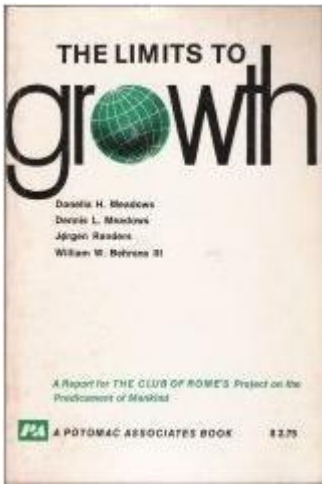
Chapter 9 – Models of Energy and Climate

We will introduce in this chapter Doly Garcia's New World Model of global energy, resources and climate, which having seen from chapters 4 to 6, we deduce is insufficient.

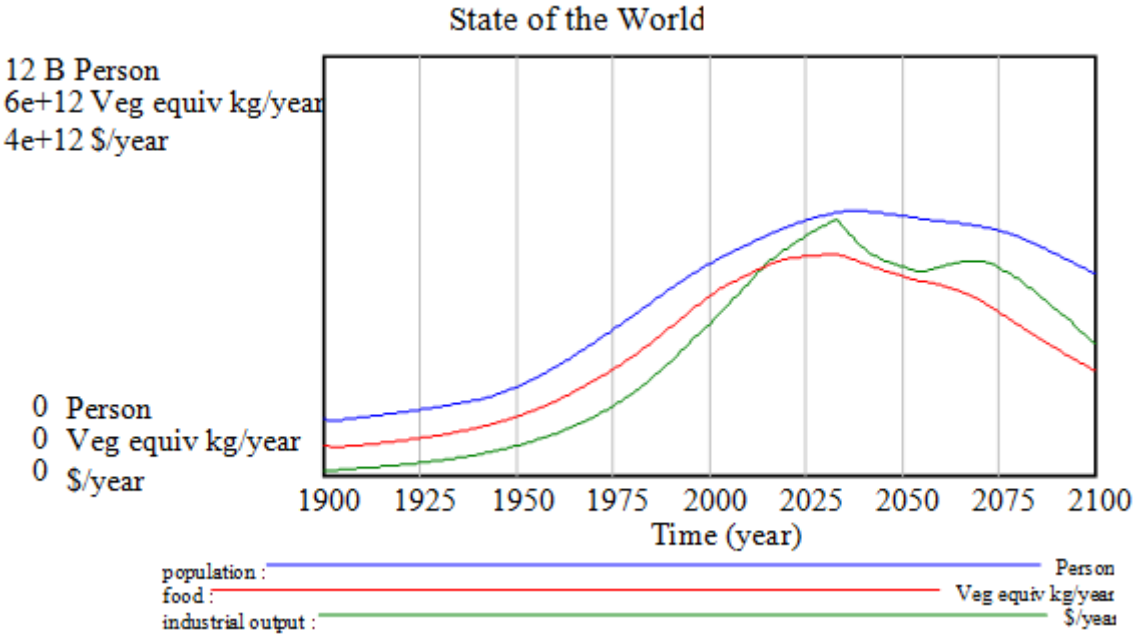
Computer Models of Energy and Climate. Doly García's Global Climate, Resources and Energy model (the New World Model). Limits to Growth. Energy Economics. ERoEI (Energy Return on Energy Invested). Feedback models of climate.

- *The García New World Model*.

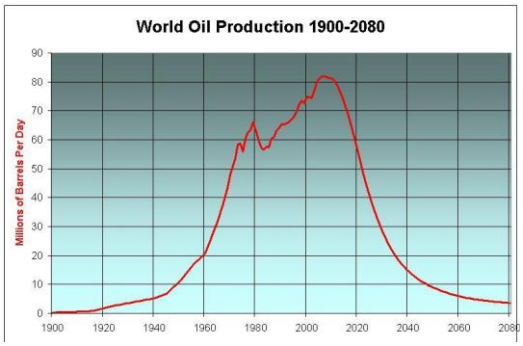


Perhaps the best known global model of all is World3, popularized in the book *The Limits to Growth, A report to the Club of Rome*, by Donella H. Meadows, Dennis L. Meadows, Jørgen Randers, and William W. Behrens III. D. García has taken some of the equations in the latest version of the World3 model and has added some more data and feedback loops to reflect some of our present knowledge of climate change and energy issues. The aim is to have a model that is more useful for the purpose of testing in theory different policies that could be applied to resolve some of the current challenges our world is facing, that have all at the root the fact that we are reaching the limits to growth.

This updated systems model of global climate, resources, and energy extends the original World3 model by inclusion of climate change and its interaction with resources and energy. Outcomes are derived for total energy resources, human population, nutrition, consumption, economic activity and other parameters. Long-term outcomes are derived for 1900 to 2100, with human population decline.

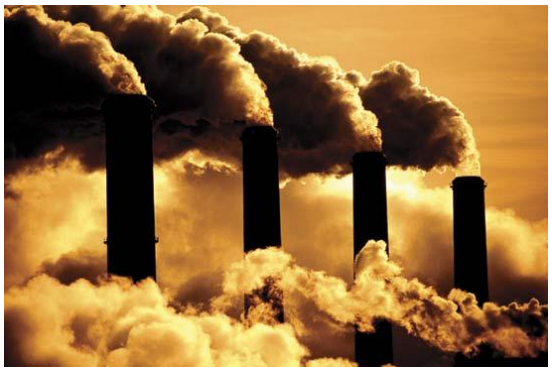


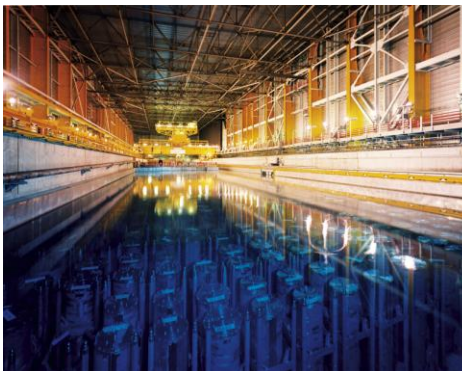
Graph 4.1.1 – Food production and industrial output in the New World Model

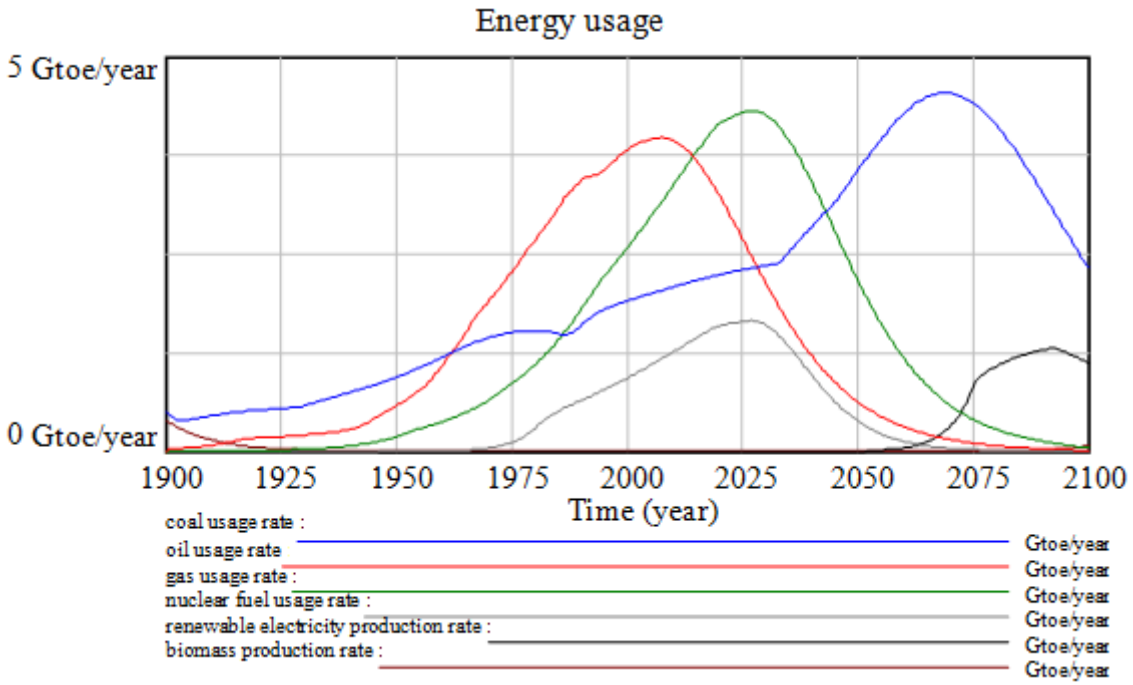


Energy variables are conspicuously absent from World3. The closest thing to an energy variable is "non-renewable resources". When considering how to best include energy in the model, Doly García has chosen to eliminate this variable, on the grounds that, in a world with unlimited energy, any chemical compounds useful as a raw material but not as an energy source could be easily obtained. Fossil fuels are the only true non-renewable resources.

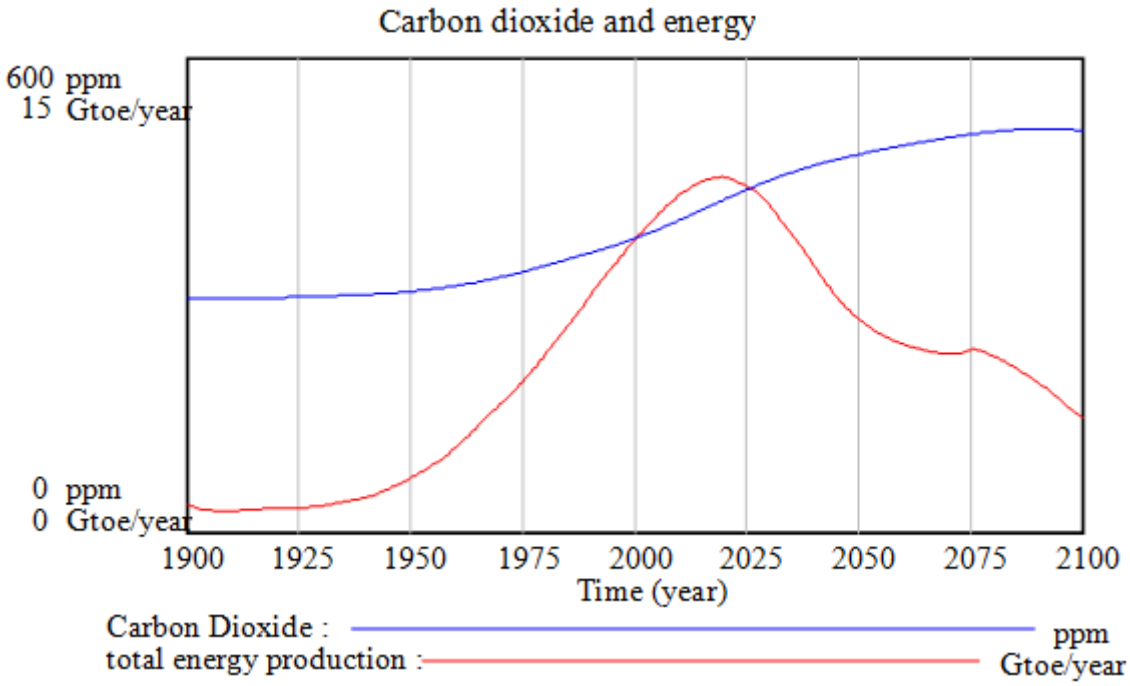
Energy supplies are substituted for each other as EROEI declines, but eventually all fossil fuels and nuclear fuels are used up. Renewables aren't used until the end of the 21st century, due to their low EROEI.







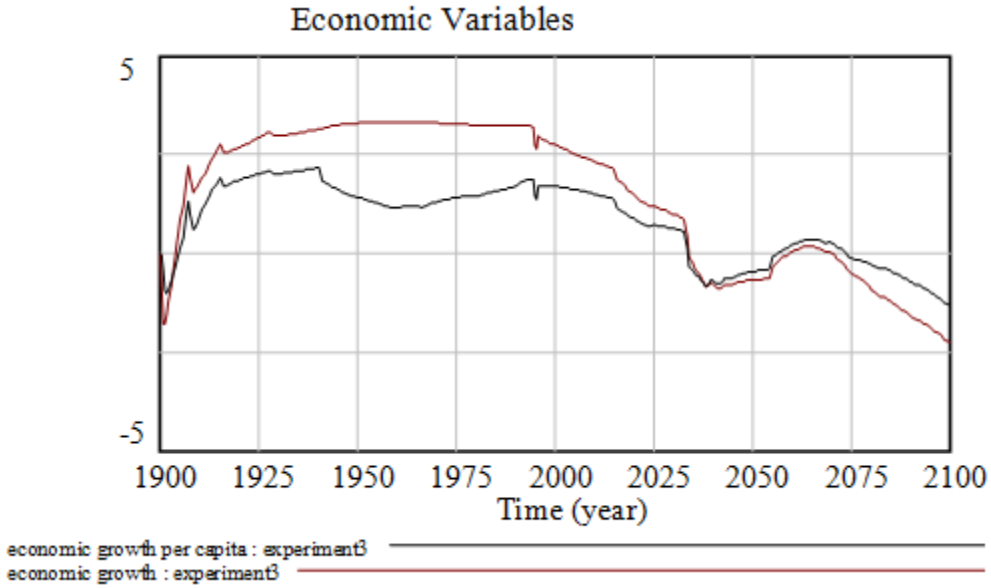
Graph 4.2.1 – Energy usage graph



Graph 4.3.1 – Carbon dioxide and energy

In the "business as usual" scenario the pattern was one of collapse of human population, food production and industrial output, in a way similar to what happens in the World3 business as usual scenario. The decline is gradual, starting somewhere around 2030.

A remarkable result of the model in the business as usual scenario is that carbon emissions don't go very high, peaking at 510ppm, which is lower than some of the emissions scenarios of the IPCC. The reason for this is double: Firstly, the limits on fossil fuel reserves mean that not as much carbon can reach the atmosphere as assumed by the IPCC even when all fossil fuels are burned. Secondly, the estimations of carbon sinks may be too favourable in the model.



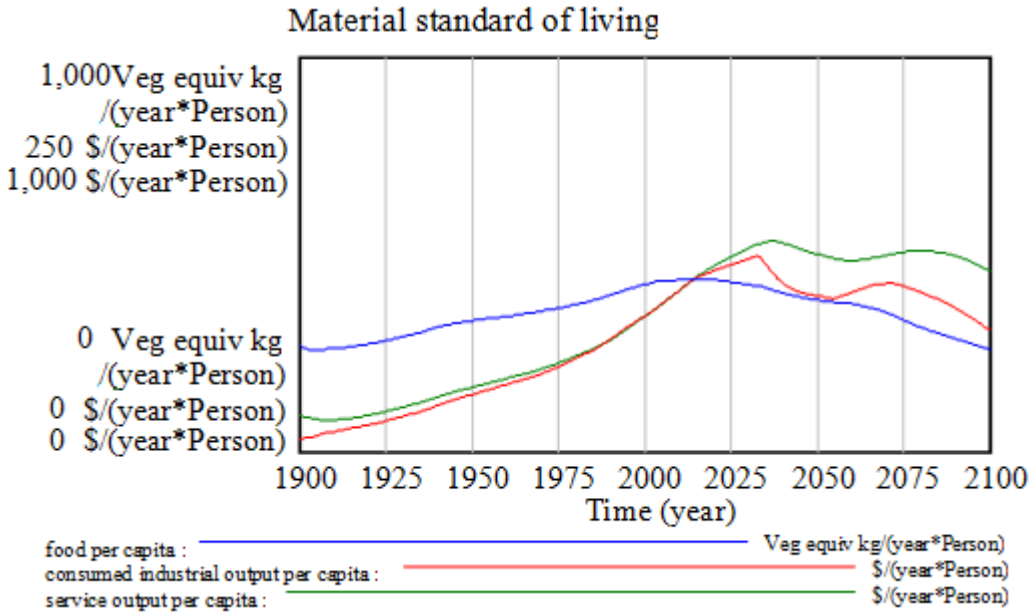
Graph 4.5.1 – Economic growth in the New World Model

The most interesting result of calculating GDP is that it allows for the estimation of economic growth. This should not be understood as the figure that economists produce, but some kind of numeric estimate of the yearly change in all the goods and services produced in the world. Interestingly, at the point of collapse, it falls dramatically, but it starts declining many years before that, providing an early warning signal.

It's also worthwhile noting that the point of peak oil is marked by a drop in economic growth. It's very tempting, but not really justified, to relate this to our current economic crisis. Certainly, if we were at the early stages of the collapse in economic growth that the model estimates, it's to be expected that a major economic crisis would happen, and a big overhang of debt is one of the logical ways for it to happen, as a result of an effort from central banks to maintain a level of economic growth that isn't justified by the fundamentals. But she doesn't have enough data at present to confirm or deny if our current situation reflects that we are at the beginning of the great contraction estimated by the New World Model.

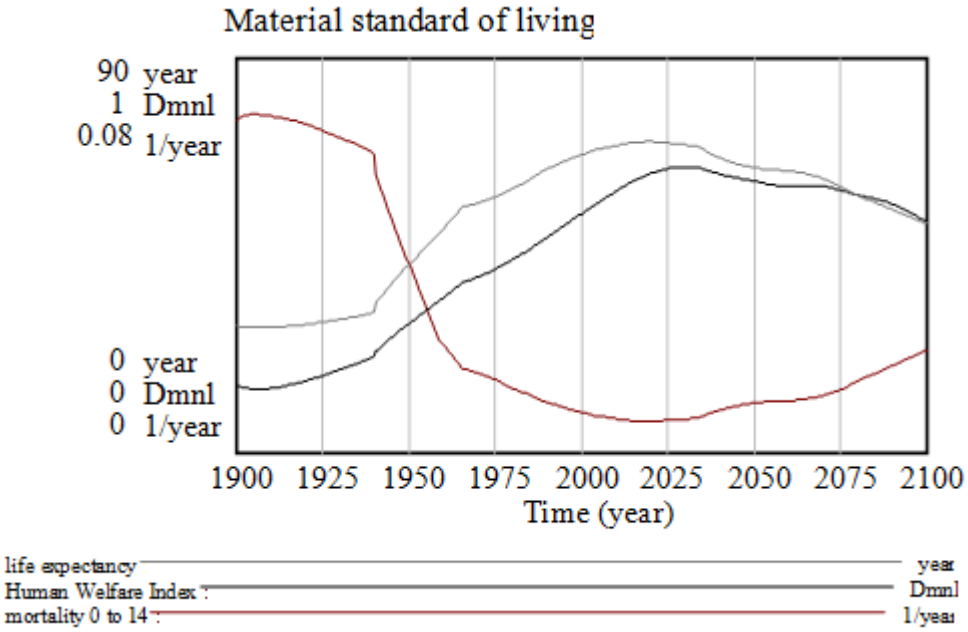
The standard of living declines clearly by all the reasonable measures that can be made in the model: food per capita, industrial output per capita, services per capita, life expectancy, human welfare index and child mortality. The levels of food per capita by the end of the 21st century are similar to the beginning of the 20th century and are in a path of continuous decline.

However, this shouldn't be taken as any kind of prediction, because the model cannot possibly include all the relevant data.



Graph 4.4.1 – Food per capita, industrial output per capita and service output per capita in the New World Model

The main conclusion of the results of the New World Model is that, if the world continues behaving as we have so far, decline is inevitable in the long run. This isn't a surprise and the fact that we are on an unsustainable path can be deduced from much simpler and reliable calculations. What this model provides is some slightly more refined ideas about how this could happen and, more importantly, it's a tool where we can experiment with our ideas on how to solve this problem.



Graph 4.4.2 – Life expectancy, human welfare index and child mortality