Post-Kyoto Reflections

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What Happened in Kyoto

There certainly are points of encouragement in the protocol that emerged from the United Nations conference in Kyoto on reducing greenhouse gas emissions in order to minimize their adverse effects on the global climate. However, the confused process leading up to the conference, the negotiations at the conference itself, and the comments coming from it, leave a negative impression that more than cancels out any feeling that the growth in emissions will be brought under control in the foreseeable future, or that Kyoto has been a great success.

The most positive aspect of the Kyoto event is not the protocol as such, but the impression that, through the preparations and the conference itself, the issue of greenhouse gases **may have** become a major concern of the governments of industrialized nations. It is hoped that such concern as there is will not just be put on the back burner as other issues arise (as happened to the environmental commitments at Rio in 1992), but will indeed remain as an issue that governments must address.

On the other hand, this is simply a protocol and it must be ratified by 55 countries before it becomes an international treaty. Individual countries will not be bound by the treaty until the protocol is ratified by that country as well as at least 54 others. Consequently in Canada, where there is a split in the constitutional responsibility for environmental matters, it remains to be seen just how the federal government is going to be able to develop the sort of national program that the provinces will be prepared to support and to implement. Canadian ratification of the protocol is thus most questionable on a national basis and is particularly so until Canada is certain that the protocol will be ratified by the United States. There will have to be a major change in the position of many US Senators before such ratification is possible.

It is also worth noting that, on the day after the end of the Kyoto conference, two of the early morning TV news programs seen in Ottawa made no mention of the conference or of the protocol produced. If this quick dec line of the conference and the protocol into a non-news event is any indication of the shallow depth of public concern about greenhouse gas emissions, then the reality may be that all the rhetoric of the past few weeks is just that – rhetoric – showing no sense that greenhouse gas emission may be one of the most crucial issues that governments have ever tried to address.

There was no stated progress at Kyoto in dealing with the major stumbling block posed by the difference in outlook on greenhouse gas emissions between the developed and developing nations. On the positive side, some of the commentary from the conference indicated that various proposals had been floated for addressing this matter. Even if such proposals take root, long and difficult negotiations will be required before reaching a final resolution. However, on the negative side there are indications that some leading forces in the industrialized countries do not seem to understand that it is developing countries with large populations such as China, India, Indonesia and Brazil who really have the whip hand; that it is the developed countries with high per capita greenhouse gas emissions who will have to pay attention to the situation in the developing countries.

Canada made a proposal to help resolve the problem caused by the disparity in greenhouse gas emissions between developed and developing nations,. It was that the developing nations would not have to take any steps to reduce their emissions until it had been demonstrated that the developed nations had indeed reduced theirs. There was also a proposal from Latin America that the developed nations should establish a fund to assist the developing nations in using low greenhouse gas emission technology in the process of their economic development. More on this issue later.

Media Comprehension

One of the most encouraging items that has come to my attention during this Kyoto event has been an editorial by editor William Watson in the *Ottawa Citizen* (7 Dec.). Watson sees Canadian policy-makers as trying to tell us that the cloud of greenhouse gas emissions has a silver lining. They argue that reducing them might provide work for Canadian businesses and therefore have a positive effect on the economy. But he warns that behind the silver lining there is still a cloud:

> *"The cloud is that we're all going to have to consume less energy, and see to it that the energy we do consume produces fewer gases per unit"*

Moreover, in order to reduce those gases, Watson notes that resources will have to be used that otherwise would be available for other more productive or beneficial purposes.

As for dealing with the problem and coming up with a policy and an implementation plan, Watson advises that the incentive approach

> *"....should govern our plan for reducing greenhouse gas emissions: Create the right incentives and people will find a way to do it on their own. The best way is to establish a system of licences, where people have the right to emit gases, and those who can find ways of reducing their emissions can sell their unneeded permits to those who can't."*

On this point, Watson's comment is the first I have seen where licenses on the basis of individuals has been proposed; an idea that I strongly endorse and first described in a paper in 1974 and later in *Issues Facing Canada* (CACOR *Proceedings* Oct 1991). Except that I believe that permits will have to be not for the emission of gases, but for the consumption of energy, and that the licenses or permits would not have to be purchased by but would be issued to the individual. More on this later.

How Real is the Threat?

As a foundation for subsequent comments on the discouraging aspects of Kyoto, here is a brief review of the debate on whether human emissions of greenhouse gases can, in fact, induce an increase in average world temperature.

There does not appear to be any controversy regarding the basic theory that certain gases in the atmosphere act as a barrier to the passage of low frequency heat reflected from the planet's surface. It is accepted that this phenomenon – the "greenhouse effect" – is responsible for the average temperature of the earth being possibly 33°C warmer than it would be if there were no greenhouse gases in the atmosphere. The equilibrium of these atmospheric greenhouse gases is literally vital to us.

The question as to whether an increase in the greenhouse gas content of the atmosphere would lead to an increase in average world temperature would seem to demand an affirmative answer. The counter argument would mean that there is some strong stabilizing feature in the world's climate that would neutralize any increase in greenhouse gas content so that such increases would have a negligible effect on average world temperature.

Some details of the long-term dynamics of world climate are ill understood. However, what we do know about system dynamics in general is that when a fundamental parameter in a complex system is perturbed (and greenhouse gases are obviously a primary factor in the earth's climate and we certainly are perturbing them), the system will adjust and thereby change its pattern, provided that the perturbation is not so severe that the system becomes unstable and either explodes or collapses. Consequently, there is now almost an overwhelming consensus amongst those climatologists who have studied the subject that an increase in atmospheric greenhouse gases will indeed result in an increase in average world temperature.

Supporting this theoretical conclusion are the studies of the temperature and the carbon-dioxide content of glacier ice-cores. They show that over the past hundreds of years there has been a strong correlation between average world temperature and carbon dioxide content of the atmosphere. While I am not aware of there being any proven causality: i.e., whether the carbon-dioxide caused the temperature to rise or vice versa, the only plausible argument is that the carbon-dioxide has indeed been the causal factor.

Furthermore, climatological models demonstrate that an increase in greenhouse gases will lead to an increase in world average temperature. Undoubtedly there are many climatological relationships that are not yet well enough known to be introduced into these models and therefore there is a certain amount of scepticism and controversy as to their validity. However, the real issue is not whether the models contain all of the factors and relationships, but whether, even with what they do contain, they make a credible contribution to the understanding of this complex process.

The credibility of these models has been supported by at least two somewhat different processes, one looking backward and one looking forward. The models have been run looking backward by using initial historic data and the recorded changes in greenhouse gas content over time as inputs and then comparing the temperature predicted by the model with the actual recorded world average temperature. Evidently the correspondence has been quite strong, thus giving credence to the ability of the models to forecast the likely results that would follow from further increases in greenhouse gases.

Perhaps the strongest support for the validity of these models is in the forward looking review of what have become known as "fingerprints". These are not the changes in average temperature as such, but rather some more obvious and easily detectable changes that would be related to average world temperature. For example the models predicted and actual measurements confirmed that an increase in greenhouse gases reduced the gap between daytime and night-time temperatures, most markedly in winter; that as maximum temperatures rise, minimums rise at a faster rate; that the effects are more pronounced in the northern hemisphere where most of the greenhouse gases are produced; that there is a greater change in the lower part of the atmosphere than in the

upper part; and that there will be more and particularly more violent storms. All of these points give credibility to the modelling process and as far as I am aware are not points that sceptics have been able to refute.

In spite of this, there continue to be some doubting Thomases who wish to continue the debate as to whether global heating due to human activity, which increases the greenhouse content of the atmosphere, is really occurring. However, more important than the debate would be convincing evidence of actual effects of the type to be expected from increased global heating. Indeed there is such evidence. For example: glaciers are retreating, the permafrost is retreating, there are more and more violent storms, the Mackenzie basin is warming, bird migrations have changed, tundra blooming is occurring, and the sultriest three years in the century have occurred in the last decade. The hottest year ever recorded was 1995 (*Time* Nov 1997). which followed a series of high average annual temperatures in the late 80's which continued during the 90's. And severe droughts are being experienced in many countries.

While I haven't see any comment by recognized authorities to this effect, the unusual intensity of El Niño in 1997-8, which obviously involves a great deal of atmospheric energy (to be expected from an increase in global heating), certainly prompts the conclusion that its unusual strength is another demonstration of the effect of global heating.

One of the arguments of the sceptics is that the changes that have occurred in world average temperature are no greater than have occurred historically due to natural causes. I have two problems with that position. First it is refuted by the evidence concerning "fingerprints" – actual manifestations of climate change. Second, by the time a significant increase in the average temperature has been unequivocally proven to the satisfaction of the sceptics, the time for effective action will be long gone.

Another argument is that surface measurements are being made in locations where there are "islands" of human induced temperature increases rather than in locations that would indicate the average temperature more accurately. That argument is given some credibility by the fact that satellite temperature data over the past several years has not shown the same temperature changes as those recorded on the surface of the planet. The argument (if I understand it correctly) is refuted by the point above about the expected temperature variation between the upper and lower atmosphere. It also is refuted by the fact that the manifestations of increased temperature that have been described have occurred regardless of what satellite temperature measurements have been recorded.

Water vapour in the upper atmosphere produces a severe greenhouse gas effect. Some argue that with increases in global temperature there will be more rain and therefore the clouds will contain less water vapour. The argument continues that increases in other greenhouse gases will be neutralized or off-set by the reduction in cloud water vapour. If valid, this condition would be an example of the type of stabilizing effect referred to in one of the earlier paragraphs. However, there is a major flaw in the explanation I have seen of this off-setting effect. That is, while global heating will give rise to an increase in global precipitation, it also will cause increased global evaporation, the result being that there will be an increase in the total amount of moisture that is circulating in the atmosphere. From a system dynamics perspective, it is almost impossible to see how there could be an increase in both evaporation and precipitation without an increase in the moisture content of the clouds. This is especially true when (as noted above) the temperature increase due to greenhouse gases decreases with altitude.

Some take the attitude that even if global heating is occurring, its effect will not really be felt for a number of decades, and therefore there is no reason to start taking serious steps to curtail greenhouse gas emissions, if doing so would have early adverse economic consequences. For example, any sea level rise which would inundate large densely-populated delta regions would not likely be experienced for several decades as it would take that long for the glaciers to melt and the ocean waters to absorb the heat that would cause them to expand.

Procrastination neglects at least two important points. First, it ignores the fact that delays in taking firm measures to reduce greenhouse gases will only intensify the ultimate damage expected due to global heating. This makes it progressively more difficult to reduce the emission of greenhouse gases, to redress the damage that has already occurred and to avoid leaving a terrible legacy for future generations. Second, as noted elsewhere in this essay, direct and most closely associated indirect climatic effects of global heating are experienced well before there is clear proof that a significant temperature rise has actually occurred.

To be unequivocal, if the emission of greenhouse gases is not reduced, the probable consequences of global heating will be terrible. We are seeing an example in technicolour today in the middle of December in southern Alberta. As the opening paragraph of one news report put it: *"The warmest and driest December in history is bringing the good, the bad, and the ugly to southern Alberta."* Alberta has just had unusual and fierce forest and prairie grass fires, followed by winds and blowing soil. Saskatchewan and Manitoba have been having most unusually high November and

December temperatures, with little snow or rain, thus raising serious concern about the lack of moisture in the ground with potentially serious effects on next year's crop. Eastern Ontario and Quebec have experienced the by far the most devastating ice storm in living memory.

We have also seen this fall the rampant forest fires and resulting smog in south-east Asia, droughts in Australia and other areas of the western Pacific, and the extremely severe hurricane in southern Mexico. On the other extreme, Guadalajara has just had 40 cms of snow, the first in a century, and snow has also fallen in Monterey. Then there is a report of a typhoon on the island of Guam with sustained winds of 240 km/hr and gusts of 350 km/hr, with the latter being the highest wind ever recorded in world. These unseasonable weather conditions may be attributed to El Niño, to unusual climatic quirks, to greenhouse gases, or to a combination of all three. Whatever the cause, the manifestations are much like what could be expected due to increasing amounts of energy surging around in the atmosphere due to its having been heated because of the increased level of greenhouse gases. Any increase in atmospheric energy would tend to amplify atmospheric disturbances, thus intensifying storms or even generating them in unlikely places.

The review presented begs the question as to what type of conditions it would be reasonable to expect if we do not take immediate measures to stabilize and then reduce greenhouse gas emissions. Aside from the type of climate changes noted above, it seems reasonable to expect other events such as sea level rise and flooding of delta habitation world wide due to a combination of melting of glaciers and thermal expansion of the ocean waters. Also changes in agricultural growing conditions with some areas having better and many having worse conditions; changes in tree lines faster than normal forest restructuring can occur; changes in ocean current patterns with all their attendant effects of climate; changes in types of fish stocks, and scores of other changes in conditions that have for centuries contributed to and formed life as we know it on this planet. To put the matter bluntly, it certainly appears that the effects of global heating due to unrestrained greenhouse gas emission would not be beneficial to humanity generally.

The scientists who have been contributing to the Intergovernmental Panel on Climate Change have now concluded that human-induced increases in greenhouse gases are contributing to global heating. Now it is time for all reasonable citizens to consider the evidence and decide whether they accept that the case is so strong that it demands that governments take immediate action to develop and implement programs that will rapidly reduce the rate of growth and then the actual level of greenhouse gas emissions. It would be the height of folly and an abdication of the basic responsibility of governments not to do so.

The Discouraging Aspects of Kyoto

In none of the reports of meetings and discussions leading up to Kyoto did I see any indication of just how seriously detrimental global heating would be. Rather, the only sense of crisis was related to the adverse economic consequences of any program aimed at limiting the consumption of fossil fuels.

There seems to be lack of sense of just how damaging the continuation of emitting greenhouse gases could be. The most unforgivable aspect **is that those who would have to cope with such effects are the young people of today and subsequent generations.**

It is our responsibility, together with that of the current leaders of government, business, education, and religion to recognize what a dreadful future we are creating for future generations in our profligate emission of greenhouse gases. Surely these young people will not easily forgive their elders for procrastinating or **NOT** taking action to avoid the. more devastating effects of greenhouse gas emissions.

It is now clear that we no longer have the excuse of ignorance. Our only excuse, and it is one of which we should be ashamed, would be that we were so concerned about maintaining our current standard of living that we were prepared to gamble that we could "eat our cake and still have it" without sacrificing the future of our children and subsequent generations.

When we procrastinate, we must constantly remind ourselves that just stabilizing greenhouse gas emissions to 1990 levels will **not** result in the immediate stabilization of global heating. There is a long delay between the increase of greenhouse gases in the atmosphere and the adverse effects of an increase in global temperature. It simply takes a great deal of time for the atmosphere to absorb the heat as it moves to a higher operating or stabilized condition.

The Growing Liability

The annual emission of greenhouse gases and their accumulation in the atmosphere are somewhat analogous to the annual deficits and their accumulated effect on the total debt in government finances. As long as the atmospheric content of greenhouse gases continues to increase (as they will as long as humans discharge more such gases than the planet can absorb or neutralize), there is likely to be a continuing increase in global heating.

If we can take determined action to reduce government deficits and hopefully government debt, then surely we can take even more determined action to reduce not only

the rate of emission of greenhouse gases but the total atmospheric content. The greenhouse gas issue in the long term may turn out to be much more crucial than even the deficit/debt situation.

If our generation does not take action to reduce our greenhouse gas emissions, then our children and grandchildren will have to experience many of the adverse effects of human-induced global heating. We will pass on to them the choice of taking the difficult decisions to face the burgeoning problems created by preceding generations, or to follow in the steps of their parent's generation by ignoring the situation and passing on to the next generation an even worse legacy than was left to them. Where is our sense of morality when we leave this kind of legacy to our successors?

The discussions leading up to Kyoto displayed no general sense of urgency or crisis. On the contrary there was a sense that dealing with greenhouse gas emissions was just like any other government chore. That is, the government has the choice to institute or not to institute a program to reduce greenhouse gases; just like having or not having child care, or allocating more or fewer resources for health care, or down-sizing or not the public sector or deciding whether or not to deregulate or privatize. What is missed by this attitude is that the greenhouse gas/global heating issue will not stand still. It is dynamic. It is an ongoing and accelerating process. It will get worse the longer we procrastinate. And the more difficult and the more extensive will be the required response. There is little if any room to doubt that sooner or later humanity is going to have to come to grips with reducing greenhouse gas emissions to a level that the ecosphere can either stably absorb or neutralize.

Is Taxation the Answer?

The spectre of further taxation, particularly a "carbon-dioxide tax", as an instrument to encourage reduction in greenhouse gas emission was repeatedly raised during the run-up to Kyoto and is still being mooted as one measure for implementing the protocol. This may seem like an effective measure, but on deeper examination, it comes out as only a government revenue generator. It may not have any appreciable effect on reducing greenhouse gas emissions.

The reason why the general type of tax is not likely to have any appreciable effect on reducing emissions is that energy, and particularly fossil fuel energy is so basic to our way or life that its consumption is quite price inelastic. That is, the price of fossil fuels would have to increase not just marginally, but drastically before there would likely be any appreciable reduction in their consumption.

To illustrate the above point, there appears to be very little difference in the driving habits and trucking habits of southern Ontario and northern Ohio, north western New York, or south eastern Michigan, despite the fact that there is a difference of about 40% in the cost of gasoline and diesel fuel across the border. Even within the United States, there is a pronounced difference in the price of fuel between northern and southern regions, but there is no apparent difference in the private driving and commercial trucking operations between these regions. Consequently, as far as road transportation is concerned, there would have to be a dramatic increase in fuel taxes for there to be any effect on reducing road fuel consumption.

To supplement the above argument, think about the total cost of owning an automobile and of the fuel component of that total cost. For a $20,000 car, there is about $2,000 carrying costs, $3,000 depreciation (at a minimum), $1,000 for insurance (again likely on the low side), and .$1,000 for licensing and non fuel operating and maintenance cost for a total of $7,000 just to own the car even if it is not in use and before any fuel costs are included. For those who drive less than about 50,000 kms. annually it would take an enormous increase in gasoline prices before there would be any significant percentage increase in the total cost of owning a car.

It might be thought with respect to commercial trucking that increases in fuel costs should result in reductions in the consumption of diesel fuel. However, there seems to be no difference in the trucking habits between Canada and the USA or between regions of the USA where there is a pronounced difference in diesel prices. Considering all the costs of operating a commercial trucking operation suggests that the cost on a kilometre basis of the driver, the amortization and carrying costs of the capital, insurance, tires, licensing, and maintenance and running costs are probably many times greater than the diesel fuel costs. Thus, further taxing of diesel fuel probably would have little effect on the level of consumption or on the related emission of greenhouse gases.

A quite similar argument is probably applicable to the residential and commercial use of energy. The cost of residential heating and electricity is only a small proportion of the total cost, allowing for annual property taxes, fire and other insurance, maintenance and up-keep. Consequently it is unlikely that increasing the cost of energy would have an appreciable effect on reducing residential energy consumption, thereby reducing the emission of greenhouse gases.

This same line of analysis suggests that even in business and industry where the energy component of total costs is relatively small, an increase in energy costs is not likely

to result in appreciable reductions in consumption. Moreover, in those processing or manufacturing industries where energy forms a significant portion of the total, any increase in energy cost would probably be passed on in the price of the product or service as in these activities strenuous efforts are probably already being made to reduce energy costs.

The argument that has been presented leads to the conclusion that there is probably very little price elasticity of energy. If this is indeed the case, then fixed per unit direct taxation of energy such as the proposal for a carbon tax would have little effect in reducing the emission of greenhouse gases. Such taxes may be promoted as a measure to encourage reductions in the consumption of fossil fuels and their emissions, but they would really be just another form of government revenue generation.

Fixed per unit direct taxation on energy, even at the present level of gasoline and diesel fuel taxes, and without any increases of these existing taxes is a regressive form of taxation, striking those at the lower end of the income scale with greater force than those at the upper end. The cost of energy is not a major item for those with more than one private vehicle (probably in the higher price range), or with large residences, cottages, boats, private planes, or other energy consuming possessions. However, those at the lower end on the income scale are already forced to live in a manner of minimum energy consumption, and any sort of energy tax or increase in energy tax has the same effect as would a tax on the basis of their life, such as their food. In today's industrialized societies, the need for energy is in the same category as the need for the basic life supporting commodities such as food and potable water. Thus energy taxes not only are likely to be ineffective in reducing energy consumption, but due to their regressive nature they would be contrary to the interests of social policy.

A type of energy taxation that would be progressive would be one in which the per unit level of the tax increased as the amount of energy used increased. Such a tax would create a strong incentive for the user to reduce energy consumption. A similar result could be achieved with a form of energy consumption licenses, such as proposed by William Watson in his *Citizen* column of December 1997. According to this suggestion, individuals would buy licenses which could then be presented for the purchase of a stated amount of energy. The cost of the licenses would increase with the increase in the number of licenses the individual had purchased during a particular period. Social security cards would be used to restrict the purchase of licenses by those below a particular age and as a means of keeping track of the number of licenses that the individual had already purchased. Licences could be sold at a profit. Businesses and industry would then have to purchase their licenses for energy on this secondary market. The steepness of the progressive rise in price of the issued rights or licenses could readily be adjusted to provide the amount of incentive that experience would indicate was required to reduce energy consumption and associated greenhouse gas emissions to the level sought by the government.

I doubt that this proposal would be gleefully accepted by affluent individuals, business or industry and it would take a determined government to first accept the idea and then produce a rationale and a publicity campaign that would generate the required public support. However, this concept of licenses to purchase energy at a progressive price would certainly provide a strong, broad incentive to reduce energy consumption. It could also be structured so as to favour the use of non greenhouse emitting energy. Certainly it would be a welcome relief for those in the lower income level, particularly if the starting level of energy taxation was less than their current fossil fuel taxes.

The Concept of Net Energy

During discussions leading up to Kyoto "net energy" was another important issue that received little attention.

For example, if it took more energy to produce a barrel of oil than is contained in a barrel of oil, then obviously pumping oil would be a losing proposition.

In the same sense, to replace a fossil-fuelled power station by, say, a central solar installation would consume an enormous amount of energy in the fabrication of components, the transportation of materials and the construction itself. Once the new system is operating it will have to "work off" that amount of energy before it shows any net gain. The time taken to do this must be considered in the overall energy strategy.

A similar situation arises in the replacement of old appliances by new "green" varieties. When does the replacement of an 80% efficient electric motor by a 90% efficient one give you a net gain?

In other words, even if it should appear that the replacement of equipment and/or the renovation of a manufacturing plant or rental property makes sense from a return on investment aspect, the question still remains as to whether such replacement also makes sense *vis-a-vis* the net energy factor.

The experience of Brazil with liquid fuel production from sugar cane is illustrative of the importance of the net energy factor. In the late 70's or early 80's after the oil shock of 1973, Brazil started a massive liquid fuel

project based on sugar cane aimed at freeing Brazil from the cost and vulnerability of Brazil's mounting importation of oil. In later years an in-depth analysis indicated that the process on a total energy basis was consuming more energy than it was producing. The total energy consumption in the process included the energy to cultivate and harvest the sugar cane, the energy to produce the fertilizers, pesticides, and herbicides, the energy to process the harvested sugar cane into liquid fuel and possibly some other by-products.

Once one starts to think about net energy, then energy takes on properties analogous to investment capital and the same type of thinking must be used regarding pay-back-time or return-on-investment. While there may be good literature on this issue, I have not as yet found any. Moreover, I have not seen an in-depth discussion of the net energy factor in any of the many reports and books that have expounded the virtues of the various methods of conservation.. This net energy consideration must be kept in mind when reading any of the hype on ways to reduce greenhouse gas emissions. If the material does not discuss this fundamental issue of net energy, then a fair amount of scepticism of the book or article is warranted.

There was controversy during the run-up to Kyoto concerning various means of generating electricity and their respective greenhouse gas emission factors. Undoubtedly discussion of the options will continue and intensify in the search for the means to achieve the reductions stipulated in the protocol. Meaningful reports and discussions on these matters must include the factors of return on investment and pay-back-time with respect to both the financial and the net energy factors which should be just as prominent in the debate as will be the issue of the greenhouse gas emissions themselves.

Electricity-Generating Systems: The Options

Another issue that must be kept in mind is the appropriate use of dispersed versus central generation and consumption of electricity. Wind and solar energy are naturally dispersed whereas hydro, fossil fuel and nuclear plants are central means of generating electricity. The trend in both the industrialized societies and the less developed nations is towards densely populated urban communities which results in the centralized consumption of electricity. While dispersed energy sources may be naturally appropriate for dispersed consumption in rural areas, they may be quite inappropriate, costly and inefficient for the centralized demand of industrialized or densely populated urban communities.

Both solar and wind energy are intermittent, due to the definite sun and darkness cycle for solar and the variability of wind. For either of these to be used to meet the constant availability load requirements of centralized consumption, they must have either enormous related energy storage means (such as pumped reservoirs, any form of batteries being impractical except for individual low consumption residential purposes), or they must feed into a power network based on centralized generation that has enough installed capacity to meet the demand when the solar or the wind energy is not available. Therefore, when considering capital costs and net energy factors, using wind or solar would introduce an additional capital cost and an additional construction energy load making it not directly comparable at the point of delivery with other methods of centralized generation. However wind or solar energy could be used to reduce the day-to-day consumption of fuels in a fossil plant, assuming that the arrangement produces an attractive net energy factor.

One of the main problems of using huge solar or wind installations to meet large centralized demands is that the complex 'collection' systems that must be provided are extensive and costly. The cost and the net energy factors of these collecting systems must also be entered into the equation when solar and wind are considered as alternatives to centralized generation to meet dense power loads.

While the analogy is perhaps over-simple, trying to use dispersed energy generation to meet centralized demand is a bit like trying to collect autumn leaves in order to burn them to gain their energy content. The energy that would be used in collecting and gathering might well be greater than the energy gained from the burning of the leaves.

Special Problems of Wind Energy

In addition to the problems of wind power due to its dispersed nature and its intermittent operation, there are also the problems of logistics and maintenance which stem from the necessarily small size of the units. Experience has indicated that the optimum size of wind generators may be no bigger than about 400 kilowatts. It would take 2500 units of 400 kilowatt capacity operating constantly to achieve the same capacity as a 1Gw power station. If an allowance is made for intermittent operation due to either too much wind or not enough wind, it may be more realistic to think about 5,000 or more wind units being required to provide as much energy as would be provided by one centralized 1 Gw station. Ontario Hydro currently has a load in the range of 35 Gigawatts. To meet that using wind would require something like 200,000 wind generating units.

The network of wires, transformers, circuit breakers switch gear and frequency control devices that would be required to collect and concentrate the energy being produced by 200,000 wind units would be costly in terms of both capital and net energy. The fact that an energy storage reservoir or centralized generating plant would still be required to meet constant minimum load demands exacerbates the problem.

Wind generators are notoriously difficult to maintain for good reasons. They are awkward to service in place because the work has to be done up a high mast, presumably in a wind (if the siting is effective) with limited shelter and working surface. If the units have to be dismantled for maintenance there is the problem of moving large cranes where all weather road access would not likely be available leading to the probable use of helicopters. Even if these units had a high reliability factor, there would still be the occasions when they require both routine and breakdown maintenance. On the one occasion when I saw what was the second largest world installation of wind generators in one of the California passes, about 1/3 to 1/2 of the units were not operating either due to lack of wind or serviceability.

The size of the blade propeller or vertical axis egg-beater that collects the wind is limited by the practical height of the structure and the complexity of the control system. The latter includes the braking, control and directing system that is required to shut-down the unit when the wind becomes too strong (so as not to tear the impeller apart). It also includes means to constantly feather or change the pitch of the impeller or alternatively change the setting of the frequency converter in response to the continuing variation in the wind's velocity, and to change the direction of the unit (not required for vertical axis egg-beaters) as the wind itself changes direction. The result is a highly complex system that reduces the reliability of these units, and increases the initial and maintenance costs as well as the amount of energy that is consumed in their construction and operation.

Solar Energy

There are two basic types of solar electricity generating systems, solar thermal and photovoltaic.

Solar thermal units are based on some form of concentrating the energy from the sun's rays so as to produce steam to drive steam turbines. The concentration can be done either by using giant mirrors to reflect onto a boiler the energy of the sun's rays that initially strike reflective panels. The other method is to collect the energy from the sun's rays in heat-absorbing panels or pipes. A 'solar farm' using either technique covers a vast acreage simply in order to collect the required amount of energy. The installations thus involve huge amounts of concrete and steel. They are not neat compact simple inexpensive installations. To achieve reasonable effectiveness, both solar thermal methods require some sort of mechanism to keep turning the solar energy collecting panels as the sun moves across the sky so that the panels are incident to the sun's rays. They also require regular maintenance to ensure that the panels are clean for maximum efficiency. All these factors have to be kept in mind when considering the financial as well as the net energy aspects of solar thermal generation of electricity. While some pilot installations have been made, the information that I have seen of their operation has not discussed the net energy experience while the financial considerations have not been encouraging.

A photovoltaic system has the additional disadvantage of producing inherently low direct current voltage per panel. Many panels thus must to be connected in series (just like old fashion Christmas tree lights where when one doesn't work the whole string is kaput) to achieve useful voltages. Then the direct current has to be inverted into alternating current and transformed up to even higher voltages for the power grid. Thus, the cost per watt of energy entering the grid is much higher than the cost per watt at the photovoltaic panel. This must be taken into account in the discussion of solar power as an alternative to any other form of centralized power generation.

When considering the dispersed solar or wind sources of energy as alternatives to centralized plants in order to cope with the centralized concentrated consumption of energy in industrialized or densely populated communities, it is essential that any costs and net energy factors being compared are indeed the cost of energy and net energy effects at the point of supply to the grid. Without these considerations, discussions of these alternatives to centralized generating plants are just hot air (fortunately not greenhouse gases!) There certainly are applications where wind or solar energy may be the most appropriate way to generate electricity, but these will most likely be where the points of consumption are small and dispersed.

Biomass

Biomass (organic material such as wood or plants) is used to produce liquid fuel (generally methanol or ethanol) which has its main application as a replacement for liquid fossil fuels in transportation. Biomass means have some of the same problems as do solar and wind as biomass uses plant growth as the means for collecting and concentrating the energy of the sun's rays. If based on using the residue (such as straw, sawdust, slash from forest harvesting or tree bark) from other forest or agricultural activity, producing liquid fuel increases the overall efficiency of the growing activity. Otherwise

large acreage's are required if the growing is solely to produce liquid fuel.

In the IIASA study "Energy in a Finite World"[1] Wolf Häfele comments as follows:

> *Our rather superficial study of how to make liquid fuels from biomass suggests that forests, rather than fields, are the more likely source and that chemical synthetic process routes (e.g., destructive distillation and oxidative hydrogenation to liquid fuel) are more attractive than anaerobic fermentation routes (e.g., the alcohol route). In both these judgements, the chief concern is to have maximum yields of liquids so as to minimize both land requirements and particularly the intrusion of energy harvesting on land needed to grow. food and fibre, to provide recreation, and to preserve natural habitats.*

As should be expected, the considerations that have been discussed about pay-back-time, return on investment and net energy effects are also fundamental to biomass production of liquid fuel. With these considerations the use of residue material should produce better results than when the biomass is grown specifically for liquid fuel production, provided that the cost and energy used in collecting the residue are not greater than those for biomass directly grown for producing liquid fuel.

Use of manure biomass to produce methane as a fuel while having merit in primitive areas, hardly enters into global energy and greenhouse gas considerations. However, the production of methane directly by the flatulence and burping of cattle being raised for meat and milk production is a most significant source of methane which is one of the worst greenhouse gases on a per unit weight basis. Aside from reducing the number of cattle by reducing the consumption of meat and dairy products or the retaining of cattle as a form of wealth as in Africa, or the protecting of cattle as in India, I understand that cattle emission of methane can be reduced by different grasses or food grains and cattle food supplements, but I do not know whether this is truly a practical proposition.

Nuclear Power

Leading up to and since Kyoto there has been a reduction in the rhetoric of the risks involved in nuclear energy generation. Also and alas, there was practically no comment about prospects for increased greenhouse gas emissions at the time of the announcement of the Ontario Hydro plan to shut-down seven nuclear reactors, and the replacement of their capacity by using electricity from fossil fuelled plants. Now that the necessity to reduce greenhouse gases has finally sunk in, it seems that the plan to shut-down the seven nuclear plants is being rethought.

It should also be kept in mind that (as reported in a *Buzzwords* column a few issues back) Sweden which had announced in the early 80's a decision to close all of its nuclear plants by 2005 had not as yet indicated any schedule nor even named the first plant to be closed. I still am intrigued to know how Sweden expects to avoid reverting to fossil-fuelled plants, thereby incurring the associated greenhouse gas emissions, when and if it shuts down its nuclear plants.

One encouraging piece of news with respect to nuclear energy generation is the report that appeared in *Globe & Mail* 20 Dec '97 which noted that:

> *"There was, of course, nothing benign about the accident at Chernobyl. But it wasn't nearly as catastrophic as had been feared, according to the findings of 800 experts from the International Atomic Energy Agency, the World Health Organization and the European Union who gathered in Vienna last year."*

The 12 trillion units of radioactivity that was released into the environment

> *"represents only between 0.1 and 1 percent of all of the radioactive matter sent into the atmosphere by all the atomic weapons tests of the 1950s and 1960s."*

The Chernobyl disaster has claimed 45 lives. 200,000 clean-up workers were exposed on average to about the equivalent of 16 or so years of radiation that they would receive due to normal natural background radiation. Of the 326,000 people removed form the area, fewer than 10 per cent received more than the equivalent of eight years of normal background radiation. Of the 800 children diagnosed with thyroid cancer, three have died and the incidence of thyroid cancer has dropped dramatically. Action has been taken and further steps are in process to improve the safety and operating procedures of the Chernobyl type reactors. The report ends:

> *"Nuclear power, in such uncontrolled conditions as Chernobyl, is devastating. But it is something that we can live with."*

Developed nations continue to live with and blithely accept the deaths and sickness arising every day from coal burning plants, to say nothing about the greenhouse gas emissions form such plants. Should we accept that condition? All the evidence suggests that we should not. But as this recent report on Chernobyl report suggests, the extremely low risk of accident in well designed and operated nuclear plants and the damages that could result from the very rare accident in such a plant are something one **can** live with. If readers believe that the nuclear reactor accident risk is too high, what do they suggest as

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[1] *Energy in a Finite World.* (IIASA). Ballinger Publishing Company, Cambridge, Mass., 1981

a non greenhouse gas emitting alternative to meet the heavy electrical energy demands of densely populated communities?

Hobson's Choice

If the above review is reasonably valid then to meet the bulk of the demand for 'clean' electricity in highly urbanized and industrialized societies there appears to be no alternative but some form of non-fossil centralized generating plant such as hydro or nuclear. Re-equipping central fossil fuel plants to use natural gas in place of coal would reduce greenhouse gas emissions somewhat as, to an even lesser extent, would some advanced types of coal combustion. But the reductions would not be enough.

If reduction in greenhouse gas emission is the goal, then every bit of hydro development that results in a positive net energy factor warrants consideration for development. The actual decisions to do so would be based on the level of net energy gains, return on investment and pay-back-time relative to other non greenhouse gas emitting generating opportunities. Many of the situations created require difficult trade-offs. For example, there has been strong objection from developed countries of China's Three Gorges project which as I recall would generate about 13 Gigawatts or slightly more than one third of the current Ontario Hydro generating capacity. The criticism centres on the fact that more than a million people will have to be resettled elsewhere and that the size of the dam structures and the resulting reservoirs could also create geological stability problems.

However, these criticisms must be kept in perspective. The population of China is 1,300,000,000 with a corresponding growth of the demand for electricity. Is the resettlement of one person in 1300 too much to pay for satisfying a vital need for electricity?

To meet China's growing energy demand, China announced a couple of years ago a plan for the construction of 100 Gigawatts of generating capacity over a period of eight years. This would require them to build at almost the rate of one 1 Gw plant per month. with about 45% of that addition being nuclear and the other being coal except for the contribution of hydro from Three Gorges. Readers may recall from one of my *Buzzwords* columns a few issues back a brief mention of the transportation bottlenecks that China even now is experiencing in that country's efforts to move coal to its coal-fired generating plants. This entire situation suggests that the critics should put themselves in the shoes of China's leaders and decide how they would get out of this situation except by following the route that China has selected.

Energy for Transportation

With respect to alternative forms of energy for transportation, there have been some encouraging reports on new processes for liquid fuel production from agriculture and forest harvesting residues, and there is stock market and industrial enthusiasm for the Ballard Power fuel cell technology. The fuel cell technology basically uses hydrogen as the fuel, with the alternatives being some form of chemically-stored hydrogen or pure hydrogen that could be produced during natural gas processing or by the electrolysis of water. In the long term it appears that the electrolysis process must be utilized to meet the energy demand of the transportation sector. However, there is little evidence that, aside from the Ballard fuel cell technology, any concerted effort is being directed by either government or industry to advance the development of the entire hydrogen system: the production, the storage, the transportation, and the development and refinement of the land, air, and maritime vehicle propulsion units using hydrogen fuel. This is regrettable, particularly for Canada which some 20 years ago was at the frontier of hydrogen technology. It is another instance of where little effort has been or is being made to address what certainly seems like an inevitable situation.

Post-Kyoto Outlook

The only really positive outcome from Kyoto is that the developed nations have evidenced an appreciation that greenhouse gas emissions are a major problem. Commitments have been made that would reduce these emissions to below 1990 levels by about 6 per cent by 2010, provided the protocol is ratified by at least 55 nations and becomes a binding treaty for the signatories. However, this seemingly straightforward stipulation then develops loopholes, perhaps because the industrialized nations are more determined to avoid having to make actual reductions than they are convinced that greenhouse gases truly are a growing problem.

Captions of two post Kyoto articles sum up the situation. Jeffrey Simpson in the Globe & Mail: "*Ottawa blows a lot of hot air about reducing greenhouse gases*". Simpson's main point is that Canada's ratification of the treaty is dependent on whether it is ratified by the United States. He discusses the problems for US ratification in the light of the determination of the US Senate not to ratify the treaty without some commitment from the developing nations to reduce their greenhouse gas emissions.

Simpson's other points address the situation in Canada noting:

> *"So far, the Canadian debate about greenhouse gas reductions has the same ethereal quality as the gases themselves.*

The debate is light on facts, which in turn renders almost useless any public-opinion polls." and, "At no time has the Chretien government spoken truthfully to Canadians about what lies ahead. Instead, the government has talked only about job gains from new technologies. And it has ruled out higher taxes, which in turn influence the price of goods and services. In a free-market economy, the price mechanism is the best tool for guiding changes of behaviour by individuals and firms. The government has largely abandoned it." and, "Petrified of reaction in Alberta, the Chretien government rules out a carbon tax. Equally uneasy about telling the truth, the government steadfastly refused to speak of sacrifices or lifestyle changes, preferring instead to point to the miracles of technology, some of them as yet speculative, as the key to a pain-free adjustment to the brave new world of substantially lower emissions."

Giles Gherson's column in the Ottawa Citizen (20 Dec. 1997) carries the caption: *"Clueless in Kyoto"*. After commenting on the crowd aspects of Kyoto and the lengthy and *"labyrinthine bargaining sessions"*, he notes that:

"And the outcome, grandly dubbed the Kyoto Protocol, is a mind-numbingly complex agreement that was crisply described by one US official: "If you understand what's in it, you couldn't have been here." and, " Back home in Canada it was especially hard to figure out what all the brouhaha was about and, even more important what it means."

I have not seen the protocol. From reports I understand that the main loopholes include emission reduction credits for the carbon absorption effects of forests and for the exporting to developing countries of non or low greenhouse gas emitting machinery and devices such as nuclear reactors. Provision is also being made for the trading of greenhouse gas emitting permits.

These are complex issues. For example, will the proposals deal with forests *per se* or with the change in the carbon-dioxide absorbing quality of the forest which is its cubic bulk. Countries with increasing forest bulk might receive reduction credits, while those that experience reductions in forest bulk would be penalized depending on whether the decrease in forest bulk resulted in an increase in greenhouse gas emissions or was forest harvesting that did not release all of the carbon in the harvested bulk.

Sorting out that mess is going to be a regulatory nightmare, even if agreement can be reached in international negotiations on just how to measure changes in forest bulk and how to assess how much of the carbon in harvested forests is released as greenhouse gas.

Further complications arise in the provisions for credited reductions in greenhouse gas emissions due to the export of non- or low-greenhouse-gas-emitting energy producing devices such as nuclear reactors to developing countries. What happens to the accounting? Do the recipients also claim some sort of credit, or when they agree with some form of greenhouse gas emission limitations will they be debited with the amount of credits that had already been given to the exporting country? Will there not be efforts in exporting countries to try to encourage their industries to develop equipment that would qualify for the emission reduction credits? The encouragement could take the form of some artful subsidy that circumvents established trade agreements.

The provisions related to both the forests themselves and to the export of non- or low- greenhouse gas equipment do nothing in the countries which would utilize them to actually reduce the emission of greenhouse gases due to the production, transportation, refining and burning of fossil fuels. In the light of the Rio agreement and previous international discussions these provisions can only be seen as instruments that would allow the countries which support them to avoid taking action to deal with the generally accepted causes of greenhouse gas emissions. These indefensible provisions are essentially loopholes pushed through by developed countries, including Canada.

The Kyoto deliberations with respect to the disparity between the per capita emission of greenhouse gases of the developed and developing nations were even more disgraceful. The United States is emitting 5.3 tonnes of carbon equivalent per capita (Canada is even higher) as compared to 0.7 for China, 0.3 for Indonesia and India, and 0.4 for Brazil. Despite this disparity, the developed nations, Canada included, were urging these developing nations at Kyoto to accept some level of reduction in their greenhouse gas emissions. Our Canadian Environment Ambassador was reported as urging China to accept some reduction in order to gain support for ratification by the United States Senate where many members have indicated categorically that they would not ratify the protocol unless there was some commitment by the developing nations to reduce their greenhouse gas emissions. This is a formula for disaster.

The clear message that is conveyed by the developed nations is very discouraging. The gist of the developed nations' argument is that although they have created the bulk of the problem due to their high level of greenhouse gas emissions over the past several decades while reaching their present level of affluence and way of life, they should be permitted to continue with the level of emissions that they had in 1990. Conversely, although the developing nations were not instrumental in creating the problem, they should none the less reduce their greenhouse gas emissions, thereby committing themselves to take a longer and more difficult route to development than did the developed nations.

Can this really be accepted as a reasonable approach when it is so unconscionable, and hypocritical. It is an insult to the developing countries. I would not like to have been a Canadian official trying to convince delegates from the developing countries that our position was credible and honourable.

The developing nations have responded as one might expect. They have not said it explicitly, but their silent message to the developed nations on this question is **"GET LOST**; we the developing nations will do what we believe we have to do in our own best interests to achieve the level of development and affluence of the developed nations." Perhaps when these developing nations have achieved the development they seek and **their levels of per capita greenhouse gas emissions approach that of the developed nations** they might be prepared to commit themselves to restraining further growth of their greenhouse gas emissions or to reducing them. Until then, the developed nations can forget about seeking support from the developing nations on greenhouse gas reductions unless the developed nations are prepared to provide some sort of assistance to the developing countries to achieve the development they seek with minimum emissions of greenhouse gases.

The developed nations, particularly the United States Senate, are evidencing an unbelievable level of naiveté on this issue. It should be abundantly clear that it is the developing nations that have the whip hand. If the developed nations really are concerned about the problem of global greenhouse gas emissions then logic would suggest that the developed nations (and the United States Senate) would realize that it is in their best interests to make it worthwhile for the developing nations to avoid increasing their emissions. Until that message sinks in the prospects are dim of there being either ratification of the protocol or any real progress in reducing global greenhouse gas emissions.

Gales Gherson finished off the column referred to previously as follows:

> *" Already a lot of folks are proclaiming Kyoto a "Rio II dud", a repeat of the grandiose 1992 Rio Earth Summit at which the industrialized world vowed to cut greenhouse gas emissions to 1990 levels in the year 2000 – then promptly forgot it."....."On the other hand, there's more than a chance that, with or without ratification, Kyoto will turn out to be a watershed event, one that launches a world-wide green technology race that changes the way we live and, maybe, our own favoured position in the world economy.*

Gherson hits on the despair and the hope of Kyoto. Given the scepticism that has permeated this article, a "Rio II dud" does seem to be the most likely outcome, but there has to be a watershed sometime and we hope it was reached in Kyoto. We can't duck the issue. It will not go away. It will just become worse and worse. It will have to be addressed sooner or later. The sooner it is the easier it will be to adjust to the measures required to redress the situation.

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