Identifying Uncertainties in Energy System Models

Will Usher, UCL Energy Institute, Central House, 14 Upper Woburn Place, London, WC1H 0NN

Abstract

- If we are to make robust and resilient investment decisions under uncertainty, we must first understand the level, location and nature of the uncertainties in the supporting knowledge-base and models.
- This “work-in-progress” applies selected complementary uncertainty frameworks to Energy System Models.

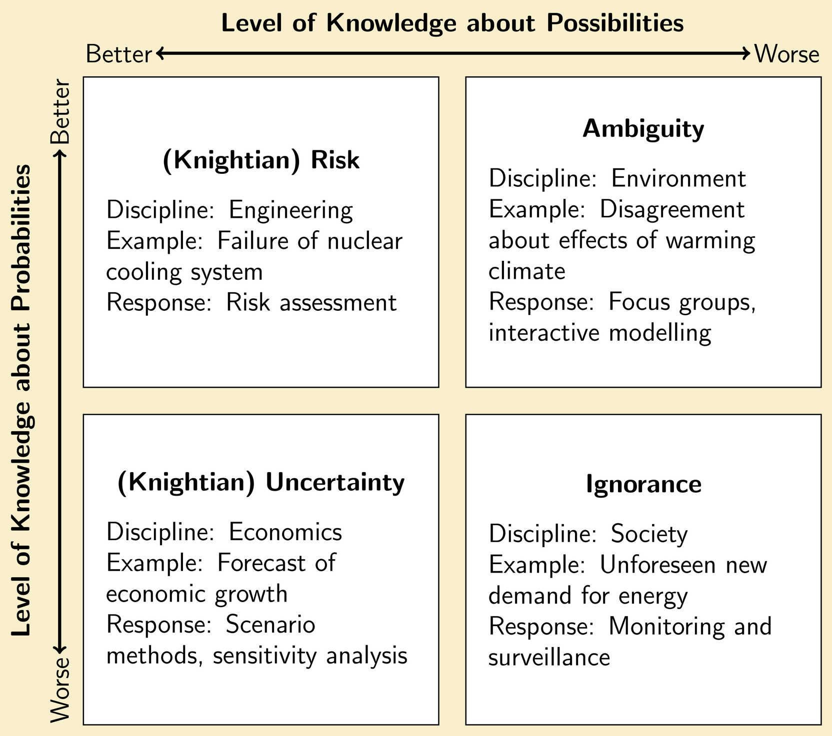
Introduction

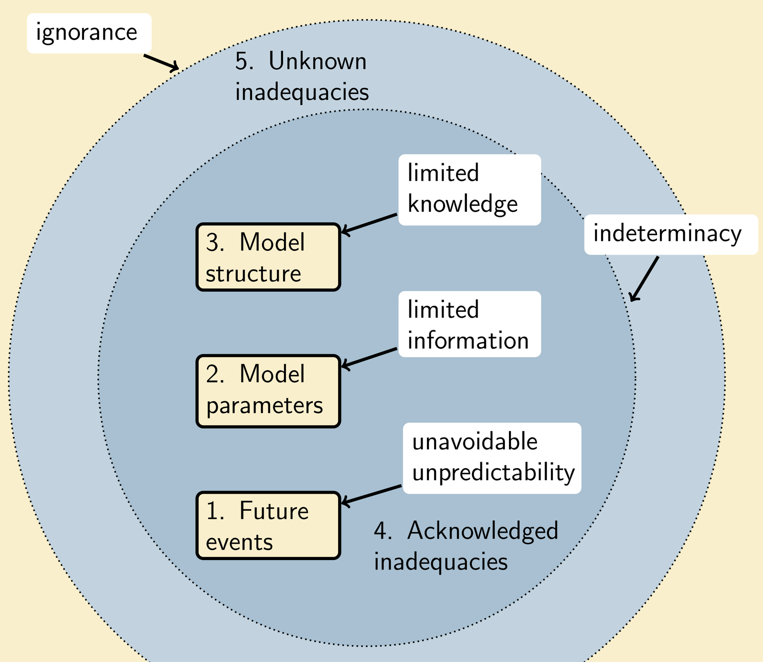
- Energy System Models are large, data intensive, quantitative computer models of the entire energy system.
- They depict in detail, the various technologies, resources and demands that make up the ‘energy system’.
- Energy System Models integrate features of several disciplines:
  - *Economic*-energy interactions
  - *Environmental* consequences of resource extraction and energy use
  - *Engineering* aspects of the energy system, such as reliability
  - Human behaviour and *societal* implications of energy use
- Typically, insights from Energy System Models are gained from running various scenarios and observing the relative differences between the results
- Insights may include:
  - optimum emissions tax to achieve a given reduction in energy related emissions
  - qualitative insights into system-wide trade-offs between technologies, demands and costs
  - welfare costs for given reductions in emissions
  - hedging strategies under uncertainty

Selected frameworks

- We illustrate selected frameworks that operate at different levels relative to Energy System Models.
- Here we give examples of each type of uncertainty for the disciplines that comprise Energy System Models.

Stirling (2007) categorises uncertainties according to the degree of incertitude in both possibilities (what could happen) and probabilities (how likely is the event).

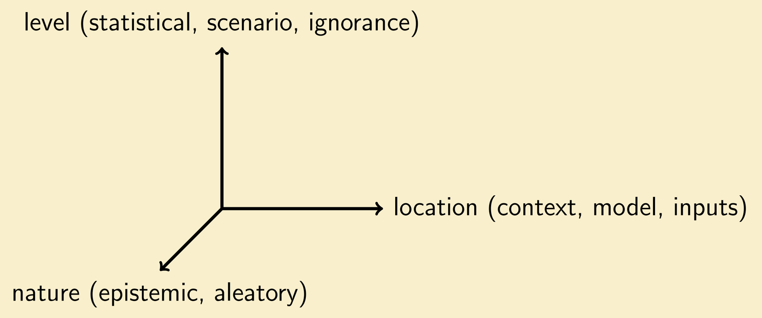




Spiegelhalter & Riesch (2011) identify five levels of uncertainty.

Walker et al. (2003) identify three dimensions of uncertainty.
For example “forecast of economic growth” is found in:

- level: scenario
- location: context (or inputs)
- nature: epistemic



Selected frameworks continued. . .

Morgan & Henrion (1992) identify sources of uncertainty from the perspective of a modeller.

Type of quantity	Examples	Treatment of Uncertainty
Empirical parameter	thermal efficiency, fuel price	Probabilistic, parametric
Defined constant	emission factor	Certain by definition
Decision variable	Investment in generation, emissions cap	Parametric
Value parameter	discount rate, risk tolerance	Parametric
Index variable	time period	Certain by definition
Model domain parameter	geographic region, time horizon, time increment	Parametric
Outcome criterion	net present value, utility	Determined by treatment of its inputs

Application to Energy System Models

Applying these frameworks to Energy System Models raises a number of questions:

- The predominance of scenario analysis within Energy System Modelling studies implies that we are operating under Stirling’s definition of Uncertainty. Is this true?
- How do we combine different types of uncertainties within an integrating Energy System Model?
- These frameworks are static, but sequences of decisions are made under an ever changing environment of uncertainty. What is the value to decision makers of learning before acting? Is there a cost to acting before learning? Under what conditions?

Summary

- Successful treatment of uncertainty in Energy System Models requires careful categorisation of uncertainties in the component parts.
- Uncertainties due to trade-offs between accuracy and tractability are inevitable when modelling these systemic interactions.
- We have illustrated some drawbacks with the conceptual frameworks applied to Energy System Models
- The frameworks show drawbacks with the existing treatment of uncertainty in Energy System Models
- Future work will investigate strategies under dynamic representation of learning in Energy System Models.
  - A nested optimisation problem will be generated which will minimise the expected cost of sequential decisions to either
    - invest and learn
    - wait and learn
    - act now.
  - The influence of both uncertainties from model structure and model inputs will be investigated

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