Renewable energy sources are plentiful and economical

In addition to being safe, clean and reliable, renewable energy sources utilize energy that is totally free, yet we hear frequent claims that we cannot afford to use such sources, or that they are not capable of providing sufficient energy. These questions are crucially important from an environmental point of view. We are already beginning to see significant climate changes and losses of biodiversity from global warming, yet in Canada we are making commitments to spend hundreds of billions of dollars in capital, fuel and operating costs to prolong the lifetime of the existing energy systems that threaten the environment.

The primary source of renewable energy is the sun but there are four different methods for harvesting that energy: via the rain (which already produces more than half of Canada's electrical power), via the wind, via solar collectors, and via inter-seasonal storage of heat. The first three are well known but the concept of inter-seasonal heat storage may be less familiar. Ground source heat pumps (GSHP's) provide one example of such storage systems (inappropriately named because the ground is not actually the source of the energy – it just stores the heat from other sources). The Enwave system that cools many of the skyscrapers in downtown Toronto provides another example, in that case storing winter's cold rather than summer's heat for use in the opposite season. The cost of the energy is free from all four harvesting methods but it is appropriate to consider whether they can provide sufficient energy for our needs and whether the capital and operating costs are competitive.

The amount of energy that is available per year from these sources can readily be calculated. Let us take as an example a one square kilometre plot of land that is situated 100 metres above a neighbouring body of water such as a lake or a river. The average amount of rainfall that occurs in the Ottawa area is 861 mm per year and from that we can calculate that 0.0008 petajoules (PJ) of energy could theoretically be derived if the water drops 100 metres from the highland to the river. Ottawa is not a good location for a wind farm but a large wind farm is planned for the Kingston area, where the average wind power is 600 watts per square metre. In a 1 km^2 site that would provide up to 10.8 PJ per year from wind turbines that have 80 metre blades and that are distributed in a grid with 100 m spacing. The mean solar insolation rate in Ottawa is 3.33 kWh/square metre per day, producing 4.4 PJ of energy per year (per km^2) that might be utilized either in thermal form or (at a lower efficiency) in electrical form. The amount of energy that can be stored as heat in the ground depends on the type of bedrock. Such storage systems can store summer heat extracted directly from the atmosphere via air to ground heat exchangers. In North Kanata most of the rock is a form of granite that can store up to 19.5 million kWh per year in the 625 individual heat stores that would fit into 1 km^2, allowing up to 44 PJ of energy to be accumulated for use in the winter. All told then, these four methods for harvesting the sun's energy could deliver up to 59 PJ of energy from a 1 km^2 site..

To put these numbers into perspective, a 600 MW nuclear power station operating 100% of the time produces 19 PJ of electrical energy per year. Although the reactors themselves occupy relatively little space the support facilities are large – uranium mines, mills and mill towns, refineries, enrichment facilities, tailings and spent fuel disposal sites, heavy water production sites, research centres, etc., so nuclear power occupies more than 30 times more space than the renewable energy alternative. Moreover, nuclear power from uranium is not sustainable for a number of reasons, including the scarcity of high grade uranium, and it is inherently dangerous as well as being risky from an international security perspective. As even nuclear power advocates have suggested, it should not be used unless there is no alternative.

The potential for building man-made rainwater catchment facilities is not attractive but bear in mind that the use of power produced from natural watersheds accounts for half of our electricity production in Canada, or 1162 PJ/yr. Similarly, solar production via solar collector fields also has only a modest potential but a mid size city in which the building footprint is 1000 km^2 would accumulate about 12 PJ/yr of solar energy that could be collected by the air conditioning systems in the buildings and injected into the ground for later use for heating the buildings in the winter, so the urban buildings themselves have a very large potential to serve as solar collectors as they stand. Those sources plus only a small amount of land used for wind and for inter-seasonal heat storage would be sufficient to meet Canada's energy requirements if the total amount of energy were the only consideration. In practice, we need energy in the appropriate forms: electricity for our computers, mechanical power for our cars, heat for our homes, etc., and we need to make the energy available at the appropriate times and in the right places. Except for the wind and solar collectors the renewable energy systems incorporate storage so they can deliver the energy whenever it is needed, and except for the wind turbines and hydro dams they can be located anywhere.

Fossil fuels are very good for dealing with power load variations. In Ontario, nuclear stations currently provide baseload power at a constant rate while fossil fuels provide the energy for the summer and winter demand peaks, for the daily load variations (which can amount to a doubling of the load in the daytime) and for the short term load fluctuations. In Denmark this ability to react quickly has made it possible to use wind turbines to produce 20% of their power, but there is currently very little scope for achieving much use of wind power in Ontario because the nuclear plants cannot compensate for either the supply or the load fluctuations. However, renewable energy systems can handle those fluctuations if the four renewable supply systems are tightly integrated. Seasonal storage can handle the seasonal peaks and can make the solar energy component more productive by utilizing energy that would otherwise go to waste. The solar sources provide power during the day, when the demand peaks, and can share short term high temperature heat storage with wind turbines to handle short term deficiencies from both sources. That also make the wind turbines more productive by extracting more wind energy during both strong wind and weak wind periods. The hydro capacity handles the longer term wind/solar variations. All three electricity generation components provide the electricity that is needed to run the pumps for the seasonal storage system, making all four sources strongly interdependent but also making them capable of replacing the fossil fuels.

There is an overriding factor that will control future energy use – global warming. The Intergovernmental Panel on Climate Change has recommended that the world should reduce its production of greenhouse gases (GHG) to 50% of the 1990 level by the year 2050. To meet such a goal the developed countries, which presently produce much more than their fair share of the GHG, will need to reduce their contributions by at least 80%. In the 60 year period prior to 1990 Canada's population grew by a factor of three so if it grows by a similar factor over the 60 years from 1990 to 2050 then the per capita production of GHG will need to be cut to less than 7% of Canada's 1990 production, or less than 5% of the current GHG production per person. Such a dramatic reduction is not likely to be achieved by conservation or by carbon dioxide sequestration so a switch to much greater reliance on renewable energy sources is the rational choice.

There are well over over one million GSHP's in use in North America, most of them installed because they are less expensive over their life cycle. Hydro power has been an inexpensive source of power for over a century. Wind turbines have proven to be viable in Canada and many other countries. If hydro continues to provide half of our electricity and wind power were to produce 20%, as in Denmark, then the question is how to deal with the balance of 30%. Over 34% of the homes in Canada are heated with electricity and nearly all of those homes that have air conditioning use electricity for that purpose (resulting in the huge summer power demand peak) so switching to inter-seasonal heat storage systems will both provide the energy we need and reduce the demand for electricity. The use of electricity for heating is particularly undesirable because of the GHG and air pollution from the coal fired generators that are employed to meet the electric power demand peaks. The remaining 66% of our homes use fossil fuels which of course directly produce GHG so they too will be cleaner and less expensive to operate if they use stored heat (and cold). In Ontario we could very easily and economically eliminate the use of fossil fuels for both the production of electricity and for heating our buildings, and renewable energy sources would still have sufficient capacity to replace nuclear power as well if we choose to do so when the existing nuclear reactors are retired.

The cost of energy has risen sharply, and if we continue to rely on fossil fuels that cost will continue to rise as demand increases and as sources like natural gas and high grade oil peter out, but there will be no corresponding rise in the cost of renewable energy (which will continue to be free) and the capital costs for renewable systems are going down as those technologies mature. Nearly all of the GHG produced in cities like Ottawa comes from our buildings and our vehicles. Carbon sequestration is not likely to be employed for either application, and even if it were there is no known site in Ontario that could contain the CO_2 forever. Piping the CO_2 back to Alberta would be a prodigious incremental expense. We need to make a choice. Propping up the existing energy system will certainly be very expensive and has a high risk of failure in the near term plus a guarantee that it will ultimately need to be replaced. Switching now to renewable energy will be both less expensive and much less risky. Most other countries do not enjoy Canada's potential to utilize renewable energy so such a policy does not endanger our exports of fossil fuels.

The conclusion is that renewable energy sources do have the capacity to meet our energy needs for stationary applications and they certainly will not bankrupt the country.