The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

Renewable Transition 1: Targets & Troubles

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In this series I will again approach the issue of energy return on energy invested (EROEI), or net energy. Rather than a detailed analysis of the EROEI value of specific types of renewable energy technology, however, my goal is to consider systemic implications and the role of uncertainty in the ability of our civilization to transition from fossil fuels to renewable energy. In this first post I will discuss the challenges and potential goals of such a renewable energy transition, noting the criticality of EROEI values to our ability to transition. Next, I will look more closely at EROEI itself, exploring our inability to produce an accurate, inclusive, and verifiable measurement, and explain why the resulting degree of uncertainty is very significant. Finally, I will consider the path forward amidst this uncertainty.

To the extent that the global community is concerned with energy scarcity at all, it is my opinion that there is a pervasive faith that, over the coming decades, we will overcome these challenges by gradually transitioning to a renewable-energy economy. Certainly not everyone shares this vision of the future, but it appears to be both the conclusion of many intelligent commentators within the field, as well as the only politically-viable vision offered by politicians to the masses. The result is that, while it is acceptable to debate the mechanics of realizing this vision, any attempts to question its general feasibility tend to be swept under the rug.

Let's start with what we know, or at least what we are reasonably confident in and that I will assume for the purposes of this series: We know that fossil fuels won't be producible at present rates forever. We know that it is possible to generate renewable energy from sources such as the sun, the wind, waves, and geothermal heat. What I will argue that we don't KNOW—despite frequent and occasionally self-serving protestations to the contrary—is whether the EROEI of available renewable energy technology makes replacing our fossil fuel-economy with a renewable-energy economy possible.

The trouble with transition begins with the issue that (present) renewable energy sources such as solar and wind require an investment of energy up-front, after which these technologies proceed to return energy over a period of time:

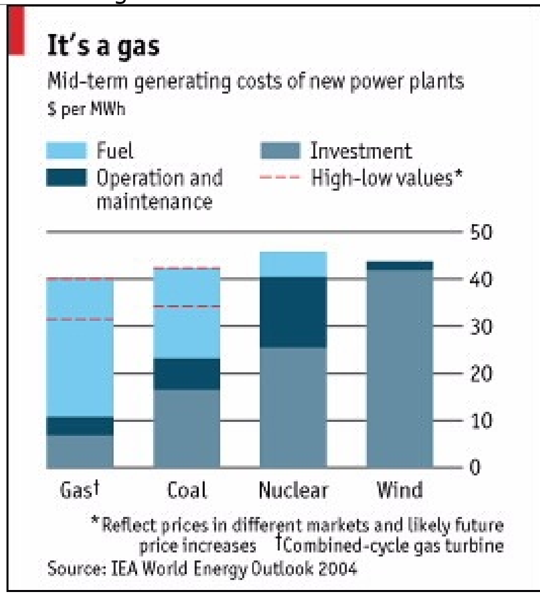

Figure 1 (up-front costs of energy alternatives)

While this is all quite straightforward, there is at least one important implication that seems to be generally overlooked: at some rate of investment in renewable energy infrastructure, the economic burden of this up-front energy investment will make the program politically impossible. What do I mean by that? If you want to increase the amount of energy derived from renewable sources (and thereby help to ameliorate energy scarcity), you need to first *exacerbate* that scarcity by using an increasing share of our currently available energy as an up-front investment in these new renewables.

If the EROEI of the renewables towards which we're transitioning is sufficiently high, if our timeline for meeting some transition target is sufficiently long, or if the transition target is sufficiently low, then this "burden" will be minimized as we will be able to meet our target with a small up-front investment of fossil fuels (minor exacerbation of scarcity) and then bootstrap the energy production of the first wave of renewables to finance the energy demands of the remainder of the transition.

However, if some or all of these conditions are not met, then the transition target will not be possible because the level of up-front fossil fuel investment will exacerbate current energy scarcity to a politically unacceptable or economically infeasible degree. Imagine: if the EROEI is only 2:1, or if we want to transition all fossil fuels to renewables within 5 years (via some kind of WWII-style economic mobilization), then a huge portion of our current fossil fuel use will need to be diverted to this renewables transition. The result, due to underlying supply and demand inelasticity, will be massive price spikes, rationing, or other politically and economically devastating events.

Of course, if EROEI is 100:1 on a generating life of 20 years, or if our target is only to maintain current rates of renewables transition, then these problems won't arise. As I will argue later in this series, EROEI is likely far lower than 100:1. And I am working on the assumption that, independently due to peak oil and climate change, a status quo transition rate is unacceptable.

Transition Goal: First, it's important to recognize that there are a variety of possible transition targets. Some include: a general transition target (either total transition to renewables, or transition to some arbitrary %), a peak-oil mitigation target, a peak fossil-fuel mitigation target, and a climate change mitigation target, to name a few. All have differences and similarities. Clearly, one can define a "target" that is plainly achievable, as can one define a "target" that simply can't be done (e.g. 100% transition by tomorrow). As such, the definition of "transition target" represents an easily manipulable variable in any discussion of renewables transition. If two people or organizations don't address the same target, they'll be constantly talking past each other in discussing renewables and the practicality of transition. While I certainly don't think that I'll be able to convince all parties to adopt a unified transition target in this article, I do plan to argue for a threshold target that, in my opinion, represents a minimum rate of transition to keep the "viridian vision" of a renewable future possible: a peak oil mitigation target.

So, it seems clear that a renewable energy transition will need to, at a minimum, replace the decline in oil production post-peak with renewable energy generation. I'll elaborate on why I draw this line in the sand below, but in brief the viridian vision (by which I mean a general continuation of our current neo-liberal, capitalist/market-socialist civilizational structure into the distant future by leveraging technological advances and a transition to a renewable energy base and "green" consumer function) requires that we maintain generally the same level of present energy consumption into the foreseeable future.

It's also important to point out the obvious, that there are significant differences between the energy produced by renewable technologies (that, for our purposes, produce electricity) and the energy lost by declining oil production. In general terms, in order to use the electricity produced by renewables to replace oil, there will be an additional energy cost required to transition the energy-consuming infrastructure to utilize electricity rather than oil. This will increase the overall amount of energy required to affect this transition. For the time being, I'll ignore this additional cost (see my note on conversion efficiency of oil to electricity, below).

One key argument in favor of the viridian vision is that we can mitigate peak oil with increases in efficiency and energy conservation. These arguments generally don't, however, address how we're going to meet the energy demands of 1) a growing population, and 2) a huge third-world population that wants to live at Western standards of energy consumption. The more optimistic population estimates show the Earth's population peaking at 8.3 billion, and more pessimistic estimates show population peaks between 9 and 13 billion.

It's important to point out that many population estimates reason that population will stabilize--and then decline--because of the effect of bringing the standard of living of the world's poor closer to Western standards. Will the energy pressures presented by population growth and efforts to improve living standards roughly balance out any improvements in efficiency and conservation? I think so, but I recognize that this is a significant source of uncertainty. In fact, I think that this is overly optimistic, and that demographic pressures will more than eat up any energy savings from efficiency and conservation.

Additionally, while the possibility of radical demand destruction due to significant global reduction in our standard of living would also “solve” peak oil, such a future is incompatible with the viridian vision that drives current transition efforts and political posturing. For these reason, I think that we must increase renewable generation capacity at the same rate that oil production declines--we can't count on efficiency and conservation to make up any of this decline with a sufficient degree of certainty.

If peak-oil mitigation is the target, then how fast must we build out renewable energy, and what is the energy “burden” of that project? Below I’ll present an admittedly rough estimate of the numbers:

The world consumes roughly 500 Quads per year (Quadrillion BTUs) from all energy sources. Of this roughly 186 Quads come from oil consumption. IF you accept a post-peak decline rate of 5% per year, then that represents a decline of 9.3 Quads per year. 9.3 Quads equates to roughly 102.3 GW-years, or 896,000 GWh. To round that off, let's call it 100 GW-years, or 900,000 GW-hours. That's how much new renewable generation must be added *each year* going forward to mitigate peak oil. That's the transition target. How does that compare with current renewable generation rates?

The current global installed (nameplate) solar capacity is about 15 GW, including about 5.5 GW added in 2008. That works out to roughly 1 GW-year of solar generation capacity added in 2008. At the end of 2008, global (nameplate) wind generation capacity was 121 GW. That works out to roughly 42 GW-years of total global wind generation annually, of which 35 GW, or about 12 GW-years of wind generation was added in 2008. Combining solar and wind, we added about 13 GW-years of renewable generation capacity in 2008. That's a bit over 10% of the rate at which we'll need to add new renewable capacity each year *just to compensate for a 5% global oil production decline rate* (not to mention future natural gas decline, coal decline, etc.). There are two take-aways from this: 1) the current rate at which we are increasing renewable energy generation is an order of magnitude lower than that necessary to mitigate peak oil, and 2) the amount of energy invested in renewable energy projects at present does not pose the kind of energy drain that will be presented by investment sufficient to mitigate peak oil.

On this last point, mitigating a decline of 4.4 million barrels of oil per day (roughly 5% of global total liquids production) *each year* with new renewable generation capacity will impose a significant up-front energy cost.* If the energy payback time is 1 year for the mitigating renewable source, and if we must increase current renewable energy investment by 90% over current levels, then we need to invest the equivalent of an *additional* 3.96 million barrels of oil each day to facilitate the transition. That's like adding another half of China to global demand, and that 1-year payback time assumes an EROEI of 40:1 on a 40-year generating life. If the energy payback time is 2 years (or a 20:1 EROEI) then you can add another full China to global demand. If it's 10 years (an EROEI of 4:1), then go ahead and add 5 Chinas. You can see where this is going--getting an accurate measure of EROEI, and properly understanding the mechanics of scalability, are critical before we can determine if it's possible to achieve the peak oil-mitigation target outlined above...

*I recognize that there is an efficiency loss if one converts oil to electricity. While some reduction in this figure may be warranted on that ground, we must also consider the additional energy that must be invested to convert our fossil fuel consuming infrastructure into an electricity consuming infrastructure. The degree to which these opposing forces balance each other out remains unknown.

Carbon considerations: One of the most powerful arguments in favor of a transition to renewable energy generation is that these systems tend to have very low carbon emissions or be entirely carbon-neutral. However, what is the carbon cost of the transition itself? At least the initial energy burden of a renewables transition will come primarily from fossil fuels, and therefore will be very carbon intensive. Here, again, EROEI (and EROEI as a function of generating life) will be critical—a high EROEI means that a transition can be financed primarily by bootstrapping the clean energy from the initial wave of renewables to build ever more renewables in short order. A low EROEI may mean that we must emit a huge lump of carbon in order to build out the renewables infrastructure on a timeline fast enough to deal with peak oil, let alone a more rapid transition designed to reduce carbon levels...

Wrapping up this first post, the issues of transition goals and carbon emissions hinge on the "true" EROEI of available renewable technology. We cannot adequately formulate realistic transition goals, nor can we understand the climate implications of those goals (or the feasibility of climate policies in general) until we have a firm understanding of EROEI values. As I will discuss in the next post, our current EROEI calculation methodology is inadequate and we (should) have little confidence in our EROEI estimates. As a result, our energy policy plans at this point are largely an exercise in faith...