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Technology and transition: 'progressive evolution of regimes and the consequences for energy regime change

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Abstract

Transition of energy systems has been under-theorised. We have argued previously that energy efficiency as a strategy for fossil fuel replacement is inadequate as energy demand is not being reduced by efficiency alone. This paper is intended to elaborate further on the reasons. We require better answers to better questions about the nature of energy regimes and how they resist change. Our present-day socio-technical energy regime is a global integrated technical arrangement based on cheap high-yield energy sources (fossil fuels) with built-in 'progressive' social and economic directions. This 'progressive' change relies on cheap energy as a resource towards ever greater global integration and economic efficiency. Energy regime change will be not a tinkering at the edges but will require a dismantling of this 'progressive' tendency with radical retrogressive economic and social consequences. We conclude a change of our relationship with energy will require the reversal of a contingent 'progressive' tendency that is as old as mankind and the necessarily modest building of a new infrastructural apparatus designed to a new 'end', or the reversion to previous low or lower demand apparatus based on non-fossil energy sources. Both solutions would imply major social and economic changes which we will deal with in another paper.

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Keywords: energy transition, urban energy system, socio-technical systems, systemic lock-in.

1. Introduction

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Today we face the need to transform our energy systems. We need to reduce our dependence on energy sourced from cheap fossil fuels and replace fossil fuels with sustainable energy sources. The problem is that the <energy efficiency + replacement of fossil fuels = sustainability> equation [1] is accepted but the hoped for reduction in the demand for fossil fuels is not materialising in an adequate timeframe. In addition, while there is significant public concern, the action regarding curtailing fossil fuel use and the release of carbon emissions into the atmosphere is not demonstrated. The priority of both politicians and electorates is consistently for economic growth. In the recent past governments and industry have reduced efforts and incentives for renewable sources [2] while fossil fuel use is projected to rise further at least until 2040 [3] by which time we should be well over the 2C climate change 'limit' [4].

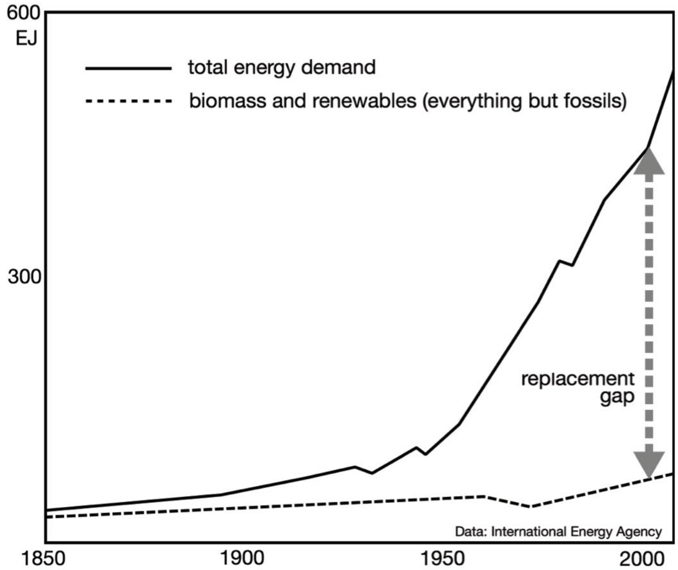

Fig. 1. Energy demand rise since 1850. The plausibility of the timely closing of the 'replacement gap' is questioned.

Oil price rises should have worked for the advancement of alternative energy sources, but overcapacity and new sources have 'solved' the economics of fossil fuel supply and stagnating demand is regarded as an economic problem rather than as a replacement opportunity. Advocates for climate change action blame the power of special interests (fossil-fuel suppliers) and the inadequacies of political control and leadership [5].

It seems there should be no argument regarding the necessity of climate change action while progress is slow and even negative and questions have been raised about the political will to stem the use of fossils fuels and avert climate change. We intend here neither to assume that will is all that is needed nor to minimise the difficulties of change. Our response is to explore further what a transition from fossil-fuelled high-energy systems to sustainable renewable-energy systems entails and to clarify the social-systemic constraints and systemic 'necessities' bound up with the political questions, to shed light on the dilemma.

There are different questions implied here. One is about whether and why fossil fuel use and economic performance and growth are linked. US President Obama reflects the scientific orthodoxy when he thinks not and uses the success of 'green industry' as a rationale [5]. We believe this to be a confusion of 'levels' as green industry is itself energy-wise 'subsidised' by and is economically a small dependent component of a much larger fossil-fuel dependent system [6] that at the same time depends on (and collapses without) economic profit. Are our societies and economies dependent on the conversion of cheap energy sources into high-yield energy – or on current levels of energy demand (levels that can only practicably be supported by fossil fuels)? We want to ask this question in a following paper.

Here we ask what energy demand represents in an advanced industrial society. What difficulties and costs are entailed in what we have to transition to? Do we know and can we act on the gap between the high-energy society we are expected to transition from and the much lower-energy society we expect to transition to? Is that gap bridgeable within the envelope of societal expectations of prosperity and economic growth? We have been made aware of the scope of the problem of climate change; could our difficulties be related to the scope of the solution of societal and economic change?

2. Technology and infrastructure

There are number of starting points that need to be made. The first is that technology is not an 'externality' when it comes to thinking about species and society. The social is sometimes understood as separate to, and to add (irrational) complexity to formalisable functional problems, but the human world is tightly organised as internally consistent 'socio-technical regimes'. Technology "is an ongoing and unfinished process through which people, society" and things "weave … the meaningful conditions of everyday life" [7]. Some [8, 9, 10, 11, 12] have asked what technology is in its essence. Their answers have pointed to mankind's own nature as fabricators of our world. Technology exists not apart from but as an integrative factor of society. It mediates every perception and every action; in its larger scales it creates an immersive environment in which we know and do in ways technology makes possible and natural.

People live in material-technical cultures. It is in the nature of technology to be highly aligned with and adjusted to the users of technology. Behaviour is mediated through material and technology so that people are enabled and purpose is embedded in these alignments and working within them becomes normal and self-evident.

But technologies are not just adjusted to us, they are also adjusted to other technologies. The tools and objects we encounter and use are organised in integrated and coherent socio-technical worlds. Technology is about the ways these worlds are made and maintained once made. Technology's essence is its integration as socio-technical and material-cultural infrastructures. These are immersive environments in which interdependencies of ends and means are established as practice [13, 14, 15].

This extends through all practical and institutional aspects of societies and economies so that it can be hard for people to even imagine alternatives. The result is that transition in any direction may be difficult because we are dealing with not just human behaviour and habit but also the practical, material and environmental conditions of their behaviour and habit. 'Regimes' themselves consist of organised bundles of interdependent practices, institutions and technologies integrating agricultural, industrial, commercial, administrative, military and exchange aspects and incorporating urban places and networks. They include technologies and our cities, constructed historically to maintain 'advanced' societies and economies. They consume and have consumed vast resources to do this

3. Regime change and 'progress'

There have been successive distinct energy regimes and demographic states, beginning with hunter-gathering, passing through agricultural and urban, then industrial regimes to the condition we live in today [16]. Pre-historians date the beginning of cultural, as opposed to biological evolution, to about 25 000 years ago [17]. Since that time humans have evolved in combination with their tools. The first major step up the evolutionary ladder involved a 25-fold population increase in an energy transition from hunter-gathering to agriculture and the foundation of cities. Cultivation provided the impulse for an economy based in agricultural productivity, the surplus of which subsidised urbanisation and social specialisation.

Stepping forward to 1800, roughly 97% of people still lived in rural areas, still subsidising the lives of those who lived in cities. The next two hundred years saw urbanisation accelerate (and the population increase seven times) as energy stored in fossil fuels was exploited to mechanise societies and economies. Infrastructure projects were part of the 'reconstruction' and 'rescaling' of city and nation state, Human population grew at 1,5% per year and energy consumption grew at 3% per year, indexing the economic expansion [18]. Fossils accounted through this period however for only a slowly increasing fraction of the energy produced.

The last (post second world war) phase was the true fossil age (see figure 1), when oil (transportation) and coal (electricity) drove massive urban development and global production of consumer goods. A geopolitics of oil led in the 1970s to a globalisation of production processes and the invention of a new economy of neoliberalism [19]. The 'flows' of materials and products at a global level fed into new metropolitan landscapes of mobility [20] where lifestyle comforts like heated houses and showers completed the picture. Large infrastructure projects were again part of this, transforming the land and housing market in the developed world for a neoliberal economy and suburban car-oriented ways of life.

Infrastructures facilitated new levels of social and urban differentiation but also enabled an intensified exploitation of natural resources at previously unheard of scales [21].

4. Transition and 'progress'

Economists believe that increasing energy consumption is a consequence of economic growth. History tells us however that economies (and populations) grow when energy consumption expands [22]. The regimes and systems that characterise societies mark a 'progressive' material-cultural evolution given teleological direction and driven forward by regime changes of simultaneous population growth and growth in per capita energy demand. This 'progress' depended also on transitions from solar to organised solar (agriculture) to stored solar (fossil fuels) energy sources and the substantial energy yield increases from the one to the next.

Once a transition to a new energy regime and its associated society and economy occurred the step backwards seemed to be foreclosed, blocked by the dependency of the increased population on the new energy system, while at the same time they were locked in by their material-cultural system and the infrastructural apparatus they had invested in.

What this 'progress' also suggests is that there will need to be a societal and economic 'retrogression' involved in a massive curtailing of energy demand. Transition in any direction may be difficult, transition backwards impossible without severe consequences for capacity to support a society and life we consider normal today.

While there is no necessary or ideal 'end' to which processes of development are directed [23], there are here very real contingent 'ends' tied up with the exact qualities of the energy sources concerned.

The differentiation of territories into urban and rural at the emergence of cities also marked out a directionality and of urbanisation which has drawn rural migrants to cities ever since. It is also the reversal of this aspirational 'direction' of power we are asked to consider when thinking about reversing the 'progress' of urban societies.

5. Retrogressing to the future

The material-cultural worlds in which people are enabled and purpose is embedded make these things normal and self-evident and alternatives, especially 'retrogressive' alternatives difficult to implement or even contemplate. Energy consuming infrastructures embody affordances, channel energy and resource flows, and causality becomes circular. They make actions cheap, convenient and easy while at the same time they are expensive to construct. They are also difficult to deconstruct in that the capacities they engender have become 'normal' social expectation.

What are the prospects for transition? We will sketch one possible outcome. There are others but space does not allow their inclusion here. Resource and commodity flows and chains are optimised at global scales. The resulting economies of scale have for the most part been achieved and further expansion is up against planetary limits. The globalisers face diminishing profits [24]. The economy must grow, but will grow only where material resources are consumed at high levels and where urban development continues and delivers the highest intensity of energy demand. And this while these conditions are increasingly difficult to sustain. What will emerge is a crisis of economic stagnation characterised by overcapacity and lack of demand [22] and the discontinuous breakdown of global supply chains. This will stimulate local supply chains as alternatives in food and other essentials as well as a need to learn to survive without economic growth and its increasingly unprofitable technologies (like global shipping).

Some of the possibilities for the future are given to us in history. 1940s levels of energy demand were one fifth of what they are today and within shooting distance of renewable energy. But renewables will turn out to be less renewable than we think they are when the energy costs (fossils today) of energy production are accounted for.

The conclusion has to be that the present economy, already stagnating, will be no longer viable on these terms. The transition will not involve an economic dip before innovation and business as usual because the innovation will not be able to scale up to present levels. Efforts at local import replacement and 'circular' and 'resource economies' will in the intermediate phase add resilience as global supply chains come under increasing threat of catastrophic failure. We will most likely see a collapse of the economy (ideally long before an ultimate collapse of the environment) and a new beginning built mainly on small-scale changes in supply of food and other necessities. In spite of a massive drop in living standards, these beginnings may well show a way towards a lower energy but also lower affordance future.

Some claim the future involves geotechnical apparatus organised to a radically different 'end' – not to that of handiness and usefulness of tools for action but constructed to produce and maintain a biosphere in a form not fatal to human habitation. The end of these 'infrasystems' would be to ameliorate the consequences of the channelling of resources and energies for our convenience [25]. But reorientation to a purpose outside of direct practice and its 'practice environment' will be very difficult or impossible. It is more likely we will have to cultivate to sustain rather than produce another machine.

Building complex new geotechnical solutions are very likely beyond our resource capacities anyway. Just finishing the one we started in order to deal with global social inequality is probably already beyond our resource capacity.

6. Conclusion

How difficult is it to change systemic direction and purpose? Jonsson has argued that transition will be from infrastructural systems that are basically humanly and economically oriented to ones that support ecological 'purpose'. History shows this is more difficult than it seems and we have begun to highlight some of the reasons.

At one level the issue is simple. Ours is a high-energy society. We are tied to high energy use by societal, economic and cultural demands. These demands are delivered today by high-energy socio-technical regimes. Climate change and proposed measures to alleviate it are an interruption to this basic character of our energy regime. In economist-speak they are an 'externality' to the 'systems' and 'regimes' we have ourselves created. They may always be and we will be obliged for the sake of our own survival to place a limit on global energy demand at the level of about one fifth what it is today. We will have to manage economy and population in the future to this limit and learn to live with the economic, demographic and social structure and lifestyle consequences.

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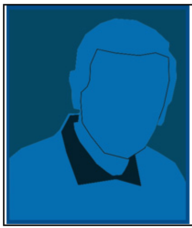

Biography

Stephen Read is associate professor at the Faculty of Architecture, TU Delft. He is an experienced urbanist, urban morphologist and philosopher of science and technology and enthusiastic newcomer to energy studies.