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Energy Technology Expert Elicitations for Policy: Their Use in Models and What Can We Learn from Workshops and Meta-analysis

Harvard Center for Risk Analysis Research Synthesis Workshop
Radcliffe Institute for Advanced Study, Cambridge, MA

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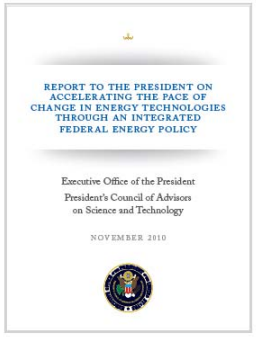
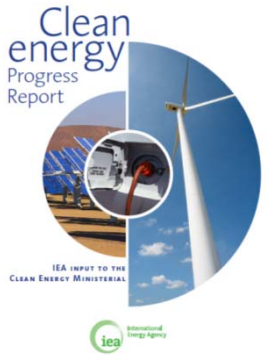
1. Motivation: use of elicitations in energy RD&D policy

Public investment in energy RD&D

- Unique role of government in energy RD&D:
  - Improved energy technologies: correct environmental externalities, improve energy security, enhance economic competitiveness
  - Public RD&D in general compensates for knowledge externalities
- Large and growing public investment globally
- Small compared to deployment subsidies, but likely larger impact
- Many calls for increasing investment and improving management
(PCAST 1997, 2010; NCEP 2004; AEIC 2010; European Commission 2007; EERA 2010; OMB 2013)





Anadon (2012). *Research Policy*
Gallagher, Anadon et al. (2011). *Wiley Interdisciplinary Reviews – Climate Change*
Nemet (2013). Encyclopedia of energy, natural resource and environmental economics

Supporting the design of public energy RD&D portfolios: managing the uncertainty

- Design of the portfolio of energy RD&D programs does not:
  - Systematically assess benefits
  - Consider technical uncertainty
  - Account for complementarity/substitutability of technologies
  - Engage the public with transparent technical assumptions

➔ Recent studies and reports from the NRC (2007), PCAST (2010), and OMB (2013) have highlighted the need for analytic tools to support the decision-making process

➔ We combined transparent, technologically-detailed, probabilistic expert elicitations with energy-economic modeling, optimization, group discussion, and meta-analysis to provide **policy inputs** and **methodological recommendations**

2. Summary of work

2030 technology cost and performance as a function of public RD&D in the U.S. and the E.U.

- 12 expert elicitations (6 Harvard, 6 FEEM) between 2009-2011
  - Nuclear power, bioenergy, solar PV, solar thermal, fossil energy, vehicles, utility-scale storage
  - **Experts estimated 10th, 50th, 90th percentiles of 2030 technology costs conditional on public RD&D investments and performance**
  - **4 online, 4 in person, and 4 via mail**

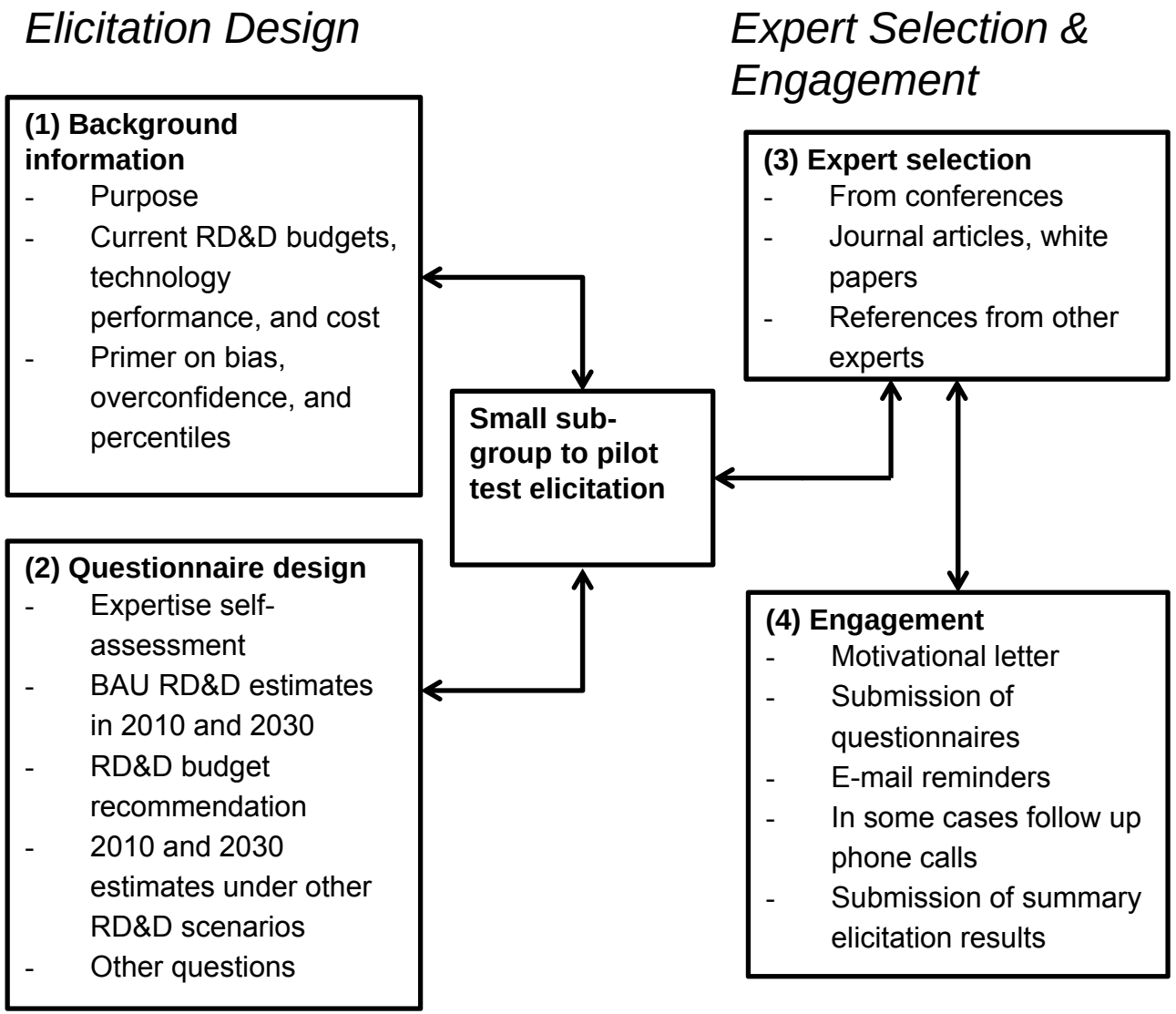
- Elicitation results of 6 Harvard elicitations introduced stochastically into an energy-economic model (MARKAL); model results used in an optimization framework for policy recommendation inputs

- FEEM & Harvard group workshop *after* individual nuclear elicitations

- Meta-analysis of 3 nuclear surveys (including one by CMU)

Anadon, Bunn, Chan et al. (2011). Transforming U.S. Energy Innovation; Chan & Anadon (2013), to be submitted
Anadon, Bosetti, et al. (2012). Environmental Science & Technology
Anadon, Nemet and Verdolini (2013). *Environmental Research Letters*

Expert elicitation protocol

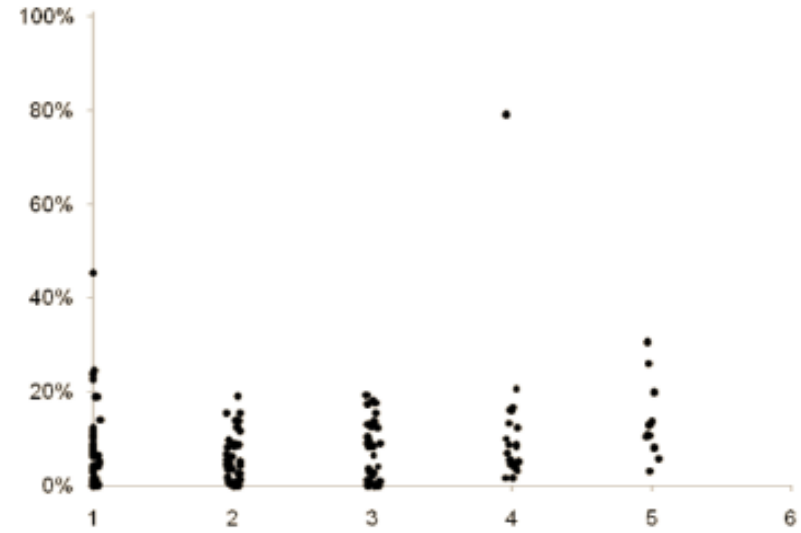


3. Insights

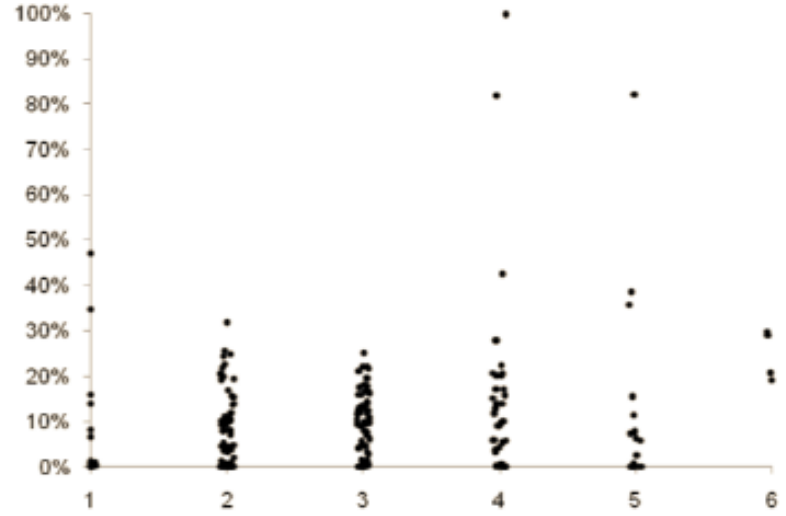
Self-assessment of expertise

- Questions about self-rating of expertise
  - Help assess bias in RD&D recommendation
  - Help credibility

X- axis: Self-rated expertise (1: lowest; 6: highest)
Y- Axis: Fraction of expert's total investment for a particular technology area



(a) Bioenergy



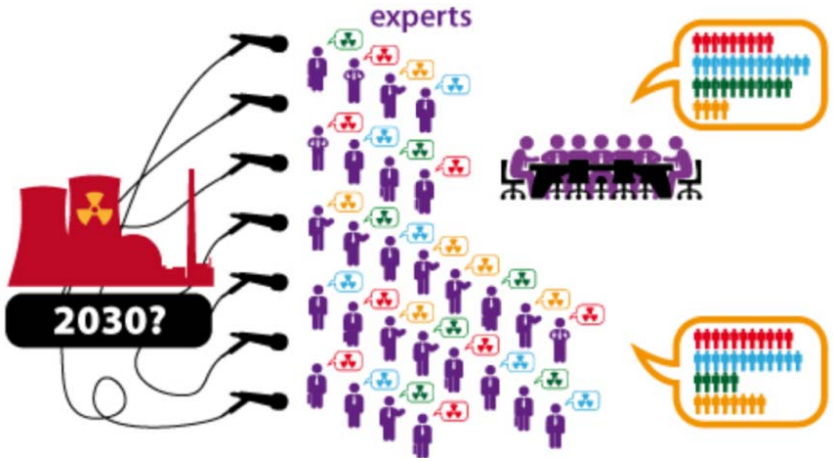
(b) Utility scale energy storage

Conducting online elicitations

- Possible tradeoff between in-person and online elicitations
  - Online elicitations are faster and cheaper
  - Quality of results may be lower (possible ambiguities even after pilot)
- Group workshop insights on online elicitations
  - Real-time feedback tools in online survey deemed useful
  - Correct interpretation of questions about cost and performance
- Normalized uncertainty range larger for online elicitations
  - But more investigation needed (collinear with technology)

Synthesizing results with a post-elicitation workshop

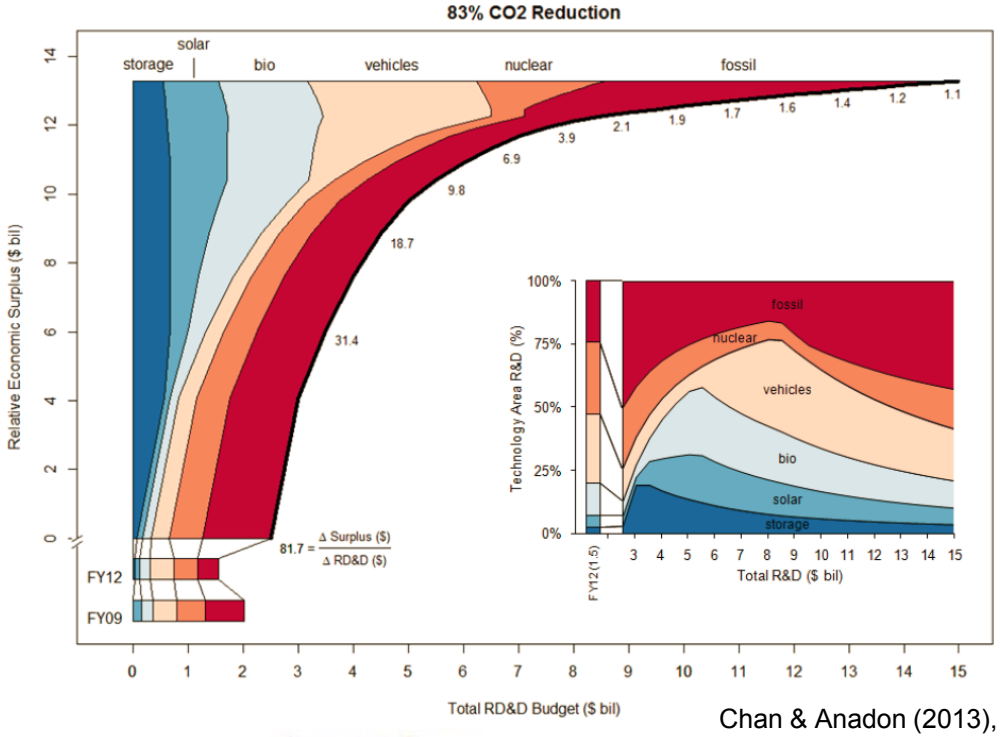
- Opportunity to explain reasoning, change answers (in private), and discuss areas that were unclear
- 'Validation' of the online elicitations on cost and performance
- Impact of workshop on other estimates
- Other insights of group workshop
  - understanding why EU focuses less on modular reactors
  - focus of US on fuel cycle due to greater private involvement



Anadon, Bosetti, et al. (2012). *Environmental Science & Technology*

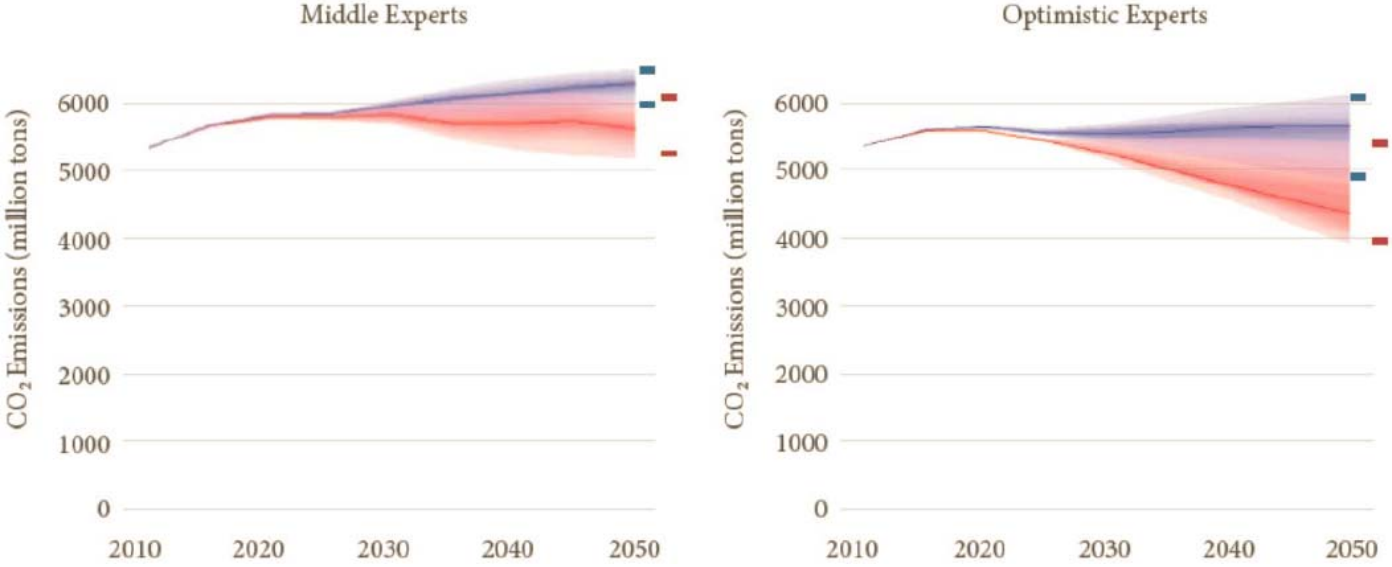
Designing elicitations for models

- Difficult to foresee all requirements
  - impact of even larger RD&D
  - dependence of advances between technologies (pilot)
  - qualitative questions help interpret results and increase external credibility



Chan & Anadon (2013), to be submitted

- Choosing expert scenarios



Anadon et al. (2011). *Transforming U.S. Energy Innovation* and (2013), *Cambridge University Press*, forthcoming.

Meta-analysis: expert selection and elicitation design

- Expert background
  - Public and industry experts 14% and 32% higher than academics
- Expert country
  - US 22% lower than EU
- Technology granularity
  - Gen. IV and SMR 23% and 24% more expensive than Gen. III/III+
- Uncertainty not dependent on RD&D
- US experts more uncertain, and less uncertainty about SMRs

Anadon, Nemet and Verdolini (2013). *Environmental Research Letters*

4. Questions

1. What criteria should be used to evaluate the applicability of different research synthesis methods to particular types of problems and data?

- Cost and reliability
  - Analysts are constrained by time and money
  - Efforts to improve the reliability of results enhances credibility: pilot testing, group workshops, replication. (e.g. are online elicitations less reliable than in-person elicitations?)
- Time constraints for the usefulness of the analysis
  - Decisions must be made in a particular timeframe that may constrain the capabilities of analysis
- Appropriateness for policy design and modeling tools
  - Methods should be designed after considering how results can be effectively integrated in decision making or subsequent analytical tools
  - Depending on model needs, existing elicitations or other tools may not be suitable (e.g., learning curve analysis and existing elicitations had not covered program-wide efforts in different technologies, and instead focused on smaller efforts, so new elicitations were needed)
  - The nature of the problem requires frequent updates: innovation makes estimates made ~5 years ago obsolete

2. What particular characteristics of the problem and data make the research synthesis method(s) you address particularly well (or poorly) suited for that context?

- Status quo decision making in energy innovation could be improved with additional decision-support tools
  - Current practice does not systematically assess benefits, incorporate uncertainty, or integrate across disparate areas of technical expertise
- Our method worked well because of the way we designed our analysis to produce results, more than the problem *per se*
  - Constructing expert scenarios (optimistic, pessimistic, median) allowed us to test the sensitivity of the results regarding the impact of investment increases and different allocations
  - If results had not been robust to expert scenarios, then perhaps an aggregation across experts with additional scenarios could have yielded useful results
- Our use of meta-analysis was aimed primarily at supporting the design of future elicitations (expert selection and question design)
  - But elicitations which are really different are not easily included

3. What are the strengths and limitations of the outputs provided, and the implications for their use in policy analysis?

- Trade off between aggregation of expert opinions (clearness of policy message) and capturing the full uncertainty expressed by the breadth of experts
- Expert selection, questions about self-assessment of expertise, and detailed qualitative questions can help build credibility with policy makers, but are time-consuming and difficult to synthesize
- The meta analysis provides estimates of RD&D returns which can be succinctly communicated to policy makers, but conveying uncertainty remains difficult
- The translation of normative expert “recommendations” to positive decision-support tools requires precise communication about the role of experts’ assessments and recommendations in driving results

4. What are the most important research needs, in terms of methodological development, given your findings?

- Testing the robustness and biases of self-administered surveys, for example by using randomized trials
- Further testing the ability of follow up workshops to reduce ambiguity in elicitation design and systematic biases in elicitation results
- Meta-analysis of elicitation results in other technology areas
- Ex-post comparison of expert-elicited technology forecasts and realized outcomes
- Designing elicitations for structural mechanisms of energy-economic models, not just parametric uncertainty
- Construction of a repository (database) of elicitation data that can be publicly-accessed (such as the MegaJoule effort).

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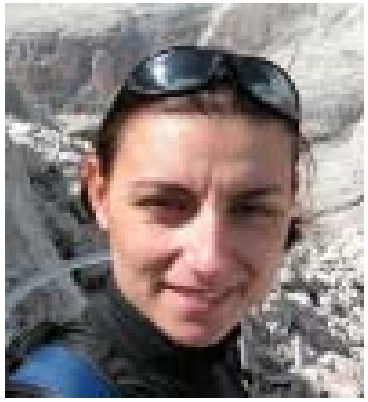
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