The Renewables Gap: The Political Challenge of Affecting a Societal Transition to Renewable Sources of Energy Revisited

Posted by jeffvail on July 1, 2010 - 10:35am
Topic: Alternative energy
Tags: alternative energy, original, peak oil, renewable energy, renewables gap, systems theory, transition [list all tags]

This post was previously run, in November 2009. - Gail

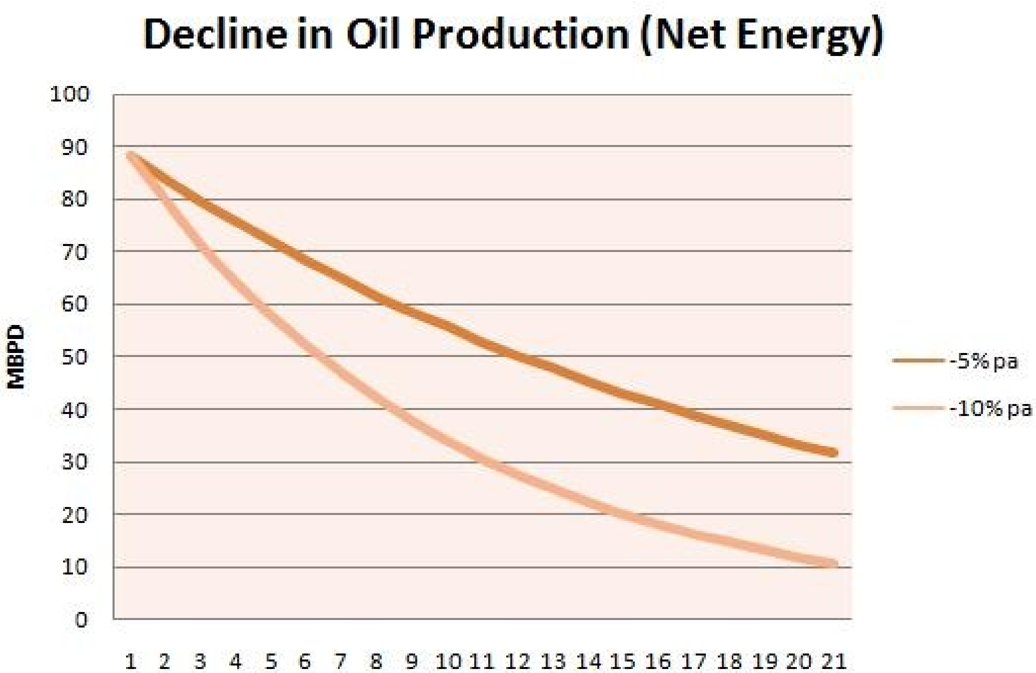
Below is a summary of my presentation, The Renewables Gap (PDF), from the ASPO-USA 2009 conference. The intent of my presentation was to highlight the political challenge of affecting a societal transition to renewable sources of energy. In particular, I focus on wind and solar, though it seems to me that the problem will be largely the same (if not worse) if we attempt to rely on other "renewables." My initial presentation focused on attempting to illustrate the Renewables Gap as an energy problem. While I briefly addressed the political aspects of this problem in my presentation, on reflection I've chosen to focus more carefully on this aspect of the Renewables Gap.

Frankly, I've never been very pessimistic about our theoretical ability to adapt to peak oil. It's what I fear we will actually do in response—or, rather, what we won't do—that concerns me. I feel the same way about our ability to transition to alternative sources of energy—the challenge that I've termed the Renewables Gap. I'm quite confident that we have the theoretical ability to deal with the problem. However, if you accept that "politics" is the process of allocating scarce resources in a society, then it is the political problem posed that appears most daunting. Like many things involving peak oil, we're sure to have all the political will that we need to deal with the problem at only some point after our window of opportunity to act has closed. The challenge is figuring out how to spread awareness of the nature of the problem and willingness to commit scarce resources to its solution before there is a crisis. Here, again, my pessimism is grounded in what I fear we will not do. I don't pretend to offer any easy solution (the desire for which gives much insight into the nature of this very problem). My goal here is only to provide a framework for thinking about this problem:

If we seek to mitigate peak oil with renewable energy, we need to first ask what do we need to mitigate. My answer: the decline in NET energy produced from oil, not the decline in overall production. If, hypothetically, 20 years from now we're producing 100 million barrels of oil per day, but it requires 100 million barrels of oil worth of energy input to do so, we have ZERO energy left for the operation of society at large. From the perspective of a society attempting to maintain itself, this is functionally very similar to producing no oil at all. Therefore, we must remain focused on the NET energy available to society.

What I want to quantify is the amount of net-energy that we need to replace going forward. A "classic" peak oil decline graph shows a plateau, followed by a gradually accelerating decline. Let's consider why that's so. What happens when we hit a plateau—as we arguably have now? The existing fields are declining at rates between 3% and 15% per year. But, because we're scrambling to bring new production on-line, the overall level of production is buoyed for some time. We're compensating for this underlying decline with more expensive oil—both financially and energetically. That keeps the level of OVERALL oil production steady, but the rate of NET energy production from oil is falling.

For the purpose of exploring the solution space of society's transition to alternative energy, I've decided to frame the issue with two simple, exponential rates of NET energy decline: 5% and 10% per year. The graph below shows these rates of decline starting from a hypothetical year zero (because, again, my goal here is not to state that global peak net energy occurred in 2002, 2020, etc.). I'll call these the "low" and "high" range scenarios. Certainly this simple exponential function is overly simple, and these numbers may be higher or lower than many estimates. That's fine —my goal here is to frame the issue, not to predict the future reality of global net energy production. I'll be discussing the potential to use renewable wind and solar power to mitigate these rates of decline.



First, I'd like to note the systemic effects of solar and wind energy's unique energy-return profiles: the vast majority of the energy invested in these sources comes up front, before they ever begin to generate. Between 80% and 90% of the total energy ever required to build, operate, and maintain these systems must be invested UP FRONT. I won't discuss other renewables such as tidal, geothermal, nuclear, and biofuels at this time, though I welcome discussion of how these options may impact the solution space.

Next, it's necessary to point out what is obvious to many: these renewables produce ELECTRICITY, not oil. I'm talking here about using them to replace oil, so it's necessary to address conversion issues. How many GWh are needed to replace 1 mbpd of oil production?
A straight BTU-to-BTU conversion: replacing 1 million barrels of oil per day production, or 365 million barrels of oil per year, equates to 70.78 Giga-Watt-Years.

Clearly, however, oil and electricity are not the same thing. Some people have suggested that you only need 1/3 this much electricity to mitigate peak oil because oil fired electricity generation can be only 33% efficient. I think that modern oil-fired electricity is actually somewhere between 50% and 66% efficient, but we need to explain the validity of using the BTU-to-BTU conversion:

First, because we need to replace oil, not electricity, and because relatively little oil is used to generate electricity, it's incorrect to use this oil-fired electricity efficiency number.

Second, our infrastructure is currently adapted to burning oil in many applications. Therefore, to the extent we want to use renewably-generated electricity to replace this oil, we need to adapt this oil-burning infrastructure to electricity. For example, if you want to replace transportation fuel with plug-in electric cars, you need to invest in significant new infrastructure in the form of cars, batteries, charging stations, etc.

Third, any form of mitigation using renewably-generated electricity will require significant additional investment in the transmission grid to handle higher loads and to balance or store electricity due to the variable availability of renewable generation.

I don't know if it's possible to calculate the exact energy balance here. However, I'll assume for the present analysis that, in order to mitigate peak oil with renewably-generated electricity, we'll need to generate effectively the same number of BTUs of electricity as we're losing in oil. Maybe slightly more, maybe slightly less, but I think the BTU-to-BTU figure of 70.78 Giga-Watt-Years per million barrels of oil per day lost is pretty close.

Another argument is that we don't need to produce as much energy renewably as we lose to peak oil because conservation and improved efficiency can largely make up the difference. There's some truth here, but it's only ½ the equation. That's because two factors—population growth and the desire of the world's poor to improve their standard of living—will cancel out some or all of the gains from efficiency and conservation. For example, if population increases by 30% over the next 20 years, that alone will negate a 23% reduction in global per capital oil consumption.

Additionally, at least 5 Billion people and growing want to "improve" their level of energy consumption to Western levels. In India, car sales are up 26% over last year, to 120,000 cars per month. Admittedly, these cars tend to be more efficient than in America, but this is new demand, and it far more than cancels out the fact that the Tata Nano gets 56 miles per gallon. Similarly, on a global scale, Jeavons' Paradox will reduce the effectiveness of energy efficiency as a tool to reduce demand. Finally, while markets or force may deny the world's poor access to Western levels of energy consumption, the geopolitical consequences of such disparity will actually serve to accelerate energy scarcity.

Another key question is: how much up-front energy input will be required to build out enough renewables to mitigate the decline in net energy from oil production? We know how much energy must be produced to meet this target, so the answer to this question is a function of the EROI and the lifespan of our renewable options. Here, I'm only evaluating wind and solar photovoltaic. I recognize that many people hold the belief that wind and solar energy have very high EROI values on the order of 40 or 50, and energy payback times on the order of months, not years, I've chosen to use significantly lower EROI values for this analysis.

We could talk about this boundary and EROI calculation issue until we're all blue in the face—my intent here is not to argue that some specific number is correct, but rather to point out the uncertainty and potential range. At the lower end of the range, I've proposed a proxy of price to account for ALL inputs and outputs. There are significant problems with this methodology, such as dealing with financing costs, but it has the distinct advantage of allowing us to account for all inputs—regressed infinitely—rather than drawing some sort of artificial boundary. IF you look at modern wind turbines using the price proxy, you get something like an EROI of 4. I'll call that my "low" value.

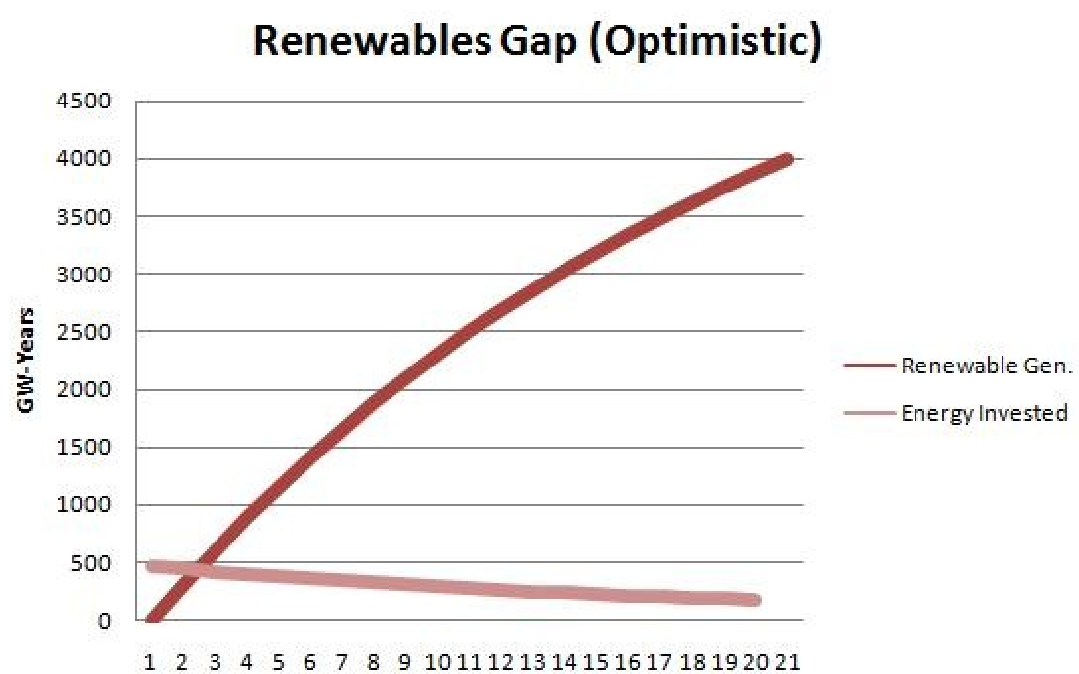
Now let's consider more conventional calculations. Wind seems to be most promising at the moment, and I'm looking specifically at a 2009 paper by Kubiszewski, Cutler, and Endres entitled "Meta-analysis of net energy return for wind power systems." The authors review 50 different studies of wind EROI. In a section entitled "Difficulties in calculating EROI," they make this statement:

"Studies using the input-output analysis [one method of calculating EROI] have an average EROI of 12 while those using process analysis [another method] an average EROI of 24. Process analysis typically involves a greater degree of subjective decisions by the analyst in regard to system boundaries, and may be prone to the exclusion of certain indirect costs compared to input-output analysis."

What I take away from that is that there seems to be a range of 12-24, but the authors—a highly respected group—suggest that the "24" figure fails to account for many inputs. That suggests to me that an EROI of 12 is more accurate.

For our purposes, though, my intent is to explore the solution space, so I've selected what I think is an optimistic upper "high" EROI value of 20. I think this is unrealistically high—especially because this figure doesn't even account for the intermittency, transmission, and storage energy costs that must be considered in such a large-scale societal transition—but for now let's use 4 and 20. Feel free to recalculate using your own preferred numbers...

With apologies for the long introduction, here's the reveal:

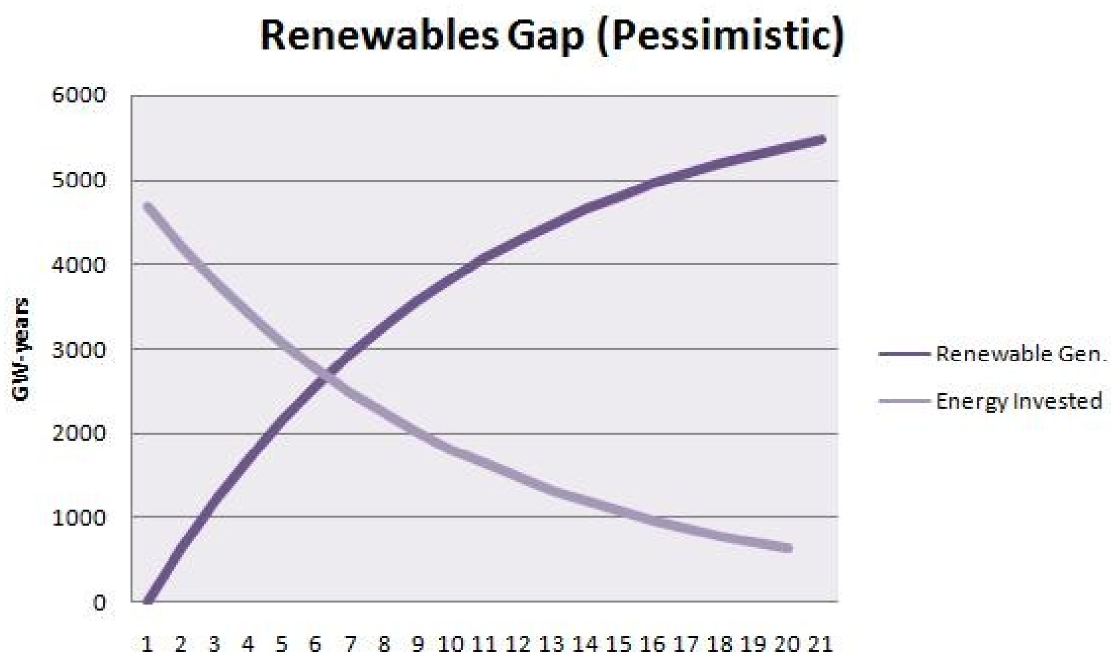


How much energy must we invest if we want to ramp up renewable generation to keep pace with declining net energy from oil? This graph answers that question using a 5% net energy decline and a renewable EROI of 20.

In this scenario, to mitigate the year-1 decline in net energy from oil, we'd need to invest 467 GWy of energy in year one without any production in return—that's the equivalent of almost 7 million barrels per day. Then in year two it's about 130 GWy more invested than cumulative production to that point, or about a 2 million barrel per day deficit. Not until year-three will the cumulative renewable generation be more than the investment deficit for that year—meaning that not until year 3 will we begin to have surplus energy available to mitigate the actual decline in oil production (which by this point leaves us 12 million barrels per day behind the peak oil decline curve.

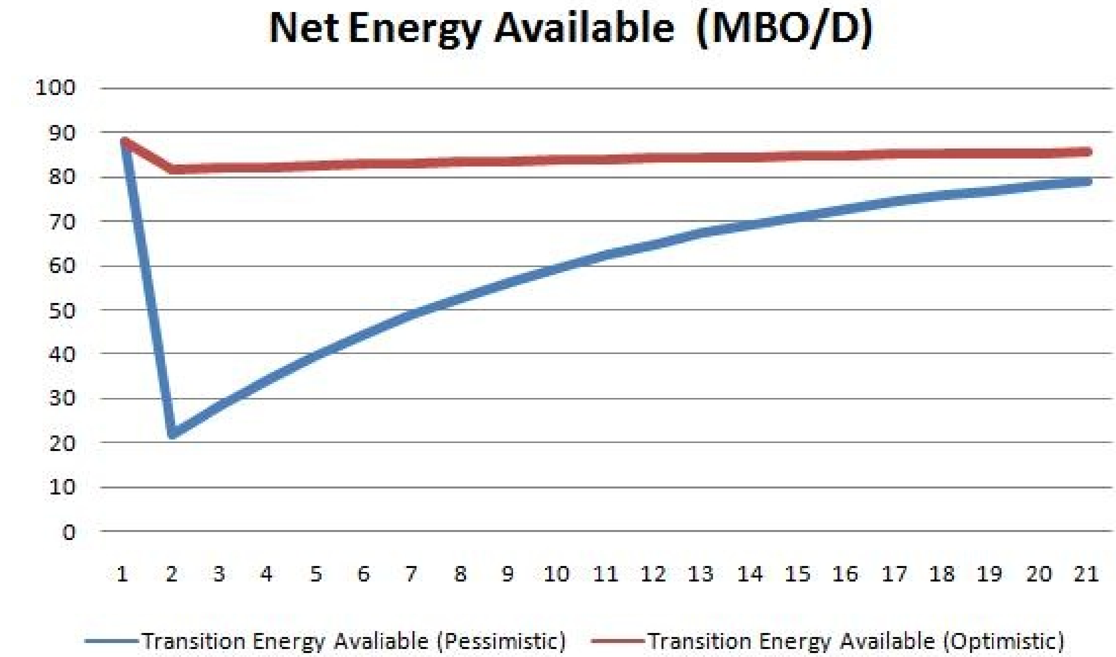
That's the "Renewables Gap."

And here's the pessimistic quadrant – 10% net energy decline, and a renewables EROI of 4:



In this pessimistic scenario, the up-front energy investment is more than 4,600 GWyears in year one. That's 58 million barrels of oil per day diverted to renewable energy production. Plainly impossible. And the level of renewable energy production wouldn't even catch up to the level of energy invested EACH YEAR until year 7.

Here you can see the boundaries of the Renewables Gap—the optimistic assumptions on top, pessimistic on the bottom. The lines represent, under each scenario, the net energy supplied by oil, minus the energy invested that year in building renewable energy production, plus the energy produced that year by the renewables brought on-line to date:



To be sure, we can slow the initial rate of investment in renewables in order to lessen this dramatic initial impact, but that option results in falling even further behind the net energy decline curve. We can also bootstrap the energy produced by renewables to provide the energy required for the next round of renewables—if the EROI is 20, this will work to some extent, but it will still have the effect of making us fall even further behind the decline curve. If the EROI is 4, it's simply unworkable—we never catch up.

Is it theoretically possible to close this gap more quickly? Sure—by investing more energy up front, which actually serves to exacerbate the problem over the short term. We'll be chasing our tail. It might be possible to catch up—to make a significant public sacrifice up front and kick start the program—IF the economy as a whole is healthy. The Renewables Gap puts us in a Catch-22 situation: using renewables to mitigate peak oil will make the situation worse before it makes it better. Our ability to absorb the up-front costs of transitioning across this gap is a function of our economic health, but to the extent that our economy remains healthy enough to do so we are unlikely to muster the political will to address the problem.

Just to provide some context for the size of this gap: Under the optimistic scenario, this is the equivalent of adding one new China to world oil demand immediately, and maintaining that for many years. Under the pessimistic scenario, this is the equivalent of adding more than 9 new China's to world oil demand.

Now I recognize that there are energy conversion issues, there are calculation issues, there are timing issues—simply too many variables to make any definitive statements here. But what I hope I've highlighted here is this CONCEPT of the Renewables Gap problem, and the uncertainty of our ability to bridge that gap.

As a civilization, we still have a small and shrinking bank of net-energy surplus with which to build our future. We have to make tough choices about how to spend it. Perhaps our most fundamental choice will be this: do we spend it attempting to bridge the Renewables Gap—despite our uncertain ability to do so? Or do we consider whether that energy could be better spent building a fundamentally different future?

Hopefully this analysis provides a useful framework for further analysis. I recognize that some will dismiss this problem entirely with the argument that wind actually has an EROI of 75 and an energy payback time of 5 months. At the risk of being inflammatory, that reminds me of a bumper sticker that says "WARNING: In event of rapture, this car will be unmanned." My point is that, at least here and now, my intent is not to proselytize or attack and defend issues of faith. Instead, I hope that, for some, this analysis highlights three important issues for further thought and debate:

1. The energy requirements of a massive transition to a society much like ours but powered by alternative sources of energy.

2. The political challenges of affecting such a transition.

3. If #1 or #2 make such a transition either physically or politically impracticable, what then?

[Here](#) are my Excel calculations for those who would like to plug in their own numbers...