Research Strategies Subcommittee: Report Overview

Esther Takeuchi (Chair)
Marc Kastner (Vice Chair)

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U.S. DEPARTMENT OF ENERGY | Office of Science

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BESAC Charge to the Subcommittee

To establish a subcommittee of BESAC to follow up on its 2021 benchmarking report and advise SC and BES on strategies for prioritizing BES research investments. The goal is to have the report approved by BESAC at the Spring or Summer 2024 meeting.

As a first step in this direction, I ask BESAC to propose strategies for evaluating the prioritization of research investments in BES-supported domains.

These proposals should be area-agnostic strategies that BES management and staff can subsequently apply to specific research topics as BES and the research community go forward. Some questions that BESAC could consider in this report include:

Questions to Consider – from the Charge

- How should BES determine that a topical area is a high priority for increased investment?
- How should BES determine that a topical area is a low priority for continued investment and could be reduced or phased out?
- How should BES identify new topical areas for investment?
- As disciplines converge on complex problems, how should BES identify and foster cross-cutting areas for investment?
- How should BES balance research and instrumentation support for National Laboratories?
- How should BES balance research and instrumentation support for academic grants?

Questions to Consider – from the Charge

- What should be the balance among the research modalities (single principal investigator, small groups, and team research [e.g., EFRCs, Energy Innovation Hubs, Quantum Information Science Research Centers, and computational science centers]) for the future?
- How should BES weigh the potential for technological impact in defining investment priorities?
- How can BES play a useful role in enabling innovations to cross the “valley of death”?
- How sharp or fuzzy should the “basic-applied boundary” be?
- How should BES take account of international competition in its research domains?
- How frequently should these evaluations be revisited?
- **Note: Demographics and appropriate inclusivity in the distribution of funding is a core consideration.**

Subcommittee Members

Berry, Joseph	NREL
Chen, Lin	ANL/Northwestern
Cooper, Valentino	Oak Ridge National Laboratory
Daniels-Race, Theda	LSU
DeBeer, Serena	Max Planck Institute
Epps, Thomas	Delaware
Garcia, Jamie	IBM
Guzman, Javier	ExxonMobil
Helms, Brett	LBNL
Huq, Ashfia	SNL
Isaacs, Eric	Carnegie Institute
Kastner, Marc **(Vice Chair)**	MIT Retired
Mallapragada, Surya	Ames Laboratory, Iowa State
Meng, Shirley	ANL/U Of Chicago
Musumeci, Pietro	University of California, Los Angeles
Segalman, Rachel	UC-Santa Barbara
Takeuchi, Esther **(Chair)**	BNL/Stony Brook University
Tirrell, Matt	ANL/U Chicago

Subcommittee Participants

Office of Basic Energy Sciences Participants

Linda Horton, Associate Director of Science for Basic Energy Sciences (to March 2024)
Associate Deputy Director for Science Programs (since April 2024)
Andrew Schwartz, Acting Associate Director of Science for Basic Energy Sciences (since April 2024);
Director, Materials Sciences and Engineering Division
Gail McLean, Director, Chemical Sciences, Geosciences, and Biosciences Division
Adam Kinney, Senior Technical Advisor
Kerry Hochberger, Program Analyst and BESAC Manager

Logistics and Technical Support

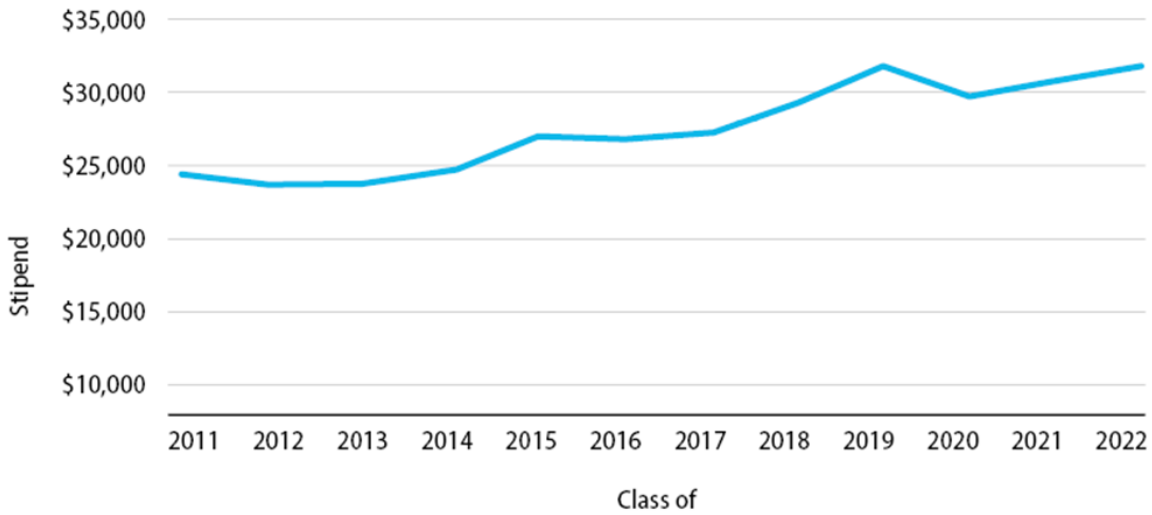
Al Hammond, editor/writer
Maggie Powell, publications design and production

Introduction

- Beyond impacting our lives and work, science and technological innovation are critical economic drivers where U.S. prosperity and security are intimately linked to the pursuit and advancement of new ideas and the technologies they spawn.
- Technologies are typically born from scientific discoveries that can then lead to innovation that translates the discovery into something usable.
- The imperative for continued U.S. investment in scientific research was recently assessed and the findings showed that due to increased international investment and the flattening of U.S. investment, the U.S. leadership position in science and technology is challenged.
- The criticality of U.S. investment in scientific research is apparent.

Introduction

- Investment by the U.S. federal government in basic and applied research has increased from 2012–2021 where a significant part of the increase since 2019 was driven by investment relevant to the COVID pandemic.
- Research costs have also increased significantly driven by inflation, supply chain challenges, and cost of living likely offsetting some or much of the apparent increase in research funding.
- It is critically important to provide an assessment of research investment strategies. Costs of research are rising, international competition is strong, thus, thoughtful, and effective strategies for investment of the available research dollars are imperative.



Graduate stipends of Physics grad. students 2011-2021 ~30% increase. From American Institute of Physics graduate follow-up survey.

Approach

- Compilation, analysis and discussion of prior reports from other organizations relevant to assessment of research portfolios.
- Discussion of current approaches in use at DOE including information provided by BES staff.
- Four topic areas were addressed by subgroups.
- Note that the findings and suggestions in this document are presented in a constructive spirit with no implication that there are significant deficiencies or gaps in current practice.

Subgroups

Desired outcomes of the study.
Matt Tirrell (TL), Lin Chen, Tino Cooper, Javier Guzman

Opportunities to enhance research portfolio selection.
Eric Isaacs (TL), Joe Berry, Theda Daniels-Race, Rachel Segalman

Research assessment: A Summary of the existing literature.
Pietro Musumeci (TL), Thomas Epps, Jamie Garcia, Surya Mallapragada

Portfolio analysis: A case study.
Shirley Meng (TL), Serena DeBeer, Brett Helms, Ashfia Huq

Desired outcomes of the study

- Through a series of in-depth discussions of the questions posed in the charge letter, a set of statements characterizing the desired outcomes was developed.
- An effort was also made to think creatively, beyond the charge letter, about possible goals of the study.

Desired outcomes of the study

- ***BES strengthens its investments to maintain and advance foundational scientific knowledge and international competitiveness*.** Achieving this outcome will depend in part on better metrics of success and better ways to analyze the research portfolio.
- ***BES is nimble in investing and disinvesting in topical areas of research*.** BES has in place an effective system of Basic Research Needs (BRN) workshops and strategic planning with the synthesis of multiple streams of input. Investing and disinvesting are not simple, reversible processes and could be enhanced by better metrics.
- ***BES optimizes the balance in its portfolio.*** There are multiple dimensions of balance including the balance of university or national laboratory research, the balance between exploratory or mission-driven research, and that between support of research or unique national user facilities as well as consideration of the funding modality supporting individual, small groups of PIs or Centers or Hubs. Achieving appropriate balance may be enhanced by advancements in assessment tools.

Desired outcomes of the study

- ***BES addresses increasing costs of research*.** Inflation, graduate student unionization, international competitiveness, and support for mid-career scientists are among the factors driving up research costs. Addressing these costs may not necessarily be achieved through overall DOE budget increases, but rather through good choices in funding priorities.
- ***BES has more effective tools for insight into evaluating basic research that is use-inspired*.** Use-inspired research can lead to new ideas about fundamental research problems. A basic-applied research continuum is desirable. It may be useful to involve industry more extensively in strategy for some fields related to the BES mission.
- ***BES has effective approaches for investing in and prioritizing workforce-enhancing measures relative to research, instrumentation, and facilities*.** This could mean early-stage efforts to encourage STEM education, support of early career scientists, support of mid-career scientists, support of facilities scientists, and more, as discussed in the benchmarking study, *Can the U.S. Compete in Basic Energy Sciences?*

Opportunities to enhance research portfolio selection

DOE/BES has been and remains an extremely effective organization in continuously evaluating its research portfolio.

Consideration of opportunities that may exist

- The use of big data analysis and opportunities to use machine learning to understand the impact of the portfolio should be considered.
- Efforts to convene the community across constituencies should continue to be inclusive of industrial researchers to align U.S. competitive needs.
- Gain understanding of how and why various basic R&D activities have impacted U.S. industry.
- Partnerships with publishers may be possible to better understand the impacts of R&D activities.
- Continues to work at broadening community engagement.

Research assessment: Summary of the Existing Literature

- Over the past decade, a substantial body of literature has emerged from various international agencies and stakeholders, reflecting the growing interest and scrutiny surrounding research assessment practices.
- There are common recurring ideas and concepts in the research assessments.
- Relevant lessons learned and best practices were extracted to inform recommendations.

RoRI RESEARCH ON RESEARCH INSTITUTE

NIH Office of Portfolio Analysis

The Leiden Manifesto for research metrics

Signatory of DORA

Research assessment: Summary of the Existing Literature

- Over the past decade, a substantial body of literature has emerged from various international agencies and stakeholders, reflecting the growing interest and scrutiny surrounding research assessment practices.
- There are common recurring ideas and concepts in the research assessments.
- Relevant lessons learned and best practices were extracted to inform recommendations organized into three themes:
  - i) publications, patents, and other numerical metrics,
  - ii) methodologies including artificial intelligence/machine learning (AI/ML) tools for portfolio assessment,
  - iii) expert input

Research assessment: Summary of the Existing Literature

Quantitative metrics

- The assessment of research quality and impact is a critical aspect and the use of publication metrics plays a pivotal role in this process, providing quantitative data to gauge the influence and reach of research outputs and can mitigate biases within peer review processes.
- It is important to normalize metrics by field.
- It is good practice to combine as many indicators as possible to provide a more comprehensive assessment, while avoiding the illusion of false precision.
- A balanced and comprehensive approach to research assessment including qualitative evidence, expert judgment, and consideration of the specific context within each academic field should also play a significant role.

Research assessment: Summary of the Existing Literature

Methodologies and AI/ML Tools in Research Assessment

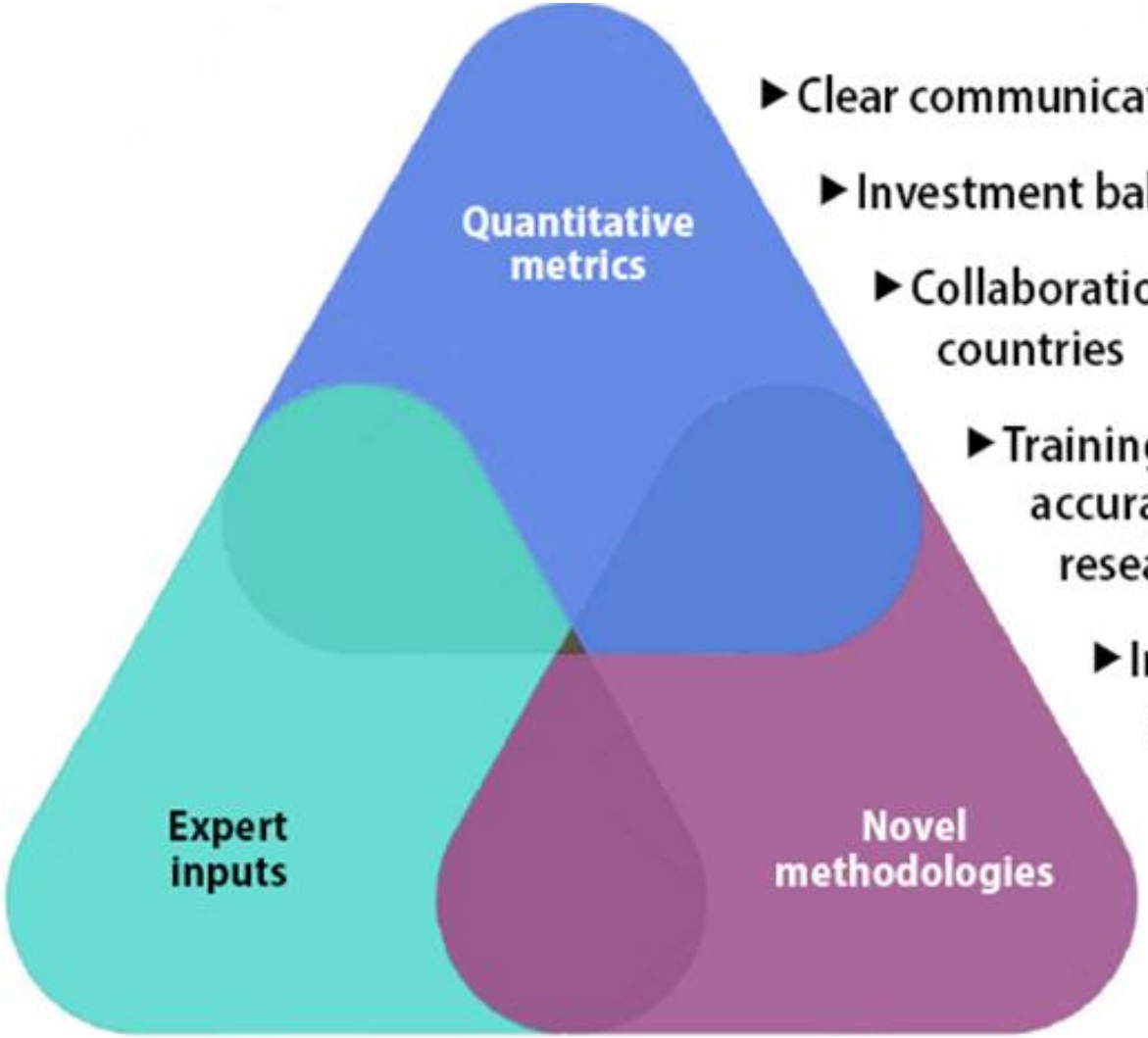
- Office of Portfolio Analysis (NIH) is developing and disseminating a multifaceted assessment approach to analyze entire portfolios of funded research projects including use of AI/ML, graph theory, and natural language processing.
- Portfolio analysis can potentially be used by decision makers to assess past impact and also predict the likelihood of desired outcomes resulting from the portfolio of funded projects.
- It is important to use simple and transparent tools, both for data collection and for the creation of indicators for assessment with clear criteria and methodologies.

Research assessment: Summary of the Existing Literature

Expert Inputs

- Expert panels play a key role in the assessment of research quality and impact within the academic and scientific community.
- Expert panels should be composed of individuals with deep domain knowledge and are essential in addressing the limitations inherent in relying only on publication metrics.
- For panels covering research in multiple areas, there is also the need for field-specific normalization recognizing substantial variations in impact factors, publication rates, and citation rates across different academic disciplines.

Research assessment: Summary of the Existing Literature



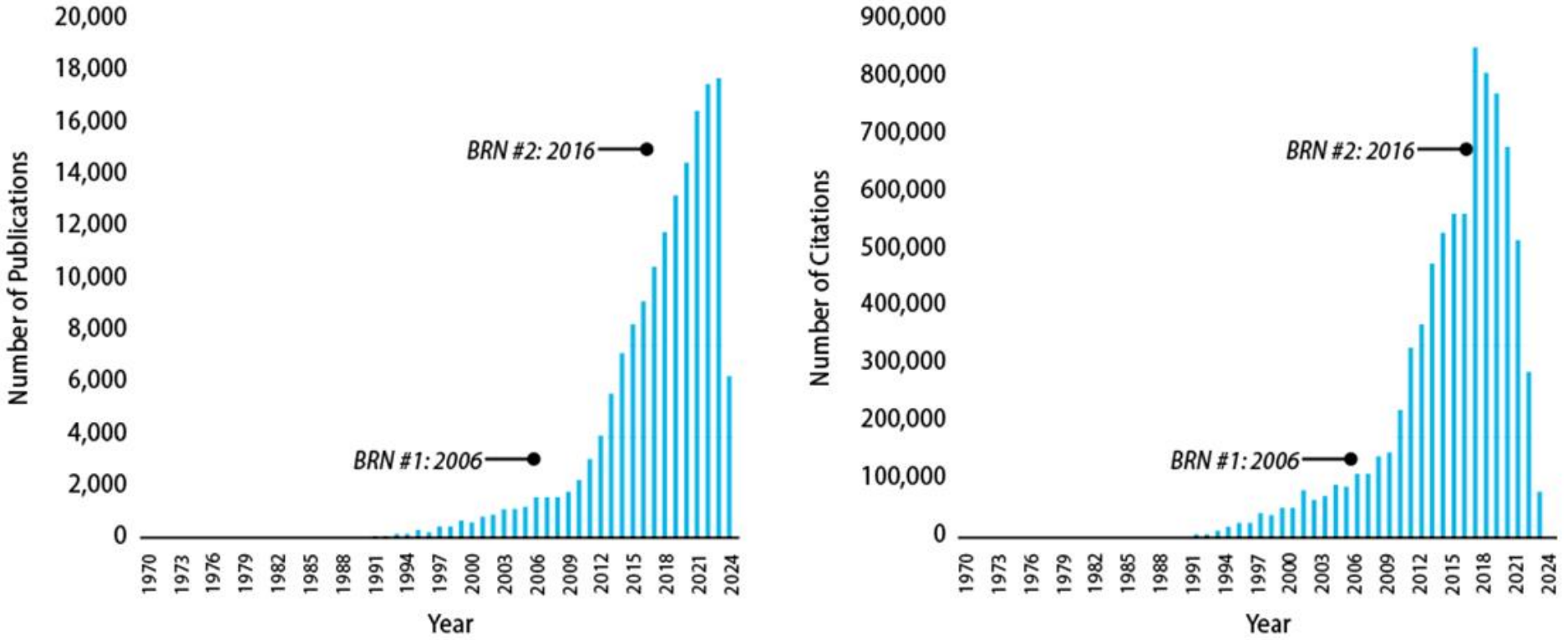
- Clear communication of objectives and goals
- Investment balance
- Collaboration across agencies and countries
- Training tools to ensure robust and accurate implementation of any research portfolio assessment
- Inclusiveness and broad perspectives at all stages

Note: Novel strategies require a good balance of quantitative metrics, expert inputs, and novel methodologies. Central elements to all of these are listed on the side.

Portfolio Analysis: A Case Study

- In a sample portfolio analysis, subgroup data were collected using publicly available data via Web of Science, Google Scholar, and public reports from various consortia and non-profit foundations.
- The test case focused on a data-driven study of the impact of basic science funding on battery technology, specifically lithium ion) and the scientific community at large including publications, citations, patents, awards, workforce development, and industry interactions.
- In the U.S., there has been significant funding for basic science research in energy storage across multiple DOE offices. Internationally, funding for energy storage science has been continuous and increasingly augmented by substantial industrial-scale R&D support from the private sector.

Portfolio Analysis: A Case Study



Publications and citations on lithium and lithium ion batteries

Notably, researchers are currently actively working on multiple alternative battery chemistries that is consistent with the decrease in the numbers in the past few years.

Portfolio Analysis: A Case Study

- **Patents:** Tracking inventions via patents and other Intellectual Property (IP) provides another dimension in portfolio analysis. In lithium ion batteries, while China dominates in lithium ion battery cell production (over 50%), the U.S. and Japan hold most of the original patents.
- **Workforce:** U.S. universities produce a vibrant scientific workforce, they also attracted the best in the world to get trained and ultimately become a part of the highly productive workforce in the country.
- Some students and professional electrochemistry scientists trained in the U.S. are now going to other countries to lead efforts abroad, thus, retention incentives may be important.

Portfolio Analysis: A Case Study

- **Industry Interactions:** Early adopters are generally new companies and startups, as more mature industry players may be more risk averse for new technology.
- The majority of the start-up companies in this field originate in the U.S., due to its entrepreneurship core values and increasing support and stewardship from universities and national labs.
- The success of bringing batteries from fundamental science research to a widely adopted technology has benefited from close collaboration of BES with more applied research agencies.
- Opportunities may exist in having industries participate in identification of unresolved fundamental issues.

Out of the Box Approaches

Ideas, based on discussions that could be considered to gain insight into new arenas of science.

- Conduct intermittent analysis to identify the fields new postdocs are pursuing.
- Survey academic department heads or chairs responsible for hiring young faculty members.
- Participate in multiple agency panels or discussions.
- Continue to facilitate collaboration modes between and among DOE offices.
- Program Managers form small groups to pitch new areas to fund.
- Track news and media for emerging areas of interest.

Out of the Box Approaches

- Energy Frontier Research Centers could be areas to incubate new ideas.
- Create a Request for Information for emerging ideas.
- At the national labs, the Laboratory Directed Research and Development (LDRD) programs may have valuable information about new ideas. For example, scanning topics of proposals that were not funded, sometimes due to lack of fit with existing programs, may provide insight into possible new areas of inquiry.

Recommendations

The subcommittee recommends several strategies for successful management of research portfolios in the future

- Continue and expand broad engagement with the research community and other constituencies to maintain and enhance technical excellence of DOE/BES science in line with its mission. Industrial engagement may help identify key knowledge gaps or opportunities to develop new basic understanding.
- Balance the funding portfolio across multiple axes including research versus facilities support, single investigator versus Center or Hub funding, and support of existing program areas versus nascent fields of inquiry.

Recommendations (continued)

- Facilitate seamless transitions from fundamental to applied research, which may involve cross-office interactions.
- Consider the benefits of investing in and adopting tools for portfolio analysis, whether gathering raw data available online and building simple tools or building complex AI/ML learning models. Couple the use of quantitative methods with expert opinion for optimal outcomes.

Thank you to all who participated in the preparation of this report.