NGI101x - 4.5B - Agent Based Modeling II

The purpose of this talk is to discuss an agent-based model of the power sector, called EMLab-generation. The underlying question really is: `how are we going to change this huge system to make the energy transition happen?' You can get a glimpse of how huge it really is… by looking around. We are now at the Port of Rotterdam, and this area is called the 'Maasvlakte'. As a Dutchman I'm proud to show you this land; reclaimed from the see; now a flourishing industrial area. Also as a researcher it is fascinating: it's a huge source of CO2 emissions, has a few of the newest coal power plants, making it a large electricity production center, and it is one of the largest energy consumption areas. So how can we get the energy transition underway?

In a previous lecture by Igor Nikolic, you already got to know Agent-Based Modeling. Agent-based models are a computerized laboratory, which help to explore what goes on here at the Port of Rotterdam area, specifically in the power sector, because they do not ignore, but rather embrace the complexity of the system! How can we start to understand and shape the system in the direction we want it to go? How can we get this system to change? We are so keen on reducing CO2 emissions – well, the things that need to change are right before our eyes!!

As an agent-based modeler, I immediately start to think: well if you want to lower our emissions, we need to change someone's behavior. Whose? In what way? To what extent? How can we achieve that? The answer to the latter is: we need the right policies. So… what are the long-term effects of climate policies?

What model can help you to tackle the problem? At least you need the existing power plants in there and the owners operating them. You represent the power plants, model the owners as agents that do the operation: they sell electricity to the market – representing the consumption – and choose when to run which power plants. You make sure that they are smart enough to run the cheapest plants: at lower demand the cheaper plants run and at peak demand also the expensive plants run. Accordingly electricity prices vary.

As of 2005, in Europe we have an emissions trading scheme, which is a market CO2 credits. By limiting the available credits, CO2 emissions become costly, and they are reduced. In order to see the effects of a CO¬2 price, we added it to the model. We find that not much changes in outcomes. The cause: we really need different kinds of power plants here! How do those get there? Well, companies need to invest in new generators. So you add the companies' ability of make investments. An investment decision is very much bound by uncertainty: it is based on expected power prices, expected CO2 prices, expected fuel prices, technology developments, company profile. In turn, these are – at least partly – affected by past investments. So all decisions together determine the system-wide developments and performance.

Now we end up with a model with existing power plants, the owners that operate them, the market to sell the electricity to, a CO2 market with limited credits to make sure there is a CO2 price that reduces the emissions, and the owners invest in new capacity as they see fit.

With the model, we now study the influence of policy on these investments in the electricity market, the CO2 emissions that result from this, and therefore also the demand for CO¬¬2 credits, the CO2 price, and so on. With agent-based modeling, this model can explore heterogeneity of actors, consequences of imperfect expectations and investment behavior outside of ideal conditions. It is also very intuitive: you can actually see the actors act & interact during the simulation through markets. The real analysis is done with data of many runs.

So what do we find? Well, it is not at all straightforward to structurally change this system. The CO2 market works fine on the very long term, but it is not unlikely that it leads to a rather expensive decarbonization path. Making the energy transition cheaper requires an incentive that is stable enough for businesses to justify significant renewable investments over longer decades. Our modeling suggests that without additional policy interventions such as a CO2 price floor this is not to be expected. As Margot Weijnen already mentioned: worldwide developments in shale gas have a significant effect on our effort to make our electricity sector renewable. Can you then say: we should not have built a new coal plant here at the Maasvlakte? Should we blame the owner for 6 Mton CO2 emissions per year? Not really, because our modeling also indicates that this plant had a reasonable business case when the decision was made.

Capturing the most relevant factors underlying investment decisions in the model is key to embrace the complexity of the power system. By doing so, we aim to understand better how the system as a whole functions, and have an impact on where it may be headed. It does not provide you with perfect prediction, but it should help a lot in the discussion on how to make our energy transition going! This modeling is part of TU Delft's energy modeling lab and is open source. For more information, see http://emlab.tudelft.nl.