Wood - the world's most sustainable raw material

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(An update of the keynote paper to the UNFF Intersessional expert meeting on The Role of Planted Forests in Sustainable Forest Management, Wellington New Zealand. (24 - 30 March 2003)

Summary

Sustainability concerns have led to efforts to reduce consumption. However, consumption is a key driver of an economy. Because economic growth requires increased consumption it is political suicide for democratic Governments to reduce consumption.

Consumption is only a problem if we consume unsustainable (finite) resources : Consumption should not be a problem if we consume renewable resources.

Energy is one of our largest resource needs. The sun is by far our most important sustainable energy resource. An environmentally friendly alternative for capturing and storing solar energy is through photosynthesis and the growing of wood.

Wood is very energy efficient and very user friendly. Wood is very versatile - being used for perhaps as many as 100,000 different products. If recent trends to substitute solid wood products were reversed not only would energy demands be reduced but the environment would also benefit. Where possible, solid wood products should replace concrete, metals and plastics.

Fossil fuel use results in permanent additions of atmospheric carbon. In contrast, wood use can result in no long term increase in atmospheric carbon. Provided most of the world practices Sustainable Forest Management (SFM) the carbon released into the atmosphere by the use of wood is quickly resequested by the regenerating forest.

SFM, in both natural occurring and created (planted) forests, will ensure a continual and increasing harvest of wood.

Wood should be increasingly promoted as a renewable and environmentally friendly raw material.

Wood - the world's most sustainable raw material

The consumption question

An increasing global population and a desire to improve living standards have increased the consumption of resources (water, fossil fuels, forests, minerals, etc). As many resources are finite, increasing scarcity will ultimately reduce consumption - a possible threat to the future of civilisation. To postpone the resource scarcity threat many have argued we should reduce consumption. Yet Governments are either reluctant or unable to do so.

Why?

Consumption is not only an essential driver of the economy it is also a major creator of employment. The more a society consumes, the more people employed. Reducing consumption means less employment. If less people are employed then not only do Governments collect less tax but also demands increase (for welfare payments, etc).

As most democratic Governments are trapped into supporting growth strategies (increased consumption), how then might we reduce consumption? If it is political suicide to reduce consumption we have to find a means by which consumption can increase but which does not reduce our finite resources.

> **Consumption per se is not the problem. The problem is the unsustainable consumption of finite resources. If a resource is sustainable, there need be no limit to how much we consume.**

The test of sustainability and environmental friendliness should be applied to all consumption.

Of all the resources we consume, energy is the most important. When we have abundant (and cheap) energy we can do almost anything. We can power all our vehicles, grow our foods, synthesize any chemical, manufacture almost any product, extract minerals (even if present in very low concentrations), extract fresh water from sea water, etc, etc.

Present energy consumption (highlighting our dependence on fossil fuels).

The Statistical Review of World Energy gives the 2006 global consumption of traded fuels (based on oil equivalents). The relative importance of these fuels is presented in Figure !. As they are not usually traded, the estimates exclude fuels such as firewood, dung etc. Figure 1 demonstrate the overwhelming importance of fossil fuels. In 2009 fossil fuels accounted for nearly 90% (oil 37%, coal 27% and natural gas 23%) of the world's traded energy fuels.

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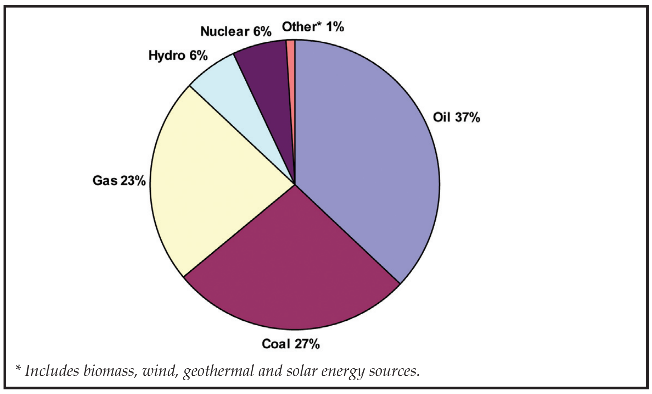

Figure 1: 2006 Global Traded Energy (in oil equivalents)

There are environmental concerns about the atmospheric release of carbon from the use of fossil fuels. There are uncertainties about the size and life of the remaining reserves of fossil fuels (especially oil). Will the world's oil reserves last another 25, 50 or even 100 years? Although it is important commercially to know how long fossil fuels will last there is no uncertainty that fossil fuels are a finite resource. Their continued use is unsustainable. Once used, it will be millions of years before fossil fuels are formed again.

In the longer term, a significant use of fossil fuels is neither environmentally friendly nor sustainable.

To maintain (and hopefully improve) average living standards the world has no option but to increasingly shift from its dependence on fossil fuels to environmentally friendly and renewable energy sources.

Environmentally friendly and sustainable /renewable energy sources.

Earth's sustainable /renewable energy sources are:

- The sun - solar energy (includes hydro and wind),
- Geothermal - heat from the earth's inner core,
- Tidal - from the gravitational pull of the moon's rotation on the oceans, and,
- Nuclear.

Nuclear energy as currently supplied (from the controlled breakdown of the unstable atomic nuclei of U^{235}) cannot really be regarded as a sustainable and renewable energy source. There are also concerns about the reprocessing, storage and disposal of nuclear waste - hardly environmentally friendly. Nuclear power is not politically acceptable in some countries (e.g. New Zealand).

Energy from tidal forces may be environmentally friendly and sustainable but efficient and convenient harnessing of tidal energy has so far proved illusive. Geothermal energy is utilised in some areas of the world but universal utilisation may never be possible.

The sun has been, and will remain, our most important and most accessible, sustainable and environmentally friendly energy source

What exactly is solar energy and what is its distribution on earth?

The energy of the sun is emitted as visual light (44%), ultra-violet (8%), and infra-red (48%). Of the huge amount of energy emitted, only one half of one billionth is actually intercepted by the earth. When the sun is directly overhead approximately 1.4 Kilowatts per square metre is intercepted by the earth's outer atmosphere. Fortunately most of the ultraviolet energy is absorbed by the ozone layer and very little reaches the earth's surface. Clouds, dust, and certain molecules (especially. water vapour and carbon dioxide) reflect and/or absorb some of the sun's energy before it reaches the earth's surface. On average less than half the intercepted solar energy actually reaches the earth's surface. But distribution is far from even and is influenced by latitude, the earth's rotation, cloud cover, etc. The greatest amount of solar energy arrives in tropical deserts - averaging over 7 kilowatt hours per square metre per day - with the least in the polar regions - averaging less than 1 kilowatt hour per square metre per day.

It is obvious that light and warmth come from the sun, but it is not so obvious that both hydro and wind are also forms of solar energy (the result of the sun's warming).

What is often not understood is that the earth has no net energy gain from the sun - on average the planet emits back into space all the sun's energy that arrives. Either solar energy is captured when it arrives or it is lost forever.

How can we utilise solar energy?

There are the well-known options:

- The damming of rivers for the hydro generation of electricity. Certain to remain important.
- Wind used to drive turbines to generate electricity. Wind will become a more important energy source.
- The direct conversion of solar energy into electrical energy with photovoltaic (photoelectric) cells or a chemical process. As costs come down, conversion rates increase and new processes develop, the direct conversion of solar energy will become more important.

Hydro, wind and direct conversion of solar energy are ideal for the generation of electricity. In the future this electricity will probably be used much as it is now. However, an additional electricity demand may come from an emerging hydrogen/fuel cell industry - hydrogen is a contender as a future transport fuel and most could be produced using electricity generated from renewable sources. Hydrogen/

fuel cells might ultimately replace oil, liquid petroleum, natural gas, etc.

Because transport and electrical requirements dominate considerations of future energy needs we may be overlooking the energy required for the manufacture of materials and chemicals. The energy requirements of these sectors are not inconsiderable.

Although some of the energy for the manufacture of materials and chemicals could come from electricity generated from renewable sources, there is an attractive solar energy alternative - photosynthesis

What is photosynthesis?

Photosynthesis is the miracle process by which plants and phytoplanktons capture visible light energy (and with the aid of chlorophyll) convert water and carbon dioxide into glucose and oxygen. Plants then convert that glucose into many organic chemicals. Consumption of plant material (in both the sea and on the land) releases the embodied solar energy and this is the energy that is the basis of almost all life on the earth.

The most common organic molecule is cellulose - a very long insoluble polymer of about 10,000 sugar molecules laid end to end. Cellulose and all other plant chemicals are essentially stored solar energy. Wood is 50% cellulose.

Wood's embodied energy can be released by burning or converting its complex chemicals into simpler compounds (e. g. methanol, ethanol, methane, etc). But why go through this indirect process? It is energy inefficient to use wood as a biofuel to generate energy (heat, electricity, etc) and use that energy to manufacture a metal or another product. It is also energy inefficient to break down the complex organic compounds of wood into simpler organic compounds and use them to make plastic products or to burn them to recover the embodied energy. Why not use the wood in its solid form in the first place?

Wood's raw material advantage is a result of how trees grow.

Photosynthesis in the tree's needles or leaves produce glucose. That glucose is translocated via the tree's cambium and transformed into cellulose and other complex organic chemicals. These chemicals form wood - a porous honeycomb structure that, although not completely rigid, is very strong for its weight. The strength of wood ensures that a 50, even a 100, metre tree can withstand severe storms.

As wood in a living tree rarely decays, most trees (except when very old) contain all the wood they have ever produced - a 100 year-old tree contains 100 years of stored solar energy.

As well as being strong for its weight, wood is also easy to process (to saw, to peel/slice, and to surface finish). The processing of solid wood requires minimal amounts of energy. The energy efficiency of wood was confirmed by an American study (Koch 1992) that established that solid wood building products are ten to thirty times as energy efficient as the equivalent non-wood substitutes (steel, concrete, etc).

In a New Zealand comparison of wood and other building materials, Buchanan (1993), concluded that the manufacture of wood products required much less process energy than steel, concrete or aluminium. Wood use also results in lower CO_2 emissions, because of less fossil fuel in the manufacturing process.

Solid wood is a very energy efficient raw material. Solid wood processing is environmentally benign and should be relatively free of pollution.

Because it takes energy to breakdown solid wood into wood chips or fibres and then to recombine them, reconstituted wood products such as wood pulping (especially mechanical pulp), particleboard, medium density fibreboard, etc are not as energy efficient as solid wood. Especially in the last few decades, wood substitution has increased. Probably every one of 100,000 different products made from wood could be substituted by a metal, concrete, plastic or ceramic product. As all wood substitutes require more energy and involve a more polluting processes, a greater use of wood would reduce both energy use and pollution. Wood could ideally replace steel and concrete in many light construction uses, small bridges, poles, cable drums etc.

Wood use does require tree harvesting but it is possible to harvest trees in an environmentally responsible manner.

A greater use of solid wood would reduce both energy use and pollution but we must be certain that wood production is sustainable.

How sustainable is wood production?

Wood comes from trees. Most trees grow in forests. These forests can be natural (including managed natural forests) or deliberately created forests - plantations. Is it possible to supply all the wood requirements of the world from plantations? No, there is currently too small an area of plantations. Estimates of the current supply of industrial wood that comes from existing plantations vary from my own estimates of 20% (Sutton, 1999) to 35% (ABARE, 1999). Some of world's plantations supply is from short rotation pulpwood crops. The percentage of the world's sawlogs that comes from plantations (i.e. for the manufacture of solid wood products) is by my estimate less than 15%. There are no estimates of how much of the world's fuelwood comes from plantations but the supply is small. Although plantations supplies are increasing, a large proportion of the world's wood supply (especially sawlogs) must come from natural forests. Regrettably, some of these forests have been (and will be) poorly managed.

Forests (especially natural forests) are often perceived as being static and unchanging ecosystems. Also, some natural forests are considered to be so fragile that ecosystems are permanently damaged by harvesting. Claims that forest ecosystems are fragile are not supported by evidence from forest ecology. Over millions of years, any existing forest ecosystem has survived countless natural catastrophes - disease, fire, hurricanes, volcanic eruptions, tsunamis, and even thousands of years of ice ages and other climate changes.

That forests survive and recover from even the powerful natural disasters demonstrates the resilience of forest ecosystems. Where only a part of a forest is altered or damaged complete forest recovery is almost always possible. There are countless examples throughout the world of forest recovery following harvesting. It is doubtful if there is a single example of long-term permanent forest damage following any responsible harvesting operatio[1]. Even where there is total and permanent forest destruction over a large area (as in total forest destruction for agriculture or urban settlement) complete forest recovery is likely, but it will take longer. Europe is an excellent example - within the last thousand years probably every hectare of low to medium altitude natural forest has at some time been completely destroyed and used for agriculture for a century or more. Although that land clearance was permanent over 20% has now reverted back to forest - most without any human help.

Although there are sound ecological reasons why forests quickly recover after responsible harvesting, forest harvesting can be controversial. Forest managers, forest owners, Governments, local body agencies, etc have a responsibility to the public to demonstrate not only that wood harvesting is environmentally friendly but also that wood harvesting is sustainable.

There have been recent world-wide moves towards forest certification and national implementations of criteria and indicator processes for sustainable forest management (e.g. the Montreal and Pan European processes). Adoption of these processes should ensure that forests are responsibly managed and that forest operations are being independently monitored.

[1] *Proof of the absence of damage comes from the lack of response to a challenge issued by the Canadian forest ecologist, Dr Patrick Moore. Fourteen years ago Dr. Moore put out a challenge to those who claim that forest harvesting was responsible for the majority of species extinctions. His challenge was to substantiate their claim by naming just* ***one*** *species anywhere in the world that had become extinct because of tree harvesting. So far not a single species has been named (Dr Patrick Moore* pers comm*).*

But can forest managers really be sure that tree harvesting is sustainable? Professional forest managers, especially in Europe, have been managing forests for the sustained harvest of wood for centuries. The skills of sustained forest management are now world-wide. Although the principles of sustained management are relatively simple they have attracted criticism because traditionally the sustainability concept related only to the volume of wood.

Although plantations are destined to become much more important globally, claims have been made that the productivity of plantations decreases in subsequent rotations. Plantations of radiata pine in New Zealand (where there is now in excess of 5 rotations of experience and several sites already been planted with three consecutive rotations) have been comprehensively studied (theoretically and in actual growth studies). Maclaren 1996 reviewed those studies and concluded that there was no decrease in productivity in subsequent rotations of plantations. A very detailed analysis of a radiata pine stand in New Zealand by Woollons (2000) found enhanced growth in the second rotation, but attributed this to better establishment standards and more favourable climatic conditions rather than any soil amelioration. The most comprehensive global study of the sustainability of plantations is that of Evans 1999. His conclusion (which supports the findings of both Maclaren and Woollons) was that "measurements of yield in successive rotations…suggest that there is…no significant or widespread evidence that plantations are unsustainable. Where yield decline has been reported, poor silvicultural practices and operations appear to be largely responsible."

The conclusion of considerable research is that the productivity of subsequent rotations of most plantations is not declining. Nor is there any evidence to suggest there should be any decline.

The carbon question

The following discussion could imply that the atmospheric carbon from wood use is somehow different from the atmospheric carbon that comes from the use of fossil fuels. While there is no chemical difference, there is a major difference in the rate at which carbon is subsequently reabsorbed.

Because of human activity, especially in the last 100 years, the concentration of carbon dioxide in the atmosphere has increased - the result of the burning of fossil fuels, the manufacture of cement, the destruction of forests, etc. Many are convinced this will adversely effect the future global climate.

Although both fossil fuels and wood are essentially stored solar energy they have different origins and their use has different effects on the net levels of atmospheric carbon.

Fossil fuels slowly accumulated over hundreds of millions of years in the crust of the earth. When the carbon in fossil fuels is released into the atmosphere that carbon will effectively stay there for millions of years until it is resequested.

The carbon in wood was sequestered in the decades or centuries before the extraction of the mature tree. With sustainable forest management the fate of carbon released by the burning or decaying of wood should not be equated with carbon coming from fossil fuels. Provided the forests are sustainably managed the carbon from wood is not a permanent addition to the atmosphere. As the forest continues to grow, carbon in the atmosphere is removed by photosynthesis and transformed back into wood. The only time carbon released from wood remains in the atmosphere is where the forest is permanently destroyed and the land converted to agriculture or another non-forest use.

This highlights a crucial difference between fossil fuels and wood. Fossil fuel use permanently increases atmospheric carbon whereas wood use need not. With responsible harvesting of forests an equivalent amount of atmospheric carbon is resequested back into more wood.

> **The use of wood effectively recycles carbon: the use of fossil fuels results in a permanent increase in atmospheric carbon.**

In contrast with fossil fuels, the world can continue to use a large volume of wood and (provided forests are responsibly and sustainably managed) there will be no permanent increase in atmospheric carbon.

Future wood consumption

The world currently consumes about 3.5. billion cubic metres of wood (a little less than half as industrial wood and more than half as fuelwood). The global totals published by FAO show that the per capita global consumption of wood has declined slightly through the 1990's (Sutton, 1999). Even though the per capita global consumption of industrial wood is declining and although the products are not really comparable, the average person still consumes a greater weight of wood than any of basic food items (wheat, maize, rice, etc) or industrial commodities (cement, steel, plastic etc) (Sutton 1999).

Because wood use need not increase atmospheric carbon, the per capita consumption of wood may not continue to decline. A greater wood use could well increase demand. The current global population is approaching 7 billion and is expected to increase to over 10 billion by 2040/2050. That population increase alone may increase the annual wood demand (assuming the world average per capita use of wood does not change) by 2 billion cubic metres more than could be supplied from existing forests (including plantations) (Sutton 1999). These projections are conservative (conservative because for environmental reasons the world could/should consume a greater volume of wood). To supply an extra 2 billion cubic metres by the year 2050 the world would require a plantation of fast growing tree species with a total area of Nigeria or the Canadian province of British Columbia. That plantation is assumed to have a mean annual growth rate of 20 m^3/ha/yr (the average yield of radiata pine plantation in New Zealand and Chile) and it would need to be established as soon as possible.

Conclusions

If the world used more solid wood civilisation would be more sustainable and more environmentally friendly. Because it is a sustainable raw material, wood use will help us to maintain consumption and employment. A world consuming greater volumes of wood will demand more sustainable forest management for more of the world's forests (both natural and planted).

Because of wood's sustainability and environmental friendliness there must be greater efforts to promote wood use. Where possible solid wood should substitute for metals, concrete and plastics. There is also the need for more research and innovation in the development of new wood products.

What other environmentally acceptable solutions do we have?

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