FUSION
INDUSTRY ASSOCIATION

The Fusion Industry Supply Chain:

Opportunities and challenges

Key findings of this report

- Fusion developers spent over $500m on their supply chain in 2022.
- Spending by fusion developers is set to grow to over $7bn by the time they build their “First of a Kind” power plant, and potentially trillions in a mature fusion industry (timescales for this range from 2035-2050).
- While most of the materials and components for commercial fusion power plants will be met through already existing supply chains (concrete, steel, power electronics, etc.), there are a limited set of supply chain needs that are unique to the fusion industry. These are mostly specialized manufactured components, such as high-powered magnets, laser components, heat management technologies, advanced materials, high powered semiconductors, and fusion fuel. Needs also include specialist contractors to help make parts, as well as legal services.
- Longer term needs could include Engineering, Procurement and Construction (EPC) firms to support the transition from fusion technology into the factories and power plants that will scale-up into a fusion industry.
- Currently, advanced fusion developers around the world source most parts locally, but all rely on global suppliers.
- A majority of fusion developers felt supply chain requirements could be met by existing suppliers, but they would need to scale up significantly to meet future demands, some as soon as 1-2 years (though timescales vary significantly).
- New innovative suppliers that address challenges in new ways or with greater efficiency will be important.
- The biggest challenge is balancing supplier scale with risk. Fusion companies need suppliers to scale ahead of demand, but suppliers are reluctant to do so without commitments or clarity, which fusion companies still struggle to give long-term.
- Contrary to widespread belief outside the industry, there was limited concern about geopolitical supply risk. No critical parts or materials face insufficient global supply or come solely from unstable countries. Where such risks exist, it is considered manageable with foresight and planning.
- Recommendations arising from our surveys and interviews – which are explored in more detail within this report – include:
  - o Increase investment, both public and private, into fusion to give confidence about the necessity of supplier scale.
  - o Experiment with risk-sharing financing to enable suppliers to invest in new capacity now.
  - o Create online networks and an annual supplier event, to help communication and awareness between fusion companies and suppliers.
  - o Deploy standardisation and regulation to bring more certainly to the supply chain and confidence to make long-term investments.

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INTRODUCTION

The promise of fusion energy is striking; unlimited amounts of clean, safe, sustainable energy. The challenge is also great, with scientific efforts over six decades focusing on how to prove that more energy can be produced than it takes to start the reaction. In 2023, that hurdle was finally passed, and, along with a raft of other breakthroughs, scientists, governments, and industry are becoming convinced that fusion energy is poised to move from the lab to the marketplace.

The member companies of the private fusion energy industry, represented by the Fusion Industry Association (FIA), are leading this move. The industry's plans in the next decade are first to build the "proof-of-concept" experiments and then to scale up to demonstration pilot plants. In the long term, industry will rely on mass manufacturing to produce fusion machines cost-effectively at scale; deployed rapidly into grid connections around the world.

But, transitioning from scientific experiments and demonstration machines into a major global infrastructure industry requires planning and foresight. Furthermore, the technological diversity of fusion approaches means that this process must be managed in multiple different technological approaches at the same time.

The companies commercializing any fusion technology will need a breadth of highly specialized and precision manufactured components, whether high-powered magnets or lasers, power electronics and semiconductors, ultra-efficient heat management technologies, or materials that can withstand the extreme conditions in a fusion vessel. And, they will need the fuel that powers the reaction.

Fusion companies will also need a skilled workforce to create and assemble these parts – which will mean a greater demand for specialist engineering suppliers and recruitment into the industry. Needs will increase across all job titles, but industry should see a gradual shift in proportionate needs from scientists to engineers and operators. Ultimately, they could also need large Engineering, Procurement and Construction Firms to understand how to build their technologies into functioning power plants.

In short, a primary challenge facing the companies commercializing fusion technology is building a supply chain. That is why, in late 2022 and early 2023, the Fusion Industry Association surveyed its members and affiliate members to determine what the current state of the fusion supply chain is, the opportunities the growing supply chain presents for firms, and what the challenges to scaling are. The results of this survey are detailed in the following report.

THE NEED FOR A FUSION ENERGY SUPPLY CHAIN

A supply chain is a representation of the challenge of scale. For the most part, the fusion industry agrees the capabilities exist to build the fusion power systems of this decade, even as significant engineering, materials, and technology hurdles remain to get to cost-competitive and reliable power plants. Today's construction needs, and even the design of pilot plants, will rely on a small workforce and a few specialist firms. But, in the next decade and beyond, moving to mass-scale, low-cost production and assembly of fusion power plants will require investment from suppliers in new facilities and will need new companies to enter the supply chain.

Once the technologies are ready, industry will want to deploy fusion as fast as possible. If industry can produce it at scale, and at a cost customers are willing to pay, this new zero-carbon power source should become in high demand around the world.

The growth projections that this survey implies are staggering. We've seen that Bloomberg projects the fusion industry to be valued at $40 trillion[1]. New data presented in this report suggests that the ultimate value of fusion supply chain spending could also be in the trillions by the time the industry is fully mature. According to our survey, in 2022 alone, fusion companies spent over $500 million, and they project increases in supply chain spending of 200-1000% by the time they have an operational 'first of a kind' facility.

Exponential growth like this represents a significant business opportunity for existing fusion suppliers, new suppliers, and many other companies – from component suppliers, to engineering contractors, to professional service providers – that could join the industry.

The survey also shows that there is an appetite from suppliers to meet this scale by investing today. But their challenge is knowing when and where to invest; and some report they are unable to raise the needed capital to invest in capacity building before technologies are proven.

We risk a 'chicken and egg' scenario. To ensure fusion can scale, it will need suppliers to start building capacity and capability now. But suppliers and their investors are uncertain of when fusion will be ready. So, which comes first: the chicken (industry), or the egg (the supply chain)? To solve this, we suggest that there needs to be defined partnerships, with clear direction setting along with risk-sharing mechanisms.

This report discusses the scale and nature of the opportunity, then looks at some specific activities that could deliver a fusion industry which works for both sides of the supply chain. It also notes that the fusion supply chain is not solely a business challenge; for an industry that could be as important as fusion, geopolitics will also play a role. Developing it in a way that maximizes efficiency while responding to governmental and societal interests will be important.

1 Dennis, Michael, "Nuclear fusion market could achieve a $40 trillion valuation" Bloomberg Intelligence December 28, 2021 https://www.bloomberg.com/professional/blog/nuclear-fusion-market-could-achieve-a-40-trillion-valuation/

SECTION 1:

The view from the fusion industry

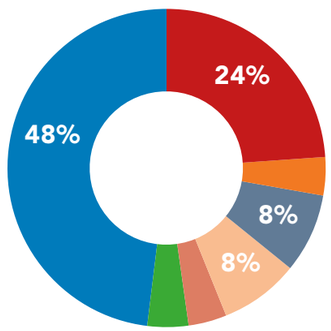
The FIA asked its member companies to share their current supply chain structure and assumed future needs, as well as their views on the challenges.

The results below are derived from 26 responses from private fusion companies including the world's most highly funded and advanced companies (see list), though not all answered all questions.

In this section, we provide a snapshot of the industry, its supply chain needs and how it expects it to evolve.

CHART 1:

Breakdown of respondents by approach



- Magnetic confinement
- Magneto-inertial
- Electostatic confinement
- Inertial confinement
- Non-thermal laser fusion
- Muon-catalized fusion
- Hybrid magnetic/electrostatic confinement
- Fusion systems technologies (microwave heating, blankets, exhaust, tritium management, energy conversion)

The Fusion companies responding to our survey

Avalanche Energy
Commonwealth Fusion Systems
CTFusion
Electric Fusion Systems
EX-Fusion
First Light Fusion
General Fusion
HB11 Energy
Helical Fusion
HelicitySpace
Helion Energy
Horne Technologies
HyperJet Fusion
Kyoto Fusioneering
LPPFusion
Magneto-Inertial Fusion Technology (MIFTI)
Marvel Fusion
NearStar Fusion
NT-Tao
Princeton Fusion Systems
Princeton Stellarators
Realta Fusion
Renaissance Fusion
TAE Technologies
Tokamak Energy
Zap Energy

THE CURRENT SUPPLY CHAIN

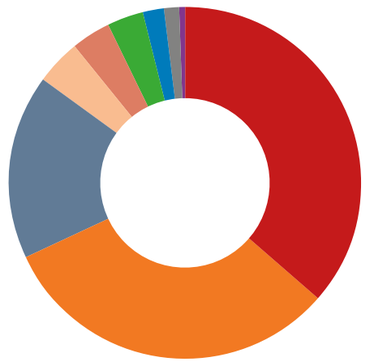
18 of the 26 responding companies provided their 2022 supply chain expenditure, with a total reported spend of $484,900,000.

This number is an underestimate. Some companies did not respond, and the survey does not include publicly funded fusion projects (at National Labs, Universities, or International Consortia) which also have extensive supply chain spending. Even with highly conservative estimates for those that did not respond, we can estimate that 2022 fusion supply chain spending was well over $500 million.

We also broke this down by areas of spend to understand where the money was flowing (see Chart 2). High end specialized components and engineering work formed the bulk of the spend, followed by raw materials.

CHART 2:

Declared annual spending on supply chain by fusion companies



- Specialized components - non-fusion specific (e.g. vacuum pumps) **$176,490,000**
- Raw materials **$154,345,000**
- Contract engineering **$82,650,000**
- Specialized components - fusion specific (e.g. magnets, lasers) **$19,665,000**
- Commodity 'off-the-shelf' components **$18,085,000**
- Software **$16,085,000**
- Professional services **$9,475,000**
- Contract construction **$6,255,000**
- Fuel **$1,870,000**

Question: *As a percentage, approximately how do the following make up your current supply chain spend?*

Calculation: *Percentages provided by each company were multiplied by their total supply chain spend to provide figures for each category, which were then added up to reach the totals.*

Looking ahead, we asked companies to project their future supply chain spend as they build their proof-of concept machines and scale-up to pilot plants.

By the time of a First of a Kind (FOAK) operating facility, companies who responded estimated their annual supplier spend to rise to over $7bn.

These projections come with some caveats. On one hand, these numbers reflect just those who answered, which represents around half of private fusion companies, though it includes today's big players. That means figures underrepresent the industry, particularly in the shorter term. On the other hand, they also represent companies' own estimates, including those of companies who are quite new and have a lot of uncertainty ahead of them.

It is also important to note that companies have different timescales for FOAK facilities and roll out (ranging from the early 2030s to late 2040s).

More speculatively, when asked about their expected spending ten years beyond their FOAK facility, numbers reached very high levels. We have chosen not to report these numbers, since they are highly speculative. However, optimistic estimates fall into the trillions, as befitting an industry that could play a large part in the multi-trillion dollar per year global energy market.

Even if just a small number of FIA companies succeed at the level they hope for, we should anticipate many billions in supply chain opportunities over the next decade alone, and likely trillions in the coming decades.

What does a mature fusion industry look like?

Our respondents' plans include the following:

- 5 x 400 MWe plants in the first few years, scaling up to dozens per year within a decade.
- Plants totalling 60,000 MWe
- 300 x 230 MWe plants
- 200 x 500 MWe plants
- 10 x 200 MWe + 10 x 1GWe plants
- 10 x 1000 MWe plants
- 10x 300 MWe plants
- 15 x 1,000 MWe plants
- 1,000 x 300 MWe plants
- 100 x 1 MWe plants
- 12 x 10 MWe plants
- 5,000,000 x 5 MWe plants
- Plants totalling 10,000 MWe
- 100,000 electrical substations with aggregate of 10 (MWe) each

Supply chain needs – now and in future

CURRENT DEMAND

Fusion companies take different technological approaches and need different components and materials for their machines. Not all components were (or will be) required by everyone. The results listed below (see Table 1 and Chart 3) are intended to provide a snapshot of what is needed across the industry as a whole.

In general, fusion technologies show several notable divides. The first is the separation between the magnetically confined fusion approaches and the inertially-confined laser approaches, the former requiring magnets and superconducting wires, and the latter lasers and their component parts.

Another key divide is between steady-state approaches that are "always on" and pulsed approaches. The latter require precision power-supply management components, particularly power semiconductors.

Common across many fusion technologies are the advanced and specialized components for heat management, the first wall, and vacuums – all the parts that will be needed to create a plasma and then to transfer the energy created into a usable power source, either electricity or process heating. Finally, nearly all require specialist engineering skills for design and assembly.

TABLE 1:

Current demands from the fusion supply chain (26 responses. Answered 'critical' or 'important').

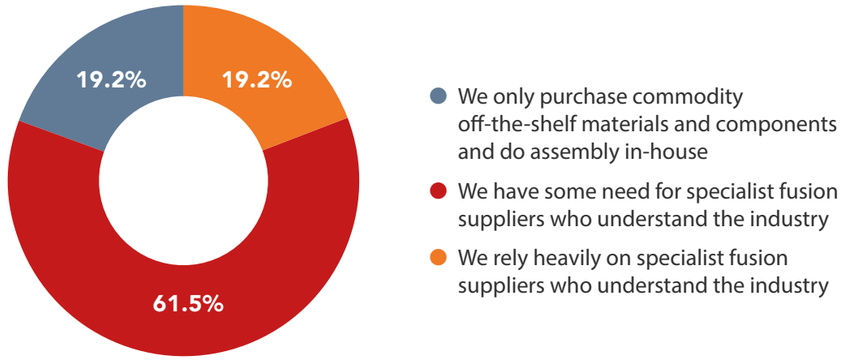
See Appendix 1 for expanded table.

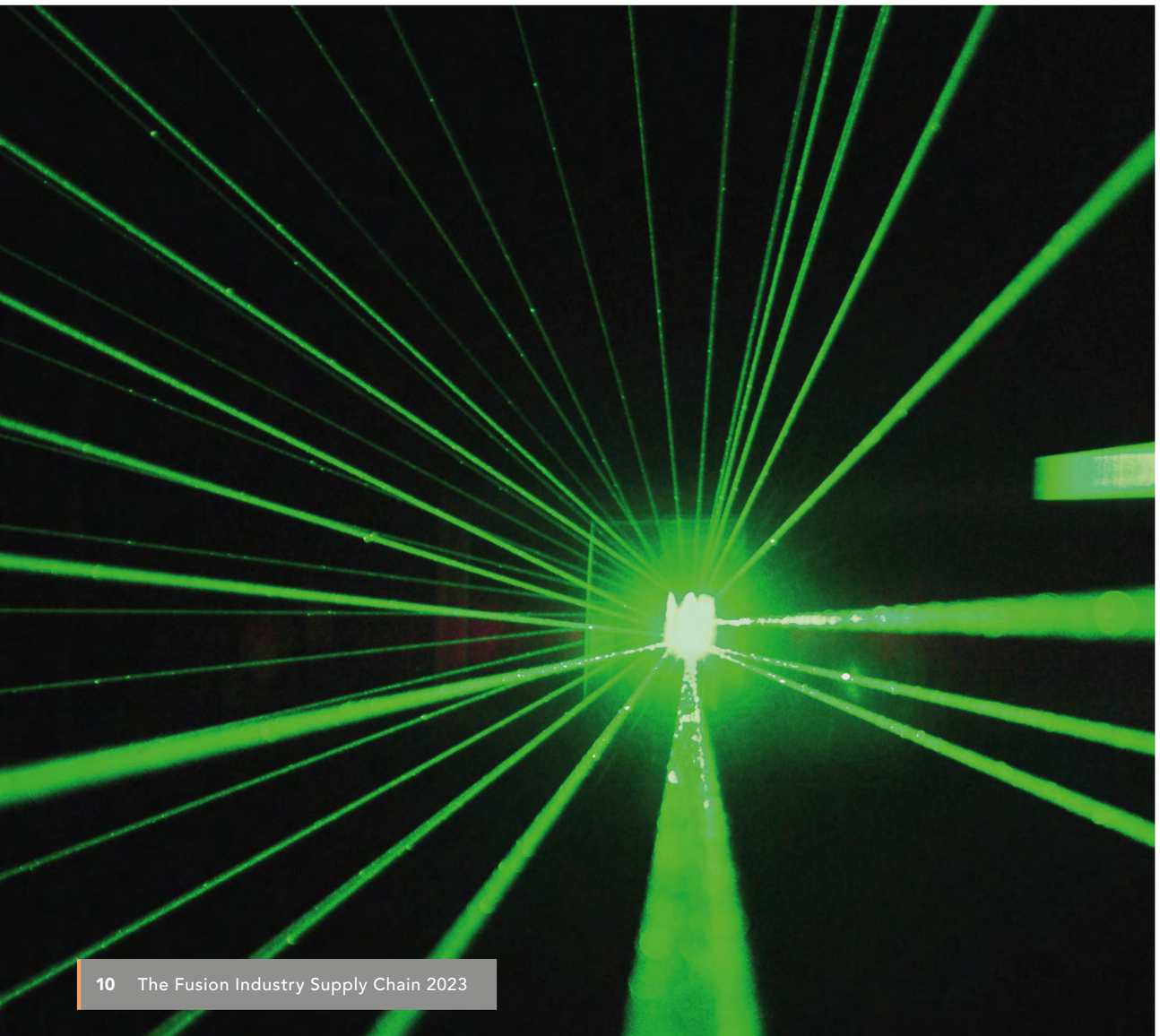
	Critical/important
Vacuum pumps	**24**
Precision engineering and manufacturing services	**24**
Control Software	**21**
Power semiconductors	**20**
Deuterium, tritium, or other gaseous fusion fuels	**19**
Recruitment	**19**
Specialized metals, e.g. high-grade steel	**17**
Common metals, e.g. nickel, copper	**16**
Engineering, Procurement and Construction Firms	**16**
Heat management technologies	**14**
Natural Lithium	**14**
First wall materials	**14**
Legal services	**14**
Cryogenic devices	**13**
Magnets	**12**
RF heating	**10**
Lithium (enriched)	**10**
High Temperature Superconducting (HTS) Tape	**9**
Lasers (assembled)	**6**
Rare earth metals	**6**
Laser components, eg. diodes, laser glass	**5**

CHART 3:

Breakdown of companies' suppliers needs

Companies rely on a mix of specialist fusion and commodity suppliers.





Most fusion companies in North America and Europe source most of their supply chain needs locally. Although home to fewer fusion companies, those in Japan and Australia both have local supply chains they could rely on for much of their needs.

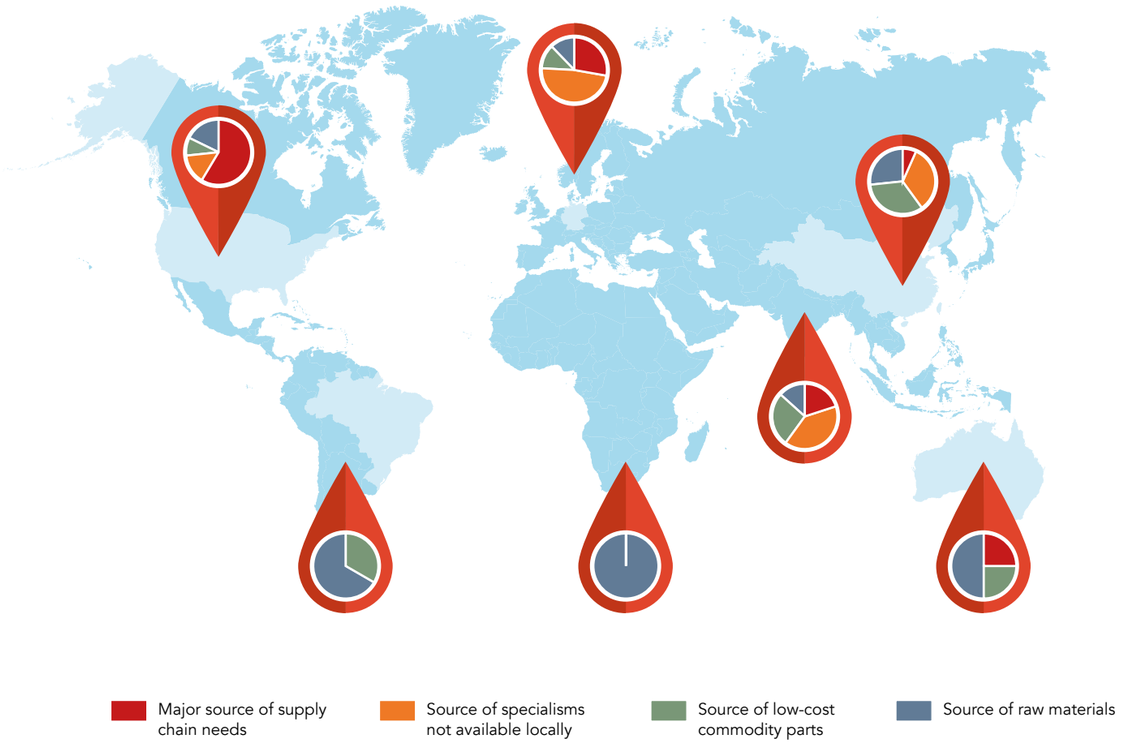
Nonetheless, supply chains are clearly global, and many companies cross-relied on Europe and North America for significant parts, suggesting strong opportunities for fusion suppliers to tap global markets (see Chart 4).

Europe and Asia were cited by some as a valuable resource for HTS tapes, cryogenics, and some electronics. Asia (excluding China) was seen by some as a source of quality precision manufacturing. Europe was the primary source for specialized, non-local fusion parts.

China was seen as a source of not just commodity parts, but also of specialty components that are not available locally. However, contrary to concerns in other industries, China is not listed as a source of raw materials for non-Asian fusion companies.

CHART 4:

Where do fusion companies source their supplies? (Respondents could tick multiple boxes)



Projected supply chain evolution

Although requirements differ by fusion technological approaches and engineering models, our results make it clear that – taken across the industry – demands on all fusion components will increase dramatically over the coming decade and beyond. Of note is that specialised fusion components – and the support to produce them – will see big increases in demand, as many are needed to put together complex fusion systems, rising from a low base demand today. However, raw materials will likely only see more incremental increases, since unlike solar and batteries, a single fusion plant can create significant energy, so plants do not need vast material resources to build.

TABLE 2:

Demand increase for fusion components over next ten years (26 responses. Answered 'critical' or 'important').

See Appendix 1 for expanded table.

	Order of magnitude/ significant increase
Vacuum pumps	14
Precision engineering and manufacturing services	14
Heat management technologies	13
Deuterium, tritium, or other gaseous fusion fuels	13
Engineering, Procurement and Construction Firms	13
Recruitment	13
Power semiconductors	12
Specialized metals, e.g. high-grade steel	12
Control Software	12
First wall materials	11
HTS Wire	10
Magnets	10
Cryogenic devices	10
Natural Lithium	10
Lithium (enriched)	8
Legal services	8
RF heating	7
Rare earth metals	7
Common metals, e.g. nickel, copper	6
Lasers (assembled)	5
Laser components, eg. diodes, laser glass	5

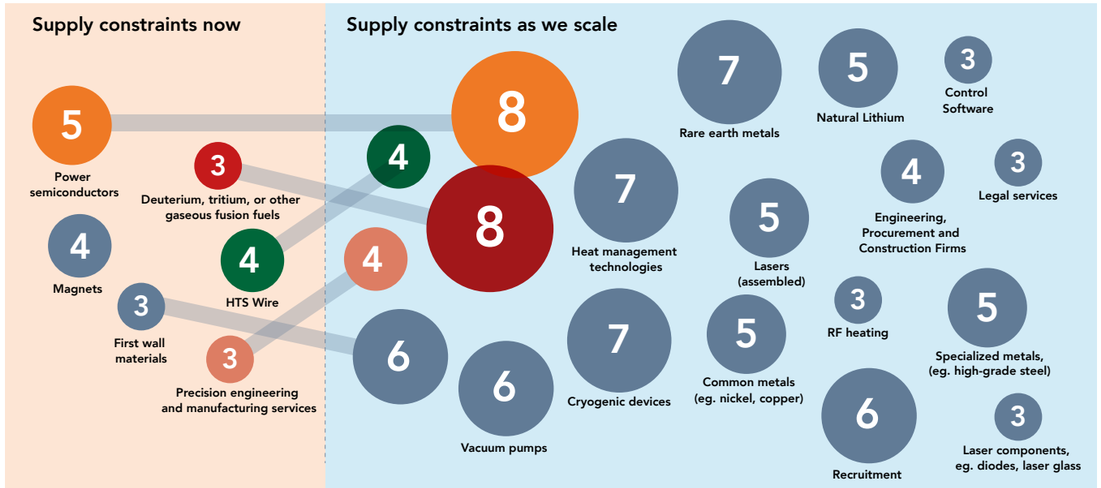
Responses were mixed with regards to the problem of existing supply chain companies meeting changing demand. A number of companies raised serious concerns about the ability of existing suppliers to deliver key components and services and scale.

Other fusion companies, however, felt comfortable that their medium-term needs could be met by suppliers on the current trajectory. That is not to say suppliers should be complacent; as fusion companies scale up, they will place a greater weight on the supply chain, but most fusion companies did have faith that, as they provide the demand, supplier companies would be able to meet it.

CHART 5:

Number of companies expressing concerns about current and future supply constraints (only categories with 3+ responses included below).

See Appendix 1 for expanded data.



Specific supply constraints

In addition to the data presented in Chart 5, respondent companies individually flagged specific challenges as likely supply constraints. These reflect the concerns of at least one fusion company, but should not necessarily be seen representative of the fusion industry as a whole.

FUELS

- Lithium-6 (enriched lithium): Production techniques are understood, but no commercial production capacity exists, because there's no demand and the total need for enriched lithium in fusion blankets is scientifically uncertain.
- Tritium: Needed in many predicted fusion fuel cycles for experimental facilities, but will not be an input in commercial power plants because companies plan to generate tritium from lithium.

Fusion Fuels: Rare? Or just not yet demanded?

There have been some concerns expressed in the media, and even the scientific literature, about a lack of tritium as a fuel for fusion. Indeed, our report indicates that a very large majority of fusion companies see deuterium, tritium, or other gaseous fusion fuels as either "critical" or "important" to their supply chain right now. A smaller number, however, expect supply constraints in these fuels, and many report no concerns at all about the ability of supply to grow to meet demand. This reflects the planning and foresight that companies are putting into ensuring access to fuel supplies.

Industry is clear that current media concerns about tritium supplies are based on a misunderstanding of fusion technologies and the ability to breed tritium. Although there is very little tritium in the world right now, every fusion company that will use tritium has plans to generate it in the fusion power plant as they scale: tritium breeding is a critical technology for fusion pilot plants to demonstrate. Although tritium doesn't exist naturally, it is available for sale from nuclear power plants in Canada and elsewhere at high prices. Without market demand, supply will decline in the coming decades as these power plants close. For experimental purposes, companies that need tritium are contracting with existing suppliers now to support their experimental campaigns, especially from nuclear power plants that produce it as a by-product. However, by the time companies move to building pilot plants, every company must plan to breed tritium in its power plant by interacting the neutrons produced in a fusion reaction with lithium in a blanket that surrounds the fusion core.

In that sense, the "fuel" – in the sense of a material introduced from the outside that is used up to create energy – is not tritium, but lithium, either in its naturally occurring form or enriched. There is still uncertainty about what the needs of a tritium-generating blanket are, and the technology readiness level for fusion blankets is low. Several companies and government programs are developing processes for how to generate tritium most efficiently from lithium, and this will be an area of ongoing scientific and engineering inquiry.

Raw Materials Needed and identified as potentially constrained in supply (not in ranked order)

- Tungsten
- Barium
- Vanadium
- Zirconium
- Beryllium
- Molybdenum
- Rare Earth Minerals (Yttrium, Scandium, Neodymium, etc.)
- Noble gases, Krypton and Xenon (currently constrained by the war in Ukraine)
- Copper

Fusion's raw materials needs

Some observers inside and out of the industry have expressed concerns that fusion may follow the path of solar and batteries; becoming reliant on unstable suppliers who control critical minerals or production.

With foresight and planning, this need not be the case with fusion. The plants themselves create high amounts of energy in a single facility, so the resource requirements for manufacture are not on the scale of batteries or solar panels. Fusion relies more on high quality manufacturing and specialist components of the type which have generally found success in the open economies of North America, Europe and Japan.

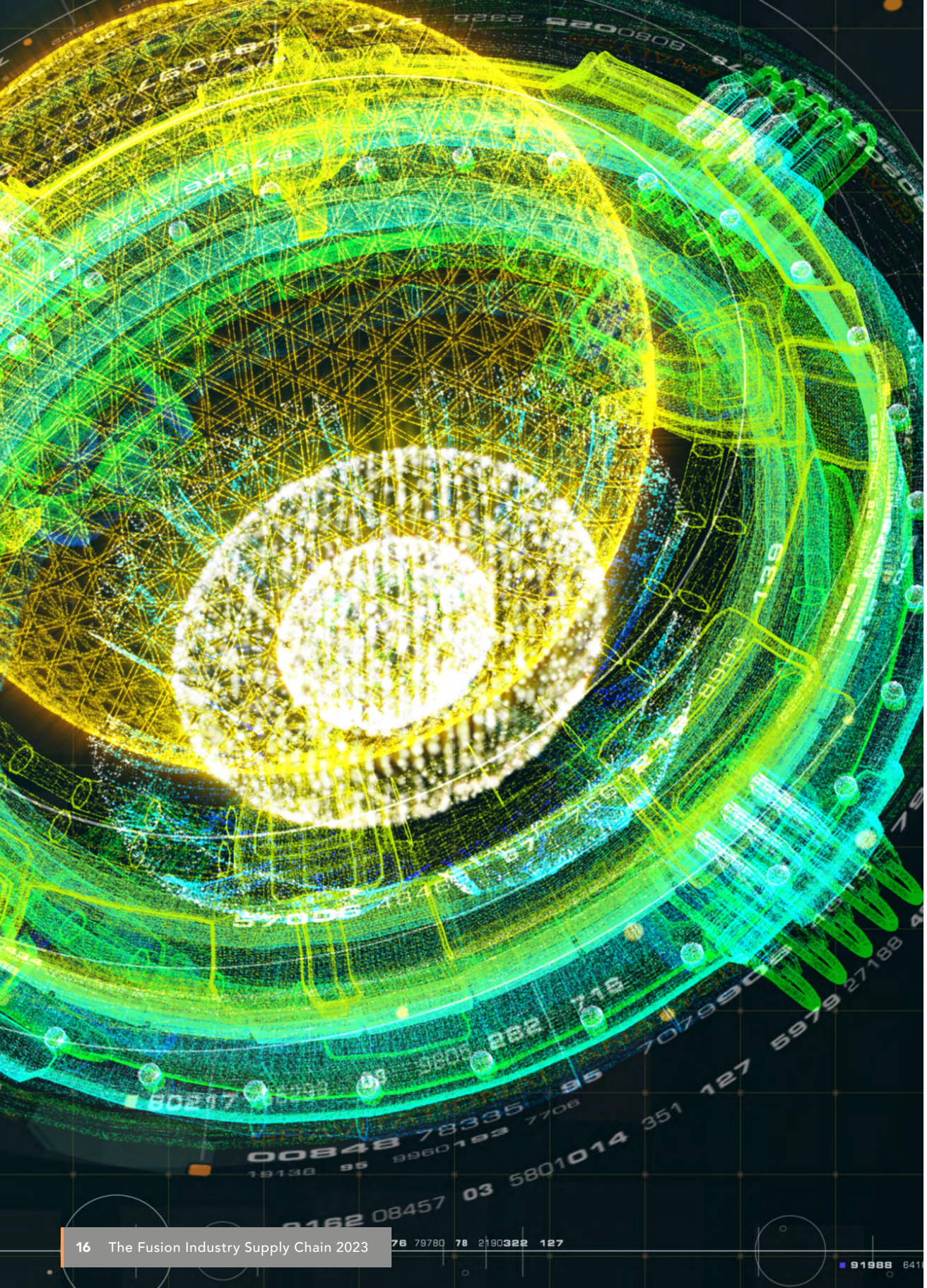
In terms of raw materials, while key minerals like tungsten, beryllium, and Rare Earth Minerals are required in different technological approaches, the volumes required should not be significant enough to slow development. With enough preparation, the minerals are unlikely to be distributed in such a way where one country can control the ability of fusion to scale.

Electronics and software

- Power supply system
- High density energy storage
- Capacitors (incl. pulsed power systems)
- Power semiconductors
- High voltage switches
- Ignitrons
- Thyristors
- AI for plasma containment

Specialist supplies and outsourced manufacturing

- Laser glass production
- High yield neutron detectors
- Vacuum Chambers
- Capability to manufacture fusion-specific materials, alloys, coatings, and components
- Tritium fuel cycle materials and cold trap materials for liquid breeders



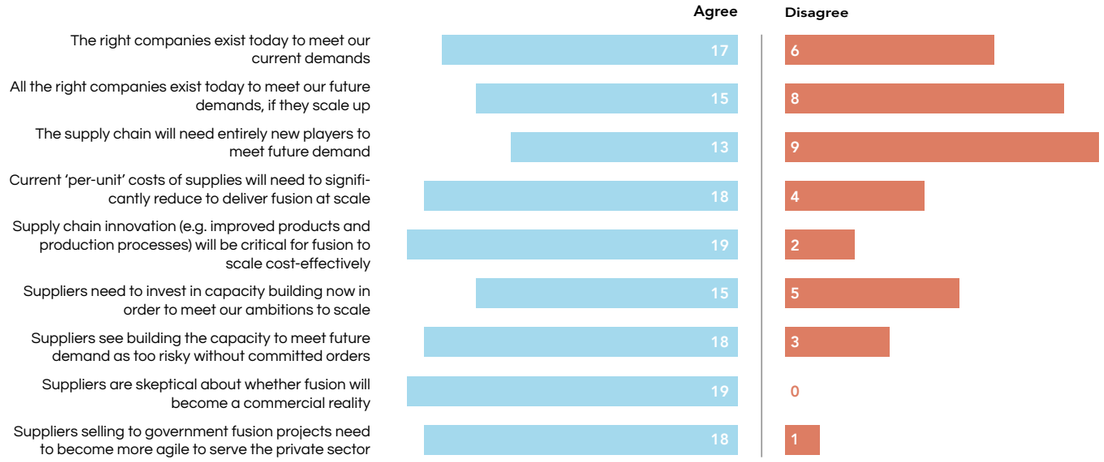
The challenges in the supply chain

Delivering a scale-up to fusion energy production will present challenges for suppliers and could require companies to consider scaling early in the fusion industry deployment phase. Although responses about specific needs varied between companies, a number of common constraints were raised. These are shown in Chart 6, which is followed by a discussion of their implications, based on both responses and interviews.

CHART 6:

Views on supply chain needs (25 responses, unreported responses indicate 'don't know' or 'neither').

See Appendix 1 for expanded data.



Balancing scale with risk

Many companies felt suppliers had the capabilities needed today, and agreed that companies would need to scale-up to meet demand soon. Timing is important, as some said significant scale will be needed within 1-2 years, while others had longer-term timelines. But, all agreed that building new capacity takes time, and that industry and its suppliers need to start that planning now – so fusion is not supply-chain constrained when it becomes time to scale.

Companies suggested that suppliers will need to drastically reduce component lead times, so as to enable rapid iterative development for key equipment. Many current components are low volume and specialized, and only manufactured by a handful of companies. Fusion companies need suppliers to find a way to speed up development cycles, by driving lower lead times and higher volume/lower costs.

Fusion companies recognize that suppliers need firm commitments or investment to deliver scale, innovation, and cost reduction. But this presents the challenge of balancing timelines for financial commitments with timelines for scaling-up, in order to meet demand.

Supply chain geopolitics and security

Companies in the US and Europe expressed concern about certain countries with geopolitical risk monopolizing critical aspects of the fusion supply chain (especially rare raw materials and specialized technological products, like power electronics). The concern is that countries could use supply monopolies like these to draw manufacturing to their shores or to hamper strategically important technologies, as has happened with other critical emerging industries. In those industries, however, geopolitical concerns were not embedded in business decisions from the start, so what may have helped cut costs in the short term created risk in the long term. In today's geopolitical environment, FIA Member companies are very aware that international relations and geopolitics will play a large role in scaling and deploying fusion.

Security and geopolitical concerns vary by company, geography and fusion technology, with some companies confident in their future supply chain and others concerned about vulnerabilities. Variations were shown even across the same component – laser glass, for example, was flagged as a major concern by some and nothing to worry about by others. It is likely that this reflects different in-house production approaches, scaling timelines, or attitude towards risk.

Lack of innovation

Some respondents noted that, while existing key suppliers are often highly technically skilled, they are sometimes not innovative. Some of these suppliers grew up around publicly funded fusion projects and are used to very specific terms and conditions that they cannot deviate from. Those same suppliers then seem to struggle with private sector buyers who say, 'this is what we want, help us build it'. This is not a criticism of suppliers, but indicates that the pace of innovation by fusion technology developers is setting a new standard for traditional fusion suppliers to have to rise to.

Opportunities for Engineering Procurement, and Construction (EPC) Firms and Incumbent Energy Developers

After the pilot plant stage, most fusion companies will need help scaling their power plants. Only two companies say they plan to own and operate their own plants. Seven say they would license their technology and 13 intend to pursue a mix of licensing and operating. This reflects that the unique skills to build and operate power plants are very different from the skills of innovating and developing technology. Experience in building and delivering projects will be needed, and fusion developers will find ways to hire those skills, find partners, and contract for expertise.

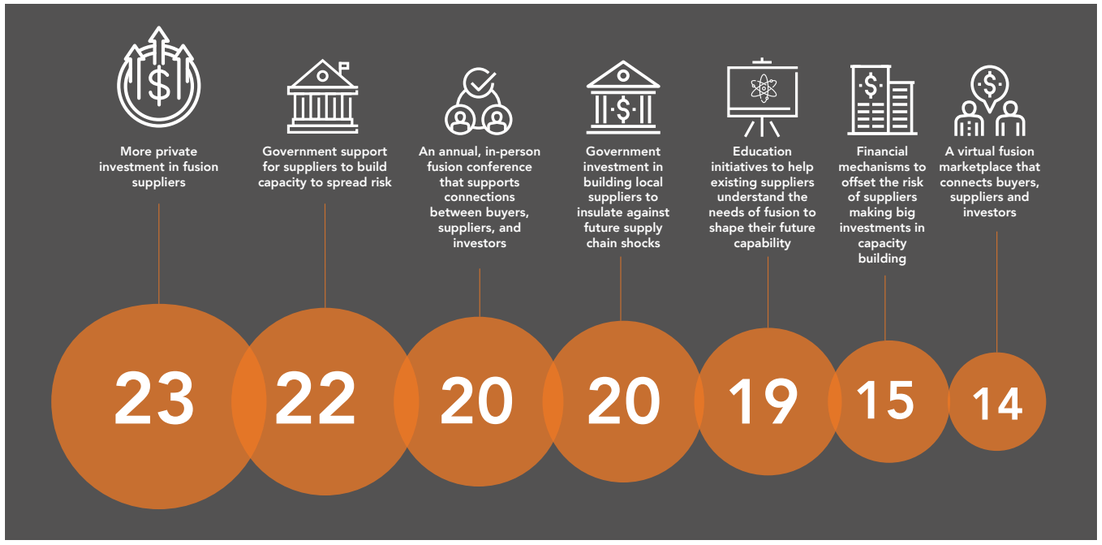
Proposed solutions to supply chain challenges from fusion companies

A number of possible solutions to improving fusion supply chains were identified and put to the respondents. The answers are presented in Chart 7.

CHART 7:

Views on proposed solutions (proposed measure would be critical or useful).

See Appendix 1 for expanded data.



Question: *Please state how much you think the following ideas would help ensure the supply chain can deliver against your future needs*

Notable in the results is broad agreement that more investment, by the private sector, the public sector, or through a mix of both, will be the most important solution to scaling up the supply chain.

Most agreed that the biggest enabler to the fusion supply chain would be secure, consistent demand, that would give them the confidence to invest and innovate. In short, that there is a market for commercial fusion. In addition to the above, the following were proactively suggested by respondents to this end:

- Funding for fusion companies with a focus on enabling supply chain commitment.
- Government programs (SBIR or similar) to develop fusion enabling technologies.
- Expand existing government incentive programs for manufacturing of critical technologies and clean energy components to include fusion (e.g. CHIPS Fund, Tax Credits, Loan Guarantees), or launch new ones in countries where these don't exist. More dedicated fusion incentives may be needed beyond 2025.
- Consistent and growing private and public investment in fusion and supplies.
- Clear commitments from government about future regulations on fusion, to provide certainty and allow suppliers to make fair assessments of risk.
- Education about fusion and its opportunities.
- Tangible, workable projects (continuous stream) for the supply chain to want to get involved/ invested in.

SECTION 2:

Views from fusion suppliers

In addition to asking industry what they need from suppliers, we also asked existing fusion industry suppliers, all affiliate members of the Fusion Industry Association, about their hopes and challenges. We surveyed 34 affiliate members to gain their views (not all responded to all questions). This included a significant number of suppliers of the specialist components discussed above (including laser and magnet components, and heating and cooling), software suppliers, and specialist engineering contractors.

It is important to note that FIA affiliates are suppliers who are already financially committed to the fusion supply chain, and represent a group more advanced than suppliers at large, so these responses should not be taken to represent the full spectrum of supply challenges. Nonetheless, they provide valuable insight into some of the challenges that fusion suppliers face, and which others will face as they enter and scale within the fusion supply chain.

A snapshot of survey respondents

CHART 8:

What is the size of your company by approx. revenue?

33 responses

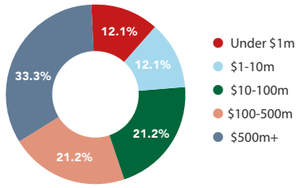


CHART 9:

Are you open to international expansion?

33 responses

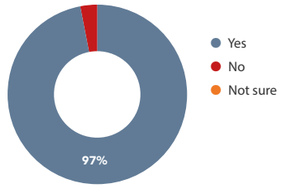
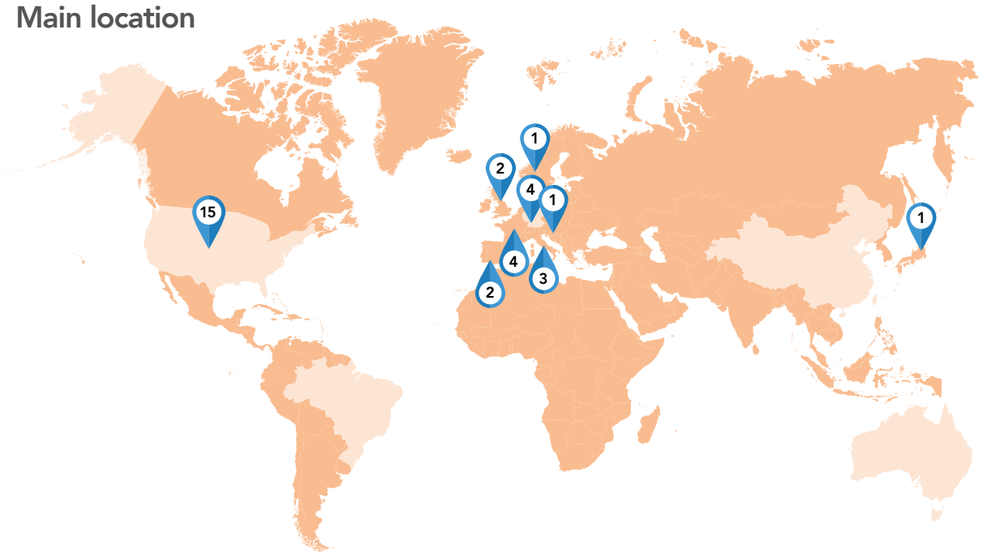


CHART 10:

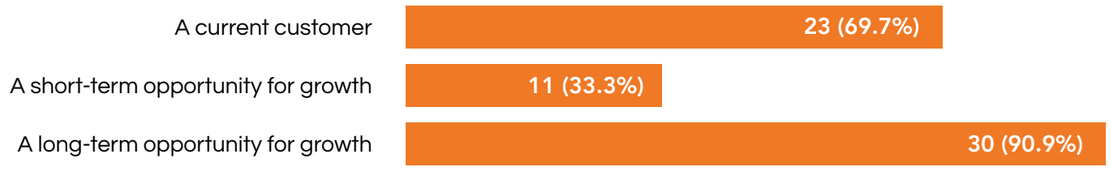
Main location



HOW SUPPLIERS SEE THE OPPORTUNITY

CHART 11:

How suppliers see the fusion industry

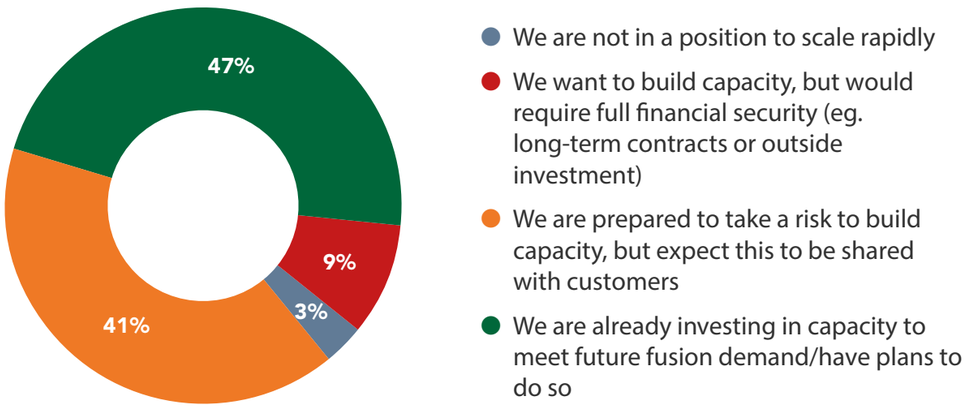


Broadly, our cohort hoped that fusion would produce a major new industry that would present a significant new opportunity for them. Reasons for entering fusion varied but can broadly be summarized as follows:

- Some specialists, such as HTS tape manufacturers, see fusion as a huge opportunity for growth.
- Some see it as a chance to commercialize previously niche products on a mass scale.
- Many manufacturers of specialist components with a range of applications, such as RF Heat or power electronics, see this as an emerging new market segment and new opportunity, where such companies need to align current products for new applications and consider long-term investments to deliver.
- Many felt excited to be providing solutions that would enable a clean energy industry that can play a significant role in decarbonizing energy systems. Some companies saw investments in fusion as part of their strategy to be green leaders.

CHART 12:

Are fusion suppliers ready to scale? (30 responses)



RISK AND UNCERTAINTY

The survey respondents suggested an eagerness to scale rapidly and a willingness to take on risk. This is promising and shows appetite, though the wider supply chain may be more cautious.

CHART 13:

Fusion suppliers confidence in the fusion industry (31 responses, missing responses = not applicable/no opinion).

See Appendix 1 for expanded data.

Question: *Fusion companies hope to scale rapidly in the coming years which may create a rapid increase in demand on the supply chain. Please indicate your position with regard to supporting this.*

PROPOSED SOLUTIONS FROM FUSION SUPPLIERS

Despite the commitment to fusion and willingness to take risks from respondents, there was still a strong sense that there was a need for financing mechanisms to minimize risk – which could include grants, investment, or long-term purchasing commitments from fusion companies – as shown by Chart 14.

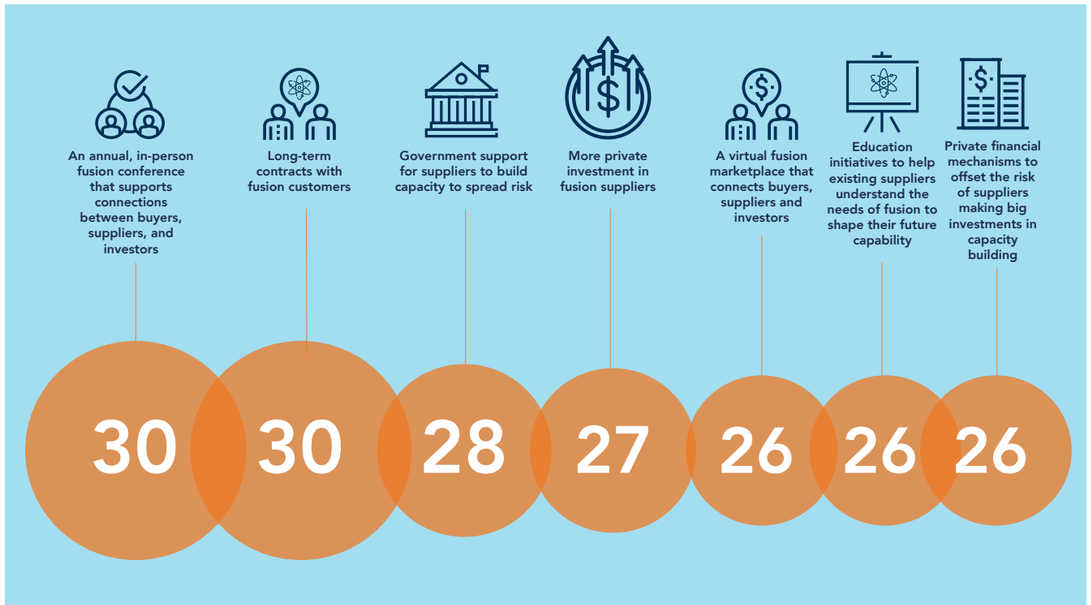
All respondents voiced strong support for the need for long-term contractual commitments from fusion companies to their suppliers, and private financial mechanisms to offset risk. A large majority went as far as saying that both would be critical to allowing the supply chain to deliver. Many also cited the need for some form of government grants or other financial support for R&D and scaling.

Although secure finances were a top priority, many also emphasized a need for greater networking and knowledge sharing opportunities between fusion companies and suppliers.

CHART 14:

Views on solutions to support the supply chain (31 responses, missing responses indicate would not find useful, or don't know).

See Appendix 1 for expanded data.



In addition, respondents were invited to provide their own suggestions. Many reinforced the above discussion, but additional suggestions included:

- A well-established fusion energy regulation framework/proper regulatory framework for commercial fusion across nations.
- An industry-wide pre-qualification program for supply-chain organizations that allows for rapid response to emergent industry needs.
- Government funding for internships or secondment of government staff for part-time help on specific projects.
- A recognition that some of the most important parts will take time, investment and technical development to become good enough and able to be produced at scale.

SECTION 3:
Recommendations

At the beginning of this report, we contended that building a supply chain for the fusion industry was a "chicken or egg" problem, where one follows the other, but it's not clear which comes first. The answer to that question, in this case, is "both." The recommendations provided below will enable the fusion energy supply chain to grow as a part of the broader fusion industry.

Based on our review and analysis of this data, the comments provided by both fusion companies and suppliers, and deeper interviews with a number of fusion companies, the FIA proposes the following recommendations to support the fusion supply chain.

1. Increase investment (public & private) in fusion to support the supply chain

Whenever included in the answers, the highest scoring answer in our survey was to increase funding for fusion. Therefore, the key recommendation is for investors and governments to support fusion energy to a scale that is relevant to its vast promise. The FIA's annual investment report, due for its next release in July 2023, will be the next opportunity to measure the investment in fusion.

Money doesn't solve all problems in business, but a lack of money certainly prevents certain problems from being solved. All companies respond to incentives, and a clear signal of growing investment by both public and private entities in fusion will create new opportunities. The fusion industry was responsible for over $500 million in spending in 2022 should drive new entrants into the market, as there's a clear case that figure is only set to grow.

However, when fusion developer companies are only funded through their next 2-3 years, it makes it harder to guarantee markets for suppliers. This will likely evolve as fusion companies successfully demonstrate their proof-of-concept devices and move to build their FOAK plants. Investors in the private sector and funders in the public sector should outline long-term funding profiles in order to give greater certainty to suppliers as they scale.

Governments can support investments into the fusion supply chain through similar incentives currently utilized for other clean energy industries. Every government may explore different suites of incentives, including: grants, loans or loan guarantees, tax credits, market guarantees, fixed-fee tariffs, or other programs to support the commercial deployment of fusion.

2. Explore risk sharing mechanisms

In our survey, suppliers contend that they need assurances that big investments in fusion-specific capacity building will bear fruit. Fusion companies counter that investment by suppliers in foundational technology is needed now to achieve the necessary scale and timeliness. Suppliers perceive these investments as risky – either because they see that fusion might not commercialize soon, and, even if fusion is successful overall, not every technological approach to fusion will win.

An important way to share risk is for the same investors that are placing their capital behind fusion developers to also make investments in the suppliers that will support those companies. This could be done either with separate investments, or with developers taking financial stakes in supplier companies – a "vertical integration" of industry that could take lessons from the early days of the automotive industry.

This would all be supported by clear communication from fusion companies about expected needs and associated risk levels, which allow suppliers and their investors to make informed business and financing decisions with respect to new technologies and/or capacity creation.

Governments can support this risk-sharing by ensuring that national labs and national fusion programs work in collaboration with private developers, not in competition with them, to create a marketplace for fusion suppliers. Governments can also de-risk investments by supply chain companies into fusion manufacturing scale by publicly communicating that the fusion supply chain is eligible for all the financial incentives and government support that have been provided to other clean energy technologies over the years.

3. Build a global network of suppliers

Using the gaps (components, materials, capabilities) identified in this report as a starting point, there would be huge value in the creation of an independent organization to build a global network designed to connect fusion companies and suppliers.

This network could include a database of both fusion companies and suppliers, which each company can update with their changing needs and capabilities. This should be promoted to global suppliers, including those not currently involved in fusion, but with the potential to be.

Searchable profiles would enable connections between the right people, and allow analysis of evolving needs, sensitive areas, and potential collaborations – to get ahead of bottlenecks.

In addition, in-person and virtual forums should be created to educate suppliers about fusion needs, including an annual trade event, online webinars and 'matchmaking' services to create strong partnerships between fusion companies and long-term suppliers who understand their needs.

Better connections between fusion companies and suppliers – which may also include academics who create spin-outs – will help innovators spot opportunities to add value.

4. Benefit from other industries

As the fusion industry builds a supply chain, it should speak to other industries who have been through the process of building global supply chains and invite them to speak at our conferences and events.

A member company suggested that the automotive industry has two important supply chain lessons to impart: (1) standardization and modularization of parts (which could be applied to parts like laser components), building strong relationships between automotive companies and Tier 1 suppliers; and (2) promoting supplier innovation, by setting a clear direction and inviting suppliers to develop solutions.

Other industries may also be well placed to switch skills and production capabilities towards creating fusion parts. One respondent to our supplier survey, an aerospace engineering company, noted: "Aerospace Engineers solve the most difficult problems in high consequence environments for a wide range of customers". There should be an active effort to engage a wide range of industries and explain the opportunities to them (we hope this report and its promotional activities will be a part of that).

5. Standardization

Fusion's history is in the laboratory, and many components are bespoke to each fusion device. As fusion progresses into an industry, standardization will be important to enable growth. Collaboration and open discussion will be important, as each supplier will want to differentiate its products.

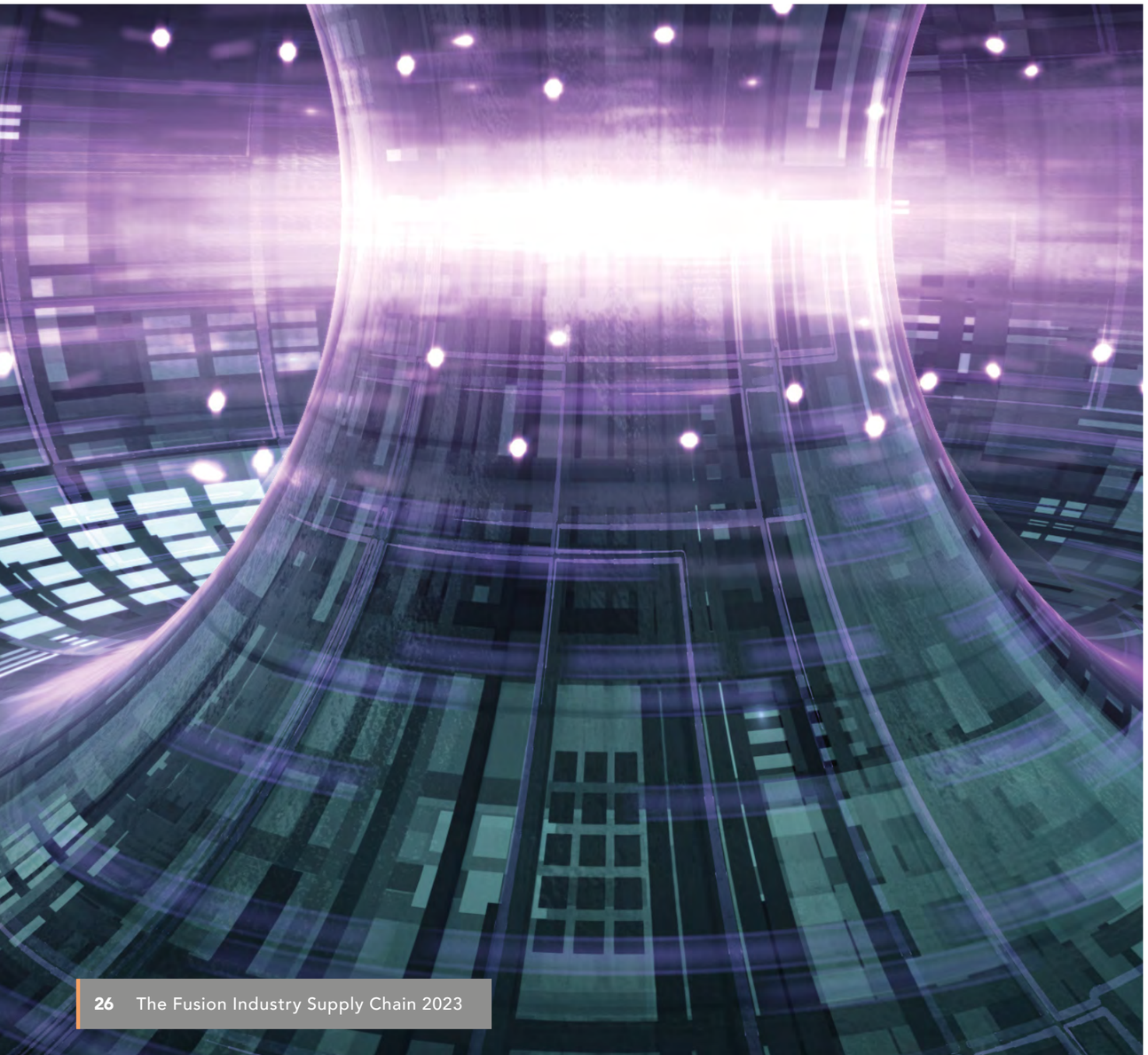
The Fusion Industry Association and its members are already engaged with the international codes and standardization bodies, where they exist. In other areas, the FIA can support its members in enabling the creation of standards for key components such as lasers and magnets.

6. Regulatory frameworks

International standard setting bodies will interact with the safety, licensing, and regulatory regime for fusion energy. The FIA is working with national regulators to support establishing a regulatory regime for commercial fusion that permanently and completely separates fusion regulation from fission. Establishing international best-practices for a regulatory regime that both protects public health and safety and supports innovation will drive fusion development – by giving suppliers confidence that their long-term design choices and associated production investments will be fit for purpose. Supply chain companies that can show their ability to build for the unique regulatory regime of fusion energy will be rewarded.

In addition, several supply-chain companies have made clear to potential fusion customers that the strict requirements of the nuclear fission regulatory framework would be too onerous, and they wouldn't do business with them.

Governments should ensure that regulations support public health and safety, while encouraging innovation. Fusion must be regulated in a different manner from nuclear fission, and governments should move to permanently and completely separate fusion licensing from fission.



Conclusion

Readers of this report could be forgiven for seeing a strange dichotomy. It seems that the results of the survey are optimism that fusion developers will be able to meet their goals without serious disruption combined with worry that fusion won't have the resources to be able to scale. If this sounds like a paradox, it's because of the difference in timeframe. On the one hand, fusion companies are working now to build the machines that produce a scientific proof-of-concept and will be ready to move swiftly into building pilot plants. This is an increase in scale from today, but in a linear direction.

On the other hand, when moving from building the "First of a Kind" (FOAK) power plant to a commercial industry, this increase in scale will be exponential, with rapid growth across nearly all needs. This is where worry comes in. The difference between building one or two pilot plants and building the hundreds of power plants that companies suggest a fully-realized fusion industry would look like will take a state-change in both the companies and the supply chain themselves.

Fortunately, the timeframe makes that manageable. Fusion companies say they anticipate producing pilot plants in the early 2030s – a decade from now. If the supply chain, supported by industry and governments, spends this decade planning to scale as needed, then this challenge and its associated risk is manageable.

Keen observers are not used to optimism about fusion. Often, there's a jaded pessimism that runs counter to the optimism expressed in this report. The fusion community's antibodies against "overpromising" kick-in when the FIA and its members say that we can reach our timelines and goals. However, as governments and industry aim for these timelines, they will need to ensure that they are driving the investment and clear goals to bring along supply chain companies.

At the same time, government policymakers' concerns about supply chains are not the same as business' concerns. In today's age of "re-shoring" and "global strategic competition" the free trade pronouncements of two decades ago look naive. It's clear from other industries that, in an age of openness, some countries chose to expropriate technology, monopolize scarce resources, and develop subsidized supply chains. As countries work to build an integrated fusion energy supply chain, governments are applying recent lessons to try to build local, secure supply chains. However, any successful effort to commercialize fusion energy must reckon with the clear truth that fusion science is global, its supply chain is global, and the expertise has developed around the world.

The FIA acknowledges that this first effort to quantify and analyze the fusion supply chain is limited in nature. Future work by the FIA and its members will include deeper dives into critical components, key technologies needed, or scientific uncertainties. This first supply chain report successfully highlights the scale and the need for coordination and communication. We hope it provides value to observers, policymakers, and industry.

The following list of FIA Affiliate Members should be seen as a resource for companies as they scale-up, alongside the list in Appendix 2 of suppliers who contributed to this report. The FIA is always open to new members. Details about joining can be found at: https://www.fusionindustryassociation.org/join.

Appendix 1: Expanded data tables

We present here expanded versions of data tables in this report for those wishing to dig deeper.

TABLE 1 EXPANDED:

Current demands on the fusion supply chain (26 responses. Where total responses are less, non-reported responses indicate component not required for a company's fusion approach).

	Critical	Important	Incidental
High Temperature Superconducting (HTS) Tape	5	4	3
Magnets	8	4	4
Lasers (assembled)	3	3	6
Laser components, eg. diodes, laser glass	3	2	6
Vacuum pumps	12	12	1
Cryogenic devices	5	8	5
Power semiconductors	11	9	2
RF heating	6	4	3
Heat management technologies	6	8	6
Rare earth metals	4	2	9
Common metals, eg. nickel, copper	12	4	7
Specialized metals, eg. high-grade steel	9	8	5
Deuterium, tritium, or other gaseous fusion fuels	17	2	1
Lithium (enriched)	5	5	3
Natural Lithium	6	8	3
First wall materials	8	6	4
Control Software	8	13	2
Precision engineering and manufacturing services	10	14	1
Engineering, Procurement and Construction Firms	6	10	6
Legal services	3	11	11
Recruitment	7	12	5

TABLE 2 EXPANDED:

Demand increase for fusion components over next ten years
(24 responses. Where total responses are less, non-reported responses indicate component not required for a company's fusion approach).

	Order of magnitude	Significant	Incremental
HTS Wire	7	3	3
Magnets	7	3	2
Lasers (assembled)	4	1	4
Laser components, eg. diodes, laser glass	4	1	4
Vacuum pumps	4	10	6
Cryogenic devices	5	5	7
Power semiconductors	6	6	6
RF heating	5	2	6
Heat management technologies	7	6	4
Rare earth metals	3	4	6
Common metals, eg. nickel, copper	3	3	13
Specialized metals, eg. high-grade steel	5	7	9
Deuterium, tritium, or other gaseous fusion fuels	9	4	4
Lithium (enriched)	4	4	3
Natural Lithium	4	6	4
First wall materials	7	4	7
Control Software	6	6	9
Precision engineering and manufacturing services	8	6	9
Engineering, Procurement and Construction Firms	6	7	8
Legal services	2	6	10
Recruitment	4	9	8

CHART 5 EXPANDED:

Predicted Supply Constraints for key components and services

	Now	As we scale	Soon without SC capacity building	No concerns
HTS Wire	4	4	2	3
Magnets	4	2	1	10
Lasers (assembled)	0	5	1	5
Laser components, eg. diodes, laser glass	0	3	2	7
Vacuum pumps	2	6	3	12
Cryogenic devices	0	7	1	10
Power semiconductors	5	8	3	6
RF heating	0	3	2	10
Heat management technologies	1	7	2	12
Rare earth metals	1	7	4	8
Common metals, eg. nickel, copper	2	5	2	15
Specialized metals, eg. high-grade steel	2	5	4	11
Deuterium, tritium, or other gaseous fusion fuels	3	8	3	6
Lithium (enriched)	2	2	4	6
Natural Lithium	1	5	3	8
First wall materials	3	6	3	7
Control Software	1	3	1	18
Precision engineering and manufacturing services	3	4	2	15
Engineering, Procurement and Construction Firms	2	4	2	15
Legal services	1	3	0	20
Recruitment	2	6	0	14

CHART 6 EXPANDED:

Views on supply chain needs (25 responses, unreported responses indicate 'don't know')

	Completely/ somewhat agree	Neither agree nor disagree	Completely/ somewhat disagree
The right companies exist today to meet our current demands	17	2	6
All the right companies exist today to meet our future demands, if they scale up	15	2	8
The supply chain will need entirely new players to meet future demand	13	3	9
Current 'per-unit' costs of supplies will need to significantly reduce to deliver fusion at scale	18	3	4
Supply chain innovation (eg. improved products and production processes) will be critical for fusion to scale cost-effectively	19	2	2
Suppliers need to invest in capacity building now in order to meet our ambitions to scale	15	5	5
Suppliers see building the capacity to meet future demand as too risky without committed orders	18	3	3
Suppliers are skeptical about whether fusion will become a commercial reality	19	4	0
Suppliers selling to government fusion projects need to become more agile to serve the private sector	18	2	1

CHART 7 EXPANDED:

Views on supply chain needs (25 responses, unreported responses indicate 'don't know')

How would the following help support the future fusion supply chain?	Critical	Useful
A virtual fusion marketplace that connects buyers, suppliers and investors	2	12
An annual, in-person fusion conference that supports connections between buyers, suppliers and investors	5	15
Education initiatives to help existing suppliers understand the needs of fusion to shape their future capability	6	13
Government support for suppliers to build capacity to spread risk	8	14
More private investment in fusion suppliers	11	12
Government investment in building local suppliers to insulate against future supply chain shocks	4	16
Financial mechanisms to offset the risk of suppliers making big investments in capacity building	6	9

CHART 13 EXPANDED:

Fusion suppliers confidence in the fusion industry

30 responses, missing responses = not applicable

	Agree	Neither agree nor disagree	Disagree
We have clear direction from the fusion industry about its long-term component needs	16	3	9
We have clear direction from the fusion industry about its long-term capacity needs	11	5	12
We would be able to produce our components at larger scale and lower cost, if industry demand scales	21	4	0
We have seen interest from fusion investors in the supply chain	16	6	6
We are confident that fusion will be a future energy source	30	0	1

CHART 14 EXPANDED:

Views of suppliers on solutions to support the supply chain (31 responses, missing responses indicate would not find useful, or don't know)

How would the following help support the future fusion supply chain?	Critical	Useful
A virtual fusion marketplace that connects buyers, suppliers and investors	6	20
An annual, in-person fusion conference that supports connections between buyers, suppliers and investors	18	12
Education initiatives to help suppliers like yourselves understand the needs of fusion to shape your future capability	12	14
Government support for suppliers to build capacity in a way that spreads risk away from your own investments	18	10
Private financial mechanisms to offset the risk of suppliers making big investments in capacity building	17	9
Long-term contracts with fusion customers	24	6
More private investment in fusion suppliers	13	14

Appendix 2:
Fusion supplier Affiliate Members of the FIA

	Company description	Website	Contact Information	Completed Survey?
ABSOLUT SYSTEM INNOVATIVE CRYOGENIC SOLUTIONS	**Absolut System** Absolut System develops and provides cryogenic systems for superconductive applications	absolut-system.com	contact @absolut-system.com	YES
AEROSPACE	**Aerospace Corporation** The Aerospace Corporation is a national nonprofit corporation that operates a federally funded research and development center addressing complex problems across the space enterprise and other areas of national and international significance through agility, innovation, and objective technical leadership. Aerospace applies decades of PhD-level complex systems engineering and integration expertise in high-consequence environments for national interest applications.	aerospace.org	julie.reiss @aero.org	YES
Air Liquide	**Air Liquide** Cryogenic equipment & gas supplier	airliquide.com	luc.gaffet@airliquide.com	YES
ALSYMEX ALCEN	**ALSYMEX** ALSYMEX, is specialized in design, engineering, manufacture, assembly, on site installation, commissioning and maintenance of mechanical sub-assemblies and high technology turnkey systems for defense, nuclear and big science applications. ALSYMEX is involved in the ITER program, in charge of supplies such as series blanket first wall panels, cryo-pumps, neutral beam injection system ion source, divertor prototype sub-assemblies, tooling for PF coil assembly and key subsystems of RF heating launchers.	alsymex-alcen.com	egiguet @alsymex-alcen.com	YES

	Company description	Website	Contact Information	Completed Survey?
AMPLEON	**Ampleon** Ampleon is a solid-state, high power transistor supplier supporting high power LDMOS and GaN-SiC HEMT technologies for high power amplifiers. The Plasma Fusion application are addressed with technologies supporting 2-400MHz.	ampleon.com	tom.dekker@ampleon.com	YES
ARNOLD MAGNETIC TECHNOLOGIES	**Arnold Magnetic Technologies** Arnold Magnetic Technologies is a leading global manufacturer of high-performance permanent magnets, flexible composites, electromagnets, magnetic assemblies, and precision thin metal foils. Arnold's magnets, metals, and systems are used in high-efficiency electric motors and generators, sensors, batteries, and more	arnoldmagnetics.com	info@arnoldmagnetics.com	YES
BRUKER	**Bruker EST** Bruker EST is a supplier of superconductor wire to customers building high field magnets.	bruker.com	nfo.best @bruker.com	YES
COSYLAB	**COSYLAB** Cosylab is the leading provider of control systems and software solutions for the world's most complex, precise, and advanced systems. Our technology enables organisations to discover scientific breakthroughs, offer state-of-the-art cancer treatment and healthcare innovations, and bring clean fusion energy to the world. We provide software products and services to big science labs, industrial accelerators, fusion projects, the largest medical device manufacturers, radioisotope producers, and cancer centres worldwide. Our experience on complex, distributed, and highly-regulated	cosylab.com	fusion @cosylab.com	YES

	Company description	Website	Contact Information	Completed Survey?
	Curtiss-Wright Curtiss-Wright Nuclear offers a comprehensive range of products and services that support the global nuclear power industry. Our advanced technologies and innovative solutions have been used in operating reactors for over 55 years, sustaining the safe and reliable operation of nuclear plants throughout the world.	www.curtisswright.com	Scot Leuenroth sleuenroth @curtisswright.com	No
ENERCON ENERGY FOR THE WORLD	**ENERCON** ENERCON is a multi-discipline engineering, environmental and professional services organization, developing technology that supports continual, carbon-free energy production. ENERCON works to advance the fusion industry through engineering support for experimental, prototype, and demonstration machines. We support U.S. commercial and federal nuclear and provide engineering, licensing,and environmental services to numerous advanced nuclear projects.	enercon.com	jbasken @enercon.com	YES
AMPEGON	**AMPEGON and OCEM Power Electronics** Together, AMPEGON and OCEM Power Electronics supplied power systems to research laboratories worldwide, enabling advances in plasma physics for fusion, particle physics, and medical research with radio-frequency amplifiers and high-voltage and high-current power supply systems.	ampegon.com	miguel.pretelli @ocem.eu	YES
eni.com	**Eni SpA** Eni Next LLC is the corporate venture capital company of Eni SpA. It invests in high-growth start-ups to boost the energy transition to a zero-carbon future.	eni.com	jfrancesca.ferrazza @eni.com	YES

	Company description	Website	Contact Information	Completed Survey?
equinor	**Equinor ASA** Equinor, a broad energy company committed to providing affordable energy for societies worldwide and taking a leading role in the energy transition. We're on a journey to net zero emissions through optimizing our oil and gas portfolio, accelerating growth in renewables and pioneering developments in carbon capture and hydrogen.	equinor.com		YES
FRAZER-NASH CONSULTANCY A KBR COMPANY	**Frazer Nash Consultancy Ltd (a KBR Company)** Frazer-Nash is a leading systems, engineering and technology company. Part of KBR Group, we help organisations deliver innovative engineering and technology solutions to make lives safe, secure, sustainable, and affordable. We work from a network of nine UK and four Australian locations. Our 1,000 people develop, enhance and protect clients' critical assets, systems and processes.	www.fnc.co.uk	s.lawler @fnc.co.uk	YES
FUSION ENERGY INSIGHTS	**Fusion Energy Insights** Fusion Energy Insights is a membership organisation for professionals to keep up to date with developments and commercialisation considerations in the growing fusion industry so that they can see opportunities emerging for their business. We run monthly Insights Q&A sessions with guest experts on topics relating to fusion energy commercialisation.	www.fusionenergyinsights.com	hello@fusionenergyinsights.com	YES

	Company description	Website	Contact Information	Completed Survey?
IDOM	**IDOM** IDOM is an independent international company founded in 1957, which has been involved in nuclear fusion for more than a decade, participating in more than 150 projects related to nuclear fusion, including JET and ITER, and is also participating in the UKAEA's Engineering Design Services Framework for the Spherical Tokamak for Energy Production (STEP) Programme. The activities and systems in which IDOM has been involved ranges from blanket and fuel cycle to vacuum and leak detection systems, nuclear safety, diagnostics integration, cryogenics, construction management, hot cells, and instrumentation, among others. We also provided advanced mechanical, structural, civil, neutronics, computational fluid dynamics and thermal hydraulics analyses.	idom.com/en	dzaragoza @idom.com	YES
INTERLOCK ENERGY	**Interlock Energy** Hardware engineering, design and fabrication Engineering services, radiation detection, testing and mitigation. Operator of vacuum plasma platform suitable for fusion testing. Tritium producer (2023)	interlock.energy	sean@interlock.energy	YES
LEONARDO	**Leonardo Electronics US Inc.** Leonardo Electronics US Inc. is a vertically integrated manufacturer of high-power laser diodes and laser diode systems in Tucson, AZ. Leonardo Electronics has a vested interest in inertial confinement fusion driven by diode-pumped (solid-state) lasers.	leonardo.us	lukas.gruber @leonardo.us	YES
METOX	**MetOx Technologies** MetOx manufactures high temperature superconducting wire (HTS) using a proprietary technology for low-cost, scalable production.	metoxtech.com	info @metoxtech.com	YES

	Company description	Website	Contact Information	Completed Survey?
OXFORD SIGMA	**Oxford Sigmas** Oxford Sigma develops novel technologies for fusion energy, provide solutions in advanced nuclear energy, and supports the defence industry. We also provide technical and regulatory-based consultancy.	www.oxfordsigma.com	info@oxfordsigma.com	YES
pillsbury	**Pillsbury Winthrop Shaw Pittman LLP** Pillsbury is a full-service international law firm.	www.pillsburylaw.com	sidney.fowler @pillsburylaw.com	YES
research instruments	**RI Research Instruments GmbH** RI develops and manufactures high performance electro-mechanical components and systems for scientific and industrial applications for particle accelerators, fusion and semiconductor industry.	https://research-instruments.de/	sales@research-instruments.de	YES
KIND	**Rolf Kind GmbH** Our company has extensive experiences in the manufacturing of forgings for Fusion Devices like ITER, JT 60SA, WendelsteinW7X, K_STAR, SPARC and others. More than 6.100 Tons of forgings in different material Grades (316 LNH, F316 L(N) ITER Grade, JJ1, XM 19, 660 stainless Steel, Alloy 718) have been delivered for Fusion devices so far.	r-kind.de/de	info@r-kind.de; benoit.forien @r-kind.de	YES
Omniseal Solutions SAINT-GOBAIN	**Omniseal Solutions** Omniseal Solutions provides sealing solutions for demanding applications within the fusion industry.	omniseal-solutions.com	nathaniel.s. handschke @saint-gobain.com	YES
	Sapientai LLC Sapientai LLC specializes in scientific and engineering applications of machine learning applied to nuclear fusion technologies.	sapientai.io	admin@ sapientai.io	YES

	Company description	Website	Contact Information	Completed Survey?
Sumitomo Corporation of Americas	**Sumitomo Corporation of Americas** We are aiming to introduce nuclear fusion power generation especially to Japan and other Asian countries.	sumitomocorp.com	Akiho Hataya akiho.hataya@ sumitomocorp.com	YES
FARADAY FACTORY JAPAN	**Faraday Factory Japan** Largest manufacturer of high temperature superconducting (HTS) tape for high-field fusion magnets.	faradaygroup.com	info @faradaygroup. com	YES
tecnatom	**Tecnatom** Our main activities are focused on services to inspect components and structural integrity, the training of personnel in advanced training environments and support engineering to the operation of plants, relying in digitization tools which support our clients in their path toward the industry of the future, more efficient and sustainable.	tecnatom.es	correo @tecnatom.es	YES
THALES Building a future we can all trust	**Thales** Thales is a long-standing partner of the science community for particle physics and thermonuclear fusion. Building on 70 years of trust, our reliable radiofrequency sources (Gyrotrons, Tetrodes, Klystrons) gives you the vantage point in particle physics, thermonuclear fusion and particle therapy treatment.	www.thalesgroup.com/ en/markets/market-specific-solutions/ microwave-imaging-sub-systems/radio-frequency-microwave-sources-3	terence. schuermans@ thalesgroup.com	YES
ATDG TRIANGLE DESIGN GROUP LLC	**TRIANGLE DESIGN GROUP LLC** TDG specializes in high purity and high integrity gas and fluid handling systems and associated control systems. We are a design-build firm with extensive experience in design and fabrication of small diameter, welded, inert and hazardous gas system to support technologies such as semiconductor, silicon solar cell production, biotech and now fusion. Our expertise in UHP gas flow controls includes custom gas source systems, gas mixing, injection, and system monitoring utilizing the most advanced technologies available.	triangledesigngroup .com	Mike Metcalfe msm@ triangledesigngroup .com	YES

	Company description	Website	Contact Information	Completed Survey?
TRUMPF	**TRUMPF Laser** TRUMPF is a leading manufacturer of industrial lasers and laser systems. It offers a wide portfolio of laser solutions from short pulse to continuous wave, leveraging its broad range of technological platforms and in-depth process knowhow. TRUMPF is vertically integrated, from the development and production of pump diodes to complete laser processing solutions.	trumpf.com	konstantin. boucke@trumpf. com	YES
Westinghouse	**Westinghouse Electric Company LLC** Westinghouse is the world leading supplier of nuclear plants, fuels and services.	westinghousenuclear .com	Edward Lahoda: lahodaej@ westinghouse.com	YES
WOODRUFF • SCIENTIFIC	**Woodruff Scientific** Woodruff Scientific performs R&D under contract to private and public institutions, as well as through awards from the U.S. Department of Energy primarily focusing on the development of fusion energy systems.	woodruffscientific.com	simon@ woodruffscientific. com	YES
CURTISS-WRIGHT	**Curtiss-Wright** Curtiss-Wright Nuclear offers a comprehensive range of products and services that support the global nuclear power industry. Our advanced technologies and innovative solutions have been used in operating reactors for over 55 years, sustaining the safe and reliable operation of nuclear plants throughout the world.	www.curtisswright.com	Scot Leuenroth sleuenroth @curtisswright. com	No
KINECTRICS	**Kinectrics** Laboratory research and testing, Component development, Tritium and Fuel Cycle Expertise, Materials and Metallurgy, Plant Engineering and System Integration.	www.kinectrics.com	Luke Bockewitz, luke.bockewitz @kinectrics.com, or www.kinectrics. com/contact	NO

	Company description	Website	Contact Information	Completed Survey?
DIVERSIFIED TECHNOLOGIES, INC.	**Divtecs** Technology Research and Product Development, Solid State Amplifier, Power Supplies, Solid State RF Sources, Modulators, Solid State Switches, ICRF.	www.divtecs.com	Kathleen Quinlan, quinlan@divtecs.com	N0
BUTTING CryoTech Germany	**Butting** Cryogenic devices, specialized metals, high grade steel, pressure vessels, vacuum insulated piping, cryogenic valves.	www.butting-cryotech.com/en/index.php	Patrice Brossard, Patrice.Brossard@butting.com	NO
OCEM POWER ELECTRONICS	**Ocem** High Voltage Power Supplies, High Current Power Supplies, NBI, ECRH, ICRH, Plasma Heating Systems and Current Drive	ocem.eu	miguel.pretelli@ocem.eu	NO
HTS HIGH TEMPERATURE SUPERCONDUCTORS	**High Temperature Superconductors Inc** High Temperature Superconducting wire manufacture.	hitsuperconductors.com	Adam Shelton, Adam.s@hitsuperconductors.com	NO

FUSION
INDUSTRY ASSOCIATION

Fusion Industry Association
800 Maine Ave SW
Suite 223
Washington, DC 20024
United States

twitter.com/Fusion_Industry
www.linkedin.com/company/fusion-industry-association
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anchor.fm/fusionindustry