Strengthening Public-Private Partnerships Through Effective Visions and Roadmaps

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ABSTRACT

While industry visions and technology roadmaps are created by industry to serve the needs of industry, the documents also help define the space for potential public-private partnerships. In this respect, however, there can be a gap in usefulness to each partner, for example, if research priorities are not defined clearly or comprehensively. This paper describes a RAND research effort aimed at assessing documents created by selected energy- and waste- intensive industries outlining each industry's vision for the future and a technology roadmap to achieve the industry's goals. The documents are used by industry and by potential partners to identify areas for R&D collaboration. One potential partner is the Department of Energy's Office of Industrial Technologies, which uses the documents to identify areas for public-private partnerships for R&D on advanced energy efficiency, renewable energy and pollution prevention technologies. RAND conducted an independent assessment of the visions and roadmaps for three industries participating in the DOE Industries of the Future program to help identify areas for improvement in the technology roadmaps to make the documents useful to all potential partners, including government agencies, academia, trade groups, and other partners. We found several areas to strengthen the documents to make them more useful to planning for R&D to aid in the potential for public-private partnerships. The topic is important to government policymakers interested in issues in industry performance and competitiveness and to industry personnel interested in providing input to government programs for policy and program development.

Introduction

Industry visions and technology roadmaps are documents created by industries to develop long-term strategic R&D agendas. Given the resource requirements of R&D, the documents also can be used to identify opportunities for public-private partnerships. Among the potential partners is the Department of Energy's Office of Industrial Technologies (OIT), which creates partnerships among industry, trade groups, government agencies, and other organizations to research, develop and deliver advanced energy efficiency, renewable energy and pollution prevention technologies for industrial technologies. Within OIT, the Industries of the Future program works with nine energy-and waste-intensive industries (agriculture, aluminum, chemicals, forest products, glass, metal casting, mining, petroleum, and steel). Two key planning elements of the strategy for the Industries of the Future program include (1) an industry-driven document outlining each industry's vision for the future, and (2) a technology roadmap to identify the technologies that will be needed to reach that industry's goals.

In an ongoing effort to improve the effectiveness of these partnerships, DOE asked the Science and Technology Policy Institute at RAND to perform an independent assessment

of select industry visions and technology roadmaps. The goals of the assessments are to identify the strengths and limitations of the visions and roadmaps toward improving the R&D planning process for public-private partnerships. The sectors RAND reviewed were forest products, aluminum, and steel.

This research suggests ways to strengthen the effectiveness of R&D planning tools in public-private partnerships in general, with a particular eye towards the partnerships created by Industries of the Future (IOF) program. Specifically, the effort examines the roadmaps of three industries that participate in the IOF program (aluminum, forest products, and steel) and, to a lesser extent, the visions created by these industries. The goal was to identify the strengths and opportunities for further improving the R&D planning processes and how the documents could be improved to realize these opportunities. The assessments consisted of reviewing the literature and consulting with experts in the areas of roadmapping, public-private partnerships, and industrial R&D as well as individuals familiar with the individual roadmaps and their respective industries including private sector, government managers, university researchers, and industry associations. An important goal of the research is to suggest ways these documents may be improved to aid federal program planning to all stakeholders.

This paper is organized as follows. First we present an overview of the DOE program and goals, and a description of industry visions and roadmaps. Next, we describe the research goals, followed by a presentation of the assessment process developed by RAND. After this, we present the findings from the evaluations. In the final section, we discuss the findings and some next steps for research in strengthening public-private partnerships.

DOE Industries of the Future Program and Office of Industrial Technologies

The Department of Energy's Industries of the Future Program (IOF) is a public-private partnership under the Office of Industrial Technologies (OIT) that seeks to stimulate R&D investments that reduce the energy intensity and environmental impact of the energy-intensive industrial sectors. As part of the IOF public-private partnership program, industries take the initiative to develop visions (of future industrial economic and environmental performance) and technology roadmaps (identifying the technology areas needed to achieve such performance) with the DOE providing support upon request.

Starting in 1994, the IOF program has worked with various industrial sectors to create long-term visions of desired industrial performance and technology roadmaps to support these visions. Nine industrial sectors have participated in this process (agriculture, aluminum, chemicals, forest products, glass, metal casting, mining, petroleum, and steel). Some sectors spend considerable resources to develop and maintain the visions and roadmaps.

The information contained in the industry visions and roadmaps provides industry, government agencies, and academia with information on industry R&D priorities. All parties can then use the information to focus their efforts in areas most useful to them. The Office of Industrial Technologies (OIT) uses the visions and roadmaps to guide solicitations for R&D proposals and to help select winning proposals. OIT uses the roadmaps and recommendations from industry to create solicitations for voluntary collaborative research partnerships with each industry, generally with a 50 percent cost sharing arrangement.

In order to be funded through OIT, a project should ideally meet the following criteria: reduce energy use, minimize environmental impacts, involve pre-competitive research, improve productivity, and be process-oriented. In addition, progress for a project should be measurable against goals so that government planners can track progress in implementing the roadmap and relate this progress to Government Performance and Reporting Act (GPRA) metrics. The anticipated outcomes of partnerships with OIT are demonstrations, evaluations, and acceleration of new technologies to enhance the economic competitiveness of industry and to meet the two major energy and emission goals of IOF, namely:

- A 25 percent improvement in energy efficiency and 30 percent reduction in emissions for the vision industries by 2010.
- A 35 percent improvement in energy efficiency and 50 percent reduction in emissions for the vision industries by 2020.

The OIT Industries of the Future Program's funding levels are modest relative to total R&D industry investments. Its overall funding for sector-specific R&D (the nine sectors) has been approximately $60 million for the last couple of years with an additional $75 to $100 million has been spent on crosscutting technologies.

Industry Visions and Technology Roadmaps.

Two key elements to achieving industry goals are an industry-driven document outlining each industry's vision for the future, and a technology roadmap to identify the technologies that will be needed to reach that industry's goals. An industry vision defines where the industry is today and where it wants to be in the future. An ideal vision portrays the desired future, focusing on areas of improvement (continuous improvements or new products and processes) shaping the economic competitiveness of an industry. The vision, thus, provides a strategic plan.

While the vision provides the beginning and desired end points, a technology roadmap is the link between the two. The roadmap represents an industry defined, long-term agenda of research and development, translating the vision into a tactical agenda. It is a planning tool that lays out potential science and technology alternatives to achieve the desired vision goals. It relates technology research and development to applications that meet needs that are consistent with the strategic plan, and it describes the temporal and structural relationships of technologies. Accordingly, the technology roadmap is a model of technology solutions to link today to the future vision. Further, the roadmap can be used to focus debate, structure decision-making, organize and collect data, and present results.

Research Goals

RAND was asked by the DOE to provide an independent assessment of select industry visions and technology roadmaps to identify their strengths and limitations toward improving R&D planning process for public-private partnerships. RAND is a non-profit public policy research institute, helping to improve policy and decision-making through research and analysis. Within the Science and Technology Division at RAND, the Science and Technology Policy Institute is a federally funded research and development center chartered to help improve public policy by conducting objective, independent research and

analysis to support the White House Office of Science and Technology Policy (OSTP) and other government agencies.

The research goal is to help ensure the roadmaps provide the information required to readily identify, justify, and prioritize R&D investments, and respond to changes in strategic drivers over time given uncertainty regarding the future. The industry sectors RAND reviewed include forest products, aluminum, and steel, which are in the process of reviewing and updating their technology roadmaps. These three sectors were selected to provide feedback into their revision process in order to facilitate public-private partnering arrangements.

Research Approach

There were three primary components to the research approach. The first component was to conduct a literature review and meet with experts on the development of "best practices" of industry visions and roadmaps. The second component was to develop criteria to evaluate existing industry documents. And the third component of the research approach was to ask experts to evaluate the selected industry documents using these criteria. Each of these is discussed in turn.

Best Practices in Visions and Roadmaps

The research approach began with a focused literature review on the development of industry visions and roadmaps. Based on an extensive review of the literature and discussions with relevant experts, industry personnel, government managers, and RAND researchers, we identified features and characteristics of "best practices" in industry visions and roadmaps. The bibliography of references is available upon request. Based on the review, our working definition of a technology roadmap is:

> A technology roadmap is a planning tool that lays out the science and technology alternatives to achieve a desired goal. It relates technology R&D to applications that meet needs consistent with strategy, and it describes the temporal and structural relationships of technologies (graphically as an interconnected network of links and nodes). It is a model that relates the temporal and spatial elements of technology options to focus debate, structure decision making, organize collect data, and present results.

Criteria for Roadmap Evaluation

In order to evaluate existing visions and roadmaps, we developed criteria for "best-in-class" roadmaps based on our literature review and many discussions. These guidelines were intended to shape the evaluation of the industry documents. The criteria we developed are presented below in two sections. The first portion of the criteria addresses six aspects of the content of the roadmap. These areas are based on the characteristics of an "ideal" roadmap. The criteria for content explore issues such as whether the roadmap under review is comprehensive, provides metrics to prioritize goals, and supplies sufficient information for implementation. The second portion of the criteria addresses three aspects of the roadmapping process and use. These criteria examine the apparent level of cooperation in the roadmapping process by management and technologists in the organizations within an industry. However, only experts with knowledge of an industry's initial roadmapping

process were qualified to address these criteria. Thus, while the criteria are important in creating an ideal roadmap, we do not include the results in this research due to the limited information available.

Criteria for Roadmap Content

1. *Contains goals that are visionary, yet reasonable given the specified time frames.*

The strategy or vision contains quantified goals over time. These goals are aggressively set (stretch goals). Despite aggressive goal setting there is the expectation that they are achievable, although the means for attaining them may not be entirely known.

The goals address the needs of the entire sector (e.g, primary producers, secondary producers, and suppliers as relevant). The assumptions that drive the vision are explicitly identified. Preferably intermediate milestones will be identified to demonstrate progress over time.

Vision and roadmap goals are described by consistent metrics. The same metrics are also used to describe the status quo.

2. *The roadmap represents a comprehensive treatment of technology relating to the goals and includes non-traditional approaches.*

To ensure that partners address the priority areas for industry, the roadmap's scope should be determined by industry's needs. These will likely be broader than any single partner's mission. For example, the OIT mission is focused on improving the energy efficiency and reducing the environmental impacts of manufacturing processes (not products).

The roadmaps are more valuable for R&D planning if they lay out alternative technology paths and keep technological options open for several reasons. First, if a change in the underlying assumptions behind the strategy occurs, the plan is more adaptable. Second, new technology development involves risks and surprises. Third, it is important to think "outside the box," since this is where many innovations (particularly revolutionary ideas) arise.

All technology alternatives should be considered regardless of whether or not they build off existing approaches or are entirely new approaches to ensure a robust portfolio.

3. *Provides insight and informs decisions (is relevant) to technologists and non-technologists within the organization.*

The roadmap should explain why certain technology areas are needed, what the knowledge gaps and technical barriers are, and the implications of success or failure in a technology area. The benefits of pursuing various technology paths are articulated clearly so that a justification or rationale for certain levels of funding for each year can be developed. Similarly, the consequences of budget changes can be estimated from the information in the roadmap.

The information contained will aid in prioritizing technology areas, balance the risk-reward of investments, and understanding the implications of success and failure in a given technology area. As a result, awards ideally will reflect a diversified portfolio of projects that balance the dimensions of risk, payoff, and time.

4. *Uses criteria for the inclusion of specific technologies, relationships among technologies, and the values assigned them.*

Clearly defined criteria should describe the boundary of the roadmap so that the scope is finite. A clearly articulated rationale for including technologies ensures that users understand what is and what is not included. It also ensures consistent treatment of technologies and alternatives. These criteria should also be used to identify how to interact with other roadmaps/roadmapping efforts (e.g., such as IOF's crosscutting roadmaps as well as those of other industries, associations, and agencies).

Determining the boundaries is somewhat of an art, but the scope should include priority areas for each industrial sector. It will also require a careful balance of industry specific or enabling technologies with a discussion of crosscutting or pervasive technologies.

5. *Contains Implementation Plans*

There is enough information to indicate the areas appropriate for industry investment and the areas appropriate for government investment.

The solicitations and resulting projects derived from the roadmap clearly move the industry towards the vision goals and track the quantitative milestones included in the roadmap. This progress should be measurable against the goals and milestones so that government planners can track progress in implementing the roadmap and relate this progress to Government Performance and Reporting Act (GPRA) metrics.

Major barriers to new technology deployment are identified and plans are proposed for overcoming them.

6. *Identifies Strategic Drivers*

Strategic assumptions regarding the goals and paths outlined in the vision and roadmap are identified. The roadmap lays out alternative technology paths to attain the goals given the political, financial and other constraints of the system.

Criteria for Roadmapping Process and Use

1. *The roadmapping process is linked to all relevant business and technology functions and activities.*

The roadmap is developed with input from technologists and business managers such as CEOs, CTOs, facility managers, technologists, field personnel, etc. This will increase the chance that technologies outlined in the roadmap will be strategically important, focused on the needs that the goals are addressing, and deployable.

2. *Created by competent and diverse contributors.*

The team represents the breadth and depth of the technological and business capabilities of all stakeholders to assure that the roadmap contains a credible estimate of technology needs and paths.

3. *Supported with management and field commitment.*

Involvement by multiple personnel levels will improve both the content of the roadmap and the likelihood that the information contained in it will be used.

The companies must be supportive of the needs and technologies laid out in the roadmap so that the program will be supported, so that RFPs get high quality responses, and so that the resulting technologies will be deployed by industry. An inclusive process builds support for the roadmap and any programs built from it.

Expert Evaluations of the Documents. We asked fifteen experts to evaluate the roadmaps for the three industries against the criterion described above. For each area, an expert assigned a value of 1 (doesn't address) to 10 (strongly addresses) and an explanation of each score. In addition we asked them to list the top strengths and limitations of the visions and roadmaps for use for R&D planning for public-private partnerships. Our ultimate goal however was not simply to score the visions and roadmaps against these criteria as much as to use them to develop a constructive evaluation of the documents. The initial reactions were shared with DOE and each industry. The primary purposes of the meeting were to ensure the accuracy and completeness of the recommendations and to possibly help the industry decide how to improve its vision and roadmap.

Findings: Technology Roadmap Strengths and Areas for Improvement

The evaluation criteria provided a structure to compare the roadmapping efforts of three energy-intensive industries. Based on the scoring and comments of the experts, we compiled a set of general findings (we do not report specific industry findings). Our assessment was directed at helping improve the documents for industry overall and for improving their use in public-private partnerships in particular. Accordingly, while the visions and roadmaps are industry documents, the findings could help industry meet their goals by improving the potential for public-private partnering.

General Findings Based on Three Industry Visions and Roadmaps

The roadmaps provided excellent overviews of the industry drivers. This is an important feature since it defines the current and future environment facing an industry.

The roadmaps tended to provide comprehensive details and discussions of the technologies. Even though the roadmaps contained technical details, portions of all roadmaps tended to be accessible to non-experts in an industry, although the level of detail in some roadmaps could overwhelm a reader.

The roadmaps identified many potential areas that likely exceed the combined resources of industry, government, and other stakeholder. In general, the approaches reflected incremental technological changes based on existing research. Although the roadmaps included some non-standard approaches, indicating thinking outside the present industry lines of attack, there were limited examples of crosscutting technology or technology that was revolutionary in scope, i.e., stretching the research horizon beyond a couple of years.

A significant limitation of the roadmaps included the lack of metrics useful to all potential partners. For example, OIT-specific metrics would include those needed to evaluate energy, R&D cost, and emissions reductions and the cost of implementing technological improvements. In general, the lack of metrics that are important to potential partners, such as DOE, makes it difficult to evaluate new research projects and prioritize an R&D agenda for public-private partnering.

There was a marked absence of strategies for tracking progress in implementing the roadmaps for the industries reviewed. While some of the details depend on researchers conducting the R&D projects, the inclusion of goals, targets, milestones, and timelines help industry (and its partners) to understand the importance and ordering of events to reach the

end vision. The addition of time-based targets helps motivate the need to innovate and may provide a sense of urgency otherwise missing.

Related to the above findings was a lack of metrics to assess the risks and rewards for various approaches. Currently, there is little information to assess an avenue of research (especially for highly speculative R&D) against anticipated advantages for an industry. Similarly, there is little information that can be used in cost/benefit analyses.

Conclusions

Overall, the reviewers found the roadmaps were good solid documents, especially since many of the firms in each industry had never cooperated previously on pre-competitive R&D planning. The three industries evaluated here were selected based on their upcoming revision of the roadmap. In our research, we have found that roadmaps commonly undergo at least three iterations to become effective planning tools for R&D. In addition, periodic review and adjustment of the visions and roadmaps are needed to account for unanticipated events in an industry or more widely, such as technological advances or changes in the economy. As such, the industries were felt to be on the way towards developing roadmaps consistent with the best roadmaps that exist today.

The goal of the research was to perform an independent assessment of select industry roadmaps to identify strengths and limitations in industry roadmaps toward improving the R&D planning process for public-private partnerships, with the focus on how to address OIT needs. Strengths of the documents toward these ends include:

- The documents are fairly good at communicating industry priorities.
- The benefits of R&D investment are often identified, though usually only qualitatively.
- There is a structured approach for program development in most roadmaps.
- The roadmaps list short, medium, and long term R&D, which can help form an R&D portfolio.
- The documents begin to create a framework for project assessment.

Some specific areas for improving the technology roadmaps include:

- The documents need to include measurable goals to help prioritize an R&D agenda and convey priorities to firms in an industry and to potential partners. A broad list of technology needs can facilitate business as usual.
- Include interim milestones, which are a key component to roadmap design. Develop metrics and targets to demonstrate short- and long-term goals. Milestones help keep industry participants on track and convey priorities to stakeholders.
- To facilitate partnering, provide metrics that are useful to potential stakeholders. For example, provide information on the estimated reduction in energy and emissions for different approaches or options, which are important goals of OIT.
- There is a need for metrics to assess the risks and rewards for various approaches. Consider metrics to aid in cost/benefit analyses. The information helps industry and partners assess tradeoffs among a host of R&D efforts and potential outcomes.
- Provide consistent measures to evaluate success of projects and progress towards goals. Setting and tracking goals is important within industry and to convey progress to stakeholders.
- Industry should consider talking to stakeholders about how roadmap metrics can help potential partners meet their goals. For example, industry can collaborate with OIT on

metrics to help OIT issue solicitations, evaluate proposals, and comply with its requirements.

- To aid long term R&D planning, it would be useful to have a structured treatment of future uncertainties by creating multiple scenarios, or "what if" analyses of critical variables, e.g., energy prices, raw materials, and foreign production capacity.
- In the roadmaps, develop and apply criteria for what is inside and outside of the scope of the roadmap. Describe the relationship between enabling and crosscutting technologies.
- Provide insight into whether a technology is revolutionary or incremental in the industry.

This research evaluated documents for three industries that currently are revising their technology roadmaps. While there were industry-specific insights gained during the research, the results reported here suggest general areas to improve the R&D planning process and the potential for partnering. For example, a critical barrier to effective partnering is the lack of metrics to help prioritize the research agenda. Such metrics would likely have elements in common across the industries. Accordingly, an important next step is to develop metrics that are adaptable to industry-specific requirements.

The areas for improvement identified in this research are based on three industries. It would be useful to evaluate documents of other energy-intensive industries to identify additional strengths and limitations that might have been absent in this research, thus affording each industry the benefit of "best practices" roadmaps.

Based on our research, there are opportunities to improve industry roadmaps, which could improve the likelihood of public-private partnering. However, there are several important, unanswered questions about the impact of roadmaps on industry. For example, what has changed in an industry as a result of its vision and roadmap? Has there been increasing participation and networking on the part of industry? For the DOE, has there been improved participation in the IOF program? Answers to these and other questions could benefit the R&D planning process in the future and the ability to form effective partnerships.

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