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SUSTAINABILITY OF BUILDING STOCK: AN INTRODUCTION

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By Ivan M Johnstone

Abstract

This paper outlines the reasons why the author is researching the sustainability of residential building stock in New Zealand. It cites the growing global difficulties in maintaining or replacing our capital infrastructure; and the history of misallocation and current insufficiency of funds due to competing demands. Current OPEC estimates of fossil fuel reserves indicate that our reliance on these is facing a transition period during the physical life-time of our existing building stock. Outlined are the areas to be investigated, with an introduction to sustainability in the context of the physical laws of energy and matter.

SUSTAINABILITY OF BUILDING STOCK:

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The primary objective of my PHD study is to establish the necessary criteria to ensure sustainability of New Zealand's residential building stock. The majority of previous building economics research and commercial activity has concentrated on adding further buildings to our existing building stock. There has been little room for pause to ask to what extent can we continue to do so or at what level of building stock will the total share of national resources used by the construction industry be required fully for maintenance and replacement only.

In the case of infrastructure, studies carried out in the United States in the early 1980's show that during extended periods of tight budgets and inflation the maintenance of highway systems, bridges, railroads and rolling stock, water supply systems and sewage systems have been deferred to the extent that many public facilities have worn out faster than they were being replaced.[1] The backlog in many cities is tremendous, and as quickly as the worst problems are resolved more problems surface. Estimates of the cost to rebuild what already is in disrepair run as high as US$3 trillion ($3,000,000,000,000) for this decade alone.[2] In June 1975 there was a major collapse of a sewer in Store Street, Manchester. The resulting hole in the street was large enough to accommodate four double-decker buses. Reconstruction of the 35 mile long central city sewer network will be necessary. In many other cities in the United Kingdom aging sewers have exceeded their design life or can no longer handle the loads that population increases place on them.[3] The difficulties in offsetting deterioration or replacing capital stock due to a history of misallocation of funds and a current insufficiency of funds due to competing demands is a world wide problem which is not isolated to the United States and the United Kingdom alone.

My study on the sustainability of capital stock will be limited to an investigation of residential buildings in New Zealand. The principles involved, however, apply to all categories of building stock and infrastructure. The following areas will be investigated:

The criteria for sustainability.
Historic and current levels of building stock.
Projected levels of building stock.
Entry and departure rates and vacancy ratio.

Direct and indirect primary energy and material resources consumed by the building industry used in the following:

additions of new dwellings;
replacement of existing dwellings;
offsetting of physical degradation.

Key materials and potential substitutes
Primary causes and rate of physical degradation
Design and economic strategies to ensure sustainability of building stock

Because I am only some 7 months into my studies it is too early at this stage to outline any preliminary results. At this seminar I will cover the context of sustainability rather than going into any great detail or specifics.

In the early 1970's I read three books which initiated my interest in sustainability - namely Rachel Carson's "Silent Spring, Paul Ehrlich's "The Population Bomb", and the Club of Rome's report "The Limits to Growth". The basic thesis of each of these books are as relevant today as they were back then.

"Silent Spring", first published in 1962, was initially criticised by the scientific community for overstating the case and being unduly alarmist.[4] Almost 30 years have passed since Rachel Carson drew the public's attention to environmental issues. There are few people today who would dispute her basic thesis that our industrial society persistently and continuously poisons the planet.

It took perhaps one or two million years to reach an estimated world population of 1 billion people in 1850[5]. As early as 1798 Malthus wrote of his concern that the rate of population increase would outstrip the rate of food production.[6] Because the industrial revolution resulted in a dramatic increase in food production Malthus' fears and predictions were regarded as groundless. However, it took only a further 80 years for the world's population to double to 2 billion people in the early 1930's.[7] The next doubling of the world population took another 45 years to reach a world population of 4 billion people in 1975. In the early 1970-'s the doubling period was down to 36 years.[8] Paul Ehrlich set out the consequences of such a high population growth rate in his book, "The population Bomb".[9]

Since the turn of the last century the population growth rate of the fully industrialised countries, such as the United States and New Zealand, has fallen. In New Zealand, we are currently barely maintaining a replacement level.[10] Population growth in the third world countries, however has been increasing rapidly.[11] Some third world countries have recognised the dangers of over population and have taken steps to reduce their population growth. China has implemented a programme to encourage their citizens to limit the size of their families while India has opted for a more drastic approach by promoting and providing sterilisation facilities.

In spite of the falling population growth rates in the industrialised countries and these efforts by China, India, and other developing countries the world population, as of 1987, is estimated to be 5.0 billion people with a doubling rate of 41 years.[12]

Demographer, Nathan Keyfitz, has calculated that if the third world countries were to achieve a replacement only fertility rate overnight then their population would continue to increase, due to an inbuilt momentum, until it stabilised at about 1.6 times its present size.[13] The high world population growth rate still remains one of our most pressing global problems because it is the available resources per capita which largely determines the potential quality of life for each and everyone. What compounds the problem is that until recently the third world countries have willingly, or otherwise, accepted a smaller per capita share of the world's resources. This situation will not necessarily continue.

The Club of Rome's report, "The Limits to Growth" was based on the first global computer model which incorporated the various factors of energy supply, food production, population, pollution and so on.[14] A year later in 1973 OPEC's oil cartel resulted in the immediate tripling in the price of a barrel of oil.[15] The timing of the report and subsequent events caused much public discussion, concern and, perhaps, alarm.

One positive impact of the OPEC cartel was to make governments and the general public more aware of their vulnerability and reliance on a continuing supply of oil. Many countries, including New Zealand, initiated energy conservation programmes and research into alternative energy supply systems over the latter half of the 1970's and the early 1980's. Governments worked towards becoming less dependent on imported crude oil and petroleum. In New Zealand the production of alternative fuels from natural gas and the Think Big oil refinery processing plants are the results.

The "Limits to Growth" report was widely criticised for being over-simplistic.[16] Advocates of a growth economy attacked the report as being an elaborate example of GIGO - "Garbage In, Garbage Out". The report was also referred to as the computer that cried "W.O.L.F". In hindsight it would appear that many critics over-reacted to the predictive nature of the report. The main thrust of the report is axiomatic. Because we live on a finite planet, the planet's stock of fossil fuels are finite. Because we are daily consuming part of these stocks eventually the stocks of available fossil fuels will become exhausted. The big question is when? No-one can answer that question with absolute certainty. That depends on the rate of consumption in the future and no-one can foretell the future.

Some 17 years after "The Limits to Growth" was first published many people today still operate as if there were no physical limits to economic activity while others operate on the basis that there is an endless line of substitutions waiting in the wings ready to replace each resource which may become exhausted. Because the real price of oil has not increased over the 1980's this could be interpreted as a reflection of the true scarcity of our global stocks of fossil fuels.[17] It would be easy to dismiss the inevitable exhaustion of our fossil fuel reserves as being a problem which can be dealt with in the more distant future. This would appear to have been the case. Programmes to set up alternative energy supply systems, such as energy farming, have not been implemented. Funding for energy research in the United States and New Zealand has been given a low priority. An indication of the importance given to energy research by the New Zealand government is the disbandoning of the New Zealand Energy Research and Development Committee in the late 1980's and the demotion of the Ministry of Energy which is now a division of the Ministry of Commerce.

As a result of my interest in sustainability I joined a small group of students at the Auckland Architectural School in 1978 to make an undergraduate study of Low Energy Settlements in New Zealand. Associate-Professor Cam McClean was our supervisor. Although various energy forecast studies, such as "Energy Scenarios for New Zealand" by Dr Garth Harris et al. and "Goals and Guideline: An Energy Strategy for New Zealand" by the Ministry of Energy had been published prior to our effort the group study was unique in that it was one of the first attempts in New Zealand to make a holistic study of Sustainability. [18] [19]

Each student concentrated on a particular aspect of human settlements while at the same time participating in a group "think tank". Some areas of study led to conventional conclusions while others - in particular Leslie Mathew's chosen topic of agriculture, a key factor - led to a group consensus that settlement spatial patterns would ultimately need to change with the advent of a diminishing supply of easily accessible high-grade energy.[20]

My own thesis concentrated on the context of a sustainable low energy future.[21] Initially, I thought the necessary criteria or pre-conditions for Sustainability could be summed up as being Zero Population Growth (ZPG) and Zero Energy Growth (ZEG). These conditions were then commonly known as "Steady State" or non-static "Stationary State" as expounded by Herman Daly.[22] The concept of a Stationary State of economics is not new. Stationary State has been referred to by the philosophers Plato and Aristotle and the 18th and 19th century economists Adam Smith, John Stuart Mill, and David Ricardo. The early 20th century economist, A.C. Pigou, wrote a serious study of Steady State Economics in 1935.[23] However, confusion and ambiguity has reigned because not all have clarified what they meant by Stationary State. After reading Nicholas Georgescu-Roegen's seminal book, "The Entropy Law and the Economic Process". I was made aware that a permanent steady state in a closed system such as our planet Earth cannot exist.[24] "Steady State" is a hypothetical time instant of sustainability.

After an absence of some 12 years from University life I have returned to carry out an economic study of building stock where the context of sustainability once again forms the framework. Because the value judgements, or pre-conceptions, of a researcher can greatly influence and cloud any investigation I consider that all value judgements which are known to bear on the research topic should be made clear at the outset. This applies especially to the working definition of "Sustainability".

I acknowledge that there may be alternative or opposing value judgements. Being value judgements they will be equally valid but not necessarily equally rational. To judge what is rational is, in itself, a value judgement. At some point, in order to avoid an infinite regress, we need to mutually agree as to what is rational. I trust that a wish to preserve the survival of the human species is a sufficiently rational first value judgement.

My second value judgement is that the system we are most concerned with is humankind, the capital stock humankind relies on for our survival, and the institutions that provide a quality of life worth living for.

My third value judgement is that while Sustainability cannot last forever, for reasons which will become clear, the duration of Sustainability should definitely, at the minimum, extend beyond the generations of our future grandchildren.

For me to wish for our species to continue for another 200 or 2,000 generations, or 20,000 generations becomes equally meaningless. What I can empathise with is the potential quality of life available for our far distant future generations. My fourth value judgement is that the actions of today's generations should not prejudice the options of future generations. But that value judgement can never be absolute. Unless our distant future generations migrate to other planets, which can only happen if they manage to tap into a high grade flow of energy, any economic process we carry out now in our closed system of the planet Earth will affect the potential life support system of future generations.

The Concise Oxford Dictionary definition of "Sustainability" is the ability to "keep going continuously". The working definition of "Sustainability" I have chosen to apply to my study is "the ability of the human species and its support systems to self-regenerate over a large and indeterminate number of cycles." The time frame that I will be looking at is over the physical lifetime of our existing building stock.

It is my firm opinion that the fundamental criteria or pre-conditions for Sustainability should be based on physical laws and not prevailing mental constructs of the economic process. I consider the scarcity of physical resources to be more fundamental than the scarcity of capital funds. This approach is a major point of departure as compared to the orthodox approach to economics. By doing so, in no way am I advocating an alternative Resource Theory of Value.

The following set of Laws of Thermodynamics appeal to me for their conciseness and simplicity:[25]

I No mechanical work can be obtained without using energy.

II No mechanical work can be obtained in actuality without some energy being degraded into an unavailable form.

III No actual system can be completely purified of unavailable energy.

The following "Laws of Matter" are a combination of well established physical phenomena:[26]

I No mechanical work can be obtained without using matter.

II No mechanical work can be obtained in actuality without some matter being degraded into unavailable form.

III No material substance can in actuality be completely purified of its contaminates.

The laws of thermodynamics and matter, in combination with our knowledge of open and closed systems, establish that the sustainability of our support systems are dependent and conditional upon the availability of a flow of energy and the availability of matter necessary for use within those support systems.[27]

In any system the encompassing system affects the sub-system. In a study of the sustainability of building stock our global reserves of fossil fuels, sources of building materials, and the flow of solar energy all need to be taken into account. Building stock in New Zealand relies on imported fossil fuels and building materials. In 1971 the direct and indirect energy requirements of the construction industry accounted for some 16 percent of the total national primary energy. Of that energy for construction purposes some 70 percent was imported in the direct form of fossil fuels or indirectly in the form of building materials.[28]

By relying on high grade energy and materials New Zealand comprises an open system in that both energy and materials flow across the boundary of that system in both directions. The ultimate source of all high grade energy and materials for each country is the closed system of our planet Earth where solar energy alone crosses the boundary. Solar energy comprises a flow of energy in that it is a constant but continuous source of energy. A stock of energy, on the other hand, is a finite store of energy which ultimately becomes exhausted. Our reserves of fossil fuels are an example. The extent of the flow of available energy sets a physical limit on the potential level of sustainable economic activity. The availability of matter sets the ultimate limits of the duration of sustainability due to the following reasons.

Available matter is matter in a bulk form which can be accessed and used within our support systems. All energy converters such as hydro dams, solar collectors, and wind generators require available matter in order to tap into a flow of energy. The matter in machines wear out due to friction. Matter in the form of capital goods, such as buildings and solar collectors undergo a process of degradation and decay. This can be partially offset by maintenance but only for a finite period of time. Even the matter in soil cannot sustain food production forever without necessary nutrients being replaced from other sources. In theory we could expend enormous amounts of energy over an infinite period of time to retrieve every single molecule which has dissipated into the environment and form these molecules once more back into bulk available matter. In practice, available matter follows the same fate as high grade available energy. Both available matter and available energy are eventually dissipated into the environment. The continual dissipation of available matter, therefore, sets the ultimate limits for sustainability. Because humankind relies so heavily on the use of bulk matter in its support systems sustainability for humankind is not for ever.

Provided that a flow of energy is being tapped, and that the eventual dissipation of this flow of energy into the environment does not lead to an over heating of the atmosphere (only the flow of solar energy meets this criterion), the actual duration of sustainability is determined by the accumulated sum of economic activity which continuously dissipates matter. This could be a high level of economic activity enjoyed by a small population, or a low level of economic activity enjoyed by a larger population over the same duration and all the various combinations in between. As Georgescu-Roegen pointed out, every additional car on the road represents part of a potential life support system of a distant future generation.[29]

Society today does not rely on a flow of energy but instead relies on stocks of energy. One indicator of the remaining life-span of our energy stocks is to divide the proven reserves of any energy stock by the current rate of consumption of that energy. Such a study has been carried out by OPEC for our proven global oil reserves which estimates that these oil reserves would become depleted within 106 years based on the 1988 global rate of consumption.[30] Such an indicator, however, is over-simplistic in that it does not take into account that during such a time period the energy requirement to extract fossil fuels will be increasing at an accelerating rate. The resulting effect will be an increase in the real cost of oil which may, or may not, reduce demand and subsequent consumption rates. If the world population doubling period is currently 41 years and per capital demands for oil remain the same then there is every indication that the global demand for oil will continue to increase in spite of any real increase in the price of oil. Eventually when the energy requirement to extract each barrel of oil approaches the energy contained within each barrel there will still be oil reserves in the ground but these reserves will be too energy intensive to extract for use as an energy source. Of more immediate and critical concern is the point of inflection of oil production when the physical rate of production can no longer match demand regardless of price. Unless oil production is immediately curtailed, or there are vast oil reserves yet to be discovered, the timing of this inflection point has more of less already been determined by our past history of consumption. This inflection point will occur long before any estimated "life-span" of our oil stocks and, based on current estimates of proven oil reserves, should occur well within the time frame of the physical lifetime of our existing building stock.

The level of building stock that we are able to sustain at any point in time is physically determined by the availability of high grade energy and building materials. There is a growing global difficulty to maintain or replace our capital infrastructure due to a history of misallocation of funds and a current insufficiency of funds due to competing demands. It seems likely that our reliance on energy stocks is facing a transition period during the physical lifetime of our existing building stock where global oil production will be unable to match demand irrespective of increases in the real cost of oil. Can we afford to assume or operate as if our building stock can be added to ad infinitum?

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