

Since it was established in 2009, the Energy Frontier Research Center (EFRC) program in the Office of Basic Energy Sciences (BES) has brought together multi-disciplinary teams of researchers to tackle challenging scientific problems and lay the foundations for future energy technologies. BES acknowledges that the approaches to managing these collaborations have varied considerably from center to center based on institutional context, historical interaction, topical area, and personal style. Nonetheless, it has also become clear that there are some key attributes that typically contribute to a successful EFRC.

In addition, BES has observed various management approaches that EFRCs have successfully implemented to achieve these key attributes. A number of these “good practices” are detailed in the bullet points below, organized based on the primary key attribute that they support.

BES emphasizes that these are intended to serve as suggestions and guidelines, *not* requirements, and encourages EFRC leadership to develop and implement management practices and procedures that are most appropriate and effective for their center.

Articulation of a clear and compelling mission for the EFRC that is broad enough to be inspirational, but focused enough to provide cohesion. The mission is supported by specific research goals that are collectively developed by the senior investigators and communicated across the center.

- The senior investigators are engaged in strategic planning that includes the formulation and periodic evaluation of research goals for the EFRC, to ensure that they remain aligned with the mission and result in the highest impact science.
- Given the size and scope of EFRCs, most have found it beneficial to organize the center into a limited number (typically 3-5) of interrelated research thrusts that collectively address the mission and goals of the center. Each thrust involves multiple senior investigators.
- Interlocking and interdependent goals that require multiple people and disciplines promote interactions within and among thrusts.
- When presented (e.g., on the center website and in reviews, annual reports, and similar documents) the EFRC research is organized based on the goals and thrusts, not the activities of individual investigators.

Synergy across the EFRC that results in research outcomes that are demonstrably superior to what would be expected from a loose collection of projects.

- Sufficient support for all senior investigators ensures their intellectual engagement in the center.
- While collaboration outside the EFRC is encouraged, center research is structured and supported in such a way that some results can be claimed as the output solely of the EFRC; in other words, EFRC funding is not meant to tie together or bridge other efforts supported outside the EFRC.
- To ensure integrated research results, the center studies common materials or systems.
- Common samples are tracked and the resulting data shared among all center members using a central database or web resource. Some centers have adapted available tools, while others have created their own.

Adaptive management of the EFRC to ensure that research thrusts and resource allocation are aligned with the center goals and result in the most impactful scientific outcomes.

- Adequate programmatic and administrative support allows the EFRC Director to focus on scientific leadership. Some centers have found it beneficial to create a coordination or operations leadership position held by someone with scientific expertise.

- EFRC leadership establishes, documents, and disseminates clear processes, timelines, and metrics for evaluating the research within the center and for making adjustments as necessary. This can include redistribution of resources among existing projects; winding down projects that have matured to the point where future work will be outside the EFRC, are no longer of the highest strategic priority for the center, or are underperforming; and the initiation of new projects to address emerging opportunities.
- Evaluation metrics typically include scientific productivity and impact, alignment with the EFRC mission and goals, and synergy leading to the generation of new ideas and results that would have been unlikely without the EFRC.
- Centralized control is maintained over some fraction of the center budget to allow for resource flexibility (e.g. to bring in new expertise or to allow promising new research directions to be explored).
- Each EFRC is required to establish an external scientific advisory board to provide objective guidance to the center leadership:
 - The scientific advisory board is actively engaged, given a clear charge, and encouraged to provide critical and constructive feedback on current activities and future directions for the center.
 - Advisory board members are selected to complement the expertise within the center. The composition of the advisory board is periodically evaluated and modified if necessary to optimize its value to the EFRC.
 - Generally, EFRCs are discouraged from naming advisory board members from partner or collaborating institutions, in order to avoid conflicts of interest.
 - The scientific advisory board has only an advisory role; final decision making lies with the EFRC leadership team.
 - The scientific advisory board meets in-person on a periodic basis (typically once a year). Often this is done in conjunction with an annual EFRC all-hands meeting.
 - Both oral and written comments are typically requested from the advisory board. To ensure that the EFRC receives honest and valuable feedback, these comments should not be shared with BES.
- Some EFRCs also establish institutional advisory boards with representatives from each partner institution. The board members are typically not part of the EFRC but have some institutional oversight. These meet on an ad hoc basis to address institutional issues such as (but not limited to) resource allocation, access to facilities, and intellectual property.

Open and effective communications channels throughout the center and between EFRC leadership and BES personnel. Dissemination of research results to both the scientific community and a broader audience.

- The EFRC Director participates in monthly calls with BES Program Managers and invites other members of the center – including PIs, students, and postdocs – to present research results as appropriate.
- A password protected internal website is established to allow internal discussion, share research results and manuscripts, and archive meeting presentations, notes, and publications. The website generally includes contact information and research expertise for everyone in the EFRC, including students and postdocs. Making the website and other center resources available on mobile platforms encourages their use.
- A two-way web-based communication tool for virtual meetings and collaboration fosters communication among partner institutions and allows center members to remain engaged while traveling. These tools typically include audio, video, and file sharing capabilities.

- A common calendar is maintained and shared among EFRC participants.
- All center members, including students and postdocs, meet virtually on a regular basis to share research results. For example, some centers have a monthly all-EFRC webinar and most have regular (at least monthly) meetings for each research thrust.
- Periodic (typically annual) all-hands meetings are held. All EFRC members are encouraged to attend, and locations are often rotated among partner institutions.
- EFRCs take advantage of other events, such as national scientific meetings, to gather members for in person meetings.
- A travel fund supports student and postdoctoral exchanges among partner institutions, with flexible length of such visits.
- Access to participating national laboratory sites is pre-approved for center members from other partner institutions.
- Procedures for publishing papers are established and documented. This can include the scope of each paper, authorship, and acknowledgements review.
- When appropriate and beneficial, alliances are established with complementary EFRCs to leverage resources and share expertise. This has included jointly organizing workshops and symposia, making specialized equipment available to each other, and serving on each other's scientific advisory boards.
- Research highlights are posted on EFRC websites and promoted by the institutions where the work was performed. EFRCs work with BES program managers and DOE communications staff to highlight the highest impact research on the Office of Science website.
- EFRCs take advantage of opportunities to share the excitement and importance of basic energy research with broader audiences. Examples have included newspaper articles, radio and TV interviews, newsletters, lectures, public websites, and social media.

Training/mentoring of early career scientists

- Students and postdoctoral researchers are given opportunities to connect with their peers and develop leadership skills. This has included student-only meetings (journal clubs, research brainstorming sessions, research presentations, team-building activities, and retreats), students responsible for thrust meetings, and portions of all-hands meetings organized by students.
- Professional development opportunities (e.g. career panels, grant writing workshops, communication training) are made available to early career members of the center.
- Mechanisms are in place to encourage students and postdoctoral researchers to share research ideas with center leadership.
- Early career scientists are promoted and mentored by involving them in symposia organization, nominating them for awards, and supporting them in tenure applications.
- Postdoctoral researchers are hired either with two or more mentors, or with the freedom to work with anyone in the center.
- Workshops, seminars, lecture series, and intensive short courses are organized to educate the center participants, particularly early career researchers, in fields central to the EFRC but outside their core disciplines.