INFUSE | Innovation Network for Fusion Energy

DOE SC FES Private/Public Partnership Program

URL: https://infuse.ornl.gov
Email: infuse@ornl.gov

INFUSE FY2025 Update

A. Lumsdaine, E. Gilson, & R. Gruener

INFUSE Update

December 3, 2024

INFUSE Overview

The mission of INFUSE is to provide private-sector fusion companies access to the expertise and facilities of DOE's national laboratories and (since FY2022) U.S. academic institutions to overcome critical scientific and technological hurdles in pursuing development of fusion energy.

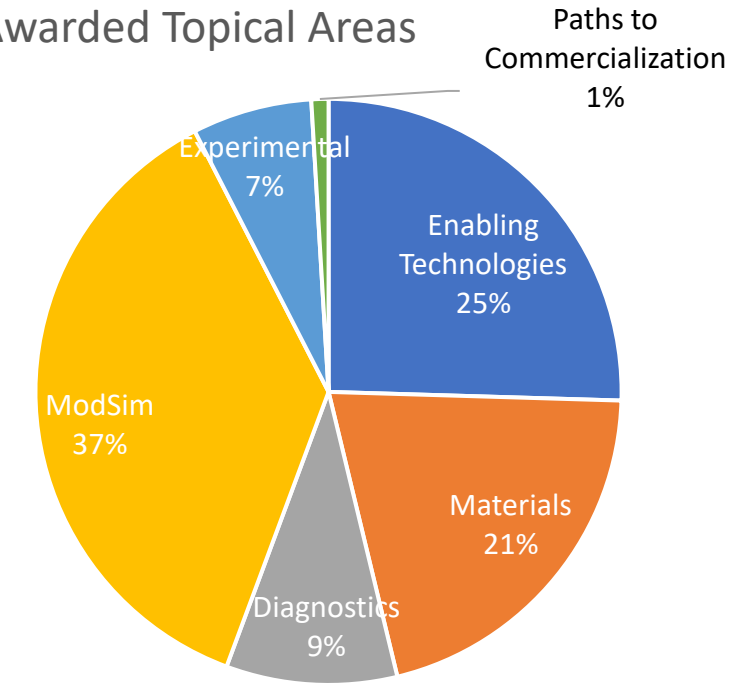
AWARDS

- **106** projects funded since 2019 with a total value of **$23.4M**
- Awards were made to **32** private companies partnering with **10** DOE labs and **12** U.S. Universities.
- Detailed list: https://infuse.ornl.gov/awards-and-statistics/

PARTICIPATING LABORATORIES

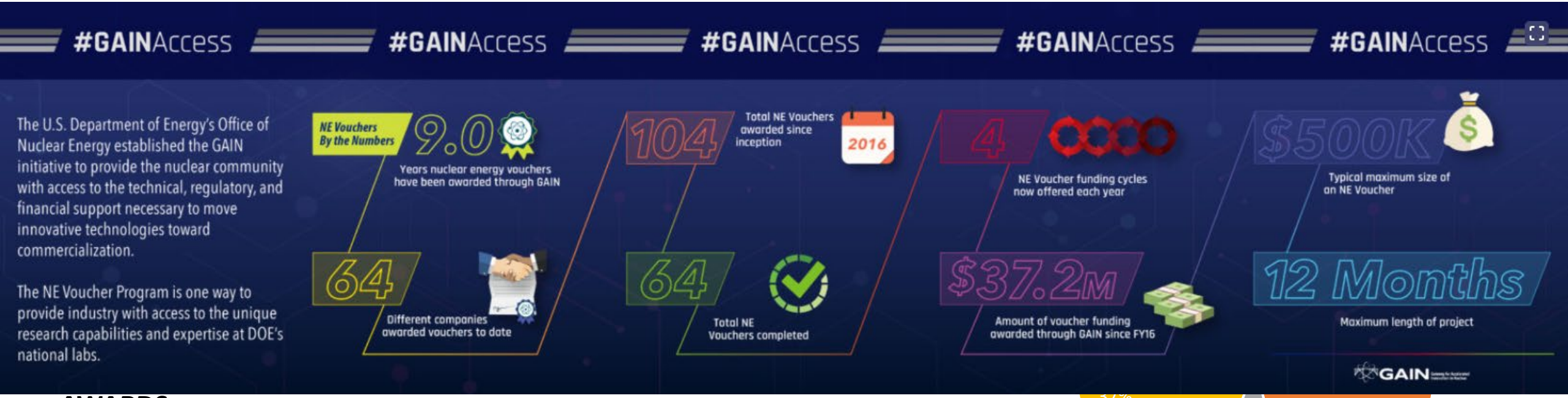
INL Idaho National Laboratory
BROOKHAVEN NATIONAL LABORATORY
BERKELEY LAB Lawrence Berkeley National Laboratory
LAWRENCE LIVERMORE NATIONAL LABORATORY
OAK RIDGE National Laboratory
Pacific Northwest NATIONAL LABORATORY
PPPL PRINCETON PLASMA PHYSICS LABORATORY
Sandia National Laboratories
Savannah River National Laboratory
Los Alamos NATIONAL LABORATORY
Fermilab

Awarded Topical Areas



TOPICAL AREAS

1) Enabling Technologies
2) Materials Science
3) Plasma Diagnostics
4) Modeling and Simulation
5) Unique Fusion Experimental Capabilities
6) Paths to Commercialization



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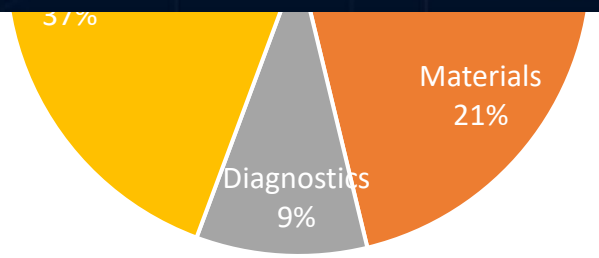


TOPICAL AREAS

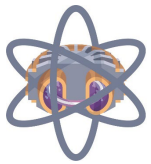
1) Enabling Technologies
2) Materials Science
3) Plasma Diagnostics
4) Modeling and Simulation
5) Unique Fusion Experimental Capabilities
6) Paths to Commercialization

INFUSE Web Site

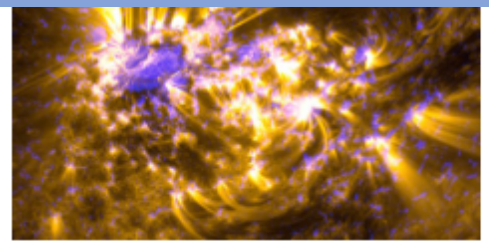
https://infuse.ornl.gov/

Any issues?

Email infuse@ornl.gov



INFUSE Web Site – Subscribe



The INFUSE program will accelerate fusion energy development in the private sector by reducing impediments to collaboration involving the expertise and unique resources available at DOE laboratories and universities. This will ensure the nation's energy, environmental and security needs by resolving technical, cost, and safety issues for industry.

Read more

INFUSE News

FY2025 RFA Call Has Been Posted
Published: November 8, 2024

Read article

DOE Job Opportunity – Program Manager for QIS and Emergent Confinement Concepts
Published: October 9, 2024

View article on content.govdelivery.com

FY2025 Virtual Workshop on Nov. 14, 2024. Draft Agenda Posted.
Published: October 1, 2024

View article on infuse.ornl.gov

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http://eepurl.com/iBeZiM

INFUSE Innovation Network for Fusion Energy

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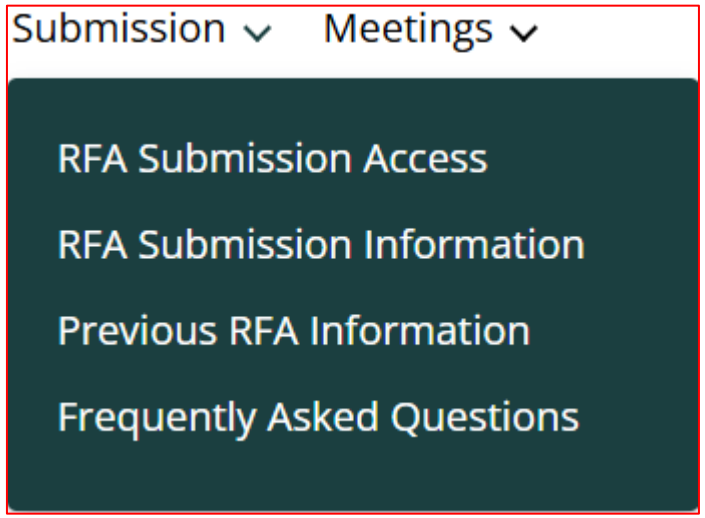
INFUSE Web Site – Submission



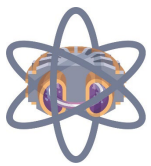
- **RFA Submission Access** – Need to start here if submitting an application
- **RFA Submission Information** – RFA call, documents and templates
- **Frequently Asked Questions** – take a look! It has been updated and reorganized. It will continue to be updated as questions come up.

INFUSE News

INFUSE Schedule

- FY2025
  - Nov. 8, 2024 RFA posted
  - Nov. 14, 2024 Virtual workshop
  - Nov. 14, 2024 RFA submission opened
  - **Jan. 17, 2025 RFA submissions closed (5:00pm EST)**
  - June 2025 Award Announcement Expected
  - Sep. 1, 2025 Work Start Date

For more details, see the slides on the FY2025 RFA presented at the FY2025 Virtual Workshop on November 14, 2024: https://infuse.ornl.gov/fy2025-workshop/



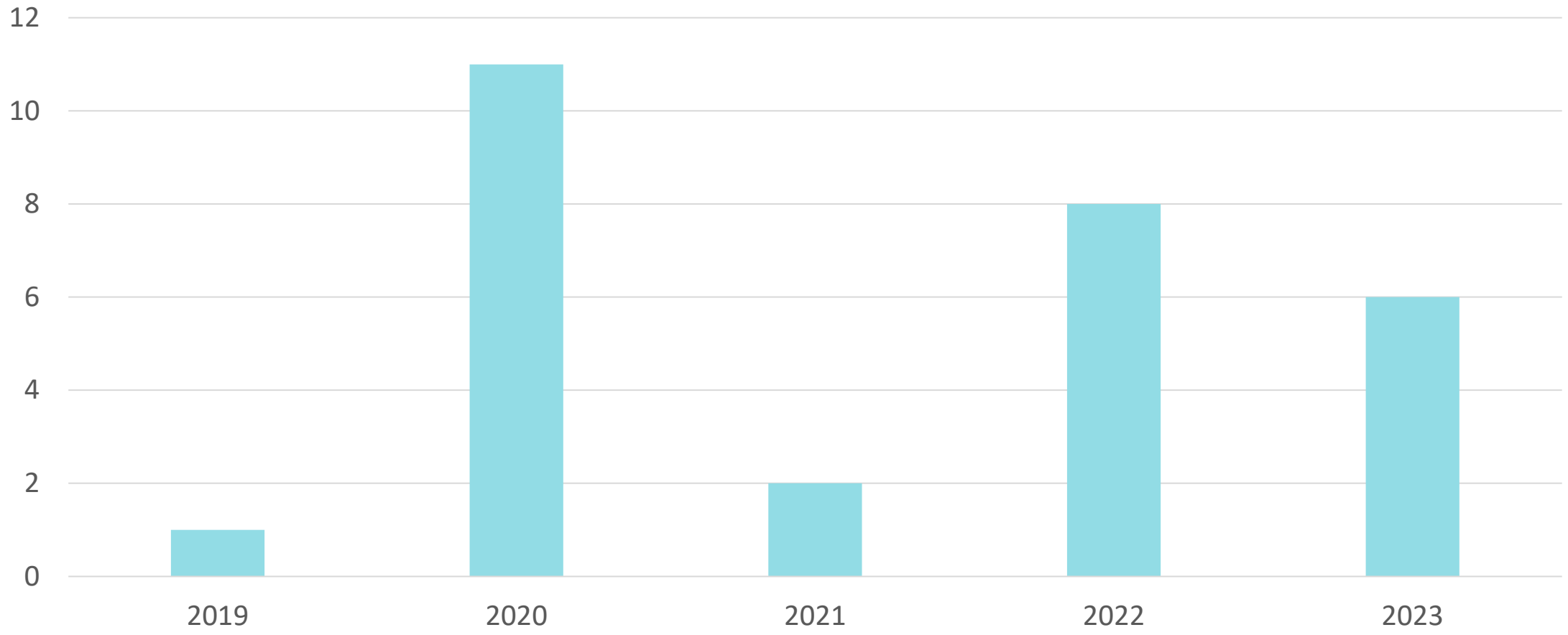
INFUSE Survey Results

Rebecca Gruener, PhD

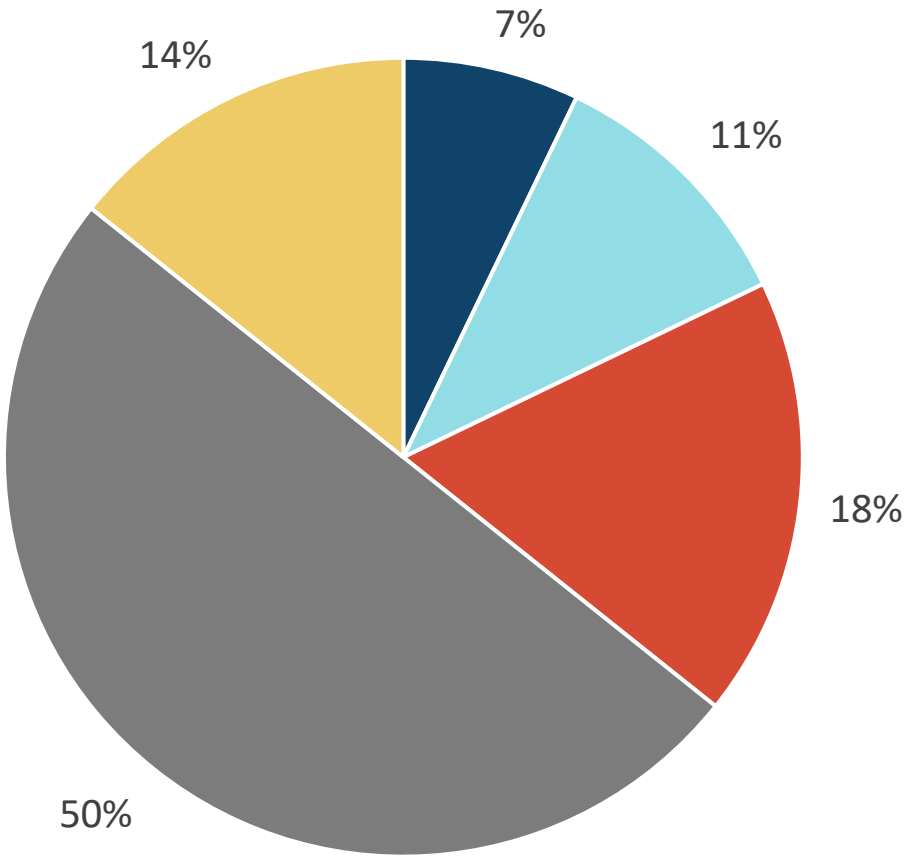
U.S. DEPARTMENT OF ENERGY | Office of Science

Energy.gov/science

28 companies responded to the INFUSE Outcomes Survey (mostly from 2020 and 2022)



The majority of the survey respondents worked on projects in the modeling topic area



More than 50% of business and technical goals were accomplished across all topic areas

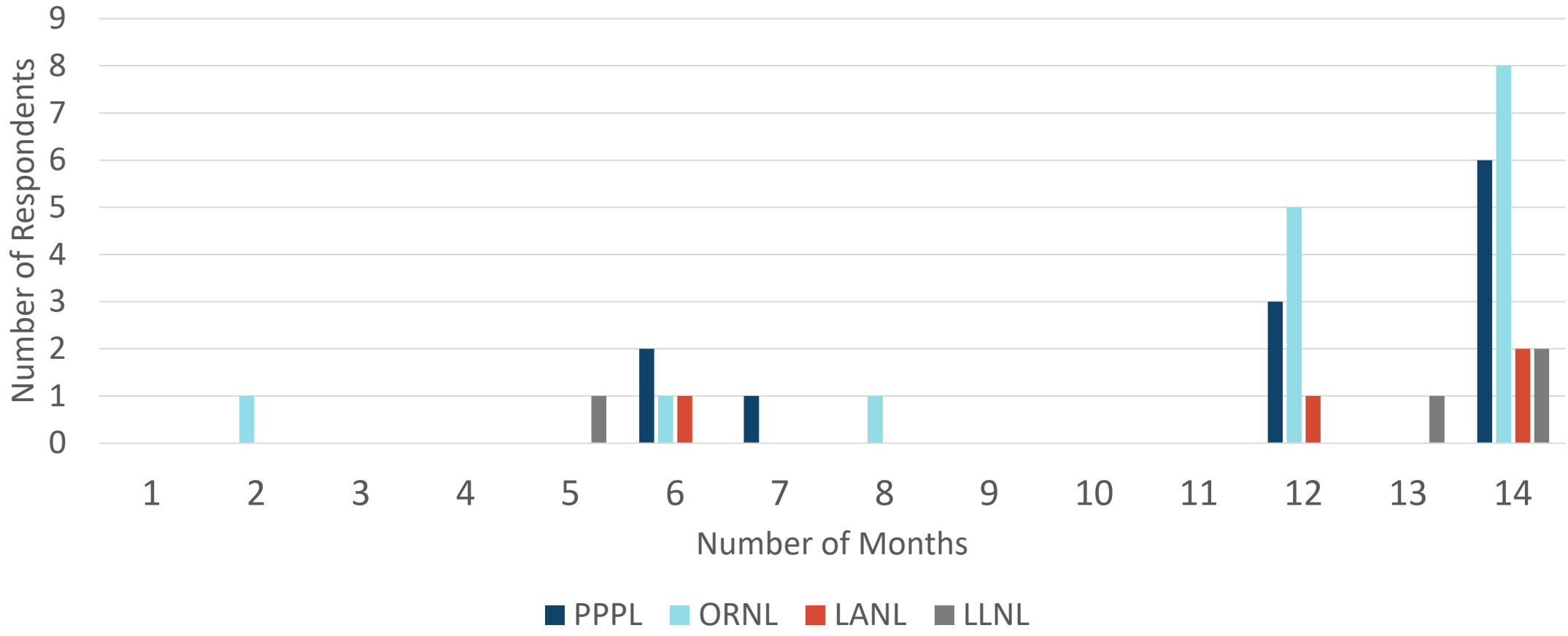
Topic Area (number of responders)	Business Goals Completed (avg %)	Technical Goals Completed (avg %)
Magnetic fusion experimental capabilities (3)	90	95
Enabling technologies including new and improved magnets (2)	88	88
Materials science including engineered materials, testing, and qualification (5)	83	77
Modeling and simulation, high-performance computing, codes, and methods (14)	73	67
Plasma diagnostic development (4)	53	52

Suggestions for improvement

Decrease time to CRADA approval

Allow for larger teams with subcontractors and multiple labs

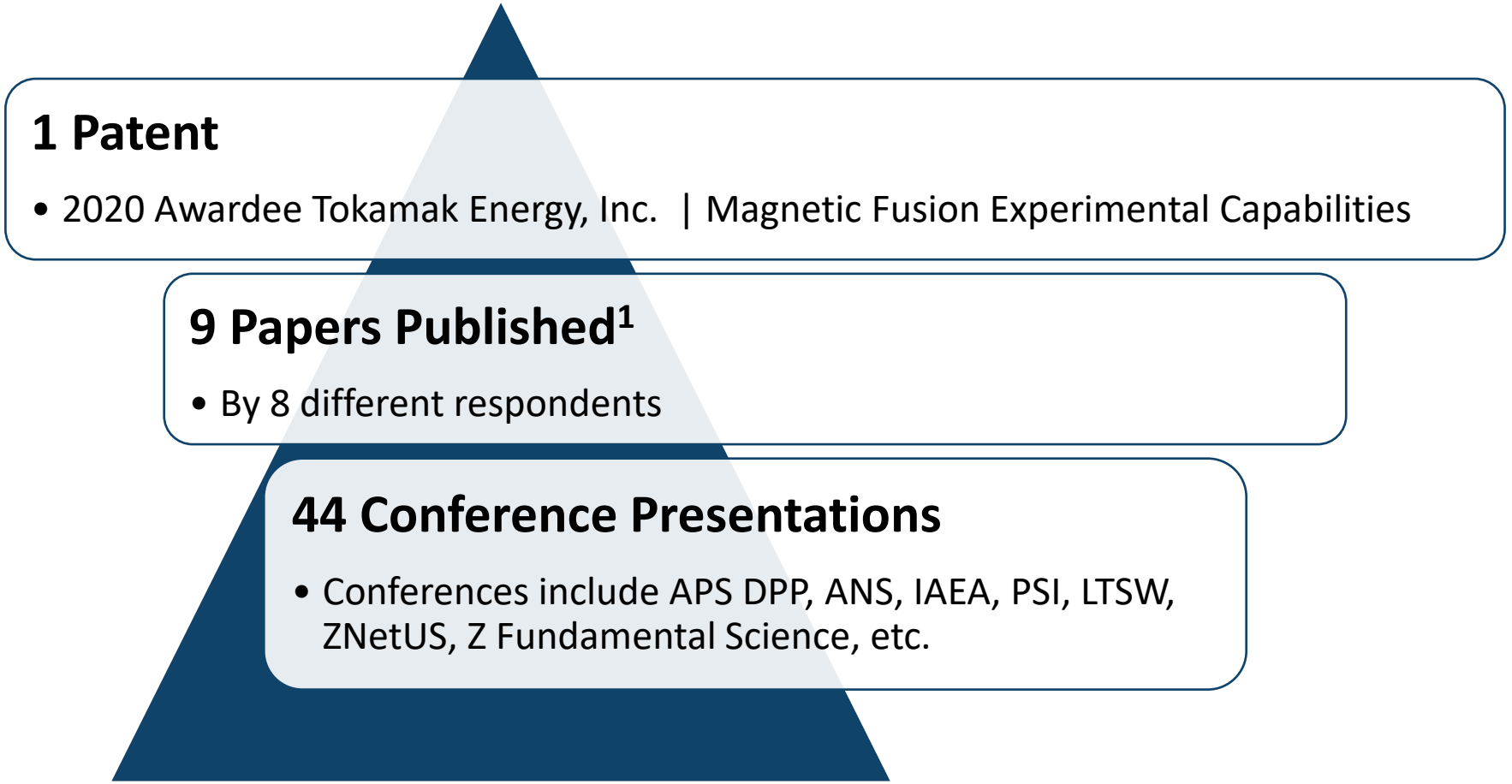
The majority of CRADAs delay projects by ~1 year across all participating labs



8 responders reported unanticipated achievements from their award, including:

Simulation	Improved TriForce making it a primary simulation and design tool for HB11 Energy USA LTD
Energy Transfer	Discovered a new compressional mode which led to further detailed studies of wave mediated transfer of energy
Manufacturing	Demonstrated resiliency of a W-W FAST-bonded interface under high heat flux with no observable delamination or other damage

Respondents report measurable success from their awards

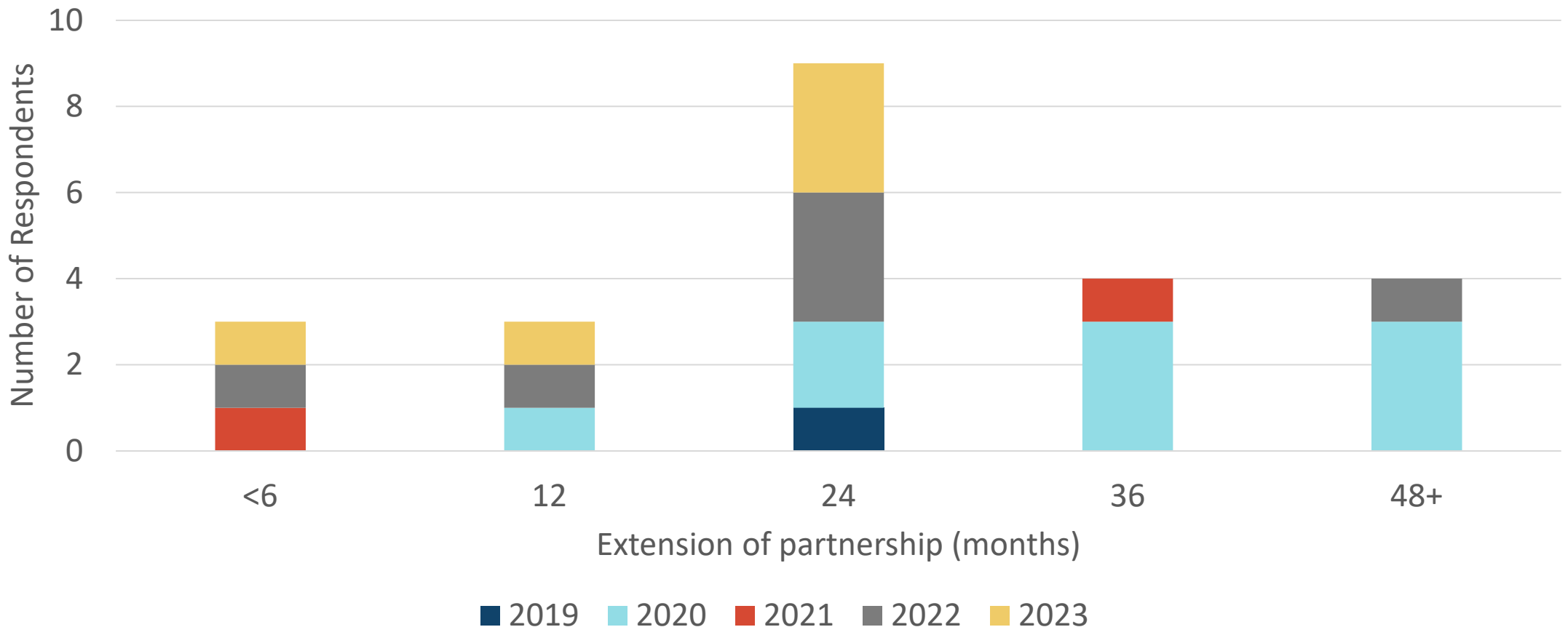


*Note LLNL's average was brought down by one project that did not start due to a CRADA delay, the second project at LLNL completed 90% of their business goals

Self reported impact of the INFUSE award

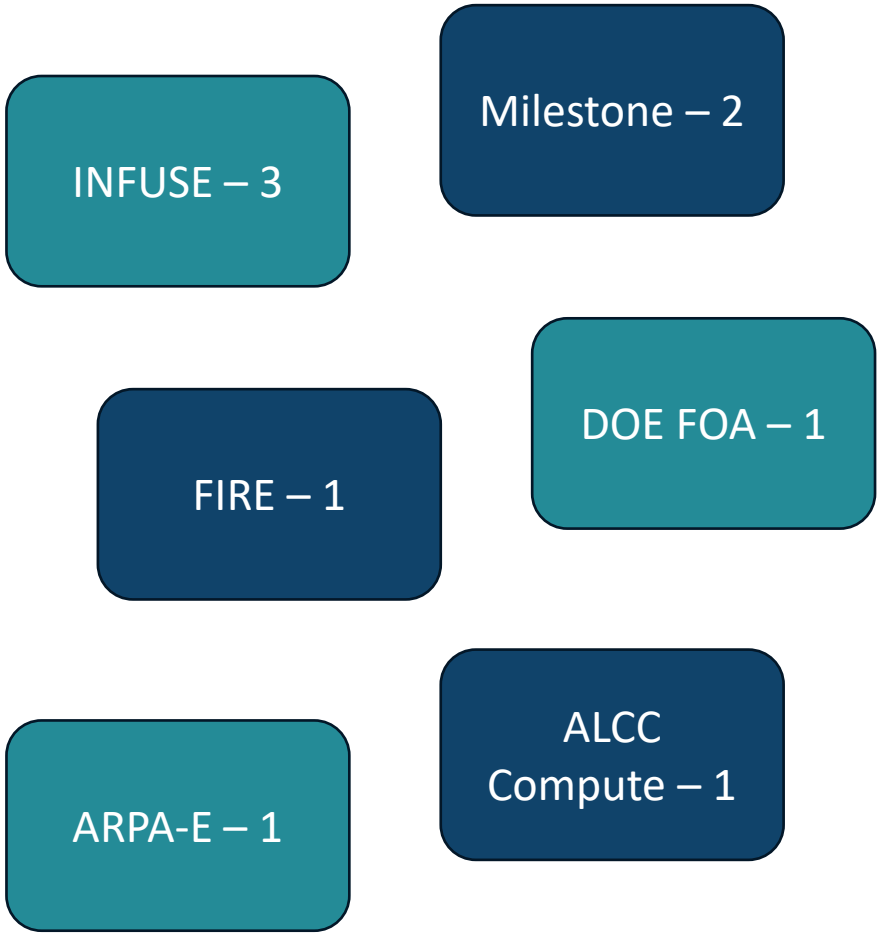
- Increased **credibility**
  - Independent modeling of the Staged Z-pinch concept confirmed its potential as a fusion energy source
  - Company recruitment aided
  - Company visibility and access to investors increased
- Allowed **access**
  - Unique measurement capabilities at the National Lab partners
  - Expert assistance at National Labs
- Accessed **resources**
  - Bi-2212 HTS wire for making a cable
  - Equipment for testing performance of REBCO wires which they did not have the capabilities to do in house
- Generated **confidence**
  - That learnings about confinement and turbulence in SPARC will predict ARC
  - In low-fidelity models and pointed to areas of improvement of the design of equilibrium facility
  - In evaluation of error field physics as an input for design work
- Hastened **progress**
  - Generated insight on the effects of material composition and manufacturing steps on material performance
  - Shed light on potential instabilities caused by Neutral Beam Injection
  - Created assessment of the divertor region in ST40

Almost 80% of respondents extended their partnership following the end of their award



Awardees have sought additional funding to maintain their partnerships

- 57% of respondents reported having applied to additional funding
- 5 respondents report being awarded additional funding
  - Some from multiple sources



INFUSE FY2025 Townhall Meeting Surveys

Several live surveys were performed during the FY2025 INFUSE Virtual Workshop on November 14, 2024.

INFUSE award process survey:

- **What is the optimal award size?**
- **How would you rate the INFUSE application process?**
- **How transformative was receiving an INFUSE award for your company?**
- **What do you believe is the best metric of impact an award has had on your organization?**

For more details, see the slides on the FY2025 RFA presented at the FY2025 Virtual Workshop on November 14, 2024: https://infuse.ornl.gov/fy2025-workshop/

1. What type of organization to you represent?

More Details

Private company	16
National laboratory	6
University	2
Other	1

2. Have you already received an INFUSE award?

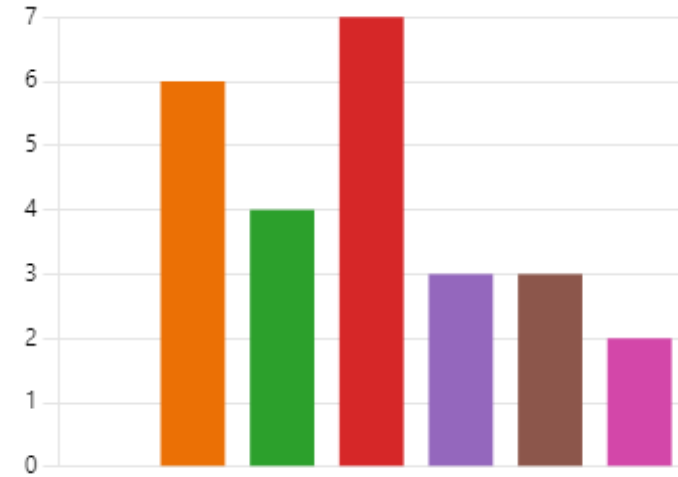
More Details

Yes	11
No	14

3. What do you believe is the optimal award size?

More Details

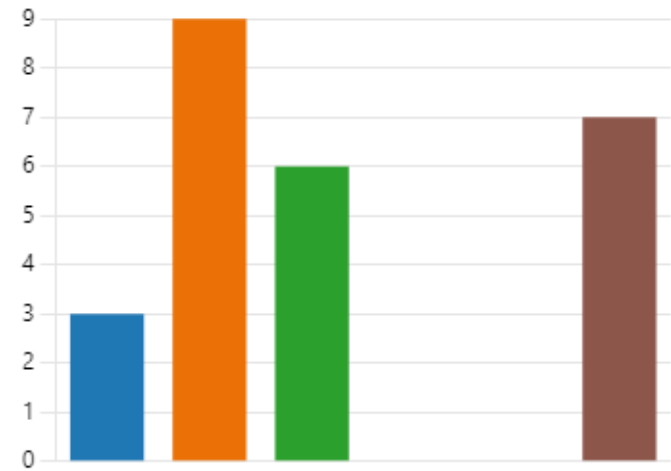
$100k	0
$250k	6
$375k	4
$500k	7
$750k	3
$1,000k	3
No limit	2



4. How would you rate the INFUSE application process

More Details

Very accessible	3
Accessible	9
Neutral	6
Inaccessible	0
Very inaccessible	0
Don't know / haven't submitted ...	7



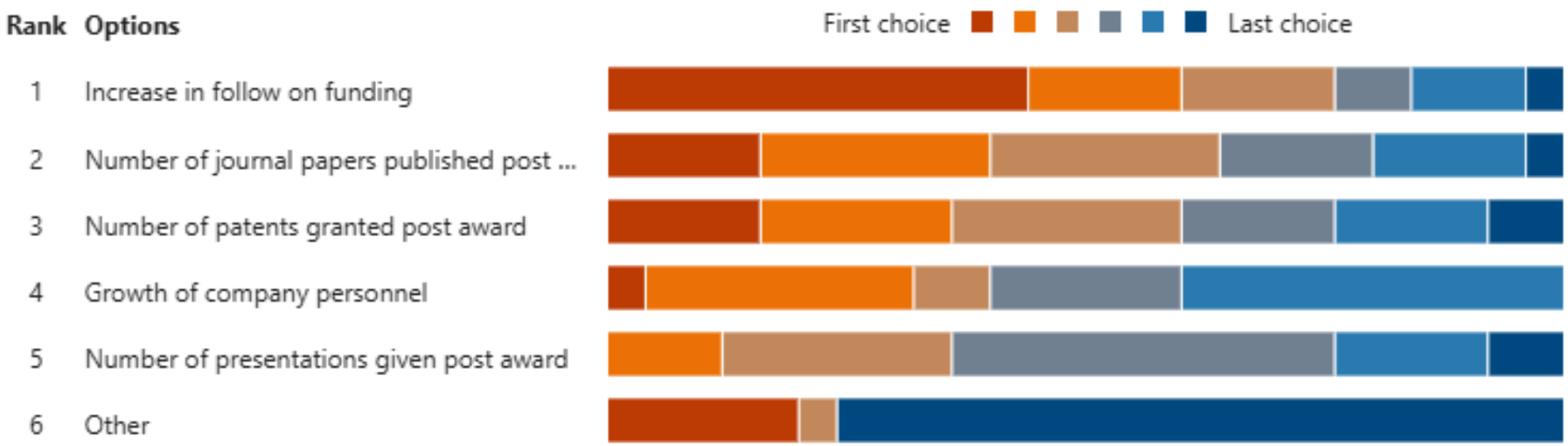
5. How transformative was receiving an INFUSE award for your company?

More Details

Very transformative	2
Transformative	10
Slightly transformative	1
Neutral	1
N/A - I have not yet received an...	11

6. What do you believe is the best metric of impact an award has had on your organization (please rank)?

25 Responses



CRADA process survey

- **If you have received an award, which of the following caused delays in your CRADA approval?**
  - **There was no delay**
  - **Lab PI was unfamiliar with the CRADA process**
  - **Lab sponsored project office had delays**
  - **Company needed to negotiate the CRADA**
  - **Lab DOE site office had delays**
  - **Delays in DOE foreign influence review**
  - **Not sure / don't know**
  - **Other (please specify)**

1. What type of organization to you represent?

More Details

Private company	14
National laboratory	4
University	1
Other	0

2. Have you already received an INFUSE award?

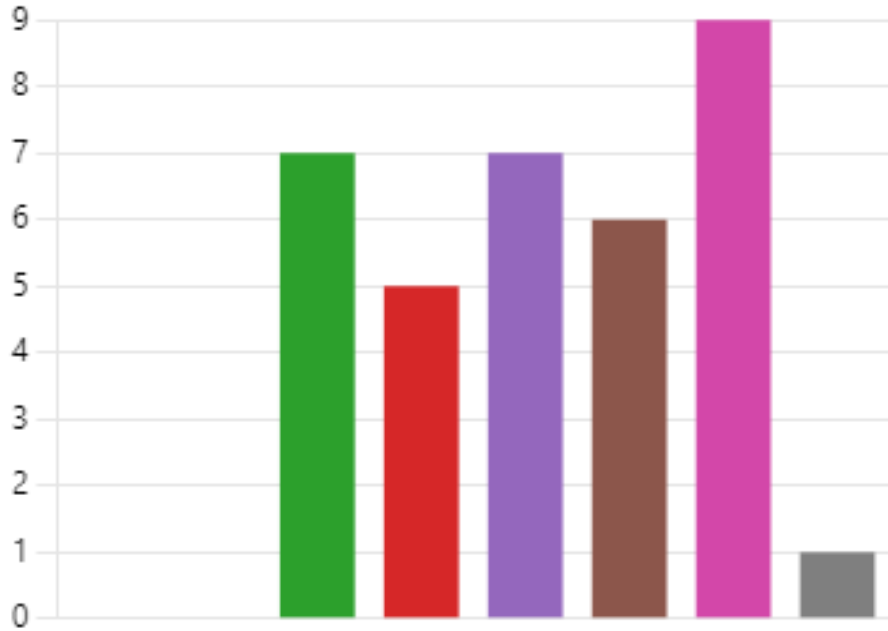
More Details

Yes	15
No	4

3. If you have received an award, which of the following caused delays in your CRADA approval?

More Details

There was no delay	0
Lab PI was unfamiliar with the C...	0
Lab sponsored project office ha...	7
Company needed to negotiate t...	5
DOE site office for the lab had d...	7
Delays in DOE foreign influence ...	6
Not sure / don't know	9
Other	1



Partnerships

- Have you participated in an INUFSE application?
- How did you find your partner?
- Was your project funded?
- For your partnership, who initiated the first contact?
- How can future partnerships be fostered?
  - ❑ Database of capabilities on website
  - ❑ Monthly webinars with presentations of capabilities
  - ❑ Site visits to national labs
  - ❑ Site visits to universities
  - ❑ University fusion fair
  - ❑ Meet and greet at national conference(s)
  - ❑ Online "matchmaking" service
  - ❑ Other

1. What type of organization to you represent?

More Details

Private company	21
National laboratory	5
University	3
Other	0

2. Have you participated in the submission of an INFUSE application?

More Details

Yes	16
No	13

3. How did you find your partner?

More Details

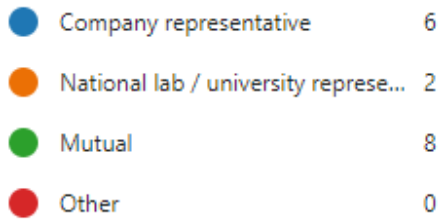
Prior working relationship (work...	5
Professional relationship (i.e. me...	11
Had familiarity with work, but di...	0
Didn't know at all, but had a ne...	0
Other	0

4. Was your project funded?

More Details

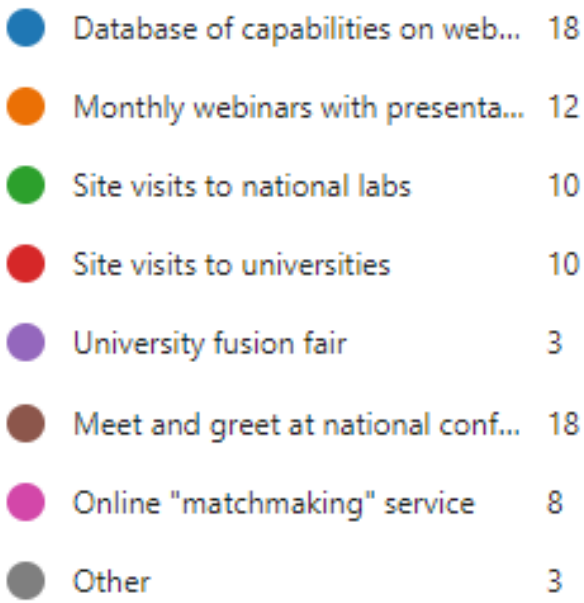
5. For your project, who initiated the first contact?

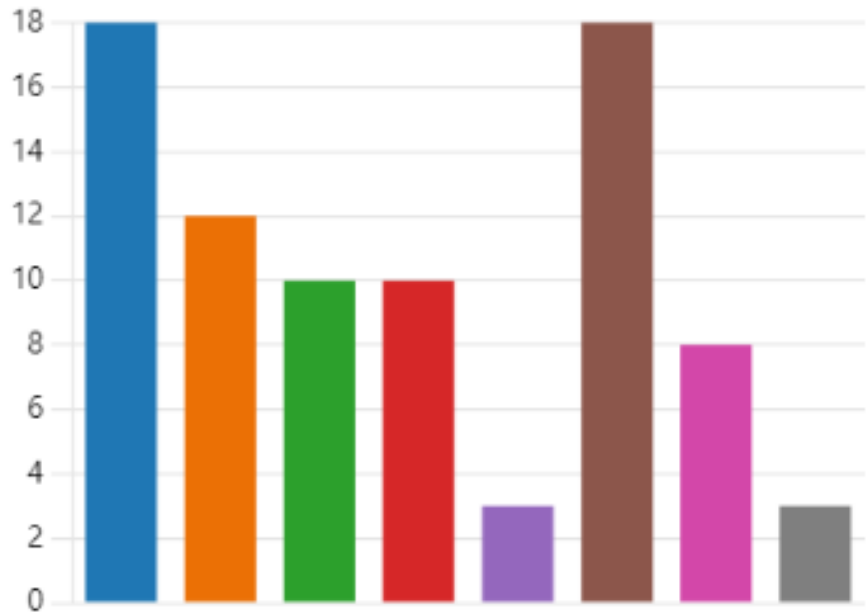
More Details



6. How can future partnerships be fostered (choose up to 3)?

More Details





Annual Workshop – FY2026

- **The FY2026 workshop has been scheduled for Nov. 6-7, 2025 at Oak Ridge National Laboratory.**
  - **Note that the International Symposium of Fusion Nuclear Technology ISFNT-16 meeting will take place from Nov. 9-14, 2025 (https://isfnt-16.ornl.gov/)**

Testimonials

"As a result [of our INFUSE project], the pulsed-power academic community is embracing FLASH as their go-to simulation code for Z-pinch modeling."

- Dr. Petros Tzeferacos, University of Rochester

The results of our INFUSE project led us to successfully raise private funding ($2.4M pre-seed end of 2021) to build ÉCLAIR, our next fusion device.

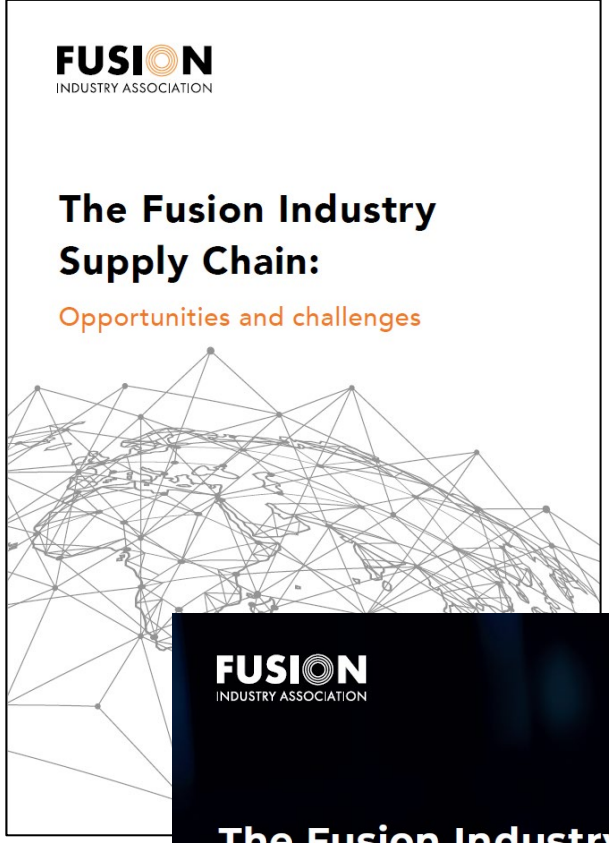
- Simulation of Plectoneme Formation Summary, Helicity Space

Why discuss supply chain challenges?

- "A fusion pilot plant design effort should begin immediately to develop cost-attractive fusion solutions on the fastest time scale possible." (FESAC Long Range Plan)
- Deployment of fusion energy on a decadal timescale will be limited not only by science and technology gaps, but also by the industrial capability to supply needed materials and components.
- This is true not only of complex technologies that are unique to fusion, but also of conventional technologies that will need to be produced at scale.

FIA 2024 Supply Chain Report

- "2023 saw a growth in reported supply chain spend. The reported figure of $484,900,000 in 2022 grew to $612,184,500 in 2023. This is a significant undercount since not all companies provided spending data."
- "Fusion companies reported plans to spend 21% more on their supply chain in 2024 vs 2023."
- "A variety of critical components were highlighted as having current or future supply risks, including cryogenic devices, HTS wire, power electronics, and vacuum chambers."
- "Greater long term certainty around financing and policy is still needed to give the supply chain confidence to scale up to meet future needs of the fusion industry."



https://www.fusionindustryassociation.org/fusion-industry-reports/

Path to development of commercial industry

Proof-of-principle to pilot demonstration

Pilot demonstration to commercial industry

OAK RIDGE National Laboratory

Path to commercial power

Proof of Principle	Pilot Plant	Commercial Power
"Kitty Hawk"	"Spirit of St. Louis"	"DC-7"
Q>1	Integrated fusion and electric power performance	Economically viable
Proof of Critical Technologies	(pre) first of a kind	N^{th} of a Kind

Taxonomy of supply chain needs

1. Technologies that have not been developed yet (still needed for proof of principle)
   - Steady-state, high frequency gyrotrons
   - Breeding blanket
2. Technologies that are existing but need modifications for fusion power application (needed for pilot plant)
   - Vacuum pumps
   - Rad hard electronics
3. Technologies or materials that are existing but need massive scale-up for a commercial fusion industry (needed for N^{th} of a kind reactor)
   - Tritium, lithium, helium, RAFM steel, etc.

TechConnect World symposium

- A special symposium on "Supply Chain Challenges for the Commercialization of Fusion Energy" was held at the TechConnect World Innovation Conference & Expo in Washington, DC from June 17-19.
  - Organized by Amelia Campbell (US ITER), Jaydeep Deshpande (CFS), and Arnold Lumsdaine (ORNL).
- The purpose of the symposium was to "present the current state of the fusion supply chain, lessons learned from exiting facilities, a look ahead to what is needed, and a consideration of what is needed to fill the gap."

https://www.techconnectworld.com/World2024/sym/Materials_Innovation_for_Commercialization_of_Fusion_Energy.html

Symposium takeaways (one person's opinion . . .)

- From suppliers:
  - Unanimously expressed that an in-person event was important to be a part of the conversation on development and supply chain needs.
  - Unanimously express that they would like to have more information, global view from the "customers," whether public or private sector.
  - Some said that it was not so much about funding as information / education to learn about needs, market sizes, etc.
- From developers / projects:
  - It is important to have multiple qualified vendors.
  - Off the shelf purchases are much preferred.
  - Rigorous testing (which takes time) is critical for new technologies.
  - Make vs. buy decisions have lots of trade-offs (vertical integration desired, not possible).
- From panel:
  - Need to take advantage of existing supply chains (ITER, other fusion projects).
  - International participation is critical.

Closing thought

- From FIA 2024 supply chain report
  - ". . . new production capabilities can take 1–3 years, and most suppliers will not invest until they have firm commitments or investments. If fusion players cannot make long-term financial commitments, then investors and/or governments will need to provide some security to enable this accelerated rate of expansion."
  - "Public investment in activities that facilitate commercialization, such as research and development, infrastructure, and regulatory support are crucial."

Questions?