and river bed have been strengthened by concrete, and this contributes to a higher flood frequency than would otherwise be expected given the natural river bank and no pavement (Fig. 12). One estimate suggests that the 60% coverage of the Tokyo central area by pavement causes a flood 2-3 times a year that might otherwise have occurred only once a hundred years in the absence of pavement.

Regional Environment as a Part of Global Human Settlement

Urban environmental problems contribute to many global environmental problems, as 0.2% of the global population lives in the Tokyo Metropolis (0.6% in the Capital Region). Air pollution caused by automobiles is the most serious problem, but there remain many other pollution problems that become more serious as a result of the rapid increase of activities in Tokyo.
Traffic-Related Pollution

Last year, the Tokyo Metropolitan government requested industry in the area to reduce the usage of vehicles by 10% on Wednesdays during winter. This was done in an attempt to decrease the occurrence of the mid-week peak in air pollution in winter that prevents the area from achieving compliance with the national air quality standard for NO. This requires that the number of days that the daily average hourly concentration of NO exceed 0.06ppm on fewer than seven days in a year. Although emission controls for individual vehicles are quite strict in Japan, the increase in traffic volume has overwhelmed all of the countermeasures taken over the last twenty years; the air-quality standard for NO has not yet been achieved (Fig. 13).

(Yearly average concentrations of pollutants as measured at general environmental monitoring stations)

Concerning NO emissions, mobile sources contribute 74%, with about 65% of this coming from cargo trucks. Although the total weight of cargo carried by trucks has not increased over the last decade, the frequency of trips is gradually increasing. High frequency delivery of parcels "just in time", reflects the growth and changing nature of the service industry in the urban area.

The pilot project in Tokyo last year seems to have failed, and traffic congestion is still increasing. This is a symptom of the city choking itself with its own supply of material, and has led to a realization that it must "diet" (Nishioka 1991).

Traffic noise is the cause of another serious complaint of residents. This is the result of increasing proximity of the main traffic streams to residential areas. Their separation is only gradually progressing while the increase of traffic is surpassing all counteractive efforts (Moriguchi and Nishioka 1990).

Problem of aggregation

Dispersed urbanization may retain some of the capability of nature to reduce pollution, but heavy aggregation cancels this ability. The suburban areas around Tokyo are tightly and densely adjacent to each other; they not only contribute to the general pollution of the area, but effectively extend the boundary of the densely inhabited district. Thus, they add to the pollution load at the same time as reducing the self purifying capability of the region. Data show clearly that Tokyo suburbs such as Urawa and Hachioji are suffering from these kinds of aggregation effects (Fig. 14).

Water pollution

The quality of drinking water has degraded because of increasing pollution of the intake water leading to the need for higher levels of treatment (Fig. 15). To meet its expanding water demand, Tokyo has extended the area from which it draws its water resources to lakes and rivers in other prefectures, including some sources which are subject to increasing levels of eutrophication.

Compliance with the national environmental quality standard is
increasing gradually in the river and in Tokyo Bay, but not yet reached a fully satisfactory state.

Loss of nature

The expansion of the urban area to western mountain side has reduced the amount of greenery in the region, and has caused many species of familiar animals and insects to abandon the Tokyo area. Children are further losing their opportunities to come into contact with nature year by year (Fig. 16).

Effort Toward A Sustainable City

Tokyo Metropolis, in step with the central government of Japan and other local bodies, has begun to restructure the city to meet the challenge to protect the global environment.

National Level Action

As mentioned at the beginning of this report, the Government of Japan established an Action Program to tackle global warming last year. One clear goal of the program is the redevelopment of urban areas which includes a significant reduction in traffic. In 1989, the annual report on the "state of the environment" pro-posed the renewal of urban ecosystems and the promotion of recycling and conservation in urban activities.

One pilot project of the Environment Agency of Japan covering the 1991 and 1992 fiscal years introduces the concept of global environmental protection into the Environmental Impact Assessments (EIA) required for Development Projects such as roads, dams, railways, reclamations, land use readiness, new residential area development, new urban infrastructure development and so on. Such assessments have been conducted since 1984 according to an Implementation Scheme adopted by the Cabinet, they are predesign surveys and investigations of environmental impacts of various alternatives, and provide recommendations on measures to reduce undesirable environmental consequences of each project. Ideally, contributions to global warming will be among the major issues identified during the screening of proposed developments. This project will clarify technical measures for evaluating options to reduce a project's contribution to global warming mainly from the point of energy conservation, but without threatening the success of any development.

As the first stage of the study, energy analyses of some existing public works and construction projects will be executed using actual regional developments in order to create an appropriate methodology. The project will also include energy analyses of other types of developments, and study the reduction of other greenhouse gases as well.

Local Level Action

Many municipal bodies have started to plan to cope with global
environmental issues through energy savings, traffic control, waste management, water conservation, greening and environmental education. The Tokyo Metropolitan Government has begun establishing an action program for global environmental conservation.

One example is a project named “Tokyo Slim ’89”, to enhance recycling. The volume of waste has increased by 25% over the last 4 years, after a period with a rather stable discharge rate. The quantity of paper, mainly from offices, increased rapidly, and the amount of non-reusable plastic packaging increased. The latter damages incinerators because of the high temperatures reached during burning (Fig. 17). Already 66% of papers are recycled, and about 80% of burnable waste is incinerated and the rest is land filled. “Dream land” is a name of an island in Tokyo Bay made by these wastes.

A new land-fill site for Tokyo had a design life of 19 years but because of the unexpected rapid increase (Fig. 18) the capacity is anticipated to be filled up within 15 years; this makes “Slim” essential. To recycle paper, bottles and cans, one million households have participated, (Fig. 19) with an annual saving of 3 billion yen (present waste treatment costs are 41,000 yen/ton waste). The number of recycling depots established has now reached 360.

To allow the permeation of rain through pavement, a special type of permeable pavement has been applied in 3,400 places in Tokyo, mainly at pedestrian crossings, on sidewalks and in parking areas. It allows rain water to penetrate into the underlying ground and thus enriches groundwater and reduces the direct surface runoff of precipitation to the river.

A test facility to remove NOx from lead-polluted air from automobile exhaust emissions will be constructed at the Tokyo Port Tunnel (Fig. 20). As the concentration of NOx is only about 1/50 of that of stack gas from factories, this trial poses a new technological challenge. Nevertheless, the worsening situation of air pollution demands this kind of expensive effort.

In 1987, Tokyo Metropolis established an Environmental Management Plan to coordinate a number of such projects with the goal of a safe and comfortable city.

Conclusion

This report has analyzed the relationships between urbanization and the global environment. Every city has its own regional and historical backgrounds, and the case of Tokyo does not necessarily represent all of the factors in common among world urban areas.

Three viewpoints have been applied to evaluate the environmental performance of an urban area, namely vulnerability, impact on the outside environment, and the quality of the environment within the city.

The main conclusions are as follows:

a. Some part of urban structure serves to keep some of its activities more efficient than they would be if carried out in the countryside, but other activities place a heavy load on the environment. More detailed research is necessary to identify those factors.

b. Some of the deficiencies can be modified by technological methods (e.g., permeable pavement) or control of activities. Participation of people plays a big role here (e.g., waste separation).

c. Intrinsically, intensive aggregation of human activities to one place can cause a deterioration of the desirable functions of a city (e.g., through congestion and air pollution).

d. The growth of consumption and loss of self-supplying ability results in additional vulnerabilities to global change; moreover, it sometimes sacrifices the countryside by pre-empting water and energy resources.
We are now have the dilemma of minimizing dependence on the environment the urban area, while attaining efficient and environmentally sound activities within it.

Taking into consideration that the world is now "closing" and there no longer exists a frontier over which there is a rainbow, the major challenge in managing an urban area today is to identify appropriate activity levels from both the demand and supply sides, to try to be "slim" and to become as independent as possible regarding needed resources. Conservation of resources and recycling of wastes may be the royal way.

Acknowledgment
The authors express their sincere thank to Mr. M. Ohno of Ex-Corporation for his collaboration in data assembly, and Ms. Mie Kobayashi in arranging manuscript and figures.

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APPENDIX: Additional relevant information

Population and Population Density (excluding Okutama Town, Hino, Hara Village and the islands)

<table>
<thead>
<tr>
<th>Area</th>
<th>Surface Area (km²)</th>
<th>Population (thousands)</th>
<th>Population Density (persons/km², 1981)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1976</td>
<td>1981</td>
<td></td>
</tr>
<tr>
<td>23 Wards</td>
<td>592</td>
<td>8,584</td>
<td>8,335</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>14.079</td>
</tr>
<tr>
<td>Tama City and Town Area</td>
<td>830</td>
<td>3,041</td>
<td>3,252</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.916</td>
</tr>
<tr>
<td>Total</td>
<td>1,422</td>
<td>11,635</td>
<td>11,587</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8,148</td>
</tr>
</tbody>
</table>

Source: Materials from the Tokyo Metropolitan Government and Tokyo Planning Bureau.

Permanent Residents and Daytime Population (Tokyo as a whole) (Estimates)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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<th></th>
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<tbody>
<tr>
<td>Tokyo Metropolis</td>
<td>804</td>
<td>968</td>
<td>1,087</td>
<td>1,141</td>
<td>1,167</td>
<td>1,162</td>
<td>1,169</td>
<td>1,181</td>
<td>1,189</td>
<td>1,197</td>
</tr>
<tr>
<td>(Ward area)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Cities, towns and villages)</td>
<td>697</td>
<td>831</td>
<td>889</td>
<td>884</td>
<td>864</td>
<td>835</td>
<td>824</td>
<td>822</td>
<td>818</td>
<td>817</td>
</tr>
<tr>
<td>Tokyo Metropolis</td>
<td>833</td>
<td>1,020</td>
<td>1,175</td>
<td>1,266</td>
<td>1,334</td>
<td>1,350</td>
<td>1,373</td>
<td>1,390</td>
<td>1,403</td>
<td>1,412</td>
</tr>
<tr>
<td>(Ward area)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Cities, towns and villages)</td>
<td>732</td>
<td>887</td>
<td>1,004</td>
<td>1,044</td>
<td>1,071</td>
<td>1,062</td>
<td>1,064</td>
<td>1,065</td>
<td>1,065</td>
<td>1,065</td>
</tr>
</tbody>
</table>


Land Use Ratios

<table>
<thead>
<tr>
<th>Ward Area</th>
<th>Tama City and Town Area</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural Land</td>
<td>1,750</td>
<td>9,740</td>
</tr>
<tr>
<td>(2.9)</td>
<td>(11.7)</td>
<td>(14.6)</td>
</tr>
<tr>
<td>Wooded Areas</td>
<td>27,760</td>
<td>27,760</td>
</tr>
<tr>
<td>Water Surface</td>
<td>2,030</td>
<td>2,030</td>
</tr>
<tr>
<td>Streets and Highways</td>
<td>4,950</td>
<td>4,950</td>
</tr>
<tr>
<td>Land for Building Use</td>
<td>36,000</td>
<td>23,030</td>
</tr>
<tr>
<td>Residences</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>Manufacturing Enterprises</td>
<td>1,950</td>
<td>1,950</td>
</tr>
<tr>
<td>Offices, Stores, etc</td>
<td>6,780</td>
<td>6,780</td>
</tr>
<tr>
<td>Public Housing</td>
<td>5,500</td>
<td>5,500</td>
</tr>
<tr>
<td>Other</td>
<td>8,470</td>
<td>13,500</td>
</tr>
<tr>
<td>Total</td>
<td>55,150</td>
<td>32,020</td>
</tr>
</tbody>
</table>

Note: Figures in parentheses are percentages of the total.

Table 4: Some 1990 statistics of Tokyo
Figure 21: Some global comparisons

- Land Area (km²)
- Population (Million)
- Population Density (1000/km²)
- Natural Increase Rate of Population (m³/Capita)
- Water Supply
- Motor Vehicle Density
Introduction

Nature's countryside, where favoured by an equable climate and blessed with clean air and ample pure water, is beautiful. In contrast, many of man's cities are dreary, even ugly in parts, and impose on their suffering inhabitants air poisoned by pollution and other unpleasant or injurious effects.

Already one third of the world's people live in towns or cities and probably will continue to do so. Inexorably, therefore, mankind's bricks, concrete and asphalt are continuing to expand at the expense of nature's green spaces and forests. The disagreeable effects of rampant urbanization are often at their worst in the hot climates of some developing countries. Jakarta is in Indonesia, which unfortunately is just where sprawling cities are growing most swiftly, often in haphazard way and without proper regard for crucial climatological considerations.

A building has to shield the interior from wind, weather and undue heat or cold, and provide a comfortable indoor climate for the occupants. It must also be sufficiently resistant to fierce winds to avoid being damaged or otherwise rendered unfit by the ravages of the climate. Complex interactions between the atmosphere and terrain over which it passes influence the climate; consequently, when the terrain surface is changed, so also is the local climate.

Jakarta is a big city which has grown very quickly since the adoption of first Indonesian Twenty-Five-Year Long Term Development Plan 1966-1980, especially in its southern, eastern and western parts where trade, industrial, community and transportation facilities mix together.

This paper will present a brief survey of the city of Jakarta and its environmental conditions due to urban air pollution.

Changes in the urban climate are mostly related to the urban air pollution. Rapid urbanization (about 6% per year) also contributes adverse effects to the urban environment and this becomes a problem in urban planning.

Appropriate technology to reduce CO₂, SO₂, NO emissions, and the photochemical creation of ozone from these and other pollutants from industrial activities, transportation and production of energy is seriously needed.

Land-use planning to maintain the stability of ground water and local climate - such as green belt, open space, urban forest - is extremely important, and is becoming a priority of the government. The efforts are manifested through many regulations and actions; the research agenda to monitor urban air pollution, air quality and its effects on local climate change is also well supported.

Jakarta and Its Development

Population and Geography of Jakarta

The Jakarta population reached 8,200,000 in 1990; at that time, the rate of natural increase was 3.42% and net migration 2.58% per year. Population density was 13,990 person/square kilometre. The total area of Jakarta is about 660,660 square kilometre, situated between 106°22'42" and 106°58'18" E, and 5°19'12" and 6°25'54" S. The average altitude is between 10 and 50 meters above mean sea level. The terrain is almost flat, with alluvial sediments from the plioceen to a depth of about 50m. Many small rivers flow from southern mountainous high altitudes into the Java sea to the north. The main rivers known as Ciliwung and Cisadane almost divide Jakarta into equal areas. In the summer season, the average daily temperature is between 25 and 32°C, with the humidity between 60% and 90%.

The wet season extends from November to April; rainfall sometimes exceeds 300 mm monthly. Jakarta's dry season lasts from May to October with minimum monthly rainfall in the range of 50 to 60 mm. The prevailing winds are westerly during the rainy season and almost north-east or east during the dry season. So, the local climate of Jakarta is strongly influenced by the North Java Sea, the surrounding mountains, and also by the buildings.

Jakarta's Development and Its Effect on Pollution and Local Climate

Policies on industrial development are aimed at fostering a better balance between industry and agriculture, and promoting the manufacturing sector as a vehicle to stimulate economic growth and expand employment. Industrial development priorities, among other things, on the development of export-oriented industries and of small-scale industries.

In Jakarta, most of industrial activities concentrate in the north and the east sectors (Pulo Gadung area), followed by the west, the central region and then the south. Industrial activities lead to environmental problems caused not only from waste but also other sources of pollution.

Development of transportation and communications in recent years were designed not only to expand and smooth the flow of goods and services, but also to improve the distribution and marketing system for commodities over all the country in order to help preserve national stability. Development of inland transportation, especially road networks, and the use of automobiles are both increasing rapidly. In Jakarta nowadays, there are about 2 million vehicles (including cars and motorcycles), creating many traffic jams.

Energy policies are directed to finding other sources (especially
renewables) while exploiting available sources of oil and gas. This increasing demand for fossil fuels means higher emissions from both transportation (which now contributes about 60 percent of emissions) and industrial activities. Based on data from the Statistical Bureau, consumption of fossil fuel in the year 1989 was 40.6% by transportation, 20.4% by industry, 11.1% by generation of electricity, 25.4% by households and 2.8% by others. (See figure 1).

Increasing numbers of vehicles (private cars, public transport and motor cycles) will exacerbate problems with air quality and local climate. Since Jakarta is a national capital city, the annual rate of increasing numbers of car is 4%, higher than the national average. Data from the Statistical Bureau show that over 63% of total vehicles in Indonesia are on Java, with 30% in Jakarta alone. The number of vehicle in Jakarta increased from 1,286,608 in 1985 to 1,515,299 in 1989; 50% of this increase was in motorcycles, almost 30% in private cars, 10% in buses and the rest in trucks.

**Present State of Air Pollution**

Air pollution networks in Urban Jakarta, especially for TSP (total suspended particulates) measurement, are used for case studies and research. About 10 permanent TSP monitoring stations have been installed. Two of the stations belong to the Department of Health, Centre for Research and Development (Pulo Gadung and Kayu Manis stations); the rest belong to the Meteorological and Geophysical Agency (BMG). The instruments used at all stations is the same, so data are compatible.

Continuous monitoring of SO₂ and NOₓ have also been conducted by the Meteorological and Geophysical Agency since 1983. Temporary monitoring and incidental sampling with periods of a week up to 2 months have also been carried out by several institutes of the Research and Development Center.

The data on air pollution in urban Jakarta and surrounding cities described in the following paragraphs are from the Air Pollution Monitoring network operated by the Meteorological and Geophysical Agency, and the Department of Health, Government of Jakarta (through its PAL, the local Agency for Pollution Protection), as well as temporary observations or studies by several Institutes interested in the impact of air pollution on the environment.

The pollutants to be discussed are in line with the proposed of National Ambient Air Quality Standard (NAAQS) as follows:

- Total Suspended Particles (TSP) 230 µg/m³/24 hr
- SO₂ (Sulphur dioxide) 300 µg/m³/24 hr or 0.1 ppm
- NOₓ (Nitrogen dioxide) 150 µg/m³/24 hr or 0.08 ppm
- CO (Carbon monoxide) 30,000 µg/m³/hr or 26 ppm
- O₃ (ozone/Oxidants) 160 µg/m³/1 h or 0.08 ppm
- Pb (Lead) 1.0 µg/m³/year

![Figure 1](image-url)

**Sources of Pollution in Jakarta**

<table>
<thead>
<tr>
<th>Source</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households</td>
<td>30%</td>
</tr>
<tr>
<td>Industry</td>
<td>20%</td>
</tr>
<tr>
<td>Transportation</td>
<td>40%</td>
</tr>
<tr>
<td>Garbage</td>
<td>10%</td>
</tr>
</tbody>
</table>

Source: Java-Times Magazine, May 1991

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136

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137
Total Suspended Particulates (TSP)

The observation of TSP from the Jakarta Urban Network (10 stations) and 12 other Stations outside of Jakarta have been underway since 1976. The data have been collected for further study and analysis of pollution levels and trends. Table 1 summarizes the data from the period 1976-1981 and compares them with the data from the period 1980-1989.

Table 1: TSP data from the Jakarta Urban Network

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Monas</td>
<td>1976-1980</td>
<td>131.6</td>
<td>159.4</td>
<td>27.8</td>
</tr>
<tr>
<td>Gledok</td>
<td>1976-1980</td>
<td>447.0</td>
<td>473.0</td>
<td>26.0</td>
</tr>
<tr>
<td>Delta</td>
<td>1976-1980</td>
<td>446.0</td>
<td>472.0</td>
<td>26.0</td>
</tr>
<tr>
<td>Ampel</td>
<td>1976-1980</td>
<td>137.0</td>
<td>206.2</td>
<td>69.2</td>
</tr>
<tr>
<td>Halim</td>
<td>1976-1980</td>
<td>115.0</td>
<td>235.4</td>
<td>120.4</td>
</tr>
<tr>
<td>Kayu Manis</td>
<td>1976-1980</td>
<td>283.5</td>
<td>472.0</td>
<td>188.5</td>
</tr>
<tr>
<td>Pulo Gadung</td>
<td>1976-1980</td>
<td>185.0</td>
<td>194.0</td>
<td>9.0</td>
</tr>
<tr>
<td>Tangerang</td>
<td>1976-1980</td>
<td>145.2</td>
<td>241.4</td>
<td>96.2</td>
</tr>
<tr>
<td>BMG</td>
<td>1976-1980</td>
<td>171.4</td>
<td>204.7</td>
<td>33.3</td>
</tr>
</tbody>
</table>

Three stations, Gledok, Delta/Bandengan and Kayu Manis had TSP concentration levels above the proposed Air Quality Standard (230 μg/m³/day) for the earlier period, and increased slightly for the later one; Tangerang, on the other hand, started below for 1976-1980, but had a large increase to take it above for 1980-1989. The rest of stations all show an increase, but on average they are still below the proposed AQI.

The TSP concentrations from stations outside Jakarta are listed in Table 2. Relatively, they have a short period of observation.

Table 2: Average TSP concentrations (μg/m³/day) during the period 1982-1988 for stations outside Jakarta

<table>
<thead>
<tr>
<th>Station</th>
<th>1982-1988</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rawalo</td>
<td>82.0</td>
</tr>
<tr>
<td>Pancing</td>
<td>63.4</td>
</tr>
<tr>
<td>Paling</td>
<td>54.6</td>
</tr>
<tr>
<td>Medan</td>
<td>109.0</td>
</tr>
<tr>
<td>P-Wangi</td>
<td>76.0</td>
</tr>
<tr>
<td>Pajajaran</td>
<td>47.3</td>
</tr>
<tr>
<td>Benculuk</td>
<td>66.7</td>
</tr>
<tr>
<td>Bandung</td>
<td>200.7</td>
</tr>
<tr>
<td>Bogor</td>
<td>291.0</td>
</tr>
</tbody>
</table>

TSP from special monitoring during August and September, 1982 at some of the Jakarta stations show daily mean values much above the AQI. Daily averages over the period were as high as 806.1 μg/m³/day at Gledok, with values over 500 at 5 other locations from the nine-station sample.

NO and SO₂

The value of SO₂ and NO₂ concentration from continuous monitoring show some interesting trends. SO₂ concentrations decreased steeply between 1983 and 1987; the 6-year average was 0.052 ppm, well below the AQI value of 0.1 ppm. NO₂ concentrations also decreased over the interval with an average of 0.031 ppm (AQI 0.00 ppm). During the special observation period (August-September, 1982), the AQI standard for both pollutants were exceeded at a number of locations in Jakarta. (CO was also observed during that period, and remained

Environmental Problems

Air pollution continues to be a major environmental problem in the Jakarta urban area and its surroundings. This is especially so in the central urban area (such as Gledok and Bandengan). Pollution in these areas seems predominantly from industrial activities and transportation. Even with the declines described above, about half of the people living in urban neighbourhoods (Gledok, Bandengan, Pulo Gadung, Kayu Manis areas) are still exposed to unhealthy levels of TSP and other pollutants (CO, NO₂, and SO₂ and H₂S). In some areas, tropospheric ozone, the principal ingredient in urban smog, is of particular concern and needs further study.

The health effects due to those compounds in the outside atmosphere remains unknown or unmeasured. Yet it is known that indoor pollution, exacerbated by poor ventilation, can be damaging. The major sources of indoor air pollution include indoor fuel combustion, consumer products and building materials.

Acidic precipitation has been reported in Jakarta (BMG Station) where the pH decreased from 6.57 in 1981 to a range of 5.25 to 5.60 for the years 1982-1986. The cause is still unknown but it is felt to be due to local pollution sources. Acidic deposition continues to be a major international environmental issue. It threatens fresh water fisheries, agriculture and wildlife. The protocol to the convention of Long Range Transboundary Air Pollution which entered into force in 1987 requires participating nations to reduce either national sulphur emission or their transboundary flows by 30 percent from 1990 levels by 1993.

As we know, generally the sedimentation velocity of suspended particles less than 10μ in diameter is very slow in areas where meteorological conditions do not favour dilution or dispersion processes; they tend to remain suspended for long periods of time in the air. This may be the reason why the TSP concentration is high at some stations such as Delta Bandengan, Gledok, Kayu Manis and Pulo Gadung.

Urban Forest

The need for green areas will become more and more urgent as time goes by. Cities crowded with skyscrapers and heavy traffic like Jakarta cannot be avoided. City forests are essential to the ecological balance of the environment and one of the answers to mitigate air pollution problem.

The ratio of city forest area to population in Jakarta is four hectares to 1,000 people. Maintaining the ratio is crucial because air pollution in the city is increasing as a result of new industries and more vehicles on the streets.

The actual definition of city forest may be different from the
concept that some people have. We consider city forest to include not only those trees in parks but also those planted along boulevards, in gardens and in recreation areas. City forest (or urban forest) also includes areas where trees have been planted for specific purposes; such are scattered throughout the city.

Plants help to regulate the environment, particularly in urban areas, in a variety of ways. They absorb CO₂ and create oxygen through photosynthesis, minimize air pollution, control water flow, and reduce noise as well as neutralize acid rain.

Concerning global warming and climate change, the function of plants as a carbon sink become important. One study estimates that it takes about 75 trees to absorb all the carbon dioxide put out by an average city dweller in his daily routine. In other words, four people would require about three acres of woods. Newsweek magazine (October 2, 1989; vol. 114, pg 59) reported that a single tree can absorb 26 pounds of carbon dioxide per year; thus, an acre of trees can remove 2.4 to 5 tons.

Trees with large canopies can reduce the amount of dust and other particulate matter in the air. Trees also have ability to control microclimates by reducing temperatures and increasing humidity. Water vapour produced by the leaves during transpiration cools the surrounding air. The photosynthesis process may help to reduce levels of carbon monoxide, a dangerous component of automobile exhaust. In the presence of urban forests, the air is likely to be cleaner than that in areas without trees.

Newsweek magazine suggests that planting 100 million trees around homes in the United States would save US $4 billion in energy costs for air conditioning and reduce carbon dioxide in the atmosphere by 18 million tons per year.

Another reason for reducing temperatures in urban environments relates to the complex interaction among trees, temperature and smog. According to Science News (July 7, 1990; vol. 138, pg 5), by cooling the air, trees can help slow the heat-driven photochemical reactions that brew ozone from hydrocarbons and nitrous oxide because smog production is so temperature-sensitive.

Conclusion

In order to monitor and improve the quality of the urban environment, especially the air, we should take several actions, including: improve the capability of monitoring pollution and climate change; study pollution sinks; create buffer zones by approaches such as promoting urban forest; obtain appropriate technologies for urban development.

The concern for shrinking green space in Jakarta due to rapid development certainly was well founded. Population increase is followed by increasing numbers of automobiles, the construction of new industries and high-rise buildings, and the existence of slum areas with relatively dense populations. These have led

environmentalists to call the preservation and extension of growing trees and urban forest.

It is important for everyone to realize the capabilities of forests in maintaining the ecological balance in a city, improving the quality of its air, and generally adding to the urban environment.
Part 4

REMARKS OF MEMBERS OF PANELS

Part 4.1

URBAN AIR QUALITY AND HEALTH

Warmer Temperatures, Unhealthier Air and Sicker Children
by
Lynne Edgerton

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Warmer Temperatures, Unhealthier Air and Sicker Children

by Lynne Edgerton

To date, there has been little focus on the aggravating effect which global warming could have on urban air pollution, and even less attention to the particular effects of worsening global air on children's health futures. Recent United Nations data reveals the severity of the air pollution risk to 4.2 million children currently die each year in developing countries from respiratory diseases. (UNEP, "Children & the Environment", 1990).

Indeed, one of the most immediate and compelling reasons for residents of large cities to support aggressive measures to curb global warming and stratospheric ozone depletion is that both accelerate the chemical reactions which produce smog and other toxic air pollutants. Cities like Los Angeles, Mexico City, Prague, Santiago, Sao Paulo and Budapest desperately need to cut their high levels of tropospheric ozone, carbon monoxide, sulfur dioxide and other pollutants. Los Angeles' air experts believe a 90% per capita cut in toxic air emissions is needed for L.A. to achieve federal clean air standards by 2003, in the face of its growing population. Increases in air toxins due to climate change are unthinkable.

Recent scientific data on the health effects of exposures to air pollution indicates that polluted air is much more damaging to human health than was formerly believed. In April, 1990, Dr. Russell Sherwin, a pathologist at the University of Southern California, performed autopsies on 197 Los Angeles teenagers who died in accidents and traumas. He found that 80% had significant lung abnormalities, and that 27% had severe lung lesions. Dr. Sherwin, a highly respected scientist, noted that the observed changes in lung tissue were consistent with previous known effects of air pollutants. What was striking, however, was the severity of the lung impairment - in a group of young people who were otherwise believed to be healthy. When asked for his prognosis for these young people had they lived, Dr. Sherwin replied, "...a very high probability of significant lung disease by the age of forty."

Dr. Sherwin's study, as well as others released in the past year, have sent shudders through parents raising children in Los Angeles and elsewhere. (See "On Ill Health and Air Pollution," New York Times Magazine, Oct. 17, 1990.) It is well known that children, who breathe about four times more air due to their smaller lungs and increased activity, are especially vulnerable to air pollution. It seems there is a new medical report every week from yet another big city, often eastern Europe, indicating unexpectedly high morbidity and mortality among children from chronic exposure to high levels of air toxics.

In 1989, ozone levels in some areas of Los Angeles exceeded 0.15 ppm for one day out of every three. In the region as a whole,
ozone levels exceeded 0.15 ppm on average one out of every five days. A reading of 0.15 ppm triggers health advisories to school officials to stop children's sports and outdoor play. Similar health advisories are issued by officials in Mexico City and elsewhere around the globe.

Indeed, Mexico City closed its schools for six weeks last year due to high ozone levels. Now its residents leave their cars at home for one day each week. In Santiago, Chile, the Andes have become almost invisible on most days, and alternate day driving is enforced.

For every degree of warmer temperature the earth experiences, there will be more urban air pollution. In its 1989 Report entitled "The Potential Effects of Climate Change on the United States", the United States Environmental Protection Agency (EPA) concluded that an increase in global temperatures would:

- increase ozone levels in many urban areas because higher global temperatures would speed the reaction rates producing ozone in the atmosphere;

and

- increase natural emissions of hydrocarbons and change natural emissions of sulfur, but in an uncertain direction. (Hydrocarbons and nitrogen oxides participate in reactions that produce ozone.)

For example, preliminary analyses of the effects of a scenario of a 4-degree temperature increase, with no change in emissions or other climate variables, by ozone concentrations in the San Francisco Bay area, suggest that:

- maximum ozone concentration could increase by approximately 20%;

- the area in which the National Ambient Air Quality Standard (U.S.) would be exceeded would almost double; and

- the number of people hours of exposure would triple.

The U.S. Midwest and Southeast also could incur high concentrations and an increase in the area of high ozone by a factor of three. (J. Smith & D. Tiptak, "The Potential Effects of Global Climate Change on the United States", U.S. E.P.A., 1989.)

Increases in air pollution levels will cause millions more children to suffer both short-term and long-term impairment to their lungs, hearts, and immune systems. Indeed, the number of the world's largest cities which now experience severe air pollution — or will soon experience it as they buy more internal combustion cars — is increasing. Los Angeles' current population is 12 million and it is expected to reach 18 million by the year 2100. It is the children living in the world's biggest cities, as well as those living in cities with unlucky geography and wind patterns, who are at such grave risk. According to the Population Crisis Committee, 58 of the world's 100 largest cities are in developing countries. By 2010, as much as half of the world's population may be living in large cities.

Medical officials are now signaling that the health effects of air pollution are worse than previously believed. Urbanization is increasing. Atmospheric scientists and conservationists confirm that long-range transport of air pollutants can be a serious health threat to the normal neurological development of children living far from the emission sources, as occurred when emissions from a copper factory in Arizona became the most toxic pollutants for children in the Great Lakes. (See T. Colborn, "Great Lakes Great Legacy?", The Conservation Foundation, 1990.) It seems that we may be fast approaching the day when even rural children will not be safe from air pollution's ill effects.

The most obvious solutions are to slow global warming and to curb air pollution.

There are three principal approaches currently underway which may contribute to solving the interrelated problems of global warming, worldwide urban air pollution and long-term damage to children's health from airborne pollutants. First, international, national and local programs have been initiated to identify and implement measures to cut emissions of greenhouse gases. Most importantly, international negotiations on a global climate change convention are also underway. In the United States, the federal Clean Air Act offers the prospect of reducing greenhouse gases by the phase-out of CFC's by 2000 and by modest encouragement for alternative fuels. Local communities are taking steps to reduce greenhouse gas emissions, also. The task is a formidable one, because 60% reduction in worldwide greenhouse gases may be required to stabilize the climate.

Second, efforts to control urban air pollution are moving slowly forward. But unless nations take bold steps to encourage the use of emerging transportation technologies (which hold the promise of great reductions in carbon dioxide emissions), there is little reason to expect a sufficient reduction in traditionally regulated air pollutants.

Californians have begun to appreciate the severity of the risk, and may lead the way for the world. Its clean fuels and clean vehicles program mandates that two percent of the new cars sold in California be zero-emission vehicles (probably electric) by 1999, and that ten percent be zero-emission vehicles by 2001. The California Air Resources Board has concluded that polluting emissions will have to be cut by 90% per capita to meet clean air standard in the face of its growing population. In April 1990, the San Francisco Board for Southern California adopted a policy requiring that its air quality measures be implemented in ways which also curb greenhouse gas
emissions.

The California "Clean Fuels and Clean Vehicles" program is technology-forcing in its best form. In fall, 1990, ARCO began marketing two less polluting, reformulated gasolines in Southern California. Two big utilities in California - the Los Angeles Department of Water & Power, and Southern California Edison - have agreed to invest jointly $7 million to develop an electric car and to get 10,000 of them on the road by 1995. The California Electricity Commission has recommended the adoption of regulations which would require that a significant portion of the state's electricity come from renewable sources, regardless of cost. As well, the California Public Utilities Commission has begun the process of revising its regulations to permit the use of compressed natural gas in automobiles. It will be interesting to see whether Southern Californians - who love their cars - can change their ways. If they can, maybe the rest of the world can also.

Thirdly, the problem of environmental degradation is more that of out children than ours. In 1988, the United Nations report on sustainable development articulated a vision of global caretaking to ensure an environment capable of sustaining present and future generations. Yet that is not the whole story. Particularly important is the emerging recognition that children's bodies are more fragile and vulnerable to environmental stress, pollution, disease, and malnutrition. In some cases, it is the human child's ability to resist disease which is threatened; in others, such as lead exposure, it is a child's innate intelligence which is subject to impairment.

Principles of intergenerational equity are needed to deal with environmental degradation and climate change. An international law and intergenerational equity study, sponsored by the United Nations University, proposed three basic principles concerning the environment. The implementation of the UN Convention on the Rights of the Child will require an environment protocol to assure compliance with its provisions on health, prevention of diseases, right to development, and the right to an adequate standard of living. The 1992 U.N. Conference on Environment and Development in Brazil will be a potential forum for international cooperation on these issues. While developed nations try to reduce their air pollution and their contributions to global climate change, developing nations can begin planning to avoid the mistakes of the developed world, and to limit their greenhouse-gas emissions as well. The success or failure of the complex negotiations on climate change will have enormous consequences for succeeding generations.

Are we up to our parental obligations? Is this generation willing and prepared to engage in serious efforts to protect our descendants? This question is one of the most critical questions facing us in the 1990's.

URBAN AIR QUALITY AND PUBLIC HEALTH: THE LOS ANGELES DILEMMA

by Carolyn Green

The print and broadcast media are replete with predictions of the dire effects of global climate change on public health. Within the past week, in fact, television news commentators took to the airwaves to warn viewers of the heightened dangers of skin cancer as a result of the larger than expected hole in the ozone layer over the northern temperate zone. In Southern California, unfortunately, such warnings often go unheeded. After all, the Los Angeles metropolitan area is known for its mild, sunny climate, and it is rare indeed to find a mature adult of northern European heritage who has not suffered from mild to severe skin cancer caused by years of exposure to the sun.

Besides, the problem in Southern California is too much, not too little ozone; unfortunately, this is near the surface, not in the stratosphere where it could do some good. The general public does not recognize that, not only is the Southern California lifestyle a major contributor to global warming and ozone depletion problems, but increases in global temperature and ultraviolet radiation will increase the smog-forming potential in the south coast air basin, thus further hindering our chances of ever meeting the health-based air quality standards.

I would like to give you a brief overview of air quality in Los Angeles, and then describe my agency's efforts to integrate our atmospheric ozone attainment strategies with the need to combat global warming and ozone depletion worldwide.

It is no secret that air quality in the south coast air basin, which has as its core the greater Los Angeles metropolitan area, is the worst in the United States. Of the six ambient air quality standards established by the federal Environmental Protection Agency (EPA) to protect public health, we exceed four. Two out of every three days, Southern California exceeds one or more air quality standards.

Our most infamous problem is ozone. In 1990, the cleanest year on record, ozone levels alone exceeded the federal standard on 117 days. That is over 100 days more than the next worst area of the country outside California. Houston, Texas, exceeded the standard on only 14 days. Ozone violations in Southern California have dropped, however, from over 200 days above the standard in 1976 to 117 days in 1990, and the peak concentrations of 660 µg/m³ are almost 17 percent lower than in 1976.

Southern California also experienced 42 days in excess of the eight-hour carbon monoxide standard. We are not the worst area of the nation for CO, although we come close. Maximum CO concentrations in 1990 were almost twice the standard. Here again, the region has made significant progress, reducing peak levels from
49,500 µg/m³ in 1976 to 19,000 in 1990.

The region is over four times higher than the average daily PM10, or very small particle, standard of 150 µg/m³. This standard has only been in place since 1987.

Finally, the south coast air basin is the only region in the nation that does not yet meet the annual nitrogen dioxide standard of 100.5 µg/m³.

In 1989 the South Coast Air Quality Management District Governing Board adopted the first ever attainment plan for the region. That plan—which has variously been called bold, far-reaching, draconian and pie-in-the-sky—predicted attainment of all federal air quality standards, including ozone, by the year 2007. The plan put forward a host of emission reduction proposals, including developing an all electric or solar automobile fleet, using electric power in industrial processes, expanding an extensive public transit system throughout the region, and virtually eliminating the reactive component of solvents and coatings.

However, in the environmental impact report that accompanied the clean air plan, the Agency acknowledged that some of the strategies could exacerbate global warming and ozone depletion problems.

Then in August of the same year, AQMD staff prepared a special briefing document on global warming and ozone depletion for the Governing Board, and proposed a work program to develop a global warming/ozone depletion policy for the south coast air basin. In addition to providing the Board with a basic introduction to the issues and their effects on human health and the environment, the staff briefing discussed how rising global temperatures may affect the region’s ability to implement the recently adopted clean air plan. Equally important, the report assessed the potential effects of the plan on global warming and ozone depletion.

Looking first at the impacts of global warming and ozone depletion on the plan, staff concluded that higher average temperatures and increased ultraviolet radiation will accelerate the rate of photochemical reactions occurring in the atmosphere, leading to higher surface-level ozone concentrations. Those higher temperatures will, in turn, increase the demand for air conditioning during the summer, causing a corresponding increase in oxides of nitrogen emissions. We also expect higher evaporative emissions from motor vehicles, refueling facilities and from vegetation. The combination of increased R0G and NO, emissions and accelerated chemical reaction rates could make it impossible to meet the already ambitious ozone attainment target by the year 2007, or ever.

And because NO, not only is an ozone precursor but also a major contributor to Southern California’s particulate and acid deposition problems, we would expect these problems to become more intractable, as well.

As sobering as the assessment of global warming and ozone depletion impacts on the air plan may be, AQMD staff recognized that a more dangerous threat is that Southern California’s clean air program could make these global concerns worse. As in most areas, the AQMD has historically has exempted CFCs and global warming and ozone depleting gases such as 1,1,1 trichloroethane from regulation as reactive organic gases for ozone attainment purposes. Such an exemption made sense, since these substances were considered non-reactive in the lower atmosphere.

In the south coast air basin, businesses inadvertently were given a double incentive to use CFCs in place of reactive hydrocarbons. First of all, the CFCs were able to satisfy the required R0G control levels. In addition, because the AQMD uses an emissions-based fee system, use of CFCs and other ozone depleting and global warming substances lowered emission fees.

Solvents and coatings aren’t the only culprits, however. Approxi-
mately 50 percent of the global warming effect is created by carbon dioxide emissions, the majority of which come from the combustion of fossil fuels in both stationary and mobile sources. Although the overwhelming majority of Southern California’s space- and water-heating and in-basin electricity generation needs are satisfied by natural gas combustion, any strategy to electrify major sectors of the economy have the potential to increase carbon dioxide emissions, depending on how that electricity is generated. In addition, approximately 75 percent of all space heating in Southern California is fueled by natural gas, and fully 95 percent of the region’s electricity is generated by natural gas combustion, making natural gas a major source of methane emissions within the basin.

Southern California is especially famous — or infamous — for its dependence on the automobile. Over 5 million motor vehicles are registered in the four counties that make up the south coast air basin, making this the largest single urban area in the world. It also makes the motor vehicle the single largest source of air pollution in the region. Mobile sources currently account for half of the R0G emissions, 2/3 of the NO, and 90 percent of carbon monoxide emissions. As a result, the air plan places considerable emphasis on reducing mobile source emissions, mostly through short- to medium-term improvements to auto emission standards and eventual replacement of gasoline with such fuels as methanol, compressed natural gas, propane, and, ultimately, with solar or electric power. With the possible exception of solar, each alternative has potentially serious negative impacts on global warming.

The 1989 plan reflects the overarching preference in southern california to improve the motor vehicle technology as the solution to air pollution problems rather than ask drivers to give up their single-occupant vehicle. Although there certainly is some truth to the sense of freedom afforded by vehicle ownership, the sad fact is that Southern Californians are rapidly becoming slaves to the automobile due to the absence of a viable transit system.
Even more disturbing is that public policy historically has favored driving alone to work and play with the result that average vehicle occupancy during the morning rush hour was only 1.13 in 1989, when the clean air plan was adopted. That means that it takes ten cars to transport just over 11 people to work. Needless to say, Southern Californians are wasting fuel by failing to rideshare or use transit and by sitting, motors idling, in the traffic jams their driving habits have created. The air plan notes that, even with an all-electric auto fleet, vehicle miles traveled in Southern California must be reduced by over 30 percent from forecast levels in 2007 in order to control NO, emissions from power plants.

So what is Southern California doing to address this admittedly pessimistic future? After eight months of sometimes rancorous public debate, the AQMD Governing Board adopted a global warming and stratospheric ozone depletion policy which recognizes Southern California’s contribution both to the global problems and their solutions. The policy specifically recognizes the failure of earlier AQMD control efforts to control emissions of carbon dioxide, methane, CFCs and other ozone-depleting solvents. It also acknowledges the dual benefits of such attainment strategies as increased energy conservation and efficiency, development of alternate fuels and reductions in vehicle travel.

The policy calls for several important actions, including:

- phase out the use and emissions of CFCs and halons as soon as possible prior to 1997, with a possible extension to 2000 in extenuating circumstances;
- discontinue the use and emissions of HCFCs and methyl chloroform as early as practicable; Phase out determinations will be based on a rule-by-rule assessment and finding that replacement substances are available;
- develop, by the end of 1990, a regulation to require recycling and proper disposal of CFCs;
- develop carbon dioxide and methane emissions-reduction strategies for inclusion in the 1991 update of the regional clean air plan;
- aggressively implement the VMT-reduction goals included in the 1989 air plan;
- develop an inventory of sources within the basin that cause or contribute to global warming or ozone depletion and include that inventory in all future updates of the air plan;
- assess the global warming and ozone depletion impacts of all AQMD regulatory proposals and all projects for which the agency provides environmental comments to other agencies.

- allocate funds through the AQMD’s Office of Technology Advancement to support research into alternative technologies and materials to reduce or eliminate the use of global warming and ozone depleting substances.

I would like to conclude my presentation by giving you a status report on our progress in carrying out the policy as adopted by the Governing Board. In November 1989, even before the policy was approved, staff did publish a report identifying sources of CFC emissions within the AQMD’s jurisdiction. This report, as envisioned, has formed the basis for regulations and for suggested control measures as part of the new air quality plan. We have adopted four CFC control rules, so far:

- Rule 1175, adopted in November 1990, controls emissions from the manufacture of foam products. The rule calls for a 40-percent reduction in CFC emissions in blowing operations during 1991, and requires CFCs to be discontinued entirely for this use by 1994.
- Rule 1405, adopted in December 1990, is primarily a rule to control emissions of ethylene oxide (ETO) emissions from fumigation and sterilization equipment, but it also controls CFC emissions by requiring that they be recovered or recycled. The rule also eliminates the use by 1997 of CFC-12 as a diluent in the sterilization process.
- Rule 1411, adopted in March 1991, requires the use of recovery or recycling equipment for the installation, servicing or repair of motor vehicle air conditioners, and for any other procedures, including vehicle salvaging, that could cause the release of refrigerant.
- finally, rule 1415, adopted on June 7, requires a yearly inspection of refrigeration and air conditioning systems containing more than 50 pounds of CFC refrigerant. Any leaks must be repaired within 14 days of detection.

In addition to the four rules already adopted, AQMD staff hopes to adopt five new global warming and/or ozone depletion control rules by the end of 1992. The top priority is to eliminate the exemption of methylene chloride from all of the agency’s VOC rule provisions, thus subject them both to emission-control requirements and to fees. Also scheduled for Board adoption during the first quarter of 1992 is proposed rule 1416, which would restrict in non-essential uses of CFCs. Proposed rule 1417 is scheduled for adoption during third quarter 1992 to restrict the use of CFC-based transport refrigeration systems.

During the last quarter of 1992, the Board is scheduled to adopt proposed rules 1418 and 1419. Rule 1418 may either require recycling of halons, or restrict their use, depending on whether substitutes can be found for building fire-suppression systems and...
Rule 1419 would reduce methane emissions from livestock waste by requiring better housekeeping, sewage treatment or anaerobic digestion as alternatives to open or lagoon composting.

As part of the update of the 1989 clean air plan, AQMD staff has incorporated a number of suggested measures to reduce emissions of CFCs, carbon dioxide and methane. These measures include control of CFC emissions from domestic products, aggressive energy conservation goals for residential, commercial and industrial electricity and natural gas use, buyback of gas guzzling and polluting older vehicles, trip reduction programs for schools and special activity centers, and control of fugitive methane emissions from natural gas transmission and distribution pipelines - just to name a few. The new plan is scheduled for adoption on July 12 for transmittal to the state Air Resources Board for review and approval. Although the plan is being developed to satisfy state air quality requirements, we think it most likely will meet federal Clean Air Act requirements, as well.

Finally, the AQMD is putting its money where its regulatory mouth is by co-funding research to develop non-ozone-depleting compounds for use in defluxing and degreasing operations in the aerospace industry, which is the largest single employer in Southern California. We’re working on the development of seven specific products: low-cost low-ROG coatings; low-cost paint spray equipment; a data base on solvent use; dense phase gas cleaning; aqueous cleaning; eutectic solders and fluxless solders. The AQMD’s aim is to make non-proprietary results available to both aerospace and non-aerospace manufacturers.

We are proud of our global warming and ozone depletion program so far. We think we have established Southern California as a leader, not only in ambient air pollution control, but also in showing how various air pollution programs can and should be integrated to achieve multiple goals. But we realize that we’ve only begun to scratch the surface and that we have much to learn from the accomplishments of programs like those being described at this conference. Solving global warming and ozone depletion problems will take time and money and, most of all commitment. It is only by sharing information and expertise among local, national and international groups that we can have any chance at all of bringing about a real and lasting improvement in our environment.

QUALITY OF URBAN AIR AND CLIMATE CHANGE

INTRODUCTION

"Before the advent of individual and collective environmental consciousness leading to the gradual improvement in many aspects of air quality, man had wantonly discharged vast quantities of waste products, into the air from house and factory chimneys and plant, and from quarries, cars, lorries, trains and ships."

(Chandler, 1976)

With the rapidly increasing, anthropogenically enhanced, atmospheric concentration of greenhouse gases, the risk of unprecedentedly rapid climate change is more and more threatening. This change is frequently called inadvertent; however, awareness of the greenhouse effect of some human activities goes back to the past century. Whatever the reasons for these changes in the global climate system, the implications might appear in all components of the system, on all spatial and temporal scales and for the multitude of climate-sensitive components of environment and socioeconomic activities.

The smaller the scale of impact of the global processes, the more complex is the procedure of its evaluation and the more uncertain its estimate. The possible effects of global change on mesoscale phenomena, and in particular, on the urban climate and air quality are hardly assessable. Besides the increasing levels of uncertainties in the estimation "cascade" (from global to local phenomena), there are much more regional and local environmental and societal factors which contribute to the formation of specific character of the urban climate and should be taken into account in climate change analysis.

The impacts of changing global state of climate on urban air can be categorized in two sets more or less related to each other in their impacts on climatic features, and in their impacts on the chemical composition of air in the urban environment. Since these processes may interact (as, for instance, some meteorological elements influence the chemical reactions), it is also reasonable to introduce the term of the combined effects of global change on the ambient urban air. In turn, these changes will hide their ecological, physiological and other impacts, so that one can differentiate among the first, second or third order climatic impacts. Of these further implications of the changing properties of urban air, the impacts on human health are of highest significance.

The potential regional effects of climate change on economic sectors - water management, agriculture, forestry and energy for example - have been intensively investigated in recent decades.
Such areas have attracted as great attention as the environment as a whole, whilst much less attention was paid to the possible impacts on air quality and health. In Hungary, recent climatological research in the context of global warming is also directed to the potential climatic implications and their impacts on the above-mentioned areas (Czélnai, 1980; Antal and Glantz, 1980; Mika, 1988; Práger and Pálfölgyi, 1989; Gótz, 1990; Faragó, Tóth and Szalai, 1990; Antal and Tarasovszky, 1990). It does not mean that the issues of environmental quality are not of high concern at present in the country; air quality problems of the capital, in some parts of which the situation is rather bad because of the high emission rates of pollutants from different sources, are receiving much attention. The supposed effects of climate change will add to these problems, occasionally creating even more "favorable" conditions for the accumulation of toxic pollutants in the air and causing higher environmental discomfort.

**GLOBAL CLIMATE CHANGE AND REGIONAL EFFECTS**

Global scenarios and uncertainties in forcing rates are significant factors affecting responses to potential adverse effects of climate change. There is no clear evidence yet that the Earth climate is presently undergoing an unprecedented rapid change, however, the increasing atmospheric content of certain greenhouse gases should be considered as growing risk of such global and occasionally irreversible changes. The impacts originate from both the limited ability of the climatic models to simulate and predict the behavior of the climate system, and the fact that the recent increases in mean global temperature are still within the range of natural variability.

The possible regional implications of global climate change are even more uncertain. By means of the dynamic models and cautiously used teleconnections (relating the macroscale and local climatic changes) estimates have been produced for various regions. In particular, higher temperature increases than those for the global average and the reduction of the summer precipitation is expected for Southern Europe (IPCC-NG-1, 1990). The change will also have an expressed seasonal character in this region; it means considerably milder winters, and longer, warmer and drier summers. Finer estimates have been elaborated for the Central European region - the Carpathian basin and especially for the area of Hungary - in order to accomplish more specific impact studies. These studies show also: the amplification of the global temperature rise for the region with a much higher factor during the winter period; the reduction of the summer precipitation (at least for the moderate equilibrium global warming); and, the increase of solar radiation. All of these are related to changes in circulation patterns and cloudiness - less intense insolation during the winter period and decrease in the average cloudiness during the summer period (Mika, 1988, 1989; Faragó, Iványi and Szalai, 1990; Mika and Pálfölgyi, 1991).

In addition to the expected change in the climatic characteristic, we should not forget about the origin of this problem; the increasing amount of greenhouse gases and other pollutants in the atmosphere does not only contribute to the climate change, but it has also direct and indirect effects on the air quality, the effect of which is significant enough to create serious health problems. Some of these gases are a direct result of industrially produced substances, while others are released as waste products of industrial processes. The relationship between climate change and air pollution is complex and interconnected. The increase in greenhouse gases leads to an increase in the temperature of the atmosphere, which in turn affects the distribution of pollutants in the air. Therefore, the effects of climate change on air pollution and vice versa are interdependent and require a comprehensive approach for understanding and management. The interactions between climate change and air pollution, and the resulting health impacts, are complex and require further research to fully understand and address the issues.
(transport, dilution, deposition, chemical transformation) of the pollutants, and at least some of the pollutants influence even the local meteorological conditions.

The most apparent examples of the later type of relation are the direct effects of waste heat or the excess in the aeroosols on the temperature or precipitation distribution in these areas; and, the indirect effects of the pollutants on the radiation processes (atmospheric turbidity), frequency of foogs, etc., (Szepesi, et al. 1977, Szepesi, 1989; Haszpra et al., 1991), whilst air quality is interpreted as an inherent part of the urban climate much more rarely in the framework of a synthetic approach (Chandler, 1965; Problád, 1974; Szepesi, 1981). Problems of atmospheric composition and related chemical processes can also be treated without an explicit indication of the meteorological factors in terms of cycle, balance, emission and deposition of the investigated components (Mészáros, 1977; Kiss and Gajzágó, 1988; Lévai and Mészáros, 1989; Hinrichsen and Enyedi, 1990; Bulla, 1991).

All components of the surface energy balance are influenced to some extent in the urban area as a consequence of the changes in the surface characteristics and the various man-made releases to the atmosphere (gaseous emissions, particulates, waste heat). In particular, incoming solar radiation is significantly smaller in cities than in the surrounding countryside because of the generally higher optical thickness. There is also an essential contribution to the heat balance from the heat release of urban energy sources. The estimates for this term in the downtown of Budapest indicate an expressed seasonal dependence in correspondence with the enhanced energy consumption during the heating season (Problád, 1988); (values MJ/m²)

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Due to the waste heat sources during the heating season, and the reduced humidity available for evaporation in summer, the heat exchange with the near-surface air is much higher than that outside the city. This results in elevated temperatures, especially in cases of only weak vertical turbulent exchange in addition. Specific meteorological conditions in cities are primarily characterized by this phenomenon called the heat island. As a consequence, the urban-rural temperature contrast is 1-1.5°C in average; however, under clear, calm conditions, it can reach 6-8°C. In other words, the most significant feature of the urban climate is the turbulent heat exchange between the surface and the air, with significant surpluses during the whole year. Its peak is observed during summer due to decreased evaporation; a secondary peak occurs in January because of additional energy sources. Of these two reasons, the second is more powerful because of deeper atmospheric turbulence during the summer period (Problád, 1971); that is why the maximum of the temperature contrast happens in winter.

The elevated temperature in large cities is the most obvious feature of the heat island; other manifestations are a lower frequency of extremely cold spells in the winter and more frequent hot days in the summer. These extreme events may have significant bioclimatic consequences.

It is worth mentioning the air humidity as well, because it is an essential biometeorological factor. As a consequence of the usually high air humidity in winter, there is no frost in urban areas. The annual average of this (negative) anomaly is about 4-6 % with the lowest values during the summer months (Problád, 1974).

Another important meteorological factor which essentially acts on the quality of ambient air is its vertical hydrostatic stability (the property which, when high, restricts vertical mixing and deep convection). The stability of the surface layer determines the turbulent dispersion of the moisture and the pollutants emitted from the urban sources, so that it plays important role in urban air quality.

Air quality problems are rather severe in some areas of Hungary. This is especially true for certain parts of the capital. In polluted towns and in the heavily polluted districts of Budapest, pathological alterations characteristic of children occur four times more frequently than the average. The occurrence of adult chronic bronchitis is three times that of the average (Mérs, 1991).

The main polluters of the atmospheric environment usually are the energy sector, traffic, chemical factories and raw material production (cement or aluminum). As concerns the local sources of pollutants, the air quality of the capital is primarily determined by emissions from the energy sector (power plants, end users) and the rapidly increasing traffic. At present, these sources of air pollution are responsible for the release of about 410 kt of NOx (nitric oxide), 50 kt of SO2 (sulfur dioxide) and 280 kt of CO (carbon monoxide) to which must be added a significant amount of hydrocarbons and lead from vehicles (Bulla, 1991). 40-45% of emissions are of industrial origin, 30-35% is attributable to transportation (vehicles), and about 20% comes from residential heating. At present, the trend is for decreasing pollution from industry, but increasing contributions from traffic.

Eastern Europe is considered as one region where air pollution is rapidly increasing. Of course, there are significant differences in the environmental quality and the environmental policy among the countries of the region; that is the case air quality problems and the emission of greenhouse gases and other pollutants. One of the most important reasons of this situation is the low energy efficiency in the countries of the region (Chandler et al., 1990; KSH, 1987). Obviously, this is also related to the energy sources available and used in the given country. The relatively low use of solid fossil fuels in Hungary explains the relatively low emission rates as compared to some other Eastern European countries (Lévai
and Mészáros, 1989):

<table>
<thead>
<tr>
<th>Country</th>
<th>Annual CO₂ emissions (Mt-C) (1982, except '1987)</th>
<th>Gas Liquid</th>
<th>Solid Total</th>
<th>TC per capita</th>
</tr>
</thead>
<tbody>
<tr>
<td>Czechoslovakia</td>
<td>3.847</td>
<td>47.118</td>
<td>63.9</td>
<td>4.34</td>
</tr>
<tr>
<td>Former GDR</td>
<td>4.393</td>
<td>14.143</td>
<td>64.183</td>
<td>83.0</td>
</tr>
<tr>
<td>Hungary</td>
<td>5.395</td>
<td>7.984</td>
<td>10.545</td>
<td>23.9</td>
</tr>
<tr>
<td>Poland</td>
<td>4.833</td>
<td>10.813</td>
<td>96.337</td>
<td>112.0</td>
</tr>
<tr>
<td>Roumania</td>
<td>21.619</td>
<td>12.460</td>
<td>16.836</td>
<td>50.9</td>
</tr>
</tbody>
</table>

This problem is amplified in large cities during the heating season. The energy used for space conditioning by burning fossil fuels (primarily for heating) has increased to 30-40% over the last 30 years. It determines the higher releases of sulfur dioxide, methane, carbon-monoxide etc. More specifically, 1235 PJ of energy was used in Hungary in 1990, which is less by 8.3 PJ as compared to the theoretical potential of the coal deposits. The share of coal was 22.2% in 1990 (19.1% in 1989) and that of the natural gas was 28.3% (28.4%); the coal is mainly used for power generation ("far" from most city areas).

For climate impact studies, it is important to note that the directly climate-sensitive part of energy consumption is about 20 PJ/°C, which is a function of the average temperature for the heating season (Garbi, 1990). That part of the pollutant emission which is related to heating energy consumption in urban areas is usually expressed in terms of heating degree days (Szepesi, 1981).

Sulfur dioxide is considered as the common indicator of air quality. It is mainly released from burning fossil fuels. Consequently, the highest emissions usually occur during the heating season. Several decades ago the high sulfur content of fossil fuels should have been considered as the dominant reason for low air quality in Budapest. In the period of 1963-1968, the average sulfur content of the brown coal increasingly used for power generation was 2.0-4.5%, and that of oil was 1.0-2.8% (Probád, 1974). The latter is now much smaller but more than twice as much than that in Western Europe. Moreover, from the burning of these fossil fuels, high particulate emission occurs. During the indicated period, annually 250 kt sulfur was emitted from the capital. This resulted in the extremely high SO₂ concentrations in Budapest - 680 µg/m³ during 1928-1960. After this period, the share of natural gas rapidly increased and the SO₂ concentrations in annual average dropped to 270 µg/m³ (410 µg/m³ for the winter half-years) - observed values for in 1969-1971).

The sulfur content of the "local" brown coal remains relatively high, at an average of 2.2%. That of the oil imported from the Soviet Union is 1.6% (Kiss and Gajzák, 1988). Nevertheless, the measures taken to cope with pollution, namely: the limitation of burning coal with high sulfur content in the capital; decrease of the use solid energy sources import and use of more natural gas, has resulted in further significant reduction of the SO₂ concentrations to an average value of 13 µg/m³ in 1988 (Bulla,

1989). This expresses annual and area average, so that in certain parts of the capital and in certain periods, much higher concentrations are observed.

The problem of the sulfur dioxide (and some other pollutants) has also larger-scale aspects because of its transboundary transport and the role in forming the acid rain. By international convention, Hungary has committed to reduce overall SO₂ emissions; in this regard, the annual emissions in Hungary will have fallen from 1633 kt in 1980, to 1420 kt in 1985 with 1140 kt projected for 1995 as required by the convention.

Apart from energy consumption for air conditioning or industrial production, transportation is the other major source of pollutants in urban areas. This sector has had an extraordinarily rapid development over the last thirty years. Number of cars exceeded 100,000 at the beginning of the 1970s and was about half a million at the end of the last century. As concerns the fuel consumption, that decreased by 30% in 1989. As concerns the traffic development, it is characteristic for the majority of the internal combustion car engines, and even recently there is only a "symbolic" share of cars with low fuel consumption or catalytic converters. This has lead among other problems to rapid increases of the NOₓ emissions and because about one third of cars had two-stroke engines, it resulted in considerably higher hydrocarbon and formaldehyde emissions.

Transportation has become, in some cases, the highest source of pollutions for the last two decades; 45-50% of CO emissions, 40-45% of NOₓ emissions, and 90% of lead emissions originated from this sector in 1988. Due to the intensive car traffic, the air quality in the city and along the busy streets has worsened in recent years. Measurements at congested road intersections in Budapest demonstrated that concentrations of carbon-monoxide and lead exceed many times the permissible limits, while formaldehyde concentrations are beyond the permissible limits in half the measurements. (Hlinčik, 1989). Low fuel quality, lead emissions of vehicles and of lead and lead oxide into the atmosphere via the exhaust gas of transport vehicles, as well as emissions of carbon-monoxide and lead exceed the permissible limits.

The strike of taxi drivers at the end of October 1990 provided a very special "experiment" for the analysis of air quality and its anthropogenic sources in the capital. This three-day event, which began during the night of 25 October, froze the transportation in the heart of the city. According to measurements of the usual heavy traffic (e.g. Erzsébet (a) and Széna (b)), the anthropogenic "load" on the urban environment is overwhelming.
Daily total amount of pollutants

<table>
<thead>
<tr>
<th>Dates, Oct., 1990</th>
<th>(a)</th>
<th>(b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>26</td>
<td>27</td>
</tr>
<tr>
<td>26</td>
<td>28</td>
<td>28</td>
</tr>
</tbody>
</table>

SO\(_2\) (\(\mu g/m^3\))

<table>
<thead>
<tr>
<th></th>
<th>136</th>
<th>89</th>
<th>37</th>
<th>15</th>
<th>83</th>
<th>69</th>
<th>35</th>
<th>16</th>
</tr>
</thead>
</table>
| NO\(_2\) (\(\mu g/m^3\))
| 119      | 106 | 59  | 49  | 116 | 84  | 43  | 35  |
| CO (ppm) | 4.6 | 2.7 | 1.3 | 1.3 | 5.0 | 2.1 | 1.3 | 1.5 |
| Dust (\(\mu g/m^3\))
| 148      | 137 | 175 | 74  | 180 | 177 | 129 | 83  |

(Off course, the SO\(_2\) is not attributed to the vehicles.) The official (mandatory) emission norms are as follows: 150 \(\mu g/m^3\) for SO\(_2\), 85 \(\mu g/m^3\) for NO\(_2\), 5 mg/m\(^3\) for CO, 50 \(\mu g/m^3\) for soot.

Haszpára et al. (1991) pointed out that, besides the regularly measured air pollutants, releases of other materials provide also high concentrations. The primary sources of hydrocarbons in urban areas is the automobile traffic; aldehyde is also partially produced in the combustion of hydrocarbon fuels and indirectly in the atmospheric photooxidation of these fuels. The average concentration of the non-methane hydrocarbons (like ethylene, ethane etc.) usually reaches its maximum during the morning peak period for traffic.

The above-mentioned primary pollutants, under certain meteorological conditions, may be transformed to even more harmful materials or secondary pollutants. The most significant of these processes is that related to ozone and photochemical smog. Earlier, the occasional appearance of reductive (London-type) smog was the consequence of the accumulation of the sulfur compounds and soot in the air because of the ineffective heating technology and high sulfur-content of the energy sources. At present, the hazard of photochemical (or Los Angeles-type) smog, during the summer is more realistic. This is characterized by high concentrations of oxidants, primarily ozone, the precursors for which are the car-emitted NO, and hydrocarbons.

Toxic materials in the air lead to high exposure of persons to them especially along busy streets. This creates hazards to health. Lung damage, developmental problems for children, and connections to various diseases have all been demonstrated. There are 24 times more patients now suffering from asthma than two decades ago, and the number of those with lung cancer has doubled for that period. These are clear indicators of the worsening air conditions in Budapest. One of most dangerous pollutants is lead.

**IMPACTS OF CLIMATE CHANGE ON AIR QUALITY**

While the level of uncertainty in the specification of future climate scenarios for specific urban areas is high, the assessment of "second order" impacts of such change on air quality and human health is even higher.

Air quality at the most basic level concerns the composition of the atmosphere environment; the focus is usually on components that have adverse effects on people or their environment. It should be noted that greenhouse gases can be "pollutants" apart from their effects on the future. Other pollutants may have no greenhouse effect but affect air quality, perhaps by participating in photochemical reactions which lead to smog. Thus, any climate change which affects the emissions of pollutants can create a feedback mechanism.

The cycle of air-borne toxic materials is closely related to certain meteorological factors. It affects, among other aspects, their emission, chemical reactions, transmission, dilution, and dry or wet deposition. Climate change can thus affect pollution. Impacts can be categorized as to their effects on the chemical or the physical aspects of what happens to pollution in the atmosphere. As concerns the chemical aspects, apparently the most important point is that reactions will accelerate under the warmer conditions. In this respect, two processes may have significant consequences. On one hand, higher temperatures provide more frequent and intense formation of the from its precursors; on the other hand, the higher oxidation rate can contribute to the more intense formation of particulate matter (as sulfate aerosoles). If the intensity of the large-scale circulation changes with global warming, this could lead to more frequent and persistant periods during which pollution can linger over urban areas, stimulating more serious smog episodes.

The possibility of higher probabilities for the occurrence of smog of both types is emphasized by Antal and Baranolszky (1990): "With the growing frequency of anticyclonic situations smog peaks are expected to recur more often in the big towns, particularly in weather situations when weak air currents may lead to the development of 'cold-air-cushions'." The higher temperatures will contribute to these processes (IPCC-WG-I, 1990): "Global warming and increased ultraviolet radiation resulting from depletion of stratospheric ozone may produce adverse impacts on air quality such as increases in ground-level ozone in some polluted urban areas."

Changing climatic elements influence the emission of air pollutants, as well. The most climate-sensitive part of energy demand is that used for space conditioning. In Hungary, more than 30% of all energy consumption is used for residential heating and it closely depends on heating degree days (HDD) for the heating season (Ambros and Parágyi, 1988). The average temperature for the given period determines the HDD.

Since temperature changes influence energy consumption, and the anthropogenic emissions of hydrocarbons, NO\(_x\), and oxides of sulfur are directly related to the use of fossil fuels, it means that changes in emission rates depend on temperature changes.

Dilution of the polluting materials depends on the strength of circulation and turbulent diffusion. In this regard, three qualities of the urban atmosphere are important - the wind speed, the mixing depth and the vertical stability of the near-surface air column. In correspondence with the regional scenarios for the
Central European region, the possibility of reduced large-scale advective processes may result in reduced ventilation within the city. Of course, the direction of the local wind is also of significance; it determines the origin of the air arriving at the city and thus the pollution content.

High pressure synoptic patterns usually create favourable conditions for low level inversions, and the accumulation of pollution from local sources.

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DENVER, COLORADO’S CO₂ TRANSPORTATION STRATEGIES

by Steven Foute and Steven Andrews

The City and County of Denver has implemented several transportation-related activities which have an affect on reducing CO₂ and other greenhouse gas production. Over the course of the next two years, under the auspices of the International Council for Local Environmental Initiatives, the City will identify additional strategies which will be considered for implementation and then transferred to other cities. A discussion of each of these strategies follows.

IMPLEMENTED STRATEGY

A. Alternative Fuels Ordinance

In 1990, Denver passed a comprehensive alternative fuels ordinance which affects both public and private fleets. It stipulates that fleets with 30 or more vehicles, registered in the City, must convert at least ten percent of the gasoline-powered vehicles to alternative fuels by December 31, 1992. Exemptions are granted to emergency vehicles, those over 33,000 GVW, and diesel vehicles. However, a two-for-one credit is given when a diesel vehicle is converted. The definition of an alternative fuel is identical to that in the US Clean Air Act of 1990 and includes compressed natural gas (CNG), propane (LPG), methanol, ethanol, electricity, and others (the State of Colorado has approved ANGI conversion kits for CNG and LPG).

Alternative fuels have the potential to reduce greenhouse gases from the tailpipe, but it is arguable whether significant reductions are achieved when analyzed on a total fuel-cycle basis. For example, it is estimated that CNG enjoys a 20% advantage when compared to gasoline; however, it is only at the percent advantage over gasoline in total greenhouse-gas emissions. Hydrogen, on the other hand, were it to be produced from electricity generated from existing hydro capacity, would have negligible greenhouse-gas emissions. Hydrogen is being considered by Denver as an alternative fuel because staff are investigating a new blended fuel which is a mixture of hydrogen and CNG. Treated Hythane (HY for hydrogen and THANE for methane), it currently consists of 85% CNG and 15% hydrogen by volume. Initial Federal Test Procedure (FTP) results at three sites (one high altitude and two at low altitude) indicate that this fuel reduces hydrocarbons and nitrogen oxides as compared to CNG. Testing will continue through 1992.

In order to make the transition to alternative fuels easier and wiser for the fleets under this law, the City developed an alternative fuels evaluation program which ranks up to ten fuels according to 34 categories. The user has the ability to weight the categories according to personal, corporate or governmental preferences. Also, three discrete evaluation years and seven vehicles types make the program useful for any fleet; the
alternative fuels use either gasoline or diesel as a basis of comparison. The program is currently in use by the Governor’s Alternative Fuels Task Force in Colorado and has been presented to the U.S. Alternative Fuels Council for their consideration.

CO2 Impacts

It is estimated that 3500 gasoline vehicles will be converted to alternative fuels by January 1, 1993. Assuming that each vehicle is driven 15,000 miles per year, that all the vehicles are converted to run on CNG, and that the average efficiency is 18 MPG, the avoided CO2 would be approximately 29,000 tons.

PROPOSED STRATEGIES

A. Incentives for Proximity of Jobs to Housing

Reducing the number of vehicle miles travelled offers a substantial CO2 benefit. The method under investigation involves offering all new employees of the City and County of Denver a financial incentive in the form of a higher starting salary based on how far their residence is from their primary work site. The City and County of Denver desires to have its employees live within the city limits, and in fact has twice passed referenda requiring that all new staff live within the city limits. This alternative strategy has been devised because it is possible to live in Denver yet be further from one's job than if one lived in an adjacent community. If implemented, this incentive-based strategy might well replace the mandated residency requirement and still accomplish the stated objective of residency.

HYPOTHETICAL EXAMPLE OF PAY FOR PROXIMITY STRATEGY

Income Effect

Pay Adjustment as a Function of Distance from Work and Residency

<table>
<thead>
<tr>
<th>Residence from work</th>
<th>Residence in Denver</th>
<th>Residence outside Denver</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1 mile</td>
<td>+ 7.5%</td>
<td>+ 2.5%</td>
</tr>
<tr>
<td>≥ 1 &lt; 2 miles</td>
<td>+ 5%</td>
<td>Par</td>
</tr>
<tr>
<td>≥ 2 &lt; 5 miles</td>
<td>Par</td>
<td>- 2.5%</td>
</tr>
<tr>
<td>≥ 5 &lt; 10 miles</td>
<td>- 2.5%</td>
<td>- 5%</td>
</tr>
<tr>
<td>≥ 10 &lt; 20 miles</td>
<td>- 5%</td>
<td>- 7.5%</td>
</tr>
<tr>
<td>≥ 20 miles</td>
<td>- 7.5%</td>
<td>- 10%</td>
</tr>
</tbody>
</table>

These pay differentials are without regard to the transportation mode (e.g., bus, single occupancy vehicle, bike, carpool).

Housing Effect

In addition to the income effect, there is also a housing effect. As income changes, the ability to incur mortgage debt also changes. This consideration becomes very important for City and County of Denver workers, as housing closer to downtown is often more expensive than housing further out. The housing effect quantifies how much more home an increment in salary will purchase to offset increased housing expense.

Assume that a prospective employee was offered a $40,000 per year salary and chose to live between one (1) and two (2) miles from the worksite. The proximity adjusted salary would be $42,000. This amount to $167 additional each month. Assuming a tax rate of 20%, the net after tax dollar salary increase is $120 per month. Assuming the prospective employee was going to buy a residence at a 10% interest rate over 30 years, this person could afford $13,500 more in mortgage debt which should compensate for the additional cost of housing in the central business district.

Fiscal Impact on Denver

A program such as this could be designed to be "revenue neutral" for Denver. In determining the fiscal impact to Denver from such a policy, the City needs to consider indirect impacts, such as property and sales tax revenue, as well as the more direct impacts, such as the increase or decrease in employee compensation (which includes salary, retirement, fringe benefits etc).

B. Trip Reduction Through Ridesharing

Denver has drafted a trip-reduction ordinance which requires that businesses of a certain size reach a 35% rideshare goal within five (5) years. Ridesharing is defined as any method of commuting to work (alternative commute mode, ACM) in other than a single-occupant vehicle. Each employer must prepare a transportation management plan (TMP) which details how they will achieve the 35% goal. The rationale behind this strategy is that consolidating trips limits the combustion of fossil fuels, thereby reducing CO2 production.

The following table describes the time-frame which employers have

<table>
<thead>
<tr>
<th>Percent of employees for a particular employer currently using an ATM</th>
<th>Time frames (measured from date the transportation management plan is filed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 - 35%</td>
<td>2 years</td>
</tr>
<tr>
<td>25 - 30%</td>
<td>3 years</td>
</tr>
<tr>
<td>20 - 25%</td>
<td>4 years</td>
</tr>
<tr>
<td>Less than 20%</td>
<td>5 years</td>
</tr>
</tbody>
</table>
to reach the 35% goal. The timeframes are dependent on their current alternate commute mode percentages.

C. CAFE Standard for City Vehicles

During the coming months, Denver will propose a minimum CAFE (Corporate Average Fleet Efficiency) standard which would apply to the purchase of light-duty gasoline vehicles (LDGVs) used by the City.

The first step will be a complete analysis of the existing fleet. A certain number of vehicles have dedicated purposes - police, airport maintenance, fire, safety, etc. - which include certain performance minimums (e.g., acceleration by police vehicles). These may be exempted in the formulation of the language. The remaining vehicles will fall under the future CAFE standard.

The second step will be the establishment of target dates and mileage requirements for the CAFE standard. A starting point in this discussion will be the CAFE law passed by the Connecticut legislature during 1990.* The eventual determination of the standard will consider at least four issues:

1. Continuing discussions at the national level, between automakers and Congress, about revisions to the present CAFE standards (27.5 mpg for light duty gas vehicles);

2. Feasibility assessments by Denver municipal fleet operators;

3. The establishment of a CO, equivalency between alternative fuels and minimum miles per gallon, and trip reduction; and

4. Compatibility with a CAFE standard which the State of Colorado is considering.

*Connecticut House Bill 5696, Public Act 90-219: "(a)Any car or light duty truck purchased by the state shall have a manufacturer’s estimated mileage rating as follows: On and after January 1, 1993, at least 29 miles per gallon combined gas mileage for cars and at least 24 miles per gallon combined gas mileage rating for light duty gas trucks; on and after January 1, 1997, at least 30 miles per gallon combined gas mileage rating for cars and at least 30 miles per gallon combined gas mileage rating for light duty trucks; and on and after January 1, 2000, at least 45 miles per gallon combined gas mileage rating for cars and at least 35 miles per gallon combined gas mileage rating for light duty trucks."

D. Education

The City and County of Denver proposes to initiate a public education campaign to inform its citizens on the steps they can take to reduce CO2 emissions through various transportation strategies.

The National Audubon Society has published a CO2 Diet Worksheet which we feel will be valuable in communicating this new environmental issue to the residents of Denver. In addition, the City is working with the American Lung Association of Colorado in producing a 1992 Clean Air Calendar. Entitles "Celebrating the Art of Clean Air", the calendar will have several CO2 messages as well as action strategies. This calendar will be distributed to over 50,000 people state-wide. Finally, the City intends to include greenhouse gas information in its public relations efforts such as school visits, brochures, etc.
THE SUBURBAN DILEMMA

REGIONAL TRANSIT ISSUES
AND THE GLOBAL ENVIRONMENTAL CRISIS

by Dale Martin

The problem of global warming means that, over the next ten years, Metropolitan Toronto and all other large North American cities will have to adopt plans to achieve a 60% reduction in the current level of greenhouse-gas emissions, if global mean temperatures are to be stabilized at levels slightly higher than today.

The transportation sector is a major contributor to the problem and must, therefore, achieve reductions, at least proportional to its relative impact. In Toronto, where transportation accounts for around 30% of CO₂ emissions, the reduction has to be achieved in the context of on-going population growth of greater than 3% annually. Over the next twenty years, the population of Metro Toronto and the four surrounding regions is expected to grow from today’s 3.5 million to 6 million persons. Added to this is an upward trend in per capita consumption of fossil fuels and thus, greenhouse-gas emissions. As a result, policies aimed at drastically cutting emissions by 60% over 1990 levels mean an unprecedented scale and rate of change for Toronto.

At current fuel efficiencies and occupancy levels, private autos have a per capita impact between 10 and 20 times greater than electric-powered public transit. Predictably, under these circumstances, the modal shift needed to achieve the necessary greenhouse-gas reduction of 60% would be dramatic. At the existing modal split of 80% auto to 20% public transit, and with existing automobile performance, the pattern of usage would have to be reversed to 20% auto and 80% transit to achieve the needed reduction.

With major improvements in fuel efficiency (to an average 10 litres/100 km) and occupancy (4 persons per auto) the automobile’s CO₂ impact could be reduced to just 5 times that of transit. Even with these improvements, in themselves difficult to achieve, the new overall modal split required would be 45% auto and 55% public transit.

The reality is that there are many barriers to implementing the dramatic changes needed to the way we transport ourselves. Although technological changes and alternate fuels will play a role, reductions in the frequency and distance travelled and shifts to low energy/water transport modes will ultimately determine success or failure. In this respect the single greatest barrier to meeting the goal for the transportation sector is suburbia.

THE SUBURBAN PROBLEM

Density, more than any other word, describes the problem posed by this most distinctive form in the North American city. Suburbia is simply too underpopulated to be sustainable. The fact of suburbia partially explains North America’s exceptionally high consumption of petroleum products and consequently its over-consumption of the globe’s environmental resources. Similarly, the fact of suburbia makes tackling environmental problems, in particular global warming, that much harder.

Although not an extreme example of the suburban city, Metropolitan Toronto faces significant problems as a result of urban sprawl. These problems must be solved if the environmental challenge is to be tackled, and if a broad range of other persistent difficulties, including social and economic problems, are to be overcome.

SUBURBIA NO LONGER POSSIBLE

The suburban form of urban development has no future. It is simply not a viable urban form in either economic or environmental terms. The lack of a coherent neighbourhood form and the large operating and capital subsidies necessary for suburbia to survive make it financially and organizationally difficult to achieve a broad range of social, economic, and local environmental objectives. In addition, the extremely high dependency on the automobile as a way to get around means excessively high per capita fossil fuel consumption and thus, air pollution and greenhouse gas emissions. It is simply inconceivable that the environmental challenges we face can be met without stopping the spread of new suburbs and without rapidly transforming those that already exist into higher density urban communities through redevelopment and intensification.

This is largely true because of the importance of sustainable transportation strategies to achieving the overall environmental objectives. Sustainable urban transportation strategies provide the means to achieve reduction goals and, in so doing, define the criteria for future urban development.

URBANIZATION AND PUBLIC TRANSIT

The Metropolitan Toronto Planning Department, among others, estimates that public transit systems require residential population densities of 4,000 persons per km² to be viable, while a rapid transit route requires 6,000 persons per km². As the final column in Chart 1 indicates, suburbia is underpopulated to the point that even high population growth (greater than 60% of the total increase) confined to the existing suburban area, falls to achieve general population densities high enough to support transit. This very important fact must shape future decisions about where population growth must be directed.
suburbia must be redeveloped and intensified thereby creating the opportunity for a more complete range of services and activities within suburban neighbourhoods. This would allow viable options to the car to emerge.

**SUBSIDIZING SUBURBIA**

The links between financial and environmental sustainability are important to explore. Little has been said about the massive public subsidies needed to support the suburban lifestyle. Although sprawl is often justified as necessary to provide lower-priced housing on cheaper suburban land, the real fact is that the general public subsidizes these lower house prices. A large number of examples are available to make this case, including the subsidy to private auto use estimated to be as high as 75% of total cost. But, for these purposes, a comparison of subsidy levels between commuter and urban transit systems is very revealing.

**Chart 2: GO Transit (serves the outer suburbs and more distant communities with persons who work in Metro)**

<table>
<thead>
<tr>
<th></th>
<th>1986-87</th>
<th>1988-89</th>
<th>1990-91</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cost per Passenger</td>
<td>$4.01</td>
<td>$4.00</td>
<td>$4.49</td>
</tr>
<tr>
<td>Subsidy per Passenger</td>
<td>$1.82</td>
<td>$1.49</td>
<td>$1.81</td>
</tr>
</tbody>
</table>

**Chart 3: Toronto Transit Commission (serves the centre and inner suburbs)**

<table>
<thead>
<tr>
<th></th>
<th>1986-87</th>
<th>1988-89</th>
<th>1990-91</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cost per Passenger</td>
<td>$1.522</td>
<td>$1.528</td>
<td>$1.589</td>
</tr>
<tr>
<td>Subsidy per Passenger</td>
<td>$0.423</td>
<td>$0.447</td>
<td>$0.446</td>
</tr>
</tbody>
</table>

The suburban commuter using GO Transit is subsidized at a rate more than 4 times higher than a comparable rider on the TTC. This means an additional public subsidy over and above that for the regular transit user of $546 per year, per commuter. While this subsidy is much lower than that given to an auto user and much more desirable environmentally, it underlines the point made above. There is a real and significant financial cost to the general public to support the suburban lifestyle. It also points to a very real limitation on our ability to act – and act decisively – in the face of the environmental challenge. While we need to shift large numbers of commuters out of their cars and on to public transit, the subsidy premium needed to service suburbia in this limit the price at which the shift might occur and consumes resources that could be used elsewhere.
There is, therefore, a very real dilemma with respect to expanding the commuter shed. Any attempt to move toward servicing an ever larger area with public transit means a dramatic upswing in subsidy levels. This is revealed by the $0.39 per passenger increase in subsidy (almost equivalent to the total TTC subsidy of $0.44) between 1989-90 and 1990-91 caused by GO Transit adding three new routes to more distant, less dense areas in Barrie and Georgetown. As the GO Transit figures show, the cost of moving people longer distances from lower-density communities is prohibitive and takes away from our ability to invest in more productive forms of transit. Simply put, the "commuter shed" must be clearly established and steps taken to discourage movement from outside its limits. At a minimum, transportation subsidies to both transit and the auto should be eliminated.

**INTENSIFICATION AND REDEVELOPMENT**

It is clear that the only environmentally and economically sustainable future is one of redevelopment and intensification within the existing urban envelope.

Intensification is a precondition to the dramatic expansion of rapid transit throughout the broader region, which is needed to respond to the environmental imperative by providing the financial means to pay for the expansion and sustain the routes.

Contrary to conventional wisdom, however, this does not mean the concentration of most future growth within Metropolitan Toronto itself. To do so would doom the existing suburban areas to a perpetually unsustainable existence, one that would be an additional and probably insurmountable burden in the drive for sustainability. As Chart 1 above demonstrates, the centralization of population growth would leave 2.2 million people in the four regions around Metropolitan Toronto, in communities with populations well below the minimum needed for a viable public transit service. This can only mean a future of huge public subsidies to shift commuters from cars to the rail portion of GO Transit, continued dependency on private autos for most non-work related trips, and thus, little progress toward significantly reducing air pollution and greenhouse-gas emissions.

**Urbanizing Suburbia**

The most useful strategy is one in which the bulk of the population growth (minimum 60%) occurs outside of Metropolitan Toronto's boundaries, but is restricted to the already built-up areas of the four suburban regions surrounding Metro. If done strategically, this urbanization of suburbia would allow population densities to develop which could sustain public transit within suburbia itself. In addition, the fundamental redevelopment of suburbia that is required to accommodate this population growth would allow existing communities and neighbourhoods to be "completed" with a full array of retail, social, health and recreation services. This combination of viable transit within suburbia and the completion of communities is the only way to deal with the problem of both employment and non-employment related auto dependency. It is also the only way to imagine a huge modal shift to a more environmentally benign transportation system without an impossibly large financial subsidy.

Metropolitan Toronto has taken the first step by calling for an immediate freeze on all development outside of the already built-up urban area in the four regions surrounding Metropolitan Toronto. Once this is done, it is possible to begin taking the tough strategic decisions that must be made if sustainability is to be reached.

The size of the commuter shed must be established and subsidies to commuter travel reduced and then eliminated. Important land-use planning decisions must be made to direct population growth and neighbourhood development throughout suburbia. Within Metropolitan Toronto, plans of the same sort must be made to ensure that population growth is encouraged in areas of strategic importance, thereby allowing the expansion of the rapid transit system by linking land-use planning, population growth and service planning, suburbia can be transformed. Then, and only then, does it become possible to imagine a transportation system that is sustainable and that contributes fairly to the overall objective of a 60% reduction in emissions of greenhouse gases.
Part 4.3

MUNICIPAL RESPONSES

Cities and Global Warming

by

Richard Gilbert

Climate Change Policies in Finland

by

Teemu Virtanen

Experiences with the Concept of CO₂ Reduction in the City of Saarbrücken

by

Jurgen Lottermoser

The Program of Hannover, Germany

by

Hans Mönninghof

RICHARD GILBERT

Mr. Gilbert is a Metropolitan Toronto Councillor, completing the last of six terms as a municipal politician. Later this year, he will become the full-time President of the newly formed Canadian Urban Institute, which is concerned with training, information exchange, and research on all aspects of the management of large urban areas.

TEEMU VIRTANEN

Mr. Virtanen is a member of the Helsinki Metropolitan Area Council. He has a special interest in energy use and greenhouse gas emissions, and is knowledgeable about Finnish federal policies on climate change.

JURGEN LOTTERMOSER

Dr. Lottermoser is with the Energy and Environment Section of the city of Saarbrücken, Germany. Since 1981, his work has focused on the rational use of energy by the municipality. Before that, following receiving a Doctorate in Physics, he worked for a decade in the field of non-destructive testing.

HANS MÖNNINGHOF

Mr. Mönninghoff is Head of the Department for Environmental affairs for the City of Hannover, Germany. The department's responsibilities include urban environmental planning and environmental compatibility testing, monitoring of water, management, and emissions into the air, pollution clean-up, operation of sewage treatment plants, protecting nature and maintaining the city's woodlands. He was a member of the Parliament of Lower Saxony 1986 to 1989. Trained as an engineer, before his election he managed a non-profit organization concerned with development and education in energy and environmental protection.
CITIES AND GLOBAL WARMING

by Richard Gilbert

This paper is in three parts. The first part sets out the context for considering local government actions with respect to prevention of and preparation for enhanced global warming. The second part comprises brief notes on some relevant activity in six North American urban regions. The third part briefly draws some conclusions. Footnotes appear after the third part.

The Context

This part of the paper first considers the challenge facing cities in industrialized countries with respect to carbon dioxide emissions and global warming. It then provides a hierarchy of styles of response of municipalities to environmental issues and ranks actions that can be taken by local governments to reduce CO₂ emissions. Finally, the importance of residential density is highlighted.

The Challenge

Human activity, chiefly the burning of fossil fuels, is raising atmospheric levels of radiatively active gases, chiefly carbon dioxide. These gases absorb the energy of the sun once it has been reflected from the earth and maintain the temperature of the earth's surface at 33°C above what it would be if there were no atmosphere. The so-called greenhouse gases thus make life possible.

For some 160,000 years before 1750, the atmospheric CO₂ level had varied within the range of 180 to 300 parts per million. Since 1750, it has risen from 280 to above 350 parts per million and it is rising at the rate of 1.8 parts per million per year.³

Continued increases in emissions of radiatively active gases at current rates will raise the average temperature of the surface of the earth by between 2°C and 5°C during the 21st century.³ Catastrophic consequences have been predicted, including inundation of coastal cities and desertification of the Prairies.³

A broad consensus of atmospheric scientists and other experts has concluded that overall cuts of 50-60% are needed to stabilize atmospheric CO₂ levels and prevent further increases in global temperatures beyond those committed by the last two centuries of industrial activity.³

The population of the world is due to rise by 33% during the next 20 years, from 5.3 to 7.1 billion, with almost all of the increase taking place in countries in the South (also known as the developing countries or the Third World).³

A 50-60% cut overall by 2011 will thus require a 63-70% cut per capita overall, and an 85-97% cut per capita in industrialized countries if global warming is to be stopped and if countries in the South are not to be forced to reduce their fossil fuel use and resulting emissions even below their present low levels.

Countries in the South account for about 30% of CO₂ emissions, but per capita emissions in these countries average only about 10% of per capita emissions in industrialized countries.³

Thus, if the challenge is to reduce per capita emissions in industrialized countries by some 90%, in order to prevent catastrophic global warming, the goal of development programs should not be to make the South more like the North (which is usually what development is said to be about) but, in important ways, to do the reverse, i.e., to reduce per capita emissions in the North to the levels in the South.

For cities in the North, the challenge is not necessarily to make them like the megalopolises emerging in the South (even though the megalopolises may be better for the planet than the energy-guzzling conglomerations of the North). The challenge is to retain as far as possible the comforts and conveniences of the North while steadily working to achieve the low level of per capita CO₂ emissions caused by residents of cities in the South.

Table: Styles of response by local government to the environment

<table>
<thead>
<tr>
<th>Styles (1-5)</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Float the law</td>
<td>Discharge raw sewage; use illegally polluting vehicles.</td>
</tr>
<tr>
<td>2. Merely obey the law</td>
<td>Do no more, or less, than is required.</td>
</tr>
<tr>
<td>3. Set a good example within administration</td>
<td>Intra-office recycling; use natural gas vehicles.</td>
</tr>
<tr>
<td>4. Advocate within jurisdiction</td>
<td>Encourage reduction, reuse, and recycling; promote transit and district heating.</td>
</tr>
<tr>
<td>5. Legislature within jurisdiction</td>
<td>Ban certain materials at landfill sites; local restrictions on automobile use.</td>
</tr>
<tr>
<td>7. Seek new legislative authority</td>
<td>To tax automobile ownership; to ban sale of items made with CFCs.</td>
</tr>
<tr>
<td>8. Legislature outside jurisdiction</td>
<td>Ban sale of items made with CFCs; ban use of many kinds of packaging.</td>
</tr>
</tbody>
</table>
TABLE 2: Effectiveness of local government in reducing CO₂ emissions.

<table>
<thead>
<tr>
<th>Class of activity</th>
<th>Actions to reduce CO₂ Effectiveness</th>
<th>(1 is strongest)</th>
<th>(1 is weakest)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation</td>
<td>1. Shift to transit ✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Reduce number and length of trips ✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Buildings</td>
<td>1. Improve efficiency of envelope –</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Improve fuel efficiency ✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Increase density of occupation ✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Reduce heat production –</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Manufacturing</td>
<td>1. Reduce consumer demand for new products –</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Improve fuel efficiency –</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Reduce and recycle ✓</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

The importance of residential density

Table 3 suggests that a large factor in CO₂ emissions from transportation is residential density, over which local governments usually have considerable control. Indeed, increasing residential densities can be made by local government to reducing CO₂ emissions.

When residential densities reach 4,000 per square kilometre over a wide area, the area can be served efficiently by a surface transit system. By mass transit (e.g., subway trains) becomes feasible, if there are also nodes of higher density at transit stops.4

Raising commercial, industrial, and institutional densities, and thus raising employment densities, may have much less impact than raising residential densities. Increasingly, trips within urban regions are to and from home rather than to and from work, and thus the place of residence is a stronger determinant of mode of transportation than the place of employment. Moreover, employment is more compatible with efficient public transportation than the reverse.

Local governments would be wise to consider now how urban sprawl, which is the predominant form of development in North America (and increasingly elsewhere) might be compatible with the disappearance of personal transportation. If the need to achieve massive reductions in per capita CO₂ emissions in the industrialized countries of the North is confirmed, less essential uses of fossil fuels, including driving cars in cities, will have to be restricted. Thus the disappearance of the private automobile during the early part of the 21st century should be considered a possibility.

Local governments in the North, as they lay down the municipal infrastructure now for the next several decades, should take the possibility of the disappearance of the private automobile into account.

Notes on relevant activity in six North American urban regions

The notes provided here are extremely cursory and mostly subjective. They should be considered as no more than a spur to substantive work.

Chicago

The urban region of 8 million comprises the City of Chicago, population 3 million, residential density of urbanized area 5,100 per square kilometre, and more than 250 other municipalities, total population 5 million, density of urbanized area 1,230 per square kilometre, overall perhaps the lowest residential density of any urban agglomeration in the world.

The region is said to be choking on growth. But although an authority to oversee planning for orderly growth and its traffic impact is essential, things are going to have to be even worse before something is done: "gridlock is preferred to more government" said one planner.

Increases in the population of the City of Chicago, in order to achieve a more efficient urban form that is less dependent on the automobile, not considered acceptable.

The federal Clean Air Act (1990) mandates reductions in vehicle miles travelled in the Chicago region, but the institutional
About environmental issues since the convulsive local elections there in 1986 that led to the replacement of most of the members of the City of Montreal Council and, consequently, most of the Council of the Montreal Urban Community. (The November 1990 elections produced little further change.)

In April 1990, the City of Montreal issued a list of 98 environmental initiatives being undertaken by the City. None of them is specifically directed towards global environmental concerns, but many—energy conservation, for example—would nevertheless help.

The Montreal Urban Community has recently moved in two directions that could contribute to the prevention of global warming: to establish and reinforce urban forests; and, to act to counter sprawl by intensification of the region’s population within the Community.

New York

New York City has a population of 7 million and a residential density of the urbanized area of over 10,000 per square kilometre—among the highest in the world for a concentration of more than 5 million people. By contrast, the more than 9 million people who live in the remainder of the New York region live at a density that is almost as low as that of the region surrounding Chicago, 1,290 persons per square kilometre.

About 35% of all journeys by public transportation in the United States are made in New York City, which has less than 3% of the U.S. population.

There is considerable sensitivity to global environmental issues at the local level in New York, but little inclination to act on account of the gravity of more pressing problems, notably the imminent bankruptcy of the City of New York.

A move to ban materials made with CFCs was stalled when it was discovered that there was little to ban.

A strong policy in place concerns the use of alternate fuels for municipal vehicles. Now, 30-40% of new vehicles use alternate fuels, mostly natural gas; there are attempts to avoid leakage on account of the contribution of methane to global warming.

Air conditioning is receiving increasing attention on account of the electricity use for it and the escape of CFC-based coolants. It is being addressed by encouraging evaporative systems and steam-driven systems.

Toronto

The 1990 population of the urban region was almost 4.0 million. Its
The region's population is expected to increase by 50% by 2021. Without intervention, most of it will be housed in the outer suburbs at densities similar to those that presently prevail. Consideration is being given to accommodating most of the increase within the core and the inner suburbs.

Local government in the Toronto region is paying attention to global environmental issues. The government of the City of Toronto (population 2.5 million, entirely within the "core" described in Table 3) may have been the first local government in the world to commit itself to meeting the target set in Toronto in 1988 at the Changing Atmosphere conference: a 20% reduction from 1988 levels of carbon dioxide emissions by the year 2005.

The target was adopted for the whole community, and adopted notwithstanding an expected increase in the City's population by some 15% by 2005. The target was to be met by creating an offsetting carbon sink through reforestation of an area of Central America. The second report of the City's Special Advisory Committee on the Environment shows how the target can be achieved without the need for reforestation.

The Metropolitan Toronto Council (the regional government, responsible for regional matters in the "core" and "inner suburbs" described in Table 3) has agreed to "establish targets for reducing per-capita fossil fuel consumption and ensuring that development and transit plans support targets to reduce global warming."

Both governments are involved in the investigation of Deep Lake Water Cooling, which would use the huge source of water at 4°C below 80 metres in Lake Ontario to cool buildings in and near downtown Toronto, replacing chillers that consume twelve times more electricity than would be needed to pump in the cold water. The chillers would leak coolant fluids that make a greater contribution to the greenhouse effect than the CO₂ from the fossil fuel used to generate the power for the chillers.

Vancouver

The urban region has a population of some 1.4 million. At the centre is the City of Vancouver with a population of 425,000 and a residential density of 3,570 per square kilometre. The density of the remainder of what is known as the Greater Vancouver Regional District is low; firm figures are not available.

In 1990, the City of Vancouver adopted (with amendments) a far-reaching report entitled Clouds of Change, the work of a task force established in response to the threat of global warming. The Council added several qualifications, some significant in terms of the conditions attached to particular proposals, but essentially left the report and its recommendations intact.

The fundamental recommendations were that the City should act to reduce the carbon dioxide emissions throughout the City of Vancouver by 20% from the 1988 level by 2005, and to ban the use, sale, and manufacture of ozone-depleting chemicals, notably CFCs. The City has also undertaken to raise the average vehicle-occupancy rate from 1.30 to 1.75 persons per automobile, in part by implementing differential parking rates.

Other measures adopted include; pushing for a regional agency like the SCAGMID in southern California; accelerating the use of methane gas from landfill sites; promoting telecommuting; promoting residential intensification; introducing an energy conservation by-law for buildings; encouraging and securing urban reforestation.

A significant adopted proposal requires the city administration to move towards preparing annual reports on vehicle emissions in Vancouver and the extent to which private transportation is subsidized.

Conclusions

The potential for catastrophe through climate change is great, as is the contribution that local and regional governments and governmental agencies can make to the prevention of and the preparation for climate change. Increasing residential densities and reducing automobile dependence are potentially the areas of greatest impact, but actions can also be taken with respect to energy use in buildings and in the production and consumption of goods that could become waste.

There appears to be large variation in the attitudes and responses of local governments and local governmental institutions across North America to the threat of climate change. Systematic data are not available. They should be developed, and the widespread adoption of policies and programs with respect to climate change should be encouraged.

Notes:

1Inquiries to the author at Canadian Urban Institute, 2nd Floor West Tower, City Hall, Toronto, Ontario M5H 2N1, Canada. Tel. (416) 392-0082. Fax (416) 397-0276.
3See Footnote 1. See also the paper by Barry Smfit in this volume. The United States Environmental Protection Agency has argued that overall cuts in CO₂ emissions of 50-80% may be required to hold atmospheric CO₂ levels constant.
Climate Change Policy in Finland
by Teemu Vitanen

Background
Finland is situated between latitudes of 60° N and 70° N. We have a common borderline with Sweden, Norway and the Soviet Union (figure 1).

The total area of Finland is about 340,000 km². 70% of the total area is covered by forests, 10% by water (no doubt Finland is the country of thousands of lakes), 9% by tundra, 8% by agricultural land and only 3% by constructed urban areas. The total population of Finland is about 5,000,000, which is one third of the world’s population living north of 60° N.

The Helsinki Metropolitan Area is a co-operative unit of four cities; Helsinki, Espoo, Vantaa and Kauniainen. The total area of HMA is 743 km² and the population is 820,000.

The annual mean temperature in the area is +5.4°C. The lowest daily mean temperature ever measured, -32.5°C, was recorded in January 1987.

In winter, we have eighteen hours of dark daily, and in the summer we have 20 hours of light daily. As you can imagine, we need a little warmth and light in our lives at least in wintertime. In short, we need energy.

Energy Usage in Finland and in Helsinki Metropolitan Area

Finland

The domestic fossil energy resources of Finland are very limited. We don’t have coal, oil or natural gas, only peat.PEAT COULD BE DESCRIBED AS SEMI-FOSSIL FUEL, BUT IT IS DEFINITELY NON-RENEWABLE IN ANY REASONABLE TIME SCALE.

Approximately 35% of Finland’s energy needs are met by domestic supplies of hydropower, wood processing wastes, wood and peat. Almost 20% of the total energy consumed is derived from imported coal and oil. Nuclear energy provides some 15%.

Both per capita and per unit of GNP, the energy consumption is considered to be relatively high. The climate, the size of the country, and the structure of business and industry can be considered the main factors influencing energy consumption.

One fourth of the energy consumption is spent on heating of buildings, while industry accounts for nearly 50% of total final energy consumption (picture 2). The products of forest based industry, the most energy intensive industry, account for 40% of total export.
Helsinki Metropolitan Area

The Helsinki Metropolitan Area differs quite a lot from the rest of Finland because of the lack of heavy industry. Industry accounts for less than 10% of final energy usage, while services and public consumption accounts from more than 25%, as you can see in figure 2.

The energy balance of the city of Helsinki is shown on figure 3. First thing to notice is the very great share of combined heat and electricity generation. More than 85% of all homes at Helsinki Metropolitan Area are connected to district heating networks (total in Finland is about 35%). Nearly all district heat is produced in combined heat and electricity plants. Combined plants account for 75% of all electricity used in the area. Because of this the energy efficiency in urban areas is exceptionally high. On the other hand, the opportunities to decrease the energy demand and to decrease the CO₂ emissions by intensifying combined heat and electricity production or district heating are limited. Only possibilities are to decrease energy demand and/or change from coal to less harmful fuels like natural gas.

Climate Change Policy in Finland

In 1990 the government prepared a report of current and planned national activities concerning sustainable development. This report was submitted to the Parliament in fall 1990. The report discusses climate change as the most important environmental issue for the future. This was the first time that the Parliament discussed the climate change issue.

In the beginning of November 1990 the government established a commission for elaborating policy to control greenhouse gas emissions in Finland. The commission will give its report in June 1991. The report has not come out yet. The work of the commission is the first step in preparing a detailed national greenhouse policy in Finland.

Finland expects that it will experience large effects from climate change. The country is situated in the area where temperatures are expected to rise strongly, especially in winter. The effects will be felt most strongly in the forestry section and in the winter tourism sector.

For the basis of the committee work, there has been a lot of research going on. Reports like "Greenhouse Gas Emissions from Energy Production and Consumption in Finland" have revealed many useful aspects about our greenhouse gas emissions.

There are three major greenhouse gas emitters in Finland. Industry with a share of 35%, heating of buildings with a share of 31% and traffic with a share of 25%. The first two out of three are easy to guess but the traffic's big share is a surprise and I am quite sure that it will be among the firsts going under more detailed inspection in the Helsinki Metropolitan Area also.
Figure 2: Energy consumption

Figure 3: Energy balance for Helsinki in 1991
I find figure 4 even more interesting. There are the greenhouse-gas emission factors for different fuels. These figures contain the emissions from combustion, the production of fuel, the transportation and the effect on carbon cycle in nature. In short, it contains the whole energy cycle. And what can you see? Wood can be the best but also the worst of all fuels. It depends on how you burn it. Biomass burning in small fireplaces seems to be very problematic in many ways and still this is the way how most people in this planet meet their energy needs. The production of energy is still only one part of the problem. That is why I would like to warn not to concentrate too much on one substance like CO₂, but to figure out total effects of different activities.

On urban level, we will have to build a local urban greenhouse gas management system. The first goal of this task is to provide local urban planners and decision makers with a reliable information system on greenhouse gas emissions. The second goal is to create practical evaluation methods for considering the effects of different planning solutions on greenhouse gas emissions.

Traditionally the contacts of our cities with another cities in the field of international environmental affairs has been very limited. So far most meetings have been arranged in governmental level. It is very good that this barrier is now breaking down. Cities and communities will always be those who put any international agreement and restrictions of emissions in practice. The real work and adaptation to new policies will be done in community level.

![Figure 4: Greenhouse-gas emission factors for the total fuel cycle from energy production](image-url)
EXPERIENCE WITH AND CONCEPTS OF CO₂ REDUCTION IN THE CITY OF SAARBRÜCKEN

by Jurgen Lottermoser

Introduction

The city of Saarbrücken has 190,000 inhabitants. The climate is relatively cold (49° latitude). Normally, buildings need a lot of heating energy, without any demand for cooling. The public utility company (Stadtwerke) is working as an integrated energy-service company, distributing gas, district heating, electricity and water.

The city of Saarbrücken had no special CO₂-reduction program in the past, but an energy reduction program has been in place since 1980. This program was instituted mainly by the Stadtwerke, but with support from the civic Department for Energy and Environment for the communal buildings of the city.

Experience 1980 - 1990

During this 10-year-period the Stadtwerke enlarged the system of district heating and for gas supply considerably. A rough estimation of the CO₂ emissions leads to a reduction of at least 15% during this period for heating and generation of electricity, without consideration of traffic.

The heating energy for the communal buildings was reduced by 39% between 1980 and 1990. The corresponding CO₂ emissions were estimated to have dropped by 52%. Overall, CO₂ emissions for heating and electricity reduced by 37% during these 10 years.

Concept for the CO₂-Reduction-Program

An overview is given in the following table of actions, schedule and expected results for phase I of the Saarbrücken program as a "International Council for Local Environmental Initiatives" (ICLEI). The phase I has a duration of 2 years.

The two first topics are of high importance for the city of Saarbrücken and are explained in more detail below. The last three topics are of less importance for the CO₂-reduction program, even points of view.

The first topic will be realized by the Stadtwerke. There are 3 main points for this work:

- Mobilisation of Retainable Energy

For the Stadtwerke, as an energy service company, this includes a large variety of consultation assistance. It is very important to give detailed information to the users to convince them of the possibilities of energy-savings. It

<table>
<thead>
<tr>
<th>Action</th>
<th>Targets</th>
<th>Expected outcomes in Phase I</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Reduction of greenhouse effect by local energy management Project</td>
<td>30% reduction of CO₂ through energy conversion by 2005</td>
<td>4% reduction of CO₂ within 2 years</td>
</tr>
<tr>
<td>2. Reduction of energy use in public buildings</td>
<td>Reduction by 48% of CO₂ from 1980 values by 2000</td>
<td>40% reduction of CO₂ from 1980 values</td>
</tr>
<tr>
<td>3. Reduction of individual traffic</td>
<td>20% reduction of CO₂ caused by traffic by 2000</td>
<td>10% reduction in gasoline</td>
</tr>
<tr>
<td>4. Rehabilitation of industrial buildings and tree planting</td>
<td></td>
<td>absorption of an additional 46 kt CO₂ than in 1975</td>
</tr>
<tr>
<td>5. Reduction of waste</td>
<td>50% reduction of waste by 2005</td>
<td>5 to 10% reduction within 2 years</td>
</tr>
<tr>
<td>6. Ecologically-oriented providing</td>
<td>Use of recycled and recyclable materials</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Saarbrücken plans for the ICLEI Urban CO₂ Reduction Project

includes also financial assistance, because sometimes the lack of finances is stopping new initiatives for economic investments in energy savings or the use of renewable energies.

- Better Exploitation of Energy

This is the "normal" work of a public utility company and includes cogeneration (today, 400 MW of district heating are purchased), gas supply, mainly for heating, and innovative technologies (e.g. pressurized fluidised bed combustion)

- Renewable Energies

This program consists of technical and financial aids for all renewable energies. Mainly this work consists of the program which is termed "1000 kW of Solar Power from the Roofs of Saarbrücken". This program makes the user also a producer of
energy, and the Stadtwerke is assuming the role of distribution of electricity. The produced solar electricity is purchased by the Stadtwerke at the same rate as it is sold to the consumer.

The given targets in the table above are based on the experience in the past and on special programs for enlarging the district heating system.

For the second topic "Energy Use in Public Buildings" it is easier to give estimates of target dates because the owner of these buildings is the municipality, and many details are well known. For the public buildings and installations, the present status is:

- Energy management is already working, based on a computer system which calculates the energy consumption for all the buildings each month.

- The running program for the modernisation of heating devices includes the change from coal or oil to district heating and gas heating. During phase I this will result in a reduction of CO₂-emissions by 1600 t/yr.

- Electricity use will be reduced by:

  - replacement of electric heating systems (3% in 1990) by gas heating
  - replacement of lighting systems with reduction of energy consumption of up to 50%
  - reducing the running times of ventilation systems, pumps... (During phase I this will result in a reduction of CO₂-emissions by 400 t/yr).

  - Insulation of buildings with typical u-values of .2 to .3 W/m²K and new panes with u = 1.3 W/m²K. During phase I this will reduce CO₂-emissions by 150 t/yr.

  - Renewable energies will be used more intensively:
    - Installation of 2 new solar plants for open air swimming pools (2 plants are already working).
    - Test of the use of 2 Solar Cars, this means small electric cars for the use in the city over short distances, the electricity is generated by solar photovoltaic systems.
    - Construction of a solar plant for a hot-water-system in an indoor swimming pool.

The use of renewable energies will reduce the CO₂ emissions during phase I by 160 t/yr.

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THE PROGRAM OF HANNOVER, GERMANY
by Hans Mönninghoff

First of all, I should like to provide you with some information about Hannover. Hannover has around half a million inhabitants within the city limits, and about one million including the surrounding area. Hannover is situated in the state of Lower Saxony, in the north of Germany, 200 km from the coasts of the North Sea and the Baltic Sea. The geographical position is quite important for our present and future economical situation as it places Hannover at the crossing point of major communication routes, in terms of both road and rail. Since the reunification of the two Germans and the opening of Eastern Europe, the east-west traffic has intensified extremely and rents for office accommodation have soared. There is a boom situation with an increase in the number of inhabitants in the future.

Compared to other cities, Hannover possesses relatively good environmental conditions. Hannover is a "green city": nearly 50% of the area of the city is forest and parkland or utilized for agriculture. Fortunately, Hannover has a comparatively low level of atmospheric pollution. The reasons for this are its geographical position on the North German Plain, the favourable structure of its industry and the low-emission gas, electricity and district heating supplied by our local, municipality-owned utility company.

Though there is much green in the city, in the last 20 years about 100,000 inhabitants have moved out of the city into neighbouring towns to live mostly in a single family home of their own. The consequence has been the sprawling of the small neighbouring towns and villages and an enormous rising of commuting. Today about 150,000 people commute into Hannover to work daily.

By this development, the car traffic has grown so much that today our citizens regard it the environmental problem number one and call for drastic cuts. Right now, a transport plan under which cars are nearly prohibited access to the inner city is to be publicly discussed.

To improve urban quality, Hannover plans an optimization of the public transport system, facing the deadline of the World Exposition in the year 2000.

Compared to some other cities, Hannover's rail transit network is already good. Within the city centre the trams run underground, and outside the city centre, they are mostly on the surface using tracks of their own separated from car traffic lanes. Municipal buses travel to areas not served by the rail network. Further measures are: 30-kilometre-per-hour speed limits in residential areas; reducing the number of goods vehicles through the provision of a central goods depot on the outskirts of the city; and improving the bicycle track network.
Another major target of our ecological urban development program is to protect and conserve our open spaces, though there is now a very strong demand for construction areas, both residential and commercial. This unexpected demand is a consequence of the opening of the iron curtain.

In Germany, the municipality has the authority to define land use. We permit development just in very few areas which should be close to public transport to protect our open spaces. We try to concentrate on redevelopment.

The most serious problem with redevelopment is the inherited contamination of the soils. We have checked up every single lot in our city that has been in commercial use which might have led over the last 100 years to contamination. So far we have about 2,000 problematic lots registered in a computer information system.

It is the law that the proprietor of the lot has to clean up the ground. I have a staff of seven experts to consult and to supervise the projects of decontamination. In some cases, when the municipality has a special interest in development of a certain area, we do the decontamination ourselves. For these cases I have a special budget of 5 - 10 million dollars a year.

At present we have three large decontamination projects of unprecedented pilot character running, and therefore subsidized by our federal government.

1. On the property which formerly had a battery manufacturing plant, we plan a science park, but there are 30,000 tons of lead and other heavy metals in the soil. We will not deposit this contaminated soil somewhere but rather wash it. We can reuse 90% of the soil and even recycle the lead.

2. At a former refinery where the soil is contaminated with mineral oil residue, we let bacteria do the job right on the spot (in situ). This method needs much time, but is very effective and with low costs.

3. At a former chemical wholesaler, the ground water is contaminated with several tons of CFC’s. We pump out the water in a gallery of wells and strip the CFC’s out by a physical and biological process.

I will not finish without saying a few words on the World Exposition in Hannover.

Hannover will host the EXPO which is to take place in the year 2000 under the motto “Man - Nature - Technology”. Thirty to fifty million visitors are expected over the five-month period from June to October. A site in the immediate vicinity of the Hannover exhibition grounds has already been selected for the central exposition area. In addition, other non-central locations are under discussion.

The motto “Man - Nature - Technology” sets the standard for a “new type” of world exposition, and commits us to fulfilling certain obligations. This exposition is dedicated to demonstrating major global problems and suggesting solutions for a better life in the 21st century. It is intended that an ecological and social reorientation of the economy be made clear at the EXPO, with the focus on environmental technology and worldwide cooperation.

If possible, the exhibition itself should not consist of conventional national pavilions but rather of theme-oriented supranational pavilions. Several states and/or organizations may combine to make a joint contribution, thereby demonstrating practicable solutions to local problems seen in relation to “Man - Nature - Technology.” Possible topics are, for example, rainforests, refuse, drinking water supply in the long term and ecological building. One of the many subjects which might be dealt with at the exposition in Hannover is the development of the measures resulting from the Urban CO Project of the International Centre for Local Environmental Initiatives. Twelve cities will establish guidelines during the next two years showing the implementation by the year 2000.

Besides the central exhibition grounds, the City of Hannover and its surrounding districts will also form part of the exposition, thereby also achieving long-term improvements for the citizens in the region. Urban redevelopment, ecological, social and cultural projects will help to show how the future-oriented and desirable qualities of urban life can be created. Hannover intends to demonstrate solutions for ecological urban redevelopment. The following themes have been suggested: the city as a garden - nature in the city; environmentally-compatible traffic in urban conurbations; progress in housing and social conditions; possibilities for reducing the energy and water demands; minimizing the amount of refuse; and the city and its environs as a cultural centre.

The construction of the EXPO residential area, close to the exposition grounds, could serve as a superb example of a “settlement for the 21st century”. It would enable architects from many countries to demonstrate future-oriented buildings utilizing materials which are not harmful to health, with minimized energy requirements (which means low-energy or zero-energy houses using renewable energy sources and power/heat combinations), and efficient waste recycling; at the same time it will be housing which is socially acceptable.

Hannover is called “the city in the green”. Urban redevelopment and the EXPO will help to maintain or rather improve this situation, despite existing environmental problems, by careful planning and action.
Part 4.4

URBAN HEAT ISLAND - RESULTS OF US RESEARCH

Introduction and Summary Overview
by Landa de la Croix

The Urban Heat Island Phenomenon
by Hashem Akbari

Implementation of Some Urban Heat Island Reduction Measures
by Greg McPherson

LINDA J. de la CROIX

Ms. de la Croix is a program manager and community energy planner at the U. S. Department of Energy. She has been the HQ program manager for supported research into strategies for reduction of the urban heat island, and coordinates liaison on the topic with other agencies. She also manages the State Energy Conservation Program and Energy Extension Service state grants in two regions.

HASHEM AKBARI

Dr. Akbari is a research scientist with the Lawrence Berkley Laboratories in Berkeley, California.

GREG MCPHERSON

Dr. McPherson is Associate Professor of Landscape Architecture at the University of Arizona in Tucson. His Doctorate from the State University of New York in Syracuse was in Urban Forestry. His present research deals with documenting benefits and costs of urban forests, and he is co-author of the recent book Southwestern Landscaping that saves energy and water.
U.S. RESEARCH ON URBAN HEAT ISLAND REDUCTION STRATEGIES, BENEFIT/COST ANALYSES, AND IMPLEMENTATION APPROACHES

by a Panel sponsored by the US Department of Energy

INTRODUCTION

Linda de la Croix

The purpose of this session is to present US research and projects that indicate that cities have the ability to respond to climate change. Recent research indicates there are simple, effective and economical measures that cities can take to control the urban heat-island phenomenon and to mitigate warming trends.

Successful mitigation of urban heat islands is definitely possible, as we can see from the following example.

Nankiang, China is a prime example of successful heat island mitigation. The heat in Nankiang used to make it a miserable place. It was known as "one of the three furnaces on the Yangtze River." But after WWII, the city began a massive tree-planting program and planted 34 million trees. The result – today Nankiang is 5 F. degrees cooler, and is praised in the travel guides with statements such as:

Nankiang, the capital of pre-revolutionary China, is a city of about 4 million, well-known for its broad, tree-lined boulevards. One is struck by the cool summer breezes that sweep through the millions of trees planted since 1949...

There are also some examples of cities in the U.S. that have become cooler, at least for a while. Palm Springs has become 2 F. degrees cooler by creating an oasis in the desert. Los Angeles used to have a cooling trend, although that trend later became a warming trend. Phoenix, Arizona, was once a lush oasis with a cooling trend.

This presentation covers U.S. research on urban heat-island reduction strategies, potential energy savings, potential for reduction of carbon dioxide emissions, reduction of smog incidents, comprehensive benefit/cost analyses, implementation approaches, and some examples of successful projects in the United States.

Dr. Hashem Akbari will introduce the topic of urban heat-island phenomenon, and will talk about the research he has done for us on the causes of urban heat islands and research on predicting potential energy savings.

Dr. Greg McPherson will talk about the research he has done on economic and environmental modeling of tree planting and how benefit/cost analysis can make a convincing case for city government to launch urban heat-island reduction strategies. He will also describe a project he did to encourage urban mass transit by making bus shelters more comfortable.

Ms. de la Croix will talk about implementation steps and implementation motivators, and some examples of projects in the United States.

THE URBAN HEAT ISLAND PHENOMENON

Hashem Akbari

Definition

For a long time, it has been known that cities are warmer than their surrounding areas. As one approaches a city from a rural area, the temperature starts rising. As this illustration

Graph shows temperature changes in degrees Fahrenheit as the density of development and trees changes.

Figure 1: The Heat Island

demonstrates, the temperature varies over different types of land use/land cover, with the warmest temperatures occurring in the core of the city's downtown area.

There are different types of heat islands. There are winter heat islands, summer heat islands, and maximum heat islands. U.S. research has focused on summertime afternoon heat islands. The heat island phenomenon is a small asset in the wintertime, particularly for those heating-dominant cities like Toronto, Montreal, and Winnipeg. But during the summer, heat islands have a negative impact on energy cooling demand, hence, the U.S. research has been mainly focused on the summer heat island.

Heat islands are documented all over the world. During the winter, heat islands are a moderate asset, but during the summer they cause discomfort, they increase the frequency and intensity of smoggy days, they increase cooling energy consumption of buildings, and there are many other factors that are detrimental, such as related
illnesses and death, and crime statistics.

So what is causing urban heat islands? Typical urban development practices make a major contribution. The very first thing we do when we develop an area is to chop down trees and replace the permeable soil surfaces that used to support trees and shrubs with blacktop and buildings. This alters the micro-climate and the result is that eventually we increase the temperature of that environment.

There are some noteworthy exceptions to this development approach. For example, the City of Phoenix was established in a desert environment. There was virtually no vegetation at first, but the city created a desert oasis effect with luscious, heavily-watered vegetation which had a cooling effect on temperatures. Later on the trend changed. There are a few factors that influence or cause urban heat islands:

1) The mass of the building.
2) Increased surface roughness.
3) The loss of evapotranspiration due to the loss of the vegetation.
4) Lowered albedo of the surfaces. Albedo is a general definition for the overall reflectivity of all the surfaces. If more of the incoming solar energy is absorbed on the surface it will warm the surface, and in turn the surface will warm the air in circulation above the surface, resulting in higher air temperatures. A lower albedo would do the reverse. It would reflect most of the incoming energy, as a result of that the surface not be as warm, and in turn the air temperature would not be as warm.
5) Man-made heat from cars, exhaust systems, houses and air conditioners, etc.

In terms of the importance of these various factors, trees and albedo are the most important factors. The man-made heat is a factor in the downtown area, but is difficult to ameliorate. Thermal mass has a small effect on the heat island.

Distinction between Urban Heat Islands and Global Temperature Rise

The urban heat island is the temperature difference between the urban area and the surrounding rural area. Global temperature rise is based on the premise that the entire globe is going to increase in temperature as a result of increasing concentrations of greenhouse gases in the atmosphere. Therefore, a city may experience a generalized, global temperature change in addition to experiencing an urban heat-island effect.

Evidence of Rising Urban Temperatures

There is substantial evidence that the temperature in cities, particularly in the largest urban areas, is increasing.

The first example is Los Angeles. Figure 2 shows a hundred years of annual maximum summertime temperature, beginning in 1880 and up to 1990. There is a period of time that the temperatures are more or less cooling, then a period when the temperature is not changing much, followed by the latest trend of rising temperatures. This first period coincides with when the city of Los Angeles was starting to expand, with a lot of irrigation and agricultural expansion in that area. It appears that the city cooled down by about 2 F. degrees during this period. This occurred from about 1880 to about the 1920’s and 1930’s. And then, just before the Second World War, the city started expanding at an extraordinary speed and the temperature started to rise at a more or less constant rate of about 1 F. degree/decade; this has continued to the present. The maximum temperatures during this period of rising temperatures increased by about 7 F. degrees. It appears that 2 F. degrees of this may be due to the loss of vegetation, and the other 4-5 F. degrees are because of the urbanization, mainly the effect of the increase in dark surfaces in the city.

This rising summer temperature trend is not unique to Los Angeles.
Washington, D.C. summer temperatures have increased since 1900 at the rate of about 1/2 F. degree per decade (Figure 3).

Figure 3: Washington annual mean temperature 1900-1984

Summary data from 31 California cities that have been analyzed for an urban heat-island effect or temperature rise indicates that the cities were cooler than the rural areas by about 1/2 F. degree in 1920, were about the same as rural areas in the 1960's, and are now about 1 F. degree warmer than the surrounding area. This temperature difference results in higher energy costs in the cities, as presented further on in this paper.

Negative Aspects of Urban Heat Islands

1. Higher electricity cooling costs

The negative aspects of the urban heat islands are the following: First, buildings in the warm climates need to be cool. The higher the temperature, the higher the cooling electricity bill. In Los Angeles alone, the cost of the heat island effect on a summer afternoon day is approximately $150,000 per hour. If there are 500-1,000 hours of residential cooling in Los Angeles area, then the total cost of the urban heat island effect is about $100 million per year for cooling.

Figure 4 shows how the utility load in Southern California increases with temperature. The figure shows the maximum annual utility load at 4 p.m. plotted for the average temperature of that particular day. The temperature sensitivity of the load in this example is about 1.6% per degree Fahrenheit, or about 225 megawatts per degree. Los Angeles is served by this utility as well as the Los Angeles Department of Water and Power (LADWP). The heat sensitivity of LADWP is about 75 megawatts per degree Fahrenheit. The combined excess energy demand of the two utilities serving the Los Angeles area is approximately 300 megawatts per degree Fahrenheit rise in the temperature. The 5 degree F. increase in the temperature of the city due to the heat island effect represents approximately 1.5 Gigawatts of powerplant capacity in Los Angeles.

The nationwide estimate for the cooling cost of the heat island effect in the United States is about $1 billion per year. This is the cost of compensating for this manmade effect.

2. Increased smog incidents

A second negative aspect of urban heat islands is that it increases smog episodes by about 10 per cent. The hotter it is, the faster the smog "cooks", resulting in an increase in the number of smoggy
days, and also resulting in general discomfort in the urban environment.

Figure 5 shows the concentrations of ozone, which is a measure of smog, versus daily peak temperature for 1985 in Los Angeles. Each square represents one day. Notice that before 70 or 74 degrees F, there is not much smog, based on a national standard. But as the temperature rises, so does the number of episodes of smoggy days. In the Los Angeles area, approximately 7 out of 10 warm days are smoggy. So a five-degree rise in temperature would actually increase the number of smoggy days by as much as 30%. The reverse is also true; if you were able to reduce temperatures by reducing the heat island effect, you could reduce by 30% the number of smoggy days.

This is applicable to other cities as well. Figure 6 shows the occurrence of smoggy days in 13 cities in Texas. A high concentration of smoggy days occurs during the warm days.

Figure 5: Ozone concentrations vs daily maximum temperature in Los Angeles in 1985

Figure 6: Ozone concentrations vs daily maximum temperatures in 13 cities in Texas

Reversing the Urban Heat Island Effect

The urban heat island effect is reversible. There are two simple strategies to reverse the adverse effects of the heat island: 1) urban trees; and 2) light-colored surfaces.

Each of these strategies can have two effects on the cooling energy consumption. A tree planted on the south and west side of a house will shade the house. Whether it is cooling down the entire city or not, it cools the house down by shading it, and therefore it affects cooling demand. The shading of an individual building is a direct effect. Light-colored surfaces, eg. light-colored roofs and buildings, also have a direct effect on avoiding heat gain in individual buildings. This direct effect on an individual building can be calculated with a fair degree of accuracy by using some sophisticated computer tools which have been repeatedly validated. (Less is known about how these measures collectively affect an entire neighborhood, although it is possible to make ballpark estimates.)

The indirect effect of the trees comes from evapotranspiration.
White surfaces have a very beneficial effect on cooling energy consumption. Light-colored roofs and walls absorb less solar energy, thereby lowering cooling energy demand. White surfaces have a negative effect on heating demand, but the negative effect is less than 1/2% per year. This is because most cities that need substantial heating during the winter either have a lot of snow, so the surfaces are white anyway, or they have a lot of cloud cover in the winter, with the result that surface color is not important.

Energy Savings

Figure 7 shows the energy savings calculated for two types of houses in the U.S. - old, typically drafty older houses and new, "tighter" houses - in a variety of climates in the United States. The figure shows the amount of energy savings in terms of dollars per year and also in terms of percentage of annual energy bills for that prototypical house. The direct effect of the trees is to reduce the energy demand of the building by about 6-16%.

As a footnote, it is important to consider the net year round effect of trees on buildings because in the colder climates trees have a significant windshading effect that reduces heating energy demand of the building by lowering infiltration. Since most of the heating in the U.S. is provided with gas, and because gas is cheaper than electricity, the monetary value of heating cost is much lower than the electricity cost.

The combined direct effect of trees and white surfaces on residential buildings is approximately a 20% savings of the total annual heating and cooling consumption.

The indirect effect of trees and light surfaces is estimated to be roughly twice as great as the direct effect. Figure 8 shows a range of potential energy savings between 12-57%.

Estimates of nation-wide potential energy savings can be derived from energy consumption data. The cooling energy consumption in the U.S. in 1985 was 1.2 Quads (10 to the 15th btu) in residential units and 1.5 Quads in commercial units, (equally distributed in large commercial units and small commercial units.) So the total cooling energy use was 2.7 Quads. In that year the total energy consumption in the U.S. was 85 or 76 quads. Therefore, about 3-4% of National energy is used for cooling energy demand. About 10% of cooling demand is due to the heat island effect.

The direct effect of trees and light surfaces would reduce about .1 quad in the residential building sector and about .15 in the total buildings sector. The indirect effect would double that factor. The total effect would be about half a quad of energy per year. Half a quad of energy saved out of the 2.7 quads of total cooling energy demand is about a 25% savings in cooling energy demand. This is an appreciable amount of energy saved. Half a quad of energy is the equivalent of the power produced by about 10 large nuclear or coal powerplants per year. If this amount of energy savings offset demand from coal-fired powerplants, it would be the equivalent of...
electricity produced by new electric powerplants. The cost of planting trees can vary a great deal, according to circumstances. It costs very little to advise someone how to plant a 4-6 foot tall tree for a residence, but if it is necessary to break the concrete and plant a 20-25 foot tree, the cost could be $500. Therefore, the research has focused on residential tree planting. Trees for residences can be bought and planted for a cost of about $5-25 each. So the cost of energy saved by planting residential trees and increasing white surfaces is on the order of less than 1 cent per kWh saved.

This cost of conserved energy derived from urban trees and white surfaces can be compared to the cost of power that from a non-nuclear powerplant at about 8 cents per kWh, or 11 cents if it is from a nuclear powerplant.

Comparisons with other forms of energy demand reduction are also favorable. Efficient appliances cost about 2 cents per kWh; improving the efficiency of cars from an average of 27 miles per gallon to 34 miles per gallon costs about 4 cents per kWh, or about 50 cents per gallon. Therefore, urban tree planting and white surfaces compare very favorably with other cost-effective energy efficiency measures.

Research Concerns

Knowledge of the direct effects of urban trees and white surfaces is sufficient to justify implementation of this urban heat island mitigation technique. Further validation of simulation models of the indirect effect is desirable. To date there has not been much experience with large scale programs of urban trees and white surfaces in terms of the costs and other constraints such as water. Careful selection of the most beneficial trees is also important to maximize benefits and avoid certain species of trees that emit some smog and pollution.

Implementation Guidelines

Increased public awareness of the benefits of the heat-island mitigation measures is needed. A heat-island implementation guidebook has been sponsored by a variety of institutions, including the U.S. Department of Energy, the U.S. Environmental Protection Agency, the California Institute for Energy Efficiency, the University-wide energy research program at the University of California, the Los Angeles Department of Water and Power, and the Energy Power Research Institute.

The objective of this guidebook is to provide what we know at this time to the designer, the legislator, the energy policy-maker, and the citizen advocate, so that they will be able to implement urban heat island reduction programs and do further analysis and develop consequent programs in their own region. The guidebook is titled "Cooling Our Communities: The Guidebook on Tree Planting and Light-Colored Surfacing" is available from the U.S. Government Printing Office, Washington, D.C. 20402.]
ENVIROMENTAL BENEFITS AND COSTS OF THE URBAN FOREST:
TWO EXAMPLES FROM TUCSON, ARIZONA

by Greg McPherson

Introduction

Growing concern about local and global environmental quality has renewed interest in the use of trees to conserve natural resources and improve our air and water. This interest comes from diverse groups such as policy makers, air-quality planners, and energy utilities, as well as tree-care professionals, urban foresters, and tree activists. Although we can describe many of the urban forest's environmental benefits and costs in general terms, our ability to quantify accurately these values for specific planting/maintenance programs is rudimentary. Furthermore, little has been done to translate urban forest environmental benefits and costs into monetary terms, which may become important when programs are competing for limited financial resources. This paper forgoes a broad discussion of environmental benefits and costs (see Dwyer et al) to describe the application of a model for two proposed tree-planting projects in Tucson, Arizona. The projects involve planting and care of 500,000 trees in yards, parks, and streets, and 64 trees at bus stops. The intent is to illustrate how this approach can be used to:

1. quantify some of the short and long term benefits and costs for tree planting and maintenance;
2. evaluate the most cost-effective locations for trees and strategies for planting and maintenance; and
3. determine if trees are cost-effective environmental controls when compared to traditional control technologies.

Modelling Approach and Assumptions

Trees for Tucson/Global ReLeaf (TGP/GR) is a volunteer-based program founded in 1989 with the goal of planting 500,000 desert-adapted trees throughout the city by 1996. The program promotes planting as a way to conserve energy and to improve environmental quality. Tucson Water, a municipal utility with a strong water conservation program, expressed concern about the impact of these trees on water supplies. The model was developed to examine water costs, as well as a range of other costs and benefits over a 40-year planning horizon.

The modelling approach used for the large-scale tree-planting project is shown in Figure 1 and completely described elsewhere (McPherson, 1991). The three major components of the model are “tree numbers”, “tree sizes”, and “benefit-cost analysis”. “Tree numbers” calculates the number of trees at each location based on expected planting and mortality rates. “Tree sizes” calculates total leaf area using data on tree numbers and growth rates. The third component projects benefits and costs on a per-unit-leaf-area and per-stem basis. A variety of local and non-local benefits and costs are calculated for plantings in park, yard, and residential street locations.

The first example assumes planting of 500,000 mesquite trees (in 5-gallon containers) from 1990 to 1996 in parks, yards, and along city streets. Approximately 215,000 of these trees are assumed to die by the year 2030 (42% mortality rate). The native velvet mesquite (Prosopis velutina) is used because of its quick growth, drought tolerance, moderately dense shade, and local popularity. Costs for planting, pruning, watering and removal are compared with benefits from cooling energy savings as well as dust and runoff reductions.

The second example uses a modified version of the model to compare the cost-effectiveness of shade provided by metal shelters with that of trees at unsold served bus stops along Tucson’s most heavily travelled bus route (Route #8). Because of Tucson’s hot, arid climate, shade at bus stops can enhance the comfort of waiting riders and can encourage new passengers, thereby reducing traffic congestion and consequent air pollution. Sun Tran, Tucson’s mass transit authority, has 2,100 bus stops, 412 with shelters that provide shade via roof and side panels. Analysis of the #8 provide benefits of using a potential suitability for 23 are "Excellent", 22 are "Good", 19 are "Fair", and 24 are "Poor". Two three-planting scenarios are modeled. Both scenarios assume planting of one 15-gallon native-
velvet mesquite in 1990 ($65 each) at each of the 64 suitable sites, and prompt replacement of mesquites when they die (48% loss rate assumed). The first scenario called TPT/GR, assumes that all trees are obtained and planted by TPT/GR volunteers at no cost to Sun Tran. The second scenario, labeled "Contract", assumes all costs associated with tree planting and maintenance are assumed by Sun Tran, except irrigation water at Excellent sites. The model links tree growth and mortality with anticipated growing conditions at each type of planting site (McPherson, in press).

In the "Shelter" scenario, annual costs are projected for the construction and maintenance of metal shelters at each of the same 64 bus stops along Route #8 over the 40-year period (1990-2030). Metal shelters have a 20-year life expectancy and cost about $3,000 each to construct and install. Removal and replacement costs are approximately $250 and $2,250, respectively. Annual repair costs are estimated to be $113.

**Benefit-Cost Analysis for Large-Scale Tree Planting**

Projected costs of the 500,000 mesquites exceed benefits during the first five years, largely due to one-time planting costs (Figure 2). During the next 25 years, benefits are three or more times greater than costs. During the last decade, costs begin to catch up with benefits as more large trees die and are removed.

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Figure 2: Projected average annual benefits and costs for trees planted in park, yard, and residential street locations.

Air conditioning energy savings are projected to be the tree planting program's greatest benefit. Average annual cooling savings are about $21 per tree (280 kWh). Although substantial energy savings from direct building shade are predicted ($5 annual average per tree), larger community benefits are projected for the aggregate effect of trees on urban climate. Trees can lower temperatures through transpiration - the evaporation of moisture released through leaves. Planting 500,000 trees will increase Tucson's canopy cover by about 10% (from 20% to 30%) in 10-15 years, and this increase is projected to reduce city temperatures by 3 degrees Fahrenheit. Although this reduction appears small, computer simulations for typical residential buildings in Tucson indicate that it may lower annual cooling costs by 20%.

The reduced demand for air conditioning power can lower the amount of coal and water consumed by power plants, resulting in conserved water and reduced emissions of carbon dioxide and other pollutants from smokestacks. On average, trees are predicted to conserve 16% (171 gal/tree) of their annual water requirement and reduce annual carbon emissions by 400 lb per tree. Since each person is responsible for adding 23 tons of carbon to the atmosphere annually (Plavín, 1988), a Tucsonan could offset their annual carbon emissions by planting and caring for approximately 12 mesquite trees.

On average, each tree was projected to intercept nearly 35 lb of dust and 73 gal of stormwater runoff annually. These environmental benefits were monetized by applying value based on the control costs for traditional programs. For example, Tucson has a road paving program that reduces air-born particulates, and other regulations to control flooding require developers to construct retention-detention basins so that runoff does not exceed predevelopment conditions. Using 40-year construction and maintenance costs for the road paving program, the average annual cost of dust control is about $0.12 per pound of particulates. Similarly, the average annual cost to control stormwater runoff through constructing and maintaining retention-detention basins in Tucson is $0.0025 per gallon of water. Because the leaves and stems of trees intercept dust and stormwater, they have the potential to complement or substitute for traditional control programs. The average annual implied values for dust and rainfall interception per mesquite tree are calculated to be $4.16 and $0.18 respectively. Average annual benefits for cooling savings, dust, and runoff reduction totalled $25.09.

Average annual costs for planting, pruning, watering, and removal are projected to be $9.61 per tree - $15.48 less than the total projected benefits. Average annual removal costs ($5.09 per tree) are a more significant expense than costs for water ($2.14 per tree) and pruning ($2.02 per tree). Planting costs averaged over the 40-year period are projected to be only $0.36 per tree.

The internal rate of return (IRR) is used to incorporate the time value of money (cash in the future is worth less than cash today) in investment analysis. An IRR of 7.14% is projected for the entire...
tree planting project. Investment in yard trees provides the highest rate of return (14%), street trees the lowest (2%), and park trees provide an intermediate return (5%). The higher IRR for yard trees compared to street and park trees is due to lower planting costs and mortality rates, faster growth rates, and more effective building shade for yard trees.

Cost-Effectiveness of Tree Shade at Bus Stops

The total costs for trees (300,940) are projected to be less than half the costs for metal bus shelters (642,816). Because of the relatively high initial costs for shelter installation (Figure 3),

200000

--- Shelter --- Contract

150000

100000

50000

0 50000 100000 150000 200000

Year

Figure 3: Projected total annual costs for shelters and trees in the "Contract" Scenario. Peaks for trees reflect the 5-year pruning cycle, while those for shelters reflect installation and replacement.

savings for tree shade are even greater when present values are calculated to incorporate the time value of money. Assuming a 7% discount rate, the present value of costs is about 60% less for trees than for metal shelters.

The cost-effectiveness of shade is calculated as the ratio of annual costs to area of shade provided by trees and shelters. This trees initially. During the first fifteen years the shelters are more cost-effective than trees due to smaller tree sizes and relatively high costs, principally for irrigation. However, over the 40-year period the trees are projected to be 20% ($4/sq ft) more cost-effective than the shelters. This finding suggests that planting trees with the construction of each new bus shelter could be another cost-effective strategy. Shelters will provide immediate shade, and in 20 years shade from larger trees will eliminate the need to replace old shelters.

Irrigation costs are the largest projected tree-related expense, averaging about $70 per tree per year for all locations. Average annual pruning costs are $40 per tree, the second highest. Tree removal and planting costs are substantially less, averaging about $3.50 per tree per year for all locations in the Contract scenario. The projected average annual expenditure of $117.55 per tree is considerably greater than the national and west-regional means of $10.62 and $13.11, respectively, as reported for street trees by Kielba (1990). This difference can be explained by the unusually high costs for "retrofit" irrigation and the relatively short 5-year pruning cycle simulated in this study.

When comparing average annual tree costs among sites, costs for trees at "Excellent" sites ($52/yr/tree) are about three times less than at "Good" ($153/yr/tree) and "Fair" ($156/yr/tree) sites in the Contract scenario. Trees at "Excellent" sites are most economical because of low irrigation costs, while trees at "Fair" sites have relatively high planting (due to pavement removal) and removal costs (due to higher mortality). This finding suggests that programs can be cost-effective by first planting trees in the most suitable sites. Because irrigation costs are important, efforts to enlist adjacent businesses to "Adopt A Bus Stop" and connect their trees to existing irrigation are warranted. Also, irrigation costs can be substantially lower if tree plantings are designed into new bus stop/roadside improvement projects, as opposed to the retrofit of existing bus stops modeled in this study.

Planting of trees by TFFT/GR volunteers reduces total costs by only 3% compared to the "Contract" scenario. However, findings from other studies indicate that public involvement in tree planting can reduce vandalism and mortality, factors not accounted for here (Sklar and Jacobson, 1985). Similarly, pruning costs can be reduced if well-trained volunteers prune bus stop trees in their neighborhoods, at least while the trees are relatively small.

Conclusions

Although the findings from these two studies are primarily of regional value, they do illustrate the potential utility of this modeling approach as an urban forest resource management tool. Monetizing environmental benefits of urban forests helps put trees "on a more level playing field" when compared to other capital investment options. The use of life-cycle costing also increases the standing of trees relative to other investments in urban infrastructure and traditional environmental controls. Generally trees become more cost-effective as they grow larger. Many infrastructure improvements depreciate as they age, and many
traditional controls become progressively less efficient with time and have shorter life spans than trees.

Despite uncertainty due to inadequate scientific knowledge and inherent limitations of benefit-cost analysis, the modeling approach described here offers decision-makers a timely and relatively sophisticated tool for evaluating the economic and environmental implications of proposed urban forestry programs and projects. To improve this tool, more studies should begin to monitor and monetize the effects of trees on urban environments, as well as the effects of urban environments on trees. This basic information is critical to model validation and subsequent application of better models for urban forest planning and management.

References


IMPLEMENTATION OF URBAN HEAT ISLAND REDUCTION MEASURES AND EXAMPLES OF U.S. PROJECTS

by Linda de la Croix

Implementation Approaches

Urban heat island reduction measures can be implemented with the following 4-step process: identification of a city’s current temperature trend; identification of motivating factors that fit that city’s circumstances; development of an overall plan and strategy; and documentation of savings.

The first step is to determine a city’s temperature trend. This should be relatively easy to obtain from the local weather stations. In the case of Washington, D.C., the local warming trend has been measured in figure 1 (page 210). This figure graphically illustrates the warming trend in Washington, D.C. during this century.

The second step is to identify the factors that would motivate a city’s government to take action. Public awareness as expressed in the media is one clue that this issue is ripe for implementation.

Energy Cost as a Motivator

Energy cost is a significant motivator, particularly if a benefit-cost analysis similar to what Professor McPherson has been doing is available. Energy is typically about 25 percent of many cities’ budgets. Energy cost can be a particularly acute motivator in locales that have either shortages of peak load electricity or a very high differential between the base energy production costs and peak load energy costs, particularly when energy costs become a factor in causing businesses to leave a large metropolis in search of lower overhead.

The U.S. Department of Energy is currently sponsoring, with other agencies and organizations, a 12-city demonstration project. (Professor McPherson is the project director.) The twelve cities represent a range of climate types. The objective of the demonstrations is to establish the benefit and costs in a particular climate type, and then translate that to other locales that have the same climate conditions. This would enable other local jurisdictions to determine what their benefit-costs of implementation would be over time, and assist them in planning for the initial cost outlays, continuing costs, and when to expect the benefits to accrue.

Air Quality as a Motivator

In a city like Los Angeles, you may find that smog is an even more compelling reason to motivate your city government to do something. Dr. Akbari had a figure (figure 5, page 212) about
the relationship between smog days and maximum temperature, as well as with energy load (figure 4, page 211).

Social Impact as a Motivator

Another motivator is social impact. According to a recent article in the Washington Post the "long hot summer" phenomenon leads to a "heat stress factor" which can cause social unrest to boil over and increase violent crime. This means that rapes, assaults, homicides, domestic violence, against women and children all peak in the summer months (with another rise again at Christmas, which is another kind of stressor).

Conversely, urban heat-island reduction strategies can be done in a fashion that has a beneficial social impact. The "citizen forester" approach used by the "Tree People of Los Angeles" shows that using volunteers in neighbourhoods rebuilds communities, increases community pride, and empowers people to feel that they, themselves, can take action on the problems in their communities. Amazing things can be done with volunteers, or even one person choosing to start an action. Another example is the man in Queens, New York, who single-handedly launched a campaign that resulted in his neighbours helping to plant 7,000 trees. A spin-off result was that property values have risen and the city now has a larger tax base.

Cost Leveraging as a Motivator

City government does not have to pay all of the costs. There are many opportunities for leveraging and partnerships that the benefit/cost ratio is even better than what Dr. McPherson described. A group of players who can be involved in going forward with an urban heat-island reduction program are listed in the guidebook described by Dr. Akbari at the end of his paper. This includes individual citizens, youths (primarily through the schools), utilities, organizations, businesses, and government. Once they are identified, such players could be mobilized to support the program and to form partnerships with the city. Everybody wins on urban heat-island reduction projects.

-Volunteers get the satisfaction of getting something concrete done, and get to see visible benefits.

-Business and industry enjoy the public relations benefits of participating, and it indirectly reduces competition for carbon dioxide emissions. (This is partly important if that industry or business is in a region that is a non-attainment region for pollution standards. They will be greatly restricted in their options of how much they can expand unless there are other ways to offset their demand for energy.)

-Utilities are really one of the best candidates for a partnership because they really understand this concept of "peak-load landscaping", once it is presented to them.

Prof. John Parker at Florida International University coined the term "peak load landscaping"; it is reflects the fact that energy demand peaks in the late afternoon, but at times that buildings receive the maximum effect from strategically placed shade trees. This brings a levelling effect to the load/time-of-day relationship. Now peak load demand is particularly important because this establishes the capacity which the utility must have to make sure there is enough energy, with no "brown-outs". In order to convince utilities that becoming involved in tree-planting programs is more than a public-relations exercise for them, must be models and studies such as the ones described by Dr. McPherson. Moreover, any utility which serves an area which does not meet national air-quality standards must be especially concerned with peak-load requirements.

The third step is to develop an overall plan and strategy. That means identifying the partners and the role each should play. An upcoming guidebook being prepared by the Department of Energy lists some of the responsibilities, particularly those that local governments should take on, as well as a number that either the private sector or both could assume.

Local ordinances can play a major role in heat-island reduction; those dealing with parking lot requirements provide an easy example. Figure 1 shows a basic parking lot in Long Beach, California with a layout for 50 cars. It is 90 feet by 300 feet, and has one tree per five parking spaces. By contrast, figure 2 shows a similar lot in Corpus Christi, Texas, with over four trees per five parking spaces. Clearly, the latter contributes much more to heat-island reduction than does the former.

The fourth, and final, step is to document the energy savings that a community can realize from such programs. This is important for two reasons. First, utilities cannot seriously embark on counting this as a demand-side offset unless they can come up with some hard numbers of how well this approach works. The other is that one demonstration of a successful community stimulates others to copy it, especially with the benefits of the experience of the first.

Last year, President Bush announced an "America the Beautiful" program, which the Washington Post promptly dubbed "Bush's Billion Points of Shade." The President stated that the country should start planting a billion trees a year, and to support this legislation that is complementary to the Forest Stewardship Act of 1990. (This Act specifically noted that "urban trees are 15 times more effective than forest trees at reducing the build-up of carbon dioxide and, in promoting energy conservation through the mitigation of the heat island effect in urban areas." It is about a $65 million program, the purpose of which is to provide educational programs and technical assistance to State and local organizations, and to expand research on this topic.)

U.S. Federal agencies are very much cooperators rather than competitors in this. The Department of Energy is working very closely with the Environmental Protection Agency and the Forest
Service. All see a common interest in it, but approach it from different perspectives. For example, some of the types of studies sponsored by the DOE are:

- demonstration projects that are in progress now;
- the urban heat island workshop;
- co-sponsored the guidebook edited by Dr. Akbari;
- grants to State energy Offices;
- Petroleum Violation Escrow monies.

States can choose the kind of projects they wish to do within their State plan. This is the kind of project we want to encourage them to consider.

A private organization that is active is the "Global Re-Leaf Campaign" through the American Forestry Association. It is serious about saying it will get 100 million trees planted by the year 1992. Many local programs get technical assistance from the Campaign to get launched.

"Tree City U.S.A." is a program run through the National Arbor Day Foundation. In the State of Kansas, it established 108 local tree boards. It works with the U.S. Dept. of Agriculture Extension Service; they have done many joint projects. A city need only make a commitment that it will spend $2 per capita on urban forestation to be designated a "Tree City U.S.A."

One of the most exciting groups that we in the Urban Heat Island Project Office of the DOE have come in contact with is the TreePeople of Los Angeles. This group got started in 1984 when it launched a highly imaginative campaign to plant 1 million trees in Los Angeles before the Summer Olympics. The members did it with almost no money; they talked people into donating time, services, or whatever else was needed. They ended up with donations of ad copy, they got Gregory Peck involved, they did Hollywood-like radio spots, they did billboard campaigns. They also arranged with the local news station to help them monitor their goal of getting 1 million trees planted before the Olympics; they encouraged people to buy a tree and plant it, and then to fill out a postcard and send it in to collect and reporting on the evening news. They also got a number of business organizations interested.

They currently have a program where they are trying to develop 500-1,000 citizen foresters, people trained to organize communities to carry out any kind of tree planting program that the community wants to undertake. Now they are trying to motivate citizens to plant an additional 2-5 million trees. They also have an educational program for schoolchildren; every year 60,000 school children go out to the nursery forest, and each child gets to plant a tree and take a seedling home. The organization has printed a book which provides instruction on everything people need to do to organize, convince citizens to make donations, the mechanics of planting a tree properly and maintaining it.
Through DOE State energy grants, Nebraska developed a partnership with the Nebrasaka State-wide Arboretum. They used DOE Petroleum Violation Escrow monies to “Plant Two Trees for Conservation.” The $50,000 that the State provided was a catalyst for generating $1.4 million in local and private funds; this resulted in 25 community projects. In the second round of this program they are doing 29 projects, using $500,000 in matching funds.

The last example is provided by the State of Missouri. “Trees Renew Energy and Environment” was its campaign. This started in November, 1990. The objective was to distribute 15,000 trees, and they did it in a unique way. In order to get a 4-6 foot tall native tree, persons brought in a 3-foot tall stack of newspapers, roughly the equivalent to the fibre of one tree. The newspapers are recycled into insulation for low income housing projects.

From the above examples, it should be clear that, given seed funding from higher levels of government and a commitment from local governments, the whole community will often get behind projects which help improve their local environment, while contributing to the solving of the greenhouse-gas issue.

Part 5

DISCUSSION

Questions to the speakers in all sessions following the keynote presentation

and

the responses of the speakers.

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QUESTIONS FOR DR. JOHN PAGE (Page 22)

Dr. Ian Burton, Session Chair

I was interested in your damage data from extreme weather events. I was wondering if that information is drawn from insurance claims, if there is any corroborating evidence and in particular if increased insurance claims might be explained by other complicating factors as well as extreme weather events.

Dr. Page

It is quite hard to get completely objective information out of insurance companies. They have their claims; anybody that knows insurance companies knows that people exaggerate claims made on insurance companies. One of the big problems if you have a big storm and you get, say, 30% of your property damaged, it becomes a serious academic question seriously linked into the insurance industry. The insurance industry is very isolated from the rest of the intellectual community; they tend to work with an internalized assessment of problems and there isn’t really the scientific link in weather insurance. Even with car insurance, you have your no-claims bonus, and if you have five crashes, you pay through the nose. If you have a crummy old building and the roof blows off every year, there isn’t the same kind of link between how badly you do things and how much insurance you pay. Another quite tricky area is flood insurance because there was some deal done with the government in the UK that flood insurance should be independent of height above sea level or risk of flooding. This means that people can build in risky situations which, in insurance terms, is rather daft. The cost is smeared over all insurance payers; the insurance premiums for building in daft places are not appropriate. So there is a huge task to be done to make insurance much more a tool of intelligent response to the problems that society faces from hazard rather than a sort of cost plus system which it tends to be at the moment.

Anon.

Your diagram of the mass flows into and out of cities listed land as an output. Can you explain that please?

Dr. Page

No, that was an output to the land. What goes out of the city must go to the atmosphere, to the land or out to the water systems. It must go somewhere.

Anon.

On your slide that was talking about the significant savings of global warming, you didn’t mention air conditioning. Did you take that into account?

Dr. Page

In the UK, air conditioning does not have a significant impact. We do not use a lot of air conditioning.

Supplementary

But if your temperature went up, ...

Dr. Page

Then, yes, there is a negative cost on the plus side for the temperature going up. One of our functions is to make research recommendations, and one of our research recommendations is that we should make a much more serious study of the impact of the summer conditions on buildings, air conditioning, and the utilities. There are a lot of problems for the utilities if you start to supply a large summer air conditioning load which we do not have at the present moment. It is all very well to talk about substitutes for CFC’s, but the new substitutes are not that proven in global climate terms, and secondly, air conditioning is thermodynamically a rather inefficient process. You are bound to have a lot of CO₂ production going with it. So if you can go down the track of natural cooling, making effective use of natural resources, you are able to maximize your harmonious relationship with the climate and extract value from it and exert the minimum destructive impact on the climate. How to address this whole question of the overheated community is one of the great world problems; it is obviously very important and very poorly addressed in most countries.

Further Supplementary

So that 3.3% savings is not really there.

Dr. Page

Oh, it really is there in the short run because with so much heat dominating, it depends on the mix. If we went to California, it wouldn’t go that way at all. If we went to Calcutta, there is never a cold day. It depends on where you are in the world what the mix is. A few countries will benefit from global warming; if you are very cold, you would be better to be 3° warmer, but there are not a lot of people in that position.

John Topping, President, Climate Institute

Recently, the climate change impact review group in the United Kingdom, of which your colleague, Martin Perry, I believe was the Chairman, issued a report which was quite comprehensive but seemed particularly to highlight likely changes in soil moisture in a number of parts, particularly of England, that were projected to cause much more shrinking and swelling and pressure on foundations, particularly in clay soils. That together with ecological impacts seemed to be highlighted as the major impacts. Obviously they are very hard to quantify in the terms of heating and other things but
in reading the report I got the impression that they seem to see those as the major stresses that the UK will face on this.

Dr. Page

I came here to deal with cities, so I had to try to reinterpret the report as a man who spent his life dealing with climate and cities, natural environment impacts. What I have tried to do is to interpret the information in that report in relation to the systems different set of studies which is concerned with the impact of on. But I did not see that on my agenda today. I have tried to focus on what the impacts are on cities.

Supplementary

Is it your sense though, looking at the overall report, that the impacts would be more severe on the rural economy than on cities in the UK, except, obviously, for those coastal cities.

Dr. Page

One of the problems is that the rural areas essentially act as points of supply for the cities. In the real sense, the rural areas, be it mountains, by river and other systems, to the cities. You at the flows between the two. You have to look at the city will have a local impact on the system through acid rain and very close impacts like exhaust down there on the street hitting us pollution. There will be a whole scale of impacts. There will be here in this building. There will be further affecting the vegetation in the near-Toronto miles. It is a juggling game; you are carrying all these balls in the CO2 track. You have to keep the city running and we have to a systems approach - micro climate and global climate interacting.

Dr. P. J. Peterson, King's College, London

Without wishing to follow along the same line, I wonder if I could refer back to the very interesting historical data which Professor one area that I think to which he did not draw to our attention was basis. It looked as though there was an increasing expenditure as into the future - 2010 or 2050 - as to whether in the UK there will have a various serious financial implication for the future of cities and the rest of the country of course.

Dr. Page

Basically, our job was to indicate areas of research. Obviously, in some areas the insurance risk goes down. The snow insurance risk and the frost-pipe freeze risk goes down, in the UK that is. There are other areas where it is unknown; basically nobody has told me in an authoritative way whether I should increase my design wind speeds by 5 meters per second or whether I should lower them by 5 meters per second. To begin to answer that sort of question, we are in a lot of trouble. We can do "what if" scenarios, and we can say "what if the design wind speed goes up 5% or whatever, what would it mean to the economy?". But we are very lucky in this area of great significance, which is the assessment of engineering risk on sound climatological grounds incorporating the knowledge implicit in GCM modelling.

QUESTIONS FOR DR. DEELSTRA AND DR. GUPTA (Pages 44 and 66, respectively)

Linda de la Croix - U. S. Department of Energy

I have a question about the houses with grass roofs. What are you using for a moisture barrier, what material? Also, it wasn't apparent what they were using instead of gutters to avoid rotting your walls.

Dr. Deelstra

The grass can dry out in the summer. It is resistant. There are several constructions; it depends on cost and the carrying structure underneath. In this case it is wood with an impermeable layer of impregnated paper, in this case coming from Germany as a sort of experiment. And then you have a layer of earth. There are handbooks and various constructions have been tested. There are no gutters essentially; the idea is that this roof works like a sort of sponge. So it absorbs the rainwater. Sometimes some of these houses have a chain of metal that leads to drops. In many of these projects, but that is another subject not for this conference, there is a principle of using as much as possible rainwater that falls on the spot for local use, for gardening, even for toilets. This is another story, about water management systems included in these types of projects.

Anon.

How do they keep the grass cut?

Dr. Deelstra

In this particular project they have goats. There is a neighbourhood little farm. But you can cut it; you have to choose the special vegetation you wish. it will find its equilibrium.
Anon.

What have been the key factors in Delft and other Dutch cities in getting people to switch from automobiles to bicycles? Is the amount of money which government has spent on infrastructure? Is it the storage facilities next to railway stations? Is it the dedicated right of ways? What have been the key factors that have got people to get out of their cars and get on to their bikes?

Dr. Deelstra

It is the comfort, I believe, the comfortable design of safe routes, in combination, for example, with greening. Out of my own experience, when I am bicycling in Delft, I enjoy the fact there are so many kids and you hear their voices as if they were birds in the city. So it is the whole urban scene that is being changed, from, let us say, a machinery, stinking, disgusting sort of ambiance towards a lively, human, attractive sort of place. I think it is these vague elements that help. But I won’t give you the impression that every Dutchman is automatically fond of bicycling only; there is a big, big struggle going on, how to get people out of their cars. There is a big debate and at this moment there is a national campaign to try to get people to think about their cars. In the Delft plan, it was mostly the availability and the choice of routes in a comfortable way. But bicycling in the Netherlands is not so comfortable at all; there is a lot of rain and wind. Maybe that is not a sufficient answer; these are my observations and you see the move in terms of statistics. Then you ask them, which the psychologists have done in Delft, and you get the perception that it is more attractive in several ways.

Phil Jessop - Director, Urban CO₂ Project

Do you have a backlash at all from owners of automobiles? To create dedicated lanes you have to take a little space away from the roadway. Has there been any problem selling the bicycle program to people who drive cars? Is there political backlash to prevent that? I am interested in the politics of it. Is there a really effective lobby that convinces politicians to create these lanes?

Dr. Deelstra

It is a bit complicated to explain. I need some slides to explain that.

Anon.

I am very interested in the concept of making the flows that the city is dependent on visible to the citizens of the city. Are you thinking of that as a public education technique or a new element of the culture of the city. Would you elaborate on that principle and on how you would implement it? Would you include for example the importation of eggs and milk from the country as well as water or energy forms of various sorts?

Dr. Deelstra

Yes it is a very basic concept to try to couple decentralized local systems with your centralized, open import-export systems. Indeed, it is a combination of the various flows - food, water. Water is very local, so that is very easy in a relative sense to try to introduce. For example there are projects where waste water is being cleaned in the neighbourhood, so if you don’t participate by avoiding chemicals in your house, in your management of the house, that will not work. You very directly experience what you contribute to the water management, so it helps to conserve. Farming, yes, on a very little scale it could be reintroduced. When you think about composting you think of the various fractions in it; there are various experiments to have a sort of neighbourhood farm, which brings also people together. That’s more or less symbolic because the quantities of food to be produced are small. But it is of a high educational value because children, on deprived neighbourhoods in particular, think that bread comes out of a factory. There is a big program in the Hague that is really urban farms in deprived neighbourhoods. There is a selection of little farm systems so you can again try to find the roots of where you stem from.

John Topping, President, Climate Institute

I was fascinated in Joyceeta’s presentation by one of the early charts which had a listing of sources of carbon dioxide in the Netherlands. Greenhouses, themselves, were listed as sources of roughly 5% of the CO₂. I wondered two things. Is this essentially heating or what would the sources be there. Also what types of vegetables, crops, etc., would tend to predominate in the Netherlands.

Dr. Gupta

I presume that you already know that a large percentage of the vegetables and fruits in the Netherlands are grown in greenhouses. There is, naturally, an energy required to heat the greenhouses, to provide a constant temperature and the lighting necessary for those kinds of plants. As a consequence, naturally, there is a 5% emission of greenhouse gas from those glass houses. I’m not really an expert in it but I could tell you that right now there is discussion in the Netherlands about how you can consider reducing greenhouses in the Netherlands and maybe moving them to warmer spots.

Patrick Findlay, Environment Canada

My question is to the first speaker. It relates to the very impressive Dutch national plan which has evolved. Could you share with us how that plan was developed in terms of the consultation processes that you went through, the different levels of government that were involved, the different industrial sectors and the different areas of expertise that were brought to bear on it.
Dr. Gupta
I would give a brief answer to that right now. In developing the National Environmental Policy Plan, which was developed in 1989, the first input was a document called "Concern for Tomorrow," prepared by the National Institute for Public Health and the Environment which considered a long term survey of environmental problems and issues in the Netherlands. It covered a period of years up to 2010. On the basis of the recommendations in that report, four ministries worked together in trying to find out what would be the best method to come to a solution. They were the Ministry of Housing, Physical Planning, and the Environment, the Ministry of Agriculture, Nature Management and Fisheries, the Ministry of Economic Affairs, and the Ministry of Transport and Public Works. These four Ministries thrashed out the issues in terms of what are the major issues before the country, which sector should be targeted, which group of people should participate, and what kinds of tools should be used to involve all these people in the creation of an integrated national environmental policy plan. This is a plan which covers the period 1990 - 2010. In explaining a little bit about how the policy document was devised, let me tell you how we are currently working on policy documents. What happens is, different departments in different ministries have their own working groups and they discuss different issues at the level of junior civil servants. That document goes up to senior civil servants and is discussed at their level between different ministries and that calls for integration between all ministries. Then it goes up to the level of ministers; they all have to agree on what should be done. When the National Environmental Policy Plan was presented to Parliament, it was signed by the ministers. So you had a sort of integrated approach towards the issue of environment.

Dr. Deelstra
Could I add a short word or two on the part on consultation with the public? We have a central board of advisors on the environment which consists of consumers' organizations, industrialists, organizations of labour, and some experts. This is a mirror of Dutch society, and, in the preparation of this process, it is normal that already drafts of this document have been circulated and comments have been invited.

QUESTIONS FOR DR. DALFES (Page 92)
Jim Bruce - Chair Canadian Climate Program Board
In many international basins, like the ones you were talking about, there are water apportionment agreements to set out some rules. Have there been any negotiations towards water apportionment agreements and what are their outcomes?

Dr. Dalfes

There have been negotiations, and they became much more serious when Turkey finished one of the dams, the largest dam on the Euphrates, and that dam started retaining water. That meant a reduction of water reaching Syria and Iraq. Now, I am not sure what international law says about these things, but these are issues that are not really well defined in international law. Since Turkey has the source region, Syria and Iraq have to negotiate with Turkey about the amount of water they get. Now there have been negotiations and there has been a lot of political play. Also, there is another region in the southeastern corner of Turkey where there is a river that originates in Syria and that goes through a very fertile region of Turkey. The region is due north of Lebanon basically. Syria immediately started constructing a dam on that river. They want to control that one to have some leverage over the Euphrates water. There have been negotiations, but I don't think those negotiations got anywhere. To my knowledge, and I do not have a lot of detail, there will be a water summit in Istanbul this fall. I should not say summit, perhaps a meeting under the patronage of our president. There will maybe be some discussions there also, but the important thing is this I think from the Turkish point of view. I think we are doing a lot in terms of using a much better technology in terms of using the water we have and irrigating it in a much more rational way. I think the state of irrigation and the way the water is used in Syria and Iraq is quite primitive. I think Turkey would have lots of sympathy for, and I am speaking for myself or general public opinion I must say, not for the Turkish government, we would have lots more sympathy for Syria and Iraq if they were also to improve their technology in terms of irrigation and water use. I think water resources in the region are finite, so surely we have to use them sparingly. Yes, there are negotiations and its a very hot question. Syria is trying to get leverage on Turkey by other not so acceptable political and para-political means.

ANON
I have two questions. You mentioned something about the demographic transition. What factor do you consider the most important for that transition? We hear about, in some cases, it is urbanization, in other cases it's per capita income or disposable income, in other cases it's education, particularly for females. What factor do you think is most important for Turkey?

Dr. Dalfes

Really I am not a specialist of demography but I know from discussions with my demographer friends that all these factors play important roles. But I think the attitudes of the people, when the attitudes of the people and security, their attitude towards life and family organization change. I think that is the most important thing. Because of the kind of education they get - they really do not get an education in rural areas - and also their whole outlook on life, change when they move from rural areas. That is just my feeling of course.
Anon.

My second question deals with the carrying capacity which you just sort of briefly dealt with. In your modelling, and particularly its focus on the impacts of climate change, is it not necessary to come up with a base line, something like some kind of regional carrying capacity to try to assess the dynamics between population and resource and environmental things and then try to assess what impact climatic change is going to have on top of that?

Dr. Dalfes

I don't know. When I mentioned the term carrying capacity, I did it unwillingly. I think the carrying capacity is very tricky and as far as I am concerned a meaningless parameter. It really depends on what kind of life quality you want, what kind of social organization you are going to have, what is your access to technology, and whether you will be able to finance that technology. So the carrying capacity of a city like Istanbul is very much dependent on the public finance in Turkey in the coming half century. It is very difficult to come up with a number; any number we come up with will, I think, be meaningless.

J. Topping

With water resources, is there much collaboration going on at all on desalination as a kind of alternative to water in the region. I know the Saudis have done a certain amount of work themselves; has there been any kind of collaboration between countries in the region?

Dr. Dalfes

There has been talk, not on a regional level, to solve the Istanbul problem with desalination. I think that desalination is a very energy intensive thing. For a people like us who would like to reduce emissions, relying on fossil fuel to power the desalination process is not a solution. What happened to Istanbul was much more of a management and finance problem rather than a limitation of the natural resource. If we had the money, if we had the vision of building some margins in our water system, we would not have that problem. Also, Turkey is very rich in water as long as you are willing to pay money to bring water from other regions which have a surplus of water. I think, in the context of Turkey, desalination should not be an issue. Now, I know the Saudis are interested in that; they are interested also in towing icebergs from wherever. There are so many resources in the region, both in terms of oil and water, and also technology - I must mention Israel first and Turkey second in terms of technology - if we were to generate a peaceful atmosphere of collaboration, I think with all these resources and technology, including human resources, we should be able to create a stable situation there. The main problem we have on our way is the history.

QUESTIONS FOR DR. NISHIOKA (Page 108)

Jim Bruce - Chair, Canadian Climate Program Board

In the Japanese strategy for addressing the global warming issue, which you talked about at the beginning, are there any specific activities or programs that Tokyo, as a city, is adopting to contribute to that action plan?

Dr. Nishioka

Tokyo is now thinking to establish another action plan. It is also trying to establish a project called Scheme '89 - it begins from '89. The scheme is to recycle all the garbage and all the waste. The third approach is an environmental management plan concerned mainly with traffic.

Linda de la Croix - U.S. Department of Energy

You made several references to density being a benefit with regard to efficiency in utility distribution, carbon use, and so forth. Do those figures include the suburban areas of Tokyo or just the one Prefecture that is Tokyo itself, and what are the differences between the suburban areas and Tokyo?

Dr. Nishioka

I am sorry that I confused some figures. Sometimes I mentioned about the concentrated areas, and sometimes the Tokyo Metropolitan area that included three Prefectures or so. The figure I showed for the comparison of the national-wide and the urban Tokyo area had the figures for the Tokyo Metropolitan Region which includes three or four Prefectures. So when we take the efficiency itself, it is my opinion that those aggregate figures show that the aggregate area has some kind of efficiency because of transportation - the commuters always use the subways and do not drive cars because of the conditions. There is some kind of [scale merit]. But this [scale merit] is attained by introducing resources from outside. They do not have the good [operators] for the parks and green areas and so some part of the quality of life is sacrificed to attain this efficiency.

Anon

You were showing a figure where there was a reduction in sulphur dioxide and carbon monoxide in the period from about 1965 to about 1982. I was interested in knowing how did you achieve this reduction since it seems that the industrial production was growing up at the same time. Is it just a matter of policy and regulations?

Dr. Nishioka

Our industrial activities grew up so quickly at that time, in the sixties, I think, we had a very bad epidemic pollution program - asthma, Minimata disease, that kind of quite miserable cases, so
that the peoples took this matter so severely that pushed
government to set very strict regulations and the industry itself
obeyed them. At that time I was with industry in charge of locating
some petro-chemical plant. We had to be conscious of how the people
were thinking to build that factory. The company recognized how
serious this matter is; they had some suit, this damage so much in
Japan. This had some kind of social system that do not allow this
kind of inequities. So, the government set very strict regulations
and the industry obeyed them. Another point is that Mr. Honda, the
founder of the Honda Automotive Company, noticed that when we set
very strict controls over the emission of automobiles at that time
- it was the California standard, but California postponed those
regulations to later and later - we attained that level. Another
time, Mr. Honda said that this was a very good chance for the
motorcycle makers at that time - Honda did not produce a big car at
that time. As well, Nissian, Toyota and Honda were not big at that
time, and we succeeded in meeting those standards which the big car
makers did not. The point is that we always set some target that is
beyond

QUESTIONS FOR ACA SUGANDHY (Page 134)

John Topping - President, Climate Institute

Aca, in terms of actual coastal vulnerability of Jakarta, if there
were, let us say, a one-metre sea-level rise, which the IPCC has
projected may happen by 2100, what kinds of impacts would that
present for populated areas of Jakarta?

Mr. Sugandhy

Many coastal cities in Indonesia, for example Jakarta with 8.2
million people, will be affected. But we must recognize that
level is expected to rise both because of warming of the water due
to climate change, and of geological effects. Our measurements show
that sea level has already risen a small amount, but we are not
sure whether this is due to climate change or local geological
effects. In any event, whatever the cause, we must adapt to protect
the people.

We know that some of the people in Sulawessi and in Madura
traditionally have adapted to changes in sea level. But now,
because of the folly of using building technology that was based on
the assumption that the structures would be above sea level, we
have many problems. Every time there is a high tide, areas are
flooded.

Another problem of great importance for large cities is the
intrusion of salt water. Because of the improper use of ground
water, Jakarta has suffered an intrusion of sea water of some 17
kilometres into the city. This affects the supply of potable water
to the citizens. Thus, we are interested in sea-level rise not only
for its impact on civic infrastructure and buildings, but also
because of this insidious intrusion of salt water into areas
previously occupied by fresh water.

Anon.

We heard yesterday that the Netherlands is about to begin a boycott
on the import of tropical woods that are not sustainably harvested.
I work in Canada with a group that is going to be lobbying for the
same kind of boycott. You talked in your presentation of an urban
forestry strategy for Jakarta, but Jakarta is a city in a country
that has such a huge tropical forest. Are you going to address that
issue in your atmospheric strategy?

Mr. Sugandhy

Yes. As I mentioned, Indonesia, as the third largest country in the
world which has tropical forest, has great concern over global
change. We are aware, and we are concerned to maintain our tropical
forest because of its role in that global issue. But, in the year
2000, the population concentration in cities will be increased; we
estimate that around 70 Million will be in the big cities, and we
know that most of the carbon dioxide emissions originate from
industry and transportation. So we should concentrate on the
tropical forest from the point of view of how to improve the forest
management. Deforestation, or improper management of forests,
affects the role of forests as carbon dioxide sinks. So we are
concerned about that.

But the policy we have adopted has a second focus. The urban forest
will improve the air quality in our cities. So, for the issue of
global warming, we try to improve through tropical forest
management. The present issue that concerns us is not only the
tropical forest but the global forest as a whole.

So, as a developing country, we are concerned about managing the
forest properly; like any renewable resource, if properly managed,
we can get the benefit without harming the global environment.

When we talk about the tropical forests, we not only talk about
wood, but also biodiversity. Biodiversity is becoming as important
as renewable resources in the discussions related to future
generations.

QUESTIONS FOR MEMBERS OF THE URBAN TRANSPORTATION PANEL (Page 167)

Anon.

A question about Copenhagen. Is the business and financial
district the centre part of Copenhagen, and if so, what has been
the reaction of the business community to these steps?

Mr. Lund Madsen

The business district, the office district, is in the centre
of Copenhagen; that is the banks and so on. The restrictions
were made so many years ago that there have not been any negative
responses on it. The parking restrictions have given some

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problems. Of course, business wants to have some parking areas, not just for their employees but also for clients and so on. In Copenhagen there is a lot of private parking in connection with offices too. The suggestion about charging a price to get into the centre of Copenhagen, the toll system, some of the companies have said that they don’t think it is a good idea. But up until now there has been no negative responses from business.

Dr. Danny Harvey, University of Toronto

I was wondering if you could say a little bit about the road pricing schemes that you are contemplating and which are the ones most favoured for possible implementation at the moment.

Mr. Lund‘Madsen

At this time, road pricing is just under discussion. We know that road pricing has a lot of problems; it is working very well anywhere in the world as far as I know. It is difficult to develop. But we know that in five years, or we expect that in five years, a good system of road pricing will be developed and that we might combine a toll system, in which you pay to get into the centre, with a road pricing system.

Supplementary

Are you thinking of a system where there is a sensor in the road and a sensor in the car which keeps track of the distance you’ve travelled or would it be a permit type approach?

Mr. Lund‘Madsen

We have discussed an electronic system. The main problem in it is more political, that you should not be registered in any way when you are running your car. So we have not decided which system we would like to use, or if it is going to be used. It is political of course.

Anon.

My question is for Mr. Martin. You mentioned the fact that, as politicians, one of the prime concerns is reelection at the next election. If you were a council-man at one of the municipalities to density increase as opposed to sprawl, how would you respond to other council members’ objections on the basis of lost businesses or lost development coming into your municipality and going to another municipality?

Mr. Martin

First of all, I have been surprised at how much support there has been in the area. I anticipated a lot of resistance outside of Metro to any proposal for a freeze. I have been very surprised, pleasantly surprised, about the support for it generally. It’s a straight up issue, and that is is it viable, is it possible to continue to allow low urban development to sprawl on the opposite of the centre. The only response you can give is that it is not viable. It is like choosing whether you can deal with the problem of organisms in the water system by using arsenic; it may be a preferred solution by some people but it is not viable, it is not on, it is not a sustainable way to treat water. I think the same point has to be made about sprawl and about suburbia. If someone can come forward with the suburban option without undermining environmental and financial integrity, obviously, that is a totally different matter. But I think that the case is so totally open and shut on that point that I think you can only deal with it straight up. Interestingly enough, I think that suburban politicians themselves, many of them, realize that. They don’t have a future with dramatic growth and large suburban lots as a part of it.

Supplementary

Do you find it difficult to be dealing in terms of time frames of ten, twenty, fifty years of sustainable development in a context of a four-year election schedule?

Mr. Martin

I do. The fact of the matter is we make public policy decisions that are thirty, forty, fifty year decisions. You are talking about infrastructure decisions that have very long lifetimes. Again I can only report that it is a very pleasant surprise to see how Metro Council itself is beginning to incorporate global warming into routine decisions on infrastructure matters. I think it is a very easy argument to sell to politicians that there is zero point in spending one hundred million dollars on something which is simply going to be a dinosaur another five or six years from now. But we do need to answer the question of how we are going to reduce emissions by “x”, whatever “x” is, within the context of this capital budget. And I should say that I am a little concerned about the fact that we are tending to try to creep up on this issue, we are tending to try to get councils to adopt a 20% reduction target with the idea that maybe down the road they will adopt a 30% and then maybe a 50%. We have to start talking about the real number that is needed and what we have to do to achieve it.

Mr. Colle, Session Chair

If I may comment on that a little further, there’s an interesting coalition that is forming between the suburban politicians or the suburban ratepayer groups and the downtown ratepayer groups and politicians, and that is that both have a constituency that is saying “we need to protect open space, whether it be prime agricultural land which is being used up by these ranch-style bungalow developments, or whether it be inner city parks that are being swallowed up by development. Those pressures are being brought to bear on the political representatives. Therefore, it is
very difficult now for even suburban politicians to oppose initiatives which protect open space, whether it be agricultural, whether it be marshlands or just wetlands that exist on the periphery. So therefore there is a lot of pressure to stop the sprawl thus you get a sort of shotgun marriage between the suburban politicians and the downtown politicians. This is what is happening in Toronto because there is an extreme sensitivity to the swallowing up of what little agricultural land we have and what little green space we have. That’s what I see developing in the metro perspective.

Anon.

I was very surprised to hear about some of the strategies for reducing CO2 in Denver. For example, telling people that if they worked for the municipal government they have to live inside the city and telling employers that 35% of their staff have to come to work sharing a ride. In America? What about personal freedom? Is that an issue? In a country where you have difficulty getting people to use a seat belt.

Dr. Foute

Perhaps you misunderstood me. On the residency requirement, that is not a new strategy, and what we’re looking at in giving people a financial incentive to live in the city is trying to do away with that requirement. The City and County of Denver in 1979 voted to have employees of the city live in the city. It just came up for a vote again last month and they voted it up again. So those are the people voting for that requirement. What I was saying, and possibly I didn’t say it clearly enough, is that I’m looking at an alternative method that I could present that would say “let’s give people a financial incentive to choose to live in the city or not and do away with the requirement”.

Anon.

I wonder if Dr. Foute could expand a little bit on one of his initiatives, that one being new development around the new airport. You mentioned the land-use planning—perhaps new policies or new criteria for land-use planning in that area. I wonder if they are similar to the types of things we are talking about here in Toronto, compact form, intensification, and so on.

Dr. Foute

Yes, those are some of the things. We are looking at coming up with environmental design standards that would help to guide development. For example, in Tucson, they have a Tucson solar village. Right now the current energy need for a typical development in Tucson is 4 megawatts per thousand people. In the solar village, it is reduced to 1 megawatt per thousand people. On water use, the same logic applies; to serve four to five people. We’ve done some calculations to show that you can probably double that—1 acre-foot can serve eight to nine people for a year. So we are looking at some energy and transportation and water conservation design standards that would then result in a different way that the urban area builds up because you only have the capabilities or you only provide a certain amount of energy to a certain area. Therefore, it would have to result in certain densities. We wouldn’t come up with those design standards capriciously; they would be based on things that you can do like co-generation and district heating at the neighbourhood level. To reduce trip distances, we would come up with indexes for “can you do everything you need to do on a given day without getting in your car.” Without getting into it explicitly, we have some fairly explicit district guidelines instead of zoning which is performance based rather than descriptive based. It’s based on what’s going around the United States; some of the things are ones we’ve come up with on our own and some of them aren’t.

QUESTIONS FOR MEMBERS OF THE PANEL ON MUNICIPAL RESPONSES (Page 180)

Nancy Wilson - Climate Institute

I guess this is for the first speaker. Is there any thought of limiting water hookups in the outer suburbs or electricity connections, or that sort of thing, to make the population more dense?

Mr. Gilbert

Yes, the answer is yes in the case of water and sewage. Not in the case of electrical connections. A lot of the area where the growth in the outer suburbs might occur is not yet properly serviced by water and sewage. So one important facet of decision is where to lay the new mains.

Jim McCulloch - Conference Director

I would just like to make the comment that, having listened to the presentations yesterday afternoon and those in this session, we might be able to solve our greenhouse-gas issue in Canada by moving all our major cities into one general location of water that’s available, planting a zillion trees, and painting everything white.

Mr. Gilbert

If you can answer that one, the energy costs of reconstructing cities is very high. But, Jim, you touch on a very interesting point. People, including very many environmentalists, like to point at cities as being the problem. If you accept the thesis that residential density is among the most important determinants of energy profligacy in the first world, then the solution is in cities and in the densities that cities, and in particular, inner cities, can afford and the economies in energy use that they permit. So, in as much as you are arguing that everybody should live in cities, then you are pointing at a solution. Whether they
should all be moved together is another matter. But I would love to see a really good energy accounting of the energy use in rural Saskatchewan, for example, where I read about people regularly going on 60-kilometre shopping trips.

Patrick Finlay - Environment Canada

My questions are for our two guests from Finland and Germany. They relate to co-generation of electricity and heat. Could you amplify and tell us a little more about that with respect to the institutional arrangements between the electric power utility and the city governments, the operators of the district heating system. Could you tell us some things about the reliability of the district heating systems and about the availability of the district heating systems with respect to winter and summer, and some idea of costs, infrastructure, and so on?

Mr. Lottermoser

First of all I want to explain our situation of the organization of utilities in our city. We say the public utilities company is a 100% daughter of the city, so the municipality itself is giving the directives for energy policy in the city. This utilities company is producing electricity and it is providing all three types of energy - electricity, district heating, and gas - distributing all in the city. All this is in the hand of the municipality. We, ourselves, dominate this field. There is no private organization which is doing part of this energy supply. So, from this point of view, no problem. It is, I think, very rare in the northern part of Europe to have co-generation than, say, in the southern part of the United States; the climate is quite different. We have to look at a certain balance on energy demand in the field of electricity and also the heat demand; this has to be a certain coincidence. We have, let us say, a maximum load on electricity demand in Saarbrücken at 200 megawatts; at this level you may put out the same amount of district heating. So, this gives us the idea of what you can do with district heating. In addition, in Saarbrücken we are connected to a larger district heating system within the region. We can have more input of waste heat from industry or from power plants into the system. This is giving us some additional possibilities of using district heating. For the costs of district heating, I would say they are similar to using gas and, for the moment, at the current oil price, it is a little bit more expensive by about 10 or 20 per cent. It is not so easy to give it very exactly because this depends on what you estimate your needs. This is a rough idea. Four or five years ago with oil.

Mr. Virtanen

The first thing is that we need heat. Electricity is somewhat a by-product of heat production. We have both privately owned and public companies running this. It works very reliably. It is a very good way to produce energy in northern parts of the world.

Mr. Gilbert

Just a word about Toronto. We have a distribution system which serves about 130 buildings in the downtown area including this one, but it is becoming irrelevant to the energy scene in Toronto because buildings increasingly in Toronto don't require heat. The typical new building that goes up in Toronto, and I am talking about the downtown, requires heating of any substantial amount for only fifty days a year. There is one building that has been designed to have none. The typical cooling requirement for a new building now is 365 days a year. The emphasis is not worrying about the heat load but on worrying about the cooling load. You can supply cooling through a district cooling service and the ultimate energy source can be very much the same. You don't have to go to the southern part of the United States to figure out that heating is not very important and cooling is the name of the game. Although nobody has ever done a proper accounting, probably in all of this is going into downtown Toronto, there is more energy used for cooling than for heating. For new buildings, that is overwhelmingly the case.

Mr. Jim Bruce

It is interesting that all of the members of the panel are from countries which manufacture automobiles. Finland and Sweden make Volvos and Saabs, and we know about the German and North American manufacturing. All of these manufacturers have prototype vehicles that are perfectly good vehicles that use less than half of the fuel of the cars they now sell. Could there not be some role of the cities in trying to encourage our reluctant national governments to get back to the business of regulating the fuel efficiency of vehicles?

Mr. Lottermoser

Yes, we have some regulations on efficiency, just with the objective of reducing energy consumption. This is done by the national government; this is not possible for the municipality to give some rules.

Mr. Virtanen

We have the same situation. Our own automobile industry is quite small. After all, I think if we are trying to decrease the demands in transportation, we should talk to Japan. About 60% of our automobiles are made in Japan.

Mr. Gilbert

I think the future of the automobile is doomed, and for cities to get distracted by advocating vehicle efficiency is probably diverting energy that could be much better used to enhance residential density, promote public transportation, and to do some other things. In any form of government by technology, the private automobile is not a sustainable mode of
transportation throughout the twenty-first century. For cities to lock themselves into the delusion that it is will lose golden opportunities for properly restructuring our environment.
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Joyeeta Gupta

**PART 3 - GLOBAL CITIES**

Climatic Change and Istanbul: Some Preliminary Results  
H. Nutzel Dafis
Megalopolis and Global Change: The Case of Tokyo  
S. Nishioke, Y. Moriguchi, and S. Yamamura
Urban Climate of Jakarta  
Ace Sugendrity

**PART 4 - REMARKS OF PANELISTS ON URBAN ISSUES (details overleaf)**

**PART 5 - DISCUSSION (questions to speakers in parts 2, 3 and 4)**

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