WHAT KEEPS YOU AWAKE AT NIGHT?

Understanding the impact of uncertainties on future energy systems

Max Langtry, PhD Student, EECi, University of Cambridge

6th October, 2022

Uncertainties impact our ability to makes decisions about the design and operation of energy systems. Value of Information Analysis is a statistical method that both provides a transparent and justifiable procedure for determining whether gathering improved information to reduce uncertainties in a decision problem is economical, and enables the impact of uncertainties on the performance of decisions to be quantified. My research aims to explore how this method can be used to understand how net-zero energy systems should be designed so that they can provide reliable, low cost energy in an uncertain future.

1 THE DELIVEROO DILEMMA

Imagine the scenario, it's a Thursday night after a long day of meetings, the desire to cook has been left way back somewhere around Tuesday, and there's only one thing to get you through the remainder of the working week – a takeaway. Scrolling through your favourite delivery platform you're confronted with just too many choices, all of which are claimed to be some flavour of 'excellent'. And so you're faced with the ever difficult question of "Where do I want to eat?".

To help you make your choice, you could make a quick visit to your preferred trip advisory website. This would give you a better idea of how good the local restaurants are and which you might like, but, reading reviews is a tiresome business and all you really want is a box of something delicious to be winging its way to you ASAP. To put it another way, reading reviews will provide you with better information on how much you'll like each of your options, but will

cost you some of your precious evening time.

This raises another question that gets between you and your dinner, "Is it worthwhile looking at reviews? Or should I just choose something and get on with it?". We can also think about this in another way, as "How much am I inconvenienced by not just knowing my favourite restaurant?". Statistical analysis can be used to answer these kinds of questions in a structured, numerical, and justifiable way. Through my current research I am studying how these questions can be applied to the context of designing future, decarbonised energy systems, and what insights they can provide into the impacts of uncertainty on the performance of those net zero systems.

2 UNDERSTANDING UNCERTAINTY IN DECISION PROBLEMS

When making decisions, be that deciding where to buy a sandwich, whether to build a new wind farm, or how to control a grid-scale battery, there are frequently many uncertain factors that influence the outcome of the decision. Often there exists some sort of opportunity to improve the quality of information you have on these uncertain factors before making a decision, such as taking a measurement, commissioning research, or seeking expert opinions, which will enable a better decision to be made, i.e. select a choice that has a better outcome. However, gathering information is costly, and so this raises the question of whether acquiring improved information on the uncertain factors is worthwhile for a given decision to be made.

If a statistical model of the decision at hand can be created then this question can be answered by determining whether the expected improvement in the outcome of the decision made is greater than the cost of improving the information on the uncertain factors. This type of calculation is called 'Value of Information Analysis' (VoIA), where the 'Value of Information' is the expected improvement in the outcome of a decision problem as a result of having some additional or improved information on the uncertain factors affecting the decision. VoIA provides a transparent, open, and auditable method for supporting strategic decisions on how much resource should be expended on improving knowledge of uncertainties affecting a given decision.

VoIA can also be viewed in a different, in fact opposite, way and in doing so can be used to quantify the impact that uncertainties have on the performance of decisions made. Instead of asking 'How useful is having better information on an uncertainty?' we ask 'How much does an uncertainty impact my ability to make this decision?'. This enables us to use the analysis to compare the impact of uncertainties and determine which have the biggest effect on the decision to be made, and so which uncertainties are most important and should be the ones keeping us up at night. Being able to quantify the impact of uncertainties allows decision strategies which are less sensitive, or more robust, to the uncertainties of the problem to be designed.

3 THE IMPACT OF UNCERTAINTIES ON ENERGY SYSTEMS

One of the biggest challenges of VoIA is finding suitable decision problems to apply the analysis to, and setting up the statistical model of the scenario so that the calculations performed provide meaningful insight into the uncertainties affecting the decision. There are lots of different decision problems in the field of energy systems to which VoIA could be applied to improve the understanding of how uncertainties such as future energy demands, generation costs, and weather patterns, affect the operation and performance of strategies for decarbonising energy systems. At the moment, relatively little research has explored the use of VoIA in an energy systems context compared to other statistical methods.

My current research aims to identify and explore where VoIA can be applied to decision problems in energy systems to gain insights into how future net zero national energy systems should be designed to improve their robustness to uncertainties, so that they can reliably provide low cost, low carbon energy in an uncertain future. A focus will be trying to determine how the uncertainty associated with variable, non-dispatchable renewable energy generation technologies affects the way that supporting infrastructure, such as energy storage and demand-side response capacity, should be developed to provide energy supply security at low cost.

4 FURTHER INFORMATION

If you would like to find out more about my research into Value of Information Analysis for renewable energy system design, please get in touch at `mal84@cam.ac.uk`. For those looking for more detail on how decision problems are set up mathematically and how they can be applied to the context of energy systems, you can find this in my MRes thesis. I would also be particularly interested to hear of any decision problems you might have in the field of renewable energy systems which could be explored to find new applications for VoIA.

ABOUT THE AUTHOR

Max Langtry is a PhD student in the Energy Efficient Cities Initiative group at the University of Cambridge, whose PhD is co-sponsored by BP and Bentley Systems through the FIBE2 CDT. Max's research investigates methods for designing minimal cost, decarbonised future energy systems, and understanding the impacts that uncertainties have on their design and operation.