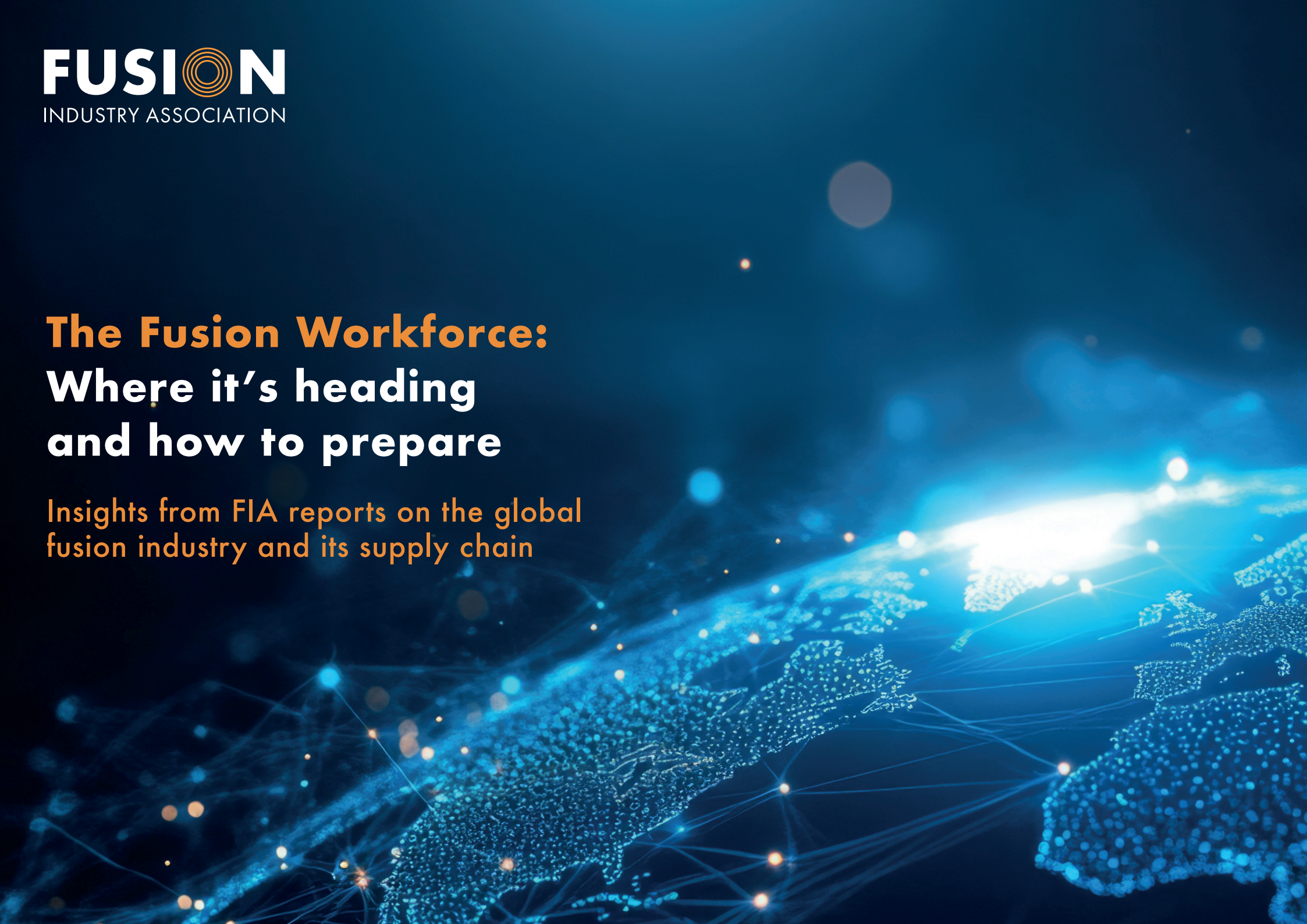
FUSION
INDUSTRY ASSOCIATION

The Fusion Workforce: Where it's heading and how to prepare

Insights from FIA reports on the global fusion industry and its supply chain



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INTRODUCTION

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The fusion industry is growing rapidly. It has attracted over $7bn in investment. Advances around the world are bringing the date of commercial fusion ever closer. As it continues to grow, we will see big increases and changes to the jobs it supports, both directly and through its supply chain.

New companies are emerging every year with new concepts, while others are progressing along their plans, building more advanced machines. With each milestone, companies need bigger teams, more parts, and higher precision. And soon – 89% of fusion companies believe by 2035 – fusion plants will deliver electricity to the grid. When they do, there will be a sudden demand for skilled people who can produce parts and assemble and install fusion machines at a huge scale.

This calls for a much expanded fusion supply chain – in fact, multiple supply chains – which will create many more jobs. Most fusion companies rely on suppliers for parts, like diodes for advanced lasers, superconducting wire for powerful magnets, and specialist components like power electronics and vacuum chambers. There will be a need for these both off-the-shelf and produced to specification by contract engineers. There is also a growing need for digital engineering and AI capabilities for the design and optimization of fusion machines.

The needs in all areas will scale slowly as companies advance the technology, then very rapidly as commercial fusion machines start to be deployed. At that point they will also need subcontractors to build and assemble their designs, so they can meet the vast global demand – beyond their own production capabilities – that will inevitably arise upon the launch of a reliable clean energy source. On top of all this, companies will need people who can build or retrofit power stations for fusion machines (which could look similar in footprint and output to current gas fired power stations, at least at first). And they will need all the services that any infrastructure industry needs – legal services, planning applications consultants, recruitment, finance – all adapted to the specific needs of fusion.

This will mark a rapid expansion of the skills needed by the industry. Whilst many expect that fusion skills will mostly come from physics PhDs, in reality needs are rapidly growing beyond this niche. As concepts are proven, there will be a big increased demand for engineers, manufacturers, installers, and more.

These are jobs that will largely be delivered in the advanced economies that are leading the fusion race – North America, Europe, Australia, Japan, and China – and many of these jobs will need to be physically performed on the power generation site itself. In short, these are home grown jobs that will be based in the countries that lead in fusion.

What needs to be done to support these future jobs and ensure the fusion industry has the skilled, local supply chains it needs? This report proposes some potential solutions – from partnerships with universities to training programs at supplier companies. But the main goal is to provide insight into the current and future fusion workforce, in order to point to where the jobs will be.

In compiling this report, we have drawn on insights from surveys and interviews that we conducted for our 2024 Fusion Industry and Supply Chain reports. While predictions always come with some uncertainty, this provides a valuable indication of the direction of supply chain needs, and the jobs that will be required to support it.

This resource will provide a useful guide for those with a stake in the fusion workforce and help them focus their energy and resources effectively – whether they are individuals considering a career in fusion, companies looking at where to focus training, or universities and governments designing and funding education programs.

THE STATS: How fusion and its supply chain are evolving

Supply chain spend growth, as reported by fusion companies

2022 **$484,900,000**

2023 **$612,184,500***

*likely a significant undercount since not all fusion companies provided spend data

YoY growth in supply chain spend

planned increase in supply chain spend in 2024 vs 2023

Jobs are growing at fusion companies and along the supply chain

Employed by fusion companies (self-reported)

2021 **1,096 (23 companies)**

2022 **1,545 (31 companies)**

2023 **3,073 (41 companies)**

2024 **4,107 (43 companies)**

Jobs supported by fusion companies' supply chain (estimates by fusion companies) **~5,900**

THE STATS: Fusion job opportunities at a glance

Where are the jobs going to be?

The Fusion Supply Chain Jobs: Future demand

Based on fusion companies predicted needs and supply constraints as they scale

THE SKILLS NEEDED IN THE FUSION SUPPLY CHAIN

Specific skills identified by fusion companies and their current supplies as being in future demand, include:

- Skills to develop advanced and specialized components for heat management, plasma-facing first wall, and vacuum pumps/chambers – all the parts that will be needed to create a plasma and then transfer the energy created into a usable power source.
- Precision engineering skills at the cutting edge of what is technically possible on a shop floor, such as for vacuum chambers, HTS wire, and laser components. These will rapidly grow as demand for such components with precise specifications – currently sourced at low volume – scales rapidly.
- Vast increase in the production of power electronics. A mature fusion industry could have an insatiable appetite for an already stretched supply of these components.
- Scientists, plasma physicists.
- Nuclear and plant process engineers.
- Specialist engineering skills for design and assembly of fusion machines and power plants.
- Machine learning and digital approaches to engineering design.
- Those experienced in navigating new regulatory frameworks.

Examples of investments companies are already making to grow their capacity to support the fusion industry...and an indicator of where jobs are coming.

- New HTS tape production facility
- Development of new power electronics technologies
- New cleanroom and orbital welding equipment
- Increased manufacturing capacities for Vacuum and Cryogenic technologies
- Hiring team to develop AI/ML solutions for control and simulation
- Expanded capacitor film production

RECOMMENDATIONS

Workforce development is crucial to large-scale fusion energy production. Through our research and conversations with private fusion companies, a number of requests and recommendations have emerged for initiatives that would support the development of fusion supply chain skills. Where progressed, these should be developed with consideration for future job needs, as outlined in this report.

Strategic Workforce Development Initiatives:

- **Governments:** Establish a dedicated program to enhance education and training in energy-related fields, including fusion energy. This program should actively promote participation of underrepresented groups in STEM fields and provide structured pathways such as internships, fellowships, and apprenticeships.
- Provide grants to educational institutions to establish or expand clean energy education programs, including those that focus on fusion energy.
- Provide grants to businesses that are directly involved in the fusion energy sector, which support the wages and associated costs of trainees during their training period.
- **Governments and Universities:** Collaborate and invest in new university courses, short skill-specific training programs, apprenticeship programs, and workforce accelerators tailored to fusion industry needs discussed in this report.
- **Universities:** Develop and expand educational and vocational training programs specifically designed for the fusion energy sector.
- **Fusion Companies/Supply Chain:** Form academic partnerships with universities and other relevant partners to co-develop courses and training for the future workforce. This will include fusion-specific courses, but also ensure fusion's needs are considered in other areas such as machine learning and AI, nuclear engineering, and project management.
- **Fusion Supply Chain:** Invest in workforce development initiatives to meet the increasing demand for skilled professionals in areas such as in precision engineering.

Establish Regulatory Frameworks and Incentives:

- **Governments:** Create clear and specific regulatory frameworks tailored to fusion energy, and separating it from fission. The certainties that such frameworks bring will de-risk long term investments by industry, including in training programs.
- Ensure fusion energy receives the same fiscal incentives as other clean energy technologies to stimulate growth and investment in jobs.

Public-Private Partnerships:

- **Governments:** Foster public-private partnerships to combine public sector experience with private sector efficiency. This can reduce costs, share risks and rewards, and speed up commercialization efforts, whilst creating jobs and apprenticeships aligned to delivering project milestones.

Online Resource Center and Skills Guidelines:

- **Governments:** Develop an online resource center to offer competency models, career mapping, and skill assessment tools for fusion energy, routinely updating each through alignment with industry demands and technological advancements.

Support Research and Technology Development programs:

- **Governments:** Provide robust funding for research and development initiatives, including grants and investments in university research programs, national laboratories, and private sector innovation.

International Collaboration:

- **Governments:** Engage in international efforts to set standards and best practices, and share expertise.
- **Fusion companies/supply chain/trade bodies:** Set up specialist technical forums that delineate specific areas of the fusion plant development process, or which are sub-component specific. These would allow specialized players to collaborate internationally, encouraging knowledge sharing, and cultivating fusion-specific expertise.

Targeted Support for Diverse and Displaced Workers:

- **Governments:** Increase outreach to minority-serving institutions and provide targeted support for unemployed and displaced workers – for example those leaving the fossil fuel sector – to enable transition into fusion energy roles including facilitating access to training programs and career opportunities.

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