Quantifying uncertainty in long-term forecasts of CO_2 emissions in South Africa

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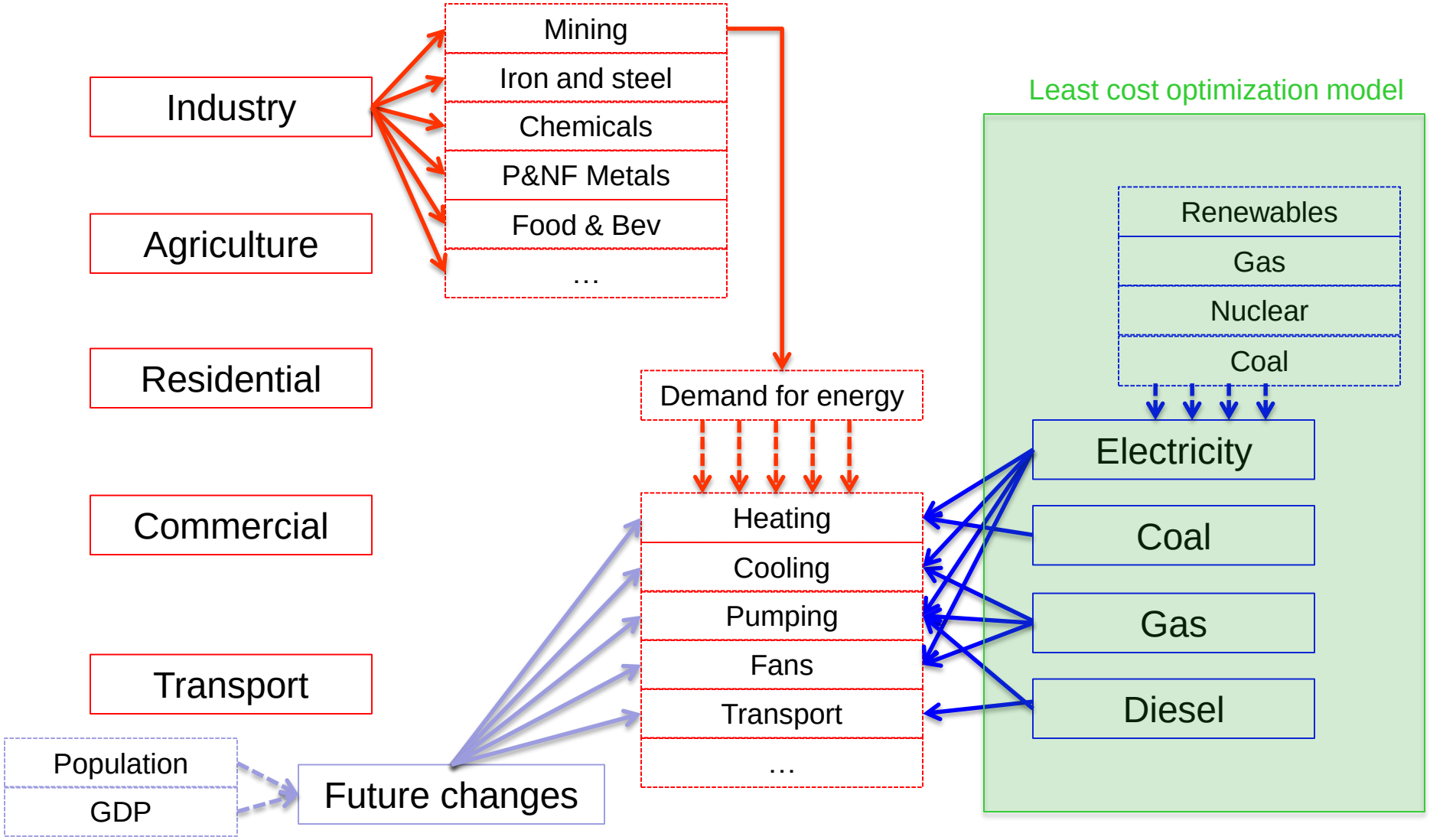
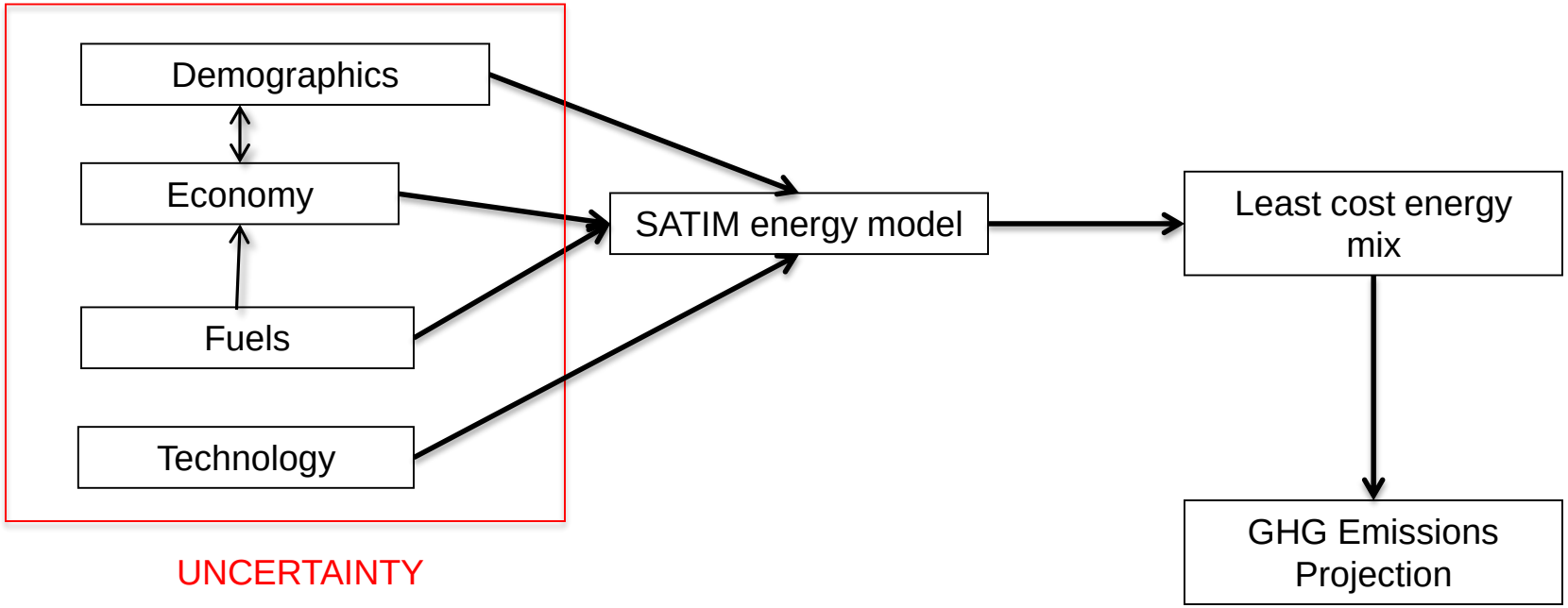
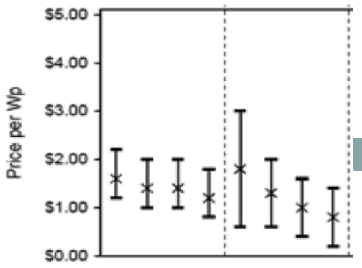
Energy modelling using SATIM

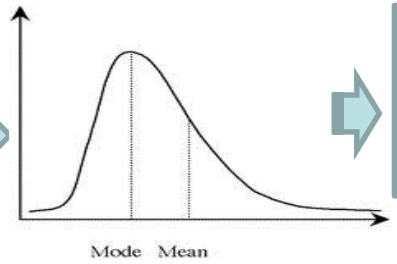


Projecting South African CO_2 emissions

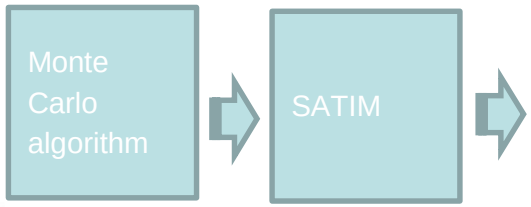


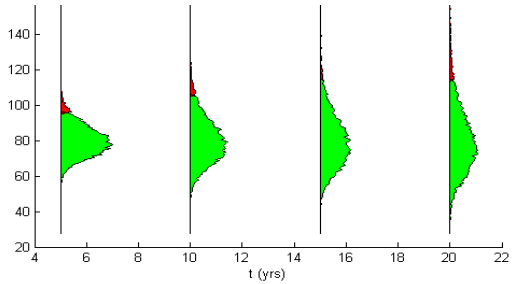


Expert Elicitation



Combined Elicited Distributions





Resulting GHG Emissions Projection
+ Full Story

Parameters chosen for uncertainty analysis

1. GDP growth rate
2. The structure of the economy (% in primary, secondary, tertiary)
3. Population growth rate
4. Domestic price of coal
5. Domestic price of natural gas
6. Overnight investment cost for nuclear
7. Overnight investment cost for CSP/PV

Measuring uncertainty using expert assessment

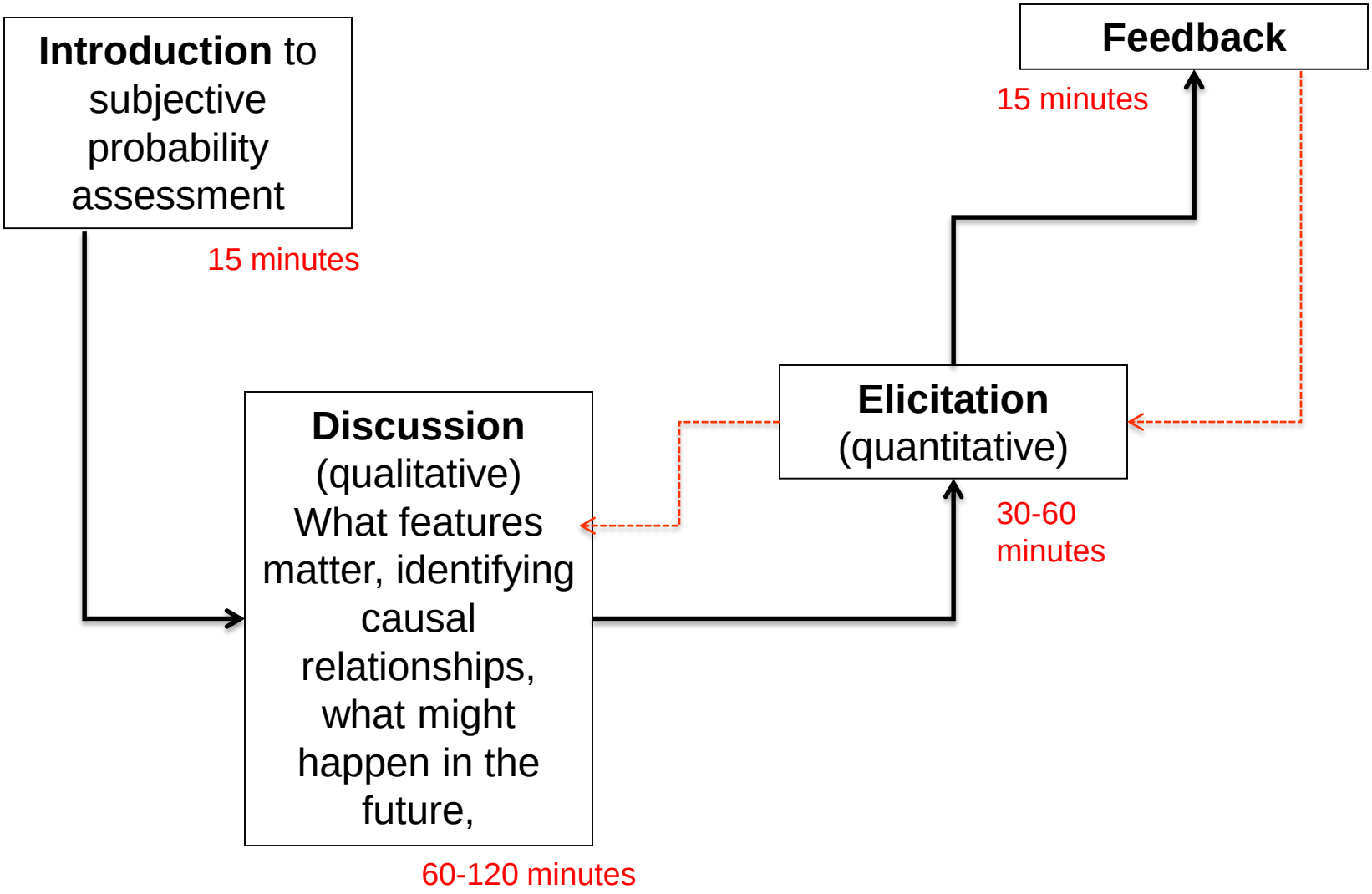
- What, no models?
  - No data sources
  - Models themselves encore many subjective judgments
  - Danger of extrapolating into future

- Expert elicitation
  - “a formal process that can produce high quality, traceable, transparent and explicitly subjective data on parameters for which there is no empirical alternative” (Usher and Strachan, 2013)

Measuring uncertainty using expert assessment

- Problem of time
  - Input data are annual time series
  - Want to assess uncertainty in these but too onerous to collect directly
  - “Solution”: Assess distributions at three time-points: 2020, 2035, 2050
    - For growth rates, elicit average rates over periods 2014-2020, 2020-2035, 2035-2050
- Simulate trajectories consistent with elicited distributions
- Aggregated over experts by simple averaging

One-on-one Expert Elicitation



Protocol for expert elicitation

- Establishing rapport with the expert
  - Being comfortable with subjectivity
  - Avoiding motivational and cognitive biases
- Acclimatizing the expert to the elicitation problem
  - Provide background information
  - Discuss broadly
  - Encode assumptions; encourage alternative scenarios and viewpoints
- Eliciting the expert's probability judgments
  - Start with extremes
  - Use easy "prompting" questions if necessary
  - Don't show CDF
- Cross-checking the expert's judgements
  - Formulate questions from derived CDF
  - Check consistency with expert's beliefs
  - Revise where necessary

Heuristics and biases

- MANY possibilities for faulty thinking

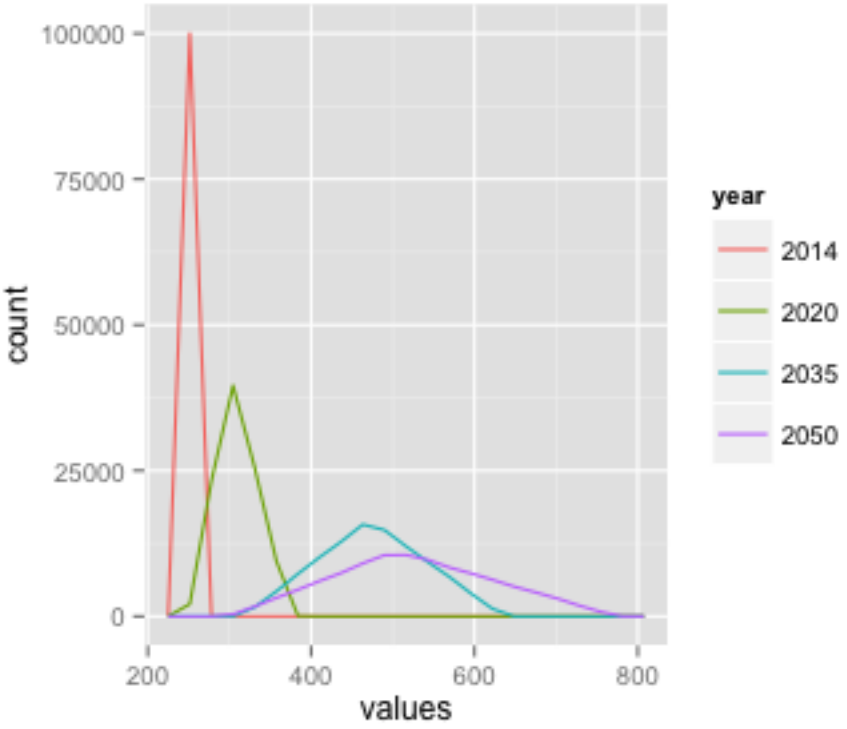
- “Difficult, but try critically examine the reasons for your judgments”
  - Is your estimate is being swayed by the vividness or recency of any information you have gathered?
  - What value are you are using as a baseline or reference case? What if you chose another?
  - Can you think of conditions under which more extreme values might occur? How easily?
  - Are you judging an event based on how much it “sounds like” something else? How close is the resemblance? How diagnostic is it?

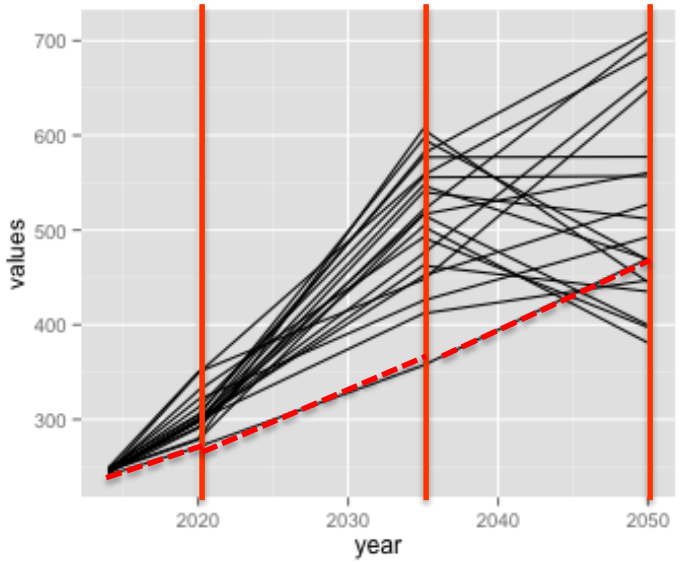
Data collected

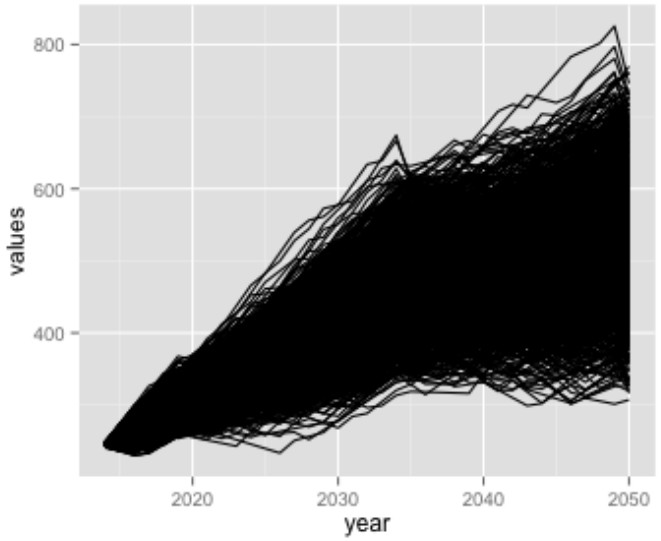
1. GDP growth rate (2 experts)
2. The structure of the economy (2 experts)
3. Population growth rate (still to do)
4. Domestic price of coal (4 experts)
5. Domestic price of natural gas (1 expert, still to do)
6. Overnight investment cost for nuclear (62 experts[1])
7. Overnight investment cost for CSP/PV (12 experts[2])

[1] Bossetti et al. (2012) The future prospect of PV and CSP solar technologies: An expert elicitation survey. Energy Policy 49, 308-317.
[2] Anadon et al. (2013). The future costs of nuclear power using multiple expert elicitations: effects of RD\&D and elicitation design. Environmental Research Letters 8(3), 034020

Domestic coal prices to 2050

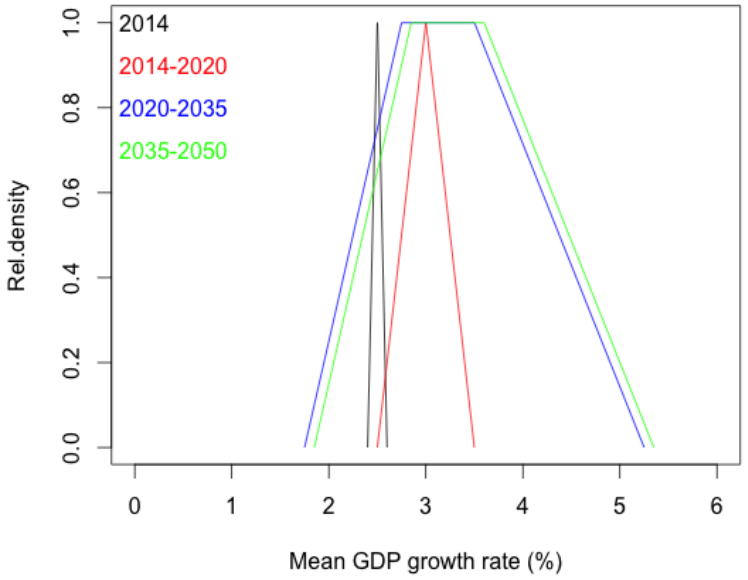


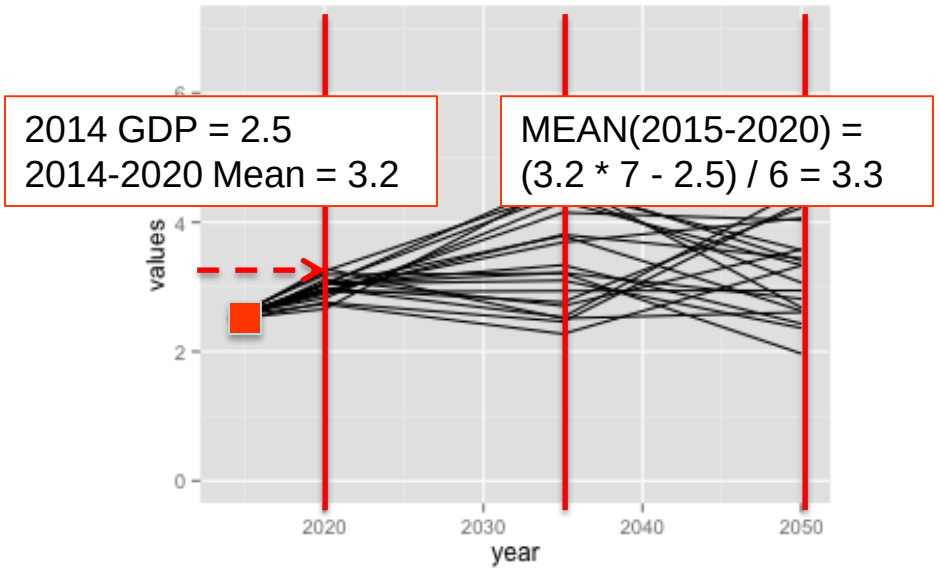


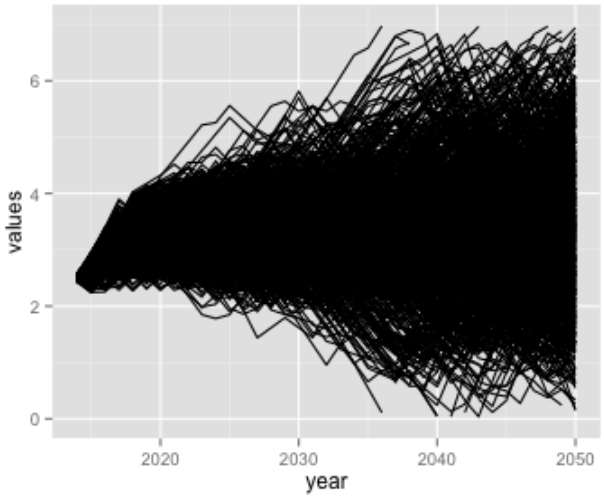


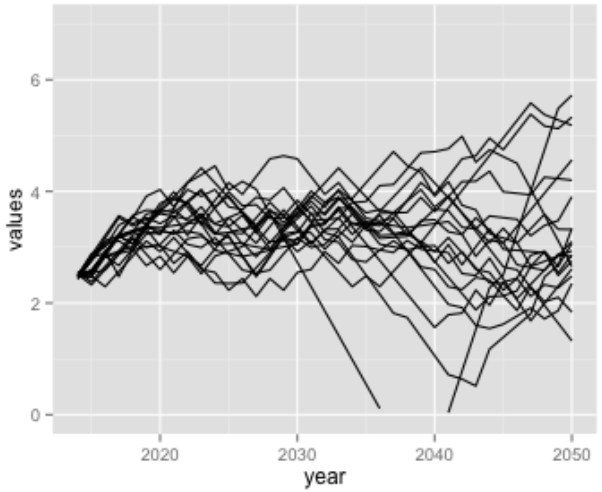
GDP growth rates to 2050

And no extreme growth in consecutive periods



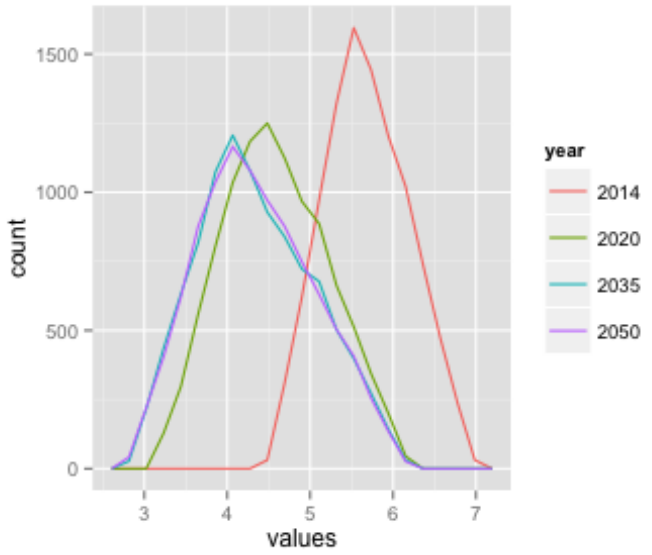


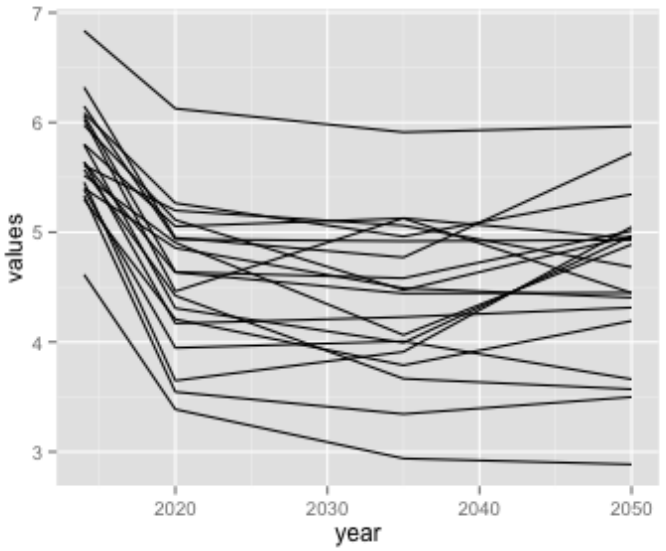


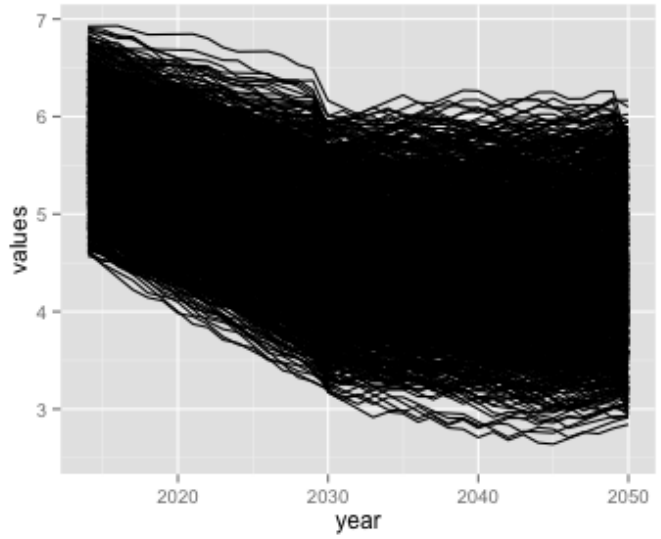


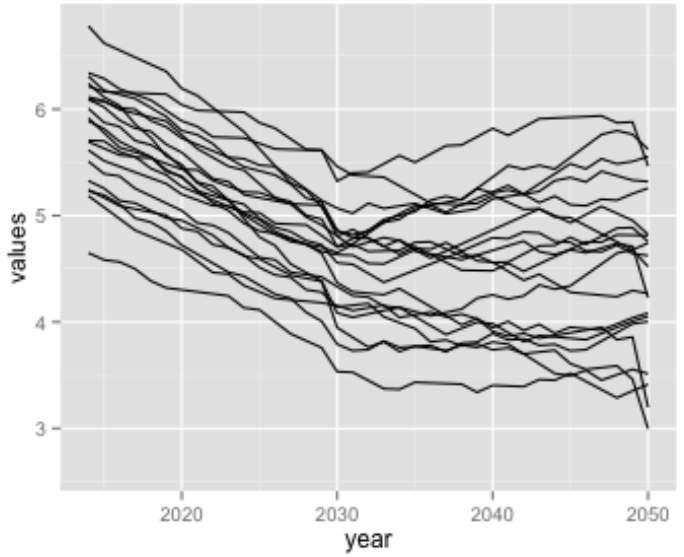
Cost of nuclear to 2050

And little or no increase in price (learning effects)









Conclusions

- Long-term CO_2 projections for SA? Still a work-in-progress!
- Gradual recognition that assessments of uncertainty are essential to long-term energy (and any other) forecasts
- Sometimes explicit models can be used to good effect (probabilistic population projections now used by UN)
- In absence of such models, expert elicitation provides a transparent, explicitly subjective approach
- Not easy, but established protocols provide guidelines for best practice