



## An alternative version for three of the “key graphs” in IEA’s 2010 World Energy Outlook

Posted by [Chris Vernon](#) on July 7, 2011 - 4:48am

*This is a guest post from Dolores García, an independent researcher based in Brighton, UK.*

Recently Jorgen Randers (best known for being one of the co-authors of *The Limits to Growth*, 1972) asked me to do some modelling work on the World3-Energy model, an updated version of the classic World3 computer model that was used in *The Limits to Growth* that includes a much larger amount of information about energy. He’d like to use it for the next book that he intends to publish sometime in 2012.

I have published on The Oil Drum before the details of World3-Energy (a dynamic systems model), can be found in:

[A New World Model Including Energy and Climate Change Data](#)

And a few answers to reader’s questions can be found here:

[New World Model – EROEI issues](#)

Part of the work I’m doing for Jorgen Randers is comparing the results of World3-Energy with IEA’s results. I thought the readers of The Oil Drum would be interested in this.

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World3-Energy doesn’t have any separation between world regions, but in spite of that, produces aggregate figures that are within the ballpark. I can’t produce any comparisons that are specific to world regions, but we can compare the aggregate figures.

An important difference between IEA’s model and World3-Energy is that World3-Energy is an attempt to model the situation pretty much from “first principles”. It uses little in terms of historical data, the data produced come from the equations, parameters and tables within the model. It isn’t supposed to reproduce history with exact precision, rather it shows that the dynamics in the formulas are probably roughly right, because the results reproduce roughly the history so far. For example, the fact that coal-fired electricity generation is within the ballpark of actual figures suggests that the formula for electricity produced from coal is probably roughly right.

Obviously, IEA have much more detailed data and their model goes into much finer detail than World3-Energy. But that makes it easier to forget that a chain is only as strong as the weakest link, or a formula is only as precise as the variables we know with the least precision. It’s the equation that you haven’t written that will prove your model wrong. That’s why I chose adapting World3, that already had in its equations all the major factors that affect the state of the world, rather than starting from scratch. Of course, this model may also contain incorrect assumptions, but at least it’s taking into account all the major factors.

I believe the IEA model has very high precision in many of its formulas, but a lot of it is rendered

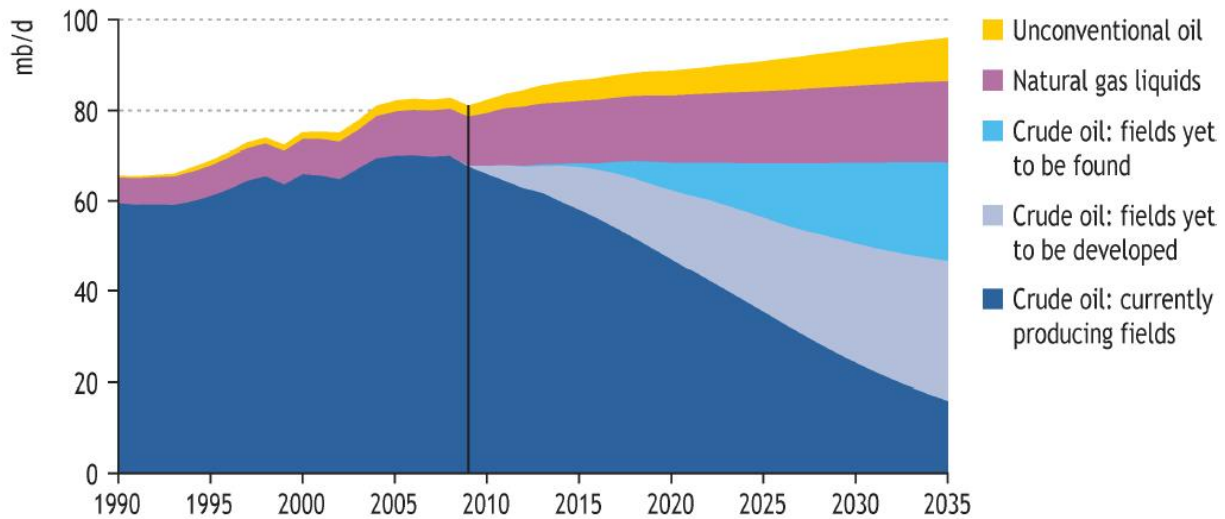
invalid because they are not taking into account major factors that will affect in a big way the results. My favourite example is the fact that they think of economic growth as a given, coming out of the blue, when economic growth depends very much on availability of energy (heavily affected by availability of fossil fuels) and availability of food (heavily affected by climate change, that depends on the amount of fossil fuels burnt). World3-Energy instead calculates economic growth from its internal variables, by adding up food, industrial output and services output.

The WEO model is to a some extent a “black box”, but we know enough about it to make a quick table of comparisons between World3-Energy and the WEO model:

	<b>World3-Energy</b>	<b>WEO model</b>
<b>Scope of the model</b>	Like World3, all the main constraints to growth in the world, with a special focus on energy variables	Purely energy
<b>Complexity</b>	Relatively simple (about 300 equations)	Very complex (about 16,000 equations)
<b>Population</b>	Calculated internally, which means it takes into account things like greater mortality due to climate change	Based on UN projections
<b>Economic growth</b>	Calculated internally, which means it takes into account the fact that a diminished industrial output due to less available energy affects economic growth	Based on IMF and World Bank projections
<b>Land &amp; food</b>	Included in the model, which allows for considerations such as if food is scarce, resources will be put to maintain food levels, rather than other activities including energy production	Not considered
<b>EROEI</b>	An essential part of the model	As far as I can tell, not considered
<b>Modelling of energy supply and demand</b>	Supply and demand are estimated separately and then matched, supply takes into account geological and technical constraints	Based on estimations of energy demand

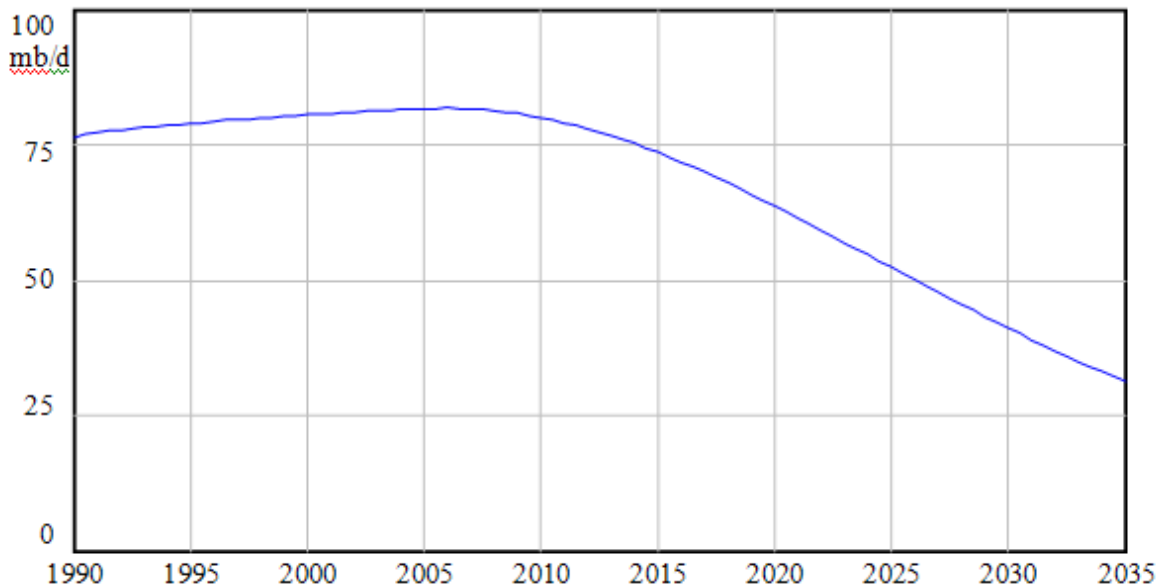
Let's start with an easy comparison: the IEA's graph of oil production. Readers of this site will know already that this is one of the most criticised, often because the horizontal straight line looks extraordinarily suspicious. There is no particular reason to think that oil production, under any circumstances, would stay flat for a long period of time. It's easy to see that it could be flat for a couple of years, but the graph assumes flat production for more than 25 years! Either there is the capacity and the demand, in which case the line would go up, or capacity or demand is lacking, in which case the line would go down.

### World oil production by type in the New Policies Scenario



My model uses conservative figures for ultimate reserves of oil, gas and coal, based on Laherrère’s estimation, simply because they were the ones that produced curves that fitted the past most closely. This is the output of World3-Energy:

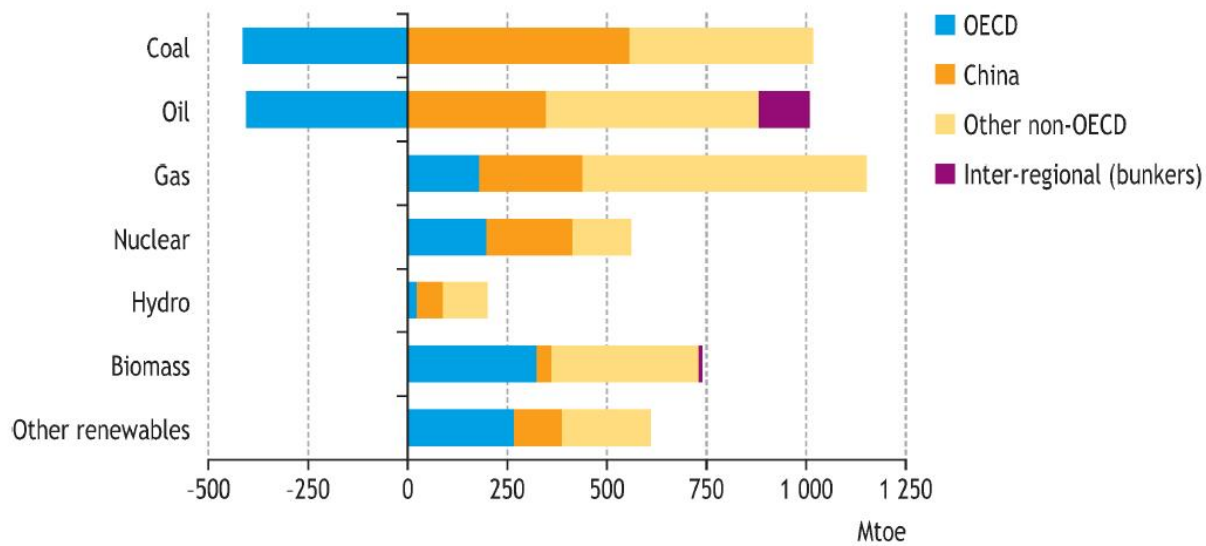
### World oil production



I’m sure oil geologists can produce much better forecasts, though. The aim of World3-Energy isn’t producing highly accurate forecasts, but doing a fairly good job modelling of the big picture.

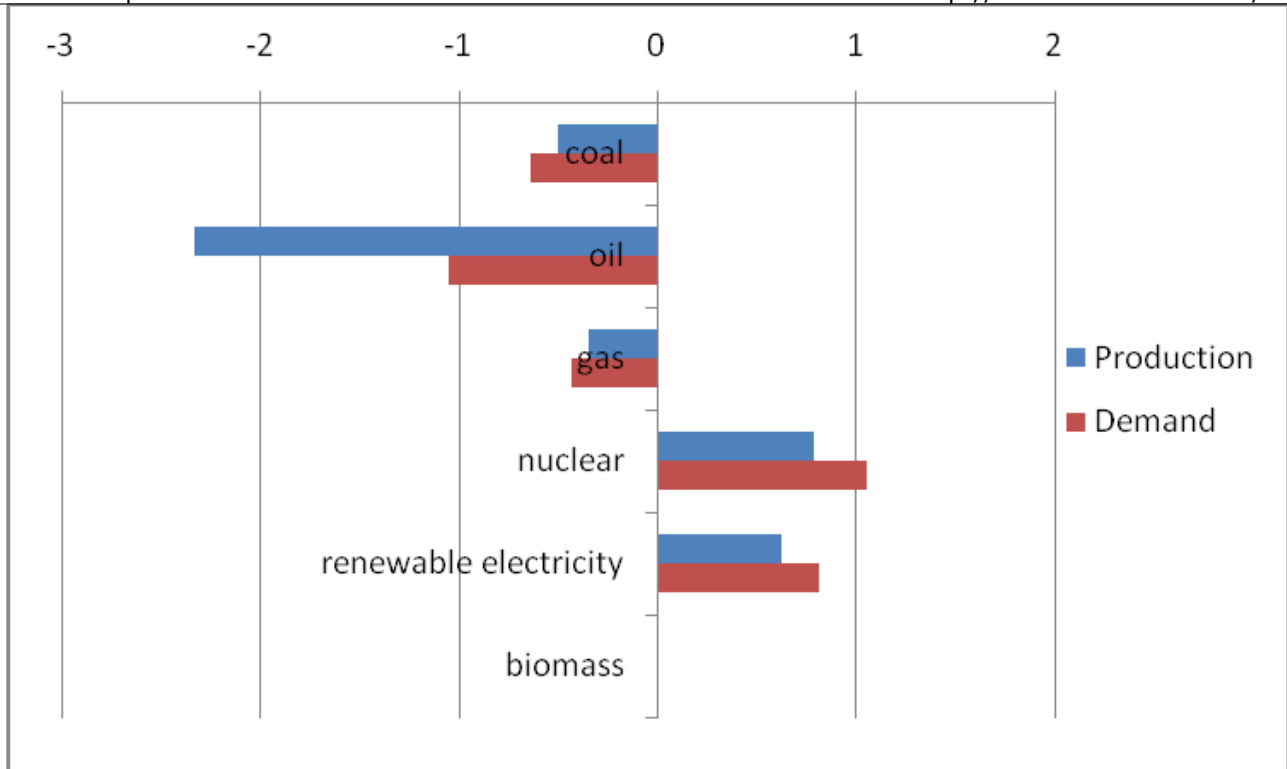
The next graph shows what I see as a fundamental flaw in IEA’s modeling: it’s based on demand, and the idea that demand might not be able to be met, if it’s been introduced, it’s only been as an afterthought.

### Incremental primary energy demand by fuel & region in the New Policies Scenario, 2008-2035



World3-Energy has the idea that demand may not be met at its heart, and the figures for demand and supply may be different. Some people object to the idea that supply and demand may be different because they are matched by price, so I'll clarify my terms. What I mean by "energy demand" is the demand calculated based on the requirements of transport, electricity and heat, regardless of any price considerations. What I mean by "energy supply" is the maximum amount of energy that can be produced taking into account geological and technical constraints. The way that the model matches supply and demand is assuming that energy demand is inelastic enough that if there are supply constraints, as much energy of a given source as can be produced will be produced. If there aren't supply constraints, the energy produced will equal demand. The model doesn't contain any price calculations or considerations of credit availability.

This is the equivalent graph on World3-Energy. (The units used are Gtoe, rather than Mtoe)

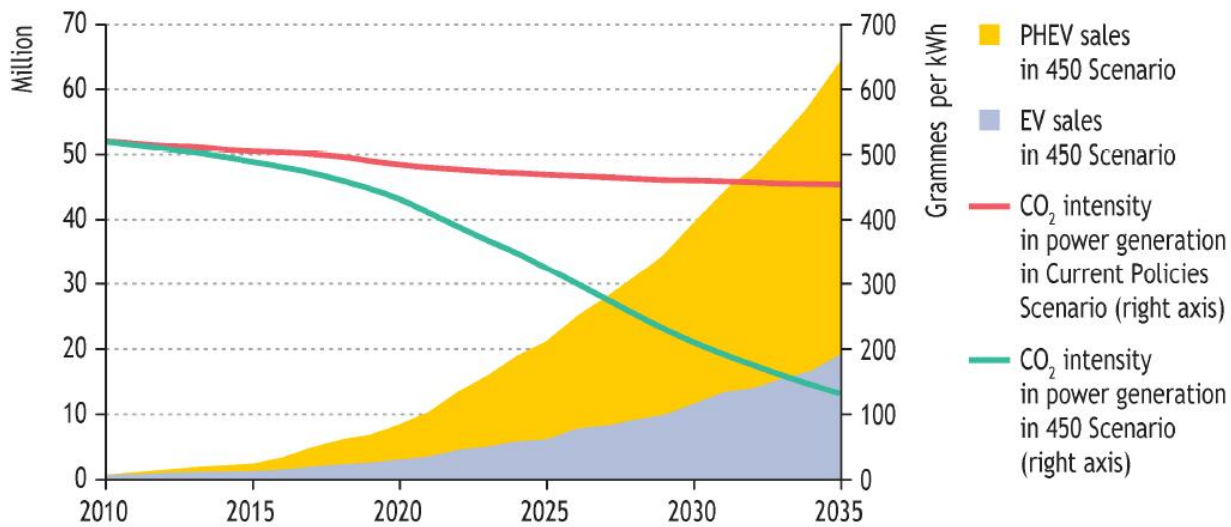


The world here looks very different, with production lagging behind demand on almost every source of energy. This graph is for the “all for renewables” scenario in my model, which means there is a deliberate and coordinated effort to cut use of coal and gas, while oil production is catastrophically low just because geology dictates it.

The World Energy Outlook 2010 has three scenarios: “Current policies”, “New policies” and “450”. “Current policies” is roughly equivalent to my “Business as usual” scenario, and “450” is roughly equivalent to my “All for renewables” scenario. “New policies” is somewhere in between. I haven’t found an exact description of “New policies”, that’s why I’m comparing the “New policies” graphs with the “All for renewables” ones.

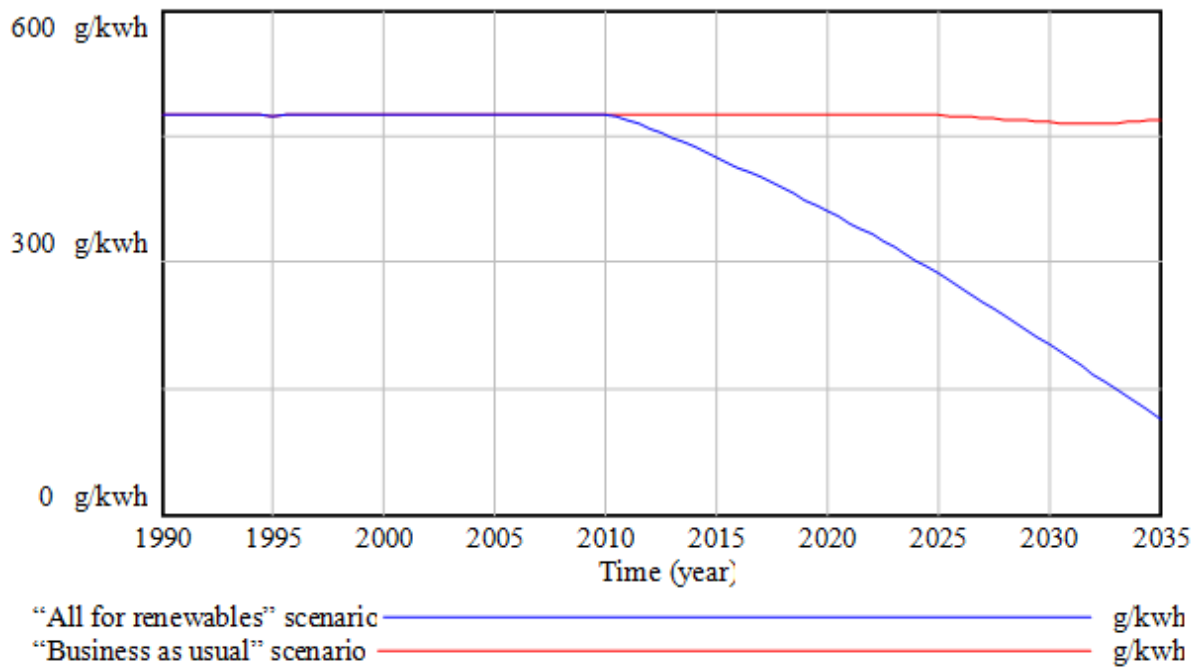
Finally, a IEA graph that may look a bit confusing because it combines two entirely different things in the same graph. I’m interested here in the CO<sub>2</sub> intensity in power generation:

### Sales of electric & plug-in hybrid vehicles in the 450 Scenario & CO<sub>2</sub> intensity in the power sector by scenario



The equivalent graph in my model is this:

### Carbon intensity of electricity generation



The "Business as usual" scenario is somewhat more extreme than the "Current policies", because it assumes no policy restrictions of any type. But it's nice to see IEA and my model have arrived to similar conclusions by entirely different paths in this case. If a policy of strict reduction of fossil fuels is applied in 2010 worldwide, we are in agreement about how quickly it's technically feasible to de-carbonise electricity. Which means that it's technically possible to stay below the dreaded 450ppm.

The main point of disagreement is that the IEA seems to believe most of the changes will happen quietly in the background, with the average citizen of the Western world barely noticing that the

brand new cars just happen to be electric. World3-Energy suggests that the changes are likely to happen among very real concerns about world food production and other similarly “minor” issues.



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