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# End of growth and the structural instability of capitalism—From capitalism to a Symbiotic Economy

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ABSTRACT

The peak of fossil fuels is probably a matter of decades rather than centuries. Setting-up a new energy mix, initially based on renewable primary energy and electrification of the economy, seems unavoidable and it may start a last expansive cycle, but it also will deplete an important fraction of reserves of several crucial minerals. Soon after it, exponential growth of energy and GDP may be no longer possible due to minerals limitations. A general crisis of resilience of global ecosystems has been predicted by 2025–2045 if the current global growth rate is sustained. Under these new circumstances of zero growth and new global problems demanding new solutions, capitalism will face challenges out of its historical work parameters and that will require much more than partial reforms. Nucleation centres of new economic practices may be the cooperative and solidarity-economy movements in synergy with transition towns and virtual communities which, with political mobilizations oriented to maintain past standards of occupation and life quality (expectations of "progress") may force a transition to some regulated *steady-state* capitalism. Tendency of the rate of profit to fall under stationary and competitive markets conditions will probably transform this end form of capitalism into a post-capitalist *Symbiotic Economy*.



## 1. Introduction

Some projections of possible evolutions of capitalism have emphasized the rising development of globalization, Information Economy (Ahlqvist, 2005), biosociety (Ahlqvist, 2005), and other post-modern patterns (Sternberg, 1993). All these tendencies are clear, but energy and minerals availability may be even more important factors to take into account. Any debate about the future of capitalism must analyse the mutual relationship between economic growth and sustainability of resources and ecosystems (Daly, 2009; Friedrichs, 2011; Harvey, 2010; Newman & Dale, 2008). Some analyses of present energy and mineral availability can be adequate to gauge more precisely the critical age we are now facing and thereby obtaining a realistic view of this problem. The dates of peak production for the three fossil fuels are difficult to forecast due to the difficulty in obtaining good estimates of their technical reserves. However, one of the most exhaustive analysis of the ultimate recoverable reserves (URR) of oil was made by Laherrere (2007) and it can be used to fit the historical data of oil consumption in the world with Hubbert curves which reach a peak between 2013 and 2021 (García-Olivares & Turiel, 2013). Similar Hubbert analyses can be applied for the other fossil fuels (Supplementary Material, Fig. 1). Leggett and Ball (2012)

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have analysed 54 published predictions of the fossil fuels peak and they found that the expected year for the peak is 2028 with a standard deviation of 8.5 yr. This provides an order of magnitude which suggests that the decline of fossil fuels is a matter of decades rather than centuries.

A recent article (García-Olivares et al., 2012) studied the whole set of potential alternatives to fossil fuels. Its conclusion is coincident with Heinberg (2009) and Jacobson and Delucchi (2011) in that the only secure alternative to avoid the spectrum of energy descent is to build worldwide a completely renewable mix. Some authors consider uranium to be an alternative for the medium term, but they do not try to quantify existing reserves to precisely quantify the exploitation horizon of this technology. When it is done, the conclusion is that the production of uranium mineral may peak between 2015 and 2035 (Energy Watch Group, 2006; Fleming, 2007). Other studies consider that the exploitation horizon of uranium may be indefinitely postponed by the use of breeder reactors. However, these kinds of reactors have never become operational for safety reasons. Also, there are social opposition concerns, risk of nuclear arms proliferation and terrorism, and the unsolved problem of the management of high activity nuclear waste. All of these factors together make it very unlikely that these reactors may become a long-term global alternative. These factors have been discussed by García-Olivares et al. (2012), Heinberg (2009) and Jacobson and Delucchi (2011).

In contrast with uranium, wind, solar concentration and hydroelectricity are power sources which have a good social perception, are already able to produce (combined) the totality of power needed to maintain present industrial standards, solve the problem instead of postponing it, have acceptable (larger than 10:1) Energy Return On Energy Invested (EROEI), and does not depend on scarce materials. Its use as an alternative mix is already possible and its deployment should be promoted even though it would involve a huge socio-economic mobilization (García-Olivares et al., 2012; Jacobson & Delucchi, 2011). On the other hand, the deployment of the global renewable generation mix and the subsequent electrification of transport would be materials intensive. As an example, it would consume 50% of the current copper reserves and the need for platinum, lithium and nickel for transportation would be larger than (or a substantial part of) the respective existing reserves. Therefore, soon after the implementation of the renewable solution (and there is no proven alternative to it available), the exponential growth of energy consumption may come to its end due to severe shortages of these raw materials (García-Olivares et al., 2012).

The potential economic consequences of such stationary energy consumption have been discussed in (García-Olivares & Ballabrera-Poy, 2014). In that work, the LINEX production function proposed by Kummel (1989) and used by Warr and Ayres (2006) to fit the GDP of the US economy from 1900 to 1998, was improved and used to predict the impact of different energy scenarios on the US economy.

Four scenarios (P, M, O and I) were studied with that model. They differ in the rate of deployment of renewable and fusion sources (P: zero rate of renewable growth; M: present rate of renewable installation; O: building of 11.5 TW of global renewable energy in 50 years starting in 2038; I: indefinite installation of fusion and renewable power at a rate of 11.5 TW every 50 years and decreasing return to scale after 2045, respectively).

In the four scenarios the GDP tended to a steady-state in the long term except if implausible hypotheses were employed. Consequently, a steady-state economy (in throughput) (Daly, 1974) emerges as the most probable scenario in the scale of the present century. Energy input seems to be a crucial production factor in any industrial economy. Therefore, steady energy consumption should be expected to impede the continuation of growth not only in developed but also in developing countries. This kind of steady economy was first discussed by Boulding (1966, 1973) as something not only inevitable but desirable for a sustainable future.

Other important sources of instability which may also contribute to push the economic system into a zero or negative growth have been further discussed by Heinberg (2011) and are mainly related to the economic costs of a future high oil price, limited resilience of global ecosystems, the exhaustion of cultivable lands and usable water, as well as the social pressures to avoid major anthropogenic climate changes.

Is the capitalist system able to adapt to this plausible future scenario? Section 2 defines the concept of capitalism and its social context and describes our methodological approach. Section 3 summarizes the main theoretical results that will be used in the discussion. Section 4 analyzes the alliance of the capitalist economy with national power and a world view based on progress; discusses the effect that a zero-growth scenario will have on these three elements; and also discusses if the future economic evolution will witness a new capitalist Kondratieff cycle, a transition to a capitalist steady-state or a change of the mode of production. The analysis shows that capitalism will be compatible with a steady state economy during a first stage, but that profits will tend to zero under stationary conditions with a competitive market. It may lead to serious market failures, intensification of social mobilization and, finally, to a post-capitalist system that we have called "Symbiotic Economy" (SE). SE will be a stationary economy able to generate prosperity without quantitative growth and with companies not profit oriented. Necessarily, SE will be symbiotic with the ecosystem where it is embedded and with the society to which it serves. We identify some social players which could press politically in favour of this transition. Section 4.4 discusses some of the patterns of the new SE economy which can be reasonably envisaged from the present, and Section 5 summarizes the main conclusions of the study. Table 1 defines the acronyms and units used in this study.

## 2. Capitalism and its social context

Capitalism is defined by Baumol, Litan, and Schramm (2007) and Jackson (2009) as an economy where property and control of means of production are in private hands instead of being state-owned. For historical reasons, production