Current status of university-based energy institutes in the United States and a pathway to forming a national organization

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SUMMARY
Over the past twenty years, the number of university-based energy institutes (UBEI) that focus on supporting energy-related research has increased substantially. A recent set of surveys, the results of which we share here, show that there are over 150 active energy institutes at Ph.D.-granting universities in the United States, many of which have a significant level of internal or external financial support (and there are likely many more at 4-year colleges and other institutions of higher learning). While most of these institutes have formal or informal collaborative interactions with other institutes, there is no existing nation-wide network or organization that all institutes can interact with. As such, we have endeavored to investigate and classify the current landscape of UBEIs, with the intent of enabling the formation of a centralized organization to further support the evolution of the academic energy research movement in the U.S. After an initial review, we convened a summit-style retreat in the fall of 2019 in Pittsburgh PA that was attended by over 100 individuals representing 67 UBEIs. Multiple surveys and elicitations were conducted before, during, and after this meeting, and we present here an overview of our findings, and a summary of our proposed path forward.

INTRODUCTION
The landscape of academic energy technology and policy-focused research institutions has been viewed as varied and fragmented: It contains a range of organizations that possess different priorities, institutional positions, funding sources, and cultural dispositions. Only rarely have these organizations communicated or coordinated in large numbers with each other on a long-term basis, with the exception of some specialized, donor-funded partnerships among teams of two or three institutions. Given the number of institutes and possible promise of their collective work, it is also surprising that a lack of a large-scale organization persists, as UBEIs are anchored to academia and are among the most important vectors of education and innovation in the global energy industry. These institutes can provide thought-leadership, policy guidance, and regional-to-national collaboration while channeling students and fellows into industry and government and driving the next generation of energy and environment development in the U.S. and abroad. More impact could occur with a higher degree of efficiency if UBEIs were to organize effectively among themselves.

Mapping this institutional space is not without precedent in the academic and non-peer-reviewed literature. The most thorough and applicable pieces of which we are aware are recent reviews commissioned and conducted by the University of Texas at Austin and the University of Michigan, though both pieces focused on less than 30 institutes (Ross Strategic, 2016). Documentation on energy-related think tanks by the University of Pennsylvania has also proved worthwhile in informing our process (McGann, 2018), and a 2003 institute review for Sustainable Energy Ireland also provided a preliminary analytical framework (Greer and Morgan, 2005). We have found that surveys of institutions in a specific academic space are not uncommon, although the cross section of organizations studied here is largely unexplored. The simplest of these surveys involves assembling the resumes of a selection of institutions, without significant comparison or qualification, while other studies extended further and did offer some sort of guidance without being comprehensive, though none followed up with recommendations for a path forward (Goto and Intarakumnerd, 2016).
As individual energy institutes grow and flourish around the country, it is natural for them to seek broader networking options and to identify themselves as a member of a group of similar institutions to gain strength, support, and have amplified impact where there is common ground. Before we engaged in this effort, there was no existing infrastructure in place aimed at connecting and interacting with UBEIs. While there are some federal-level organizations such as the Department of Energy (and ARPA-E), these have a programmatic mission to fund and otherwise support energy research, and they do not have a function aimed at interfacing and connecting energy-related institutes at universities.

The assessment we present here shows that there is strong opportunity to create a new national network of institutes in the United States. Many of these have a track record of working quickly and efficiently to produce relevant and timely information in a constantly changing world. The ability to share research, connect researchers, educate students, and organize cooperative events could make previously siloed institutes nimbler, more impactful, and more relevant to a broader audience. We suggest that a simple network, and perhaps even a stronger centralized organization, of energy institutes, should be created and sustained. The balance of this document contains a brief synopsis of our findings as well as recommendations that are currently being acted on in finding the University Energy Institutes Collaborative.

**SUMMARY OF SURVEY AND SUMMIT FINDINGS**

The academic energy institute space has grown considerably in the past decade. As recently as 2009, energy institutes growth, which would eventually occur at a fast pace, was not apparent (Falkowski and Goodman, 2009). Our recent survey (see the Supplemental Data S1 for methodology) found that there are at least 157 university institutes supporting work aimed at solving the world’s energy technology-related challenges. The institutes are spread across 128 universities, 111 cities and towns, 45 states, and Washington D.C (Figure 1). Fifty-six institutes are anchored to universities with fewer than 20,000 students, 73 are anchored to universities with 20,000–40,000 students, and 28 are anchored to universities with over 40,000 students.

Many institutes were started with a founding gift and then sought to cultivate donor networks and/or won leveraged grants to begin operation and subsequently attract researchers. Fewer institutes accept or are funded via direct support from their host university. We suspect this setup is common because (a) institutes can fund and promote high-value work more nimbly than a university otherwise might be able to, and (b) it is likely a fact that few universities have chosen to allocate significant internal funding on energy institute development when there is the promise and in many cases the reality of external support. In some cases, these institutes are very inclusive and host a variety of fellows and external faculty who may or may not have formal ties to the university and may or may not be directly supported by the institute.

UBEI leaders were asked to rank their institute’s most important strategic focuses, and the results are shown in Figure 2. Nearly 90% of institutes identified multidisciplinary or interdisciplinary research among
their five most important strategic focuses, and slightly fewer institutes identified educating and training students, suggesting that there is significant alignment between the institutions.

The distribution of institute research focuses is shown in Figure 3; infrastructure and grids (which includes power sources) are ranked first or second by over 40% of the institutions. This shows that while many institutes are focusing on low or zero carbon energy technology, there is also a wide portfolio of emphasis on other technologies. The bottom chart in Figure 3 shows the distribution of power sources that are of ranked interest; not surprisingly, there is an emphasis on renewable/low carbon technologies.

To support their work and research, UBEIs have a range of financial backing (Figure 4); 80% have annual budgets that exceed $500,000, while the plurality (39%) of the institutes spend one to three million per year.

While there is a wide range of financial support for the institutes, conservative assumptions based on the data we have collected and analyzed suggest that, in aggregate, there is between $150M and $250M that is being expended nationally each year by theses institutes to further the cause of energy research. This significant amount of support in the energy field is worth tracking and understanding; there could be ways to operate more efficiently and/or to have more impact via collaborations on focused initiatives.

Another key area of collaboration is the potential for developing a national set of educational standards to help define the related academic fields of “Energy Science,” “Energy Technology,” or “Energy Policy,” which are offered as degrees (of various designations) by many universities. Figure 5 shows the distribution of energy-related degrees universities support.

It is surprising that nearly 70% of the host universities offer energy-related master’s degrees while just fewer than 20% offer an undergraduate major. The programs span business, engineering, management, science, systems, law, and sustainability; the educational goals vary widely, though all topically focus on energy. Additionally, there is not an accepted set of national educational standards or curricula, nor are there many, if any, Ph.D. Programs in Energy (though some exist internationally). Most institutes offered professional opportunities for students. Institutes offered internship and research positions, career placement opportunities, grant writing workshops, professional development and training, teaching assistant positions, and scholarships.

This brief overview of our findings clearly indicates that there is substantial movement in the related academic fields of “energy research and education.” The fact that this has been occurring in a distributed or local fashion across the country without a unifying organizational network is remarkable and supports the idea that there exists a strong and wide-ranging need. We now consider what forming a network might look like and the potential outcomes.
EXPLORING THE PROMISE OF A NATIONAL NETWORK

All energy institutes surveyed indicated that they would consider joining a new national-level network of UBEIs in some form. Figure 6A presents institutes’ evaluations after attending the summit of the idea of forming a network. Forty-four percent of attendees evaluated the network as an excellent idea while 42% ranked it as a good idea. In addition, 94% of stakeholders (businesses, nonprofits, government, etc.) surveyed indicated that they would consider interacting with a network in some form, such as collaboration or partnership. Figure 6B shows institute rankings of desired priorities for a national organization. Research and communication initiatives were ranked as the most important priority, while other possible efforts such as equipment sharing and support of entrepreneurial efforts were found to be of less mutual interest.

Summit participants suggested that any effective network should offer the following products (in no particular order): Providing a clearinghouse of information and best practices, research, educational material, career resources, conferences, meetings, webinars, workshops, collaborations with universities, collaborations with stakeholders, funding for research (direct or through valuable collaborations), reports on...
As shown in Figure 6B, seventy-nine percent of institutes identified research initiatives among the five most important assets, and 64% of institutes identified a website (portal for stakeholders) among the five most important assets. Institutes also ranked, among the five most important assets and in order of decreasing frequency of selection, an industry membership or consortium program, mission statement, digital repository of publications, shared resources (equipment, tools, or facilities), full-time secretariat, policy office, staff exchange, entrepreneurial support, staff roster circulated among institutes, and dedicated physical space.

In our pre-summit survey, we asked stakeholders from the private and public sectors how they would interact with a network (in this case, “stakeholder” is an outside entity that would elect to interact with the proposed network). As shown in Figure 7, Eighty-eight percent ranked participation in events hosted by a network among their five most likely interactions, and 63% identified sharing knowledge among their five most likely interactions. Furthermore, 65% of stakeholders identified more collaborations with academia among the five most important benefits they desired from a network, and 60% identified bigger impact on national policy. Stakeholders also identified the following benefits (partial list) in order of decreasing frequency of selection: More collaboration, reduced tech to market translation times, a stronger ability to engage the general public, a larger impact on state policy, more research funding, and more collaborations between institutes and government. Summit participants suggested that a network could serve as a collective voice to impact public policy for both industry and academic interests.

From an educational perspective, a network would facilitate communication and collaboration among institutes and stakeholders, offer a common core of energy-related skills and topics in higher education, and
impact energy policy. In terms of educational topics, summit participants identified business, engineering, environment, management, science, systems, law, and sustainability as key topics that could contribute to an energy-related “common core” in higher education and suggested that institutes share course resources, such as notes and syllabi, through a repository. A common core in higher energy education could comprise a range of topics, including business, economics, engineering, law, policy, and the social sciences, as well as a range of skills, including collaboration, communication, and project management. Also, professional mentoring and internships could be pooled and supported in energy education initiatives by awarding students, offering capstone courses, supporting student energy organizations, and, through a network, offering fellowships, student exchanges, and a repository of job and internship openings. Advisors and mentors could help match students with job and research opportunities.

For those interested, we offer a complete and detailed report of all findings in the supplemental information associated with this piece.

POSSIBLE CHALLENGES AND ISSUES ASSOCIATED WITH FORMING A NATIONAL ORGANIZATION

While there is a strong case for creating an energy institute organization, there also are some possible challenges and issues that should be considered and addressed as we move forward. Specifically, there is a wide range of institute size, degree of support, and ability to interact with a national organization as such; it is possible that the smaller institutes will not be able to achieve the same degree of interaction and impact within the national organization. There are also potential issues associated with any kind of consensus building or policy messaging that the proposed organization may seek to do; not all university energy institutes will have perspectives and voices that agree with any possible majority opinion. Despite these (and other possible issues), we continue to believe that forging ahead with such an organization is appropriate, and we describe our process below.

THE PATH FORWARD

There is a burgeoning national presence of energy institutes that are aligned in both interests and goals. These institutes tended to be interested in forming and participating in a national organization. This organization would be significantly different from any existing Federal entity such as the DoE as it will be focused not on programmatic funding or program development, but instead on creating connections and forging projects that are of interest to many university energy institutes. This organization will also seek to introduce member institutes (and collaborations of member institutes) to broader energy-related funding initiatives, as well as to form relationships with the Department of Energy and Department of Defense.
To this end, a volunteer group of institute leaders that emerged from the above described process has elected to move forward in forming the University Energy Institutes Collaborative by taking the following steps:

- Form a diverse and engaged steering committee to oversee planning and formation of a network. The steering committee helped develop the structure around a network meeting in fall 2020 which then resulted in agreement on a path forward.

- Create initial “light” secretariat function with at least one dedicated employee. To maintain momentum beyond a nascent network, hiring a dedicated staff member focused on network-related issues is critical. A secretariat would facilitate the network’s day-to-day operations, including administration of joint projects, event planning, communications, and website updates.

- Create an external-facing website for institutes to communicate and share information. A web portal would allow stakeholders to quickly learn about a network and form partnerships with academic experts. A portal could initially be a directory or archive that summarizes expertise areas, funding and partnership opportunities, and institute resources (e.g., laboratories) and eventually evolve into a network affiliate program.

- By way of a discussion board, repository, website, or network portal, institutes could share best practices, course materials, funding opportunity announcements, student opportunities, literature, news, and preliminary research findings and ideas. As a network develops, these forms of communication could evolve into joint projects, including reports and research proposals, and the exchange of faculty, staff, and students.

- Create a web portal for stakeholders to interact with a network. If a web portal can be created soon, it would allow stakeholders to immediately learn about the network and form partnerships with experts in areas of mutual interest. The web portal could be a directory or archive that summarizes areas of expertise, laboratories, collaborative opportunities, and institute resources. As a network evolves, the portal could become a landing site and registration page for a network affiliate program.

- Hold regular meetings among energy institutes to build consensus around a network’s vision and objectives. There could be several annual or biannual meetings among institutes to discuss and
converge on a network’s mission, vision, focuses, and funding path. These meetings could consist of smaller “breakout” meetings to focus on energy-related topics and organizational founding questions.

- Establish a set of subcommittees to address needs for the larger network. These could include governance, education, industry engagement, and the like, and would be facilitated by institute leaders on a voluntary basis.
- Conduct ongoing research on the national university energy institute movement to gauge trends, needs, and the impacts of both individual institutes as well as the network as a whole.

The nation’s university-affiliated energy institutes provide an enormous resource for training, research, and insights for decisionmakers in government and business. Working together through a network should serve to create possibilities for UBEIs and provide even more valuable inputs for society and the economy.

SUPPLEMENTAL INFORMATION
Supplemental information can be found online at https://doi.org/10.1016/j.isci.2022.104151.

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