Science Council of Canada Report No. 27

September 1977

Canada as a Conserver Society

Resource Uncertainties and the Need for New Technologies

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September 1977

The Honourable Hugh J. Faulkner, PC, MP,
Minister of State for Science and Technology,
House of Commons,
Ottawa, Canada.

Dear Minister Faulkner,
In accordance with Sections 11 and 13 of the Science Council of Canada Act, I take pleasure in forwarding to you the Council's Report No. 27, *Canada as a Conserver Society: Resource Uncertainties and the Need for New Technologies.*

Yours Sincerely,

Josef Kates
Chairman
Science Council of Canada

August 1977

Dr. Josef Kates
Chairman,
Science Council of Canada.

Dear Dr. Kates:

May I, in submitting this Report to you, add a few personal remarks.

First of all, I would like to acknowledge my indebtedness to a remarkably diverse and knowledgeable committee, and to the creative and thoughtful work of the Council's science advisers. To the committee, Ran Ide brought his skills as educator and communicator and his involvement in future research. John Pollock gave us a sense of reality, stemming from his own responsibility for his employees and their work. From Gabriel Filteau we all learned more about the implications of human intervention in the world's fragile environments. As project officers, Arthur Cordell and Ray Jackson lived with the study for more than two years, and their contributions to both the concept and the form of this Report must be especially acknowledged. Jean-André Potworowski created *Conserver Society Notes* and made it an attractive and challenging publication, a task that Bruce Henry continued capably during the past few months.

When a committee like this winds up its work and summarizes its conclusions, there remain experiences and insights that go beyond the scope of the initial study. These do not always become part of the Report, and I would like to share two of them with you. One relates to the question of why the Science Council of Canada would study a topic such as the Implications of a Conserver Society. The other is concerned with worldwide response to the reality of "limits."

The need for Council's involvement in concepts such as the Conserver Society follows from the very nature of technology itself. In contrast to the essentially analytic approach of science, technology is basically a synthetic endeavour. It is the purposeful application of scientific knowledge to meet human needs. As long as this is so, the issues of technological choice will contain and reveal elements of the conflicts among those needs, and conflicts between the preferences of various segments of society.

Thus the study of the scientific and technical components of a problem may not be a sufficient condition for its solution, though it is a necessary one. Without sound knowledge of viable scientific alternatives, no progress toward a solution can be made. Finally, however, the choice comes down to a matter of social preferences, and its implementation often waits on political will.

For these reasons, we have felt throughout our study the need to be part of an ongoing civic discussion of questions and initiatives related to the concept of a Conserver Society. *CS Notes* provided forum and focus. The response of individuals and organizations to *Notes* has left us with one firm impression: most Canadians are aware of the problems caused by wasteful and thoughtless consumption. Many of them are willing to make personal choices that would help to redress this situation. They are waiting now for worthwhile opportunities to do so – and for the assurance that the appropriate technologies are at hand.

The need to come to terms with resource scarcity, environmental pollution and the associated social questions is, of course, not specifically a Canadian problem. It is recognized throughout the world, often much more keenly than in our country. I only wish I could adequately convey to you the nature and magnitude of this global response.

It is now understood that in many fields the continuing expansion of current practices will not be possible in the future. This recognition is having a strong and stimulating effect; far from being restrictive, it is releasing creativity, imagination and initiative all around the world. In many countries the best minds are being challenged and the impact of this challenge is beginning to be felt. We see novel technical processes, fresh designs, new theoretical models, the questioning of established concepts, and experimentation at the workplace and in the community at large. To suggest that moving toward a Conserver Society means regression, or moving "back to the woods", is totally misguided.

In other words, in a Conserver Society, conservation is the result of critical analysis and technical as well as social innovation. To be successful, it requires a sophisticated understanding of the interdependence of human, social and technological factors on both the small and the large scale.

Having been exposed to the ongoing work on the international scene, I have come to realize that much of the world around us is tooling up for a future that is not a mere extension of the present. I am convinced that the tools to build a humane and democratic future are being conceived, researched and tested right now.

Unfortunately, this process goes on without a great deal of Canadian participation. Our country has the talent, the human resources and the sense of global responsibility to contribute to the task of preparing for a different future. But the awareness and the willingness which I sense at the grassroots seem to find at best a reluctant political expression. It may be that this apparent inertia is due to the lingering of the old illusion that Canadians, as a small population possessing immense natural resources, have only to sit back and let the world take its course, to enjoy perpetual prosperity.

I can only hope that this study will help to destroy that mirage and free Canadians for action. Not only are we not as rich as we have grown to think, but our complacency and indecision could cause us to miss participating in the most stimulating and rewarding global tasks of the next decade. Not to respond now could mean losing control over the design of our future.

As I hand over this Report, I can only pray that its insights will be used and that it may become, in the hands of many Canadians, a tool for the good of all.

Yours sincerely,

Ursula Franklin
Chairperson
Committee on the Implications of a Conserver Society.

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I. Background of the Study

Over the past decade we have been rapidly changing our images of the future. Space-ships there still may be, but probably only for a very small minority. Our science-fiction visions of limitless energy and luxurious life-styles must be tempered by realism. The continuation of growth trends of the recent past in the industrialized countries, plus growth in the rest of the world toward comparable levels, would imply a doubling of total energy use every 16 years. Present known reserves of petroleum will be virtually exhausted by the turn of the century.[1] More will be discovered, but even if additional supplies are found, equal to twice all those discovered up to now, the time to exhaustion would be extended a mere 16 years. For that time to be 32 years, an *additional four* times as much would be needed. It is hardly a sustainable future.

Burning such large amounts of fossil fuels could raise the carbon dioxide level in the atmosphere and raise the average temperature of the earth's climate – such unassessable and drastic changes are now a matter of real concern for the next century. Similarly, even if nuclear fission and fusion were to supply vast quantities of energy, we can now foresee the possibility that the generation of such quantities, approaching 1 per cent of the total solar input over significant areas of the earth, could seriously affect global weather patterns within one or two hundred years. Whether in the long range future the human race will find ways to manage the global system to compensate for these effects – as, for example, by deliberately distributing dust in orbit around the earth to marginally reduce solar input – can only be speculated at this time. What is clear is that we have reached a point on some exponential growth curves where we suddenly sense the approach of the 29th day.[2]

More subtle, but perhaps even more important than the appreciation of approaching direct physical constraints (energy, materials, pollution) are two other levels of perception that have been developing. One is the sense of human beings as biological creatures, immersed in vital ecological relationships within the earth's biosphere. We do not yet understand many of these relationships – for instance, the multiple predator-prey interactions in a complex insect-bird-bacterium-plant ecosystem. Some of our interventions may be going too far too fast, and setting in train deleterious changes that cannot be reversed. This perception suggests that we proceed with greater respect for the earth as an ecological system of finite capacity, with system equilibria that have evolved over millions of years. There is a growing feeling that we must temper some of our "bulldozer" enthusiasms while we devote much more effort to improving our scientific understanding of living ecosystems. We can then better foresee the consequences of what we do, the impacts of which can be global in scale.

The second level is of the impact of technology on the human being as a social and economic creature. The process of industrialization, the drive to high productivity and a high material standard of living are having some worrisome side effects. The diagnosis is uncertain: we do not know how much of our social malaise, or our economic anxieties, are contingent on high, perhaps unnecessarily high, throughput, high rate of change, or – like the case of the biological ecosystem – are the result of pursuing particular purposes and expectations without understanding their indirect consequences. We do not, at this point, know how many of our societal problems can be attributed to the way technologies are designed and organized, and how many will require changes in attitudes, expectations or social structures.

Suffice it to say that present indications are that we face a period of exceptionally rapid change and transition, the extent and depth of which are not yet clear. The future will not be simply an extrapolation of the past. Some of the changes that we foresee as inevitable – in energy use, in materials, in ecology, and in social behaviour – are embodied in a concept we have termed the *conserver* society. The meaning of a conserver society and some of its implications are developed in the following pages. The concept of *a conserver society* has not come upon the Science Council suddenly. Most of the principles involved have been developing steadily over a considerable time. While the concept is often linked with discussions following the report, *Limits to Growth,* done for the Club of Rome (1972), or with the considerable public notice of the term "conserver society" that seems to have arisen almost spontaneously over the last two years,[3] its roots really go back to the growing awareness of problems of the environment characteristic of the 1960s. Science Council reports as long as nine years ago raised concerns that can be identified as having a "conserver" orientation.

Report No. 3, *Major Program of Water Resources Research in Canada,* (September 1968), drew attention to the ecological role of water systems and the needs for sound management of our resources (p. 29). In Report No. 4, *Towards a National Science Policy for Canada* (October 1968), a number of conserver-oriented recommendations can be found, *viz.*, (p. 14), the call for the "development of sound programs for the use, conservation and replenishing of resources," and the need for "control of existing and threatened health hazards already created by the misuse of science and technology, e.g., pollution." (p. 15)

In Report No. 7, *Earth Sciences Serving the Nation* (April 1970), it was noted that (p. 34): "the great majority of Canadians have scarcely a rudimentary knowledge of the earth on which they live. The fast-growing interest in our physical environment, the mounting pressures concerning landscape preservation and anti-pollution, the need for improved urban planning, and the importance of natural resource development in Canada highlight the relevance of earth sciences for Canadians."

Other conserver oriented references can be found in Report No. 8, *Seeing the Forest and the Trees* (1970) (pp. 10, 14, 19). In Report No. 9, *This Land is Their Land* (1970), came the call for making environmental improvement a new national goal. Elsewhere in the same report was discussed (p. 9) the need to create an Environmental Council, the desirability (p. 9) of creating a Department of Renewable Resources, the need to increase research on chemicals and biocides (p. 19), the importance of developing long-term ecosystem studies (p. 19) and, finally, the need to more fully develop the environmental sciences.[4]

Report No. 11, *A Canadian STOL Air Transport System – A Major Program* (December 1970), contained a comprehensive discussion of external costs and technological impacts on environmental quality (p. 17). The report noted that:

> "The noise, pollution, congestion, questionable land usage and ugliness associated with the expansion of the automobile-highway system, and similar problems associated with larger and faster conventional aircraft systems, are sometimes referred to as "external costs", and they raise questions of the validity of extrapolating these types of technological growth into the future. It is questionable whether the benefits provided by supersonic flight, high-capacity jumbo-jets and multi-lane super-highways sufficiently justify the degradation of the environment and the problems of congestion which they create. Alternatives are being sought, and the dedicated promotion of technology for its own sake is being halted."

Thus was expressed a concern, not only for environmental effects but for other consequences of choosing one technological path over another.

Report No. 14, *Cities for Tomorrow* (September 1971), moved from predominantly natural environments to the urban environment, to social effects, and problems of waste. An entire chapter was devoted to recycling (pp. 48–56). The broad context in which recycling is discussed anticipates some of the concerns regarding economic growth, its measurement, and its relationship to the quality of life that are raised in the Conserver study.

Concern for the environment and a discussion of the relationship between societal activities and the health of the environment can be found again in Report No. 16, *It is Not Too Late – Yet: A look at some pollution problems in Canada's natural environment; an identification of some major concerns* (June 1972).

The term *Conserver Society* itself was used for the first time in Report No. 19, *Natural Resource Policy Issues in Canada* (January, 1973). This report contained a wide variety of recommendations regarding both policy and the need for new institutions specifically designed to protect and control resources development. For example (p. 32):

> "At an appropriate federal-provincial meeting, the Secretariat of the Canadian Council of Resource and Environment Ministers should be strengthened and renamed a National Resource Management Authority. The structure of the Authority should permit the concern of all levels of government, industry, labour, professional organization and citizens' action groups to be expressed and considered during analysis by the Authority of policy alternatives which are later to be considered by the CCREM.
>
> This National Resource Management Authority should develop and coordinate long-range policies for integrated management of resources and the environment, and should be concerned with the development of policies for the prudent and efficient use of both renewable and non-renewable resources. These proposed policies and their background studies should be published and freely available to the public.
>
> Further, this National Resource Management Authority should increase support for programs to heighten public awareness, and encourage mechanisms for community involvement in decisions affecting resources and the environment."

The Report re-stated the need for recycling cited in the earlier Urban Report and recommended that (p. 38): "industrial institutions incorporate the concepts of durability and recycling in process and product design and, in cooperation with all levels of government, establish effective programs for the recycling of municipal, industrial and agricultural wastes."

Finally, the term "conserver society" occurs in the recommendation (p. 39): "that Canadians as individuals, and their governments, institutions, and industries, begin the transition from a consumer society preoccupied with resource exploitation to a conserver society engaged in more constructive endeavours. Ideally, Canada could provide the leadership necessary to work toward more equitable distribution of the benefits of natural resources to all mankind."

Recommendations and policy discussions with a "conserver" orientation can be found in other reports following No. 19. In particular, *Strategies of Development for the Canadian Computer Industry* (No. 21, September 1973) raised fundamental questions regarding the impact of powerful new technologies.

In Report No. 23: *Canada's Energy Opportunities* (March 1975), Council made the following statement on shaping energy demand (p. 46): "Faced as we are with a different and expensive supply problem we should ensure henceforth that supply projections strongly influence policies for the shaping and moderation of demand and we should promote an energy conservation ethic throughout Canadian life."

On page 47 of that same report, the following was stated (The Conserver study was by now in progress): "A strategy to eliminate waste and to promote efficiency of use in our energy system would be an integral part of any attempt to create a conserver society."

In Report No. 25, *Population, Technology and Resources* (July 1976), the following statement appeared: "We see Canada in the longer term becoming a conserver society using food, energy and resources frugally and using transportation and communications technology to permit a very wide choice of lifestyle, often in smaller communities."

The proposal for a specific study on "The Implications of a Conserver Society" was adopted at the 42nd meeting of the Science Council in June 1973. In the meantime the Club of Rome study on *Limits to Growth* had appeared and was being widely and heatedly discussed. In the fall of 1973 the Arab-Israeli war, the Arab oil boycott, and subsequent coordinated action by the OPEC nations to raise the price of oil roused the world to awareness that the period of relatively inexpensive and apparently unlimited fuel resources was rapidly coming to an end.

The study was set back in getting under way by the untimely death of the Chairman-designate of the Committee, Mr. W. J. Cheesman. The first formal meeting of the new Committee was held in March 1975. One of its first tasks was to define more exactly what was meant by "conserver society". A provisional definition was developed:

> The concept of a Conserver Society arises from a deep concern for the future, and the realization that decisions taken today, in such areas as energy and resources, may have irreversible and possibly destructive impacts in the medium to long term.
>
> The necessity for a Conserver Society follows from our perception of the world as a finite host to humanity, and from our recognition of increasing global interdependence.

A Conserver Society is on principle against waste and pollution. Therefore it is a society which

- promotes economy of design of all systems, i.e., "doing more with less";
- favours re-use or recycling and, wherever possible, reduction at source;
- questions the ever-growing per capita demand for consumer goods, artificially encouraged by modern marketing techniques, and
- recognizes that a diversity of solutions in many systems, such as energy and transportation, might in effect increase their overall economy, stability, and resiliency.

In a Conserver Society, the pricing mechanism should reflect, not just the private cost, but as much as possible the total cost to society, including energy and materials used, ecological impact and social considerations. This will permit the market system to allocate resources in a manner that more closely reflects societal needs, both immediate and long term.

The scope of the study presented difficulties. Not only would it represent a synthesis of many related ideas that had been developing through previous studies, but it would aim to probe deeply into the inter-relations of technology, industry, commerce and human psychology, their implications for the quality of Canadian society and for the future. The thrust of events tended to move energy conservation to centre stage, but these other fundamental concerns, relating to certain structural and inflationary features of our high-consumption throw-away culture, poised against the need to come to terms with our biosphere, remained important.

Their roots run deep. Recent writers have expressed great concern for the economic, political, and social tensions developing in the Western political systems, and between them and the less-developed world, under the pressures for growing affluence. Some writers go so far as to claim that a high level of affluence (in a limited world) is incompatible with democracy. For example, some of the images that shape our aspirations may be derived from minority lifestyles that intrinsically cannot be enjoyed by a majority. To the extent that "being rich" depends on being able to command relatively cheaply the personal services of others, everybody cannot be rich.[5] The more recent reports commissioned by the Club of Rome have taken the direction of emphasizing that the "limits" creating problems for the world today may not be so much physical or environmental, as social.[6]

These are apocalyptic times, full of prophets. Whether they speak truth, or false opinion, is difficult to judge. But these kinds of questions are beyond the scope or competence of the Science Council to answer. We have tried to stick to practical matters, with an incremental approach, to identify some of the technological paths that lead in the right direction, toward sustainable relationships with material resources and the biosphere. Whether those paths, about which in our view we do not have much choice, imply other changes can only be decided by Canadians through democratic discussion. That is why we have emphasized public interactive processes in the course of the study.

Several background studies on such topics as renewable energy supplies, recycling, rising costs of minerals, and effects of advertising were commissioned when the Committee felt the need for specific information or reviews. Generally, the flood of information and the ferment of ideas related to these problems and issues have been so prolific worldwide, over the last three years, that the greater task has been to bring them into the orbit of our thinking and place them in perspective. Mention should be given to relevant work in federal and provincial government agencies, such as the Office of Energy Conservation in Energy, Mines and Resources, Environment Canada, Central Mortgage and Housing Corp., National Research Council, the Ontario Department of Environment, the Man & Resources Institute in P.E.I., and others too numerous to mention. A useful study was done on "The Selective Conserver Society" by the GAMMA group at the Universities of Montreal and McGill,[7] contracted from the federal Department of Supply & Services, with the involvement of several departments and the Science Council.

As part of the Science Council study, many of these activities were brought together and reviewed, with bibliographic material, in an informal journal, *Conserver Society Notes/Carnets d'Epargne,* distributed approximately quarterly by the Science Council to a mailing list of over 1500 interested respondents. The first issue was published in October 1975. "Notes" became an important instrument in the public dialogue initiated by the Committee and its staff. A position paper, "Toward a Conserver Society – a Statement of Concern" was put out by the Committee in February 1976. It was published in *Science Forum* (June 1976), *Québec Science* (June 1976) and, in an edited version, in *Canadian Consumer* (June 1976), the magazine of the Consumer's Association of Canada. The statement was, in large part, well received. In March 1977 it was, in its entirety, read into the U.S. Congressional Record. The statement outlined the need for a transition to a Conserver Society and some of the characteristics of such a society in general terms. The intent of the present Report is to be more specific.

However, it is important to emphasize that we are not attempting to set out a complete blueprint for a new society, nor to specify the exact modes of transition or how long they may take. The Report should be seen as our view of some new directions related to science and technology that the conserver principles imply, and some actions in those directions that agencies at all levels – government, business, labour, and private citizens – can take.

It should not be construed, as it sometimes has been, that these prescriptions for re-directing and modifying Canadian patterns of growth are aimed at slowing, or freezing in the *status quo,* the productive system in which large number of Canadians have done well, and in which large numbers of less well-off Canadians still hope to realize their aspirations. To the contrary, within finite resources and limited environmental regenerative capacity, it is only by being more efficient, more intelligent, more far-sighted, and by changing the style of some technologies, that we shall all find room for continuing growth and distributive justice. What applies within Canada applies also to Canada as one of the more developed countries, in relation to other parts of the world.

II. Introduction: Perspectives on the Development of Canada

The foundations for the development of Canada have come from the primary industries. Agriculture, forestry, fishing, and mining have contributed to making Canada a prosperous nation. Much of our present wealth has grown from the successful production, manufacture and export of both renewable and non-renewable resources.

The earliest instance of development based on resources was the trapping and fur trade. The fur trade helped to establish a political presence, open up to the Europeans unexplored areas of the country, and indicated that the wealth acquired by trapping animals and shipping pelts out of the country in large quantities could initiate development. The vast river system provided a natural means of transportation. The rise in forestry and the lumber trade came some years later and lumber soon eclipsed the fur trade as an economic force. The demand for lumber of all types (squared timber, ships' masts, planks) locally, as well as abroad, spurred the growth of this industry. Here again, the transportation system, at least in the early days, was simple: it consisted of floating large rafts down the rivers. Later developments included the establishment of sawmills, an active shipbuilding industry and, still later, merchant shipping.

A railroad was built as a condition for Confederation, partly for commercial and partly for military reasons. Its effect was to open up the West; wheat (and other grains) from the prairies became another primary commodity. The railroad transported wheat east from the prairies and carried west manufactured goods produced in what is now central Canada. The primary industries led to the flourishing of a variety of secondary manufactures: flour mills, breweries, shipyards, paper mills, and so on. To service these industries, and the growing needs of the inhabitants, businesses and banks were established.

Still later the mining industry became a strong force. Here again the railroad was the dominant transportation mode used to carry the product to port for shipment. As trade links with the United States became more firmly established, the railroad had important influences on trade policies, land development, and price structures; it had been a very expensive undertaking for a small population and had to be paid for.

Oil and gas provide another example of the development of a resource and the simultaneous establishment of a transportation network to bring the resource to a border or port for export. Here the dominant transportation mode has become the pipeline.

Canadian development has, in large part, depended on the availability of renewable and non-renewable resources, on a satisfactory method of transportation to the market for sale or shipment abroad, and on effective demand for the products, first by Europe and later by the United States. This, known as the *staple* theory of development,[1] provides an interesting framework within which to examine the economic development of Canada and to ask questions about its future.

The three main elements in the past have been resources, transportation, and exports. On that foundation, the countless other structures of goods and services production, commerce, education, law, and government that make a functioning society have developed. A change in any one of the three primary variables has severe repercussions on economic stability. We have little control over exports beyond various subsidizing schemes such as low interest loans. Exports depend on economic conditions abroad. We do have control over transportation: much of the history of Canada revolves around the development of various transportation modes. Assurance of railroad facilities and access to markets in central Canada and abroad were guaranteed to some areas before they would enter Confederation.

Resources, however, depend on natural endowment and wise management. It is in this area that Canada clearly faces a number of problems. Because resources have played such a dominant role in our development, we have tended to assume that they will always continue to be available in almost unlimited quantities. But even a casual reading of the daily press, or of the projections prepared by government agencies, shows that this is not the case. Many non-renewable resources are depleting rapidly. For example, our most recent staple, petroleum, will have peaked only 50 years after the famous Leduc oil find. Our petroleum exports swelled from $103 million in 1960 to over $4 billion in 1974, the largest single item in our mineral exports, only to be reduced to zero within 10 years because present estimates indicate that we have not enough for ourselves. From the perspective of historical time this brief peak stands like an exclamation point, emphasizing the practical absence up to that time of policy for resource stewardship, and our sudden awakening. Other non-renewables, i.e. minerals, are still available, some with very large known reserves, but some are becoming of noticeably lower grade and are being sought in less accessible places.

With regard to renewable resources, too, we have not always exercised wise management. Fur trapping and trading depleted that resource to dangerously low levels before conservation agreements were established within and between provinces. A similar concern is now being raised about forest management practices. The perception that resources can be depleted to the point of scarcity is not strange in our history, but our responses have been fragmented and specific, like band-aids. To what extent are we ensuring that future Canadians will inherit complete natural ecologies in operating condition?[2]

Canada is often assumed, by Canadians, to possess endless acres of arable land and is thought to produce huge surpluses of food that can be directed abroad, at will, to feed a starving world. Agricultural commodities, most notably wheat, played an important part in Canadian economic development. Immigrants were lured to Canada by attractive posters in their home countries depicting the happy and bountiful agricultural life on the Canadian prairies. However, the amount of land in Canada that can be used for agricultural purposes is limited and must be managed wisely. Only 13 per cent of Canadian land is classified as agricultural and only 42 per cent of that (124 million acres) can support commercial crops on a sustainable basis.[2] In many areas of Canada the best agricultural land is being converted to residential and industrial use, lessening our ability to grow food.

During the last decade the industrialized world has entered a new phase. Natural resources are much less taken for granted. A study prepared for the United Nations forecasts that world consumption of copper, bauxite, zinc, nickel, lead, and iron ore could grow by the year 2000 to five times what it was in 1970.[3] There would be a doubling and, in some cases, a tripling of extraction costs. Even with the industrialized countries slowing their growth somewhat, and recycling to the maximum considered feasible, the study predicts shortages developing which may impede the development of the less advantaged nations.

Energy supply is a mounting concern; estimates of remaining reserves fluctuate almost month by month. In 1970, the then federal Energy Minister assured Canadians that "we have approximately 923 years supply of oil and 392 years supply of natural gas left."[4] In 1973, the National Energy Board revised those figures downward to say that we had only slightly more than a decade's supply of oil remaining in our established producing zones, that our frontier potential appeared disappointing and difficult, and that, as far as natural gas was concerned, the potential was only about 15 years.[5] The latter figure has since been revised upward by about 20 years, but that is still a far cry from 392 years. The atmosphere has changed. Fossil fuels are coming to be regarded as an "endangered species."

Two main forces have been set in motion to cope with the end of the era of cheap and easily available resources of all types. First is the normal market reaction to find still more resources, albeit at a higher cost. Thus, huge high-cost energy and mineral projects are underway in the Beaufort Sea, the Oil Sands and the Labrador offshore fields. These will place immense pressures on capital and skilled labour. Canada's capital needs for the next ten years are estimated at $600 billion (1974 dollars), of which about $120 billion, or 20 per cent, is for major energy projects. To meet the challenge of scarcity, a second force has arisen which questions the demand side. It is the conservation argument – but on a much broader scale. Do we need to use up resources at such a rapid rate? What is there about our resource transformation process which dictates such a rapid use of resources and energy?

In considering demand, we are forced to examine the way in which our society has chosen to transform resources into commodities, the way in which we generate our incomes, the way in which we use our leisure time – in short, we are forced to critically examine many aspects of our way of life.

The Canada of the last quarter of the 20th Century is into a new "ball game." Some new constraints and boundary conditions have emerged and others are just becoming visible. These constraints give rise to a series of challenges for managers at all levels of Canadian society – from households to governments to industry. Some of the constraints and boundary conditions and changing "rules of the game" which have emerged have already been noted. Paradoxically, the most important problem is that of scarcity in the midst of abundance. We have built a highly productive, industrialized society which while eliminating some scarcities tends to create others – such as, in some areas at least, scarcities of clean air and water. We could find ourselves commodity rich and environment poor.

What are the new constraints and problems?

- There is an increased awareness of the fragility of biological systems. Concern for survival of various species has broadened to include the viability of entire eco-systems, for example, concern for the Gulf of St. Lawrence, the Fraser River, and the Prairie grasslands. There is a growing scientific concern about the biosphere and the amount of pollutants it can absorb before it is irreversibly altered.
- Environmental problems will move from concern to action. The widespread externalization of costs (that is, the avoidance of costs by poor housekeeping, pollution of the environment, etc.) that has characterized Canadian industrial history needs increasingly to be controlled by legislation and a demand for the reckoning of total costs. When all costs of industrial processes are reflected in the prices of products, dislocation will be inevitable. Some commodities may be priced out of international markets. International cooperation and resource-environment treaties will become essential.
- The demand to participate in the decision-making process will continue and increase. Canadians want to take part in those decisions which will affect their lives. People are no longer content to leave decisions to a few government departments or to one or a few industries. The desire for participation, in the industrial context, will only be realized to the extent that labour and management move away from we-they confrontation politics toward recognition of a new mutuality of interests. New management modes may come about in Canada, developing from industrial experience in West Germany, the Netherlands, Yugoslavia, and other countries.
- Realization that more growth in all areas is neither possible nor desirable will lead to discussion of the need for and creation of selective growth strategies. Allied to this concern is the question of availability of capital. How much is needed? How much is available? Do we continue to import from abroad? If so, what is the long-term cost? This may lead to selective capital allocation strategies.
- Canadian culture and society are in a state of change. The few models which defined appropriate behaviour for the 1950s and 1960s have continued, but were augmented in the late 1960s, by a growing variety of "sub-cultures". Canadians appear to want still more choice in their living patterns. There is resistance to homogenization by the mass communications media. The demand for social diversity could lead to greater institutional flexibility and the creation of new institutional modes to accommodate changing living patterns.
- There is a related growing trend toward regionalization and decentralization. The demand to be "maîtres chez nous" by Québécois is now and will increasingly be echoed by Canadians in other parts of the country. Managers in government and industry will have to contend with the demand for decentralization of control. There are implications for resource strategies, industrial policies, and energy policies.
- A growing redundancy of labour is arising from increasingly capital

intensive production processes. This could lead to new and expensive job creation programmes, concern for managing leisure time, blurring of the work-leisure dichotomy, and the creation of new non-market employment schemes.

- Perhaps most important is the emergence of the reality of limits. The era of cheap energy is over. Other material resources can no longer be taken for granted. The merging of environmental concerns and shortages of lower cost resources means effective management of all Canadian resources to avoid waste. What is the significance of all these factors for the continuation of the "staple" theory of Canadian development?

These are the elements of the scene as we move to consider the implications of a conserver society as a possible future.

III. The Principal Policy Thrusts of a Conserver Society

Concern for the Future

Canadians are already concerned about the future. But the point of this policy thrust is that they are not concerned enough. The time horizons of individuals, business, and government are too short. Reports concerning the longer term future of the environment, the depletion of resources, and the deterioration of cities indicate that the planning being done is too often of a kind that is short-term or is aimed at solving yesterday's problems. At best it provides a measure of relief. However, by not taking either a broader or longer perspective, the results of "muddling through" only deepen the problems in the longer run.

The Canada of today is the result of a multitude of conscious and unconscious past decisions. Both small and large discrete decisions in housing, office construction, and transportation have determined the size and shape of our urban centres and have profoundly affected our quality of life. The creation of growth centres, the establishment of tariff walls and the configuration of freight rates have led to the present outcome.

We are like the adolescent who has suddenly come of age, possesses all of his/her faculties and must now make decisions that will affect the rest of his/her life. As a society, we have matured to a stage of considerable affluence but multiple problems. The problems are not insoluble but demand close attention if they are to be handled in such a way as to ensure for Canadians a healthy and prosperous future. We are coming to realize (perhaps like the adolescent) that we cannot keep growing in all ways indefinitely. But (unlike the adolescent) we cannot depend on in-built biological controls to limit our physical growth smoothly and automatically. Unless we, as a society, develop better management techniques, our undirected growth processes will run blindly into biological, social, and physical resource limits, with the result that we shall face a future characterized by capital shortages, increasing pollution and waste disposal problems, and increasingly complex social conflicts – controls and counter-controls – wasteful of human time and energy.

Even as we deliberate, the processes that will shape our future continue apace. The thoughful questioner may comment that little can be done. The only answer can be that the times will no longer allow us the luxury of evasion. Economists used to say that the market would look after everything: when things got bad enough prices would rise and lead to corrective behaviour. We have only to remember our present concern regarding the probable effects on the ozone layer in the upper atmosphere 30 to 50 years hence of fluorocarbon aerosols used today to realize that continuing to discount the future (waiting for economic effects to show in the market before we act) cannot be regarded as responsible behaviour. Particularly is this so when we possess the technical and scientific knowledge to foresee the consequences of our acts with reasonable certainty. A conserver society will act as responsible steward, to make sure to the best of available knowledge that present actions are not setting consequences in train that will impose serious costs on our descendants. A conserver society will also be a "smart" society, taking advantage of new opportunities in science and technology to find new ways of doing things that will hold for the long term, rather than escalating one expensive short-term solution on top of another. Above all, a conserver society will *conserve,* to gain manœuvering room to keep options open, rather than being driven, by one supply crisis after another, to desperate solutions that box us in for many decades.

The inverse relationship between high productivity and employment provides an example where we face paradoxes made worse by short-term thinking. Governments are elected for limited terms, and within their terms in office they try to initiate policies and programs that will better the lives of their constituents. But results have to be visible by the time of the next election. If the results of a program will only be seen in the longer term, and if to achieve a desirable outcome there are some disagreeable short-term costs that must be met first, then such a program is often rejected as politically impractical. So some modern governments try to deal with unemployment problems by a make-work approach, inherited from the ideas of John Maynard Keynes applied during the depression years of the 1930s.

Over the interim, we seem to have forgotten why it was so important to have a job. The pre-Keynesian era was a time when income-transfer schemes were non-existent. Lack of employment meant going without. Today the unemployed individual has a variety of ways to maintain income – unemployment insurance being the main source. Though to be without an apparent useful function in society is still an unsatisfactory state to almost anyone, we can afford to ask today, in a less desperate way, what work it is that our society most needs to have done.

For example, one way to solve the unemployment problem would be to make automobiles half as durable as they are now. With a time to the scrap heap dropping to about 5 years, manufacturing would almost immediately absorb large numbers of our unemployed. We would also increase the amount of resources dug up, which would add to the waste disposal problems and create still more jobs. Service stations would be busier and, of course, energy demands would rise because of the extra production. Everyone would have work to do and money to spend. Yet, surely, we can think of better solutions.

Our society is enormously productive and has the capacity to turn out a large number of goods and services. Our capacity is great and growing every year, especially as the rate of capital investment continues. Capital investment, automation and widespread computer utilization, it was earlier feared, would displace workers and unemployment levels would rise. However, these fears of the early 1950s were not realized, largely because the investment levels were so high that jobs of new types were created as new industries became established. Displaced office clerks became computer programmers and keypunch operators.

Thus the fears of employment displacement were lulled for a time. It is possible that the optimism was premature; the full impact of automated technology may be yet to be felt. With the mini-computer the era of automation and automatic control systems has begun in earnest. Fully automated factories are increasingly commonplace – in fact, automated factories now turn out machine tools to build still more automated factories.

In many places machines have practically eliminated the need for human muscle power. Human labour is used to start and stop processes, and to repair the machines when they break down. The repairmen and technicians will always be needed in this ever more complex computer and machine world. We will also need inventors and designers, though even this has lessened as computer-aided design of circuitry has become more common. The first flush of employment for programmers and keypunch operators has passed, in much the same way as did the armies of telephone operators that were a feature of the early days of telephone systems. Today the computer is displacing draftsmen from their desks, typesetters from their machines, and typists from their typewriters.

There is a growing realization that many people in the production process are becoming redundant. What should be the response of the system? Conventional wisdom would say that we must create more investment to create more jobs. But is this the best way to deal with the situation? With capitalization and automation, we already have the capacity to more than provide our basic goods and services with the present workers. There is nothing in economic theory that says that all people must be employed for wages, and certainly, as the domestic sector of our economy demonstrates, it is not necessary to be a direct participant in the wage-and-market sector to be a useful and productive member of society. Government-initiated job creation schemes are usually costly and often ineffectual. This response may be the result of carrying over past habits of thought without appreciation of the real origins of the problem.

An analogous problem appears at the national policy level. Just as a given individual may begin to wonder where he/she can find a useful niche in the industrialized society that will justify participation in the income stream, so Canada now faces important questions of what it is going to offer in trade to other countries whose factories are even more automated and efficient than our own. How long can we maintain a balance of trade based on selling off our fixed assets – our non-renewable resources? If that is a viable program for 30 years, what happens after that?

Some of these questions are common to other industrially-advanced countries. Some are being discussed by a committee of the Science Council formed to study the problems of industry and may result in recommendations. At this time the Council does not pretend to offer solutions, but wishes only to draw attention to some features that must be addressed if the policies are to be satisfactory in the longer term.

Part of the problem is the success of industrialization. Our capital intensive, high technology system has created a situation of potential abundance. In the dynamic drive to industrialize, however, little thought was given to resource limits, waste, environmental impacts, or to the availability of energy over the longer term. We are not certain of the extent to which our present industrial structure (including agriculture) has been built up by, and is dependent on, low-cost petroleum (as well as on ignoring those other factors) and therefore we cannot be sure in how many respects it has to change to be sustainable in the future. Nor can we be sure of the extent to which our system presents a feasible pattern of development for other societies to follow. Yet, as we are faced with employment dislocation, our only policy seems to be to try to drive the productive machine that much harder, putting still greater strain on resources and environment.

To return to the example of the automobile, suppose we moved in a different direction and required that automobiles should be made twice as durable. Scrapping times would approach 20 years. What would happen to all the workers? One possibility would be to redistribute the employment through shorter work-weeks, longer vacations, sabbaticals, and re-training leave for workers. Another approach would be to place workers where society still has large unsatisfied needs, for example, in fields of information and knowledge, recreation, health care and preventive medicine, low-cost housing, and energy-efficient technologies. The probable outcome would be that the need for material resources of all types would decline and energy demands would be lessened. Yet society could be more productive than ever of those satisfactions that Canadians are really seeking through their material consumption and search for income.

Canadians are at a critical juncture in their history. To go on as we have will mean depleting our resources (and therefore driving up costs) while threatening our fast dwindling energy reserves. To keep options open for both present and future Canadians we must strive for greater efficiency, and the elimination of waste; we must change many of our expectations. To assume that the resource problem will solve itself will only create problems in those areas where we now are blessed with abundance – in the ability to produce goods and services of all types.

The Conserver approach involves a realization that actions taken today have implications that will define the living conditions for future Canadians. What sort of Canada will we leave to them? If we perceive that present behaviour is likely to prove increasingly harmful to our descendants, what sorts of modifications and structural changes must be initiated now to ensure a more desirable – and sustainable – future?

A heightened awareness that present planning does affect our future is already apparent. Large investment projects such as the hydroelectric system of Ontario, or the Mackenzie Valley pipeline, which only a generation ago would have been conceived and implemented by a relatively small group in society, are now being held up to public scrutiny.[1] Citizen groups are forming to discuss the pros and cons of major decisions that will impact on us all. The planner is often frustrated by these groups since many seem to say the same thing: slow down and open the process so that we can participate and have something to say about our future.

We are witnessing the emergence of ongoing public discussion of the future of Canada. It would be unfortunate if citizen group concern

were interpreted as **confrontation for** its **own sake. Public concern for** the future should be fostered. Ways must be found to have a thorough discussion of major issues, such as the need for new energy sources, and, more important, we must develop a way to know when sufficient facts and ideas have been discussed in public forum so that a decision can take place.

Economy of Design

The central thrust of this policy initiative is "to do more with less." To the designer or engineer this objective may seem so obvious as to be trivial. Designers and engineers have always built and designed their products under criteria of economy and efficiency. Doing more with less is part of the training. But, with the society as a whole it has been another story. As inhabitants of a "consumer society," most Canadians have lived through a period when materials seemed plentiful, energy cheap, and growth in size and quantity, whether of cities, automobiles, monuments, or lawnmowers, was the natural order of things. Status, of individuals or societies, was measured by conspicuous consumption, and economic prosperity was demonstrated by what you could afford to throw away. Designers, engineers, architects tended to be caught up in it too, placing the emphasis on the "more" and forgetting "with less."

Now, as we become aware of constraints and uncertainties in the future, we question our implicit assumption that "bigger is better." Engineers are returning to the drawing board; as fuel costs rise they are designing smaller and more efficient automobiles, more efficient furnaces, and even reviving and improving the wood-burning stove so that householders can recover heat from materials that were formerly scrap – or that were burned in highly inefficient fireplaces purely for show.

Partly because of an infatuation with growth and activity, we have tended to build over-capacity into all aspects of our system. Automobiles which only need about 30 to 40 horsepower to achieve the goal of transporting people about often have engines which are 10 times that powerful. Packaging tends to be more costly and excessively more bulky than the contents it is designed to protect. Transportation systems have been designed to operate and accommodate users at peak hours and are underutilized the remaining 20 hours of the day.

By adopting flexible hours, a four-day work week and extensive car pools, the traffic capacity of some cities could be expanded significantly. Re-ordering patterns of use in this fashion could be far less expensive than alternative solutions, new streets and expressways, which could cost 100 times more. Expansion of the system or more efficient use achieve the same outcome: the latter approach, "doing more with less," saves resources and scarce social capital.

Economy of design should not be equated with an approach that is either anti-technology or anti-industry. Rather the principle means simply that we must use the technology we have in more thoughtful ways. For example, with governments and leading corporations setting an example for others we can substitute the teleconference for much business travel. The challenge is to make this technology operational and to legitimize a form of communication that is energy-saving in place of one that is both energy and resource intensive.

Houses and buildings can be more economically designed to make use of natural advantages. They can be oriented to gain heat from the sun in winter or from the ground via a heat pump; or they can be designed to enhance natural air flow so as to reduce the need for air conditioning. Orienting our houses to have a more southern exposure, installing better insulation, and shielding the north side from winter winds, can cut heating costs to half or less of much current Canadian practice.[2] Automatic control devices, using little energy themselves, can be used in many ways to save expenditure of energy and resources.

Some design economies have already been achieved, as in the replacement of the vacuum tube by the tiny transistor, and that in turn by the microscopic LSI (large-scale integrated circuit). A package the size of a dime can accomplish the amplification, computation, and control of a roomful of air-conditioned equipment two decades ago. For some purposes, such as navigation, mapping, and weather survey, space satellites yield high performance per unit of materials and energy, compared to alternative methods. Agriculture could gain much from conserver approaches, too. Solar greenhouses placed near or even within cities may save not only wasteful heating costs but transportation and spoilage costs as well. Genetic research, directed to nitrogen fixation by plants, may greatly reduce the need for fertilizers. Research on the design of closed-cycle ecological food systems, self-regulating with a minimum of human labour, such as are being developed by the Ark project in Prince Edward Island, may show more ways in which scientific knowledge, and technical ingenuity, can achieve the same results more economically than brute-force, high-energy and resource-intensive approaches.[3]

The "more" and the "less" need to be interpreted in a total system sense. It will be to no avail if the re-designed automobile engine travels more miles to the dollar, but at the cost of high pollution. The conserver view is to broaden the constituency: we must aim at *total* social efficiency and best use of resources, keeping in mind the broader needs of present and future Canadians. We tend to deceive ourselves when the costs of our actions are indirect, or return to us (or to others) by roundabout paths. Apparent economies can turn out to generate extra work and waste that imposes on everyone.

Recycling must become part of the fabric of all production activities – not an afterthought. When products are designed with recycling as part of the process, the problem of unscrambling the materials at the end of the product's life will be simpler, less costly, and more conserving of scarce or potentially scarce materials. Of course, recycling can never be perfect, and the need for recycling should be reduced by making the product more durable, reparable, and re-usable in the first place.

Canadians have become accustomed to a high throughput consumer society that takes for granted obsolescence, a high rate of consumer spending and an almost total disregard for waste – both individually and socially. The realization of an approaching end to low cost resources, of limits to environmental carrying capacity and of limits to easily available energy means that traditional values of thrift, saving, avoidance of waste, efficiency, and an appreciation of quality will, once again, become important aspects of our lives.

Once we realize how we can do more with less, the wastefulness of the other path becomes plainer to see. To continue to follow the wasteful path will lead to a society in which costs of resources will continually rise, energy will become increasingly scarce, and environment will deteriorate. Incomes may continue to rise, but taxes (to cover all the indirect costs) may rise even faster. People will find their lives increasingly busy, trying to keep up; the enjoyment of life or the quality of life may actually decline.

Diversity, Flexibility and Responsibility

A common reaction when faced with the need to economize is to seek economies of scale through standardization – a single colour of car, a single style of clothing, a single mode of energy supply. However, one of the virtues of our free enterprise system is the great range of diverse products and services it has created, and the constant flux of innovation it maintains. We must take care not to jeopardize that diversity, either through misguided efforts to bring everything under government control, or through allowing business and institutional concentrations to grow indefinitely large in scale. Consequently, we draw attention to the positive value of diversity. Just as it does in natural ecological systems, diversity in human society increases flexibility, adaptability, and resiliency. It allows decentralization of responsibility, and optimal performance from local resources.

Transportation illustrates how a system that relies on one large-scale component can be more vulnerable than a system that is more diverse and offers a variety of ways to transport people and goods from one point to another. When a major expressway is closed by a traffic accident, the other travellers have little choice but to wait. Diversity may initially cost more in an accounting sense, but the advantages of choice and resiliency may justify it. This is not to argue that multiple expressways should be built nor that secondary roads and residential streets should be oriented to handle large flows of traffic but, from the technological point of view, it is simply an elaboration of the old admonition against putting all one's eggs in one basket. The basket may fall, the expressway may be blocked, or the airport may cease to function when a handful of employees go on strike or when a snow or ice storm occurs.

For many years transportation planning has been preoccupied with multi-lane expressways and large airports. The automobile has irreversibly altered the way in which cities have developed and our culture has evolved. The space affected by a major airport is so large, and affects the lives and interests of so many people, that a suitable new location is extremely difficult to find. Some of our older cities exhibit a healthy diversity of transportation systems: expressways and arterials, buses, streetcars, subways, commuter rail, canals, bicycle paths, sidewalks, and footpaths. Some of our newer cities and suburbs are a different story – in them mobility cannot be achieved except by travelling great distances with great expenditure of energy. In some places even a bottle of milk or a loaf of bread cannot be purchased without a trip in an automobile. Concentration in this way on a single or monolithic system can mean that the needs of the elderly, the young, the incapacitated, and the poor are overlooked. By including the notion of diversity in the initial planning one is only recognizing the normal statistical distribution of needs, roles, capacities, and incomes in a given population. Mobility is a basic need, if not a basic right. Diversity is essential if social justice is to be served.

Where many people depend on a single system, such as a rapid transit system, or an electrical power grid, the reliability and safety of the system have to be correspondingly greater. In some cases this may become increasingly costly; further integration and centralization may not be the best way to go. In these cases, however, it is never all of one and none of the other. The development of precision gauges, leading to the interchangeability of automobile parts, was a great step forward, and we would never think of recommending returning to hundreds of different sizes of screw threads, nor to a world in which every district is supplied by a different electrical voltage and frequency.

Electric power provides a practical illustration. Economies of scale, in terms of dollar cost per kilowatt of installed generating capacity, have led to larger and larger centralized generating stations. At present, questions against continuing that trend are being raised regarding the total cost, including social and environmental costs, of these large custom-made installations in comparison with the possibilities of many diverse sources using wind and water turbines mass-produced by modern techniques. The latter would be adaptable and could exploit many local situations that the former have to leave untouched. Being closer to the point of consumption, they would have lower transmission costs. In addition, because of the small size and proximity of these plants, the relation between high consumption and cost of new supply would be more readily perceived by the local consumer. Since marginal costing of new supply is difficult to apply at present, this relationship is not easily perceived in the existing large electrical grids. The way of interconnecting such distributed sources with each other and/or with mainline grids to optimize quantity, economy, and resiliency would need study. A study may show that a new development in this direction would be timely, now that so few large hydro sites remain unexploited and solid state circuitry and microcomputers may provide low-cost solutions to previous problems of system stability.

Other energy sources can be developed to make optimal use of each local situation – and can provide security against interruption of supply due to some remote mechanical or political breakdown. In one part of the country a district heating scheme with wood may make sense; elsewhere, coal, nuclear, or solar/electrical hybrid schemes may prove more practical. Because great hydro-electric potential in one province allows for the production of low cost electricity – so low that it can be used for space heating – it doesn't mean that electrical space heating should become the norm for the entire country. Though the total costing of nuclear-electric systems is yet to be settled to everyone's satisfaction, indications are that under many circumstances these diverse sources could be cost-competitive with nuclear, and would not suffer from the same social or environmental objections.

Large extensive systems, not properly designed in relation to their users, can be a prime cause of waste. If the system is remotely and impersonally managed, or appears so to the user, the user will feel no share of responsibility in its operations. Any difficulties, any shortage of supply, will be shrugged off onto "the system", never to the fact that the user and his/her neighbours have all been leaving taps running, windows open, or have all been switching on their stoves during peak time. Whatever the system provides will tend to be wasted by individuals, who see no obvious connection between what they use, and the costs that fall on others or indirectly on themselves through taxes or the environment. This is particularly true when services are provided without direct charge, but it is true also when the prices seem relatively low, as they often do for such services as electricity and water. As the European experience with gasoline prices has shown, prices may have to be raised to quite artificially high levels before the behaviour of individuals is influenced substantially on self-interest alone. Action from socially responsible free choice is to be preferred wherever the circumstances can make it effective.

Diversity, in the sense of decentralization, can conserve when it encourages responsible participation. The latter, and the sense of independence and freedom that comes from self-reliance, can be additional positive values in themselves that should be weighed in cost/benefit calculations. The 1973 OPEC oil embargo emphasized to nations the dangers of excessive interdependence; a greater degree of self-sufficiency has become national policy for many.

Diversity in sources of energy has implications for science and technology. Research, development and demonstration programs must be carefully developed in a way that will ensure that Canadian society has available a state-of-the art competence in a wide variety of areas. To the extent that Canada is not locked into one energy system or another, a transition can more easily be made to alternative energy sources, should one system develop problems of supply or environmental impact.

Renewable energy based on solar, wind and biomass sources, has the potential to be decentralizing in its impact. To the extent that technologies are used and controlled by individuals and community groups, they can give people energy systems tailored to local needs. Local citizens are likely to remain more aware of what is needed in the way of management to keep them sustainable and ecologically sound. They provide opportunities for local initiative and ingenuity.

The aspects of diversity and flexibility that are possible in renewable energy will only be obtained if technologies that are inherently small-scale are introduced in such a way that they are kept small scale. Public utilities are already beginning to talk of "solar farms" with vast expanses of solar panels creating electrical energy to be fed into giant electrical grids. In our view, it remains to be proven whether the use of solar energy to produce electricity in such a centralized way is really the most efficient approach. It seems more likely that, with mass-produced modular units and taking into account the already distributed nature of sunlight, the optimum will be found at something like community or city-block scale, particularly when the other benefits of local involvement are considered.

For consumer products, diversity can be interpreted as the availability of a genuine choice, allowing the consumer to meet his or her unique needs, whether in housing, transportation, home appliances, food or whatever. This is in contrast to "product differentiation" – the proliferation of marginally different competing products whose true difference may be only in the ingenuity of their packaging. In the context of a conserver society, diversity should provide clear options, flexibility and adaptability. It is the means by which production conforms to changing conditions and needs, as against attempting to shape the consumer to suit the convenience and profit of a large-scale system that may have gotten out of touch.

In housing and urban design, the development of new communications technologies opens options for more flexibility of lifestyles. These possibilities are enhanced by new technologies for self-contained water, energy and sewage systems, and small scale agriculture. A Conserver Society approach will thus be able to offer the choice of new forms of settlement. The possibility of communicating with instead of commuting to the city, along with a rising interest in "hybrid" lifestyles, may mean a revitalization of smaller towns and villages; urban sprawl may be curbed in favour of intensive food-growing on farmland near cities; congenial and productive urban communities may organize themselves in new ways.[4]

Diversity has implications far broader than energy or transportation. The desire for control over work and living environments raises fundamental questions regarding scale in many aspects of our lives. Economies of scale have led to ever larger productive units and a large bureaucracy to manage the whole effort. New perspectives now raise questions as to whether scale economies can be achievable at lower levels of output and, therefore, with smaller production units. The use of electronics should allow for greater decentralization. The emergence of new worker-management modes of interaction suggests that human scale is often more important, for workers and management alike, than lower bookkeeping costs. The social costs of worker alienation, for example, may offset and be greater than the production economies in large production units. The flexibility, human scale and opportunities for individual initiative offered by small business, suggest that this once vital sector of our economy should be rejuvenated and expanded.

The notions of diversity, decentralization, and community responsibility are reviving in Canada. In previous decades people have been concerned with issues more broadly national or international. Now the pendulum is swinging the other way and it appears that individuals, not only in Canada but in many other parts of the world, are trying to exercise more control over their own regions and communities.

A society both expresses itself and structures itself by the technology it uses. When a decentralizing social trend runs up against a technological trend that is inherently centralizing, or seen to be centralizing, feelings of alienation, loss of freedom, and abdication of responsibility may be the result. Responsible agencies should try to make sure that their systems are designed with sufficient diversity and responsiveness and that control is sufficiently dispersed that these desires and needs are taken into account and given room for expression.

Recognition of Total Costs

Much of the waste and excess that has characterized our "consumer" culture has resulted from not taking the total costs of our actions into account. If the total costs – the true costs to others, to ourselves, and to future populations – could be seen for what they are, a conserver society would be an almost automatic result.

Between that hope and its realization lie many practical complications, however. The logic of individual choice in a market situation is one of them. Classical economic theory of optimization by market behaviour rests on many assumptions. One of them is that all of the costs of a particular act or of a particular product are internalized in the private accounting of that item, that is to say are expressed in the price. When consumers buy the product, and when the producer earns a sufficient profit on the production of the product to keep the firm viable, then we say that the product has met the market test. To survive without subsidies or outside support in a competitive market in the long run indicates that the firm is an important contributor to the optimal allocation of society's scarce resources.

However, when costs are incurred or induced which are not reflected in the price to the consumer, or when the individual firm consciously or unconsciously externalizes costs (into the air, or water, or noise into the surroundings) then prices do not reflect all the costs and the possibility for misallocation of resources arises. To the extent that costs are externalized and become social rather than private, or are deferred into the future, prices are lower than they should be. With lower prices we tend to produce and consume more than if prices reflected all costs.

For example, some years ago it was "cheaper" for pulp and paper manufacturers to flush mercury down the drain than to remove it through a costly extraction process. We now realize that externalizing costs in this way resulted in imposing costs on those people who ate the fish from the waters polluted by the mercury. We now realize, too, that the price of the pulp and paper was artificially low. To build in a mercury extraction process has been costly. But now the costs are beginning to be borne by the producers and in turn passed on to consumers. Prices now reflect more closely true production costs. As the price has increased the market feedback system has become a better allocator of resources. We may or may not choose to consume less pulp and paper. What is clear, however, is that this action moves in the direction of enabling the market system to make better choices.

We often do not know how to measure the costs we may impose on others or on the future by our careless housekeeping. They may be smaller than the costs we avoid, but they may also be much larger. For that reason it is not always enough to depend on prices and the market system. The influence of prices often has to be augmented by the discipline of regulation, taxation, and other penalties. To the individual purchaser a higher price may be only a small deterrent, when in fact the benefits of the purchase of the polluting product accrue to the individual, while the extra cost is only an averaged share of a remote or distributed impact. Thus people are willing to pay more for gasoline, and persist in driving large cars, in spite of the aggregate effect on the national balance of payments or on the cost of energy to future generations.

These are aspects of what has often been pointed out – our system produces bads as well as goods, and the GNP tends to measure the sum of both (except that many of the social costs, and many of the collective social benefits, for that matter, do not get accounted in the GNP at all). Because of the problem of accounting social costs, and of allocating them to their source, they have not seemed part of the process of achieving a productive and efficient economy. Smokestacks, pollution, noise, traffic, for a long time seemed welcome evidence of industrial activity. We are coming to realize now that many of our problems are the result of questionable ways, as a society, of keeping our books. When we ask just *what* we produce altogether, what are the *total* costs of doing so, and is it sustainable – whether we are paying as we go – we shall find some things we want to change.

Some moves toward full-cost pricing are already occurring. As a result of legislation or the threat of legislation, automobiles now have certain safety features and pollution control devices. These actions were taken to reduce the accident load on hospitals and to reduce environmental pollution from engine exhaust. While the price of automobiles has increased somewhat, the number of deaths and injuries has decreased and urban pollution has been reduced.

Total costing will increase the prices of some products. Many people will complain – with justification – that Canadian producers will be priced out of world markets. Undoubtedly Canada would have difficulty going it alone, but the direction in which we should try to move is clear, and other industrially developed countries are facing similar problems. Progress should be sought as a component in international trade negotiations, and with the assistance of international agencies such as the OECD and the UN.

While there will be dislocations, higher costs and higher prices will by no means be the inevitable result. An example is a large machine-shop operation in Kitchener, Ontario. The plant used large quantities of oil-based cutting fluid, which it discharged into the sewage system, meeting effluent standards by diluting it with large quantities of water. The implications of that path are plain: expansion of business means that the municipality has to invest in both a larger capacity water supply *and* in a larger capacity sewage system. When the municipality began to be concerned about the implications for capital funding, and about the adequacy of the local river system over a dry summer, the industry looked at alternatives. A new technology, developed by another firm in the area, provided an effective means for separating the oil from the waste. The oil could be reclaimed, and the water recycled; the new equipment paid for itself within the year. Thus, innovation actually reduced the costs to the company, *besides* reducing pollution and other socially distributed costs.

The closer we get to the goal of total costing, the more apparent will become the high costs of our present ways of doing things. Innovation using the conserver approach will lead to efficiency and, despite temporary dislocations, an eventual improvement in the quality of life for everyone.

Respect for the Regenerative Capacity of the Biosphere

Much has been made of the implications of rising costs and, ultimately, finite limits to material resources, fossil fuels, and so on. There is another kind of limit, one with consequences at least as serious and perhaps more imminent. This is the carrying capacity, or the regenerative capacity, of the biosphere.

A central thrust of the conserver approach is to promote techno-socio-economic processes that are in principle sustainable. From this follows a preference for obtaining our energy ultimately from "renewable" sources, and for methods of food production that do not "mine" the soil. Not only do we look to the biosphere for these self-renewing productive processes, but we depend on it to assimilate, store, and digest the various waste effluents of industrial civilization. The consequences have been recently surfacing to make us more and more aware that for decades we have been releasing new chemical molecules into our environment at a rate that has far exceeded our knowledge of their potential effects. Concern has been voiced in previous Science Council reports, for example in Report No. 16, *It Is Not Too Late – Yet,* published in June 1972. Report No. 9, *This Land is Their Land . . .* published in October 1970, recommended: "a stable and healthy environment of high ecological quality, maintained over the long term, should be defined as a new national goal."

Suggested elements of that goal were:

- maintenance, improvement and restoration of the harvestable productivity of high-quality land, freshwater and marine environments
- education and information programs to achieve a high level of public understanding of environmental relationships
- pollution control based on recycling of materials and the establishment of national and international standards
- more intensive regulation of chemicals, biocides and fertilizers used in the manipulation of environment; intensive research to anticipate the effects of new chemicals on ecosystems
- integrated management of land and water, based on classification and comprehensive planning
- preservation, maintenance and management of as complete a range

as possible of natural communities, landscapes and geological features of Canada.

The ecological balances in the biosphere are the culmination of millions of years of evolution. They represent a highly ordered state or a state of low entropy,[5] even though the nature of the order is not always obvious to us. With increasing knowledge of ecology comes increasing respect for the subtle feedbacks and interdependences, the checks and balances – and potential instabilities – of the living systems of the earth. If a living species is rendered extinct, or a finely adjusted ecological system destroyed, it is irreplaceable – even given inexhaustible energy supplies:

> All the king's horses, and all the king's men,
> Couldn't put Humpty Dumpty together again.

Since these features are not valued in our usual economics, we need to be constantly vigilant against automatically yielding wherever economic or market arguments seem to push. The heritage of the living biosphere is one of the things a conserver society will most seek to conserve. Minimizing material throughput and waste will tend to reduce the load on the biosphere and make the task easier. A continuing growth in the biological and ecological sciences will improve our ability to work *with* the natural systems rather than against them. There is no reason why we should not be able to improve on natural ecologies, given sufficient intelligence and understanding of our human role. At the same time we would be wise to maintain some natural ecology preserves as insurance against our remaining ignorance. The desire to pass on unimpaired, and possibly improved, these systems that embody a million years of evolutionary investment is another implication of the conserver concern for the future.

IV. Some Areas of Application

Energy Efficiency and Conservation

Energy supply is becoming a primary constraint on present patterns of Canadian growth. The evidence is all around us. Prices of fuel oil, natural gas, gasoline, electricity are rising month by month; ever-more-costly schemes for investment in pipelines, Arctic exploration, oil-sands plants, and expansion of electrical capacity are pressing on available supplies of capital; brown-outs threaten in some parts of Canada; and the import/export balance is turning from surplus to deficit.

Canadian thinking about energy has changed dramatically over the last four years. Recent studies have sharpened significantly our perception of supply as well as demand for the next decades. While the extent of supply will be determined by geological and other circumstances, future energy demand will be very much a function of social, economic, and technological evolution. It is remarkable how predictions for energy demand for the year 2000 have shifted downward – by a factor of two since 1973, as shown in Table 1.

Table 1 – Energy Demand

Year	Estimated demand in year 2000 (secondary consumption) 1 quad = 10^{15} BTU	Source
1973	20 quads	EMR, *An Energy Policy for Canada*
1975	16.2 quads	Science Council, *Canada's Energy Opportunities*
1976	14.5 quads	EMR, *An Energy Strategy for Canada*
1977	9.8 quads	EMR (based on G. M. MacNabb's presentation to the Third Canadian National Energy Forum, Conservation scenario)*

Notes: The range of rational speculation, i.e., the range of predictions deemed worthy of study without being rejected out of hand, has expanded even further, down to 5 quads, or even lower when time is allowed for re-structuring of industrial, institutional, and domestic investment. See, for example, A. Lovins "Exploring Energy-Efficient Futures for Canada," *Conserver Society Notes/Carnets d'Esparne*, vol. 1, no. 4, May-June 1976, pp. 5-16.

*Reported in *Geos*, Energy, Mines and Resources, Ottawa, Spring 1977, pp. 2-4.

For the next quarter century, the energy supply mix cannot be expected to differ significantly from the present one. We shall still depend to a large extent on fossil fuels (oil, gas, coal), we shall probably have a greater contribution from nuclear power and hydroelectricity, and we shall begin to feel some impact from such renewable energy sources as solar, wind, and biomass. The extent to which renewables will or will not contribute significantly to the total energy supply will not depend only on technological progress, however, but on government policy at the federal and other levels. Present official estimates place the contribution of renewables at 3 per cent for 1990. This is significantly more than was thought five years ago. However, if Canada adopted a serious conserver program, the figure could be twice as large by 1990, and escalating rapidly thereafter.

Similarly with energy demand: the extent to which the potential of conservation measures to reduce demand will be realized will depend very greatly on national policy and political will. At the present time government policies are moving rapidly to encourage conservation and to develop alternative supplies, though still not with the financial support and readiness to innovate that many Canadians would like to see.

We present some examples to illustrate the application of the conserver principles laid out above, in the hope they will provide some guidance to citizens and policy makers in choosing among the various options and opportunities. Since we begin from a standpoint in a society that is acknowledged to be wasteful of energy, consuming in some cases almost twice as much energy per capita and/or per unit of industrial output as some countries with comparable or higher GNP per capita and similar industrial mix,[1] it should be clear that the most immediate gains per dollar are likely to be made through energy conservation and improvements in energy efficiency. Many of the technologies are known and in use in other countries and are giving them a competitive edge in terms of total efficiency, which is likely to become more apparent as our own energy costs rise.

It is important over the next two decades or so to keep our energy options open, because of the great uncertainties we face at this stage, e.g., regarding the supply and the price of oil, or what can replace it, and the uncertainties regarding the cost and the social and environmental acceptability of nuclear-electric systems. Premature commitments to these large-scale systems could prove extremely costly. The more time and maneuvering space we can gain by conservation, the more flexibility we will have among options.[2]

Ways to Conserve Energy

Conservation by better management: It has already been demonstrated that very substantial savings are possible by turning down thermostats, repairing windows and stopping leaks in homes, warehouses, and industrial plants, closing fireplace chimney dampers when not in use, tuning up furnaces and automobile engines, turning off unnecessary lighting, and so on. Carleton University, in Ottawa, by such measures, plus reducing peak loads, turning off ventilation in rooms when not in use, shortening the air-conditioning season, and so on, reduced its electrical consumption by 25 per cent and its fuel consumption by 27.5 per cent for a total annual cost reduction of nearly $600 000. This was done with minor changes in existing installations, at a total cost over 3 years of under $20 000. Further reduction is feasible but will involve some equipment changes and some reconstruction and will cost a little more. School boards in the same region, sensitive to budget restraints, have started programs for improvement in custodial management, and have found similar cost reductions possible; in a few cases heating costs have been reduced as much as one half. The Science Council, in its own offices, seeking to implement a government directive to reduce unnecessary lighting levels by 10 per cent, found that a reduction of 24 per cent was easily feasible without impairing working efficiency. Indeed, the subjective appearance of the environment was, if anything, improved. Each 4-foot 40-watt fluorescent tube not in use will save $2 to $3 per year in operating cost alone, not to count the saving if the fixture had not been installed in the first place. These small items add up. Carleton

University across its campus *removed* more than 15 000 such tubes. The saving is double, since lighting in buildings is often the largest component of the air conditioning load.

Conservation through direct efficiency: This means improving the efficiency of existing equipment, methods, or processes. It means improving the shelter efficiency of a particular house by insulating it better, or replacing an old oil-burning furnace by a more efficient one, still burning oil. It means replacing incandescent lighting by fluorescent, to obtain the same light levels with less electricity. An industrial example is the development of ceramic heat exchangers to recover heat from high-temperature exhaust gases from the heating of steel billets prior to forging, a procedure that may cut fuel consumption by as much as 75 per cent. These heat recuperators could cut fuel use by 40 per cent in such processes as heat treating, annealing, wire drawing, and the manufacture of cement, glass and pottery. Calculations for the US indicate that retrofit of half the furnaces in those industries would cost $1 to 2 billion but would save $18 billion in fuel costs over a 20-year amortization period.[3] Heat wasted in these kinds of processes amounts to over 40 per cent of US industrial energy consumption.

Closer to home, the Office of Energy Conservation estimates that by relatively straightforward efficiency improvements, such as better automobile mileage, better insulation in homes and commercial buildings, adjustment of furnaces, improvement of industrial processes and housekeeping (changes much less radical than the heat recuperators described above), the expected annual growth rate of total Canadian energy consumption would drop from the 3.7 per cent estimates in the Energy Strategy Report to less than 2 per cent per annum.[4] The effect, by 1990, would be petroleum consumption lower by the equivalent of the annual output of 6 Syncrude oil-sands plants, natural gas consumption lower by 80 per cent of the annual Canadian output of the Mackenzie Valley pipeline, electricity by the equivalent annual output of 15 Pickering sized nuclear plants, *and* coal by about 10 million tons.

When efficiencies of moving people are considered, in passenger-miles per gallon of fuel, some modes are clearly superior to others. In inter-city use buses, on average, achieve over 110 passenger miles per gallon, the private automobile 45, and the airplane between 20 and 31, depending on the distance of the flight. Canadian inter-city trains demonstrate a relatively poor performance of about 25 passenger miles per gallon because of low utilization factors. There are, of course, trade-offs in time and convenience in all these modes of travel, but the increasing concern for energy efficiency will require some re-evaluation of those trade-offs. Efficiency considerations under this heading take it as given that people need to move about. Questions as whether it is better to save energy by leaving people in place and communicating electronically instead belong under the next heading.

Conservation through total or thermodynamic efficiency: The concept of efficiency developed above is often spoken of as "first law" efficiency, referring to the First Law of Thermodynamics, which states only that energy can be neither created nor destroyed. Efficiency is directed to obtaining the maximum conversion at each stage, from one form to another, without regard for the *quality* of the energy. For example, maximum efficiency in burning natural gas in a furnace may be sought, without asking whether the task at hand could just as well be performed by some lower-grade lower-temperature source such as solar heat, or waste heat effluent from an electrical generating plant.

The key to the difference is the concept of *entropy,* expressed in the Second Law of Thermodynamics, which is analogous to a law of gravitation for energy. *Energy,* strictly speaking, can never be used up; it can only be degraded. By what criterion, then, are we to *value* it, or judge whether it is being used in the optimum way? The criterion resides, as the physicists have pointed out, in the concept of *available work.* If the primary source of the energy is heat, as in combustion of fuel, then the available work that can be developed by an engine depends *both* on the initial quantity of heat energy *and* on the temperature difference down which it can flow. If we had massive quantities of energy, but at lukewarm temperature in lukewarm surroundings, the *available* energy we could extract for use would be virtually zero. This is an important concept. *Energy is not consumed: available work is.* Therefore available work is what we must aim to conserve. We should put a high value on high-grade sources of energy, such as electricity and fossil fuels, which are capable of generating very high temperatures, and a lower value on energy as it gets progressively degraded to lower temperatures and diffuse concentrations. We should compute our efficiencies of use accordingly.

A new measure of efficiency, termed "second-law efficiency" is the result. It is the ratio of *the least available-work that could have done the job, to the actual available-work used to do the job.* A simple example is the home heating plant. A well-adjusted oil-burning furnace will yield an efficiency, defined in the usual "first-law" terms, of 75 per cent for converting the heat in the fuel to heat in hot air ducts or hot water radiators. Yet the "second-law" efficiency is only 8 per cent or less.[5] This is fundamentally because a high quality source capable of many uses has been used to produce relatively low-grade low-temperature heat. If the same fuel were used in an engine to drive a heat pump, or if it were used to generate electricity to drive a heat pump, the second-law efficiency for the house heating could be three times higher.

Another example has to do with the frequently-made recommendation for making use of the waste heat from fossil fuel-fired and nuclear electrical generating plants. Although very useful gains can be made, it is important to understand how they come about. The simple "first-law" figures show approximately two-thirds of the energy being thrown away to obtain the one third in the form of electricity. On the other hand, the "second-law" numbers show that the *available work* is being extracted quite efficiently and only 2 per cent or less is being rejected in the cooling water, because of the low temperature to which that energy has been reduced. The point to note is that useful gains nevertheless come about because that energy is still sufficient for many heating requirements, which *otherwise* would inefficiently consume high-grade sources. To conserve *available work,* therefore, the householder, or the industry, should use *both* outputs of the generating plant – the electricity to drive motors, lights, control systems and the like, and the low-grade heat for space heating. Studies have shown that, in favorable circumstances, one unit of fuel used in this integrated, conserving way can meet the same needs as two units of fuel used separately.

This criterion of total efficiency, or asking whether the whole system might not be designed a better way, leads to recommendations for development of integrated total-energy systems, providing communities locally with combined district-heating and electrical systems; industries in generating heat for their processes, can efficiently supply their own electrical needs as a by-product and feed the surplus into the electrical grid. In West Germany, nearly one-quarter of total electrical consumption is generated at industrial sites in this way.

New houses and communities should be designed as part of a total system with their environment, to make optimum use of solar heat, ground heat, air currents, snow cover, and deciduous shade trees, in order to conserve electricity and fossil fuels for back-up reserve and for the motors, appliances, control devices and communications that require energy in its high-quality form. When the whole shelter is properly designed as an environmental system, it will be found that worthwhile gains of solar heating in winter, and air or other cooling in summer, can be obtained at much lower costs than by the separately designed tack-on approach. Optimum economics are unlikely to be reached by an individual-dwelling approach, but community developments, apartment complexes, and whole sections of cities should immediately follow the lead of Central Mortgage and Housing Corporation and other government agencies, with commercial developers, in exploring these possibilities and in encouraging the architectural and planning professions in these new directions.

Conservation through education and incentives: Some conservation will automatically come about from rising prices. Some will result from better information. Consumers to some extent will make better choices in the market place if there is better information about the total costs of things over their life cycle. This information is now being developed fairly widely and should be encouraged and published. It may not always be enough. A prospective buyer still may not have sufficient incentive to choose a house on the basis of energy efficiency. If a house is poorly insulated, the price will fall and at some price it will be purchased: from an overall system point of view energy losses will continue. The buyer has simply opted for lower capital costs and higher operating costs.

Another problem has to do with the mobility of our population. If an individual expects to move in the next few years why invest in insulation that will not pay for itself for 5 years? The individual who rents a house will have little incentive to insulate, nor will the landlord, especially when the tenant pays for the heating bills. These are reasons why some forms of grants, subsidies, or tax credits may be justified (for example, the insulation grants in the Maritimes).

Manufacturers have little incentive to produce energy-efficient products when the consumer is only aware of the first cost and not the full or life-cycle cost. Builders of new houses and office buildings typically aim for the lowest market price; operating costs are someone else's problem. To counter this, some government and industrial purchasers are now insisting on a new kind of contract, by which the builder guarantees certain performance characteristics of the building over its life.

Other impediments to conservation may arise from the way we have organized ourselves. Bulk metering of electricity, for example, offers no incentive to conserve. Apartment buildings that employ bulk electrical metering typically use 20-40 per cent more electricity than those buildings in which each apartment has an individual meter. Other cases can be cited where the reward for good behaviour does not return to the individual. The individual who buys the smaller car and/or uses mass transit regularly helps to reduce social costs in general. This action means less congestion, less pollution, lower total energy demand, and gasoline prices that will not rise as high or as quickly as would have otherwise been the case. The conserver by his/her actions renders a benefit to the community as a whole. But the conserver may feel that he/she is making a sacrifice or suffering an inconvenience while everyone else reaps the benefit. This could lead to a public attitude of letting everyone else conserve – "everybody's business is nobody's business." It illustrates the importance of education in a common ethic, and the importance of raising the social awareness. Under some circumstances government intervention in the form of law or regulation is inevitable.

Our decisions depend heavily on how we perceive the future. If we perceive it as unimportant, near-term resources are valued over future resources, and consumption is valued at the expense of conservation. Our planning horizon is short. When uncertainty is added, as in the case of our uncertain knowledge of petroleum reserves, the decision-making calculation can go two ways. Either extra contingency can be built in, or the future can be still more discounted, by such arguments as "we will find more – we always have." With respect to energy resources, it has more often been the latter argument. In many cases, mistakes do not matter very much where things are fundamentally reversible, as in shifting from one agricultural crop to another.[6] But in some cases there is no turning back. If we misjudge our petroleum reserves and exhaust our resources at a rate faster than substitutes can be developed we will have imposed a severe cost on future Canadians. The energy conservation issue must be seen in this light. Tax, pricing and financing schemes must be devised that will shift planning horizons toward the longer term.

Unfortunately the future has little economic or political power: it has no votes. The government in power, which is a surrogate for the country itself, must take the longer view. It is the responsibility of the government to ensure that future citizens are provided with options – if necessary a trade-off may have to be made against the demands and perceived needs of present citizens. Thus, not only does energy conservation pay in terms of lower cost supplies vis-à-vis higher cost replacements, but it *extends* our reserves. **It extends our time horizon** for petroleum. It increases the time Canada has for creating the transition to a substitute form of energy which can perform the type of tasks for which petroleum is suited.

A host of political and economic factors militate against conservation. Complaints are made about industrial dislocations, possible balance of payment problems, possible unemployment, etc. – yet the decision to stretch out resources, to increase medium-term flexibility, and to provide options for future generations is sound. The uncertainty and constantly changing estimates of oil reserves may even mean that not only will energy conservation provide options and the possibility for an orderly transition for future generations but it will likely benefit many of the readers of this Report.

To engage in energy conservation throughout the entire social system will require greater cooperation between the various sectors of our society. Governments, regulatory bodies, and federal, provincial and municipal standards authorities all have roles to play. New efficiency standards, pricing policies and rates of taxation must be developed and agreed upon. Government will have to act as the honest broker between energy producers and consumers; scientists and engineers will have to demonstrate efficient energy systems, new conservation ideas and help to innovate new energy sources.

Renewable Energy

The aim of a conserver society will be to achieve reliance on sources of energy which are in principle sustainable over the long term. This will mean a preference for sources such as hydro, solar, wind, and vegetation that are in ongoing equilibrium with and are constantly renewed by the sun's energy. This will contrast with present policies in the industrialized countries of maintaining high standards of living by drawing down the world's capital stocks of non-replaceable fossil fuels.

It should be remembered, however, that this is very much a long-term goal. In the short term, i.e., in this century, the contribution from renewable energy sources will probably not exceed 15-20 per cent of total energy supply.[7] Until these renewable sources become firmly established and provide a major share, present plans to open and develop new supplies of fossil fuels and electric power will have to continue (present uranium fission nuclear reactors are generally regarded as a "temporary" or "bridging" source; at this point in time, along with the U.S., the U.K., and Sweden, we should leave open for choice the extent to which we will become dependent on the longer-term "breeder" reactors and/or thorium-cycling reactors, with the fuel handling and re-processing they will entail).

The dramatic economic growth experienced in Western societies has been based on a large and cumulative structure of capital investment on easily available resources, and on a series of scientific and technological advances. But the unheralded actor in the great drama of economic growth has been energy.

Energy to build factories, fuel cargo ships, mechanize factories, make thinly distributed resources economical, fertilize fields, mechanize growing and harvesting – energy in its various forms has been given little consideration in economic theory. It has been used and wasted in vast amounts, without a thought for the consequences; depletion has been so rapid that it has caught us almost unaware. This once relatively hidden but important factor of production has erupted centre stage. It is now recognized to be the *sine qua non* of industrialization.

But fossil fuels are a non-renewable resource. They are, in many respects, a capital stock. In the world of capital goods which can be replaced, methods have been devised to ensure that capital stocks are replaced as they are used up. In the case of fossil fuels, however, we have been drawing down a capital stock with little thought to ensuring that the service it provides can be maintained in perpetuity. The service provided by non-renewable fossil fuels is, of course, the work that is accomplished as the energy transformation process takes place. The rates of depletion have been so great in recent years and new finds have become so infrequent that we can no longer avoid recognizing the finiteness of this capital resource. We are coming close to being able to calculate just how much longer it will last.

Looking at the oil exploration process from the point of view of social investment, there is some logic to having used retained earnings to look for still more oil. There is also some logic to devising ways and means to exploit such relatively high cost reserves as the oil sands and the Arctic reserves. However, we must be careful we are not led by that logic into investing ever more of our capital – both money and energy – in pursuing those fuels to the last expensive drop, or to that final margin where the net energy yield is zero, where the energy put into extraction would be equal to the energy gained. We could find at that point that we had neglected an important opportunity to use that capital to build the base for the alternative supplies that would continue after the fossil supplies were gone.

As the recognition of a future energy shortage has spread among governments, the initial reaction has been to allocate still more investment to find the as yet undiscovered sources, to gamble that more will be found in increasingly remote areas of the world, and to go back to wells which were once "exhausted" and extract the last few barrels available. As costs rise it now pays to move onto less productive sources. Thus conventional energy policy dictates ever more investment in pipelines and exploration. Ironically and tragically the capital investment which in the past has been used to provide unprecedented rates of growth will increasingly, in the future, be shifted to making investments in the energy sector to prevent economic collapse. The invisible factor of production which was taken for granted for so long, will, in the next decade, be the recipient of up to 6 per cent of the GNP.[8] This will divert scarce resources away from other social priorities into the energy sector at a time when other economic difficulties are pressing. It will involve more and more the intervention of government to ensure the financing of larger and larger capital-intensive projects, and to ensure the stability of markets and demand that will reduce the risk of the investment. Such a policy, which has been characterized as "strength through exhaustion" is not an attractive prospect.

The development of "renewables" offers hope for an alternative path. There is some doubt as to whether these new technologies such as solar heating, electricity from wind, and liquid fuels from biomass, can be developed economically on a sufficient scale to meet the energy demands estimated by extrapolating our present wasteful ways but, given the improvements in conservation and efficiency advocated above, it could be a different story.[9] These possibilities are now being explored intensively throughout the world. The situation is changing too rapidly to attempt more than a few illustrations here.

Solar space heating: The idea that Canada is too cold a country to benefit from solar energy is quickly dispelled as one puts a hand on the pipe coming out of a solar collector on a sunny midwinter's day: at a temperature as high as 100°C or more, it can be too hot to touch. Something like 55 per cent of the total energy we use in Canada is in the form of low-grade heat, for example, water or air heated to 140°C or less to heat buildings. In principle much of this could eventually be supplied by solar collectors.

In practice, sunlight as an energy source is intermittent and diffuse. At current prices, buying and installing the equipment to capture, transfer, store and distribute solar heat is an expensive undertaking for the homeowner. Partial or total solar systems for typical single-family dwellings range in price between $4 000 and $25 000 depending on how sophisticated the rooftop collectors are and on the size and time period of the heat storage unit. There is no question that the high initial investment will even out over time. And as gas, oil, and electricity prices continue to rise in coming years over and above the inflation rate, the economics will gradually favour solar systems. Every BTU of energy one gets from the sun is a BTU's worth of conventional fuels one does not have to buy and burn.

There are about 100 000 single-family housing starts and slightly more multiple-unit starts in Canada each year. The total present stock is about five million units. The rate at which new units will be equipped with solar space heating will depend to a great extent on economic factors and institutional incentives, public information, and developments in oil, gas, and electricity prices.

The latest survey of solar heated buildings by Prof. W. A. Shurcliff of MIT describes 319 buildings in the US and Canada and acknowledges rumours and partial details of 500 more.[10] The book will now cease publication because growth has passed the point where a comprehensive survey is feasible or useful. During 1976 over $50 million worth of solar collectors were sold in the US and the market was estimated to be growing at the rate of 60 per cent every six months. About three quarters of the market is for industrial systems.[11] In Canada in 1976, the total number of private and publicly-sponsored solar projects and buildings was 15 to 20. By 1977, this number had grown to 50 and, by 1978, it is expected to be 250 to 300 units. Current studies indicate that, for Canadian conditions, the most attractive proposition appears to be solar collection with full seasonal storage for multiple-unit housing. Because of the square to cube ratio of surface to volume, the larger the storage tank is, the more efficient thermally and the less costly it becomes; the reason is that thermal losses are proportional to the area, while the heat capacity is a function of volume. This factor is the key to the "mini-utility" concept developed at CMHC, which consists of centrally providing essentially 100 per cent solar space heating for medium density housing projects such as town houses, using seasonal storage.

Wind Energy: The principle of the wind-turbine is to capture the energy of the wind and transform it to a mechanical motion that will generate heat, pump water, or drive an electrical generator. The major technical problem is the intermittency of wind and therefore the need for storage. The advantage, of course, is the permanence of the wind over a long period of time. Several methods for storage have been suggested. One way of by-passing the storage problem is to develop the technique for connecting the windmill to a larger electrical grid. A wide distribution of wind machines will have some areas feeding into the grid, while other areas that are becalmed can draw from the grid.

Windpower could undoubtedly provide a supplement to a primary energy source which can meet base load needs under any conditions. Under particularly favourable conditions, and with sufficient windmills in place, the situation might, of course, become the reverse, with wind supplying base load and liquid fuel or hydro needed only for topping up.

Wind generation development and demonstration projects are now working in Canada on les Îles de la Madeleine (200 kW) and in Prince Edward Island (4 windmills of 10 kW each at the Ark). Several projects are being supported by ERDA in the US, including one 1.5 Megawatt (MW) mill being designed by NASA. Denmark is one of the leading countries in studies and demonstration projects showing the feasibility of basing a national electrical grid on wind.

Energy from Biomass: Forests are the most familiar source of solar energy stored in vegetation, that can be harvested on a continuing basis, but there are others, ranging from agricultural wastes, to crops deliberately grown for the purpose. Brazil has embarked on a program to manufacture ethanol from sugarcane and cassava to take the place of petroleum for automotive fuels. Studies approved by Environment Canada indicate that in BC, the most prolific forest region of Canada, a 150 MW electrical generating plant could be operated on a continuous sustainable basis by rotation of cropping of red alder on an area of 65 square miles, i.e., a square plot about 8 miles each side. While no one of these sources appears to have the potential for large-scale centralized production comparable to nuclear-powered stations and some hydro sites, this need not in itself be a disadvantage when the economics of mass production and the advantages of diversity are taken into account. Moreover, though we should not raise false hopes, we should not dismiss the possibility of breakthroughs. An instance of the latter might be the microbial production of fuel hydrocarbons from a substrate of carbonaceous materials, possibly even from the almost limitless limestone rocks.[12]

The potential contributions of these systems to meet Canadian needs are being carefully evaluated by the Science Council committee formed to follow up the recommendations of the Energy Report (Science Council Report No. 23, *Canada's Energy Opportunities,* March 1975) and will be commented upon by that group.

Questions of sustainability: One of the main questions regarding the potential of energy from biomass concerns the sustainable level of production – without adverse environmental effects and without depletion of the soil. The principal alternatives being investigated for the long term future are nuclear fission (with fuel reprocessing and the thorium cycle and/or the uranium breeder) and nuclear fusion. These, too, have to be carefully evaluated for the sustained vitality of the biosphere, under the impact of their waste products. Other issues surrounding the use of nuclear systems remain to be publicly and politically resolved and will not be discussed here.[13] Suffice it to say that the "renewable" technologies offer advantages of clean-ness, diversity, technical simplicity, and low risk that merit serious research, development, and demonstration to establish them as genuine options as the fossil fuels rise in cost.

A Note on Efficiency: The application of the "second-law efficiency" criterion is complicated in the case of solar energy, which seems to be a "free" resource. This may serve to remind us that it is an oversimplification to think only in terms of energy-efficiency. More fundamentally, we should be concerned with the use-efficiency of whichever is the limiting resource – and there may be several. In the case of solar, hydro, wind, fusion, etc., the limiting resource will not strictly be fuel supply, but more likely capital costs, suitable sites, and perhaps supplies of some of the materials involved in construction of the energy-capturing mechanisms. Further, it should not be assumed that solar is necessarily a low-grade energy source, of low available work. Though the sunlight arriving at the earth's surface is at relatively low energy density, it comes from a source at very high intrinsic temperature. This it what makes it feasible to generate electricity from sunlight by the photovoltaic effect, and to reach very high temperatures in wavelength-selective collectors and in focussing collectors. An instance of the latter is the solar furnace in the south of France, capable of producing one megawatt of power at a temperature of 3500°C.

Materials

Questions of conserver policy for materials can be addressed at two levels: first, as applicable to any more or less industrially developed country of the present epoch and, second, as applicable to Canada in particular, as a country which is thought to have enormous material resources in comparison to its population.

In industrialized countries the flow of materials in the economy has been used almost as a measure of economic well-being. Minerals are extracted from the ground from concentrated deposits, they are refined, processed, fabricated into products, transported, used, and ultimately returned to the ground. Canada exports much larger amounts than are used within the country; some come back in the form of finished or semi-finished products. The rate of flow of all materials into and out of the system is generally used in economic accounting rather than the amount of existing stock which is what actually yields a service to users or consumers. We predominantly measure throughput or flow, since it is a component of Gross National Product, the widely used indicator for estimating economic wellbeing. From a conserver point of view, however, we would be better off to pay more attention to materials as *stock*, both fixed and circulating – fixed in the form of buildings, roads, equipment, etc., and circulating in the form of new investment, depreciation, recycling, consumption, and disposal. Thinking in terms of these categories we shall be able to promote economic welfare more efficiently – using materials more effectively, extending the life of scarce materials, and reducing the burden of increasing costs associated with finding, extracting, and disposing of large volumes of materials and associated wastes.

Until very recently the prices of most minerals have remained constant or, in real terms, have declined. While we have been extracting our most abundant sources and moving onto marginal areas, dramatic advances in technology and the continuing availability of low cost energy have helped to keep prices relatively favourable. Our reliance on low cost energy has lulled us into a false complacency: as future energy costs rise, the extracting costs and therefore the price of many materials will rise as well.

The problem is not so much that resources are limited in any absolute sense, nor that many are non-renewable. Even though the planet we live on is visibly round and finite, its mineral content as far as human operations are concerned is essentially inexhaustible. For example, a single cubic kilometre of average crustal rock contains $2x10^8$ metric tons of aluminum, over $1x10^8$ tons of iron, 800 000 of zinc, and 200 000 of copper. Strictly speaking, from a physical point of view, most mineral resources are bountiful. The problems which we must address concern rising costs, and some ores becoming uneconomic to mine. The fact that at some future time they may *become* economic to mine, in that circumstances may become so desperate that society will be willing to pay the price, is hardly the kind of benefit we would wish upon our descendants if it can be avoided. We have always assumed, irresponsibly, that our descendants will be able to invent the technology, and find the energy, to extract these materials more cheaply than we can today.

Many factors are now coming together to raise the costs of minerals, and are more likely to increase in intensity than to go away in the foreseeable future. These include the depletion of rich and accessible deposits, the increasing size and complexity of mining operations, the difficulties of capital financing, rising cost of energy, transportation over greater distances, stricter environmental regulations, and insistence on regard for social costs and benefits, such as safety and health of workers and continuity of social infrastructure. Labour and exploration costs have been rising in Canada.

Not the least among all these factors is the political element. Pressures are mounting for a new world economic order, one that will redress some of the imbalance between the developed and the developing nations; the industrialized nations draw resources from the less-developed and, because of their economic power, tend to get the better terms of the trade. As the UN agencies urgently point out, a shift in the terms of trade is one of the best ways to assist the development of these countries, and if such a shift does not come about voluntarily it will likely be forced by various concerted political actions. OPEC may have been the most successful so far, but we should expect others.

Canada, being to a considerable extent a resource-supplying country, may stand to benefit from these price trends over the short run. This may appeal to economic expediency, but the costs of distorted industrial structure, and the stresses from market fluctuations as sources of supply shift around the world, advise against building an economy heavily dependent on such a base. While the export of "staples" has been a characteristic of Canadian economic development, its extrapolation as the main plank of a policy for the future is debatable. Though Canada has large mineral resources for the size of its population, several, iron, nickel, copper, silver, lead, zinc, asbestos, and potash, are now being exported at rates similar to, or greater than US, not Canadian, rates of consumption. A century and a half ago, England was a major producer of metals. It extracted and shipped copper, lead, tin and other scarce materials around the world. But conditions have changed and it has increasingly become an importer of raw materials. Similarly, the US is now becoming a major importer of raw materials. Canada is being turned to by other nations for one material after another. It cannot be long, a few decades at most, before we are forced to face the reality that our best and most accessible mineral deposits are ephemeral. They, too, like the purified materials above ground, should be regarded as capital stock. The history of our oil and gas reserves, once the largest single item in our mineral or non-renewable exports, should be a warning of things to come. Canada's mineral policy is now beginning to reflect these concerns, to some extent, by basing export licenses on the requirement that the amounts exported be surplus to Canadian needs as foreseeable 25 or 30 years ahead.

These warnings should not be taken as applying across the board without qualification, however. They apply particularly to minerals of low average abundance in the earth's crust, for the extraction of which we depend on unusual geologically concentrated deposits. Examples are copper, gold, uranium, lead, zinc, nickel, mercury, chromium. Materials that are inherently abundant, such as iron, aluminum, silicon, carbon, calcium, magnesium, sodium, cannot be regarded as globally limited, from the standpoint of depletion, even in the long term. Their excessive use, however, still presents costs, in the form of energy consumption, environmental impacts, and the other costs mentioned above. There is, therefore, still a strong case for conservation and more efficient use. Some suggestions follow for how this can come about.

Recycling: The ultimate will be a change from a system of high extraction, high flow, and high disposal, with recycling a minor component, to a system in which optimal use is made of a fixed and recycling stock, with new extraction necessary only for growth, and "topping-up" as materials degrade from wear and tear and mixing. We are very far indeed from such an "ultimate" conserver society. However many decades it may take society to make that transition, it means that for a considerable time gains will be very easy to make and returns obvious. The average American, and presumably it is similar for the average Canadian, at present requires about 40 000 pounds annually of new mineral materials, from crushed stone, cement, iron and steel, to copper, zinc, gold, etc. and including nearly 18 000 pounds of petroleum, coal, natural gas and uranium. Simply by better recovery and recycling from solid waste, the typical community of 100 000 could conserve up to 3.5 million gallons of fuel per year, 30 000 tons of paper and cardboard, 3600 tons of ferrous materials, 700 tons of non-ferrous (aluminum, lead, zinc, and copper) and 4000 tons of glass. The operating cost of incinerators would be reduced by 30 per cent and their capital cost by 60 per cent, and 15 acres of land per year would be spared from use for waste disposal by landfill. Producing aluminum from scrap rather than virgin sources can yield energy savings of over 90 per cent, reduce air pollution effluents by 95 per cent and water use by 97 per cent. Similarly, copper from scrap requires about 70 per cent less energy, generates 98 per cent less air pollution and reduces water use by 40 per cent. Similar figures apply for steel.[14] In Canada, if all copper and aluminum were recycled, the energy savings in 1972 would have been the equivalent of 6.4 million barrels of oil or 838 000 tons of coal.

Citizen awareness has been rising, assisted in no small measure by environmental and public-interest groups such as Pollution Probe and SPEC (Canadian Scientific Pollution and Environmental Control Society). Some detailed studies have been made, notably by and for the Ontario Ministry of the Environment. Nevertheless, progress in recycling in Canada is still hampered by a severe dearth of statistics and other information needed to trace the paths of materials through the system, to map the extent of the resources, and to assess the economic potentials of recycling. This lack was noted by the Science Council six years ago in Report No. 14, *Cities for Tomorrow* (p. 50). Improvement has been slow. We stated in that report: "Within the next decade, Canada will require a major, co-ordinated, and multifaceted program to establish and enforce systemic procedures for reducing the quantities of urban and other wastes, identifying and separating residuals, and applying existing and emerging technologies to their treatment." The recommendation followed: "that a detailed study of waste recycling and disposal be given the highest possible priority, either in the program of the proposed National Institute for Urban Analysis or on the part of such new urban and environmental agencies as are being created by the federal and provincial governments."

Some progress is visible. A pilot plant for the recovery of resources from urban waste, capable of handling up to 800 tons a day (about one tenth Toronto's output) is now operating in the North York borough of Metro Toronto. Results will be evaluated, and the plant will serve as a prototype for others across the province. Industry is ready to move; for example, a partnership of Consumers Gas Co. and Canadian Industries Limited is prepared to erect and operate complete facilities near any suitable city in Canada with 1000 to 2000 tons per day of municipal solid waste. This quantity (after extracting ferrous scrap) can be incinerated to produce and market 25 megawatts of electricity and 800 000 pounds per hour of steam or hot water for district heating.

Recycling can never be perfect. It is easiest for metals, though even they are put to many dissipative uses from which recovery is difficult or impracticable. Zinc, for example, is dispersed in paints, and is thinly plated over thousands of acres per year of galvanized iron. Lead is widely used in solders and in paint, is worn away in bearings, and is widely dispersed in the atmosphere and over the landscape from its use in the gasoline additive, tetraethyl lead. Other materials, such as paper and plastics, follow a constantly downgrade path, being recycled each time into less critical uses. Ultimately their energy content can be recovered by burning, but there is no reason why that last stage should not be postponed as long as economically possible. Because recycling can never be perfect, however, we must at the same time look for ways to reduce the need for such large extracted volumes in the first place.

Demand reduction: Substantial changes could follow from widespread shifts of attitude, a new ethic. If each governmental, institutional, or industrial decision maker, each designer or engineer, or each private citizen, would ask himself or herself whether the job could not be done with less – less consumption, less ostentation, less extravagance, less waste – demand would drop dramatically. As a former member of Science Council put it in a recent essay: "A preference for the optimum rather than the maximum, for renewal rather than exploitation, requires some form of self-denial or austerity. I have often advocated a *joyous austerity* as the key to a wise utilization of our resources and a just distribution of their products. Maybe this would also induce a greater satisfaction in our work, a keener sense of relevance to our world."[15] Whether or not a "joyous austerity" takes hold throughout the Canadian population, there are some simple technical principles that should be applied.

System management: As soon as material flows in the society are looked at in the context of a total system, it is clear that rational revisions of the system bristle with problems of jurisdictional ambiguities, problems of allocation of costs, absence of market incentives, impediments built in as tax structures and freight rates, attitudes, myths, and other inhibitions to system organization.[16]

The fact that recycling cannot be perfect and can at best act to *slow* the downward progress of materials from purified states to landfill suggests that design for durability and simple repair is an equally important principle. The *entropy* concept provides a useful principle for valuing the quality of a material stock as it moves around the system. The quality of a material would depend both on the energy that has been invested to bring it to that state, and on its position on a scale of entropic quality, extending from extreme high purity at one end (low entropy) to the ultimate state of degradation (high entropy) at the other, where it is intimately mixed with all kinds of other materials, common and uncommon. This criterion would recognize that more is lost by careless mixing and contamination than can be restored by mere energy. Often the unscrambling of material requires scientific knowledge, finely instrumented apparatus, and chemical or physical techniques that are not applicable on the large scale needed to be economic. For example, metals recovery from waste can be relatively simple and economic, but when iron scrap is inseparably contaminated with copper, or when aluminum is inseparably mixed with iron, as in the steel soft-drink can with aluminum top, quite another order of difficulty and nuisance is created, much of which might have been avoided in the first place by design.

The sorting factor is important in the system design. It is important to reduce the dissipation, especially of scarce materials; for these some form of resource-tagging might be considered, along with deliberate design of products to make later recovery simple. Often the largest cost in the urban waste system is its collection in the first place. More attention might well be given to that point in the system. Pre-sorting of garbage in the home – a deviation of the hand six inches to right or left as it chucks out an item of refuse – might mean that the "soft" garbage need travel no farther than a backyard or neighborhood compost heap.

Design and substitution: Besides design with the remainder of the loop in mind and design for long service life, a wide range of possibilities resides in the substitution of materials. The needs of the future should be anticipated, with more imagination than simply waiting for market prices to rise. The technologists of the future, for example, may have much better uses for helium, or platinum, or mercury than we have today. New organic coatings, plastics, epoxies, etc., could be used today to replace scarce metals. And we may find it worthwhile to pay more regard to the solar energy (low entropy) already locked up in the molecules of natural organic materials, such as the lignin in wood, rather than investing additional energy in synthesizing very similar molecules from lower forms. This is a form of conservancy in the materials realm that is in its infancy.[17]

New Business and Employment Opportunities

A move toward a Conserver Society does not mean a move away from industry, technology or private enterprise. On the contrary, a conserver approach will lead to the introduction of new technologies, new opportunities for Canadian business, and unprecedented challenges to the entrepreneurial spirit. It should help to create a large number of new jobs. In Canada, many areas which provided for growth and expansion in the past are now approaching satiation. New growth areas will be related to new resource and energy realities.

The emergence of the Conserver Society could suggest solutions to many of the problems facing strategists concerned with the industrial future of Canada. The quest for more indigenous ownership and control of industry and technology becomes somewhat more possible and plausible in a scenario where very many new industries and technologies will be developed, and where selective growth becomes the central policy thrust of our industrial strategy.

There have been two major waves of industrialization in Canada. The first was associated with agriculture, the extractive industries and the development of primary manufacturing: mining, pulp and paper, steel, textiles, building materials and rail transport. This, broadly speaking, was the era of "metal bending and smoke stacks." The Canadian economy was geared to the industrialism of both Europe and the United States. Over time, Ontario and Quebec began to develop a manufacturing industry (protected by tariffs) which corresponded with the industrial north-eastern region of the United States. Railways and rate structures were designed to encourage large-scale transportation of major resources to world markets.

At about the time of World War I, Canada entered its second great wave of industrialization. Large quantities of munitions, merchant ships and other war-related production poured from Canada's industrial plants. At this time Canadian industrial output surpassed agricultural production for the first time: the nation's economy was transformed into an industrial one. Economic expansion continued in the primary industries – most notably pulp and paper – and there was growth and development in secondary manufacturing. Assisting industrial growth in this era was the expansion of hydroelectric power particularly in British Columbia, Ontario and Quebec. Secondary manufacturing included electrical and electronic equipment for the home and industry, chemicals, aircraft, and the widespread development of the automobile.

The third wave of industrialization will be based on:

- society's needs for new energy sources and the developments arising out of the need to use present sources as efficiently as possible
- miniaturization involved with the development of the micro-computer to its full potential
- the further development of electronic control technology of all types
- new technologies based on the sciences of biology and ecology.

Some examples of new industrial opportunities will be the development and commercialization of hardware and software associated with solar, wind and biomass as energy sources; electronic control equipment associated with the extractive industries (scarcity will demand even greater efficiency in this area); hardware associated with efficient use of current conventional energy supplies (district heating, heat pumps, insulation).

For the remainder of this section, the emphasis will be on those conserver technologies associated with renewable energy and energy conservation.

Solar Energy: A major constraint that will determine the rate at which solar heating can be implemented is the number of new housing starts. Current studies indicate that retrofitting, or adapting solar heating to existing houses, is not yet practical on a large scale. There are important gains from scale, however; community-shared installations, such as the new mini-utility concept, and industrial-scale installations may be found economic, even in retrofit.

Studies commissioned by the Science Council sketched an envelope of solar implementation possibilities: out of a total housing stock of 4.7 million multiple housing units and 5.3 million single-family housing units estimated for 1990, 300 000 to 1 million multiple units and 250 000 to 900 000 single-family units could be solar-equipped. The upper figures assume equipping some 40 per cent of new housing starts with solar between 1978 and 1990; they also assume that by 1990 some 10 per cent of the existing 1977 stock will have been retrofitted.

These two scenarios can be examined in terms of likely dollar sales as well. The higher use of solar indicates about $5 – 6 billion (1976 dollars) in the manufacture and sale of solar collectors between now and 1990. The process should start relatively modestly but will grow more rapidly as 1990 is approached. The total capital cost of high solar usage, including associated parts, storage systems and labour costs, is estimated to be $11 billion by 1990. Low usage indicates $1.5 – 2 billion in the manufacture and sale of solar equipment by 1990. Here the total capital cost, including related parts and storage facilities, is estimated to be $4 – 5 billion.

Benefits will flow to a wide variety of industries. For example, the flat plate solar collector is largely made up of glass or plastic, with aluminum, copper and sheet-metal of various types. These collectors can be assembled in relatively small operations. Preliminary studies indicate that there are not great economies of scale in simple flat collectors. Installation could be done by firms currently active in the area of heating, ventilation and air-conditioning. One problem with the widespread adoption of a new technology is dissemination of information. Training programmes will be needed. The building trades, traditionally small, conservative businesses will need to be introduced to the new construction techniques associated with the use of solar heating.

A more sophisticated solar collector known as the evacuated-tube type has been developed. It is more efficient than the flat plate collectors (it is mass produced of specially-coated glass similar to the tubing of fluorescent lights) and can function better at the lower temperatures found in Canada. This "second generation" collector, already being produced in the United States, lends itself to economies of scale in production. It is in areas such as this where decisions will have to be taken very soon. If the second generation evacuated tube collector comes to predominate, then government industrial strategists will have to decide how and on what terms the new technology will be produced in Canada.

Traditionally, Canada has opted for technology transfer from abroad, usually the United States, in the form of direct foreign investment. Branch plants were created in Canada behind tariff walls and new technologies were introduced by subsidiaries of foreign-owned companies. We can change this trend with the new energy technologies. For example, with regard to the evacuated tube solar collector, we can opt for a licensing arrangement and maintain Canadian ownership of the production. Or we may decide that since a "third generation" collector is inevitable, we should build and develop the product in Canada so that innovations surrounding all new developments in solar technology can be understood by researchers in Canadian industry. This latter approach could lead to a selective licensing strategy. Early Canadian experience of branch-plant dominance does not have to be repeated with these new technologies. New technologies – especially those that must be adapted to the Canadian climate – open options for greater Canadian participation in the areas of ownership and control.

Liquid Fuel from Wood: As our non-renewable fossil fuels are drawn down, a likely replacement in the area of liquid fuels appears to be methanol. Methanol, which can be mixed with gasoline to power internal combustion engines, can be produced by the pyrolysis of wood. At present, methanol (also known as methyl alcohol, wood alcohol, or methyl hydroxide) is produced from non-renewable fossil fuels. Since our forests, properly managed, are a *renewable* resource, Canada has the potential of developing a liquid fuels industry which is sustainable. Some estimates of the liquid fuels potential from Canadian forests are astonishingly high. Assuming the use of residues from the current annual cut of the wood and adding a special harvest of other woods that at present have neither an economic nor recreational value, one study estimated that liquid fuels could be made available in an amount equal to almost twice as much as is now used to fuel all present transportation in Canada.[18] To convert wood and pulp to fuel on such a massive scale, we would have to solve difficult problems of finding the capital investment to provide the plant and distribution capacity. The net impact of such an activity on the Canadian environment would have to be considered and technical questions regarding the behaviour of water-methanol-gasoline mixtures in the cold Canadian climate await answers. A complete technology assessment of this technique will have to take into account *all* possible environmental costs, as well as determine whether production of methanol is the most energy-efficient use of wood and wood wastes.

Methanol production could become an important industry in Canada. A wood-methanol plant with a capacity of 150 tons per day would yield about 7×10^{11} BTU/year. A plant of this size would cost about $5 million (1977). By 1990 there would be between 40 and 400 of these plants in operation, depending on one's optimism. The total cost of construction would range from $200 million to $2 billion respectively.

Of course, the extent of implementation of methanol, solar and wind will be a function of the research, development and demonstration undertaken now. *Our view is that renewable energy is feasible, desirable and inevitable; the rate of introduction, however, is a policy decision. This decision must be taken very soon if Canada, as a nation, is to make an orderly transition to renewable energy.* This will be discussed in greater detail in the part of this Report where proposals and recommendations for action are presented in greater detail.

Windmills: One of the areas of renewable energy in which Canada has demonstrated international leadership is that of large-scale wind electrical generators. The research of the National Research Council has led to the development of the vertical axis windmill (the egg-beater). A prototype (of 200 kW), operated by Hydro-Québec, is functioning in les Îles de la Madeleine.

A number of locations in Canada have sufficient wind throughout the year to provide useful power. These include the St. Lawrence basin, the Atlantic coasts of Nova Scotia, Newfoundland, Labrador, and areas on the West Coast of Hudson Bay, as well as Southern Saskatchewan and most of Alberta.

By 1990 we could have between 1000 and 3000 windmills in Canada each with a 200 kW capacity. The windmills can be manufactured by metal fabricators, large engineering companies, aerospace and electrical companies. The major users will be hydroelectric utilities. The advantage of a windmill is that it is site-specific. Smaller, localized areas can be serviced by wind machines without the enormous cost of erecting transmission lines. The back-up source of energy to meet base load requirements in remote areas could be diesel generators.

The industrial opportunities are significant. One thousand mills by 1990 would generate sales revenus of about $140 million for manufacture, sales, distribution and servicing. Three thousand mills would mean over $400 million in sales revenues.

Total Energy Plants: There are opportunities in the design and installation of energy-saving total-energy plants, integrated with complete systems for urban living. In a system on trial in Jersey City, N.J., for example, 5 diesel engines, each with an electrical generating capacity of 600 kW, supply electricity, space heating, hot water, air conditioning, and pneumatic waste collection for 488 dwelling units in 6 buildings, plus 2 schools, a swimming pool, and a commercial building. The cost of such total-energy systems is typically less than when the services are supplied separately.[19]

Heat Pumps: A useful device with increasing application is the heat pump. In its most familiar form, the household refrigerator, it extracts heat from the contents and dissipates it into the room; uses are rapidly expanding for the heating and cooling of buildings, since the heat pump can shift heat from where there is too much – on the sunny side, say – to where there is too little, instead of having heating and air-conditioning systems inefficiently working against each other. Thermodynamically, it is a more efficient way to use high-quality energy, such as electricity, than direct heat generation, since the motive power or available work is used to upgrade locally available energy which may simply be a little too low in temperature. In a district heating system, for example, an electrically driven pump may be used to extract a useful quantity of heat from the circulating water toward the tail end of its temperature cycle; the water at that point otherwise might still be warm, but not warm enough for domestic washing machines or for good heat transfer. Provincial utilities and the federal government are jointly supporting the development of heat pumps optimized for Canadian temperature ranges.

Greenhouses: Canada imports many of the vegetables and fruit consumed during the winter months. While some of the market is supplied from greenhouses in Canada, costs are high since conventional energy systems are used to supplement the heat from the sun. One obvious application of solar technology is to supply heat to the greenhouse. Perceiving the greenhouse as a solar conversion system means that it will be designed in a different way.

The major disadvantages of conventional greenhouses are a high rate of heat loss at night and large daily variations in temperature. To maintain a stable temperature, a greenhouse requires adequate ventilation during the hot summer months and large amounts of supplementary heat at night – especially in the colder months of the crop year. A number of siting and insulation techniques are now available that lower the need for supplementary heating. Part of the design of the structure could be rock or water (or both) which would absorb the heat of the day and radiate the stored heat during cold periods. Solar greenhouses could be little more than well-designed conventional greenhouses with some type of heat storage system or they could actually employ solar collectors and a water circulation system to increase the heat absorption efficiency. By designing the greenhouse as a solar unit, fuel costs could be reduced by as much as 40 per cent. Commercial greenhouses in Canada are currently estimated to have about 35 million square feet of capacity. The use of solar techniques could mean a considerable expansion of this capacity. The result would be new industrial opportunities, increased self-reliance for Canada and less pressure on our balance of payments.

Renewable Energy Areas Requiring Further Study: Tidal power has often been discussed in Canada and, as electrical costs continue to rise, this approach may become more feasible. Another approach is to harness the effects of wave energy. The principal research on the latter method is at present being conducted in the U.K.

Electronics: The conserver technologies aim at long-term sustainability and at "doing more with less." Few technologies exhibit the potentials of doing more with less energy better than electronics. For example, the world's first electronic digital computer weighed 30 tons and ran on 18 000 vacuum tubes. This achievement of about 30 years ago pales beside the development of the micro-computer. This device is basically a complex of circuits on a chip of silicon a fraction of a centimeter square. A medium strength micro-computer with its basic components weighing only a few grams can perform 100 000 calculations per second. It is 20 times faster than its 30-ton counterpart of 30 years ago.

The micro-computer was invented in 1970, but the range of application is just coming to be understood. Small computers will affect our places of work and leisure, the profitability and productivity of corporations and the nature of society itself. The micro-computer in its simplest form is inexpensive (often under 10 dollars) and can be designed into existing machines to help them operate more efficiently. It can be part of an electric typewriter, a butcher's scale, a microwave oven, a sewing machine, a gas pump or a traffic light. Micro-computers will soon replace wheels, gears and mechanical relays in a wide variety of control applications. It is much faster, more reliable, and more efficient to move electrons around than mechanical parts.

Micro-computers are expected to appear in automobiles in the next few years. When fully in place automotive engineers expect that fuel consumption in the average car can be reduced by as much as 20 per cent. In addition to extending mileage per gallon, the new technology will help to reduce pollutants. The micro-processor will be designed to adjust the air/fuel ratio flowing to the engine, based on data received from a sensor monitoring the oxygen in the exhaust stream.

The price of the transistor dropped 99 per cent from 1960 to 1970. As prices have dropped and new technology has been introduced, the use of electronics has increased. In the vacuum-tube era, digital electronic sales grew at about 10 per cent per year. With the introduction of the transistor, the rate of growth increased to about 18 per cent per year. Integrated circuits increased the sales growth of the industry to about 30 per cent per year. With the micro-computer, sales of electronic components are expected to increase at 50 to 60 per cent per year.

New technologies will allow for the satisfaction of traditional human needs in ways that are less energy intensive and in ways that demand less physical movement of people and things. For example, the use of telecommunications will promote energy savings in a number of ways. By improving the control of transportation modes the vehicles in a system can be more optimally distributed. Low-priced mini-computers are being developed for taxis that will allow for picking up more than one passenger and metering each separately. The use of the teleconference will increase as transportation costs rise and as airport congestion becomes more serious.

Dramatic savings of energy and forests will be possible as new methods are put into practice for electronically transmitting to homes and offices the information we now find in newspapers, books, and periodicals. The development of the optical fibre transmission line (the first installations are being tested in London, England, and in New York, Atlanta and Chicago) is opening a new era in telecommunications. Made primarily of silicon, one of the abundant materials, and one tenth of a millimeter or so in diameter, the optical fibre carrying laser-generated light can transmit signals of greater bandwidth and with less crosstalk and interference than coaxial cables of many times its size and weight. The result ultimately may be to greatly reduce the consumption of copper for these purposes and turn many present installations into copper mines.

The increased use of telecommunications should lead to a decentralization of work places and could foster structural changes in land use, places of economic activity and population distribution. Through a staggering of the work day, more efficient use of existing transit services, and extensive use of telecommunications, much of the proposed highway and mass transit development may be avoided or put off for many years.

Summing-up: Other business opportunities will be found in recycling, in waste recovery systems, in the production and application of heat pumps, in energy conservation consulting and retrofitting, and so on; and their scope is indicated under other sections. The examples given may suffice to make the point that, far from being disheartened by not having "energy to burn," the engineer and the entrepreneur will find the conserver society full of new challenges and opportunities.

Renewable energy in its many forms offers a challenge to scientists and industrialists. To the extent that these new technologies will form the basis of entire new industries, those who are concerned with industrial strategies for Canada must ensure that these industries will, to the greatest degree possible, be owned and controlled by Canadians.

Further Questions

In the preceding sections we have set out a number of principles on which a conserver society would operate, and some of the ways these would apply – in energy conservation and supply, in materials, transportation, and so on. However, we would be remiss, and even naïve, if we did not take note of some structural features of our present society that may create difficulties for the coming transition. Even though many Canadians are already changing their views toward high consumption and waste, as we believe that they are, the continuation of built-in structural and economic impediments, forces, and policies – and the absence of consensus on how to modify them – are likely to cause severe strains in the Canadian social fabric. Symptomatic is the persistence of inflationary pressures, along with unemployment, amidst a very uneven context of optimism, puzzlement, and disappointed aspirations.

At a time when we see severe crises ahead, the longer we continue growing past unsustainable levels of consumption of material, energy, and environment, we find ourselves, in the so-called *consumer society,* with what has been termed the *institutionalization of high demand.* We shall try to review as objectively as possible some of the ways in which this has come about, and how it works to inflate demand, without pretending that we know a better way to design a dynamic and innovative society.

Many features of our *consumer* society have grown from solutions sought to the great depression of the thirties.[20] The solution to depression and unemployment was discovered in the stimulation and maintenance of demand. A *White Paper on Employment Policy,* published by the Churchill government in the United Kingdom in 1944, clearly stated: "A country will not suffer from mass unemployment so long as the total demand for its goods and services is maintained at a high level." Even more important than the maintenance of consumer purchasing power, was the stimulation of investment in capital goods. This was demonstrated by the rapid recovery of North American economies in wartime, and by their good "health" throughout the reconstruction period afterward. The lesson was perpetuated in the United States through the massive government-backed innovation programs associated with defence and space industries. In fact, innovative growth and investment were kept at such a high pitch that the normal dropping of market prices as first costs of innovation were amortized, often never got a chance to occur. The economic doctrine had changed from *laissez-faire* in the 1920s, to *faire-aller* in the 1950s and subsequently.

The conditions for maintaining the growth of demand involved a generally rising level of incomes and an inflationary component. The latter made adjustments of wages and prices easier to negotiate, and encouraged investment and borrowing, by depreciating the cost of future payments. Everything depended on a continuous expansion of credit. In the United States between 1953 and 1970 consumer purchases increased 2.7 times, while credit to companies and to consumers increased more than four-fold.

These factors underlie the expectations of consumers, business-people, and governments. Since the trends extend over 30 years, many of us, as working adults, have known no other era. (In the United States from 1923 to 1929, the increase in hourly wages in industry over the whole period had been only 8 per cent.)

It is easy to see how people have come to aspire to first one automobile, then two, and perhaps three, along with continually growing incomes that will allow more of everything else too. *There is nothing wrong with such aspirations, nor with the economic growth on which they depend, provided their consequences are understood.* The Science Council is concerned, however, with discerning feasible technological paths, and we recognize that it is essential to keep certain questions in mind: (1) Growth of what? (2) At what cost? (3) Within what constraints?

The worst and the most persistent inflation is likely to be the result of a general pressure for demands that cannot be met. The reasons why they cannot be met may not be obvious to see, and that will be a reason why the pressures continue blindly to push. We have raised in previous sections of this Report the problems of rising costs from energy and resource depletion, and from environmental deterioration, and how these costs come back on our decisions in indirect ways. The aggregate of our small apparently inconsequential energy decisions, for example, affects our international balance of payments, with repercussions on industrial stability and on employment. A simple example of indirect costs is the purchase of an electric heater. One private expenditure of $20 for a one kilowatt heater will require the utility to make a capital investment of 10 to 100 times that amount to ensure electrical supply.[21] That cost will return indirectly in everyone's utility bills and taxes and it will not be obvious that the increases had anything to do with the original purchase. The private purchase of a soft drink in an apparently cheaper non-returnable bottle may impose a cost on society of about 30 cents for cleaning up the litter. These costs seem to have been multiplying all around us. They help to explain how it is that *something* economic seems to be growing, and yet the quality of our lives and what we are *really* able to purchase may not seem to be going anywhere.[22]

One element in the inflationary pressure is the inelasticity of many services to productivity change. Advances in the mechanization and automation of material production have led people to expect declining prices relative to income for other goods and services. But many services are not as susceptible to technological advance as material production. The relative costs of medical services and education will probably continue to rise – inasmuch as the physician will have to spend time talking with the patient, and the teacher with the pupil. Thus there is often an illusory element in people's expectations of what the industrial system can produce. Our expectations of buying three automobiles with our rising income must be tempered by the recognition that other costs may be rising more steeply, including costs of things or services we value more.

Classical economic market theory has held that total aggregate demand is the simple sum of independent choices by consumers. Assuming that prices reflect all costs, and that no monopolies are present to distort the play of the market, then aggregate demand should reflect individual consumer preferences and cannot be questioned, since to do so would imply making a judgement on the values held by individual consumers.

It is observably clear, however, that structural elements, such as the nature of the technological infrastructure (a railroad, for example), may also play a role in determining demand. Consumers only demand the quantity of gasoline they need to run their automobile engines which, it is now recognized, are unnecessarily large. A critical analysis of the demand for gasoline forces the analyst to examine the technology that dictates such a high demand. Managing demand in this complex area has, in the first instance, led to lowering speed limits on Canadian highways and, as following steps, imposing mileage performance standards on manufacturers and taxes on cars according to their weight. A second level of analysis would suggest ways in which transportation needs could be met by other systems having a lower demand for fossil fuels – electrified rail, for instance, or substitution of telecommunications for the physical movement of people or things.

Similarly, the design of our homes and places of work define to a very great extent the amount of energy and materials used. The careful conserver has to travel some distance to find a store where food products are sold in bulk or where containers can be refilled to be used again. In general, people have little choice but to buy over-packaged products in energy-inefficient supermarkets which are simultaneously cooled by open freezer bins and heated with large systems. Our homes and office spaces are designed and in place; we have little choice if we wish to conserve but to lower the thermostat in the winter, or raise it in the summer. Thus to more fully understand aggregate demand and how it can be reduced to conserve scarce resources and costly energy, one must more closely analyse many of the structural components which dictate, by their very design, high resource use.

The automobile is illustrative. While we all desire the privacy, mobility and convenience offered by the automobile, we pay a price in its pervasive effects on our cities and its heavy consumption of resources. Its use is still increasing. In 1966, just over 14 per cent of households in Canada (722 000) had two automobiles. By 1974 two-car families had increased by 63 per cent while the numbers of households increased by only 26.7 per cent. In Canada in 1971 there were 3752 new-car dealers, with almost 72 000 employees. The largest single number of establishments in the retail and service trades was automobile service stations (almost 20 000 in 1971). They outnumbered restaurants (16 153). Over 150 000 workers were employed in 1975 in the direct manufacturing of automobiles, components, and replacements parts. Thus a drop in sales of new cars puts many people out of work and is both an indicator and a significant determinant of the business cycle.

Automobiles account for over half of all fuel used in transportation in Canada. Thus the ways automobiles are used and designed are major factors in any program of energy conservation. In 1974, the nation's auto fleet of 8.5 million cars consumed 5.7 billion gallons of gasoline, carrying Canadians 169 billion passenger miles. In fact, over 85 per cent of all passenger miles in Canada are travelled by the private automobile. All Canadian air carriers account for only 9 per cent. Yet, of all modes of transportation in Canada, at least in urban areas, the private automobile is least energy efficient. It achieves on the average about 18.6 passenger miles per gallon, in contrast to urban buses at 102 and commuter trains at 123 passenger miles per gallon. In intercity travel, the automobile is more energy efficient since the average load factor is higher – about 45 passenger miles per gallon. In all, the automobile is a major consumer of resources both in construction and in use; it has helped to create an entire way of life which, to the extent that it is based on rapidly depleting fossil fuels, is unsustainable.

The automobile is also the prototype for the mass consumption society. The rise to dominance of the major automobile companies was paralleled by the growth and development of large consumer appliance corporations. Their advertising and marketing approaches became increasingly alike. The aim was to mass produce a full line of items which could be continually upgraded in quality and price. The story is well known of how General Motors took a leaf from the fashion industry and introduced the annual model change, changing the course of the auto industry. The auto manufacturer would "give the public what it wants" but in doing so would be sure to offer a product that made the consumer feel that last year's model was old hat. This was the era when the term "planned obsolescence" entered our vocabulary. The appliance manufacturers followed suit and every year's refrigerators, stoves, radios, and vacuum cleaners were expected to be new, different, and better. In its original conception the automobile was a triumph of the production engineers and of the economies of scale based on the production line. During this later phase, however, which perhaps reached its peak during the 1950s with the tailfins, and the Edsel, the engineer lost place to the stylist and the marketing manager who together would judge which "new" model would be most likely to catch the public's fancy. In automobiles as with many other industries the imperative of fashion, once restricted to a relatively small part of our lives, had come to predominate, aided by the new professionalism of advertising and the developing communications media. Fortunately the silly period seems to have passed its peak and industries and consumers both have entered a more mature phase. Consumers are aided in more objective assessments by research organizations, "consumer advocates", and by legislation; manufacturers are showing themselves increasingly aware of their responsibilities for developing safer and more economical vehicles. Dealers appreciate the extra costs involved in maintaining an inventory of four different models of refrigerators in five different colours.

The excesses of sales promotion and advertising in encouraging high consumption, and in promoting products as "new" when all that was changed was the package, are well known. Yet, the decades of the "consumer" society were also decades of rapid change and innovation. It is advertising that has kept the consumer aware of new products and has prepared him or her to buy the latest and thus support new development. Even now, solar collectors are being purchased in the United States in far greater quantities than could be justified by a strict economic-returns analysis. We can be sure that, as awareness of energy costs grows, advertising will take up energy operating costs, and total life-cycle costs, as competitive selling points.

It is clear that heavy advertising, and rapid obsolescence, have their costs. How do we decide what they are worth? Is there a way to regulate advertising and product diversification in such a way as to continue to encourage genuine novelty and innovation, while discouraging the escalation of advertising in satiated markets where products have stabilized (household detergents are a familiar example)? One category of business firm could, for instance, be allowed to continue deduction of development and advertising costs against taxes, while another would be denied that privilege. How would this be adjudicated? Advertising might be taxed on a sliding scale related to market share, so that small innovative businesses would be given some advantage in breaking into a market dominated by large corporations. These suggestions and others deserve study, always bearing in mind the trade-offs between the waste implicit in obsolescence and the value of innovation, and between the costs of excess promotion of "throwaway" goods and the costs of regulation.

Would advertising be different in a conserver society? In a thoroughgoing conserver society one would envisage a different set of images of what would constitute the "good life". The shift in values would be reflected in a different sort of advertising. More emphasis would be placed on information and less on persuasion. Greater attention would be given to life-cycle costing and less to initial purchase price. Product durability would be emphasized rather than fashion and trendiness. Throwaway products would be in disrepute, if they had not been priced off the market by energy taxes and disposal taxes. Would innovation continue, and would it be advertised? Yes, but with a different focus. Human ingenuity and development would be directed to different problems than accelerating material consumption for its own sake. As suggested in the section on business opportunities, the scope for invention and enterprise in wresting a growing quality of life out of and in harmony with a limited environment would not diminish, though its challenge might be greater.

While the mark of progress for the individual has been ever increasing possession and consumption of goods, the social infrastructure has also been expanding. Public or quasi-public consumption has been increasing at a rapid rate. Using tax dollars, governments at all levels have provided Canadians with a social infrastructure which may be too large, too costly and improperly suited to meeting the real needs of all citizens.

Normally we depend on various checks and balances, including elections and markets, to keep systems related to the needs of citizens. However, as technological systems get larger and more complex, they require more planning. This planning, whether by institutions, governments, or industrial corporations, may at times become insulated from feedback. A massive new airport may be planned, based on extrapolated assumptions of demand, without thorough exploration of social alternatives.

Rather than always designing for peak demand, on an ethic of *your wish is my command,* utilities and governments might assume that the citizenry will often be prepared to accommodate somewhat, since it is they who pay the bills. Designers in a conserver society would pay more attention to the savings possible through peak levelling: traffic rush-hours can be spread out by *flexi-time* and staggering of working hours; electricity can be supplied at lower rates at off-peak hours; temperatures in air conditioned public buildings can be allowed to fluctuate over a wider range. The approaches are applied today in off-peak pricing for long-distance telephone calls, railroad and airline fares, and matinee theatre performances; supermarkets even out their loading by allowing discouragingly long queues at some times. The costs of instant service are sometimes high; it will be found that the average citizen is often willing and able to make some adjustments and trade-offs in the use of his or her time, once the costs of the alternative are understood.

The bureaucratic isolation or impersonality of large systems can in itself be a cause of excessive demand. The user is apt to get the impression that services or goods provided by the system are in some sense free, or paid for by someone else. Irresponsible attitudes develop, leading to unnecessary consumption, waste, and cheating of the system.[23] This is something that systems designers will have to be careful of as they seek to increase the productivity of services through automation and computerization. It is one reason why we have emphasized diversity and decentralization as important principles in a conserver society.

Finally, there may be considerable excess capacity and waste that arises because some organizations in our society have the power to pass on their costs to others. Government departments may indulge themselves in lavish office space or padded personnel establishments. Universities, schools, and hospitals may – perhaps more in the past than now – splurge on expensive equipment. Large business corporations with power over a large segment of the market may feel secure in their ability to pass on large advertising costs to consumers in the price of their products. Some of the most luxuriously appointed hotels and restaurants in our large cities were built to serve the expense-account and convention trade. Labour unions bargain for and often get their wage demands, because the industries that employ them will simply pass the costs along to the consumer, knowing that their competitors deal with the same union and will have to follow suit. The election campaigns of the various political parties hold out the promise of a better life for all. The government that finally gets elected then has to satisfy the raised expectations and, in so doing, often runs a deficit. Prices and taxes continually rise to pay for this ever-growing "sheltered economy". Thus we may have, to dimensions we are not fully aware of, what might be termed a "cost-plus" economy.

One outcome of a cost-plus economy, when expectations outrun new productive capacity (which is most of the time), is inflation; it is a system that may not be subject to normal market feedback signals. Thus the consumer buying a box of breakfast food in the supermarket helps to pay for new air-conditioned shopping malls, sales meetings, conventions, jet travel, luxury hotels, television programs, and the development of another new breakfast cereal in a different package. How much of it would the consumer support if he or she had a choice? We raise difficult questions here, and we have no ready answers. We can only propose that we need better economic studies and analyses that will lead to better understanding of how our present system works. We then may come to understand better some of the reasons why our society has such a high throughput of resources and why energy demands of all kinds have been rising at such an alarming rate. We may also come to understand more about inflationary processes and why these forces at the present time seem so resistant to conventional solutions. We then may be able to see how to modify the system at various points without destroying its dynamism.

In implementing solutions, governments, as major consumers, can set the example and lead the way in the transition to a conserver society. They can examine their own demands, cutting down expenditures that are unnecessary, wasteful, or that are merely expressions of bureaucratic ambition. Governments can take the lead in applying conserver criteria to their purchases, insisting, for example, that buildings be designed to conserve energy and that equipment have low environmental impact and low operating and maintenance costs, as well as low purchase price.

As producers, governments must restrain their own tendencies to grow; they should refrain from promoting the use of their own services. We would expect electric utilities to respond to consumer demand, but not to artificially stimulate it. Here, just as in the advertising of commercial messages, one must draw a fine line between the role of advertising to inform the consumer that a product or service is available and the persuading of the consumer that he or she has a desperately unfulfilled need.

The expression of governments' responsibility is, in large part, in the legislation which parliaments pass, in the types and rate of taxation imposed, and in the policies of the regulatory agencies. Existing laws, taxes, tariffs, and regulations need to be carefully reviewed, to ensure that they neither create incentives to waste nor act as impediments to conservation. For example, industrial representatives often complain that they are forced into wasteful and more resource-using forms of behaviour by the structure of tariffs, freight rates or some other regulatory dictate.

Since all citizens of Canada, as consumers of products or as taxpayers, ultimately pay for the activities that are carried out in their name by corporations and governments, their views should be brought into the decision-making process. New energy projects, airports, complex road systems and products of all types should not be planned and developed without consulting those who must ultimately pay and/or whose lives will be affected. By consulting citizens on a wider variety of issues we can collectively determine whether a new project or product is needed, whether an alternative can be devised, and what would be the costs (or benefits) of doing without.

A more-is-better philosophy has too often seduced us into thinking that more is necessary. More is almost always costly – economically and socially. With energy constraints, capital shortages, inflationary pressures and environmental limits coming to predominate, we are forced to consider less costly and, in many cases, different ways of satisfying the demands and needs of Canadians.

V. Recommendations

A conserver society is not something that can be legislated into existence. The many aspects that we have reviewed in this Report will require actions at many levels. Legislation can only confirm and formalize ethical rules and principles that are generally believed in. Individual citizens, educators, business people, engineers, if they agree with the principles set out here, will change their perceptions of our society and its problems, and will do things differently. There are many things governments can do to facilitate changing perceptions, but widespread sharing of perceptions and attitudes is fundamental. This gives great importance to the informational, educational, and communication processes of society.

The Science Council's recommendations, which follow, illustrate the kinds of things that need to be done and thought about. Some are obvious and can be done immediately. Others bear thinking about, since Canadians, may not yet be sufficiently agreed that they should be put in place – though, of course, this need not prevent various institutions, communities, regions, or individuals from being motivated to act independently. So much has been changing so fast in the public acceptance of these ideas that many already may have been implemented by the time this Report appears. If so, that is all to the good.

Throughout these recommendations we recognize as an underlying assumption that the ecological systems of the biosphere are resources to be conserved. Without due care, the long-term health of the biosphere could be irreversibly damaged. We must care for natural elements even though they may have no immediately apparent ecological role. We need an attitude of stewardship, that will act as a restraining influence on human activities, and will stem not simply from fell needs but from recognition that human beings are dependent on the well-being of the things and creatures around them. This kind of conservation may require some radical innovations in technology. For instance, population growth is recognized as a world problem, but some of the world's difficulties arise from an even more rapid growth in some kinds of technological systems, with consequent growing consumption of energy and raw materials, environmental damage, and production of wastes. We have to guard the natural environment against threats from ourselves. We have to be aware that cause and ultimate effect may be separated by decades, and we have to learn to recognize as early as possible signs of damage. Our concept of nature must change from seeing it as a shopping basket of unrelated goods that we can consume at will, to a set of living ecosystems from which we may take only that part that does not threaten the continued viability of the whole.

Thus, although no specific recommendations on this ecological theme may appear explicitly, these considerations will be implicit throughout.

Things to do Immediately

Transportation

(1) Improve fuel economy of automobiles

The federal government has announced new standards for automobiles (sales-weighted fleet averages) of 24 miles per gallon for 1980 and 33 miles per gallon for 1985. Some method to improve acceptance and to enforce these standards is needed. Development of an inexpensive miles-per-gallon meter would help user awareness. Governments should follow through on the proposed weight tax on private automobiles. Lower speed limits should be enforced. Government agencies as purchasers and operators can set the example.

(2) Promote automobile and van pooling
The utilization of the automobile in urban travel can easily be increased from its present average of about 1.4 passengers, thereby reducing traffic congestion and fuel consumption. Many companies in the U.S. and Canada have set up incentive schemes to promote the use of vans that carry 7 to 10 employees to and from work. In some places, too, cars carrying 3 passengers or more can travel in express lanes or can cross toll bridges at reduced rates. In addition, car and van pools should be given the same kind of management, organization and support we extend to other public transportation modes. We have to treat car and van pools as a transportation system.

Impediments, such as insurance restrictions, exclusive privileges granted to bus monopolies and income tax penalties, need to be removed. Individuals, companies, municipalities, and higher levels of government can all act to facilitate and encourage improved automobile and van usage. Schemes that have proven successful should be publicized.

(3) Upgrade public transit in urban areas
This is essential because urban traffic is the least fuel-efficient use of the private automobile, and the need for downtown parking areas, street widening, and traffic control increase indirect costs.[1]

(4) Upgrade and electrify railways in high-density areas
Inter-city buses average over 110 passenger miles per gallon (pmpg) and commuter trains can achieve better than 120 pmpg. However, present inter-city trains average only 25 pmpg, because of low utilization. In view of the fact that air travel, is one-third to one-quarter as energy efficient as rail travel, railways in the high density Windsor-Hamilton-Toronto-Ottawa-Montreal-Quebec City corridor should be upgraded. Electrification, too, has potential. Where the capital costs can be justified and when electricity comes from hydro or nuclear plants, electrified trains are more energy efficient than their diesel counterparts. Electrification would save liquid fuel and could lead to better utilization and lower maintenance costs.

(5) Improve utilization of existing systems
Rather than always building to meet peak demands, urban transit companies, airlines and airports, highway traffic planners, municipalities, and employers should pay more attention to smoothing out peaks and increasing average loading, by incentives, ticket-pricing, taxes, and scheduling, including flexible working hours.

(6) Substitute electronic communications for travel
To expedite progress in this direction requires that users rapidly become familiar with the techniques, and that the telecommunication utilities provide facilities that are of high quality and convenience, shaped to the human interactive process.

(7) Prepare to introduce restrictions on gasoline use
As fuel shortages develop and prices rise, social inequities will be aggravated. Gasoline rationing or a two-price quota system will likely be necessary soon to ensure fair distribution and encourage conservation. Preparations should be made.

Shelter and Community

(1) Provide incentives to improve home insulation
A study commissioned by Central Mortgage and Housing Corporation has shown that an average 37 per cent saving in fuel for space heating can be achieved in existing residences by insulating them to levels that will pay back the investment on insulation in 5 years. If 70 per cent of the existing housing stock were to be retrofitted in this way over the next 12 years, the saving by the end of that time would be the energy equivalent almost 40 million barrels of oil per year. (Present annual consumption for home heating is about 150 million barrels per year.) The financial incentive in many cases should already be sufficient to justify the individual owner's investment, but action may still be inhibited by lack of awareness, unfavourable interest rates, expected mobility, property and income tax structures, and so on. Impediments should be removed; and loans, grants, interest rates and/or tax incentives should be provided to accelerate the process. Outright grants, as were used recently in Prince Edward Island and Nova Scotia may actually be less expensive for governments than loans, because of lower administration costs.

(2) Adopt new building codes in all provinces
The new National Building Code, incorporating new energy standards for buildings, is only a guideline. The provinces, which have the jurisdiction, should adopt and enforce the new energy standards without delay.

(3) Improve energy efficiency of all buildings
Cost-effective methods for reducing energy consumption in buildings range from adoption of energy-conserving standards during construction, to commonsense housekeeping measures such as adjusting furnace efficiencies, reducing thermostat settings to 20°C during the day and 18°C at night, and more efficient use of air conditioning and lighting systems. A conservation program involving such measures would make possible zero total energy growth in commercial and residential buildings, at current rates of construction.[2] The program would be aided significantly if governments, institutions, and industries made energy-efficient performance a condition of purchase or tenancy.

(4) Legislate sun-rights

The harnessing of solar energy, if it is to be seriously encouraged, requires that people's investments be protected by law. The high-rise building going up next door or in the next block may deprive a number of people of their heating systems. Questions of law must be addressed to determine whether and under what conditions solar rights can be defined and protected, and what redress can be sought for infringement. Some legal precedents exist in property rights, riparian rights, zoning regulations, but detailed studies in law schools and faculties of architecture and urban planning must proceed immediately with a sense of urgency. Legislation must follow.

(5) Give priority to energy-efficient multiple-unit housing

Some urban geometrical situations will still justify highrise apartment buildings but, in general, *once solar rights are recognized,* there is no advantage to the high-rise in achieving greater urban density or better land-use. The optimum may well be found to be four stories, and building to this scale will have the advantages of reducing the need for structural steel, elevators, and other energy-intensive practices, besides providing other advantages of lower scale, such as fire safety, and parents being able to keep an eye on their children at play. Where possible such units should be designed for individual metering of electricity, water, and heat, so that tenants will reap more directly the benefits of their own conservation efforts.

(6) Plan district heating

Developers, engineers, and town planners must join together to plan district heating for new communities. District heating is most applicable in densely settled areas and is especially efficient when it makes use of low temperature or waste heat from electric power production and from industrial processes. Hot water can be piped thirty miles or more without significant heat losses. Systems can be introduced by the Swedish step-by-step method, as long as the houses are designed for hot water interconnection in the first place. They then remain flexible to use whatever heat source becomes available, including combinations of industrial waste heat, gas, oil, coal, nuclear, combustion of urban waste, local wood supplies, or solar.

(7) Revise electrical rate structures

Under present rate structures the price per kilowatt-hour goes down with quantity used, providing the user a diminishing incentive to conserve. Three ways to change this have been suggested: a flattened or inverted price per kilowatt-hour, off-peak pricing, and marginal-cost pricing. If users paid the same rate for electricity no matter how much they used, plus a servicing charge, say, then homeowners would have some greater incentive to save electricity. A larger incentive would be provided to the industrial and institutional users, who are by far the largest users, and who also possess the analytical and organizing ability to devise ways to conserve. Such a change might have to be introduced in stages, to provide time for adjustment, with due care for an industry's competitive position and for possible hardship to householders tied to electrical heating.

Off-peak and marginal-cost pricing are expressions of the fact that electrical supply involves high capital costs. Charging lower prices for electricity at other than peak times encourages greater use of existing capacity and reduces investment in excess capacity. Schemes for storage heaters, electric battery chargers, and water heaters, which are timed to operate during the night, are examples. A full marginal-cost-pricing scheme would charge the new subscriber a rate corresponding to the cost of expanding the system to meet his or her needs. Thus a new user would face the full implications of the costs of meeting future demands, e.g., the new hydro or nuclear development, rather than being led deceptively into a rising cost situation and, incidentally, raising the price for the existing users. Marginal-cost-pricing (including peak-pricing) has been used in Britain, Sweden, and France, and it is being considered by Ontario Hydro, though it is difficult to apply because of metering, bookkeeping and user identification problems. It is important that these three schemes be studied and changes made. Without attempting to suggest here what would be optimal, we can recommend that some revisions in the direction of flattening the rate structure should be made immediately.

(8) Provide incentives, not impediments, to homeowners
Local by-laws, and the raising of tax assessments can inhibit the homeowner from investing in energy-saving improvements such as insulation and solar heating. Ways should be devised to encourage rather than penalize people who make such investments. One suggestion would be to defer any rise in assessment until the building is sold to a new owner.

Renewable Energy Sources
(1) Create institutional foci
The success of the more conventional energy technologies can be attributed in part to well established public and private institutional structures for research and development. Except for hydroelectric power, no such structures exist for renewable energies. Until quite recently, most R & D activities on solar, wind, and biomass energy have been conducted by small and isolated groups of dedicated individuals. This diversity and enthusiasm must not be lost. However, new institutional arrangements are needed to assist and vitalize the many diverse experiments, trials, and budding enterprises in all the regions of Canada: these may take the form of Crown corporations, various forms of federal, provincial, or municipal government, and private business and university consortia.[3] Not all of the new technologies require the same approach. Solar and wind require physics, aerodynamic, and electrical and mechanical engineering; biomass a combination of chemical engineering, forestry and agriculture; geothermal would involve geology and drilling. Foci or agencies are needed for the following functions:

- to speak for and channel funding at adequate levels
- to gather and disseminate information aimed at tradespeople, contractors, and the general public

- to perform comparative evaluation and analysis to assist forecasting and policy formation
- to contract or otherwise organize pilot demonstration projects of meaningful scale
- to undertake joint ventures with private industry to share knowledge and risk
- to organize and undertake joint ventures with provincial and municipal governments and utilities
- to focus Canadian cooperation in joint international projects
- to negotiate for, licence, and modify foreign technologies for adaptation to Canadian conditions
- to ensure that technologies, patents, and innovations remain under Canadian control
- to define and maintain performance standards for various technologies to ensure consumer protection
- to conduct scientific research in support of various applied research and development projects.

Whatever agencies are established must be kept publicly accountable.

(2) Increase support for Research, Development, and Demonstration (RD&D)
A much increased federal budget allocation, building quickly to not less than $50 million per year, is needed to begin to create the appropriate technological base to make renewable sources genuine options. Full-scale demonstration projects serve not only to test and improve a new technology or to make it more cost-effective, they also play a major role in familiarizing building contractors, tradespersons, consumers, local politicians, and energy specialists with that technology. RD&D projects are needed in (a) liquid fuels (methanol and other alcohols from agricultural, forest, and other organic wastes), (b) solar energy (space and water heating, greenhouses, cereal and grain dryers, electric generation), (c) wind (replacing diesel fuel for electric generation in remote and northern communities and where wind régimes are favourable, as on the coasts and in parts of the Prairies).

(3) Show leadership through purchasing
Governments, utilities, industrial plants, and educational and other large institutions should lead the way in incorporating experimental and demonstration projects in their new buildings and, for example, in making solar heating and energy-efficiency conditions of tenancy in a building. The federal government could, through such agencies as the Department of Public Works and Central Mortgage and Housing Corporation, specify that by a certain year all new government buildings would have to be solar heated, or that they would have to incorporate other energy-conserving practices.

Materials Conservation
(1) Improve information base on material flows
As a first step in promoting the recycling industry in Canada there must

be a more comprehensive statistical base to provide data on the types, compositions, volumes, distribution and sources of wastes and scrap. Resource recovery may be regarded as a second-generation mining industry and this information as equivalent to the Geological Survey.

(2) Support municipal resource recovery pilot projects
With collection costs averaging $17 per ton and municipal solid waste in Canada averaging three-quarters of a ton per capita, local governments are experiencing an increasing financial burden. The prevailing method of disposal has been by landfill and landfill sites are becoming harder to find. Major cities have to transport garbage as far as forty miles. At present less than 1 per cent of municipal solid waste undergoes any kind of segregation aimed at recycling. It is time for practical demonstration projects to show what can be done, say for cities of 100 000 people, with an integrated system involving recycling, incineration (with heat recovery), pyrolysis, composting, hydrolysis, fermentation, etc. Disposal solely by landfill or incineration should be discouraged.

(3) Support research and development in resource recovery
This work should embrace not only technology but should include marketing and aspects of systems management. Governments, particularly, can broaden the necessary research effort in three ways:

- provide financial aid by grants, contracts, or tax reductions to firms, individuals, associations and governments who conduct the work
- carry out R & D that will be broadly supportive of the work of industries and utilities
- disseminate information published or acquired in other countries.

(4) Remove impediments and provide financial stimulants to encourage recycling
Some of the actions governments can take are:

- subsidies for collection and sorting of waste and scrap
- three-year tax holidays for newly established recycling ventures
- forgivable or special low-interest loans for R & D, for acquisition of recycling machinery and equipment, and for financing scrap materials inventories during periods of weak scrap markets
- freight subsidies for scrap shipments (as against subsidies for shipment of newly extracted resources)
- taxes on the use of virgin materials, particularly on scarce materials, possibly with remission of taxes when the materials are recycled
- sales taxes on new appliances or durable goods, that would be remitted if a used appliance was turned in at time of purchase (this would help to set up the recycling channels – to close the loops)
- elimination of sales taxes from all recycling equipment and supplies
- sponsorship of design competitions and awards for products that facilitate recyling
- graduated tax penalties for particularly wasteful products, or for products which entail irretrievable dissipation of scarce materials.

(5) Increase public information

Though the idea of recycling is generally accepted as desirable, even necessary, it is far from being practised to its potential. Trade associations, government agencies, professional groups, teachers, and citizens' groups must increase their efforts to raise awareness and change current practices. Among the points that need to be publicized are:

- Energy expended in collecting, transporting and reprocessing waste materials is usually far less than the energy required for the extraction, refining and transportation of virgin materials.
- As the extraction of minerals continues and lower grade ore is mined, the energy expenditure involved in extraction and refining is likely to increase.
- Recycling is essential if we wish to extend the life of our non-renewable resources and keep down their cost.
- Canada is a net importer of ferrous scrap. Increased recovery of iron and steel scrap in Canada will improve our balance of payments.
- Over one-half billion dollars is spent each year on solid waste collection and disposal. Landfill sites are becoming scarce. Recycling reduces the waste disposal problem.
- Recyling reduces the escalating environmental damage consequent on mining lower-grade minerals and fuels.
- Public awareness and participation are essential for effective waste reduction, management, and recovery.
- Sorting and disposing of refuse by the householder can be a key link in the chain of efficient recovery. Small grass-roots organizations that work closely with households in facilitating this stage of organization should be commended and supported.
- Designers, purchasing officers, specification writers, and code-writing authorities should become aware of the unnecessary barriers that many of them erect against more effective use of recycled materials.
- Municipal and privately-owned waste disposal operations should be urged to switch their emphasis from removal to utilization of the wastes they collect.
- The recycling industry needs to upgrade its own evaluation of its role and potential.

(6) Make products more durable

Recycling is inevitably imperfect. Resource recovery and reprocessing consume energy, labour, and plant facilities. The value initially incorporated in a product is largely lost when the product is scrapped. These features all provide arguments for making products more long-lived in the first place.[4]

Several approaches can be used:

- design initially for durability, e.g., use corrosion-resistant materials, use gears rather than rubber belts, seal sensitive parts, design mechanisms to be fool-proof and fail-safe
- use modular construction for easy repair, renewal, and updating, even of style features such as coloured panels
- reduce environmental causes of corrosion and breakdown. For example, the costs of shortened life of automobiles from corrosion, from

using salt on the roads in winter in some Canadian cities, are in total very large and would justify considerable effort and expense by municipalities to find and use less corroding methods.

These approaches would improve the prospects for a market and an industry in reconditioned or re-manufactured goods. They can be encouraged by the promulgation of life-cycle cost information by consumers' associations, industry associations, and governments, and by the setting of durability and efficiency standards, possibly with the award of a special certificate or label. Governments at all levels spent about $28 billion in Canada in 1973-74. They can use their purchasing power to specify durable products, purchase them, test their performance, and publish the results.

Industry and Employment

(1) Encourage and assist improvement in industrial processes

Large gains in energy and materials conservation can be made by modifying industrial processes; these savings will often be advantageous to the industry. Modifications can be encouraged by advisory teams making energy audits, and through industry seminars, such as those being carried on at the present time by the federal Office of Energy Conservation. Assistance can be rendered by capital grants and accelerated tax write-offs for new equipment. Besides many kinds of housekeeping and process management improvements to save energy, heat recuperators can be installed to recycle or use elsewhere heat from high temperature processes, electricity can be co-generated with process steam, and industries can cooperate in industrial parks; waste heat from one plant might be input for another, or be used for district heating of buildings and houses.[5]

(2) Encourage and protect new industries based on conserver technologies

In renewable energy supply, energy-efficient technologies (heat pumps, co-generation, insulation, storage, heat recuperation) and resource recovery, whole new industries will be established in Canada. Whether these will be owned and controlled locally and by Canadians, or whether they will be operated as branch plants of multinational corporations depends on decisions taken now.

Several specific measures are needed:

- Incentives and subsidies should favour Canadian firms that show potential in the new technologies.
- The Foreign Investment Review Agency should be given specific direction to block takeovers of these firms once they are established. (Traditionally, Canadian taxpayers have helped support the development of new enterprises only to have them bought out by foreign firms once their promise and potential have become established.)
- Governments must seek to ensure the maximum degree of technological sovereignty in these new industrial areas; control of technology either by indigenous development or selective licensing is essential.
- Broad support is recommended for the short term, but this should give way to a more selective strategy of supporting key firms over

the medium and longer term. This may mean rationalization and mergers under government auspices and with encouragement of the various government regulatory agencies. (International competitive pressures will be very strong in these new areas. While a diversity of technological solutions must be encouraged, we must be wary of supporting too many firms in any one industry. This has been the "fair-play" approach taken in the past, but, in a world of fast moving technology and giant multinational firms, Canadian firms have been the losers.)

(3) Train people in new skills

Most of our engineering schools and community colleges have been alert to new developments and have introduced relevant course material and student projects. They should be encouraged through federal, provincial, and industrial grants on a sufficient scale to realize the potential of the interest, enthusiasm, and creativity these projects obviously excite. (For example, the University of Toronto low-pollution automobile, "Miss Purity", was co-winner of a cross-continental car derby in 1970 organized by the Massachusetts Institute of Technology.) A selected number of community colleges in different regions of Canada might be assisted in setting up "Arks" similar to the one in P.E.I. as combined research and teaching laboratories for the development of ecological technologies (energy and production) adapted to the features of the region. In the construction and installation trades a variety of technical workshops should be organized to acquaint building contractors and tradespeople with new methods of construction and insulation, the use of heat pumps, design and installation of solar heating, and district heating. This requires concurrently a broad educational program on the scale of the government program on metrication. The construction and installation trades are often dominated by small firms which do little research of their own and tend to be slow to adopt technological change. Thus an extensive as well as an intensive program is needed. A precedent exists in the agricultural extension services. Governments, as major consumers, can help by demonstrating new ways of designing buildings and specifying construction.

(4) Assist homeowners by lease financing

The disparity between the capital-raising abilities of the supplier (the gas, oil, or electric utility) and the user (the homeowner) can be reduced, to mutual advantage, if the utility will install the needed energy-saving equipment and lease it to the homeowner so that the capital investment is paid for over time in regular bills. Some gas and electric utilities do this now for water heaters (though this was initially an arrangement designed to increase demand). Under present circumstances of uncertainty in fuel supplies and risk in planning very large capital-intensive expansions, the action of assisting the homeowner to insulate his or her house or to install solar panels can be for the utility a lower risk, less expensive, and more profitable way of meeting additional demand than borrowing to invest in new capacity. Since most solar-heated homes would have gas, oil, or electrical back-up, the utilities should be able to devise rental plans or ways of paying off the cost through the homeowner's regular monthly bills. In the latter case, the owner would accumulate equity that could be passed on to the next owner.

(5) Assist transition to new employment patterns

Many people remain unemployed despite repeated efforts by government to create jobs. Many of these individuals have received post-secondary education, some in technical schools. Such employment programs as Local Initiatives and Canada Works should be used to put the creative energies of Canadians to work on conserver problems and opportunities. Besides helping to solve the present unemployment problem, this approach will assist and guide the transition of the work-force into occupations that will continue in the longer term. It is our impression that many individuals would like to work in "conserver" related areas, but the traditional market mechanisms have not been creating the jobs. To begin with, the ventures in this "conserver direct employment" program would be extra-market, but, as individual initiatives became viable in a business sense or began to compete with existing business firms, the direct support could be phased out. This plan would have the following additional advantages:

- Many of the people employed would otherwise be unemployed; they would be drawing unemployment insurance or would have no other source of income and would be a drain on community resources.
- Job creation by what has come to be the traditional capital-intensive approach is becoming increasingly expensive and difficult. It involves expensive public and private infrastructure, such as mass transit, highways, and office buildings.
- "Conserver" types of employment, if along the lines of diversity, and community-scale, should help to keep people in their communities and regions.
- Projections indicate that, with capital-intensive production, the need for labour will still increase, but at a decreasing rate. Econometric models show employment tending to grow at a higher rate on low-energy-growth scenarios than on high-energy-growth scenarios.[6]

Thus for one reason or the other, a conserver direct employment assistance scheme could become a cornerstone of future employment policy.

Citizen and Community

Individuals and communities need not wait for governments and other large organizations to act. Much of this Report has emphasized diversity and types of technology that can be organized and used on an individual and community scale. In many cases, their implementation waits only for local initiative. Conferences, meetings and school projects can raise awareness, change attitudes and exchange information. Local food production, cooperative transportation, health care and preventive medicine, recycling, composting of vegetable refuse, insulating houses, checking furnace efficiencies – all can be organized by local groups or community associations. Considerable improvements in the quality of life can be achieved by such organization and exchange of services, with or without the exchange of money. Local groups and associations also can be the beginnings of political action, bringing pressure to bear on their Members of Parliament, local politicians, and local institutions and businesses. These activities are extremely important, and central to the conserver concepts as developed in this Report; but it is almost a contradiction for the Science Council to make specific recommendations in this area. Individual creativity is what we wish to encourage, and individual creativity is best left with an open field.

Things to Think About

Transportation

(1) Study comprehensively Canada's transportation systems

Air travel and automobiles dominate the Canadian transportation system. Greater emphasis must be given to making these modes more efficient (increasing load factors) and to developing less energy-intensive ways of moving people and commodities in Canada. While historically much of our transportation network developed around conduits for shipping staples abroad, we should now be shifting emphasis to serving the internal transportation needs of Canada as a sovereign nation with its own social needs.

To build the basis for a sustainable future we must keep aware of total costs, including the costs of future fuel supply. With respect to petroleum pricing, it will help if we do not subsidize one transportation mode to the disadvantage of another, nor subsidize one energy system to the disadvantage of another. The relationship between transportation and energy costs is fundamental, and transportation planning must be done keeping in mind the implications of a long-term rise in petroleum prices.

It is urgent that we take a new comprehensive look at transportation, with intermodal system comparisons, and considering the overall resource efficiency of the country, so that we can assess and plan for energy-efficient alternatives.

(2) Review the need for additional airports

The costs of a new airport should be compared with the benefits of upgrading railway service and encouraging off-peak air traffic. For example, an alternative to a second airport near Toronto might be to upgrade the Quebec City-Windsor rail corridor to make it competitive with air travel. These alternatives should be studied as aspects of the transportation study recommended above.

(3) Develop low-energy urban transport

Energy-efficient urban transportation by private and public vehicles is being developed and tried in many places. The relevant agencies in Canada are urged to keep abreast of these developments and to support research, development, and demonstration projects to assess their applicability. Such projects might include electric automobiles, or trolley-buses with flywheel energy storage.

Shelter and Community

(1) Design total-energy communities

As alternatives to present and recent trends to highly-centralized large-scale production with high transportation requirements, various concepts of total-energy communities merit study. These range from the simple concept of a housing development organized around a "mini-utility" for solar energy, district heating, electricity, and recycling of waste, to the concept of a "micropolis", described by Prof. Theodore B. Taylor of Princeton University. The latter would be a community of about 3000 individuals, on an area of about one square mile, be entirely solar powered, and be technologically organized so that almost all of the community's needs for food, water, and energy could be met from within its boundaries, without significant environmental pollution. First rough calculations for middle latitudes in the US suggest that such a community could be feasible and attractive to live in. In parts of Canada a somewhat larger area might be needed. Utopian as it sounds, sufficient analysis has been done to suggest that more detailed design studies and demonstrations would be worthwhile.

(2) Design energy-efficient northern communities

A variation of the above, particularly pertinent to Canada, is the design of northern isolated communities as nearly as possible self-sufficient for basic needs of energy and food.[7]

(3) Study "retro-fit" of suburbs

Canadian suburban developments have grown as expressions of a high-energy-consumption lifestyle, with very high dependence on the private automobile. Should fuel crises become desperate, or prices rise exorbitantly, it may be useful to consider ways of modifying the typical suburban development to reduce its dependence on the automobile (build a communications centre where people can communicate with their offices, say, or build local electronic merchandise ordering services); or we could revise codes to allow construction of local greenhouses, energy utilities, etc. Since predicted energy shortages and balance-of-payment problems are not far off, it is not too soon to commission architectural and planning studies of these potential responses to emergency.

(4) Study energy-efficient and materials-efficient urban design

A great advantage of urban concentration in northern climates should be its potential for energy and material conservation. The possibilities of heat sharing, storing, and recycling, and the efficiencies of communication and transportation (were it not for the dominant patterns of daily commuting to suburbs) that could inhere in high density urban areas have not been systematically studied. Design studies and modelling would suggest what to aim for in guiding urban growth over the longer term.

(5) Study the costs and benefits of urbanization

A number of studies question the desirability of urban growth beyond a certain size, which tends to fall in the range of 100 000 to 500 000 population. In cities larger than 500 000, the social costs per capita, e.g., of crime, police protection, education, family breakdown, and health, appear to rise. Studies are needed to establish the extent to which these social costs are due to sheer size, density, or administrative factors, and how much to design, layout, technology, and so on. The conserver project studies, and much of the related literature, have raised many questions about urban growth, its economic "imperatives" and its social costs. It is important to address these questions and attempt to understand better, for example, whether there could be a "conserver" *city*, as against, or as well as, the small-scale alternatives.

Renewable Energy Sources

(1) Analyse total costs of energy alternatives

The first step in providing energy alternatives, such as solar, wind, biomass, etc. is to demonstrate technical feasibility and "first-order" economic costing. The second step, to be consistent with conserver principles, is to analyse as far as possible the *total* impacts, including social and environmental costs, of these systems, e.g., a total system for fertilizing, growing, harvesting, and recycling wastes from a forest-based system for liquid fuel production. The same should be done for hydro, nuclear and other options, so that rational long-term choices can be made.

(2) Study ecological sustainability of technologies

Research in greater depth is needed on the carrying capacity of the biosphere and the cumulative effects of various technologies, e.g., of agriculture, chemical manufacturing, energy production.

(3) Develop new engines

To use alternative fuels (such as methanol, ethyl alcohol, propane, hydrogen), different engines, such as the external combustion Stirling cycle (of which the steam engine is an example), may be preferable to the familiar internal-combustion gasoline and diesel engines. Engines are needed to extract motive power from lower temperature environmental (e.g., ocean thermal gradients) and industrial heat sources. Research and development of these aspects of efficient energy use should be supported so Canadian scientists and engineers can keep up to date and contribute to world-wide developments.

(4) Develop methods of energy storage

To make maximum use of intermittent sources of energy such as solar and wind, efficient methods of short and long-term energy storage are needed. These may include hot water, rocks, earth, batteries, fly wheels, chemical energy, and liquid and gaseous fuels. Research, development and demonstration for Canadian needs should be supported.

Materials

(1) Consider methods of slowing down depletion of scarce resources

Canadian minerals policy has been changing, mostly in the direction of extracting more benefit through royalties and taxes before the minerals are gone. We should seriously consider further changes, designed to slow down the rate of extraction of those resources judged scarce and/or of high value for future Canadian economic development. Such changes might include:

- extraction charges or taxes in place of depletion allowances, and removal of the subsidies that encourage rapid extraction and export
- adjustment of rates of return by the principle of a social discount rate, applied to various priority resources. The intent would be to make investment opportunities for certain resources a little less attractive, by lowering the rate of return, thus slowing the pace of development and exploitation to help ensure that future Canadians would have access to resources at reasonable costs.

(2) Educate in conserver approaches to design

Engineering schools, community colleges, and other educational institutions develop curricula and a design ethic to emphasize the following:

- design for durability, simple maintenance, and low life-cycle cost
- design for convenient recycling of materials. Components made of different materials should be distinguishable and separable for scrapping; alternatively, they should form a useable mixture or alloy when scrapped together. Surface coatings should be designed not to create problems in recycling. Design in a modular way, so that the failure of one module does not require scrapping the entire article

(3) Curb wasteful consumption

Public attitudes have been shifting markedly. They will shift more if, as we expect, shortages develop and prices rise. Specific actions that might be considered are:

- Government purchasing could take the lead in demanding standard, reliable, low energy products. For example, government fleet purchases of automobiles could be used to specify a standard automobile that is durable, operates at low cost, and is easy to repair. New priorities of utility and reparability would be reflected in different dimensions and appearance (*viz.* the army "jeep", the Volvo taxi). Educational institutions, as they have done in West Germany, could insist on rugged equipment, e.g., scientific instruments, for school laboratory use, with 10 to 15-year warranty. Other people would have the opportunity to purchase these more durable models which, since they would be known to have been tested and used by government, would need little, if any, further advertising. In some cases initial cost might be higher, in other cases lower (it has been estimated that annual model changes, advertising and promotion add up to a cost in excess of $1000 per automobile). While general consumer demand for such products might be low initially, they could become an "in" style (like the early Volkswagen) and could help to change consumer attitudes.
- Encourage rental and sharing of capital equipment; total inventory and excess capacity can be reduced if homeowners share equipment such as lawnmowers and roto-tillers (this might be assisted by the

development of the block or local "mini-utility" concept), or if urban citizens rent small interchangeable vehicles (as in the Dutch Witkar experiment).[8]

Other Questions

(1) Study the role of advertising and other forms of promotion in encouraging wasteful practices

The following questions naturally arise in any discussion of the "consumer society" and need study:

- What is the role of advertising in a saturated market, where total demand is virtually constant, innovation has almost ceased, and the market is dominated by a few large firms? (Examples might be soaps, detergents, cigarettes, beer, and personal hygiene.) It is characteristic that large advertising campaigns are conducted simply to maintain market share; if a suitable mechanism were devised, might all participants welcome a détente?
- Do marketing and advertising power in saturated markets tend to block or make difficult the entry of new firms with innovative products? Would differential tax schemes help to overcome this problem? For example, tax deduction for promotional expenses might be denied to the top 4 or 5 firms, but not to firms with smaller market shares.
- What is the factual or information content of advertising? Is it practical to require that some fixed proportion of media time or space be devoted to technical information about the commodity? (This is done as a matter of course in professional journals where buyers are skilled and demand more information, e.g., pharmaceutical advertising in medical journals, or machinery in construction magazines.)
- What is the proper role of communications media? For many magazines, newspapers, and radio and TV stations, the editorial or program content seems to have become only a vehicle for carrying advertising, which is the real *business.* Is this the proper use for powerful communications media – the "nervous system" of society? If not, how can the emphasis be reversed? How many of the products advertised on TV need to be advertised (soaps, headache tablets, soft drinks)?

(2) Study feasibility of total-costing of products

To suggest additional taxes is never popular and can be counterproductive, if, for example, administrative and other costs outweigh what is gained. Nevertheless, the importance of having market prices reflect more of the total social costs consequent on manufacturing and using a product suggests that the following types of tax merit study:

- a disposal tax on some forms of packaging and on some "throwaway" products
- a health-care tax on cigarettes, alcohol, caffeine, etc.
- an energy tax on gasoline, fuel oil, large automobile engines, plastics, electric appliances
- an environment tax on paper, coal, fertilizers, aerosols, insecticides, gasoline, etc.
- a resource extraction or severance tax on virgin non-renewable materials.

(3) Improve understanding of the extent of and manner of working of the "cost-plus" component of the economy
It appears that the cost-plus economy may be a runaway system with few checks. If this is true, the system contributes to the faster pace of life, to the growth and distortion of urban centres, and to speeding up the throughput of resources and the consumption of energy. To the extent that power nodes can plan and expand with impunity, without being subject to the checks and balances of market place and democratic process, they must contribute significantly to inflationary pressures. Understanding and moderating the operation of a "cost-plus" economy is essential for an orderly transition to a conserver society. Studies should be based on a realistic industrial organization model of the economy rather than on an abstract econometric model in order to yield sensible policy options.

(4) Conduct studies to clarify when, and under what circumstances, increased scale ceases to bring advantage
When do the social costs of larger scale outweigh the benefits that gains in productivity and economies of scale bring to specific producers and consumers? When does larger corporate size come about for reasons of economies of scale, and when for reasons of market power? Is it possible to produce in smaller units and still be world competitive? Do micro-computers and efficient information networks help to make this possible? Under what principles can large systems, such as a telephone system, an egg-marketing system, or a national government, be designed so that local participation and responsiveness are preserved? Can *optimal* scales be identified for different types of activity?

VI. Epilogue

Over the past few years the phrase "Conserver Society" has come to be an accepted, albeit short-hand, way of denoting a rather complex set of considerations and options. To some degree the popularity of the phrase is a result of the growing acceptance of the reality of "limits" – from the limited carrying capacity of the biosphere and the finiteness of certain resources to limits set by competing claims on capital expenditures.

The transition to a Conserver Society is part process and part analysis; we are heartened by the speed at which changes in attitudes on the part of individuals and institutions are occurring and, similarly, by the large number of research projects which are aimed at providing solutions to some of the very difficult problems posed in this Report.

The response to the awareness of boundary conditions or limits has been an extraordinary surge of intellectual creativity and of practical innovation. Fresh critical thought and new methodology have emerged and been applied to energy analysis and energy forecasting, to traditional economics and cost accounting, to marketing and systems design. Industrial processes have been analysed, monitored and redesigned to achieve greater internal efficiency and reduce detrimental external effects. The energy costs of materials and processes (including raw and processed food) have been determined and tabulated; the environmental and social costs of many projects have been assessed and quantified.

Nowhere has inventiveness and creativity been more apparent than in the utilization of non-conventional energy sources. Solar energy uses, wind and biomass conversions have yielded unexpectedly promising developments; developments that combine the sophistication of modern design with a scale appropriate to their diverses applications.

The reader of this Report is by now no doubt aware that the Conserver Society implies more than conservation. Conservation becomes a function or output which arises both from an understanding of our system and its various sub-systems and when that understanding leads to innovation. In other words, conservation occurs as the result of a much more appropriate and sensitive re-ordering and redesigning of activities. This is the creative core of the Conserver Society concept, and it is closely linked to the need for diversity and flexibility.

It is difficult to end this study, neatly wrapped, and declare that our work is done. The transition to a more conserving society has just begun and much more work and thought will be needed during the course of our Canadian, North American and global "mid-course correction". We hope that this Report will contribute to a deeper understanding of the issues and that the concept of a Conserver Society and a sustainable future is found to be helpful to all Canadians.

Notes

I. Background of the Study

1. This way of putting the situation can never be exact, because such "limits" are always somewhat elastic, according to the price people are willing to pay. Nevertheless, whatever measure of crisis is used, the logic of the argument remains.

2. Various versions of a similar story are told. A farmer has a barrel full of grain, and a flock of chickens growing at such a rate that their consumption doubles each day. The farmer, not having thought much about it, decides nothing will need to be done about ordering more until the feed is half gone. Indeed, for a long time very little seems to be happening, the barrel remains nearly full. Then, on the 29th day he notices the barrel is half empty. How long does he have in which to act? Answer: one day. Even if he had been watching the barrel closely, it would only have been about the 29th day or a little sooner that an apprehension would have struck him that something was about to happen.

3. See, for example, the March 1977 issue of *Saturday Night.*

4. In fact, some of these things are being done; the federal Department of the Environment was created in 1971.

5. These ideas are developed in a significant recent book by Fred Hirsch (*Social Limits to Growth,* Harvard University Press, 1977). The result is what Hirsch terms "positional consumption", a jockeying for relative position that forces everyone to seek more income even when they may only wish to maintain a modest *status quo* in their standard of living. It is more basically economic than the older concept of status competition, which was primarily concerned with social prestige. The book was reviewed by Robert L. Heilbroner in *The New York Review of Books,* 3 March 1977. Heilbroner commented: "I have only one small complaint to voice about this remarkable book. I regret that Hirsch did not add to his analysis of the social limits of growth the basic argument of the environmental limits to growth. For the two arguments are remarkably parallel. Both limits will worsen as time goes on." Heilbroner goes on to speculate that the actions that will be necessary to remedy these intensifying environmental and social tensions, both within Western economies and around the world, may have the effect of altering our present economic system beyond recognition. His review is of particular interest because Heilbroner, a respected economist, is himself the author of one of the more influential (and gloomy) analyses of the future prospects for western industrialized democracies. He sees the drive to maintain growth of the present economic system, under increasing strain from inflation, energy shortages, and social problems, as leading to increasingly authoritarian and repressive political regimes. (Robert L. Heilbroner, *An Inquiry Into the Human Prospect,* Norton, 1974, and "Second Thoughts on the Human Prospect," *Futures,* February 1975, pp. 31–40.)

6. M. Mesarovic and E. Pestel, *Mankind at the Turning Point: The Second Report to the Club of Rome,* Dutton, N.Y., 1974; A. O. Herrerra *et al., Catastrophe of New Society? A Latin American World Model.* Report No. LDRC-064e, to the International Development Research Centre, Ottawa, 1976; Barry Commoner, *The Poverty of Power: Energy and the Economic Crisis,* Knopf, 1976.

7. Conserver Society Project, *GAMMA,* University of Montreal and McGill University, Montreal, Canada, July 1976. Vol. 1, The Selective Conserver Society; Vol. 2, The Physical & Technological Constraints; Vol. 3, The Institutional Dimension; Vol. 4, Values & the Conserver Society.

II. Introduction: Perspectives on the Development of Canada

1. See, for example, H. A. Innis. *Essays in Canadian Economic History.* University of Toronto Press, 1956.

2. *Population, Technology and Resources,* Report No. 25, Science Council of Canada, July 1976.

3. "The Future of the World Economy: A study on the impact of Prospective economic issues and policies on the International Development Strategy", UN Secretariat, N.Y., 1976.

4. I. McDougall, *Canadian Public Policy,* vol. 1, no. 1, Winter 1975, p. 47.

5. By the strict letter of the wording, both statements could be construed as correct. Their practical meaning, for public and politics, was however quite different.

III. The Principal Policy Thrusts of a Conserver Society

1. See, for example, *Northern Frontier, Northern Homeland,* the report of the Mackenzie Valley Pipeline Inquiry, Commissioner T. R. Berger, Ottawa, 1977, vol. 1.

2. See "Energy Conservation: A major element in Canada's energy strategy", Department of Energy, Mines and Resources, Ottawa, 1977.

3. The Ark is a structure designed by the New Alchemy Institute and funded by the federal Department of Environment, which is testing and demonstrating many of the principles of energy conservation, renewable energy, and small-scale sustained-yield food production in a closed ecological circuit. It has been designed so that it blends with and is adapted to local environmental conditions and constraints. While it incorporates a residence area for a family and/or technicians and researchers, it is fundamentally a scientific research establishment. It includes a small commercial greenhouse and aquaculture tanks that are mutally supportive. Solar collectors, with water-tank storage, supply heat and hot water year-round, with wood fuel as a back-up system. Windmills supply average electrical needs and feed a net surplus into the P.E.I. grid. It is expected to have a variety of spin-offs for small-scale energy technology and agriculture. The research findings should help to settle many questions regarding the total-system costs and benefits of small-scale, self-sufficient food and energy production, as well as the techniques of maintaining a closed-cycle ecological system in balance with minimum intervention.

4. David Morris and Karl Hess, *Neighborhood Power: The New Localism*, Beacon Press, Boston, 1975.

5. The concept of *entropy* is being found useful for interpreting the interactions of living systems with energy and the natural environment, helping us to see that some processes or trends have an irreversible downhill character that should not be lightly condoned. On the "information" definition of entropy used here, the state of highest entropy is the state of maximum disorder, or chaos. Thus *low entropy* is to be valued. The economist Georgescu-Roegen has promoted the idea for several years that economic theory, particularly when dealing with resources, should draw on the conceptual models of entropy and thermodynamics, rather than simply on mechanics and equilibrium chemistry. His ideas are developed in detail in: Nicholas Georgescu-Roegen, *The Entropy Law and the Economic Process*, Harvard University Press, 1971.

IV. Some Areas of Application

1. L. Schipper, A. J. Lichtenberg, "Efficient Energy Use and Well-Being: The Swedish Example", *Science*, vol. 194, 3 December 1976, pp. 1001–1013. See also the subsequent correspondence in *Science*, vol. 196, 3 April 1977, p. 121.

2. These arguments are persuasively elaborated in the report by Mans Lonnroth, Peter Steen, Thomas B. Johannson, *Energy in Transition: A report on energy policy and future options*, Secretariat for Future Studies, Sweden, 1977.

3. *Energy Research Report*, vol. 3 no. 1, 1 January 1977.

4. "Energy Conservation: A major element in Canada's energy strategy", E.M.R., forthcoming in 1977.

5. These examples are taken from "Efficient Use of Energy: A Physics Perspective", the report from a study performed by the American Physical Society for the National Science Foundation, the Federal Energy Agency, and the Electric Power Research Institute. US Department of Commerce PB-242 773, January 1975. See also: M. H. Ross, R. H. Williams, "Energy Efficiency: Our Most Underrated Energy Resource", *Bulletin of the Atomic Scientists*, November 1976, pp. 30–38; and M. H. Ross, R. H. Williams, "The Potential for Fuel Conservation", *Technology Review*, February 1977, pp. 48–57.

6. It should be noted that this may not always be as reversible as it seems. An example given in Science Council Report No.16, *It is Not Too Late – Yet*, (June 1972) is that when the corn leaf blight struck the US, many farmers found it impossible to switch to the alternative crop of soybeans because the soybean is adversely affected by the residual herbicide, atrazine, used to control weeds in cornfields. Current methods of agriculture have similar implications for land on which tobacco and cotton are grown. Paving over good farmland is not reversible, because good topsoil is a delicate and complex ecosystem.

7. Where the figure falls, between the 20 per cent and the 3 per cent (1990) mentioned on p. 40, will depend greatly on the success of conservation efforts (demand management).

8. *An Energy Strategy for Canada: Policies for Self-Reliance*, Energy, Mines and Resources, Ottawa, 1976, p. 109.

9. The order of the problem can be appreciated from the estimate that the *present* US consumption of energy, mostly from fossil carbon sources, is about equal to the total net annual storage of solar energy in the US biomass.

10. W. A. Shurcliff, *Solar Heated Buildings, a brief survey*, 12th ed., Cambridge, Mass., 1976, pp. 212.

11. *Energy Research Reports*, 21 February 1977.

12. At present, in research at the University of Toronto, Department of Chemical Engineering.

13. See *A Nuclear Dialogue, Proceedings of a workshop in Issues in Nuclear Power for Canada*, held at the Guild Inn, Toronto, March 1976, ed. R. W. Jackson and J. A. Potworowski, Science Council of Canada.

14. These figures are drawn from "Materials Recycling", a paper prepared by F. T. Gerson Ltd., for the Science Council Committee on The Implications of a Conserver Society, February 1977.

15. Pierre Dansereau, *Harmony and Disorder in the Canadian Environment*, Occasional Paper No. 1, Canadian Environmental Advisory Council, Ottawa, 1975, p. 12.

16. F. T. Gerson Ltd., *op cit.*

17. See, for example, Ingemar Falkehag, "Utility of Organic Renewable Resources," a tutorial lecture at the Fourth National Materials Policy Conference in Henniker, Mass., August 1976.

18. J. E. Marshall, *et al.*, "A Look at the Economic Feasibility of Converting Wood into Liquid Fuel", Environment Canada, Information Report E-X-25, 1975, p. 47.

19. Wilson Clark, *Energy for Survival*, Anchor Books, 1975, p. 239.

20. Rather than call it the *consumer* society, the economist Bertrand de Jouvenel has chosen to call it the *inflationary* society. This and the following 2 paragraphs in the text draws on de Jouvenel's interpretation. Bertrand de Jouvenel, "La société inflationniste", *Analyse & Prévision*, vol. 17, March 1974.

21. Current capital costs for new electrical generating capacity in Canada, hydro or nuclear, are in the range $700 to $1400 per kilowatt, and these figures are approximately doubled by the costs of new transmission and distribution capacity and other associated costs. Thus, depending on whether the heater is used on the average one tenth of the time or all the time, the capital cost of exanding the system to meet its demands would fall in the range $140 to $2800.

22. A statement by a past Deputy Secretary General of the OECD was quoted in Science Council Report No. 14, *Cities for Tomorrow*, in this context, "What is involved in the current questionning of 'growth' is to challenge growth as now measured by such economic indicaters as GNP and to suggest that if GNP were corrected for such negative factors as deterioration of the environment, growth would be nil or almost nil . . . Just what is economic growth other than a reduction in the scarcity of goods and services? So long as goods such as pure air, unpolluted water and amenities derived from nature or a pleasant environment were regarded as 'free' goods belonging outside the economic sphere, it was quite legitimate not to account for them. Today an altogether different situation has arisen – to make these goods less scarce is to add to the world's assets and to increase human satisfaction. It thus means contributing to economic growth taken in a broader sense than the mere expansion of production, which itself is but one means of better satisfying man's needs. Extending the goals of economic policy to embrace a new 'quality of existence' concept is apt to change the allocation of resources significantly (structure of consumption, needs met by private consumption as compared with the consumption of services made available to the entire community, reduction of working time regarded as an amenity, etc.)." Gérard Eldin, "The Need for Inter-governmental Co-operation and Co-ordination Regarding the Environment", *OECD Observer*, February 1971, p. 5.

23. Every reader can think of examples: the consumption of paper and typewriter ribbons in any large office, the use of hot water and paper towels in public washrooms, the casual requisitioning of *materiel* by armed services personnel, the game of cheating the telephone system with home-made electronic devices, the padding of insurance claims, the dweller in the large apartment house leaving the window open and the thermostat up.

V. Recommendations

1. Studies show that the total indirect or social costs of automobile use in the U.S. average about 50 cents per gallon of fuel used. W. C. Wheaton, reported in *Technology Review*, February 1977, p. 16.

2. *Energy Conservation: A Major Element in Canada's Energy Strategy*, Energy, Mines and Resources, Ottawa, 1977.

3. Recommendations for the creation of institutions specifically responsible for the development of renewable energies are not new. The report prepared by Sewell and Foster for Environment Canada called for a Crown Corporation. See W. R. D. Sewell and H. D. Foster, "Images of Canadian Futures: The Role of Conservation and Renewable Energy," Office of the Science Advisor, Report No. 13, Environment Canada, 1976. More recently, a private member's bill (C-309) was passed in Parliament to create a Solar Institute. However, consistent with the nature of private member's bills, any public funding requires additional action by the government in power and, at the time of writing this Report, no provision for funding had been made.

4. See also R. T. Lund, "Making Products Live Longer," Technology Review, January 1977, pp. 49–55 which reviews some of the studies done along this line at the MIT Center for Policy Alternatives.

5. These ideas are already moving very quickly from policy to implementation. See, for example, Tom Alexander, "Industry Can Save Energy Without Stunting its Growth," *Fortune*, May 1977, pp. 186–200.

6. E. A. Hudson and D. W. Jorgenson, "Economic Analysis of Alternative Energy Growth Patterns, 1975–2000," in Appendix F of *A Time to Choose: America's Energy Future*, the report of the Energy Policy Project of the Ford Foundation, Ballinger, Cambridge, Mass. 1975. See also: Bruce Hannon "Energy Conservation and the Consumer," *Science*, vol. 189, 11 July 1975, pp. 95–102.

7. See, for example, "Integrated Community Alternative Energy Master Plan" by Battelle Memorial Institute's Group on Energy Systems and Environmental Research, October 1976.

8. The potential for rental is discussed at greater length in some of the GAMMA papers. See Note 7, Chapter I, this Report.

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