UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

Improving Decision Making for Public R&D Investment in Energy: Utilizing Expert Elicitation in Parametric Models

EPRG Working Paper 1631

Cambridge Working Paper in Economics 1682

Gabriel Chan[a,*] and Laura Diaz Anadon[b]

[a] Humphrey School of Public Affairs, University of Minnesota
[b] Department of Politics and International Studies, Cambridge University
[*] Corresponding Author: gabechan@umn.edu

Effective decision making to allocate public funds for energy technology research, development, and demonstration (R&D) requires considering alternative investment opportunities that can have large but highly uncertain returns and a multitude of positive or negative interactions. Such considerations have become more pressing in the wake of the Mission Innovation initiative, in which governments of 22 countries (and the European Union), representing more than 80% of global clean energy R&D funding, committed to doubling their R&D investments from 2015 – 2020. Allocating greatly expanded energy R&D budgets will require clarity about the goals of new R&D funds.

The paper first proposes the following four design principles for a decision-support method that can feasibly and effectively improve public R&D portfolio design: (1) quantifiable - technological improvement benefits of a decision must be prospectively quantified and account for uncertainty; (2) comprehensive - social benefits of R&D investments must be evaluated in a common framework; (3) adaptive - benefit analysis should be flexible to changing assumptions; and (4) transparent - transparency in developing assumptions and analytical methods should be feasible. The first two principles deal with analytical requirements and the second two principles concern institutional feasibility of implementing a decision support tool.

The bulk of the paper is devoted to proposing and implementing a method to support R&D decisions that addresses the four principles and propagates uncertainty through an economic model to estimate the benefits of an R&D portfolio, accounting for innovation spillovers and technology substitution and complementarity. The proposed method improves on the existing literature by: (a) using estimates of the impact of R&D investments from one of the most comprehensive sets of expert elicitations on this topic to date; (b) using a detailed energy-economic model to estimate evaluation metrics relevant to an energy R&D portfolio: e.g., system benefits, technology diffusion, and uncertainty around outcomes; and (c) using a novel sampling and optimization strategy to calculate optimal R&D portfolios. This design is used to estimate an optimal energy R&D portfolio that maximizes the net economic benefits under an R&D budget constraint.

Results parameterized based on expert elicitations that included 100 experts conducted in 2009-2011 in the United States provide indicative results that show: (1) an expert-recommended portfolio in 2030, relative to the BAU portfolio, can reduce carbon dioxide emissions by 46 million tonnes, increase economic surplus by $29 billion, and increase renewable energy generation by 39 TWh; (2) uncertainty around the estimates of R&D benefits is large and overall uncertainty increases with greater investment levels; (3) a 10-fold expansion from 2012 levels in the annual R&D budget for utility-scale energy storage, bioenergy, advanced vehicles, fossil energy, nuclear energy, and solar photovoltaic technologies can be justified by returns to economic surplus; (4) the greatest returns to public R&D investment are in energy storage and solar photovoltaics; and (5) the current allocation of energy R&D funds is very different from optimal portfolios. Taken together, these results demonstrate the utility of applying new methods to improve the cost-effectiveness and environmental performance in a deliberative approach to energy R&D portfolio decision-making.

Contact gabechan@umn.edu
Publication December 2016
Financial Support