



**FUSION
FOR
ENERGY**

Building the European Fusion Supply Chain

2007 – 2026

Developing Industrial Capabilities,
Skills and Expertise



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Summary

Since 2007, F4E has transformed Europe's fragmented fusion research and industrial base into a continental ecosystem capable of designing, manufacturing and delivering first-of-a-kind components suitable for reactors. Working with the EU public procurement framework, F4E designed innovative strategies and toolbox of agile procedures suitable to industrial needs, strategically managed intellectual property, developed market intelligence to involve the supply chain from the start, while balancing risks responsibly. This way, we transferred know-how from the research community to industry, reduced technical and commercial barriers, encouraged competition and enabled suppliers to progress from R&D to series industrial production.

Building on this expertise, F4E enriched its procurement functions with industrial-policy insight. Supplier relationship initiatives include the Small and medium-sized enterprises (SMEs) roadmap, the Technology Development Programme (TDP), technology-transfer instruments and private-sector collaboration frameworks. These industry engagement mechanisms support innovation, supply-chain resilience and the preservation of critical European capabilities. The combination of these elements provides solid know-how, managed by one organisation, to align public investment, industrial capacity and emerging private fusion initiative.

Europe must now convert this knowledge into industrial leadership. Fusion expertise is perishable if specialised production lines, qualified teams and system-integration skills are not maintained through a credible pipeline of demand. By anchoring the completion and exploitation of ITER, Japan-Torus60 (JT-60 SA), International Fusion Material Irradiation Facility Demo oriented Neutron Source (IFMIF-DONES), Divertor Tokamak Test facility (DTT), or future pilot plans, the EU can invest wisely, reinforce strategic autonomy and accelerate commercial fusion.

F4E has the mandate, procurement expertise, supplier networks and industrial-policy tools to support the implementation of the future EU fusion strategy. It can help build a sovereign, competitive and European-wide fusion ecosystem.

Key messages

Since 2007, F4E has used strategic procurement, industrial partnership and technology development to turn Europe's fusion expertise into a continent-wide industrial capability. The following messages capture the principal conclusions of this publication.

1. **F4E has transformed European fusion know-how into industrial capability.** Through staged and collaborative procurement, early industrial involvement, balanced risk sharing and structured management of intellectual property, F4E has enabled laboratories and companies to progress from research and prototyping to series manufacturing of reactor-scale components.
2. **Europe now possesses the largest fusion supply chain, with proven economic and technological value.** More than 7 billion EUR invested through over 1,400 contracts has mobilised around 2,700 companies and 75 R&D organisations. Independent analysis links F4E's 2018–2024 activities to 5.95 billion EUR in Gross Value Added and 39,000 job-years. This investment has also generated new skills, know-how and market opportunities beyond fusion.
3. **The supply chain is delivering and it must be sustained through continued demand.** F4E and its contractors achieved 91% completion of planned activities for 2025, supported by professional procurement, thanks to disciplined contract management and strong supplier partnerships. Sustaining these capabilities, resulting from ITER, IFMIF-DONES, DTT, requires a credible European plan to provide for the needs of future fusion plants.
4. **F4E is ready to execute the next phase of Europe's industrial fusion activity.** Its established procurement mandate, supplier networks and industrial-policy instruments such as SME support, technology development and transfers, private-sector collaboration illustrating Private Public Partnership principles, and market intelligence, offer an organisation ready for the roll out of a competitive, continental fusion ecosystem. The F4E environment provides the conditions for European sovereignty in developing safe and clean fusion energy.

¹ Including contractors and companies engaged in pre-procurement activities

01

The creation of the European fusion supply chain since 2007 has been led by Fusion for Energy

By placing large complex contracts² for the manufacture of ‘first-of-a-kind components’ F4E established an industrial learning programme. Its objective was to transfer European know-how from laboratories to industry. Thanks to systematic and full-cycle contract management, F4E built and structured a robust portfolio of Intellectual Property Rights to support such know-how. As a result, F4E has been able to comply with its obligations under the ITER Agreement while protecting the sovereignty of the European supply chain for fusion.

F4E transformed Europe’s fusion supply chain from a fragmented research landscape into an industrial ecosystem capable of delivering reactor-scale components.

The initial market conditions

At the outset, F4E often operated in a very restricted market and therefore developed strategies that considered the European markets’ actual capacity and appetite for the development in fusion technologies. Such strategies were implemented using the tools available within the EU public procurement framework applicable to F4E under its Financial Regulation. Industrial suppliers needed to strengthen their technical capabilities whilst also protecting their commercial interests. F4E therefore built robust partnerships with European industrial actors and laboratories to accelerate fusion innovation.

Innovative Procurement Strategies

Since the very beginning F4E adapted its procurement strategies to the scope and specificities of the large, complex and first-of-a-kind projects that it manages. These strategies are illustrated hereunder with examples from ITER components in areas such as In-Vessel, Gyrotrons, Vacuum Vessel, Magnets.

²Procurements launched in 2008-2009 for the manufacture of Superconducting magnets, Vacuum vessel components, cryogenics and plasma systems

A partnership with industry for design development and manufacture of the In-Vessel components

The EU's objective of increasing competitiveness relies partly on boosting innovation and research within industry. F4E incorporated this concept into its strategy for several components of the in-vessel first wall with very precise design requirements, and specific materials requesting innovative techniques, to manufacture them correctly.

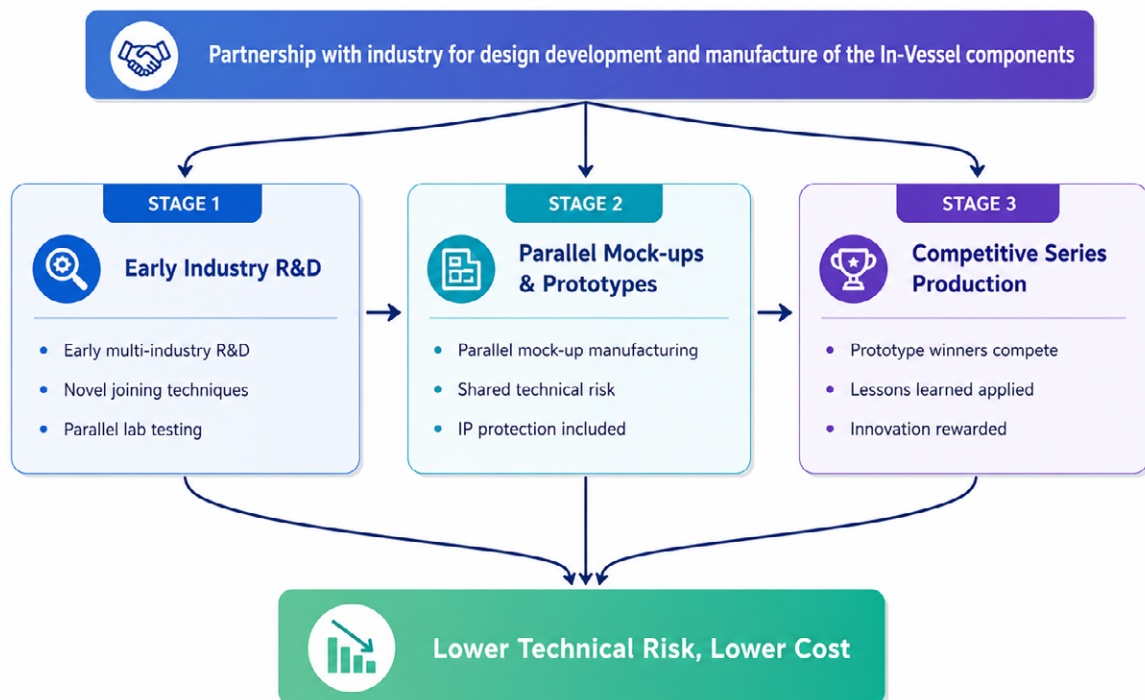
F4E developed a staged approach to procurement, designed to reduce technical risk and contain costs. Key to this was the early involvement of multiple industries in the initial R&D activities that helped to reduce overspecification, and allowed research into specialised techniques in order to join distinct materials. Laboratories and universities led parallel efforts on testing and the analysis of results.

During the second stage of the strategy, several companies worked in parallel to manufacture mock-ups and prototypes. They refined joining techniques, with each using their own specific engineering know-how and experience to identify gaps in the requirements and reduce risks. This stage included a tailored risk-sharing mechanism to address the economic consequences of technical failures, as well as provisions for investigating issues and implementing corrective actions. Specific conditions on intellectual property were included to foster innovation and safeguard breakthroughs.

The third, and final stage of the strategy, saw those companies that had produced successful prototypes compete for contracts paving the way to series production. These companies had to compete on the robustness of their technical understanding. They applied lessons learnt from prototyping into their manufacturing and tendering strategies. Apart from reducing technical risks, this staged strategy lowered bidding costs and the risk of cancellation.

In-Vessel Components: A Staged Procurement Approach

Reducing technical risk and containing costs through progressive industry involvement



The Gyrotron case: securing Critical Technology for Europe in an initially fragile market

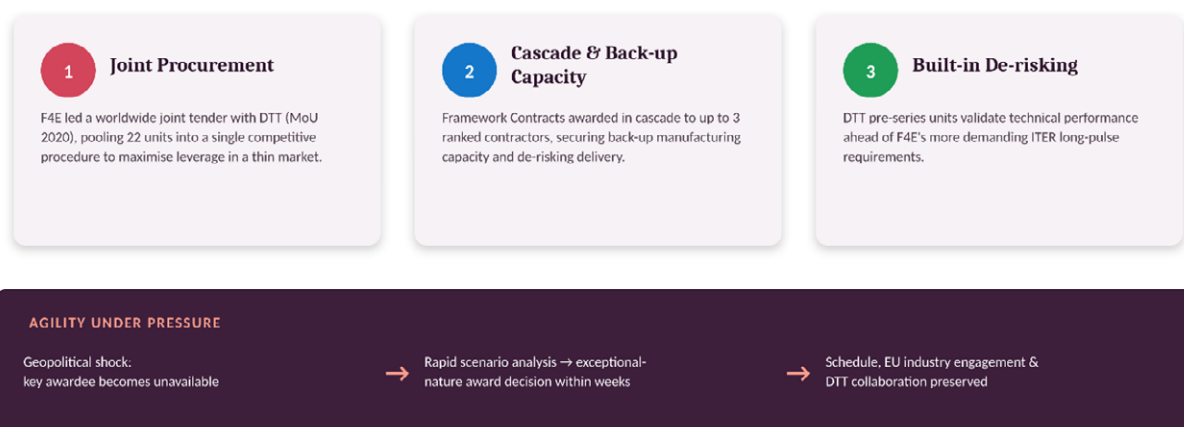
F4E has shown a notably adaptive and pragmatic approach to procuring Gyrotrons, a highly strategic item constrained by an extremely narrow global supplier base. Both F4E and the contracting authority for the Italian Divertor Test Tokamak (DTT) were conscious of the fact that neither could secure a competitive environment or economies of scale acting alone. Consequently, F4E developed a Joint Tender Procedure with DTT under a 2020 Memorandum of understanding (MoU).

The procedure combined 6 ITER gyrotrons and 16+ DTT gyrotrons into a single worldwide competitive procedure with negotiation, awarded through cascading Framework Contracts to up to three ranked contractors. The procurement built in customised price-quality weighting and bulk-discount mechanisms to capture economy-of-scale savings. Technical risk mitigation was ensured by using the DTT pre-series units as a proving ground for F4E's more demanding ITER pulse-length requirements. The strategy's resilience was tested when the Russia's invasion of Ukraine, removed a viable awardee shortly after evaluation. This reduced the intended two-contractor cascade into a de facto sole-source situation. F4E assessed the available scenarios and moved quickly to an exceptional award rather than cancelling and restarting an EU-only negotiation. The lessons-learned (for example o joint-team governance, MoU drafting, and avoiding rigid dates) have been exploited by F4E in subsequent procurements.

As a result, F4E adapted its procurement architecture to a severely restricted, geopolitically exposed market. In doing so it, secured timely delivery of the DTT prototype and preserved competitive and cost benefits. The case illustrates the limits of procurement strategy alone to fully insulate strategic supply needs from external shocks.

Gyrotrons Procurement: Agility in a Strategic, High-Risk Market

F4E-DTT Joint Tender (F4E-OMF-1108) · RF Sources for ITER



F4E-OMF-1108 · Supply Chain Strategy Group

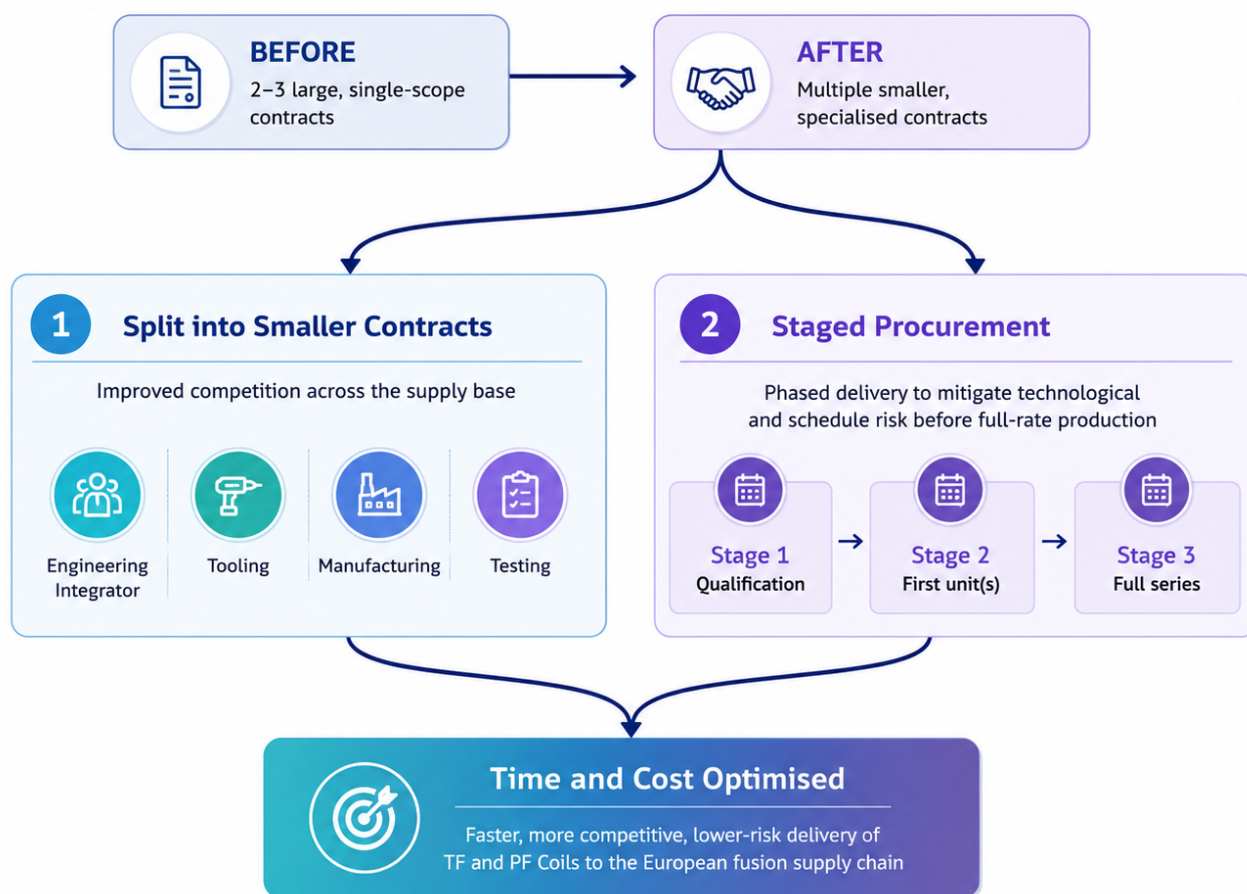
Shaping the European ecosystem

Where appropriate, contracts awarded by F4E encompass a large scope to frame the responsibility of the manufacture with a unique contractor or consortium having a supply chain under their control. This was the case of the manufacturing of the **European ITER Vacuum Vessel sectors**. The contract for the manufacture of seven sectors of the vacuum vessel was signed in 2010 following a negotiated procedure. The final European sector has been delivered on the 5th October 2026.

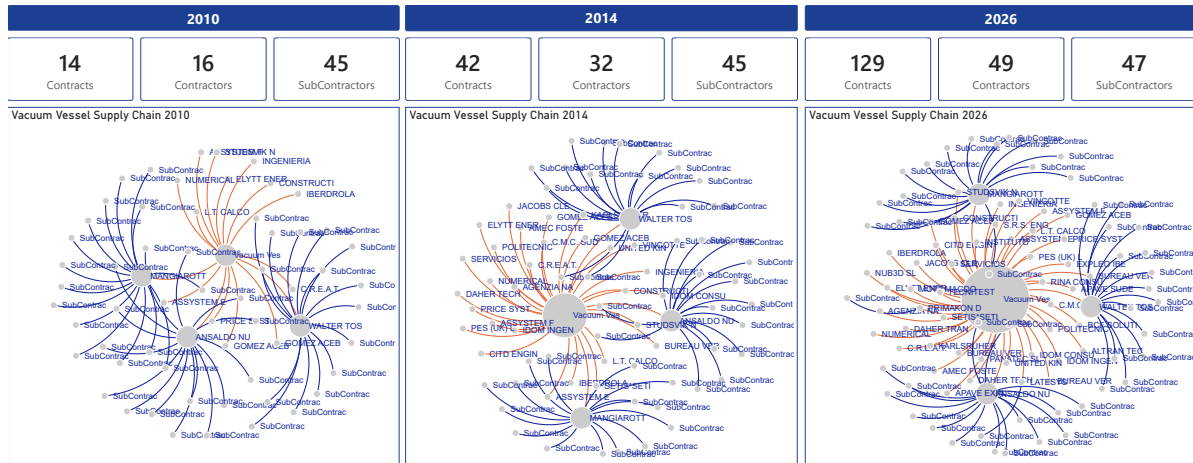
In a different context, **the ITER Toroidal Field (TF) Magnets** project was split into several main packages. The core contract (Winding Packs manufacturing, WP) was signed in 2010 and was concluded in 2021. The last fully assembled TF magnet was delivered in 2023. To promote competition, the subsequent procurement of the ITER Poloidal Field (PF) magnets by F4E, the original procurement strategy was further defined, by placing six contracts in a staged approach improving the overall competition. The PF coils manufacture was broken down into one contract with the engineering integrator in charge of the oversight of the manufacturing process, one contract for site and infrastructure, one for the coils manufacture, two contracts for tooling and one for the test facility. The last PF magnet was delivered in 2024.

Magnet Procurement Strategy Optimisation

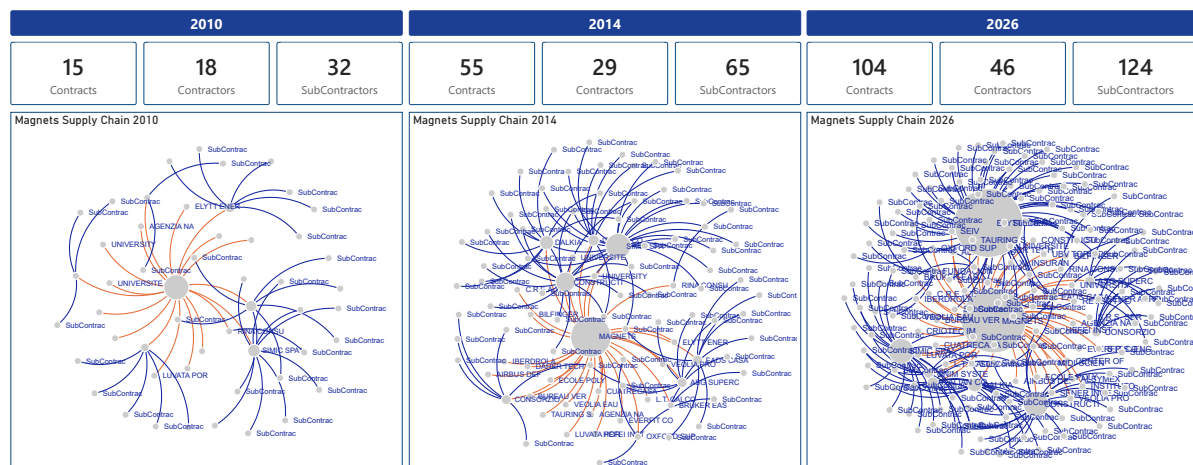
TF Coils & PF Coils — from single large-scope contracts to a split, staged, tooling-optimised supply chain



Those complex and long-lasting contracts shaped the European ecosystem and mobilised a substantial part of the available actors in Europe as shown below for the evolution of the supply chain of the Vacuum Vessel and Magnets. Overall F4E's supply chain has grown around 500 % since 2010.



Vacuum Vessel Supply Chain evolution 2010–2026 (Source: F4E supply chain database)



Magnet Supply Chain evolution 2010–2026 (Source: F4E supply chain database)

Such staged strategies also involved tailored contract schemes aimed at sharing capital investment and manufacturing risks. In some cases, such schemes were not simply “nice-to-have” but were essential due to the level of risk linked to particular components. In this regard, F4E was able to exploit close relations with other big science organisations like CERN and the European Space Agency. Benefitting from their experience was a factor of re-assurance for stakeholders demonstrating F4E alinement on standard approach across Big Science Organisations (BSO).

A solid communication strategy and dissemination set-up

In order to ensure broadest participation and interest, F4E's practice was to distribute early information about the future work programme(s) and to make business opportunities accessible and easy to find. F4E publishes prior information notices, contract notices, market surveys, information days, call for tender, award notices on its Industry Portal. With time, the F4E Industry Portal became the place to find fusion business opportunities. In addition to the Official Journal of the European Union, information was also disseminated via the F4E Industrial Liaison Officers (ILO) network.

From the start, F4E deployed a wide **Market Intelligence toolset** (market analyses, surveys, database, suppliers feedback etc.) to prepare markets, identify potential bidders and analyse industrial alternatives. F4E also introduced Information Days to explain the business opportunities and associated tender documentation to the potential bidders. This practice helped to foster meaningful dialogue, enabled networking between industry actors, provided concise explanations on requirements and administrative modalities in relation to published documentation.

Communication actions were designed to raise awareness on various fora such as Industrial Days, ITER Business Forum, Big Science Business Forum, World Nuclear Exhibit and the biennial Symposium on Fusion Technology. Early interaction between F4E and European actors, whether industry or laboratories, conducted under appropriate conditions safeguarding transparency and fairness, also supported a more strategic approach to the supply chain management. It enabled F4E to contribute more effectively to negotiations with the ITER Organization (IO) on the scope and details of in-kind contributions, while serving cost-containment objectives by removing requirements that would be unrealistic or impossible for the market to achieve.

In this context, the **Industry Liaison Officers (ILOs)** nominated by most F4E Members, through their close links to national industrial and research actors, played a key role by establishing an open dialogue with those communities. ILOs help F4E to better understand market interests and capabilities, act as facilitators for the formation of transnational consortia while supporting national actors to understand F4E's needs and the objectives of the ITER project. ILOs are invited every two months to dedicated exchanges with F4E, where they receive an overview of upcoming calls for tender, the status of market surveys, and other relevant procurement developments. They are an important channel of communication with industry regarding F4E's TDPs (see section 3) and keep European industries informed about the F4E Technology Transfer Open Calls, such as the annual Demonstrator projects, and the Fusion Technology Transfer Award.



Country
AUSTRIA
BELGIUM
CZECH REPUBLIC
DENMARK
ESTONIA
FINLAND
FRANCE
GERMANY
HUNGARY
IRELAND
ITALY
LATVIA
MALTA
NETHERLANDS
POLAND
PORTUGAL
SPAIN
SWEDEN
SWITZERLAND

ILO representation in F4E member states (Source: F4E supply chain database)

02

F4E procurement expands the European fusion ecosystem

Applying Lessons learnt

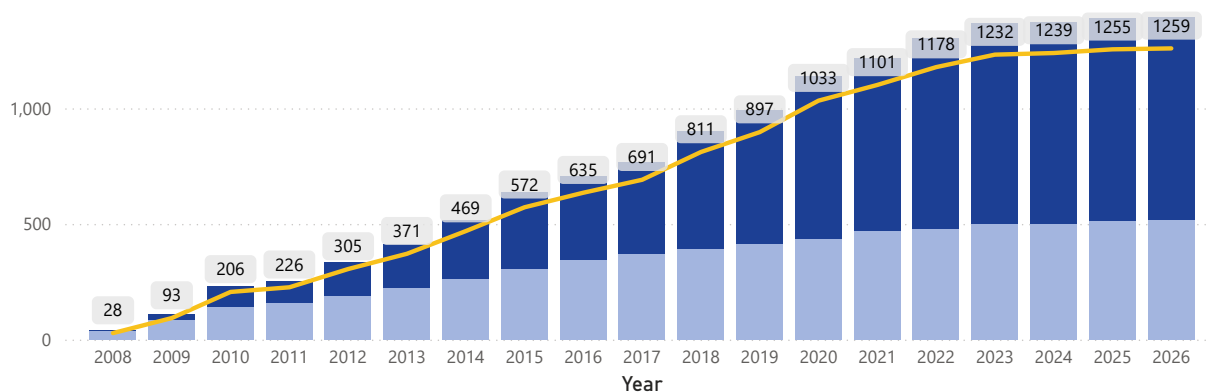
Building on the experience gained from the first contracts, and the adoption of an Industrial Policy by its Governing Board in 2012³, F4E progressively structured its procurement strategies to better reflect the realities of the European fusion market and the complexity of ITER and Broader Approach (BA) respective supply chains.

This evolution aimed to further increase industry's interest and participation, by calibrating requirements and obligations so that the market could absorb, drawing on lessons learnt from procurement and project execution. Consequently, F4E moved towards a more balanced and genuine risk-sharing approach in the contractual instruments for the supply of the EU contributions to the ITER and BA projects.

F4E's Industrial Policy sets the direction on Intellectual Property (IP) oriented to Europe's industrial competitiveness. The use of IP rights is such so that industry can benefit from the work beyond the scope of the F4E contracts. With this in mind, F4E's intellectual property management helps companies to operate in fusion and non-fusion markets, while ensuring full compliance with F4E's international obligations.

Cumulative of Contractors and Subcontractors

● Contractors ● Subcontractors ● Total



Growth in the supply chain considering the number of entities, following the number of contracts signed by F4E since 2008.

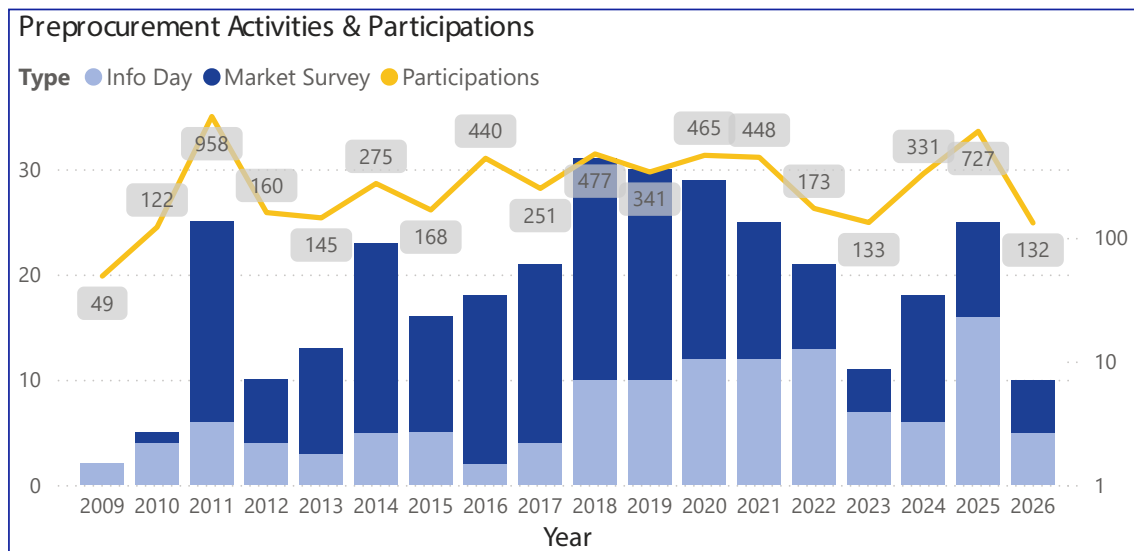
³11 December 2012 Decision of the Governing Board of the European Joint Undertaking for ITER and the Development of Fusion Energy adopting an Industrial Policy F4E(I2)-GB26-10.4

A sourcing strategy implementing F4E's Industrial Policy

During the pre-procurement analysis, F4E investigates the capability, maturity and capacity of potential suppliers. As of 2012, F4E further reinforced the application of its Market Intelligence toolset, while developing new action lines such as:

- Production of industrial mappings in advance of tenders to stimulate interest and facilitate consortium formation;
- Active gathering of Market Intelligence by visiting European industry and Fusion Research Laboratories, explaining F4E technical requirements and exploring technical solutions and fabrication strategies;
- Consultation with external technical expertise when needed;
- Targeted dissemination efforts in Member States with a perceived lower-than-expected participation to calls for tenders;
- Automatic business opportunity alerts to Suppliers registered in F4E's Industry Portal according to their business interests.

the view below shows the scale of pre-procurement activities over the years which enabled F4E to grow its supply chain substantially, i.e. around 500% since 2010.



Overview of pre-procurement activities from 2009 to 2026 (Source: F4E supply chain database)

An innovative Procurement Toolbox

Based on the expertise acquired during the initial years, F4E adapted its procurement process aiming to broaden participation by increasing competition, making entry requirements suitable for industry and laboratories.

F4E adopted measures fostering innovation such as use of competitive procedures with negotiation or dialogue, simplifying administrative formalities, avoidance of overspecification of technical qualification and certification, prohibition of unnecessary financial restrictions; while preserving the essential features needed to mitigate risks of regulatory non-compliance.

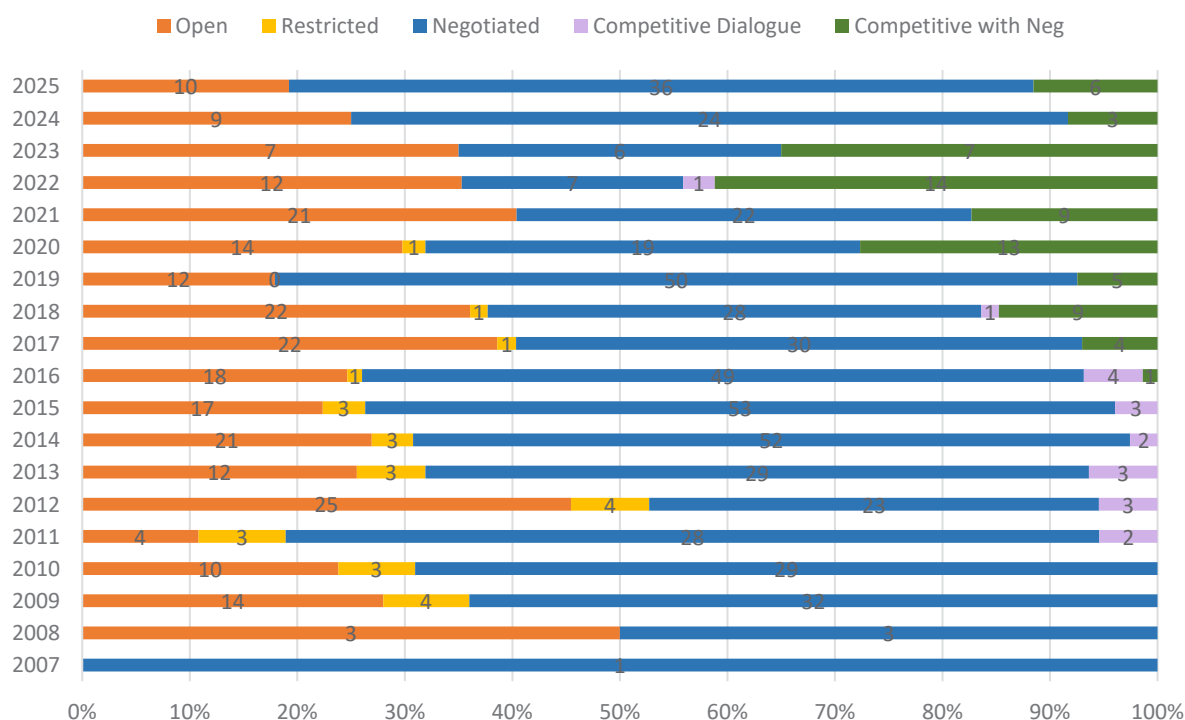
Within the boundary conditions of the [F4E Financial Regulations and its Implementing Rules](#), F4E focused on the use of the agile procurement and contract management practices. As a result, F4E increased the attractiveness for industry and demonstrated that the EU public procurement frameworks are suitable for complex projects. F4E supports bidding mechanisms in stages which reduce tender risk premiums and transaction costs associated with public procurement.

F4E is also fully aware of the resources deployed by suppliers during the tendering phase. Large and complex tenders require an intensive effort and under competitive bidding only one tender will be successful. Tenderers are often unwilling to disclose full details (possibly including proprietary information) of a manufacturing process in advance of being awarded a contract. The risk either deters potential bidders or leads to higher prices for F4E – both of which need to be avoided.

F4E's approach has been to reduce to the maximum possible extent the administrative and technical requirements in the bidding process. By opting for **interactive multi-stage procedures** (restricted, competitive with negotiation and competitive dialogue) F4E considerably reduces the initial investment on resources and volume of information disclosed by tenderers.

This approach also provides bidders with more clarity on the scope and requirements of the tenders. It strengthens mutual understanding of the technical solutions adopted, provides an opportunity to give constructive feedback to ITER Organization on design and topics on manufacturing. Last but not least, it improves the efficiency of contract management.

As indicated in the figure below, the procurement procedures designed for contracts of a complex scope are the preferred procurement tools: since 2009 the share of negotiated, competitive dialogue and competitive with negotiation represents more than 50% of operational procurement procedures.



Number of operational procedures awarded by type of procurement procedure. (Source: F4E annual activity reports)

F4E exploits its procurement tools to facilitate the Industrial Policy objectives while maintaining legal and regulatory compliance, around the following main concepts:

1. The **scope and maturity of the technical specifications** agreed with the ITER Organization (IO). When the specifications allow flexibility, F4E uses dialogue or negotiation to optimise the scope and reduce costs during tendering. Technology readiness levels of the key technologies are assessed to determine the need for specific strategic and contractual features.
2. The **risks and opportunities** identified and consolidated during the early pre-procurement phase are monitored, mitigated or maximised through the procurement strategy and model contract features. Examples include early qualification of materials, components or specific processes and the identification of specific risks that require contractual negotiation (e.g. activities needing R&D).
3. **Exploring synergies** via the use of frameworks, agreements with the European Commission, joint procurement opportunities with other organisations. Such synergies achieve a greater impact in a restricted market where common interests can be better managed in a single contract, e.g. health and safety inspections, transportation, and site insurance. A concrete example was the pre-procurement activities linked to Radiological Environmental Monitoring System procured by F4E. ITER IO made a magnetic test facility available for manufacturers to test their equipment prior to the launch of the procurement. This helped set the appropriate level of technical requirements.
4. Adapting **IP management** to the needs of contractors/subcontractors that seek to commercially exploit their innovations and developments in the market.
5. Actively advertising the support of F4E for **commercial development** beyond the term of the contract, via technology transfers.
6. Feedback from **Industrial Liaison Officers (ILOs)** to ensure that industrial concerns are considered when developing procurement strategies.

Gaining efficiency through contractual strategy

F4E is committed to procuring ITER and Broader Approach scope more efficiently, thanks to special efforts shaping the upstream conditions of procurement, early involvement from supply chain and better risk sharing in contracts:

- **Control and optimisation of the scope of the EU obligations:**
 - Encourage the sharing of industrial scope in order to create opportunities for the EU industrial and research capabilities, by reducing interfaces and control integration costs;
 - Assess technical specifications based on traceable and quantifiable requirements, to consider the full lifecycle costs of the EU scope (procurement, commissioning, operation, maintenance and disposal).
- **Early partnership with EU industrial and research actors, to ensure that subsequent competition remains transparent, fair and unbiased:**
 - Engage with associations and networks representing the relevant EU industrial and research sectors alongside the definition of Procurement Arrangements.
 - Promote the participation of industry and research organisations in pre-procurement R&D and design activities, through grants or dedicated R&D contracts, supported by clear and fair rules on intellectual property, information sharing and exploitation that do not unduly limit future competition;
 - Facilitate long term collaboration between European Fusion Laboratories (EFL) and industry via joint events, with special focus on technology and know-how transfer from the research to the industry ensuring that the appropriate skills and expertise are available through the design/manufacturing/operation lifecycle of the components and will contribute to the overall competitiveness of European R&D and industrial players.
- **Assessing and managing the risks related to scope, schedule, cost and resources:**
 - Accept a balanced risk allocation between F4E and contractors, with the objective of creating value for both parties by allocating each risk to the party which is best suited to manage it.
 - Reduce build-in financial contingency for risk and overheads. F4E revised its model contracts on the basis of lessons learnt and negotiations with economic operators while preserving the key risk-mitigation elements for the benefit of the project. In particular, adaptation of payment schedules to fit an appropriate pace of completion of the project together with a proportional cashflow; and the adaptation of financial threshold for requiring performance and advance payment guarantees, especially in the case of relatively low value contracts for which the marginal cost of setting up and managing guarantees would offset any net benefit.

KEY MESSAGE

With added focus on market intelligence, upstream inputs and feedback from industry, adapted procurement and contract strategies, F4E helped scale Europe's fusion supply chain into the largest in the world.

03

F4E activities structure and support European competitiveness

As presented in the [13th annual assessment](#) of F4E, “F4E activities have strengthened European industrial competitiveness in the fusion domain and beyond. While 53% of F4E contract spending is directed towards buildings and site facilities (...) the remaining 47% was allocated to develop the high-tech components of the ITER machine. (...) Through F4E contracts, European firms have built recognised expertise in high-tech, fusion-related fields such as vacuum vessels, magnets, heating systems and cryoplants, while also enhancing their credibility and reputation as reliable, high-quality providers. This visibility has opened access to new markets both inside and outside the fusion sector, allowing EU companies to translate the demanding experience of ITER and Broader Approach into competitive advantages across a range of high-technology industries. (...) Despite strong international competition, EU firms are well positioned in different supply chains, including vacuum vessel manufacturing, magnet production, cryoplants, blankets, tritium handling, divertors, and wall materials.”

F4E investments in high-tech components of the ITER machine and Broader Approach have “effectively strengthened European industrial leadership, generating technological spillovers and competitive advantages that extend well beyond the fusion sector.”

Substantial economic benefits from F4E activities and European fusion investments

EU investment in fusion via F4E activities has a clearly positive impact on Europe’s economy and industrial competitiveness. The above-mentioned independent [report](#), conducted by institutes [CSIL](#), [Trinomics](#) and [Cambridge Econometrics](#), highlights the ripple effect from F4E’s activities, revealing returns in knowledge, growth and jobs for the companies involved.

Since its creation in 2007, F4E has invested over 7 billion EUR to provide Europe’s contribution to [ITER](#) and other international projects through more than 1,400 contracts. This has shaped the largest fusion supply chain in the world, with some 2,700 companies and 75 R&D organisations. Besides the infrastructure and technologies delivered, the analysis shows the far-reaching benefits resulting from these funds.

In the period from 2018 to 2024, F4E’s investment amounted to nearly 5.6 billion EUR (in 2024 prices). Such expenditure generated an estimated 5.95 billion EUR in Gross Value Added (GVA), compared with a no-spending scenario. These activities also sustained an average of 5,600 additional full-time jobs per year in the same period (a total of 39,000 job-years). Looking ahead, F4E’s contributions are expected to yield 9.88 billion EUR in GVA and 4,500 jobs per year from 2025 to 2039.

In terms of sectors, business services, industry and construction have benefited the most from these activities. This underscores how projects like ITER rely on advanced manufacturing capabilities and highly skilled services, stimulating innovation in those fields.

Companies that collaborated with F4E experience positive outcomes, both in technical capabilities and market position. Surveys conducted within the frame of this independent study show, for example, that 66% of firms reported that their staff had acquired new skills, while 73% acknowledged enhanced know-how, driven by ITER and Broader Approach's complex requirements. In addition, collaboration with F4E strengthened firms' internal capabilities beyond technical areas, including valuable knowledge of public procurement. Participants to the survey also reported gains in knowledge exchange through collaborative partnerships driven by F4E procurement, identified as a key driver of their capability development.

There is, therefore, a clear return of investments from F4E's fusion projects for the EU economy. The benefits translate in an increased industrial competitiveness for the European ecosystem as a whole, with plenty of examples of technological spin-offs, new business lines or job creation.

KEY MESSAGE

The European fusion supply chain has become economically significant, technologically mature and increasingly central to EU competitiveness.

A mature procurement organisation

F4E benchmarks its procurement and contract management performance voluntarily against the indicators used in the European Commission's Single Market Scoreboard for access to public procurement. For example, on decision speed – the time between the deadline for submission of offers and the signature of the contract – F4E's internal target of 88 calendar days compares favorably with the Scoreboard's satisfactory-performance threshold of 120 days for Member State authorities.

As indicated in the [13th annual assessment](#), "F4E's management of procurement and contracts has positively evolved over the years." The table below summarizes the efficiency gains obtained for multiple procurement and contract management processes.

Most of the companies replying to a survey in 2024 declared to have had a good relationship with F4E during the management of their contracts. F4E's interactions are positively perceived as 'technically competent and procedurally sound. Suppliers reported high levels of clarity in communication, responsive staff, and a shared understanding of contractual expectations. It was recognised that communication with F4E was well-structured and effective throughout the contract execution and that, when issues arose, F4E operational staff engaged in constructive dialogue to find solutions, rather than rigidly enforcing contractual clauses. A constructive, pragmatic approach prevails in most cases. However, respondents admit that F4E should still do efforts to avoid heavy bureaucracy.

When asked about their satisfaction with various aspects of the procurement processes, more than half of surveyed firms replied positively. These assessments ranged from 91% of satisfaction for the procurement e-submission tool to 57% for the management of compensations in cases of deviations from the technical specifications.

INDICATOR (DAYS)	BEFORE 2017	END 2020	END 2021	END 2022	END 2023	END 2024	EFFICIENCY GAINS (2024/BEFORE 2017)
Time to procure	287	189	183	184	185	181	37%
Time to sign a contract	41	11	14	13	27	26	37%
Time to prepare technical assessment report of the supplier deliverables related to a payment	16	12	8	11	7	7	56%
Time to pay before 30 days	23	15	13	19	16	18	22%
Time to perform a contractual deviation	90	36	49	49	46	40	56%

Extract from 13th Annual assessment Report: Efficiency gains in procurement process.

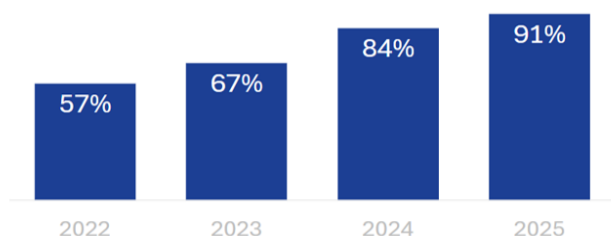
Reinforcing relationships with the Key Account programme

F4E has invested in building a strong relationship with its contractors to face the changes and challenges of its projects and moved towards a structured approach to managing strategic suppliers. The Key Account programme drives engagement from both F4E and the suppliers, effectively transforming contractors into partners. The overall aim is to establish long-term collaborations ensuring stability in the delivery of critical components and guaranteeing optimal contractual performance while managing technical complexity and unexpected external factors or events (e.g., supply shortages, pandemics). F4E assigns Key Account Managers to build effective contract management and mutual trust. Beyond the operational level, F4E invites its Key Accounts for dialogue on strategic or innovative topics (e.g. sustainability, intellectual property strategy in fusion) and feedback on contractual models.

F4E's supply chain delivers on its commitments

In 2025, F4E and its contractors achieved 91% on-time delivery for its project milestones– a record performance for F4E and a very solid result for a first-of-a-kind international project, demonstrating Europe's capacity for industrial delivery. This performance was earned, not given: the early phases of ITER and Broader Approach presented the difficulty of industrialising first-of-a-kind fusion technology, with well-documented schedule and cost challenges during those years. The

contract-management discipline, governance reforms and supplier partnerships built in response are precisely what today's delivery record rests on.



Evolution of F4E Schedule Performance Index from 2022 to 2025. (Source : F4E annual activity reports)

Europe's progress in ITER and BA projects increased the industry's level of maturity and created capabilities that can be leveraged in other sectors. In several areas, such as [in-vessel components](#), Europe has seen an industrial transition from prototyping to series production. This development has entailed the deployment of bespoke production lines with specialised tooling and the construction of new factories to industrialise production.

The EU's industrial fusion capability covers a vast spectrum of technologies from material engineering, precision manufacturing to system integration. This breadth of skills shows that the European supply chain is not just about manufacturing but is also nurturing system integrators, technology developers and engineering partners. This progression marks the move from an **R&D focus to industrial scale delivery**.

Strive for Excellence

Engaged into continuous improvement, F4E is striving for excellence and has launched various initiatives to remain best in class⁴.

• STEPS methodology

F4E's procurement methods are being subjected to independent benchmarking. Under an agreement concluded with the OECD⁵ in 2026, the OECD's Support Tool for Effective Procurement Strategies (STEPS) is being applied to F4E's procurements for the DONES programme, bringing international scrutiny to assess how Europe's work for a next-generation research infrastructure.

• Collaborative contract model

F4E's efforts to align its contractual provisions to best practice in the sector led to the creation of a [model collaborative contract](#). Developed by F4E together with King's College London and the support of industry experts, it was presented at F4E's [Supply Chain Days](#) in 2025. This new contractual model has been created for future fusion projects, facilitating public-private partnerships thanks to its collaborative approach. Reflecting international best practice, it standardises what worked well for ITER and Broader Approach and proposes innovative solutions to ensure the successful delivery of a future EU power plant.

⁴ [F4E Supply Chain Days bring together European companies of different sizes – Fusion for Energy](#)

⁵ Organisation for Economic Co-operation and Development The OECD is a forum and knowledge hub for data, analysis and best practices in public policy. They work with over 100 countries across the world to build stronger, fairer and cleaner societies – helping to shape better policies for better lives.

• A specialised fusion match-making tool

F4E invested in the continuous improvement of its [Industry Portal](#) to allow easy and timely access to tender-related information. The F4E portal offers [a tool](#) for the identification of possible partners in the creation of cross-border consortiums to respond to calls for tender. By increasing the visibility of European companies, showcasing upcoming calls for tender and success stories, the F4E Industry Portal helps potential tenderers access business opportunities in fusion, while the [SME Channel](#) allows smaller companies to find partners, information and targeted resources.

• Recognising supplier excellence

In July 2026, F4E launched its first Supply Chain Excellence Award. It's an open, non-monetary award across five categories – delivery, innovation, sustainability, SMEs and collaborative partnership – with winners to be announced at the Big Science Business Forum in Maastricht in October 2026. The goal is to recognise outstanding contributions by companies involved in F4E's projects. Even if ITER has not yet yielded scientific results, the industrial efforts to build it have already created many examples of excellence, which deserves to be celebrated.

In fact, in a recent survey, suppliers had already signaled the value of their collaboration with F4E in terms of reputation. Eight in ten report that working with F4E increased their visibility and credibility, while two thirds formed new collaborations and more than half found it easier to attract talent. The award amplifies the value these companies already earn and draws on established practice among F4E's peer organisations

Shaping competitiveness for future needs: Industrial Policy Implementation Plan

Following a review of its Industrial Policy in July 2023, the F4E Governing Board endorsed the Industrial Policy Implementation Plan (IPIP), a set of complementary action lines covering strategic procurement, SME-targeted measures, the Technology Development Programme and structured coordination with EUROfusion, subsequently extended with dedicated action lines on private sector and supply chain engagement.

Taken together, these action lines constitute **the only structured industrial-policy implementation framework for fusion at EU level**: a strategy to support fusion R&D and industrialisation, operationalised through procurement and aligned with the EU's priorities.

• Assisting Small and Medium-sized Enterprises (SMEs)

F4E continues its efforts to support the involvement of SMEs in fusion projects. Particularly, it focuses in setting appropriate qualification levels and financial requirements to remove overspecification, which can restrict their participation. The specific action plan discussed with SME [in 2024](#) **globally reduced administrative complexity** for all tenderers and contractors especially in the area of acceptance of deliverables and thus reducing the overall time to pay.

Within the given regulatory framework, F4E places special emphasis on assisting SMEs, recognising their important contribution to the resilience, competitiveness and innovation capacity of the European fusion supply chain. Information Days organised online and across Member States, together with dedicated SME Days, have proven to be effective instruments for connecting SMEs with larger industrial suppliers, fostering the creation of **new transnational supply chains** through company presentations, networking opportunities and business-to-business meetings.

Targeted Information Days addressing specific procurement opportunities are organised with the participation of the relevant technical, contract and quality assurance experts, enabling key topics to be clarified at an early stage. By improving the quality, transparency and accessibility of the information provided, these events increase both the preparedness of potential tenderers and the attractiveness of F4E procurement opportunities for SMEs and larger industrial partners alike.

To build on these initiatives, F4E has developed an **SME Roadmap 2027–2030**, providing a structured, multi-year framework to further strengthen SME participation across the fusion supply chain and facilitate access to F4E procurement opportunities. The roadmap is organised in four progressive phases—**Build Foundations, Scale & Professionalise, Standardise & Integrate, and Institutionalise**—supported by eight dedicated workstreams covering governance, communication, digital tools, market engagement, SME-friendly procurement, financial and execution enablers, performance monitoring, and ecosystem cooperation. The planned actions include enhanced communication and training, simplified procurement documentation, digital support tools, strengthened market engagement, systematic performance monitoring and closer collaboration with fusion stakeholders. Through this roadmap, F4E aims to create a more accessible, transparent and supportive procurement environment, enabling SMEs to participate more effectively in the delivery of Europe’s fusion programme while strengthening the resilience and competitiveness of the European industrial ecosystem.



• Increasing maturity for critical technologies

With its Technology Development Programme (TDP), F4E is looking to address technology gaps for ITER and future fusion reactors, helping align industrial capabilities to long-term needs as well as mitigating risks and anticipating technology dependencies. The initiative was launched in 2024 as one of the branches of the F4E Industrial Policy Implementation Plan to support Europe’s fusion supply chain and ensure its competitiveness.

Based on [participatory workshops](#), the TDP is mapping critical technologies, co-creating an agenda for investment with experts across the community. The workshops have brought together hundreds of participants from industry, research, academia and Big Science projects, covering eight areas so far. The findings and recommendations of each workshop are presented in reports, with six being available: [Fuel Cycle](#), [Magnets](#), [Additive Manufacturing](#), [Metrology and Reverse Engineering](#), [Artificial Intelligence](#) and [Plasma-Facing Components](#).

- **Supporting growth of European private sector fusion start-ups, including maximisation of return of investment.**

In terms of public-private collaboration frameworks and the development of private sector interest, F4E's role is increasing. A [Call for Expression of Interest](#) was published in 2025, open to private initiatives interested in establishing a collaboration with F4E for the development of fusion. This call allows to explore synergies with other actors working in fusion, leveraging F4E's experience in ITER and BA to support the growth and success of the EU fusion private sector.

The resulting collaboration agreements provide a framework for the exchange of information, knowledge and best practices. Specific arrangements for joint projects can be formalised, outlining commitments, intellectual property management and resource allocation. Five collaboration agreements have been signed as of mid-2026, and more are in preparation.

Through these partnerships, F4E builds on its strength to shape the European ecosystem, developing its role of European capacity developer, to help Europe capitalise on the new inflow of funding and the acceleration of private capital investment. By connecting with these entities, F4E demonstrates its capability to take the lead in developing the link between the private startups and public actors to integrate and expand the fusion landscape.

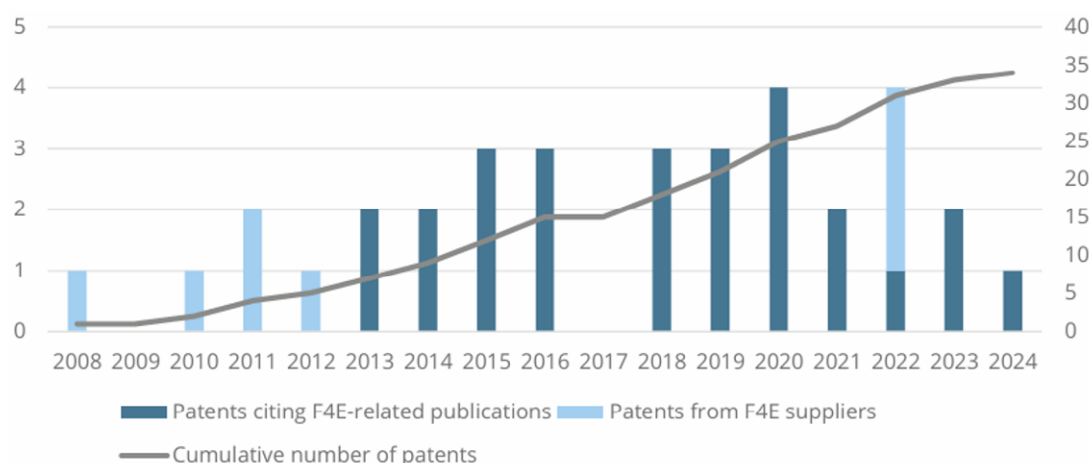
Innovation and Business Development

- **Driving collaborative research and innovation across high-tech sectors**

As analysed by the [13th annual assessment](#), patents citing F4E-related publications increased steadily from 2013, peaking in 2020 (see figure below). F4E-related patents span a diverse range of technological fields, especially mechanical and electrical engineering, reflecting the multidisciplinary nature of fusion.

Applicants are internationally distributed, with most based outside the EU. This is primarily due to patents citing F4E-related publications which often involve international co-authors and generate global knowledge spillovers, **while patents filed directly by F4E suppliers are all European-based**. About one-third of these patent families received citations, confirming their knowledge spillover potential.

Overall, F4E emerges not only as a coordinator of fusion-related procurement/manufacturing but also as a driver of collaborative research and innovation across high-tech sectors (see the 13th annual assessment Annex 10 for further details).



Extract from 13th Annual assessment, Evolution in the number of new patent families filed (2008–2024)

The figure below shows the multidisciplinary nature of technological domains influenced by F4E. The most important domains are the following:

The most important domains:

1. Mechanical engineering, particularly in areas such as engines, pumps and turbines, due to ITER's core focus on plasma containment and thermal systems.
2. Electrical engineering, reflecting the complexity of ITER power systems and electromagnetics.
3. Other significant domains include materials, metallurgy and environmental technology, critical for addressing challenges such as plasma-facing materials, neutron damage, and tritium breeding. Notably, areas like computer technology, optics, and measurement demonstrate the importance of digital systems and precision instrumentation, supporting control, monitoring and simulation functions.



Source: CSIL

Extract from 13th Annual Assessment , Distribution of patents across technological sectors and fields

• **Driving collaborative research and innovation across high-tech sectors**

F4E's Technology Transfer Programme aims to maximise the potential of fusion breakthroughs and support EU industry to capitalize on the technologies developed under F4E activities. The programme is based on three main pillars:

- **Technology brokerage** creates a match between the new technologies and acquired capabilities of F4E contractors or subcontractors and the needs of companies in different markets, with the aim to increase F4E supply chain's resilience and competitiveness.
- The [European Fusion Technology Marketplace](#), a portal jointly managed by F4E and EUROfusion, showcases the commercial potential of technologies born in Europe's fusion projects, by fusion laboratories and the F4E Supply Chain. The site's portfolio contains over 50 technology offers supported by F4E, as well as 20 success stories of technologies that have made it to new markets. These cases showcase how different industries are already using fusion technologies, helping F4E suppliers obtain a competitive advantage, expand their business reach and grow. As an example, a German SME developed a technology to manufacture magnetic sensors for ITER, and this know-how proved to be an asset to other projects relying on state-of-the-art magnetics diagnostic tools⁷.
- **Demonstrator projects** increase the technology readiness level of fusion technologies and adapt them to market applications.
- Each year F4E launches the Fusion Technology Transfer Award to reward innovation in Europe's fusion supply chain. The call is open to European companies and organisations that take -or plan to take- a technology or know-how developed in fusion to the market. An expert jury will assess the applications and select the winner, who will receive a reward of 10.000 EUR.

⁷ VIA electronic takes microelectronics from ITER to the fusion market – Fusion Technology Transfer

04

Building a sovereign, competitive and continent-wide fusion supply chain

Europe enjoys a position of scientific and industrial strength in the quest for fusion. It counts with the legacy of JET, it is the host and main contributor to ITER, and has built JT-60SA, the world's largest tokamak in operation. Europe has built a large industrial base via Fusion for Energy (F4E) and is now advancing IFMIF-DONES as a strategic materials-testing facility for the path to DEMO and commercial fusion power. Europe also coordinates a continent-wide research programme through EUROfusion. The supply chain is now economically significant and a driver of EU competitiveness.

The urgency of achieving sustainable and sovereign energy mixes has brought increased attention and [growing investment](#) in fusion technologies. However, Europe is at risk of falling behind the United States and China in the commercialisation phase because private fusion investment and start-up scaling remain significantly more concentrated outside the EU9.

In 2025, Europe initiated efforts to build a distinct Industrial Policy to translate its substantial public investment and industrial know-how into an integrated commercial fusion ecosystem. In June 2025, the European Commission launched a [call for evidence](#) for the first-ever EU fusion strategy. This initiative highlighted the need to create a competitive industrial ecosystem, mobilise the supply chain, strengthen start-ups and private-sector participation, build skill pools and establish enabling governance and regulation. Since then, the Commission has adopted the Euratom Research and Training Work Programme 2026–2027, allocating 222 million EUR to fusion, including the establishment of a European public-private partnership for fusion and dedicated support to fusion start-ups through European Innovation Council instruments. These are priorities that F4E's Industrial Policy has anticipated and is operationalising.

In its [resolution](#) of 29 April 2026 accompanying the discharge of the Joint Undertakings (JUs), the European Parliament acknowledged that JUs constitute a critical instrument for strengthening the Union's research and innovation capacity by fostering large-scale public-private partnerships in strategic industrial domains. F4E gives that assessment concrete form in the fusion domain: through its ability to pool resources, coordinate cross-border collaboration and bridge the gap between scientific research and market deployment, F4E helps accelerate technological progress that individual actors could not achieve independently. F4E's involvement also ensures transparency, accountability and efficient management of public resources.

By mobilising industry, laboratories, SMEs and public authorities around shared objectives, F4E ensures the efficient use of EU funds, promotes Europe's leadership in strategic key technologies, supports value-based innovation, furthers the European Union's strategic autonomy and contributes directly to sustainable economic growth and high-quality employment across the

⁴In June 2025, the F4E Fusion Observatory estimated that the US absorbed **61%** of global private fusion funding, China **24%**, and Europe only around **5%**; the Observatory's later update still placed the EU at roughly **5%**, versus **53%** for the US and **34%** for China.

Union. This is precisely the contribution the European Parliament attributed to the JUs in its 2026 discharge resolution – a resolution which further singled out F4E for embedding sustainability requirements in more than half of its procurements in 2024, and which stressed the importance of procurement as a tool to advance strategic autonomy, innovation and security of supply.

Therefore, F4E is well-placed to support the implementation of EU-level industrial policy objectives. F4E has the procurement experience, supplier networks and industrial credibility to operationalise that agenda. Additionally, F4E's knowledge of the ecosystem, strengthened through its Fusion Observatory, industry roundtables, industrial policy tools, technology transfer initiatives and collaboration frameworks with private initiatives, further consolidate its credentials.

This position reflects the direction of contemporary European thinking on industrial policy. Recent academic and policy work on mission-oriented public procurement –notably by Mariana [Mazzucato and the UCL Institute for Innovation and Public Purpose](#)– argues that public value is created when procurement is directional, assessed dynamically over time, co-created with market actors, and backed by a risk-taking public sector. F4E's practice embodies each of these characteristics: a prioritised technology agenda gives procurement direction; multi-year staged strategies assess value over the full development cycle; technology mapping workshops co-create the demand specification with industry and research; and instruments such as the Technology Development Programme (under which F4E funds development while contractors retain ownership of the intellectual property they generate) place development risk deliberately with the public side in order to build private capability.

Via the contracts placed and managed by F4E, Europe is supporting industrial repeatability, supply chain robustness, SME participation and the emergence of European fusion prime contractors and system champions.

The supply chain described in this publication is a strategic asset –and a perishable one. Industrial capability in fusion is retained only through sustained use: as the peaks of ITER manufacturing pass, the specialised production lines, qualified teams and system-integration skills accumulated over two decades will migrate to other sectors, or to other jurisdictions, unless a pipeline of European demand sustains them. That demand already exists in credible form: the completion and exploitation of ITER, IFMIF-DONES, the Divertor Tokamak Test facility and the first private pilot plants. Anchoring these opportunities in the European industrial base, through the strategic procurement approach, is the most direct way to ensure that the next phase of fusion is built on what Europe has already paid to create.

From the Innovation, Knowledge and Technology Transfer point of view, F4E, in collaboration with EUROfusion, is acting as a Technology Transfer Office for fusion technologies in the EU. It

is facilitating and supporting the EU Industry to commercially exploit the fusion breakthroughs developed under F4E’s projects.

Mario Draghi’s report on European competitiveness (2024) highlights the importance of fostering innovation in the energy sector. On fusion, the report specifically calls to *“develop an overarching EU innovation strategy for fusion energy and support the creation of a public-private partnership to promote its rapid, economically viable commercialisation. The partnership should aim to create a stable and predictable ecosystem for industrial innovation, leveraging the ITER project, while ensuring a clear technology development roadmap. The deployment of fusion energy will require public and private investment to act in synergy.”*

Independent legal expertise points in the same direction. The FELEX EU Group, an independent expert panel examining the legal and regulatory dimensions of fusion energy, has identified public procurement as a core instrument of demand-side industrial policy for fusion – the mechanism through which public investment shapes industrial capabilities and develops supply chains. It has also observed that the EU has a unique operational foundation to build on: the largest fusion procurement programme ever undertaken under the EU legal framework, delivered through F4E.

The European Parliament has stressed that, in the context of the next MFF for 2028–2034, JUs will remain instrumental in underpinning the Union’s strategic autonomy, sustainability, security and competitiveness, and has called on the Commission and the budgetary authority to endow them with sufficient, stable and long-term financing, commensurate with their expanding responsibilities. F4E has the expertise and experience to remain instrumental in the implementation of those recommendations.

KEY MESSAGE

F4E is successfully delivering ITER and is ready to support the future EU fusion strategy.

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