FUSION INDUSTRY ASSOCIATION

The Global Fusion Industry in 2023

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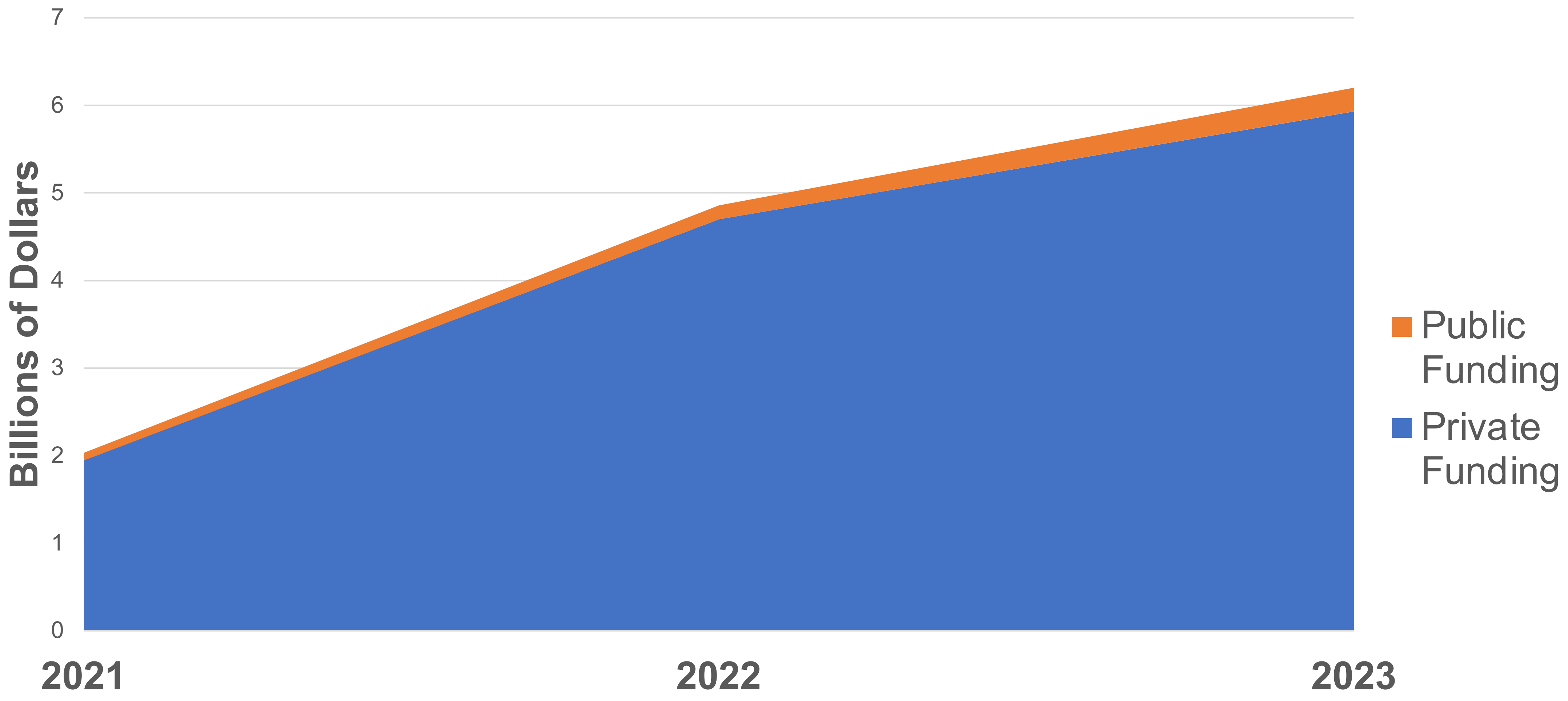
Chief Executive Officer

Overview: The Private Fusion Industry Today

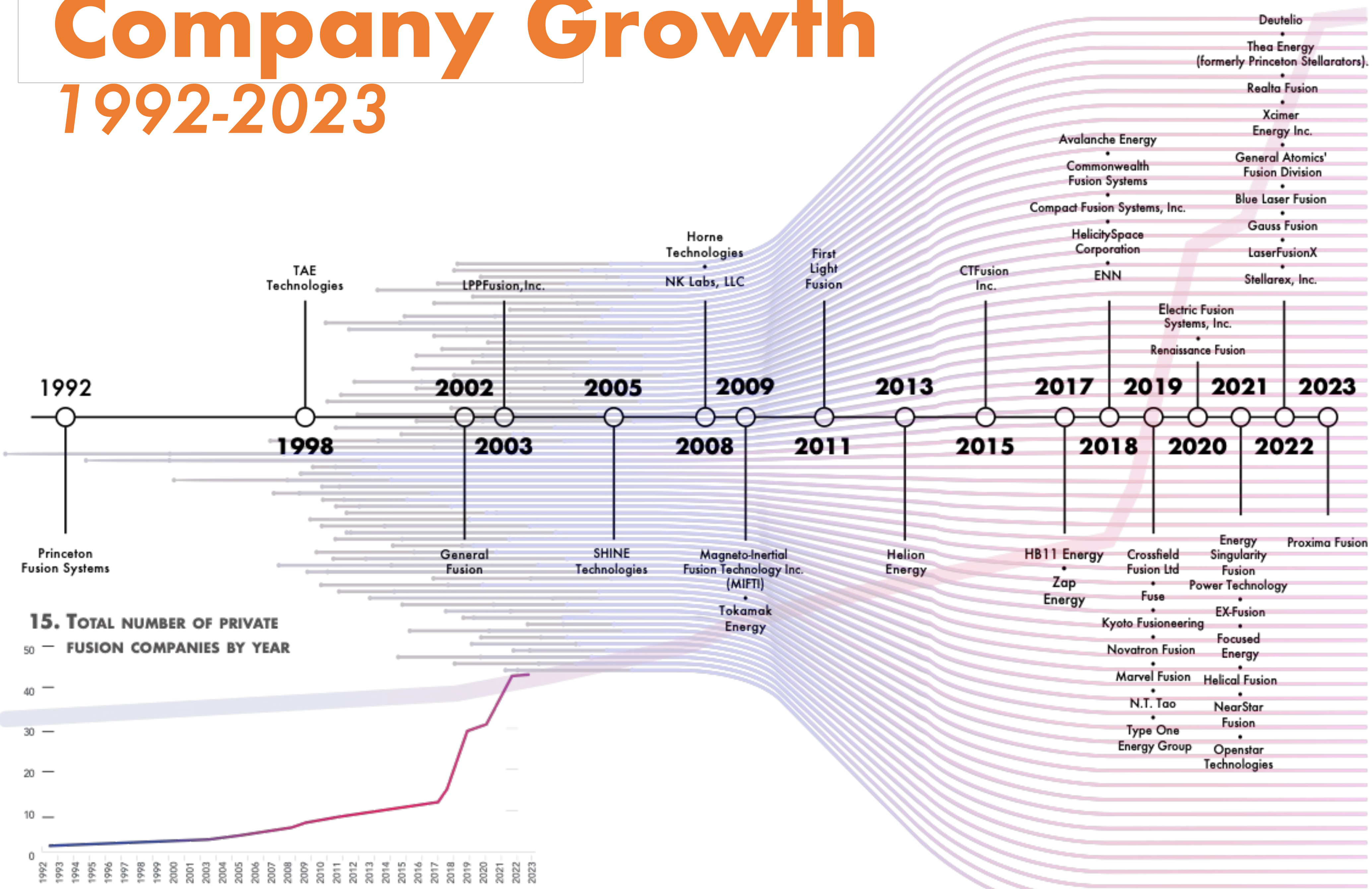
- 43 verified private fusion companies
- **$6.2 billion in investment**
- 13 new fusion companies
- Increasing optimism on timescales
- Growing interest from governments in Public Private Partnerships
- Growing geographical diversity
- But – many challenges remain

Private Funding Growth
2021-2023



Company Growth

1992-2023



Notable investments since last survey

$23m
THEA Energy

$250m
TAE

$79m
Kyoto Fusioneering

$55m
Energy Singularity Fusion Power Technology

$200m
ENN

$50m
SHINE Technologies

$41m
Avalanche

$22m
n-Tao

$20m
General Atomics

$67m
Focused Energy

Trends: Broad-Based Investment

- 27 announced capital raises
- Median raise: $9,000,000

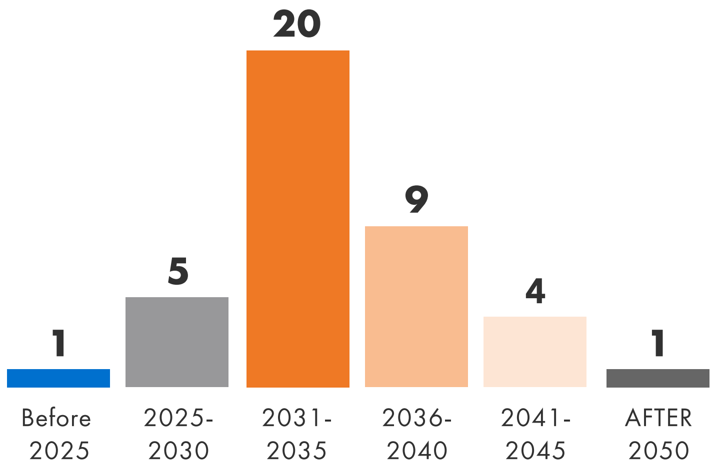
But…a difficult investment environment for large raises?

Variety of Approaches

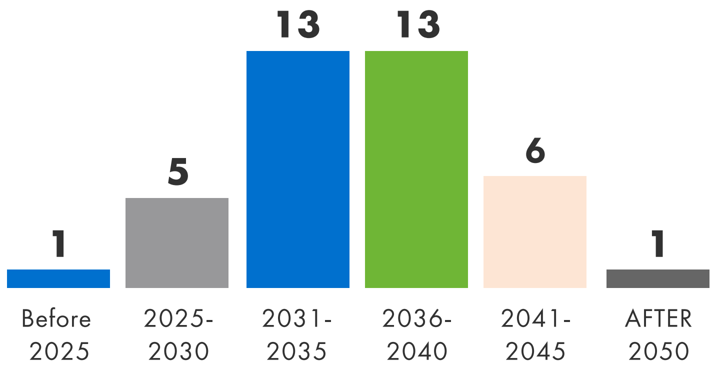
- 1 Dense Plasma Focus
- 1 Direct laser-driven pB11
- 1 Epicyclotron: a hybrid beam background approach
- 1 Electro-centripetal confinement with magnetic plasmas not in thermodynamic equilibrium
- 3 Field Reversed Configuration
- 1 Hypervelocity Gradient Field Fusion
- 1 Laser-driven inertial confinement
- 1 Laser-driven Direct Drive Inertial Confinement Fusion
- 1 Levitated Dipole
- 1 Magnetic mirror
- 1 Mirror machine
- 1 Magnetized target fusion
- 1 Modified Stellarator
- 1 Muon-catalyzed fusion with high density fuel
- 2 Magnetic-electrostatic confinement
- 1 Magnetized Liner Inertial Fusion (MagLIF)
- 1 Plectonemic reconnection
- 1 Poloidal magnetic confinement, e.g. Levitron, LDX, Intrap
- 1 Pulsed magneto-plasma pressurized confinement
- 1 Shock-driven inertial confinement
- 1 Spindle cusp, superconducting shielded-grid Inertial Electric Confinement
- 6 Stellarator
- 6 Tokamak/Spherical Tokamak/Advanced Tokamak
- 2 Z-pinch
- 1 N/A

Growing Confidence

When will the first fusion plant deliver electricity to the grid? (40 responses)



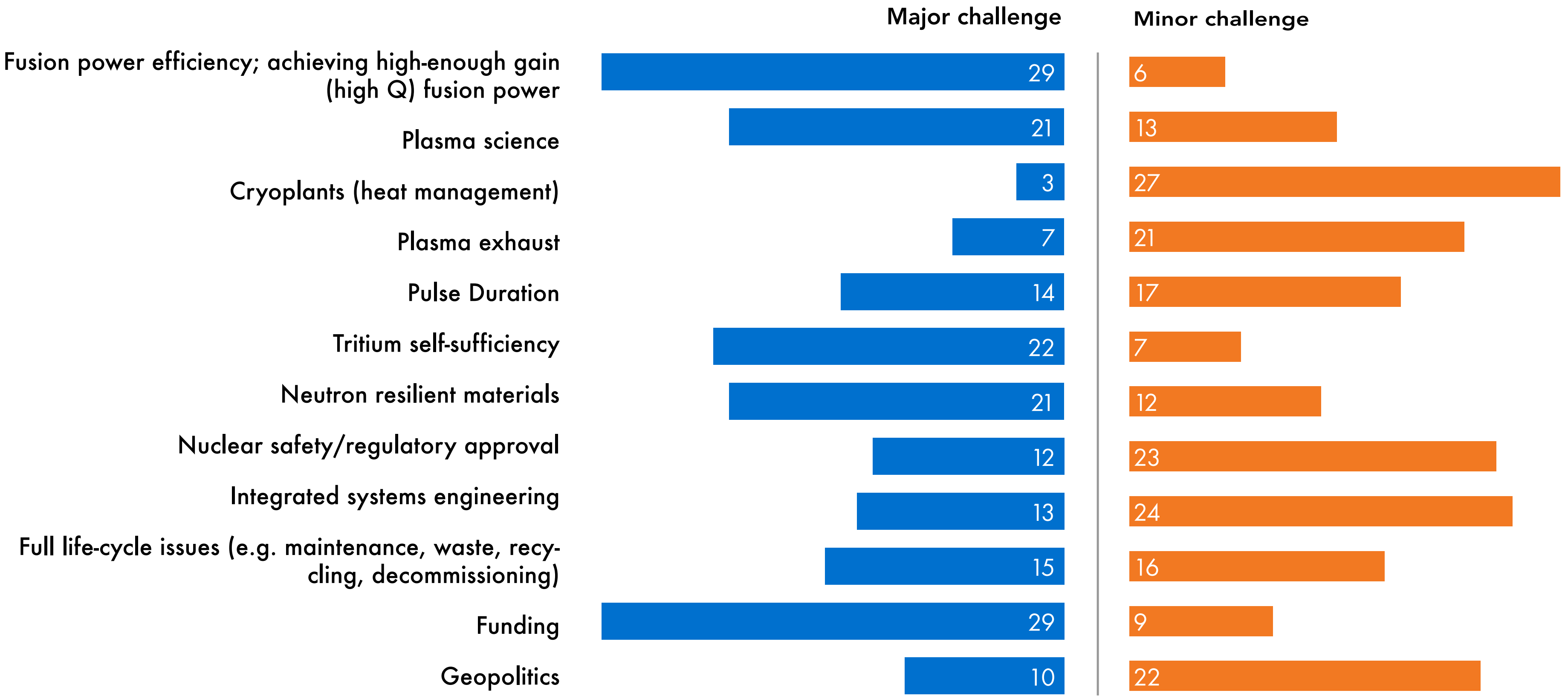
When will the first fusion plant demonstrate a low enough cost/high enough efficiency (Q) to be considered commercially viable? (40 responses)



- 88% expect fusion power on the grid in the 2030s or before
- 84% expect commercial cost competitiveness on same schedule

Expecting Challenges

What do you see are the main challenges for fusion energy up to 2030?
(38 Reponses, non-reported answers indicate not seen as a problem/don't know)



A Global Industry
Led by American Companies

- 25 American Fusion Companies
  - With > 80% of the investment
- Growing global diversity
  - 12 countries with at least one fusion company
- A global supply chain
- A global workforce
- Global scientific leadership

Why Now?

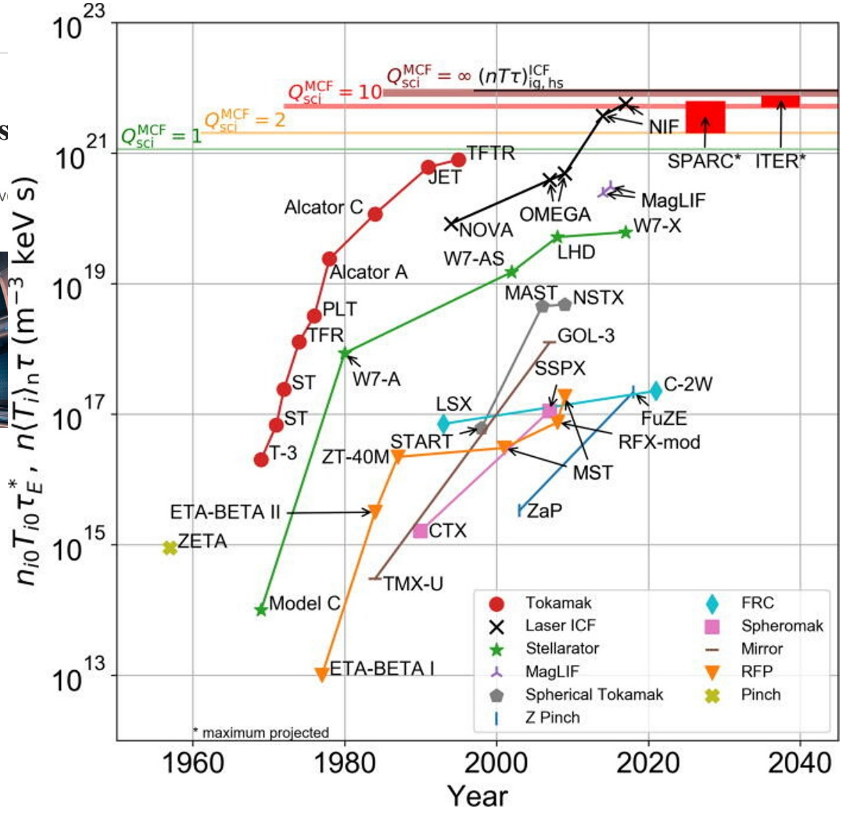
Fusion is READY + *The world NEEDS fusion*

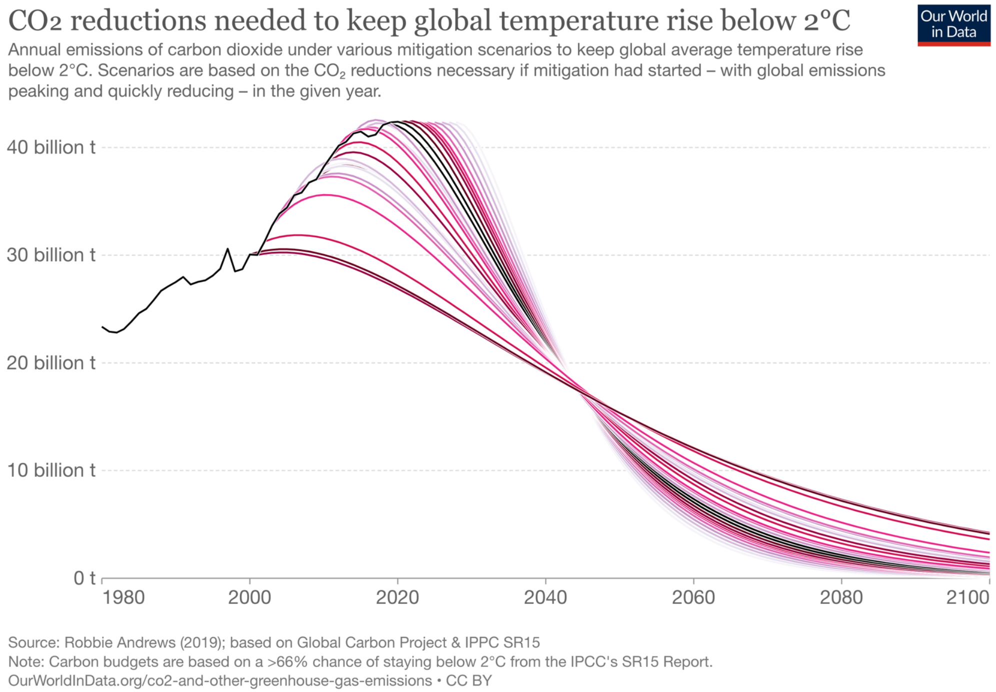

WSJ

SCIENCE

Nuclear-Fusion Breakthrough Accelerates Quest to Unlock Limitles Energy Source

Experiment yields net-positive energy, a milestone in effort to dev nuclear fusion as a source of clean power





Industry's Timeline

60 years of research

- Scientific basis for fusion energy

Mid 2020s

- Scientific Proof of Concept

Late 2020s

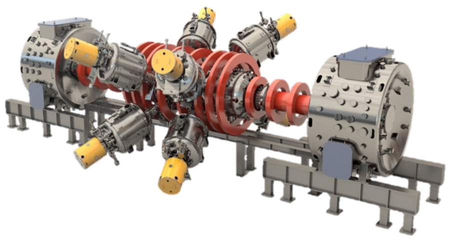
- Design and build Pilot Plants

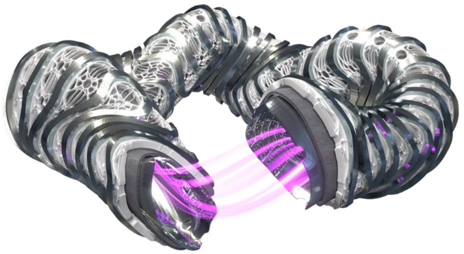
Early 2030s

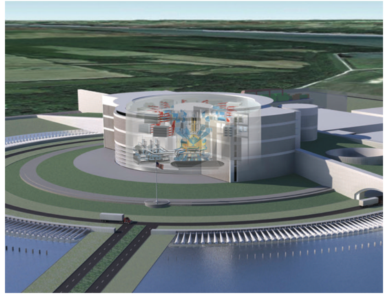
- Operate Pilot Plants, first sales

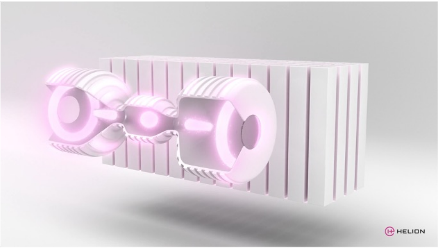
Mid 2030s

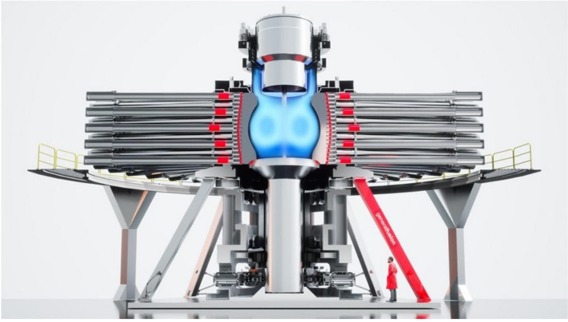
- Commercial Fusion, rapid scale-up to global deployment







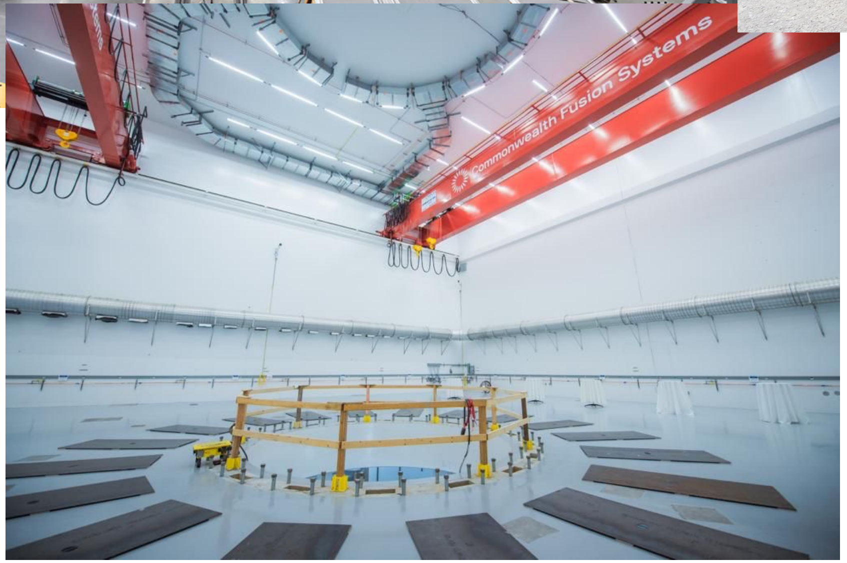




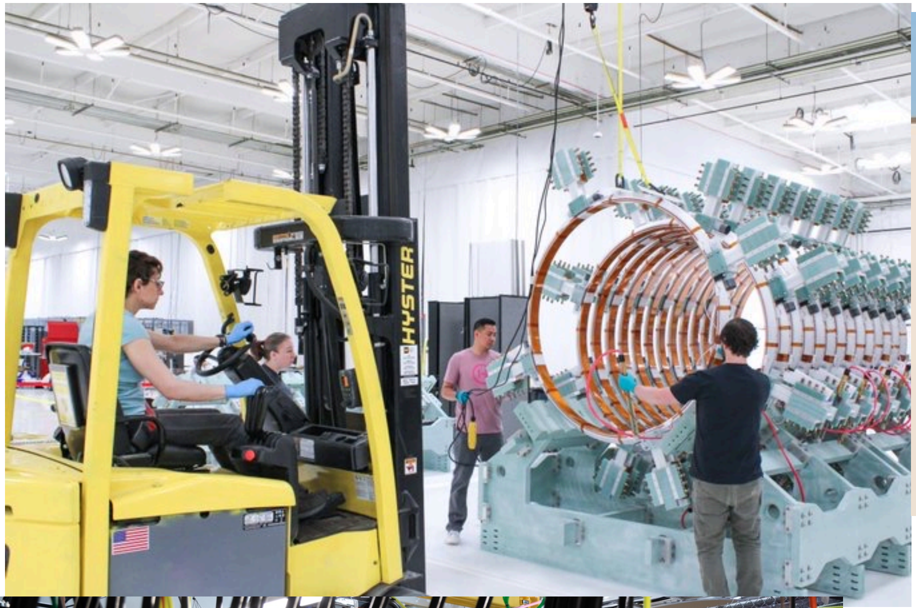
FIA Membership

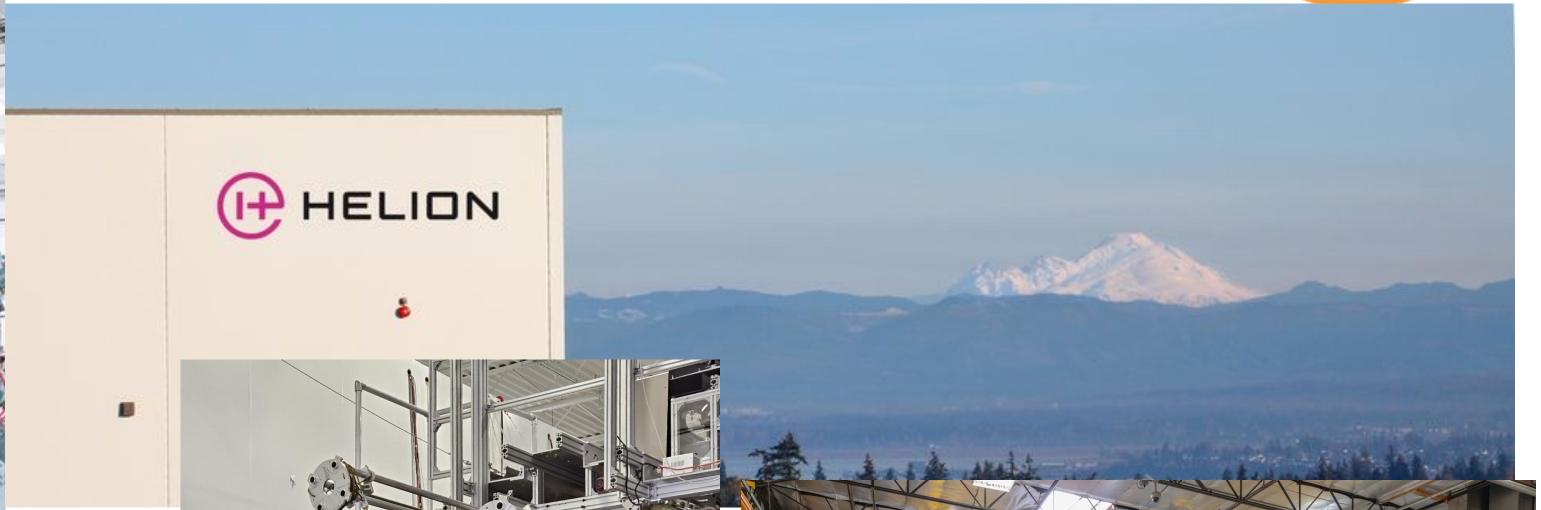
Commonwealth Fusion Systems
HELION
tae
ZAP ENERGY
generalfusion
TYPE ONE ENERGY
GAUSS FUSION
HB11 ENERGY LASER BORON FUSION
AVALANCHE
Tokamak Energy
FOCUSED ENERGY
KYOTO FUSIONEERING
XCIMER ENERGY CORPORATION
first light
EX-Fusion
fuse
THEA ENERGY
MIFTI
RENAISSANCE FUSION
Proxima Fusion
HelicitySpace
ELECTRIC FUSION SYSTEMS
REALTA FUSION
Helical Fusion
LONGVIEW FUSION ENERGY SYSTEMS
BLUE LASER FUSION
SHINE
MarvelFusion
STELLAREX
OPENSTAR TECHNOLOGIES LTD
NOVATRON
nT-tao
LaserFusionX
HORNE TECHNOLOGIES
PrincetonSATELLITE SYSTEMS
nearstar FUSION
NK
LPP FUSION

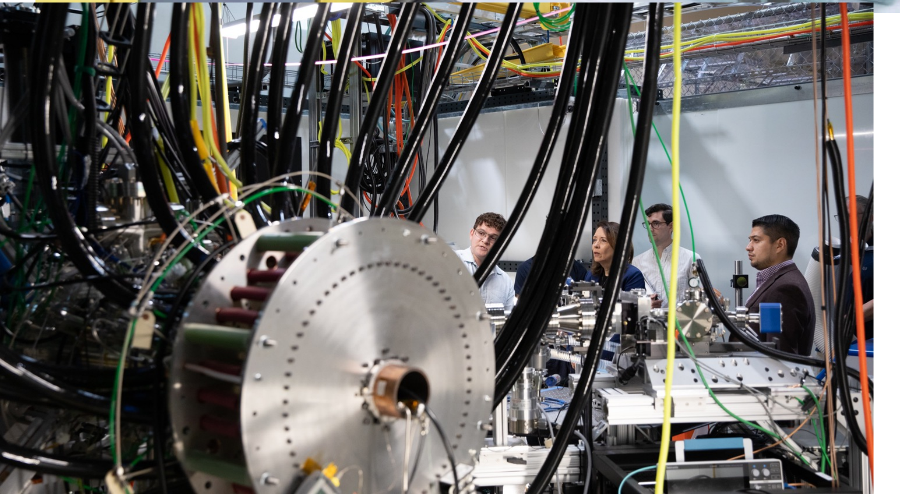
Progress

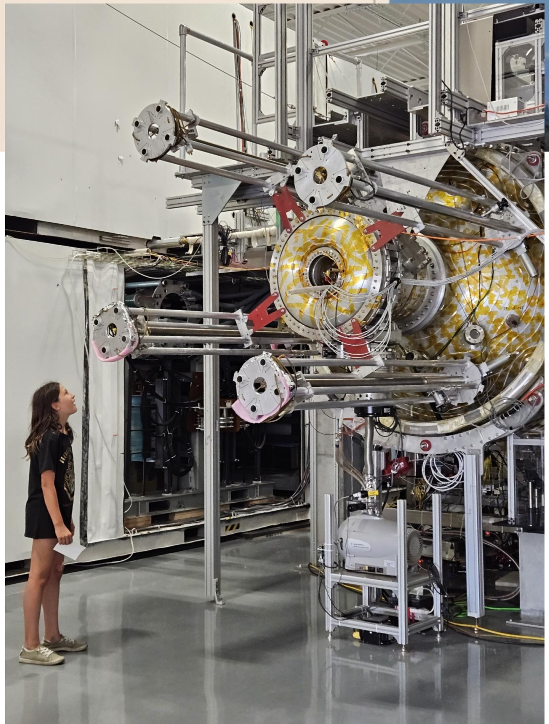


Progress









Why? Fusion will Change the Outlook for 2050 Net Zero

Fusion is a source of nearly unlimited ***clean, firm power***

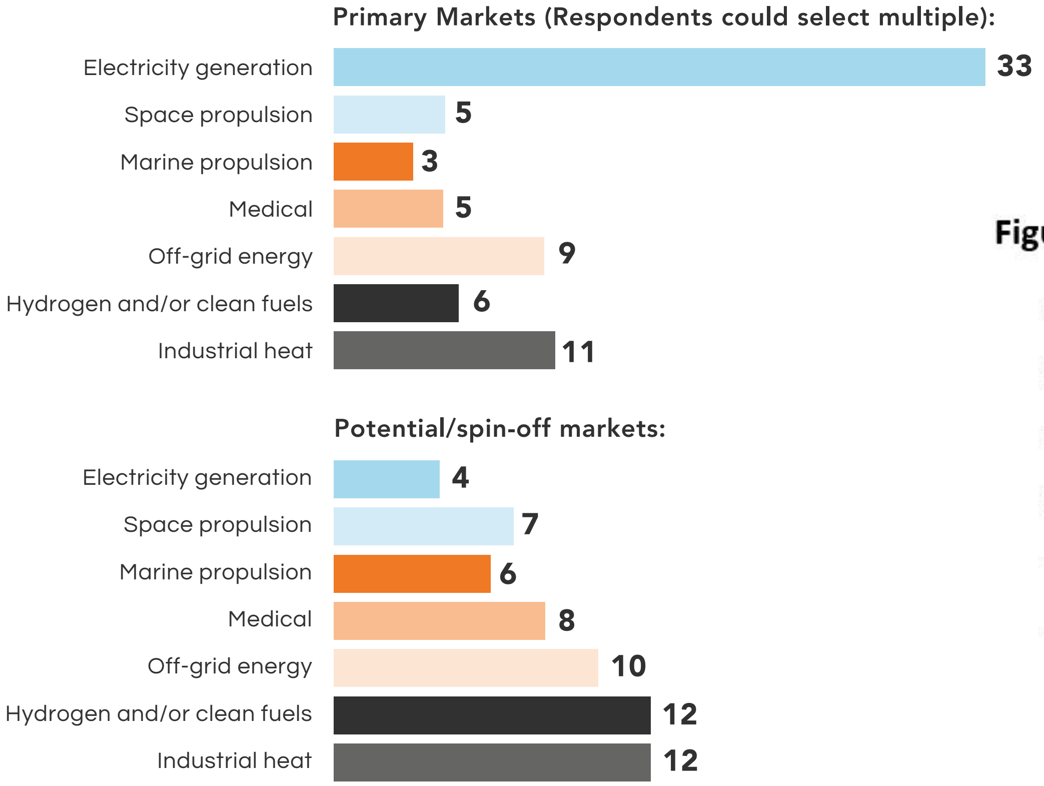
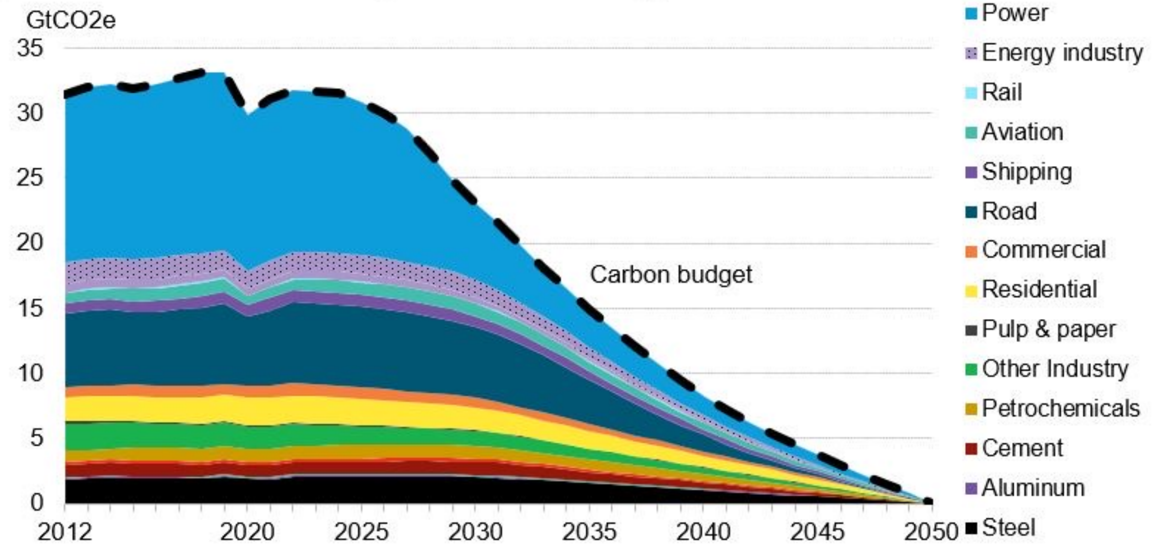


Figure 1: Total carbon budget for the energy sector



Source: BloombergNEF

How to Accelerate Fusion

Public Private Partnerships

The private sector should have access to the scientific research that governments have pursued for decades. Public-Private Partnerships that include government support to private fusion companies can rapidly accelerate fusion development by driving new private financial support.

Ensuring Regulatory Certainty

The regulatory regime for fusion should be predictable, proportional to the risk, and supportive of innovation, while also giving confidence about ensuring public safety and security. Fusion energy regulation must be permanently separated from fission regulation and should not require lengthy permitting process for every facility.

Incentives to Build a Global Fusion Energy Industry

Fusion does not need special status or excessive subsidies but should have a level playing field as it grows into a new industry.

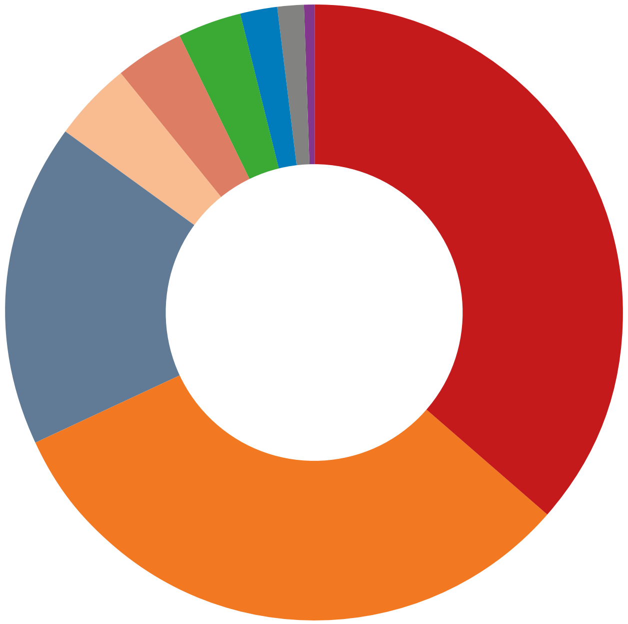
FIA Supply Chain Report:
Key Findings

- Fusion developers spent **over $500m** on their supply chain in 2022, and that will grow to over $7bn per year 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).
- *Technological diversity in fusion*: there is not a fusion "supply chain" – there are fusion "supply chains"
- High value supply chain needs are primarily **specialized precision manufactured components**
  - Steady-state Magnetic = high-powered magnets + resilient materials
  - Pulsed power = power electronics and semiconductors
  - Laser IFE = specialized laser & optics components
  - Fusion Fuel Cycle = Lithium blanket
- Biggest challenge = balancing suppliers' scale with business risk.
  - Fusion companies need suppliers to invest in scale ahead of demand, but suppliers are reluctant to do so without confirmed commitments or clear timelines.
  - Chicken vs Egg?

Industry Growth

- $500 million per year industry today -> $7 billion in a decade

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**

Supply Chain Needs Now

- Vacuum technology is (almost) the only shared technological need across the fusion technologies
- In a fusion energy facility, the walls exposed to the plasma will be bombarded by highly energetic neutrons.
- A solution is a composite wall consisting of a suitable coating on a substrate chosen for its strength and ease of fabrication. The techniques employed to deposit several of these candidate materials onto stainless steel substrates as thick coatings are described.

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

Supply Chain Needs Will Grow

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

See Appendix 1 for expanded data.

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

Results: FIA's Vision for the 2030's

- **Industry** builds multiple fusion pilot plants of different sizes, technologies, and fuel cycles, preparing to scale-up into a globally-leading export industry.
- **Fusion Supply Chain** grows to over $7 billion per year industry (already over $500 million today)

- **Governments** support fusion commercialization push with world-leading science, computing power, and test facilities - the **infrastructure** that enables a fusion industry.
- **Research Universities** form the backbone of the **fusion workforce** and train the next generation.

Thank You

For more information, contact Andrew Holland, FIA CEO:
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www.FusionIndustryAssociation.org