# The Steady-State Economy: The only path to a sustainable future?

## Abstract

Ecological Economists (e.g.: Herman Daly) claim that sustainable development can only be achieved by drastically changing our growth based economic system. Continuous economic growth, which is the goal of every government, is inherently incompatible with sustainable development, unless sustainable development is defined in a weak sense; that is as accepting substitutability between human made and natural capital. This is currently done by neoclassical economic theory, the roots of which are based on a value concept, analogous with the conservation principle of classical mechanics. Some authors argue that it is this value concept combined with the panacea of technological progress, which allows neoclassical economic theory to believe in unlimited economic growth.

Not only is continuous economic growth physically impossible (i.e.: the dematerialisation hypothesis is a myth), given Georgescu-Roegen's interpretations of the laws of thermodynamics, but also undesirable. Various studies (e.g.: calculations of the Index of Sustainable Economic Welfare) suggest that the actual wellbeing of the human society is not increasing, but in fact decreasing with further growth of the economy.

The alternative to growth or decline is the steady state. Most classical economists acknowledged the existence of a steady state, including Adam Smith, Thomas Malthus, Karl Marx and John Stuart Mill. They all had their own ideas about such a state; some equated it with disaster, others glorified it. However, most of them had a positivistic concept of such a state.

Herman Daly supports Mill's view of a positive i.e.: inevitable, but also normative steady state. He believes that humanity would be well advised to bring about a steady state economy (SSE) before it is forced upon it. Daly offers a theoretically simple political framework, which could be used for such a goal. Three institutions are to be employed to stabilise the system at a constant level. The first one would be in charge of stabilising the human population, which is inevitable. The second institution introduces depletion quotas, which are auctioned by the government, in order to reduce material and energy throughput. Finally a distributionist institution ought to secure social justice by introducing minimum and also maximum income limits.

Obviously this is a very controversial concept and has been mostly ignored by fellow scientists or rejected as utopia. Robert Ayres argues that given enough energy, which could be generated by finding new ways to capture the abundant solar rays, almost anything could be recycled, allowing for even more economic growth. There are many flaws within Daly's ideas and there are issues, which are not discussed (e.g.: imports, expropriation of the rich, entrepreneurial incentives). One important aspect is whether the functioning of the capitalist system could be maintained in a steady state. Mill, Marx, Schumpeter and Keynes, all implicitly assumed that a steady-state economy would be equal to socialism (or at least the end of capitalism).

Nevertheless these flaws in Daly's SSE concept do not justify a rejection of his approach and of the steady state as such, but should give rise to the development of other concepts or suggestions for its improvement. The sustainability discourse cannot and should not ignore the concept of a steady state.

## Introduction

At least since the Brundtland Commission's Report (WCED 1987), *sustainability* and *sustainable development* are buzzwords among politicians and within international institutions. The very meaning of these words and their implications however, remain ambiguous to date. In fact it is supposed that the only reason why there is such widespread support for the sustainability concept is that it has been left rather vague by the authors (Costanza, Norgaard et al. 1997). Neither did the Brundtland Commission distinguish between strong and weak sustainability, nor did they point in anyway towards the sharp conflict between sustainability and growth.

Since the earth is finite and non-growing, any physical subsystem must also eventually become non-growing. It follows that economic growth and sustainable development are incompatible. The former refers to a quantitative expansion in the scale of the physical dimension of an economic system, while the latter should refer to the qualitative change of a physically non-growing economic system in dynamic equilibrium with the environment (Costanza, Norgaard et al. 1997). The modern 'growth debate'[1] is however much older than the Brundtland Report. The influential report to the Club of Rome, *The Limits to Growth*, by Meadows et al. (1972), predicted an imminent depletion of natural resources, using an integrated world model. Even earlier than that some authors pointed to the limits imposed by the second law of thermodynamics for economic systems (Boulding 1966; Georgescu-Roegen 1971).

The aim of this paper is firstly to analyse the origins of what will be referred to as, the 'growth paradigm'. Then the physical possibility and socio-ethical desirability of continuous economic growth will be further discussed. The two final parts of this paper will then present the steady state economy (or stationary economy), as the only sustainable alternative to the growth economy. After looking at the theoretic history of this alternative concept, Herman Daly's (1992a) visionary institutions for bringing about a steady state are presented and critically analysed.

**The growth paradigm and its theoretical background**

Economics began as a branch of moral philosophy, where the ethical content was at least as important as the analytical, up to the writings of Alfred Marshall (Brandis 1989). Marshall's *Principles of Economics* (1890) established neoclassical economic theory as the mainstream economic theory. From then on, so Daly (1992a, p 3), "(...) *the structure of economic theory became more and more top-heavy with analysis. Layer upon layer of abstruse mathematical models were erected higher and higher above the shallow concrete foundation of fact.*"

Stanley Jevons (1835 –1882) suggested renaming what was then called *Political Economy* into *Economics* and the change of words was coupled with the most important paradigm shift in theoretic economic history. It brought about a „destruction of the classical system" (Schumpeter 1970 [1908]) with far reaching consequences. Motivated by the successes of the natural sciences, in particular physics and classical mechanics, efforts were undertaken to establish economics as a more scientific subject. This was a direct result of an influential philosophical movement of the 1920s and early 1930s, called *logical positivism*. It originated from the Vienna Circle, a group of loosely knit philosophers, led by Moritz Schlick (Okasha 2002).

Culminating with Marshall's Principles (1890) economics gradually adopted a mechanistic philosophy in the period between 1870 and 1939 (Wiener 1966).The field theory of value, which is based on the energy field of classical mechanics became the core of neoclassical economic theory. Therein value is equated with utility and thus no longer resides in the goods, but in the mind of the individual (i.e. peoples preferences) (Söllner 1997). The resulting human behavioural goal of maximising utility also originates in the analogy between energy and utility. From this moment normative concepts became exogenous to economic theory, ethical issues were now a matter of personal taste and economics emerged as the simple "mechanics of utility and self-interest" (Jevons 1924). Economists fully embraced "the mechanistic, reductionistic and positivistic mode of thought" (Daly 1992a, p. 20) at the time. The consequences were far-reaching, in particular with respect to the position of the ecosystem relative to the economy.

[1] The 'growth debate' itself probably goes back to the writings of Thomas Malthus in the 18th century.

Even today the Economy is often portrayed as a closed, isolated system in economic textbooks, similar to a clockwork (Georgescu-Roegen 1971), or the circular flow model depicted in Figure 1 (Daly 1996; Martínez-Alier and Roca 2000). Hence there are no inflows from and outflows to the environment. The supply of natural resources and the capacity to absorb waste are therefore not perceived as limiting factors for economic development. However in the late 60's early 70's, environmental problems became more and more evident and this economic model was challenged, probably most famously by Boulding's (1966) concept of ‚*spaceship earth*' and the *Limits to Growth* by Meadows et al. (1972) The response to these developments was the creation of the sub-discipline of environmental economics, but it was built upon the same foundations, i.e. the energy analogy, as neoclassical economics and is therefore affected by the same shortcomings (Söllner 1997).

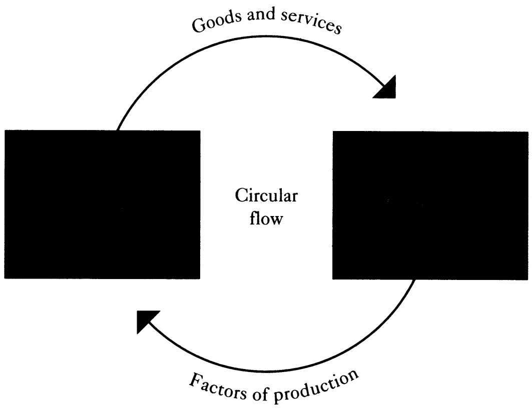


Figure1: The economy as an isolated system (taken from: Daly 1996, p. 47)

Firstly resources are assumed, in principle, to be substitutable without restrictions. Although this might be true for some goods and raw materials, it is ridiculous to assume for example that copper could ever substitute rice in the human diet. Nevertheless orthodox economists (e.g.: Barnett and Morse 1963) reject the concept of *absolute scarcity* advocated by Daly (1992a) , to them resources are only scarce relative to another resource, or a different (lower) quality of the same resource. Relative scarcity can be overcome by substitution, whereby relatively abundant resources are eventually substituted for relatively scarce ones. Resources are therefore unlimited in total and merely non-homogenous in quality. Advances in science and technology are supposed to overcome this obstacle by making them more homogenous.

According to Daly (1992a) *ultimate means* in the form of low entropy matter/energy are scarce in an *absolute* sense i.e. there are absolute limits beyond which availability is nil. The allocative efficiency of markets, based on the price mechanism, which is the focus of neoclassical economic theory, can only deal with relative and not absolute scarcity. Since there is no substitute for low entropy matter/energy, to raise the *relative* prices of *all* of these resources would merely increase the absolute price level and cause inflation. Since Meadows et al. (1972) it became evident that in terms of sustainability, absolute scarcity of sinks is going to be even more problematic for future generations than that of natural resources. It will possibly be much easier for future generations to find a substitute for petroleum than to deal with climate change for example. Environmental Economics intends to counter pressures on the environment, which they regard as negative externalities, by internalising them via

Pigou Taxes. This strategy again ignores the fact that most services provided by nature are scarce in an absolute way.

The so-called *weak* interpretation of sustainability is also based on factor substitutability. Human-made capital is assumed to be a perfect substitute for natural capital. Thus the loss or degradation of the stock of natural capital (resources and sinks) to future generations is being compensated by what is being created by humans (structures erected, technologies developed, knowledge gathered, etc.). The fact that virtually all human produced artefacts are 'perishable' (Ricardo 1817), i.e. they depreciate, is completely ignored. Most of them will probably have to be replaced entirely within 100 years time (Viktor 1991) (the same could be argued for technology and knowledge).

Natural capital and man-made capital are indeed supplements and not substitutes. This has often been illustrated on the example of the fishing industry. Historically, in an 'empty-world-economy' (see below), the scarce factor were the fishing boats (manmade capital). This role has been changed over the last decades. Now that we live in a 'full-world-economy' the scarce factor is fish (natural capital). New fishing boats equipped with high-tech instruments are in total not increasing the amount of fish caught, instead the opposite is true. Meanwhile over-fishing has lead to a decrease in the world stock of fish, which has dramatically reduced their reproductive capacity. Hence the fishing industry has clearly exceeded the limits of the newly scarce factor (Costanza, Norgaard et al. 1997).

Secondly, the mechanical value concept has a strong impact on the treatment of *time* in neoclassical economic theory. It is argued hat often even its very existence is denied. In those cases, where time *is* taken into account, it is treated in a mechanical way. There is no such thing as uncertainty; everything is known either with absolute certainty or in the form of some probability distribution (Georgescu-Roegen 1971 ch. 5-8; Edmonds and Reilly 1985; Perrings 1987). Furthermore the interaction between the economy and the environment is assumed to proceed in infinitesimal, qualitatively identical and *reversible* steps without the consideration of possible thresholds or points of no return (Söllner 1997). Reversibility therefore leaves humanity free to cut down forests, because they could be replanted; contaminate its freshwater supply, because it could be de-polluted; exploit species to extinction, because they could be re-introduced from stocks in zoos and botanical gardens or be reproduced in genetic engineering laboratories, etc.; In reality, "of course, all real economic (and other) processes are *irreversible*."(Söllner 1997 p. 181, own emphasis)

Finally technological optimism seems to act as a reinforcing and 'gap-filling' mechanism in neoclassical economic theory. It facilitates both, the assumption of factor substitutability (i.e. the rejection of absolute scarcity) as well as the assumption of reversibility. Human technological progress appears to be the panacea for mainstream economists. This optimism is by no means substantiated (Aage 1984) as the laws of thermodynamics will always impose limits. Of course physical laws have been found untrue in the past, but according to most physics, among those Albert Einstein, the laws of thermodynamics are the least likely ever to be overthrown (Daly 1992a).

**Many problems one Solution**

Neoclassical economics does not demand economic growth as such, but it provides the theoretical preconditions for it and sees it as “axiomatic necessity“ (Georgescu-Roegen 1977). Orthodox economists are convinced that only economic growth can solve the ‘classical problems’ of society, formulated by Smith (poverty), Malthus (overpopulation), Marx (distribution) and Keynes (involuntary unemployment). Not only that, it is also offered as a (or the only) remedy for pollution problems, debt repayments, balance of payment deficits, depletion of natural resources, crime, etc. Most of theses claims are backed up by more or less plausible theories, most of which are hardly supported by empirical studies. Only poverty and environmental pollution shall be considered more closely her.

Firstly economic growth is portrayed as the “high tide that lifts all the Boats” (Daly 2001, p. 15). Although it does not increase everyone’s relative income, it is supposed to do so with absolute income. If the *cake* is made larger, then everyone can (could) get a larger piece. This is the dominant philosophy with most governments and international organisations. In reality growth has resulted in a widening of the gap between the lowest and the highest incomes (Daly 2001). The IMF recently had to admit that despite growth in the West and in some developing countries; one fifth of the world’s population has regressed (Palast 2001). The metaphor itself seems inappropriate for this argument, because as a matter of fact high tide in one part of the world causes low tide in another.

Secondly, it is alleged that societies experiencing economic growth will eventually begin to value their nature as a “luxury good” and start to protect it and repair the damage already done (e.g.: World Bank 1992). Selden and Song (1994) hypothesised that the environment-income relationship might be similar to that brought forward by Nobel laureate Simon Kuznets between income inequality and economic development. Seldon and Song (1994) argued that economic growth initially results in more pollution, which is eventually reversed, producing an inverted U-shaped curve, the so-called Environmental Kuznets Curve (EKC). While this hypothesis enjoys empirical support for some pollutants (Cavlovic, Baker et al. 2000), it does not hold true for example for carbon dioxide (Holtz-Eakin and Selden 1995) and several other important air pollutants (Harbaugh W., Levinson et al. 2000).

Moreover the EKC hypothesis is characterised by a variety of fundamental conceptual flaws, which have been described in detail by Tisdell (2001). Many of these flaws originate from the mechanical analogy discussed above. Thus it is assumed that pollution is *non-cumulative* and its effects are reversible. In reality it is a known fact that some pollutants are cumulative or could be regarded as such because of the long time they need to be broken up by the ecosystem (e.g.: $CO_2$ and CFCs). Moreover not all damage to the environment is reversible, such as the loss of biodiversity. Thresholds might be crossed after which ecosystems could collapse and require hundreds of years to recover.

Related to the EKC is the “dematerialisation hypothesis” or “de-coupling”. It is based on the argument that economies become more service and knowledge oriented as they grow and therefore use fewer natural resources. De-coupling is either achieved in an absolute sense or relative to GDP (weak dematerialisation). If its weak definition is adopted then the latter would suffice for achieving sustainability. Material and Energy Flow

Accounting, which has celebrated great advances in recent years, continues to provide strong empirical evidence against dematerialisation (Haberl, Fischer-Kowalski et al. 2004). Although there are some economies that experience weak dematerialisation only, e.g.: Austria (Krausmann, Haberl et al. 2004), there are numerous examples in particular from southern countries where not even weak dematerialisation can be witnessed e.g.: Spain (Canellas, Citalic González et al. in press), Greece (Eurostat 2002) and Chile (Giljum 2004). It is further alleged that those industrialised countries, which do achieve weak or strong dematerialisation, do so by shifting "environmental weight" to southern, less developed counties. This hypothesis is know as "environmental load displacement" (Giljum 2004; Canellas, Citalic González et al. in press)

## **Uneconomic growth**

In microeconomic theory the optimal scale of a microeconomic activity (production of a company or consumption of a household) is determined at the point where marginal costs equal marginal benefit. Indeed, variations of the solution of this problem dominate microeconomic theory. The law of decreasing marginal benefit indicates that after the point of optimal scale further growth becomes uneconomic, because costs are higher then benefit. A similar concept is not known in macroeconomic theory. According to Daly (2001), the reason for this is that microeconomics solely considers single parts – the growth of each part is limited by opportunity costs, which the rest of the system has to bear. Macroeconomics on the other hand only considers entirety and growth of the entirety does not cause opportunity costs, because there is no such thing as the 'rest' of entirety, which would have to bear such costs (Daly 2001).

In the absence of opportunity costs, there is no optimal scale for human economic activity and thus no limits to economic growth. As this growth has generated the advances of our modern society, at least in the west, in the absence of a trade-off, bigger can only mean better. This worldview completely ignores the role of the environment as a provider of vital goods and services. As already mentioned above, the economy is portrayed as a closed system. True, the rise of Environmental Economics *did* bring about recognition of the value of these services (compare: Costanza, d'Arge et al. 1997). However the environment is seen as a subsystem of the economy (Figure 2), which has to be brought under the governance of market mechanisms. In other words negative externalities have to be internalised and an economic value (in terms of money) has to be attributed to nature's services (e.g.: via contingent evaluation, travel cost method or hedonic pricing). Details and criticisms of these approaches are discussed at length elsewhere (e.g.: Martínez-Alier and Roca 2000) and are beyond the scope of this paper.

Because of substitution possibilities and technological progress the environmental sub-sector does not impose limits to the extension of the economy as Figure 2 above clearly illustrates. Ecological Economics offers a more "Copernican" approach, as the human economy is *not* seen as entirety but as a subsystem of the ecosystem. Figure 3 below is central to the ecological economic paradigm and summarises this "world view": The economy is depicted as a subsystem of the larger ecosystem, which has limits and is closed. Only with regards to the solar flow of energy can it be seen as open, however the solar flow is limited and non-growing.

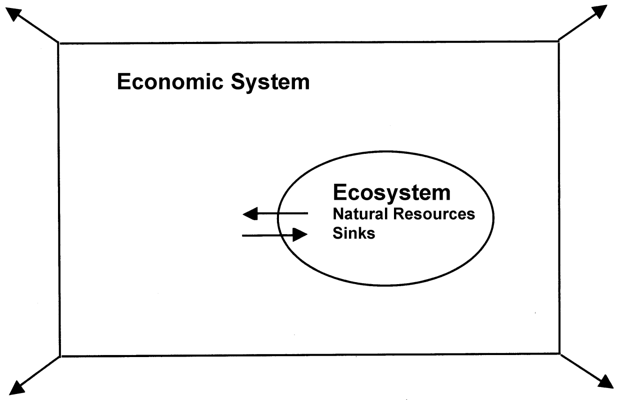


Figure 2: The ecosystem as a subsystem of the macro-economy (taken from: Daly 2001 p. 8)

Figure 3 shows two sources of human welfare: services from the economy and services from the ecosystem. A growing economy will transform natural capital in human capital, resulting in a larger flow of services from the economy and a smaller one from the ecosystem. Moreover growth of services from the economy reduces with an increasing economic system, because of the law of decreasing marginal utility. Assuming rational human beings, the most urgent needs are satisfied first. Since the economy claims ever more ‘space’ from the ecosystem, society has to give up ever more of its services. Assuming rational behaviour, the least important services will be given up first.

Hence there *are* opportunity costs involved in economic expansion, and there *is* an optimal scale for an economy, beyond which growth becomes *uneconomic*. The optimal scale could be defined as one for which total service, from the economy and the ecosystem, is maximised (this matter will be further discussed below). However the concept of microeconomic opportunity costs must be applied with caution, because of the interrelation of ecosystem services, i.e. giving a seemingly unimportant service up could affect other services in a chain reaction, which *are* important for humanity. Despite considerable advances in science, the interrelation and complexity of ecosystems or the climate on Earth are still far from being fully understood. In fact complexity in (natural) systems is now widely acknowledged and studied (Martinez-Alier, Munda et al. 1998). Attempting to determine an optimal scale with crude economic methods is therefore a daunting task and may not be appropriate.

Initially, when the economics discipline (including neoclassical economic theory) emerged, lost ecosystem services were arguably negligible, as economies were still small. As shown in Figure 3 the human society lived in an “empty world” (Costanza, Norgaard et al. 1997): empty of people and their artefacts but full of natural capital. Since the seventies evidence is mounting that humanity now lives in a “full world” i.e.: overpopulation (Ehrlich and Holdren 1971); approaching the limits of possible human appropriation of biomass (Vitousek, Ehrlich et al. 1986); climate change (IPCC 2002); ozone shield rupture (UNEP 2000); land degradation (Pimentel, Allen et al. 1987); biodiversity loss (Goodland 1991) and global water shortages (Shiva 2002).

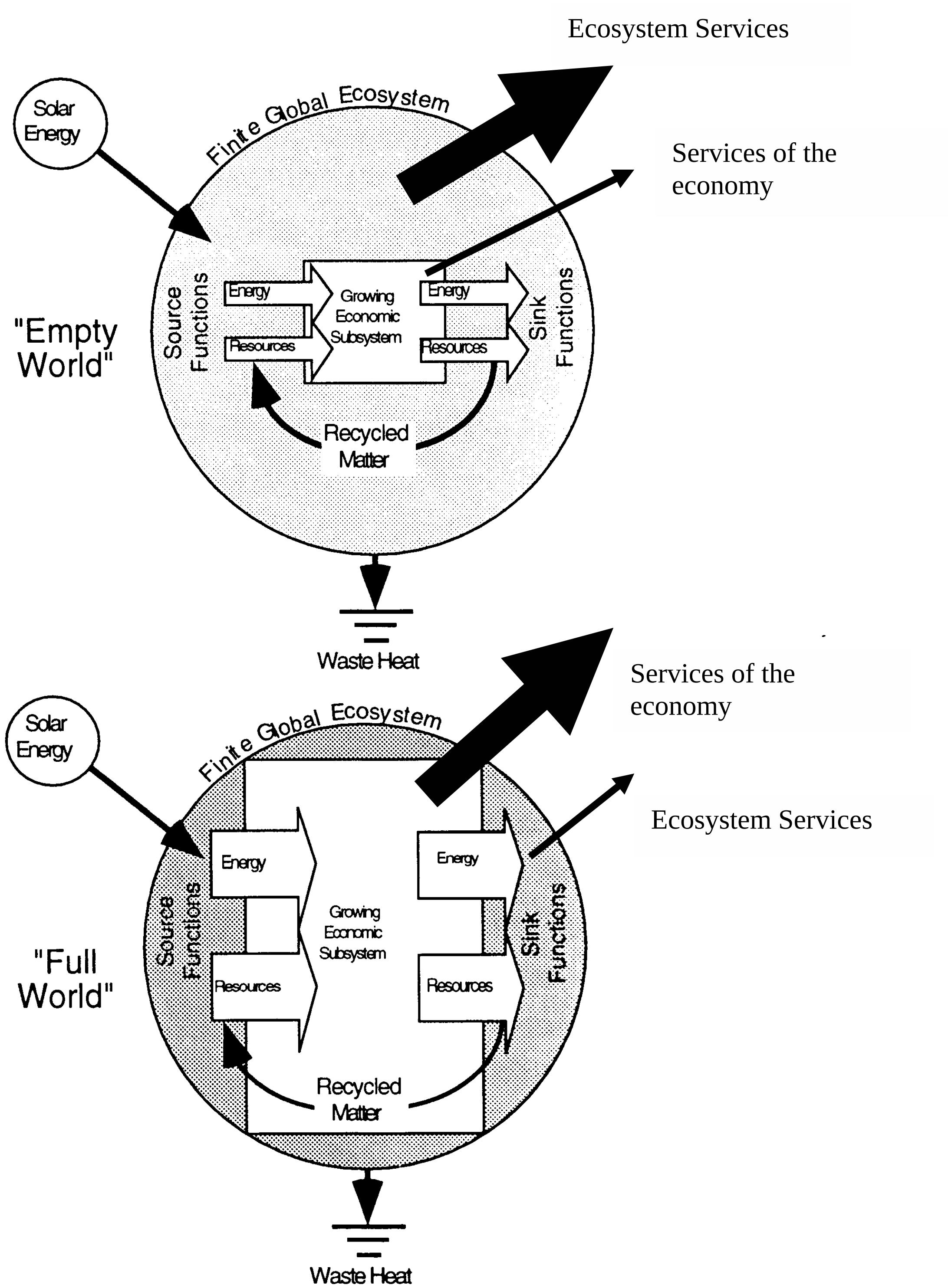


Figure 3: The finite global ecosystem relative to the economic subsystem (Taken from: Goodland, Daly et al. 1992; reproduced in: Costanza, Norgaard et al. 1997, p. 6)

**Measures of Economic Growth**

Usually when one talks of economic growth, one refers to an increase in the Gross National Product (GNP) or the Gross Domestic product (GDP). As an accounting tool GNP is perfectly legitimate, however its' use as an indicator of wealth is highly problematic. Daly (1992a) argues that GNP adds up three categories, which are very distinct and should be kept separate: throughput, additions to capital stock and services generated by this capital stock. Throughput is defined as the entropic depletion-pollution flow and it's the "*ultimate physical cost*" (Daly 1992a, p. 30) of economic activity. Hence the goal of maximising GNP also implies to some extent maximising costs! Service rendered by physical and human capital is benefit, or psychic income. Additions to capital stock represent a potential to render service in the future, but their costs (throughput) have been incurred already. Only by accounting for these magnitudes separately, would one be able to determine whether growth is actually still contributing to increasing economic welfare.

It should also be mentioned that GNP contains what has been defined as 'regrettable necessities' (Daly 1992a) or 'defensive expenditures'(Leipert 1989). This includes removal costs for environmental damages (e.g.: refuse collection) but also time and resources wasted because of modern lifestyles (e.g.: time lost when commuting, traffic jams, car accidents, etc.). These costs increase GNP instead of reducing it. Considering these facts it seems pretty counter intuitive to argue that GNP measures economic welfare. In fact hardly anybody explicitly does. The problem is however that "*everyone is using it in a way as if it did*." (Stockhammer, Hochreiter et al. 1997, p. 19)

Ever since GNP started to be used as a measure of welfare by proxy, it was met with scepticism ranging from Boulding in the 1950's to Daly in the 1970's. Numerous have thus been the attempts to extend / alter GNP (e.g.: 1988; El Serafy 1997) or to develop better national indicators altogether, such as the *Measured Economic Welfare* (MEW) (Nordhaus and Tobin 1972); the *Economic Aspects of Welfare* (EAW) (Zoltas 1981), the *Index of Sustainable Economic Wealth* (ISEW), the *Genuine Progress Indicator* (GPI) (Redefining Progress 1995), or more recently the *Sustainable Net Benefit Index* (SNBI) (Lawn and Sanders 1999; Lawn 2000). The evidence gathered from empirical applications of these indicators, in particular the ISEW, GPI and SNBI, suggest that in many industrial countries economic growth has actually become detrimental to human welfare (Lawn 2003).

Figure 4 below shows the revised ISEW for Austria with a widening gap between the two measurements (ISEW & GDP), particularly since the 1970ies. Daly and Cobb themselves however emphasised the necessity of a cautious use of these alternative economic indicators. They argue that any measure would abstract from many features of actual economic welfare. One has to avoid the *fallacy of misplaced concreteness*, which is being described as "the fallacy involved whenever thinkers forget the degree of abstraction involved in thought and draw unwarranted conclusions about concrete actuality" (Daly and Cobb 1989, p 36). Ideally policy makers and analysts should have several indicators available; however this can also pose problems in those cases when individual indicators themselves point in opposite directions.

While the impact of the ISEW and other alternative measures has been minimal[2], the newly emerged field of Industrial Ecology provides new accounting tools, which could be used for a better interpretation of GNP. Material and Energy Flow accounting (MEFA) (Eurostat 2001), the Human Appropriation of Net Primary Production (Vitousek, Ehrlich et al. 1986; Haberl, Erb et al. 2001) and their combination with Input-Output

[2] In terms of the ISEW, Stockhammer et al. (1997) conclude "*while ISEW seems qualified to kick GDP from the throne as leading indicator for economic policy, it is not ready to usurp that throne*." (Stockhammer et al. 1997, p. 33)

Analysis seem promising candidates for becoming some kind of *sustainability indicators* (Haberl, Fischer-Kowalski et al. 2004). Hence they could serve not so much as measures of welfare, but to better interpret GNP. The economic growth in Chile for instance is often portrayed as the result of its role-model behaviour in terms of implementing neo-liberal development strategies. A study by Giljum (2004) however established a case to argue that Chile is fuelling its economic growth by overexploitation of its natural resources and indeed by impoverishing itself. The MEFA framework and Input-Output Analysis could become important tools for establishing the optimal scale in terms of energy and mass throughput of an economy and should therefore be central to the growth debate.

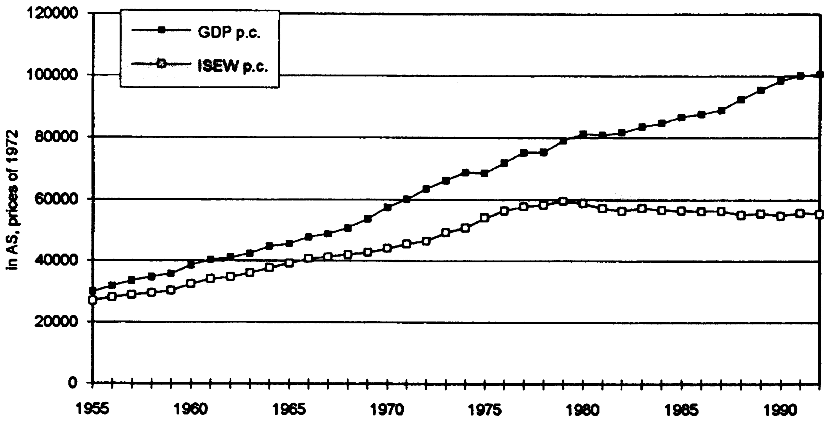


Figure 4: GDP and ISEW per capita for Austria from 1955 – 1994 (taken from: Stockhammer, Hochreiter et al. 1997, p. 30)

**Socio-ethical and physical growth critique**

The standard textbook definition of economics, according to Daly (1992a), states that economics is the study of the allocation of scarce means among competing ends. *"[T]he object of the allocation is the maximisation of the attainment of those ends."* (Daly 1992a, p. 18) However, much confusion about economic growth, in Daly's (1992a) view, arises from economist's sole focus on the middle range of his 'ends-means spectrum'. This implies that only the allocation of *intermediate means* (artefacts, labour power) to achieve *intermediate ends* (food, comfort, education, etc.) are considered. Figure 5 illustrates Daly's (1992a) ends-means spectrum.

While the right hand side of the continuum shows the different levels on the spectrum including some examples, the left hand side indicates the discipline that is traditionally most concerned with each corresponding level. Each intermediate level in the continuum is an end with respect to lower categories and a means with respect to higher levels. *The ultimate end* is therefore achieved through the *intermediate ends* which in turn are made possible through the service of the *ultimate means*. Only at the two extremes there is the pure end and the pure means. The *Ultimate End* is such that it does not derive its value from being an instrument for the attainment of some other end; it is elementally good in itself. At the other extreme, the *ultimate means* are those means, which are used for serving human ends but unlike intermediate means cannot be created by humans and are therefore unable to become the end of any human activity.

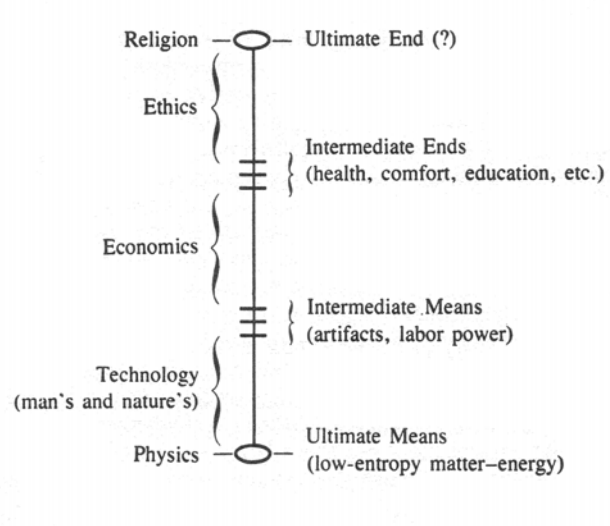


Figure 5: Daly's ends-means continuum (adapted from: Daly 1992a, p. 19)

By the mere concentration on the intermediate levels of the spectrum, economists traditionally did not include absolute limits in their consideration, because absolute limits can only be found in *ultimates*. This negligence of *ultimate ends* translates directly into a lack of attention to ethics. As mentioned before, due to the adoption of the mechanical value concept, ethical issues became a matter of personal taste and are therefore exogenous factors in economic models. *Ultimate means* and the absolute limits of their availability, situated on the other side of Daly's (1992a) spectrum, are equally ignored in mainstream economic theory. It is assumed technology can almost limitless transform ultimate physical means (low entropy matter-energy) into intermediate means.

The goal of never-ending economic growth can thus be defined "as the conversion of ever more ultimate means into ever more intermediate means (stocks of artefacts) for the purpose of satisfying ever more intermediate ends, whatever they may be."(Daly 1992a, p.23) Hence by looking only at the intermediate levels of the ends-means spectrum, economists came to the conclusion that although any given want can be satisfied, in the aggregate they are infinite and therefore can never be satisfied. It follows that if ends and means are unlimited, the process of growth may indeed continue forever.

**Thermodynamics and Ultimate Means**

Much to the contrary Nicolas Georgescu-Roegen (1971) argued that based on thermodynamics, unlimited economic growth is physically impossible. Ultimate means are in effect *low entropy*[3], which exists on earth in two different forms only: in terrestrial stock and in solar flow. Terrestrial stock can be divided into such

[3] Entropy is, technically speaking an extensive state variable (Baumgärtner 2003), which can be defined for any material substance or any system (Ayres 1998). An extensive state variable is a variable that "*is proportional to the size of the system and at any time only depends on the state of the system*" (Baumgärtner 2003 p. 1) Mass or volume are examples, whereas temperature or pressure would be examples for *intensive* variables. The second law of thermodynamics provides that entropy increases with every physical action or transformation occurring in an *isolated* system, i.e. a system that does not exchange matter or energy with other systems. Within such a system or in fact in the entire universe entropy can never decrease, which is why it has also been called 'time's arrow' (Ayres 1998). An internal systems equilibrium is reached, when entropy is maximised (Ayres 1998).

resources, which are renewable in a human time scale and those only renewable in a geological time scale, known as *non-renewable*s. All of these sources of low entropy are absolutely limited. The non-renewables such as oil are limited in the total amount available on earth, while renewables are limited in rate of use, although they are practically unlimited in terms of the total amount eventually harvested over time (Daly 1992a). A similar argument can be made for solar flow which is practically unlimited[4] in total amount, but strictly limited in its rate and pattern of arrival to earth.

Although matter and energy cannot be created or destroyed, as the first law of thermodynamics states, it is being transformed during the economic production and consumption processes. This process always involves the transformation of low entropy states into high entropy states. Organised, structured and concentrated low entropy states of matter are for example converted into still higher structured commodities and then, through use, into dispersed, randomised, high-entropy states (waste). Energy is also transformed during the process of production and consumption of commodities. High-temperature energy for example, with a potential to do work becomes low-temperature energy whose ability to do work is lost as soon as the temperature equalises with its surrounding environment.

The most abundant source of low entropy on the planet is solar flow. All the worlds fossil fuels burned together would only provide a few days equivalent of sunlight energy (Daly 1992a). The rational thing for mankind would therefore be to use most of the non-renewable resources for the construction of facilities to better capture the energy of the sun. What has happened instead, during the last 200 years, is that the human economy has become dependent on the scarcest available forms of low entropy – non-renewable minerals. Technological optimists often argue that modern technology is freeing mankind from the dependence on resources (Barnett and Morse 1963; cited in: Daly 1992a). In Fact rather the opposite is true. Technology, the *deus ex machina* of neoclassical economics, can only contribute to a more efficient use of the entropic flow, but will not be able to reverse the direction of the flow.

The reason why this heavy dependence on terrestrial non-renewables creates the illusion of more independence is because man can choose the rate at which he makes use of it. Solar flow on the other hand is limited and subject to seasonal and diurnal variations. Rapid economic growth is therefore easier to achieve, at least for limited time period, than with solar flow or renewable resources. The result is the depletion of geological capital and the overloading of ecosystems with newly produced materials for which no natural cycles exist (Daly 1992a). According to Daly's ends-means spectrum (Daly 1992a) low entropy is the 'real cost'; the ultimate opportunity cost involved in satisfying ends. Low entropy must be evaluated according to the worth of the best alternative sacrificed, since it can only be spent for one purpose (Daly 1992a).

**Ultimate ends and sustainability**

Ultimate ends are more difficult to define, than ultimate means. As a minimum, avoiding any religious issues, the ultimate end could be seen as the "survival and continuation of the evolving life process..." (Daly 1992a, p.

[4] It is generally assumed, that nuclear fusion on the sun will continue for another 4 -5 billion years. (http://en.wikipedia.org/wiki/Sun)

27). This is merely a crude definition of sustainability. Söllner (1997), in his search for ways to integrate thermodynamics (ultimate means) into economic theory concludes that this must be based on an explicit value decision (ultimate end). Sustainability is such a decision. It can only be justified on ethical grounds and can therefore not be left to the market. This decision must be followed by specific environmental policies [(Ayres (1991, 1994); Binswanger (1993) Daly (1991); Georgescu-Roegen (1979); Hampicke (1992); Hyman (1980); Slesser (1993); all cited in: Söllner 1997)]. Such policies would have to include *absolute limits* for the containment of the economy if it is to be sustainable (Daly 1991; Daly 1992b; cited in: Söllner 1997).

The growth paradigm rests on the two doctrines of relative scarcity of means as discussed above and the insatiability of wants to satisfy ends. Most of these ends can however not be served by aggregate growth (Daly 1992a). On the contrary, production and consumption and its side effects seem to get increasingly in the way. The satisfaction of some needs such as the need for leisure, contemplation, silence and conversation, become more difficult because of the production-consumption drive. There are already some social movements in place, which promote the enjoyments of a simple lifestyle. One group calls itself 'voluntary simplifiers'. They voluntarily reduce their consumption levels in order to live a materially simplified lifestyle and are part of a larger anti-consumption movement, which is constantly growing in number (Zavestoski 2002)[5].

Moreover it is incorrect that *all* wants are insatiable. John Maynard Keynes ((1963) 1997) distinguishes absolute and relative wants, only the latter of which he regards as unlimited. In affluent societies consumers derive most satisfaction from having something someone else does not have and not so much from the good itself. Relative wants are only felt when their satisfaction serves to distinguish oneself from others and makes one feel superior (Keynes (1963) 1997). Or as John Ruskin (1986; cited in: Daly 1992a, p. 27) wrote: "*the art of making yourself rich, in the ordinary mercantile economist's sense, is therefore equally and necessarily the art of keeping your neighbour poor*". Since everyone cannot be relatively better off then everyone else, relative wants may indeed be insatiable. Normatively it could be argued that the pursuit of relative wants, while many still struggle to satisfy their absolute wants (food, shelter, clothes, etc.) is inappropriate. Moreover it has to be questioned whether an economic model that requires people to be unsatisfied is indeed beneficial to humanity. The alternative to an economy based on the axiomatic necessity of growth is the steady state economy.

## The history of the stationary state (steady state)

For most of man's history economic growth and the problems associated with it were not an issue. As illustrated above, humanity lived in an *empty world* until some 50 years after the onset of the industrial revolution in the late 18th and early 19th century. Before the industrial revolution the human economy could be described as *organic* i.e. not only foodstuffs, but most materials used for production could be traced back to organic (biotic) natural resources (Wirgley 1987; cited in: Luks 2001). Over about the last 200 years this has changed to the *mineral* economy we live in today. The most important impact of this change is of course environmental degradation.

[5] Nevertheless, despite these growing movements, most people still follow unsustainable consumption patterns and the overall consumption level is on the rise (Niemi 2006).

Dennis Meadows (Meadows 1977; cited in: Luks 2001) argued that this was the point in time when humanity gave up sustainability and before that man basically lived in steady-state societies. This argument, if un-quantified, is clearly false. Human history is full of examples where societies have surpassed local carrying capacity by overexploitation of *renewable* resources. There is also evidence that even hunter-gatherers, despite only consuming less than 0.01% of the net primary production (NPP) of their habitat (Boyden 1992; cited in: Haberl, Fischer-Kowalski et al. 2004), contributed significant to local species extinction of their preferred prey (Sieferle 1997; cited in: Haberl, Fischer-Kowalski et al. 2004). Similarly agricultural societies such as the Ancient Mesopotamians gradually degraded their soils by irrigation techniques. Peasants had to first give up wheat production in favour of more salt resilient barley and finally had to abandon cultivation all together (Haberl, Fischer-Kowalski et al. 2004). This however only means that human history does not hold readily available sustainable lifestyle models. It does not mean that there cannot be a steady state alternative to economic growth.

**The classical economists**

All classical economists share the concept of a stationary state caused by population growth and decreasing revenues. They use the stationary state mainly as an ontological final point of economic development and only some also as an analytical fiction (compare Ricardo's famous chapter on machine capital).[6] The *ontological stationary state* has been defined as referring to economic reality, even if this reality is only expected to become relevant in a distant future. The stationary state is used in "the notion of an economy whose end-point of development is one in which capital accumulation has ceased because the profit-rate has fallen so low that there is no further incentive to accumulate capital" (Brandis 1989; cited in: Luks 2001).

The *analytical stationary state* on the other hand is an assumption that serves for analytical purposes only (Luks 2001). Marshall (1961 [1890]; cited in: Luks 2001) for example described the steady state merely as a "helpful auxiliary hypothesis". Because of its simplicity, the theory of a stationary state is used as a first step for the analysis of a more complex developing economy. The actual attainment of such a state is however regarded as "horribly unrealistic" (Meade 1965, p. 25; quoted in: Luks 2001, p. 29). Further it can be distinguished between the '*positive*' and the '*normative stationarity*' (Luks 2001): In the former case stationarity is or will be attained by an economy without interference. The latter case refers to the perception of various authors such as John Stuart Mill, mentioned above, and nowadays Herman Daly, who believe in the desirability of a stationary state (e.g.: for ecological or social reasons).

It is assumed (Robbins 1930; cited in: Luks 2001) that the expression of a stationary state was first mentioned by Adam Smith (1723–1790), in "*The Wealth of Nations*" (Smith 1776). Although he certainly laid the foundations of the future growth paradigm, he did not believe that growth would be possible indefinitely. This was a worrying thought for Smith (1776), as growth for him was the source of wealth that would include all social classes. Only economic growth, he claimed, could prevent wages to fall to subsistence levels. In *Stationarity*

[6] This statement is of course debatable: Kolb (1972) for example insists that Malthus and Ricardo used the stationary state only as "an analytical device rather than a view of reality because in terms of the time horizons which Ricardo and Malthus felt were operationally meaningful the stationary state was not considered to have substance at the level of reality" (Kolb 1972, p. 26; quoted in: Luks, 2001, p. 141)

wages and profits have to be low, which makes it a "dull" (Smith 1776, p. 99) state to be in. Thus for Smith (1776) the stationary state is ontological and equal to decreasing living standards and generally to poverty.

For Smith the "blessing" of economic growth could only continue until a country had attained its "full complement of riches" (Smith 1776, p. 99; quoted in: Luks 2001).This situation arises as soon as the necessary capital is accumulated. The maximum possible level of wealth is in turn determined by the land and climate of the particular country. Growth in "The Wealth of Nations" (Smith 1776) is therefore a temporary normality, which can continue for a long time, but not forever. Although Smith regards the 'dullness' of a stationary state unavoidable at some point, his work is generally known to be optimistic, unlike the writings of Thomas R. Malthus (1766-1834).

To Malthus both unlimited growth and a stationary state were impossible. He did not share Smiths optimisms for progress as he was convinced that "*no possible form of society could prevent the almost constant action of misery upon a great part of mankind, if in a state of inequality, and upon all, if all were equal.*" (Malthus 1993 (1798); quoted in: Luks 2001) Malthus came to this conclusion through what he called *population principle*, which is the basis of today's concepts of *carrying capacity* (Seidl and Tisdell 1999). Three basic facts are the essentials of his theory: Firstly the fact that human population increases exponentially (1,2,4,16, etc.).[7] Secondly food is necessary for the existence of man and is sole limiting factor on human population growth. Finally he claimed that food production could only be increased linearly (1,2,3,4,5, etc.).

For Malthus (1993 (1798)) these three facts were the explanation of the scarcities and misery he observed in England at the time. In his view there were two checks which naturally limit population: On the one side there is the foresight of the difficulties identified with the rearing of a family, acting as *a preventive check.* On the other side, "*the actual distresses of some of the lower classes, by which they are disabled from giving the proper food and attention to their children, acts as a positive check to the natural increase of population*."(Luks 2001, p. 111) Positive checks increase mortality (e.g.: famines, pests, wars, etc.) while preventive checks reduce the birth rate (e.g.: abortion, birth control, prostitution, later founding of families, etc.) (Gilbert 1993; cited in: Luks 2001).

Hence for Malthus all checks resulted either in vice or misery, which mankind was doomed to live with eternally. In other words he predicted that the human society would continuously fail to stabilise at a stationary state. Instead it would constantly overshoot its carrying capacity only to be decimated again by the forces of nature. Given the fact that Malthus' work was based on false empirical observations[8] because of normative assertions and a mechanistic concept of nature and society (Seidl and Tisdell 1999), it was surprisingly influential[9]. Even today it continues to be important for various academic disciplines.

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[7] Interestingly Malthus deducted this exponential growth from the increase in population in North America, not observed elsewhere at the time and which was largely accounted for by immigration, a fact he ignored. Nevertheless this does not impinge on the validity of the assumption of exponential growth (Seidl and Tisdell 1999).

[8] See footnote above.

[9] Darwin for example claimed that Malthus' work inspired him for his work on evolutionary theory (Barnet and Morse 1963; cited in: Luks 2001).

While Smith concentrated on the conditions of economic growth, with a main interest in the effects of the division of labour, David Ricardo (1772 - 1823) focused his work on the limits of growth and on the analysis of capital accumulation and its effects on distribution (Luks 2001). His theory of distribution is based on the scarcity of land and its non-homogeneity in quality. An increasing population forces agricultural production to expand into marginal lands with lower and lower quality. That in turn requires a growing effort of labour, which is the reason for the increase in the value of the products of the land. As a result revenues of food producers decrease, while food prices increase. Labourers will then need higher wages, because their expenses increase with food prices. The increase of prices and wages can however only continue until wages equal the total income of the farmer. Then accumulation must come to an end; "(...) *for no capital can then yield any profit whatever, and no additional labour can be demanded, and consequently population will have reached its highest point*" (Ricardo 1817; quoted in: Luks 2001, p. 119).

This means that for Ricardo, not the accumulation of capital itself leads to a decrease of profits, as it was claimed by Smith, but the connection between profits and subsistence costs. He stresses however that long before this state of high food prices and low wages, the very low rate of profits would have eliminated the motive for capital accumulation. The reason being that *„(...) no one accumulates but with a view to make his accumulation productive, and it is only when so employed that it operates on profits*" (Ricardo 1817; quoted in: Luks 2001, p. 120). Without such a motive for capital accumulation, the stationary state is unavoidable (Ricardo 1817; cited in: Luks 2001). However everything in Ricardo's writings points towards the fact that he believed this stationary state would only matter in a distant future. He believed that foreign commerce could prolong the attainment of the stationary state for a long time or even indefinitely (Ricardo 1817; cited in: Luks 2001).

John Stuart Mill (1806 – 1873) is often regarded as the last important thinker in the classical tradition (Welch 1989; cited in: Luks 2001) and is known as a sharp critic of the (then) existing capitalism. He was not only economists, but also philosopher and political scientist. Mill advocated a separation of production and distribution and for him economic 'laws' only apply to the former and not to the latter. (Schumpeter 1965 [1954]; cited in: Luks 2001)

Just like Malthus, Mill was convinced that technological improvements would eventually be unable to keep up with population growth, which would result in decreasing living standards. He is therefore a proponent of birth control measures. (Mill 1965 [1948]; cited in: Luks 2001). Whilst classicals before him postulated that an increase in living standards would automatically result in an increase in birth numbers, Mill hoped that this could be avoided for instance via education and birth control. This hope is important to understand his optimism regarding a stationary state, because in his view only a constant population would eliminate the permanent pressure on wage levels.[10]

The limiting factor for economic growth according to Mill is land but similarly to Ricardo he thought that such limits would only become relevant in the distant future (Mill 1965 [1948]; cited in: Luks 2001). The question of limits was of ultimate importance for Mill and he saw the neglect of these issues by his colleagues not just as an error, (...) *but (as) the most serious one, to be found in the whole field of political economy*" (Mill 1965 [1948],

[10] This is a deviation from the writings of Smith and Ricardo. (Luks 2001)

p. 173; quoted in: Luks 2001, p 130) Without a thorough understanding of these limits to production, set by finiteness of the land and therefore the natural environment, so Mill, it is pointless to think about economic problems (Mill 1965 [1948]; cited in: Luks 2001).

Once a country reaches the *minimum rate of profitability*, he believed, no further increase of capital can for the present take place and that country will attain stationarity (Mill 1888). The attainment of the minimum profit rate depends on various conditions such as the propensity to accumulate and the security of capital. Although generally varying and difficult to identify such a minimum always exists in Mill's view. Countries with high levels of living standards are much closer to this state than poorer countries, unless the former are endowed with large yet undeveloped reserves of fertile land (Mill 1965 [1948]; cited in: Luks 2001). The attainment of this stationary state is therefore a result of the large amount of capital, which would be accumulated during a period free of crises. The actual time of this attainment could however, just as it was suggested by Ricardo, be prolonged by technological progress and by international trade (Mill 1965 [1948]; cited in: Luks 2001).[11]

For Mill the attainment of the stationary state as a final point in economic development, could be much further prolonged than for other classical economists. Nevertheless he hoped that future generations "(...) *will be content to be stationary, long before necessity compels them to it*" (Mill 1965 [1948], p. 756; quoted in: Luks 2001 p. 138). He 'romantically' thought of it as a condition where mankind had satisfied its essential needs and where it could focus its attention on other issues; away from the hectic and tense life of perusing commercial and economic goals (Claeys 1987; cited in: Luks 2001), with a society characterised by:

*" (...) a well-paid and affluent body of labourers; no enormous fortunes, except what were earned and accumulated during a single lifetime; but a much larger body of persons than at present, not only exempt from coarser toils, but with sufficient leisure, both physical and mental, from mechanical details, to cultivate freely the graces of life, and afford examples of them to the classes less favourably circumstanced for their growth. This condition of society, so greatly preferably to the present, is not only perfectly compatible with the stationary state, but, it would seem, more naturally allied with that state than with any other"* (Mill 1888, p. 454).

Economic progress, in what he calls our "progressive society", subject to a growing capital stock, population growth and technical progress ("improvements in production") is unsatisfactory for Mill (1888) and he questions the goals of such a progress: *"(T)o what ultimate point is society tending by its industrial progress? When the progress ceases, in what condition are we to expect that it will leave mankind?"* (Mill 1888, p. 453). The argument clearly changes here from an economic one to an ethical one, which is also evident in the following quote. Mill therein reminds us of the fact that the stationary state was acknowledged by nearly all economists at his time:

*"It must always have been seen, more or less distinctly, by political economists, that the increase in wealth is not boundless: that at the end of what they term the progressive state lies the stationary state, that all progress in*

[11] Taking Mills argument further one could make the assertion that in order for growth to continue after a certain point (i.e. when technological progress does not keep up with population growth), the economy of a country either needs acquisition of another country's resources via trade or destruction via crisis (war?). It follows that a country can not only export and import goods but also sustainability (Pearce, Turner et al. 1993; cited in: Luks 2001). Some regions are apparently already "*running an unaccounted ecological deficit – their populations are appropriating carrying capacity from elsewhere or from future generations*" (Rees and Wackernagel 1994; cited in: Luks 2001). Germany for example would have to be a few times larger than it is, in order to produce everything consumed by its population. In other words Germany 'occupies' land belonging to other counties (Schmidt-Bleek 1994; cited in: Luks 2001). This phenomenon is known as ecologically unequal exchange in trade (usually from North to South) and is discussed extensively elsewhere (e.g.: Hornborg 1998; Muradian and Martinez-Alier 2001;)

*wealth is but a postponement of this, and that each step in advance is an approach to it...(...) This impossibility of ultimately avoiding the stationary state – this irresistible necessity that the stream of human industry should finally spread itself out into an apparently stagnant sea – must have been, to the political economists of the last two generations, an unpleasant and discouraging prospect"* (Mill 1888, p. 452).

Mill does not share this pessimism regarding the stationary state but on the contrary sees it very positively and desirable:

*"I cannot ...regard the stationary state of capital and wealth with the unaffected aversion so generally manifested towards it by political economists of the old school. I am inclined to believe that it would be, on the whole, a very considerable improvement on our present condition. I confess I am not charmed with the ideal of life held out by those who think that the normal state of human beings is that of struggling to get on; that the trampling, crushing, elbowing, and treading on each other's heels which form the existing type of social life, are the most desirable lot of human kind, or anything but the disagreeable symptoms of one of the phases of industrial progress. (...) (T)he best state for human nature is that in which, while no one is poor, no one desires to be richer, nor has any reason to fear being thrust back, be the efforts of others to push themselves forward"* (Mill 1888, p 453).

In what could be considered as a kind of cultural critique on growth, Mill states that instead of growth, distribution and population control should be the main goals:

"*I know not why it should be a matter of congratulation that persons who are already richer than any one needs to be, should have doubled their means of consuming things which give little or no pleasure except as representative of wealth. (...) It is only in the backward countries of the world that increased production is still an important object: in those most advanced, what is economically needed is a better distribution, of which one indispensable needs is a stricter restraint on population*" (Mill 1888, p. 454).

In answering one of the first point of criticism which is normally brought forward against the stationary state, he claims that such a condition is *perfectly compatible with technical progress* and argues that this progress would even be stimulated:

"*It is scarcely necessary to remark that a stationary condition of capital and population implies no stationary state of human improvement. (...) There would be as much scope as ever for all kinds of mental culture, and moral and social progress; as much room for improving the Art of Living, and much more likelihood of its being improved, when minds ceased to be engrossed by the art of getting on. Even the industrial arts might be as earnestly and as successfully cultivated, with this sole difference, that instead of serving no purpose but the increase of wealth, industrial improvements would produce their legitimate effect, that of abridging labour*" (Mill 1888, p. 454).

This 'romantic' optimism about the stationary state is often criticised as absolutely utopian (Levy 1987 [1981]; cited in: Luks 2001) and incompatible with modern capitalist democracies. It is argued that Mill's vision of a stationary state is the result of his 'naive' believe that capitalism was only a transitional phenomenon, which would, driven by its own in-built dynamic, soon transform itself. Similarly to Marx, Mill believed that a fundamental societal change would have to take place for the kind of new social order that he had in mind (Levy 1987 [1981]; cited in: Luks 2001). Unlike Malthus and Smith, Mill believed in society's ability to change fundamentally, a fact which is considered his main interest (Bladen 1974; cited in: Luks 2001).

Mill was clearly attracted to socialist ideas (Levy 1987 [1981]; cited in: Luks 2001), however he dissociated himself from the socialist critique of competition. He argued that it is not the best incentive, but absolutely necessary for societal progress and that any artificial limits to competition are wrong (Mill 1888). As stated by

Levy, Mill expected the stationary state to be accompanied by a new, post-capitalist political economy, dominated by producer co-operatives (Levy 1987 [1981]; cited in: Luks 2001)[12].

Although most classical economists acknowledged the prolonging effects of technological progress on the limits to growth (and therefore on the stationary state), they had no idea of the changes brought about by the approaching industrial revolution. Economists, during and after this revolution, changed their visions fundamentally. In Karl Marx's (1818-1883) work, which is by many seen as classical - but at least Ricardian (Schumpeter 1965 [1954]; cited in: Luks 2001), capital and labour already become the most important factors of production and land loses its importance. His concept of stationarity (simple reproduction) is already merely an analytical fiction, which will be the case in the works of most of his successors.

Marx's 'simple reproduction' (Marx 1988 [1867], p. 592; quoted in: Luks 2001, p. 143) describes a mere repetition of the production process on the same level, which basically assumes net investment to be zero. It describes a situation of equilibrium, which Marx believed to be unachievable for a capitalist society. (Schumpeter 1993 [1942]; cited in: Luks 2001) He does however have his own vision of the ontological stationary state, but only beyond capitalism in his idea of socialism. Marx believed, that under socialism *"(...) output and real wages would increase up to the point where the society would decide, through some unspecified mechanism, that enough is enough (...).*" (Rostow 1990, p. 144; quoted in: Luks 2001, p. 144) Similarly to Mill's and much later Keynes's version of the stationary state, Marx's system is brought into a steady state equilibrium by diminishing relative marginal utility and not diminishing returns.

The work of Joseph Schumpeter (1883-1950) although not classical should be mentioned at this point, as he is neither a Marxist (although he liked Marx's ideas), nor neoclassical, nor a Keynesianist and he strictly opposed the formation of a 'Schumpeter – school' (Luks 2001). A considerable amount of his work was dedicated to the stationary state, which he calls 'circulation'. In 'circulation' whatever is produces is consumed in the same period and there are no savings, no profits and no capital, so credits are not needed (Schumpeter 1952 [1911]; cited in: Luks 2001). The main difference to his description of a developing economy however, is that it might grow (growth of population and wealth) but does not develop. Development, in his view, can only take place if entrepreneurs, financed through loans by capitalists, *push through new combinations* (Schumpeter 1952 [1911]; cited in: Luks 2001). (e.g.: new products, new markets, new sources of energy, etc.).

To Schumpeter the entrepreneur is the key to economic development (Wienert 1990; cited in: Luks 2001).. If there are no more credits for her available, or if a sudden change in the environment result in a situation, where she can no longer fulfil her function, then that's *the end of capitalism* for Schumpeter (Luks 2001). Exactly that is what he predicts in his late work '*Capitalism, Socialism and Democracy*' (Schumpeter 1993 [1942]), when his analytical stationary state becomes ontological. Capitalism is to collapse because of its own success, as "the growth and prosperity will eventually cripple the entrepreneur and his desire to innovate" (Allen 1994; quoted in: Luks 2001). Without the 'creative destruction' that he causes, specialist big enterprises will take over and innovation and development will stagnate.

[12] The contemporary author Douglas Booth (1998) also promotes producer co-operatives, as a way to establish a stationary state. He sees growth as inbuilt dynamic of the capitalist system, which is why capitalism in its present form is not compatible with a stationary state.

According to Schumpeter (1993 [1942]) this self-destruction process of capitalism will eventually pave the way for Socialism. "*The capitalist process brings objects and souls into shape for Socialism*" (Schumpeter 1993 [1942], p. 351; cited in: Luks 2001, p. 165). However does this also lead to a stationary state? Schumpeter believed that capitalism cannot be stationary, which implies that a non-capitalist economy *could* be stationary. But also other statements in Schumpeter's work point towards such an assumption (Luks 2001). Schumpeter's prediction for the future of capitalism is therefore similar to that of Marx – capitalism cannot survive over the long term (Schumpeter 1993 [1942]; cited in: Luks 2001).

John Maynard Keynes (1883-1943) also doesn't fit the neoclassical tradition of rejecting the ontological stationary state. Just like for Schumpeter, stationarity only started to interest him at a later stage of his life, especially in *Economic Possibilities for Our Grandchildren (Keynes 1972a [1930])*. Contrary to what is mostly believed he was not a growth-fetishist, but had his own view of a pleasant future in a stationary economy; based on his ideal of a socially and economically just society, which respects the freedom of the individual (Nolte and Schaaff 1994; cited in: Luks 2001). Keynes was convinced that within the next hundred years the '*economic problem*' would be solved (Keynes 1972b [1931]; cited in: Luks 2001). The economic problem is "(...) *the problem of want and poverty and the economic struggle between classes and nations* (...)" (Keynes 1972b [1931], p. xviii; quoted in: Luks 2001, p. 167) or more generally the problem of scarcity. Before such a state can be established however, Keynes predicts a "*general 'nervous breakdown'*"(Keynes 1972a [1930], p. 327; quoted in: Luks 2001, p. 169) because "*mankind will be deprived of its traditional purpose*" (Keynes 1972a [1930], p. 327; quoted in: Luks 2001, p. 168) of struggling to solve the economic problem.

The scenario of abundance in which he describes a stationary state compares to that of Marx; contains similar 'romantic' features as Mill's stationary state and reminds of Hermann Daly's socio-ethical critique of growth. According to Keynes accumulation of wealth will lose its importance (Keynes 1972a [1930]; cited in: Luks 2001); the love of possessing money as an end and not a means will be recognised as "*somewhat disgusting morbidity*" (Keynes 1972a [1930], p. 329; quoted in: Luks 2001, p. 169). Just like Schumpeter he thought however that the time was not ripe for such a development yet. Until then those criticised values have the important function of guiding us "*out of the tunnel of economic necessity into daylight*" (Keynes 1972a [1930], p. 331; quoted in: Luks 2001, p. 170). Moreover, according to Keynes (1972a [1930]; cited in: Luks 2001) four factors determine the time when the light at the end of the tunnel will become visible: control of population growth, avoidance of wars, the role of science and the rate of accumulation.

As far as the role of science is concerned it appears in some of Keynes' statements that he was very optimistic about technological progress, because he believed that the economic problem would be solved by capital accumulation and technical innovations. Furthermore he claimed that the "standard of life in progressive countries one hundred years hence will be between *four* and *eight times* as high as it is today" (Keynes 1972a [1930], p. 325f; quoted in: Luks 2001, p. 168), or even higher. Although this was only written in 1930 and living standards (defined as material wealth) in industrialised countries might already be four times or more as high today. In other words Keynes writings do leave scope to interpret him as a growth-optimist and technophile, until humanity attains all the riches that he promised.

**Neoclassical Growth Theory**

As already mentioned, the paradigm shift during the 'marginal revolution' in the 1870ies brought about a destruction of the classical system according Schumpeter (1970 [1908]). With Marshall the stationary state became an analytical tool only and the concept of an ontological stationary state was rejected (Luks 2001). It was argued that classical economists had underestimated the potentials of technological progress. Moreover Malthus' and Ricardo's predictions regarding population growth and the situation of landowners respectively were not confirmed in the century following their work. Hence it is argued that "(...) *the empirical facts that the modern theory of growth attempts to explain are quite different from those which the classical theory confronted*" (Stiglitz and Uzawa 1969, p. 3; quoted in: Luks 2001, p. 176).

As a result the population principle became irrelevant by the end of the 19th century because the marginal utility system could incorporate any hypothesis of birth and death rates, preferred by the author (Schumpeter 1965 [1954]; cited in: Luks 2001).[13] Similarly land as a factor of production became irrelevant[14], which can partly be attributed to the increasing industrial sector (Perman, Ma et al. 1996; cited in: Luks 2001) and the declining importance of agriculture relative to manufacturing (Stiglitz and Uzawa 1969; cited in: Luks 2001). Today neo-classical (growth) theory focuses on capital and labour as the only factors of production. Land, the essential factor for economic growth in classical economics was 'replaced' by technical progress to provide theoretical possibility of unlimited growth (Stiglitz and Uzawa 1969; cited in: Luks 2001).

Solow's (1956; 1957) and Swan's (1956) essays are considered as the beginning of the neo-classical growth theory. Swan (1956; cited in: Luks 2001) describes a *classical case* characterised by one limiting production factor: land. Under these circumstances capital must grow faster than labour increase, in order to sustain per capita output, when confronted with decreasing land revenues. Since capital grows faster than output, profit continually decreases. Given this situation the economy tends towards a „*classical*" stationary state (Swan 1956; cited in: Luks 2001). Hence the inclusion of "(...) (*t*)*echnological progress, very broadly defined to include improvements in the human factor, was necessary to allow for long-run growth in real wages and the standard of living*." (Solow 1988, p. 313; quoted in: Luks 2001, p. 179)

With the assumption that this progress compensates the diminishing returns, the economy tends towards a 'stable growth equilibrium' and not towards a classical stationary state (Swan 1956; cited in: Luks 2001). This equilibrium, also known as "steady-state growth", refers "*to models in which population and capital are growing absolutely, but in which certain ratios between absolutely growing magnitudes remain constant*" (Daly 1993, p. 366). This was seen as closer to reality considering the rapid growth in western industrial economies during the fifties and sixties. With technological progress and the assumption of quasi limitless substitutability of the factors of production as discussed earlier unlimited growth became (theoretically) possible.

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[13] A seperate discipline, demography, was created, which however seems to be excluded from the sustainability discourse.
[14] The incorporation of land into the production factor capital is nowadays common practise.

## Herman E. Daly's Steady State Economy

Daly could be considered as the „growth critical" writer who provides the sustainability discourse with the most important food for thought (Luks 2001). He bridges the growth discussion of the 70's (e.g.: Meadows, Meadows et al. 1972), with the recent sustainability discussion. While the former postulated a reduction in economic growth, he argues solely for a reduction of the throughput of material and energy. Together with Georgescu-Roegen, whose pupil Daly was, and Boulding, he is often seen as one of the founding fathers of ecological economics. The steady state economy (SSE), for which Daly is regarded as a theoretical father, is regarded by many authors as being one of the central pillars of the slowly developing structure of ecological economics (Luks 2000). Some authors even claim identity of ecological and steady-state economics (Underwood and King 1989; cited in: Luks 2000), while others such as Daly[15] himself talk of the identity of the latter with sustainable development (Schröder 1995; cited in: Luks 2000). This does however not mean that the SSE concept goes unchallenged, much to the contrary it is criticised by many as naïve and utterly utopian (e.g.: Proops 1989; Luks 2001).

Daly's vision of a SSE was inspired by Malthus and Mill in particular but also by other classical economists. He sees himself as a representative of a classical tradition, which is why he stresses the use of the term 'steady-state' in a classical sense, referring to what Mill called 'stationary state'(Daly 1981). John Stuart Mill used the term 'stationary state' to describe an economy in which population and capital stock had ceased growing. The noun *state* literally means the standing or stability of something (from the Latin stare, to stand). The adjective stationary (and steady) amplifies this idea of standing as opposed to running; of constancy as opposed to increase or decrease (Daly 1981).

The use of the term *stationary state* became problematic when the neo-classical economists redefined it to refer to an economy in which tastes and technology were unchanging but in which population and capital stock could be growing. Daly therefore adopted the term '*steady state'* from the physical and biological sciences, as "the term means to physical scientists nearly what the term stationary state had meant to the classical economists before the neoclassicals redefined it" (Daly 1981, p. 366). Adding to the confusion over terminology is the already mentioned concept of '*steady-state growth'*, defined by neo-classical growth theorists such as Hahn and Matthews (Hahn and Matthews 1964; cited in: Luks 2001). It even became a central concept in neoclassical growth theory e.g.: Stiglitz and Uzawa (1969; cited in: Luks 2001)

### The Pre-analytic Vision

The vision of Daly's steady state concept is based on two physical magnitudes: A *stock* of capital (people and artefacts) and the physical flow of *throughput* (matter and energy) (Daly 1992a). The two physical populations of people and artefacts are characterised as providing *service* on one hand and requiring maintenance and replacement on the other. The stock of artefacts is directly dependent on the number of people, since they are

[15] Daly for example talks of "sustainable or steady-state economics".( Daly 1996, p. 149)

considered as 'extensions of the human body', as has been suggested by Lotka (1956; cited in: Daly 1992a).[16] These artefacts (houses, cars,...) serve human needs (accommodation, transportation,...) and so do human beings to others (doctors, carpenters,...) and themselves.

However the artefacts wear out and have to be repaired or replaced and people need food, get cold, etc. and eventually die. Therefore there is a continuous inflow via production and birth and a corresponding outflow via depreciation and death of these two populations. This maintenance and replacement of artefacts and human bodies requires the throughput of matter and energy. This throughput begins with depletion of nature's sources of useful low entropy (natural resources) and ends with the pollution of nature's sinks with high-entropy waste (waste, pollution and waste heat) (Georgescu-Roegen 1976; cited in: Söllner 1997).

From this general vision Daly (1992a, p. 17) deducts his 'stock orientated' definition of a SSE, [17] which he describes as: " (...) *an economy with constant stocks of people and artefacts, maintained at some desired, sufficient levels by low rates of maintenance 'throughput', that is, by the lowest feasible flows of matter and energy from the first stage of production (depletion of low entropy materials from the environment) to the last stage of consumption (pollution of the environment with high entropy wastes and exotic materials).*" Daly (1992a) emphasises that the SSE is a physical concept. What is being held constant, therefore, is capital stock, in the broadest *physical* sense of the term. Certain non-physical magnitudes, such as culture, knowledge, goodness, ethical codes, etc. are *not* held constant. In other words a SSE is an economy that *does* develop, but does not grow physically. As it was discussed earlier GNP adds up throughput, additions to capital stock and services generated by this capital stock. It is therefore irrelevant to the definition above. A large part of it reflects throughput and therefore a cost, which is why a reduction of GNP in a SSE is possible and totally acceptable, if it is a result of reduced 'costs'.

While the theoretical background for *capital* in the SSE originates from Lotka (1956), as mentioned above, *income* goes back to Fischer (Fischer 1906; cited in: Daly and Cobb 1989) " (...) that a proper accounting of income must reflect only the flow of services of capital enjoyed in the subjective stream of consciousness by people, during the relevant time period."(Daly 1992a, p. 36) To give an example, the purchase of a piano this year is not part of this year's income, but an addition to capital. This year's income on the other hand is solely the service rendered throughout the year by producing music.

Intermediate transactions, which involve the exchange and transformation of physical goods will, according to Fisher, cancel out, leaving only Fisher's "*uncancelled fringe*" of *psychic income* enjoyed by the final consumer (Fischer 1906; cited in: Daly 1992a). By taking this fringe and deducting the psychic disservices incurred in labour, Fisher arrives at his net psychic income, which he saw as the final net benefit of economic activity.

[16] Lotka (1956) postulated the view of capital as "exosomatic organs". For example clothes and houses extend our skin; stoves, cooking utensils, and sewers extend the digestive tract; libraries and computers extend the brain, and so on.

[17] At the beginning of the 1990ies, Daly has gone over from a 'stock-oriented' to a 'flow-oriented' definition of a steady state, which however does not vary in its economic objectives. Therein a Steady-State-Economy is described as an economy "*whose throughput remains constant at a level that neither depletes the environment beyond its regenerative capacity, nor pollutes it beyond its absorptive capacity*." (Daly 1992a; quoted in: Luks 2000, p. 46)

However he does not include the ultimate real costs, against which the ultimate value of net psychic income should be balanced. Daly therefore supplements Fisher's income with the physical concept of real costs elaborated by Kenneth Boulding (1966) and Nicholas Georgescu-Roegen's (1971). These unavoidable costs are due to the fact that the stock of capital wears out and has to be replaced (Georgescu-Roegen's fourth law, see below). After these clarifications the three basic magnitudes of Daly's SSE, can be summarised as follows:

| | |
|---|---|
| STOCK | "The total inventory of producers' goods, consumers' goods, and human bodies. It corresponds to Fisher's (1906; cited in: Daly 1992a) definition of capital and may be thought of as the set of all physical things capable of satisfying human wants and subject to ownership."(Daly 1992a, p. 35) |
| SERVICE | "The satisfaction experienced when wants are satisfied, or 'psychic income' in Fisher's (1906; cited in: Daly 1992a) sense. Service is yielded by the stock. The quantity and quality of the stock determine the intensity of service." (Daly 1992a, p. 35) There is no unit for measuring service, so it is debatable whether it can really be called a 'magnitude'. Nevertheless, everyone can and is experiencing service or satisfaction and recognise differing intensities of the experience. Although service is yielded over a period of time and thus appears to be a flow magnitude, it cannot be accumulated, but flows can. Therefore it is probably more accurate to think of service as a psychic flux (Georgescu-Roegen 1971; cited in: Daly 1992a). Service is the final benefit of economic activity |
| THROUGHPUT | "The entropic physical flow of matter-energy from nature's sources, through the human economy, and back to nature's sinks and it is necessary for the maintenance and renewal of the stocks"(Boulding 1966; Georgescu-Roegen 1971; Daly 1992a, p. 35) "The throughput flow does not yield services directly; it must be accumulated and fashioned into a stock of useful artefacts (capital)."(Daly 1992a, p. 36) |

Table 1: Daly's definitions of stock, service and throughput (adapted from: Daly 1992a, p. 36)

Going back to the discussion of the optimal scale of an economy, this could now be defined as one for which total service, from the economy and the ecosystem, is maximised. According to Daly (1992a, p. 35) "[*T]his will occur, when the addition to service arising from a marginal addition to the stock is equal to the decrement to service arising from impaired ecosystem services that result from the incremental throughput required by the increment in stock*." For reasons already mentioned above it might not be appropriate to attempt to compute such an optimum. Instead Daly (1992a) advocates *satisficing* because "it is a better strategy than optimising; that is it is better to be safe than sorry. Minimising future regret is wiser than maximising present benefit."(Daly 1992a, p. 35) The following identity illustrates the interrelations between Daly's three magnitudes:

| | | | | | |
|---|---|---|---|---|---|
| Daly's identity | $\frac{\text{service}}{\text{throughput}}$ | ≡ | $\frac{\text{service}}{\text{stock}}$ | X | $\frac{\text{stock}}{\text{throughput}}$ |
| ratio | (1) | | (2) | | (3) |
| efficiency measure | throughput service efficiency | | stock-service efficiency | | stock-maintenance efficiency |
| limits | ------------- | | possibly: human nervous system and time | | $2^{nd}$ law of thermodynamics |

Table 2: Service, Stock and Throughput and their interrelations (adapted from: Daly 1992a, p. 36)

Capital stocks are at the centre of Daly's analysis, because they are the intermediate magnitudes – accumulated throughput, temporarily frozen in ordered structures. On one hand it provides services (ratio 2), on the other hand it needs throughput for maintenance (ratio 3). Stocks in ratio (2) and (3) cancel out just as they wear out in the real world. The ultimate benefit that remains is therefore service, not stocks and the ultimate cost of service is throughput, or better, the sacrificed ecosystem services provoked by the throughput. "Stock is neither a benefit nor a cost, but both benefits and costs are functions of the stock." (Daly 1992a, p. 37)

Each of the three dimensions requires a different treatment in Daly's (1992a) steady-state paradigm. Stocks should be *satisficing,* which means that a level should be chosen, which is sufficient for a good life and sustainable for a long future. Throughput on the other hand is to be *minimised*, subject to the maintenance of the constant stocks and service is to be *maximised*, subject to the constant stocks. As indicated in Table 2 above, ratio (1) embodies the final service efficiency of the throughput i.e. the final benefit over the final costs, ratio (2) represents the service efficiency of the stock and ratio (3) the stock-maintenance efficiency of the throughput. Economic development in terms of these ratios can thus be defined as increasing ratios (2) and (3) and thereby getting more service out of each unit of throughput. Economic growth on the other hand means increasing service by increasing the size of stocks, but with no increase (or even a decrease) of the efficiency ratios 2 and 3. Thus the steady-state economy would force an end to pure growth, by holding stocks constant and would not curtail, but stimulate development (Daly 1992a).

While ratio (3) is according to Daly (1992a) limited by the second law of thermodynamics, the limits for ratio (2) (service efficiency) are less clear. It could be argued that there are no limits to the amount of service derivable from a given stock. On the other hand, as was mentioned above, at a certain level, further stock could just get in the way of welfare. Moreover one could consider the limits to the human nervous system: For example the human eye does not recognise a further improvement in quality above a certain amount of pixels per inch of a computerised image. Time could also be mentioned as a limit in the sense that someone who owns a tennis racket and then buys golf clubs, he will have less time for his tennis, the more gadgets one owns the less time one has for each of them, thereby setting a limit to service derivable from them.

These considerations beg the question, of how much stock is enough? This question is inherent in the sustainability discourse as such. If the Brundtland sustainability definition (WCED 1987), is adopted a similar problem arises over the definition of *needs.* Often it is argued that there is no point in advocating an SSE unless we know what exactly the optimum level of stock is. According to Daly (1992a) this is a wrong inference for two reasons: Firstly stability and viability are more important than optimality. As the actual levels of population and artefact stocks are historically given, humanity should first learn how to become stable and then worry about the optimum. Secondly, as it has been mentioned at the beginning of this paper, evidence from various fields of research is mounting that ecosystem limits of human expansion have already been reached. According to some authors the optimum has already been overshot in the 1970ies (Meadows, Meadows et al. 1972; Daly 1992a).

**The three institutions for Daly's SSE**

Daly (1992a) insists on the absolute necessity of a steady state and he provides a seemingly sound and holistic concept to attain it. This includes also three concrete institutional recommendations. However Daly (1992a) points out that there might be other institutions that could be more appropriate. The three institutions are based on two widely excepted economic establishments, the price mechanism and private property, but Daly (1992a) extends them to areas, where they were not applied previously: control of aggregate births and control of the aggregate throughput. Given the definition of a SSE above there is a need for (1) an institution for stabilising population; (2) an institution for stabilising the stock of physical artefacts and keeping throughput below ecological limits; and (3) a distributionist institution limiting the degree of inequality in the distribution of constant stocks among the constant population.

Firstly, and this is arguably the most controversial suggestion, Daly (1992a) advocates transferable birth licenses, as put forward by Kenneth Boulding (1964). Boulding's plan combines macro-stability with micro-variability and suggests that every woman[18] should be issued with an amount of reproduction licenses that corresponds to replacement fertility (or less if a reduction in population numbers was needed). Hence, they would receive 2.1 licenses each. The licenses would be divisible by units of one-tenth, where ten such units give the legal right to one birth. Licenses are freely transferable by sale or gift which means that those who want more than just two children can either buy them on a competitive market or acquire them by gift. It shouldn't come as a surprise that this concept was received with scepticism and rejection, which should however not be elaborated upon here.

A second institution is to limit the degree of inequality and the size and the monopoly power of corporations. This is to be achieved via minimum and maximum limits on income and a maximum limit on wealth[19]. There is hardly any economic reasoning behind this proposal. Daly (1992a) merely states that the other institutions would not be accepted without this one, as private property and the whole market economy lose their *moral basis* and the case for extending the market to cover birth and depletion quotas would not be strong enough (Daly 1992a). In the absence of large concentrations of income and wealth, savings would be smaller because they would truly represent abstinence from consumption rather than surplus after remaining satiation (Daly 1992a). This would support stability because less expansionary pressures from large amounts of surplus would seek ever new ways to grow exponentially and thereby causing either physical growth, inflation, or both (Daly 1992a).

It is important to mention at this point that Daly's (1992a) SSE is not motivated by a leftwing ideology. It is based on conservative premises (private property, the free market, opposition to welfare bureaucracies and centralised control), but also follows the call for 'power to the people' since according to Daly (1992a, p. 55): "(...) it puts the source of power, namely property, in the hands of the many people rather than in the hands of the few capitalist plutocrats and socialist bureaucrats." Daly (1992a) continuously emphasises that his approach is

[18] To woman only, because the female is the limiting factor in reproduction and since maternity is more demonstrable than paternity. (Daly 1992)

[19] As wealth and income are largely interchangeable, a limit on both is needed (Daly 1992a). Moreover a concentration of wealth, according to Daly (1992a), becomes inconsistent with both a market economy and political democracy.

neither leftwing nor rightwing and calls on politicians and economists to stop thinking exclusively within these two directions.

On the one hand the proposition of such an institution might be intuitively very attractive but on the other hand it is clearly the component with the weakest theoretical foundation in Daly's (1992a) concept. A variety of problematic issues are not tackled, such as how to deal with intra-family accumulation i.e.: inheritance; the role of public limited companies and its stockholders and the possible cessation of entrepreneurial incentives.

As it has been argued earlier the market price can only take care of relative scarcity not absolute scarcity. Aggregate physical depletion quotas are therefore brought forward as the third SSE institution. Because of the law of conservation of matter and energy, a limit on aggregate depletion – i.e. an imposition of a control on the throughput flow – will also indirectly limit aggregate pollution. A limit on the throughput flow on the other hand also limits indirectly the size of the stocks maintained by that flow. Unlike the end-pipe approach adopted in the Kyoto Protocol (UNFCC 1997) or as advocated by Booth (1998), Daly (1992a, p. 56) insists that *"[e]ntropy is at its minimum at the input (depletion) end of the throughput pipeline and at its maximum at the output (pollution) end. Therefore, it is physically easier to monitor and control depletion than pollution - there are fewer mines, wells, and ports than there are smokestacks, garbage dumps, and drainpipes, not to mention such diffuse emission sources as runoff of insecticides and fertilisers from fields into rivers and lakes and auto exhausts*."

This is a direct critique of neoclassical environmental policy of 'internalisation of externalities' applied to Pigout type taxes and other policy tools based on the 'polluter pay's principle'. The problem with such taxes is that they do not necessarily limit aggregate throughput for the following reasons: While it is true that price plus tax determines demand in a given demand curve (assuming policy makers know their elasticity), these curves shift and are moreover subject to great errors in estimation even if stable (Daly 1992a). Such a shift of a resource-demand-curve could for example be induced by an increase in population, change in taste, and increase in income. If petrol for example was to be taxed more intensively this could have two effects both of which would not necessarily result in less resource use. People could use their cars less and change to say riding bikes or using (cheaper) public transport, but would then maybe spend the money they saved on other resource intensive goods – the so-called rebound effect (see e.g.: Hertwich 2005). And secondly, people could simply change the components of their budged - i.e. continuing to use the car as much as before but spending less money on other consumption or on savings.[20] Moreover the effects of a tax could be offset by a credit expansion by the banking sector, an increase in velocity of circulation of money, or deficit spending by the government for other purposes (Daly 1992a). Taxes are therefore not suitable for limiting aggregate throughput (Daly 1992a).

In fact pollution taxes could actually lead to an increase in throughput. Resource extraction industries could seek more effective technologies to increase depletion, in order to become competitive again by. Many developing countries are heavily dependent on exports of one particular natural resource (e.g.: Chile and Copper). If they receive increasing competition from the recycling industry, which ultimately profit from pollution taxes, they

[20] Fuel taxes in the UK (€ 766 per 1000 litres) for example are almost twice as high as in Germany (€ 440 per 1000 litres), which has the second highest fuel taxes in the European Union (Ökosoziales Forum Österreich 2003) Nevertheless the British are among the most intensive car users in Europe.

could be forced to extract more in order to avoid a decrease in income. Nevertheless pollution taxes are useful, but only for fine-tuning at the micro-level (e.g.: for regulating one particular industry), on the macro-level some form of quotas would be more effective in reducing aggregate throughput.

Daly describes the market for resources in his SSE as two tiered. The government would first of all exercise a monopoly in the auctioning of limited quota rights to many buyers. These resource buyers, after having bought quota rights, would then meet many resource sellers in a competitive resource market. The market resource price would tend to equal marginal costs and more efficient producers would earn differential rents. The pure scarcity rent resulting from the quotas, would be captured in the depletion quota auction market by the government monopoly (Daly 1992a). This windfall rent could be used to finance the minimum income component of the distributist institution, as discussed above. Such a type of redistribution mechanism is also made necessary by the fact that the poor would suffer most from an increase of prices of most goods because of the quotas.

The direct effect of such a policy would be that pollution would be reduced as aggregate throughput decreases as the first law of thermodynamics predicts (Ayres 1998). Indirectly probably all products would become more expensive, but mainly those using many of the limited resources. This would encourage switching to less resource intensive goods, recycling and the investment in resource saving technologies and methods to capture the *free energy* from the sun more effectively. The quotas could also be used to impose a maximum corporate size, by not allowing a single entity to own more then x percent of the quota rights for a given resource or more than y percent of the resource owned by the industry of which it is a member. X and y could then be set in order to allow for legitimate economies of scale.(Daly 1992a)

Quotas would at first be set at present levels of resource consumption, with the first task being to stabilise the system and stop an increase in resource use. Then it should be tried to reduce quotas to a more sustainable level in order to avoid excessive pollution and ecological costs for present and future generations. For renewable resources quotas should be priced considering some reasonable calculation of maximum sustainable yield. Quotas for non-renewables on the other hand would reflect purely ethical judgement in terms of how many resources should be left for future generations – a decision the market is unable to make because future generations cannot bid in present resource markets.

In summary Daly’s (1992a) SEE concept uses the allocative efficiency of the market for (1) the allocation of the limited aggregate of resources among competing firms; (2) the reallocation of the birth licenses, after they have initially been distributed equally among all people and (3) distribution of the income within the maximum and minimum boundaries. The combination of all three institutions offers, according to Daly (1992a), a good reconciliation of efficiency and equity, while at the same time it provides the ecologically necessary macro-control of growth, with the least sacrifice in terms of micro-level freedom and variability. The market is allowed to move freely within the imposed ecological and ethical boundaries.

**SSE Critique: Utopia and moral growth**

To most people Daly's (1992a) SSE concept is simply utopian and he admits himself that in the short run it is probably not an option. However in the long run, if people voted for it because environmental degradation and the problem of overpopulation became more evident and if there was, the necessary *moral growth* then it could work (Daly 1992a). The fact that Daly (1992a) relies heavily on this "moral growth"[21] in society has lead some authors to suggest that he might have replaced the optimism for technical progress of the *neoclassical economists*, with his hope for moral growth, to cover the analytical shortcomings of his concept (Luks 2001). Daly's (1992a) responds is that science is still obsessed with positivism and statements about moral values or ethics in the social sciences are still taboo. *In scientists quest for mechanistic and sophisticated technological resolutions, " (...) appeals to moral solutions and to a correction of values are considered as an admission of intellectual defeat, as a retreat from the rules of the game – as cheating*" (Daly 1992a, p. 47). Moreover it could be argued that "*attitudes of 'more forever', 'aprés moi la deluge', and technical arrogance"* (Daly 1992a, p. 47) are also normative value statements.

A true weakness of the SSE concept is that the international perspective is truly underrepresented in Daly's (1992a) work. He (Daly 1992a, p. 71) points out that the scheme ('probably') must be designed to include imported resources. "*The same depletion quota right could be required for importation of resources, and thus the market would determine the proportions in which our standard of living is sustained by depletion of national and foreign goods. Imported final goods would now be cheaper relative to national goods, assuming foreigners do not limit their depletion. Our export goods would now be more expensive relative to the domestic goods of foreign countries. Our terms of trade would improve, but we would tend to a balance of payments deficit.*" However he goes on to claim that the balance of payments can take care of itself by means of freely fluctuating exchange rates. Equilibrium would simply be restored by a rise in the price of foreign currencies relative to the *dollar*. "*If foreigners are willing to sell us goods priced below their true full costs of production, we should not complain*." (Daly 1992a, p. 71) This statement reveals Daly's "americo-centric" worldview and clearly excludes small countries from trying to attain a SSE. Furthermore, even for an economy as big as the US, a sudden drastic shift in demand to foreign products would surely cause major disruptions. Hence without the imposition of import taxes the introduction of Daly's (1992a) SSE concept would probably not be feasible. Is he therefore implicitly asking for a return to intensive trade barriers, or even autarky? Confronted with this question via email correspondence, Mr. Daly responded: "Regarding international relations I would not advocate autarky, but trade cannot be free, (...)"(Daly 2002) Nevertheless it is not clear from his response, what the solution would be for the SSE concept.

Apart from international trade, there is also immigration which would cause problems that are not addressed by Daly (1992a). Pressures caused by population increase through immigration would clash with the scheme of transferable birth licences and in general with the attempt to keep population constant. Hence borders would have to be closed to immigrants. On the one hand this seems a harsh and maybe unethical proposition. On the

[21] Daly (1992a) names altogether four moral first principles upon which he built his Steady State concept: some concept of enoughness or material sufficiency; a sense of stewardship for all of creation and an extension of brotherhood to future generations and to subhuman life; humility – not everything that can be done, has to be done and holism i.e. recognising that the whole is greater than the sum of its parts:

other hand it could be argued that it is better than to exploit immigrants as cheap labour. Also, if this policy would allow a country to become sustainable, resources would be freed up for the development of poorer countries. Clearly it is preferable to enable poorer countries to develop themselves instead of exploiting, not only their resources, but also their manpower.

There is also a problem during the transition towards a steady-state economy with regards to those who are already rich and powerful and to resource owners. Daly only addresses the latter as he points out that "(...) current resource owners would suffer a one-time capital loss when depletion limits are imposed and, in fairness should be compensated." However, if this compensation would push these individuals over the income/wealth maximum, it would be taxed away from them anyhow, making it equivalent to at least partial expropriation. It is naïve to assume that the rich and powerful would also be inspired by the generally hoped for "moral growth" and give up their position and possession without struggle. Although Daly suggests that the maximum income level could be quite generous at first, those who are expecting to have their fortunes taxed away, will do everything possible to prevent that from happening. Hence it seems that a 'Marxist-type revolution' would be a necessary precondition of a SSE.

Booth (1998) sees growth as an inbuilt dynamic of capitalism. Thereby he refers to Schumpeter's view that the creation of new industries based on new technologies is fundamental to macroeconomic growth. These new industries automatically create new environmental problems and moreover vested interests that oppose environmental regulations or the imposition of Daly's (1992a) institutions. He therefore argues that capitalism, at least in its present form cannot become sustainable and is not compatible with the steady-state paradigm (Booth 1998).

**SSE critique: the second law of thermodynamics**

Daly's pre-analytic vision, described earlier, is based on Georgescu-Roegen's (1971) interpretation of the entropy law. In particular on what he refers to as a 'fourth law of thermodynamics':"*[c]omplete recycling is impossible. (...) [M]aterial objects wear out in such a way that small particles (molecules) originally belonging to these objects are gradually dissipated beyond the possibility of being reassembled*."(Georgescu-Roegen 1971, p. 60) Without this law, so Daly (1992a), the economy could be a closed system, because a litre of petrol for example could be burnt over and over again and nothing would ever wear out. Although Georgescu's fourth law appears plausible, it is only based on rather intuitive arguments, which rest on a collection of practical examples. It cannot prove the theoretical impossibility of perfect recycling. In fact rather the opposite is true, it directly contradicts the first law[22], which clearly implies the possibility of complete recycling (Hall, Cleveland et al. 1986; Ayres and Kneese 1989; Binswanger 1992; Söllner 1997; Ayres 1998).

Ayres (1998, p. 198) argues that Georgescu-Roegen's (1971) 'fourth law' could only be true "(…) *if the recovered and purified materials were insufficient in principle to maintain the capital equipment required for the materials recovery operation.*" He adds however that this is certainly not true because materials are trapped in the gravitational field of the Earth (Ayres 1998). Even 100% recycling would theoretically become feasible if

[22] Conseravtion of Matter and Engery

enough exergy[23] was available. ”Given enough exergy any element can be recovered from any source where it exists, no matter how dilute or diffuse” (1998, p. 197). Thus gold or uranium for example could in principle be recovered from seawater. According to Ayres (1998), the main problem is environmental pollution until all the non-renewable resources are used up. The long-run dangers arising from human activity are not found in the finiteness of resource stocks, but the fragility of self organised natural cycles. In his critique of the misinterpretations of the entropy law, Ayres (1998) refers to some of Daly’s central arguments…:

“*Service comes from two sources, the stock of artifacts and the natural ecosystem. The stock of artifacts requires throughput for its maintenance, which requires depletion and pollution of the ecosystem. In other words the structure (low entropy) of the economy is maintained by imposing a cost of disorder on the ecosystem. From the entropy law we know that the entropy increase of the ecosystem is greater that the entropy decrease of the economy. As the stock and its maintenance throughput grow, the increasing disorder exported to the ecosystem will at some point interfere with its ability to provide natural services.*”(Daly 1992a, p. 34)

The central truth in this paragraph, is according to Ayres simply not true. The argument in the quote above would only be true if ‘the ecosystem’ is interpreted as the planet earth as distinguished from the solar system, including the sun (Ayres 1998). Since it is however applied to ‘the ecosystem’ as in ‘the biosphere’ considered in isolation, the above quotation is a misinterpretation of the entropy law. Ayres then goes on to point towards a passage, where Daly (1992a, p. 277) argues that in recognition of a medium-run time frame (one generation or an average lifetime) “ (...) *industrial growth is limited by the stock of terrestrial low entropy, rather than by the stock of solar low-entropy, which is superabundant but is itself irrelevant because solar energy is flow limited...”* For Ayres (1998), Daly (1992a) stumbles on a point of fact in this quote: Although solar radiation is flow-limited, “(...)*the flux of available low-entropy energy (exergy) from the sun is extremely large”* (Ayres 1998, p. 197). The biosphere apparently only utilises some 3% of the solar exergy arriving upon the earth’s surface (Ayres 1998).

Ayres believes that very soon technology will be advanced enough to capture the solar flow more efficiently e.g.: photovoltaic cells and fuel cells powered by solar hydrogen. It would not affect the heat balance of the earth if for example deserts were to be covered by devices to capture solar energy and to transform it into hydrogen. The surface of the earth is also no particular limit because according to Ayres (1998), satellites could capture solar exergy and he concludes that “(..) in the long run, solar exergy is certainly available for human use in almost unlimited quantities.” Ayres (1998) is possibly referring to the concept of an economy based on hydrogen (i.e.: hydrogen economy), which was later made popular by Jeremy Rifkin (2002).

Although Ayres claims that direct consumption of biomass by humans requires a tiny fraction of this amount, he also mentions a study by Vitousek et al. (1986). In this study it is estimated that around 40% of the earth’s biosphere-production is already used by humans, when indirect uses are taken into account. At one point population would become too large even if energy were superabundant (unless settlements on spaceships are considered feasible). Ayres (1998, 199) admits that and even argues that “(...) a slightly disguised version of the dilemma posed by Malthus is upon us.”

[23] available energy (Ayres 1998)

**Conclusion**

The aim of this paper was to establish a logical path from the already widely accepted paradigm of sustainability as it was defined by the Brundtland Commission (WCED 1987) over an extensive critique of the economic growth paradigm, to the necessity of the attainment of an economy that does *not* grow – a steady state economy. At the very end of this path, one possible concept for the attainment of such an economy by Herman Daly was provided and critically analysed. It has been shown, that most preconditions, for the growth paradigm, have its roots in the adoption of a mechanic value concept. Generous assumptions of substitutability of resources with other resources, as well as of natural capital and human made capital, coupled with seemingly limitless optimism in technological progress, have been identified as the main preconditions for the theoretical possibility of unlimited economic growth.

Furthermore, it has been demonstrated that economic growth is *not*, the panacea for most problems of human society. This is in particular so if growth as measured in GNP is indeed becoming *un*economic, which seems to be the lesson from various empirical studies. Moreover according to Georgescu-Roegen's (1971) fourth law of thermodynamics, unlimited growth is physically impossible. Ayres (1998) on the other hand suggests that virtually unlimited growth becomes theoretically possible, as soon as the solar flow can be utilised more efficiently with future technological innovations. Although Ayres (1998) reasoning seems correct, it remains questionable, whether the theoretical possibility of 100% recycling has any practical relevance. In addition Ayres (1998) appears overly optimistic about the advances in energy technologies. The enthusiasm about a coming hydrogen economy, which he seems to refer to, is becoming increasingly controversial (e.g.: Luzzati and Franco 2005)

Daly (1992a) on the other side calls for prudent technological scepticism. Before such technologies are indeed available, humanity would be better served by trying to become stable. Natural resources are considerably undersold (El Serafy 1988; Daly 1992a) and the market mechanism cannot be relied upon to provide enough incentive for technological advances. By the time the hydrogen economy is ready to replace the carbon economy[24] it might be too late – the ecosystem damage could be too large for a recovery[25]. Daly's (1992a), depletion quotas, would automatically make natural resources more expensive, by charging a scarcity rent for the resource in the ground. This would not only guide technological research into the development of devices to better capture the solar flow, but also allow humanity to reduce its pollution impact gradually.

One could event take this argument further and ask whether it would be beneficial to humanity's current growth driven society, if it was to discover an unlimited source of energy. Daly (1992a) believes that such a discovery would only accelerate the process of environmental destruction. A population explosion coupled with rapidly expanding economic activity would cause the collapse of ecosystems and the breaking out of famines and wars (Daly 1992a).

[24] Which is not certain, if this will ever be the case.
[25] On a human time scale.

Moreover it has been mentioned, that there is already strong evidence that humanity is approaching the ecosystem limits, most of which are directly related to total number of people on the planet. Vitousek et al.'s (1986) state that around 40% of the net primary product of terrestrial photosynthesis (NPP) is already appropriated by human activities. The Brundtland Commission (WCED 1987) concluded in 1987 that in order to guarantee US living standards for all of the world, this would require a multiplication of economic outputs world-wide by a factor of five to ten (Vitousek, Ehrlich et al. 1986) - a goal, which is simply impossible[26]. Climate change, ozone shield rupture, land degradation and biodiversity loss are further evidence for the impact of human economic activity and the approaching of ecological limits.

In a socio-ethical growth critique, it has further been demonstrated that unlimited economic growth, even if possible, may actually be undesirable. Alternative indicators to GNP show a decrease in welfare for about the last 40 years. Moreover the satisfaction of ultimate ends (whatever they may be) and the cultivation "*of the graces of life*" (Mill 1965 [1948]) appear to be endangered by the growth economy's need for a dissatisfied consumer. Servicing insatiable relative wants has become the *raison d'etre* of the western economic system. At the same time in other parts of the world, people are still struggling to satisfy their most basic needs.

It has been argued that without *moral growth* Daly's SSE concept would probably not be feasible. However, the adoption of the goal of sustainable development, which is clearly based on ethical values and normative concepts, might be the first sign of such growth. Nevertheless, issues of sufficiency, frugality and most of all life style changes are still underrepresented in the sustainability discourse. The same is true firstly for tackling overpopulation and secondly for decreasing distribution inequality by freeing up resources in wealthy countries. Eventually this discourse have to address these issues and thus will be unable to ignore the concept of a steady state.

Maybe the classical economists were right, and the steady state will come upon humanity by itself. Maybe Keynes and Schumpeter were right in regarding the present economic system merely as a path to a better (stable) economic order. Mill (1988) and Daly (1992a) argued that the voluntary transition to what seems inevitable at one point, would avoid major disasters to humanity in the future and create satisfying living standards for everyone. Nevertheless, it remains questionable whether a steady state, even if people voted for it, could be made compatible with the capitalist system of today. Thus it is unclear whether the institutions proposed by Daly (1992a) or Booth (1998) could put the capitalist system within boundaries or if, as it was implicitly assumed by Mill, Marx, Schumpeter and Keynes, a steady-state economy would be equal to socialism. On the other hand, would it matter what the economic system it was, if moral growth became as strong as Daly hopes?

[26] Technological optimists would again argue that these limits could be overcome by the advances of molecular bio-chemistry (or other disciplines). However given the considerable efforts that are under way already to produce crops with higher yields, world grain stocks have been decreasing considerably over the last years (Brown 2004).

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