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The Federal Government's Role in Supporting the Commercialization of Fusion Energy

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Chairman Manchin, Ranking Member Barrasso, and members of the Committee, my name is Bob Mumgaard and I am the CEO of Commonwealth Fusion Systems (CFS), a fusion energy company that spun out of the MIT Plasma Science & Fusion Center in 2018, and a Board Member of the Fusion Industry Association, which advocates for the commercial fusion industry here in Washington, DC. I would like to thank the Committee for holding today's hearing on the Federal government's role in supporting the commercialization of fusion energy.

I want to start by also thanking the Committee for your efforts to support commercial fusion through the passage of recent legislation, including the *Energy Act of 2020* and the *CHIPS and Science Act of 2022*, and by providing critical funding through the annual appropriations process and the recently enacted *Inflation Reduction Act*.

We are at a unique moment in time with the advent of new commercial technologies, a dramatic change of fusion's commercialization timelines and significant private investment of $4.7 billion flowing into over 20 commercial fusion companies in the U.S., and at least 35 worldwide, all while countries around the world enact new fusion programs and supportive policies in their attempt to lead in this sector. At CFS, we are confident that, with the right collaboration between the public and private sectors and sufficient funding, the feasibility of net-energy (i.e., the ability to generate more power out than it takes to start the fusion process, which is the most critical next step for the viable commercialization of fusion energy) will be demonstrated and improved upon within this decade. From there, we believe we have a real shot at commercial fusion power plants on the grid starting in the early 2030s. This confidence is shared with the Fusion Industry Association and increasingly with foreign governments.

Commercial fusion energy will be a game changer in the energy sector. It will provide zero-carbon, safe, affordable, and limitless power for the world. Most importantly, it is a solution that can be deployed at scale to improve our energy security and at the speed required for the clean energy transition to achieve our decarbonization goals by mid-century.

Despite being a historical leader in fusion, the last 20 years have seen the U.S. cede that leadership in the publicly funded programs to other nations who were willing to enact bold new programs. These countries are moving aggressively to be first to commercialize this transformational energy source and will outspend the U.S. on publicly funded programs, such as critical R&D and enabling technologies, as well as developing appropriate licensing and siting regulations to support this technology and encourage the industry. As an American, I want to see the U.S. win this race. But as a fusion company, we have a responsibility to go where the best environment is to quickly build this new industry to prevent future impacts of climate change and to meet the growing global demand for clean energy.

For the U.S. to succeed, it should exploit its significant advantages in innovation relative to other countries by leveraging the U.S. private sector to create a commercial fusion product. This requires two things. First, the U.S. must increase public resources and investments in targeted fusion energy R&D. Second, we must ensure better coordination between the Department of Energy (DOE) and the private sector in those R&D efforts. Better public-private collaboration means programs to facilitate publicly funded scientists to continue their research and learn as much as possible from newly built private fusion facilities, private company contributions and access to publicly funded capabilities and results, and public facilities and fusion test stands participating in de-risking private commercialization endeavors on the private sector's timeline. In short, we need a realignment of federal R&D efforts to match the direction and current timeline of the U.S. private sector, and need sufficient funding for those R&D efforts and other already authorized fusion programs to bring this technology to market as quickly as possible.

Collaboration is not going to be sufficient to win, we also need a renewed focus by DOE on a commercialization pathway of this promising technology.. The U.S. has an opportunity unlike any time before to accelerate fusion research and development by partnering with the private sector to de–risk certain technological gaps and building out important R&D facilities and test stands identified in the 2020 Fusion Energy Sciences Advisory Committee (FESAC) recommendations to DOE[1]. To do so requires implementing a comprehensive plan, such as the *Bold Decadal Vision for Commercial Fusion Energy,* on the timeline that the private industry is currently working on, which includes funding key programs, such as the milestone fusion development program and developing a fusion industry.

But capturing a first-mover advantage will require Congress, the Administration, federal and state regulators to take concrete steps now to enable a thriving domestic fusion energy industry here in the United States. If the U.S. does not act in a timely manner, there is a real risk of private companies investing and constructing their fusion power plants elsewhere in the world. Failing to act means that instead of selling commercial fusion power plants as a large globally important industry, the United States could be buying them from overseas.

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[1] FESAC_Report_2020_Powering_the_Future.pdf

Fusion's role in the global energy transition

From clean energy policies across the world, to transitions already underway in the global economy, and the mounting costs of extreme weather, we need deep decarbonization at a global scale that can support continued global economic growth and prosperity, while at the same time achieving the stated U.S. goal of a net-zero economy by no later than 2050. Members of this Committee are all aware of the progress the U.S. has made in reducing our emissions through fuel switching and the rapid growth of the renewables sector in the past decade, specifically wind and solar. But strong continued growth of intermittent resources, like wind and solar, alone cannot get us to net-zero emissions in a time frame that matters given renewables have been shown to have unfavorable cost scaling above 50% share[2][3]. To achieve our net-zero goals, we need a new dispatchable, zero-carbon electricity source that is scalable. To achieve this midcentury net-zero goal, we will need one of the largest industrial transformations in history, with replacement plus expansion rates of ~100GW in new power plants. This is the largest problem and opportunity facing humanity and to solve it the market needs a fundamentally new energy generation technology.

Fusion can be that technology. Fusion is a zero-emission, firm, dispatchable energy source that will be economically competitive and can scale-up rapidly.

Key attributes of commercial fusion energy:

- **Zero emissions**: no greenhouse gas or pollutant emissions
- **Dispatchable**: can operate constantly, 24/7 and integrate with intermittent sources
- **Scalable**: freely available and inexhaustible fuel supply
- **Safe**: inherently safe with no meltdown or long-lived nuclear waste
- **Siting flexibility**: relatively small footprint and can be built anywhere, close to load centers
- **Robust domestic supply chain**: built of mostly steel and concrete with some high technology components; manufacturable in the U.S. and would not require reimagining supply chains
- **Markets**: beyond producing electricity, fusion is also a dispatchable source of high-quality heat that can unlock other hard-to-decarbonize markets (e.g., hydrogen production, industrial process heat, green fuels, district heating, direct air capture of carbon dioxide, desalination, and others)
- **Jobs**: creates and supports good paying clean energy jobs

[2] https://www.iea.org/reports/net-zero-by-2050
[3] https://link.springer.com/article/10.1007/s10894-021-00306-4

A growing fusion industry

For decades, the goals of the U.S. fusion program have been, broadly, to understand the scientific basis of fusion, and to pursue fusion as a viable energy source. However, in the U.S. the advent of the private fusion industry has always been understood to be an inevitable stage on the pathway to the widespread deployment of fusion power to the grid, as highlighted in the 2020 FESAC report as well as a 2021 National Academies of Science (NAS) report, *Bringing Fusion to the U.S. Grid*[4]. I believe that we are now at that stage and I am not alone in that view.

According to a recent survey conducted by the Fusion Industry Association (FIA)[5], there are now at least 35 global fusion companies and, of those surveyed, 52% were founded in the last 5 years alone. The report also indicated that of the 29 companies surveyed, of which 57% were U.S. companies, nearly $4.7 billion of private capital has been raised for commercial fusion energy, a 139% increase since the 2021 report. Of that amount, more than $4.1 billion went to American companies. All indications are that this investment trajectory is likely to continue. The vast majority of fusion innovation is focused on electricity generation, and a majority (93%) of the companies that responded to the survey stated they believe the world will see fusion power on the grid in the 2030s or earlier. By contrast, a purely government-led effort would likely put commercial fusion on the grid in the 2040-2050 time horizon.

It is recognized that the private sector builds on the previous successes of fusion energy achieved at laboratory scale around the world. Now scientists, investors, and business leaders believe that net gain or net energy (that is more energy output than input or Q>1) from fusion is within reach. The growing fusion market is showing encouraging signs of diversity in technological approach which increases the likelihood of overall sectoral success. Private companies are exploring numerous approaches to achieve fusion, including:

- *Magnetic Confinement Fusion*: Confining hot plasma fuel within a chamber with new types of magnets;
- *Inertial Confinement Fusion*: Compressing and heating the fuel so fast that fusion takes place prior to the central fuel interacting with surrounding materials; and
- *Magneto-inertial Confinement Fusion*: Combining aspects of magnetic and inertial confinement to contain the hydrogen plasma fuel.

This rapid growth in the private sector demonstrates the need for a significant shift in the priorities of the government-funded public programs if they are to remain relevant and engaged in the deployment of fusion power plants here in the U.S.

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[4] https://nap.nationalacademies.org/read/25991/chapter/2
[5] https://www.fusionindustryassociation.org/about-fusion-industry

The need for a bold decadal vision for commercial fusion energy

In order to maintain U.S. leadership in fusion energy and center this rapidly growing industry here, it will require a *Bold Decadal Vision for Commercial Fusion Energy* as announced at a White House event this past March[6]. There are several pillars to achieving this vision.

a. *Shifting Priorities of current Government-funded Programs*

Executing on a *Bold Decadal Vision for Commercial Fusion* will require executing a consensus view that we must shift the priorities of current government-funded public programs to focus on helping the private sector and expedite the deployment of fusion power plants in the United States . Previously, public programs were focused on the plasma physics architecture and the only major new fusion devices resided at international and national laboratories. However, the private industry's progress and results no longer justify this approach. To use an example, rather than NASA building and designing every aspect of a commercial aviation industry, from testing and understanding the science of flight to designing and building the airplanes themselves, the government focuses on what it does best, the R&D (e.g., aerodynamics research), the infrastructure (e.g., the wind tunnel), while industry utilizes those R&D resources and expertise to build the products themselves (e.g., the planes) and as aligned with what the end-users need and want. The system works together towards a common goal (e.g., a leading aviation industry and corresponding jobs and technologies) faster than any one element alone could.

A recent report by the National Academies of Science made a similar point in their 2021 report, *Bringing Fusion to the U.S. Grid*[7]; The NAS report stated: "A great deal of scientific and technological progress has been made, but significant remaining technical and scientific issues must be addressed in parallel with developing a successful pilot plant design that would enable an economically attractive power plant. There is increased risk associated with this approach, as compared to solving technical and scientific issues prior to designing a pilot plant, but urgency in clean energy needs, coupled with the promise of fusion energy, motivates this approach."

As a result, if the U.S. is to win this race for the commercialization of fusion energy, there must be a collaborative partnership between the public and private sectors, who need to work together, divide and conquer, and focus on their corresponding strengths. To achieve this, we need clear roles and responsibilities.

Private fusion is proving its ability to execute large hardware projects, including integrated fusion device demonstrators, and enabling technologies such as high-field magnets, at speeds many times faster than possible in public programs. CFS is doing that right now with the

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[6] Readout of the WH Summit on Developing a Bold Decadal Vision for Commercial Fusion Energy
[7] https://nap.nationalacademies.org/catalog/25991/bringing-fusion-to-the-us-grid

construction of our demonstration device, SPARC, in Devens, Mass (Figure 2). Helion Energy is building their fusion generator, called Polaris, in Everett, Washington and TAE Technologies have announced their plans to construct its next fusion research facility, Copernicus, in Irvine, California. More importantly, the private sector is engaging with end customers, bringing market relevance and the ability to speed up development of customer-driven solutions for fusion power systems. Having private investors and customer involvement in commercial entities can prevent dreaded white elephant projects.

On the other hand, we need DOE, the National Laboratories and universities to de-risk outstanding research and technological gaps. Rather than building their own fusion pilot plants, as some countries are doing, U.S. taxpayer dollars and government resources would be better spent by focusing on science and technology towards commercially relevant implementation. Specifically, DOE should follow the FESAC recommendations and move quickly to building important R&D facilities and test stands that align with our best, fastest opportunities for commercialization, including:

- Fusion Prototypic Neutron Source (FPNS), which will provide unique material irradiation capabilities;
- Material Plasma Exposure eXperiment (MPEX) and high-heat-flux testing experiments, which will enable solutions for the plasma-facing materials;
- Blanket research and the associated Blanket Component Test Facility (BCTF), which will provide the scientific understanding and basis to qualify fusion power system blankets for a fusion pilot plant.

These new facilities, and the researchers who use them, the scientists who develop the understanding, the computer simulations that incorporate the results are all a powerful package that the U.S. National Labs and Universities know how to execute. These are widely endorsed but not yet completed and in some cases not yet started. We know what to do, we need to do it.

b. Leveraging Public-Private Partnerships to Maintain U.S. Leadership

This shift in roles in fusion energy development also brings new relevance to, and enhanced need for, public-private partnership (PPP) initiatives. In 2019, the DOE launched the INFUSE program to connect private fusion enterprises with National Labs, supported by DOE's Office of Science's Fusion Energy Science (FES) program. The program offers funding opportunities for projects with awards of $50,000 to $200,000 each and a 20 percent cost-share for private industry partners. While this is a helpful government funded program for the commercialization of fusion energy, INFUSE continues to be funded at a much lower percentage compared to other fusion science programs and relative to the private industries other efforts or programs overseas.

Likewise, the DOE Advanced Research Projects Agency-Energy (ARPA-E) program has funded over $80 million in fusion research at both public and private organizations since 2015 and is currently executing another round of funding expected to support $29 million in programs through 2025. It's worth noting the ARPA-E fusion projects leveraged tremendous amounts of private sector funding with relatively modest funds from American taxpayers. For example, $30 million invested in ALPHA leveraged $570 million in private funds and $40 million in BETHE has already leveraged $200 million in private funds. I believe this serves as a useful model for how the U.S. government can partner with the private sector to bring this disruptive technology to market on a timeline our energy security and changing climate demand.

By contrast, DOE is partnering at scale with the private sector on advanced fission pilot plants. Through DOE's Advanced Reactor Demonstration Program, DOE is putting up $2 billion for implementation of an advanced nuclear pilot plant program such as TerraPower's Natrium reactor in Kemmerer, Wyoming. This is the type of scale and level of commitment the commercial fusion industry could utilize as the U.S. government looks to maintain a leadership role in deploying new clean, firm power sources.

We appreciate the U.S. government's - and this Committee's - support of the private fusion industry to date, however, current federal appropriations for helpful programs such as authorized public private partnership programs are simply not sufficient for the U.S. to gain global leadership position in fusion energy, nor to retain, attract or meaningfully support commercial fusion companies capable of building a domestic fusion energy sector. Indeed, the described ARPA-E programs are one-time, and the only annually recurring fusion public-private partnership program, INFUSE, is currently supported at just $6 million per year. By comparison, the private fusion industry is poised to construct over $2 billion of new integrated fusion demonstration facilities over the next couple of years. It is critical that PPP programs for fusion scale up to remain relevant with the planned private sector investments and accelerated timelines.

c. Maximizing federal resources and funding

Industry's central organizing goal is to put commercial fusion energy on the grid in the early 2030s, a current goal among 92% of the fusion companies that participated in the earlier mentioned survey conducted by the FIA.

The pathway to achieving this goal does not only require us to shift the current priorities of already funded programs, but also to maximize federal resources and funding and make every dollar from the public go further. Thanks to this Committee's leadership, the programmatic architecture for achieving a *Bold Decadal Vision for Commercial Fusion Energy* already exists through current and recently authorized DOE programs and we have successful PPP case studies to point to and emulate to achieve the goals of the Vision. What is needed from Congress and the

Administration is robust and sustained funding through the decade to match the billions in private funding already flowing into this sector.

As an example, a promising development for the fusion industry has been the milestone-based fusion development program, as established by Congress through the *Energy Act of 2020*. Under this new program, companies would accept the bulk of the risk by funding their activities until agreed upon milestones are achieved and verified at which point the company would be reimbursed at an agreed upon fixed price. This is a highly leveraged and ideal option for government investment in fusion with the private sector carrying the risk of schedule and cost overruns and the government supporting companies that have skin in the game by covering a meaningful cost of the program. This type of public-private model has proven successful in other sectors and unleashed an abundance of societal benefits in a short period of time.

The milestone-based fusion development program is modeled after the successful National Aeronautics and Space Administration (NASA) Commercial Orbital Transportation System (COTS) program demonstrated to great success with SpaceX and Orbital[8][9], a program Congress played a key role in establishing several years ago. The COTS program provided NASA with a 10x reduction in launch vehicle program costs, as well as a 2.5x reduction in management costs and has directly contributed to a thriving commercial space industry.

This Committee had the foresight to authorize the fusion milestone program in the *Energy Act of 2020*, and Congress provided the first tranche of funding for the program - $45 million - in FY22. DOE is in the process of standing up this new program and we expect a Funding Opportunity Announcement (FOA) soon, perhaps by the end of this month. We are grateful for this funding and look forward to working closely with Congress, DOE, and others in the private sector to move quickly and put these dollars to work to advance critical commercial fusion energy technology. However, we fear the funding that has been provided for the milestone program in FY22 and what's been proposed for FY23 falls short of the COTS model in order to replicate its success. COTS was successful, in part, because NASA was provided a significant, upfront appropriation of $500 million spent over five years[10]. This level of funding did two things: 1) it provided the private sector a level of confidence that the public sector funding would be there to drive investments in the private sector; and 2) it gave the NASA the ability to plan over a longer time horizon (five years vs a single fiscal year) and de-risk multiple barriers to faster deployment of commercial space, at scale. In short, it enabled the U.S. to move fast.

In order to achieve the *Bold Decadal Vision for Commercial Fusion Energy* and replicate the tremendous success of the NASA COTS model, it's critical that funding levels for the DOE milestone-based fusion development program align with the full, authorized amounts. This will,

[8] NASA Commercial Orbital Transportation Services (COTS) Program
[9] https://www.nasa.gov/content/cots-final-report
[10] https://www.nasa.gov/commercial-orbital-transportation-services-cots

in turn, unleash millions more in private sector funding, helping to drive deployment of commercial fusion in this country. If the fusion milestone program is successful, it will lead to new privately constructed fusion facilities testing key aspects for commercial fusion energy and possibly one or more net-energy fusion systems deployed in the U.S. The time to put fusion energy on the grid would be reduced dramatically and the potential net savings for the taxpayer (versus a fully government funded approach) would be profound.

We are at an inflection point for fusion energy. The DOE's FES program needs to act quickly on already developed plans and utilize existing and new programs that support private industry's accelerated timelines. If we are to be successful in maintaining U.S. leadership in fusion energy, we need the following:

1. Full funding for the DOE FES program, as recently increased in the *CHIPS and Science Act* from $713 million/year to $1 billion/year;
2. Direct better alignment between the FES program and the private fusion industry to advance critical R&D necessary to deploy fusion energy commercially, in line with industry's technology pathways and timelines;
3. Full funding for critical DOE R&D facilities and fusion test stands, such as: Fusion Prototypic Neutron Source (FPNS), Material Plasma Exposure eXperiment (MPEX) and high-heat-flux testing experiments, and the Blanket research and the associated Blanket Component Test Facility (BCTF); and
4. Full funding for the DOE milestone-based fusion program, *INFUSE*, and ARPA-E fusion projects to help achieve the goals of the *Bold Decadal Vision for Commercial Fusion Energy.*

By making the best use of existing and recently authorized fusion R&D funding, better aligning those DOE R&D dollars to support a commercialization pathway, and fully funding these important recently authorized DOE programs, I believe the chances of the U.S. being the first nation to put power from fusion energy on the grid in the early 2030s are greatly enhanced.

This achievement would be one of the most significant advances for all mankind, have the potential to re-order geopolitics that center around energy, and provide humanity with a powerful new tool to tackle the climate crisis.

International governments competing for leadership in fusion energy

The U.S. is not alone in its pursuits and other nations are aggressively supporting development of fusion energy. Foreign governments are also making significant investments in public-private efforts to promote a domestic fusion industry. The United Kingdom has committed over $500 million to fusion PPPs[11]. China is spending hundreds of millions per year[12] on their private fusion industry. This compares to $32 million in the U.S. for both the DOE's INFUSE public-private partnership program and the milestone-based program in the FY23 budget request.

The United Kingdom has continued to build new facilities to test the components needed for a fusion power plant. These include facilities to develop the fuel cycle for fusion, to practice maintenance on a fusion power plant, to extract the heat from the fusion components, and to test materials. The U.S. has no such set of test stands or development programs despite the long-identified need for these facilities. Over the last five years, the United Kingdom has built in steel and concrete while the U.S. program has yet to implement the recommendations from expert reports. I would also note that FIA member General Fusion has announced plans to build a Fusion Demonstration Plant (FDP) in the United Kingdom, which will demonstrate their Magnetized Target Fusion (MTF) technology.

The United Kingdom and China are targeting having a fusion pilot plant operational by the late 2030s. The UK will soon announce their site selection for their STEP fusion pilot plant[13], and China has shared their plans[14] for a fusion pilot plant. However, neither of these timelines are where the U.S. private sector is today and the U.S. could beat these other countries to market by pursuing a PPP model for de-risking R&D and industry development which complement the private sector's plans to build their own pilot plants. Many FIA member companies are planning on operational plants in the early 2030s. In the case of CFS, we are already building our demonstration facility, SPARC, and in the siting process for our first commercial-scale facility, ARC, to support a construction time of being operational in the early 2030s.

If the U.S. wishes to take an international leadership role in fusion, then it needs to accelerate the timeline for a fusion pilot plant to be ahead of its peers by aligning itself with private industry commercialization goals and leveraging the best of DOE and private industry strengths and resources.

Regulatory landscape

While not the jurisdiction of this Committee, I would be remiss if I didn't briefly discuss the importance of having a predictable licensing and regulatory framework to support the growth of fusion energy. In addition to other nations investing significant public funds to develop

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[11] https://www.neimagazine.com/features/featurefusion-projects-make-progress-in-2020-8492724/
[12] https://www.neimagazine.com/features/featurefusion-projects-make-progress-in-2020-8492724/
[13] https://www.gov.uk/government/news/step-closer-to-naming-site-of-first-fusion-energy-power-plant
[14] http://firefusionpower.org/FPA21-2_CN_ASIPP_Fusion_Song.pdf

commercially viable fusion energy, they are also moving quickly to develop a regulatory framework that provides certainty to companies and investors.

For instance, the United Kingdom is leading in the development of a regulatory framework for commercial fusion that recognizes the significantly lower risk profile that fusion presents compared to fission. The United Kingdom government established a commercial fusion regulatory framework and earlier this year published its response to a public consultation, and confirmed that current UK regulators of fusion R&D facilities, the Environment Agency (EA) and Health & Safety Executive (HSE), will retain responsibility for future commercial fusion facilities[15]; and the government will legislate to make the regulatory treatment of fusion energy clear in law. From a risk perspective, fusion energy facilities are much more like particle accelerator facilities that one would find in a hospital, and it makes sense to regulate them in a similar manner, rather than impose the more onerous and wholly inapplicable requirements developed for fission reactors which simply do not match the risk and safety profile of a fusion system.

In the U.S., the Nuclear Regulatory Commission (NRC) is laying the foundations now for the licensing and regulatory approach of fusion energy. We support this work, which began over two years ago, and appreciate the careful and attentive approach the NRC and its staff are taking in its development. It is our hope the NRC designs a framework that aligns with the risk and safety profile of fusion energy (which is quite different from fission), instills public confidence, and provides industry with the certainty it needs to invest and meet our 2030 deployment goals. We believe the NRC already has the authority it needs to regulate fusion energy under 10 Code of Federal Regulations Part 30, Rules of General Applicability to Domestic Licensing of Byproduct Materials. The NRC staff is scheduled to release their draft recommendations for the regulatory framework for fusion energy next week and we look forward to continuing working with them in this process.

Commonwealth Fusion Systems - Our path to commercial fusion energy

Commonwealth Fusion Systems (CFS) is among the many start-ups we have seen emerge and join the private sector over the past 5 years. In 2018, CFS was spun out of Massachusetts Institute of Technology (MIT) Plasma Science and Fusion Center after many years of DOE funding of MIT's long-standing fusion program. At that same time, new high temperature superconductors were becoming commercially available. The MIT team that would become CFS co-founders were exploring how this new material could be used to build a novel design for magnets that would be the strongest fusion magnets of its kind in the world. Magnets are the key technology in a fusion machine called a tokamak, the most widely studied machine for the magnetic confinement fusion approach described above. If we were able to build

[15] https://www.world-nuclear-news.org/Articles/UK-developing-regulatory-framework-for-fusion

high-temperature superconducting (HTS) magnets, we knew that we could build smaller, faster, and less expensive fusion devices that would achieve net energy and become commercial power plants. It meant that we could provide economical fusion power, supplying humanity with abundant clean energy.

CFS set out on an aggressive timeline for bringing fusion power to the grid. As a first step, with with the backing of private capital and by attracting top talent, the company and its funded collaborators at MIT delivered on its commitment to build and successfully test a first-of-a-kind high-field large-bore HTS magnet (Figure 1) in September 2021. It is the largest HTS magnet in the world with a magnetic field of 20 Tesla.[16] The HTS magnet enabled smaller fusion devices than previous magnet technology. The demonstration was what was needed to start construction on SPARC, a tokamak fusion device, that will be 1/40th the size of the International Thermonuclear Experimental Reactor (ITER).

As mentioned earlier, CFS is currently building our magnet factory and SPARC (Figure 2), our fusion device in Devens, Massachusetts. The plasma physics for SPARC was validated in a series of seven peer-reviewed papers published in the Journal of Plasma Physics[17]. The papers show, point-by-point, using the absolute best simulations, physics, and tools - all built from previous world-wide fusion science - that if SPARC is built according to its design, it will work and achieve a net energy gain of Q>10, which is on par with ITER. Gains of Q>10 would serve as the basis for the design of an economical fusion power plant, which we call ARC.

[16] Figure 1 - 20-Tesla HTS Magnet
[17] [Status of the SPARC Physics Basis]

Figure 2

The SPARC facility is aimed at the same basic physics questions of the ITER facility and uses the same scientific and technology advances that underpin ITER. However, the reduction in scale afforded by the HTS magnets means that it can be constructed in a fraction of the time and cost. This puts a burning plasma – a long sought scientific goal – in a much-accelerated time frame. In fact, SPARC is expected to become operational in 2025 and reach net energy from fusion for the first time in history in the following year with burning plasmas soon after that. This is the power of innovation and commercialization. This is a domestic facility, built by a U.S. company, backed by private capital, creating a leadership opportunity for U.S. science, engineering, and industry creation. I would note that despite our best efforts to engage, without a comprehensive plan for public private partnerships, there is no readily apparent pathway for the DOE to engage at the scale needed to take advantage of this advancement in the sector.

Following the SPARC demonstration in 2025, CFS plans to construct the world's first commercial-scale fusion power plant, ARC, and put electricity on the grid in the early 2030s. In parallel with the construction of SPARC, we are already conducting a global search for the site of the first ARC such that we can achieve our ambitious goals, in what I believe are achievable timelines.

ARC will further demonstrate the science and technology required for economically competitive, mass production of fusion energy. It will pave the way for fusion systems that will provide carbon-free, safe, virtually limitless power for the world. However, the current publicly funded program's roadmap for developing the required technologies is not at the scale, timeline, or technology choices the private sector requires, thus companies could be forced to duplicatively develop technologies themselves. It is for this reason, the U.S. should move quickly to develop and fund a *Bold Decadal Vision for Commercial Fusion Energy*.

At CFS, we are building a company with the know-how and capabilities to achieve these timelines. We are hiring the best talent to bring this technology to market as quickly as possible and then scale. We also recognize the value in continued collaboration with DOE, the National Laboratories and universities for science research that can support and accelerate development in the fusion private sector. We look forward to growing existing and developing new public sector partnerships that put the U.S. on the fastest path to fusion energy on the grid.

I thank the Committee for holding today's hearing and look forward to working with you to ensure the U.S. will remain at the forefront of this rapidly changing landscape.

Executive Summary of Recommendations to Secure U.S. leadership in Fusion Energy

- Expanded support from the federal government for fusion energy programs is necessary to keep the center of the private fusion industry based in the U.S. To achieve this goal, the U.S. should develop and fund a *Bold Decadal Vision for Commercial Fusion Energy* that leverages the strengths of existing Department of Energy (DOE) programs and National Laboratories and those of the private sector.

- If the U.S. does not scale the public sector efforts and does not align them with the private sector, it may fall behind other nations, like the United Kingdom or China, and miss the opportunity to be a leader in a large-scale energy transition to fusion power.

- The private sector is moving quickly with nearly 35 companies having raised $4.7 billion in private funds and driving towards commercial fusion in the 2030s. Now is the time to make the necessary changes to align DOE resources and funding to partner with the private sector to drive innovation and leadership in fusion energy.

- We need better alignment between the DOE, National Laboratories, universities, and the private sector to work collaboratively towards a common-objective of deploying commercially viable, fusion energy in the early 2030s. Specifically, the DOE and National Labs should focus on their core strengths, such as building out important R&D facilities, test stands and focusing on the science, while the private sector brings its capital, market insights, engineering and execution expertise to move more efficiently towards power plants.

- Congress and the Administration should move quickly to implement a *Bold Decadal Vision for Commercial Fusion Energy* by fully funding existing and newly authorized DOE fusion programs and by leveraging milestone-based, public-private partnerships in order to rapidly deploy commercial-scale fusion energy. Specifically, Congress and the Administration should:
    - Provide full funding for the DOE FES program, as recently increased in the *CHIPS and Science Act* from $713 million/year to $1 billion/year;
    - Direct better alignment between the FES program and the private fusion industry to advance critical R&D necessary to deploy fusion energy commercially, in line with industry's technology pathways and timelines;
    - Move quickly to fund and build important fusion R&D facilities and test stands, including, in line with Fusion Energy Sciences Advisory Committee (FESAC) recommendations:
        - Fusion Prototypic Neutron Source (FPNS), which will provide unique material irradiation capabilities;

        - Material Plasma Exposure eXperiment (MPEX) and high-heat-flux testing experiments, which will enable solutions for the plasma-facing materials;
        - Blanket research and the associated Blanket Component Test Facility (BCTF), which will provide the scientific understanding and basis to qualify fusion power system blankets for a fusion pilot plant.;
    - Provide full funding for the DOE milestone-based fusion development program, *INFUSE,* and *ARPA-E* fusion energy projects.

- Fund and implement the DOE milestone-based fusion program to emulate the successful NASA Commercial Orbital Transportation System (COTS) program model, demonstrated by great success with SpaceX, which provided significant upfront funding ($500 million over five years) to move quickly and drive innovation in a strategically important sector.

- Implement a predictable, reliable licensing and regulatory approach from the Nuclear Regulatory Commission (NRC) that aligns with the risk and safety profile of fusion energy, instills confidence with the public in the technology, and provides the industry with the certainty it needs to invest and meet our early 2030s deployment goals.