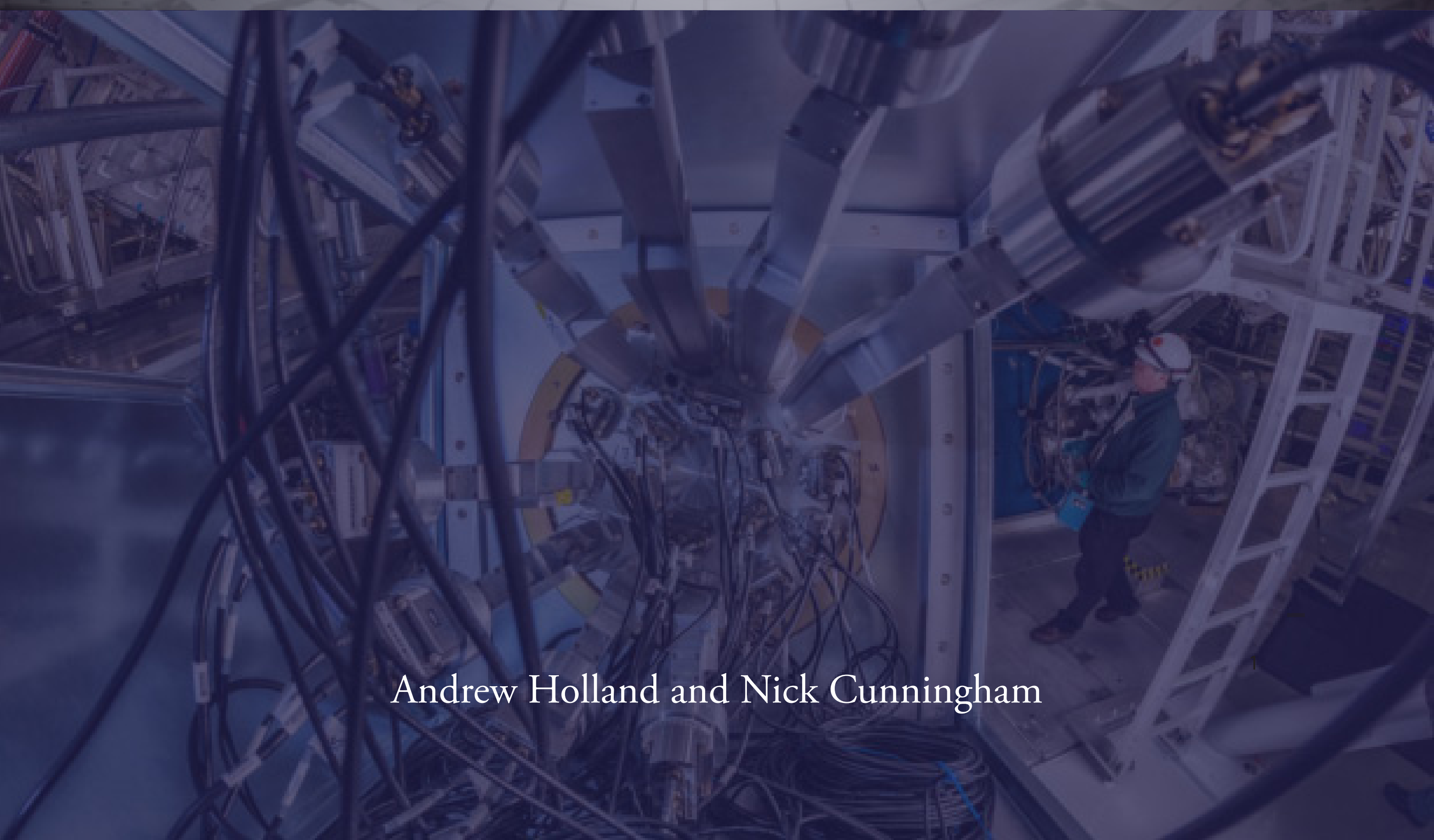
Fusion Power

A Ten-Year Plan for American Energy Security

American Security Project



Andrew Holland and Nick Cunningham

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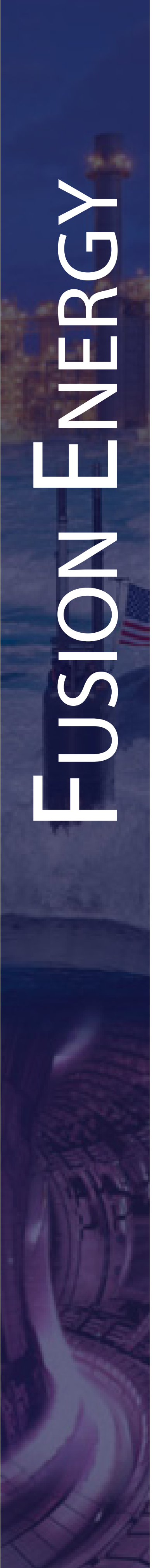
Christine Todd Whitman is the President of the Whitman Strategy Group, a consulting firm that specializes in energy and environmental issues.



"Execution of research and development activities leading to a Fusion Nuclear Science Facility will close the majority of remaining technical gaps in establishing the readiness to initiate development of a fusion demonstration plant."

The Question:

The American Security Project asked the five leading magnetic fusion scientists, **assuming a well-funded and aggressive program of development in magnetic fusion, how close can the U.S. come to a working fusion power plant in 10 years?**

The Scientists' Answer:

The scientific basis now exists to support greatly accelerated magnetic fusion energy development.

With adequate resources and appropriate program structure, a device that would test key fusion technologies and ultimately produce demonstration levels of electric power could begin operations about 10 years from now.*

Signed,

Dylan Brennan, President of the University Fusion Association

Raymond Fonck, Professor of Physical Sciences, University of Wisconsin-Madison

Miklos Porkolab, Director of the Plasma Science and Fusion Center at MIT

Stewart Prager, Director of the Princeton Plasma Physics Laboratory

Tony Taylor, Vice President of Magnetic Fusion, General Atomics

**full response found in epilogue*

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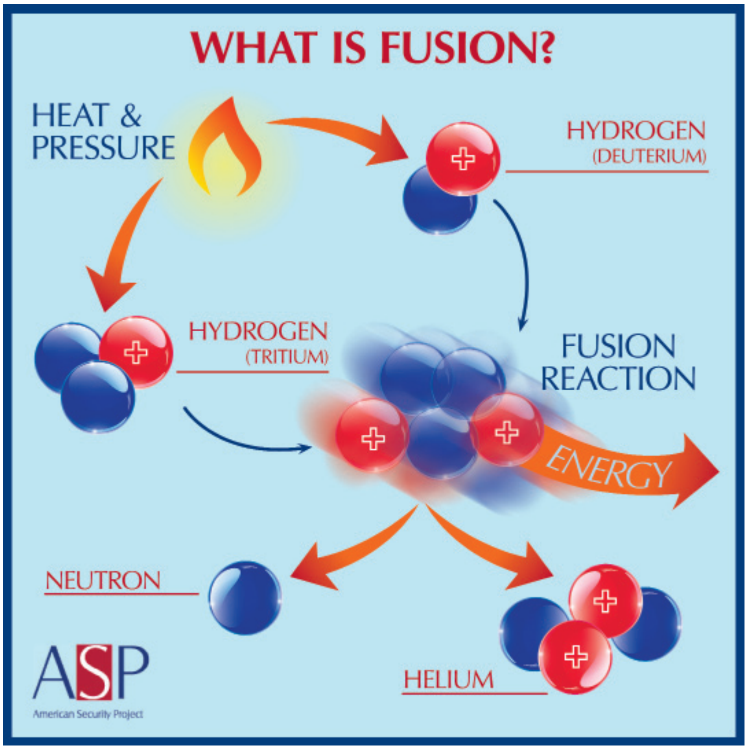
Introduction

A modern and thriving economy depends on its energy supply. Choices we make today will decide America's energy mix for the next generation.

Over the next several decades, almost all of our country's power plants will have reached the end of their life and will need to be replaced. We need to make the choices today on what those future plants will be.

Across the globe, replacing energy infrastructure and expanding capacity to meet growing needs will result in cumulative investments of $37 trillion by 2035.[1]



America's dependence on fossil fuels saps resources from our economy, exacerbates climate change, and constricts our foreign policy. Current-generation renewable energy – solar, wind, hydro, and biomass – will continue to add capacity, but there are real logistical difficulties to scaling-up these technologies to meet a significant portion of base load electricity demand.

We must develop energy technologies that will power America's economy for the next generation – technologies that are also clean, safe, secure and abundant.

One technology holds great promise in meeting our needs: energy from fusion.

It is a national security imperative that America demonstrate practical fusion power within 10 years. This will set the stage for full-scale commercial power that will drive American prosperity for the next century.

This is the same process that powers the sun, and it will completely revolutionize the world's energy system when commercialized.

By fusing together two hydrogen atoms, enormous amounts of energy could be produced, which is at the heart of the world's most famous equation, $E=mc^2$. The heat from a fusion reaction could be used, like ordinary power plants today, to spin a steam generator to make electricity.

Fusion holds the promise of providing a nearly inexhaustible supply of energy.

Even better, no pollutants or greenhouse gases are emitted, and there is no threat of a nuclear meltdown as there is with the nuclear fission reactors of today.

But this will not be easy. While fusion has already been achieved in laboratories all around the world, the challenge is to create conditions for net energy - where more energy is produced than has been consumed.

This is possible. We can do it. We need focus, invesment and commitment.

Why Fusion?

Fusion is clean. Energy from fusion produces no greenhouse gases or air pollutants. Only clean power is generated during fusion.

Fusion is safe. It does not rely upon a chain reaction. Unlike nuclear fission, there is no chance of a runaway reaction that could lead to a meltdown. A Fukushima-type event is not possible with a fusion power plant. In the event of an equipment failure, the small amount of fuel available stops reacting instantly and the plant cools automatically.[2]

Fusion energy is practically unlimited. Fusion produces energy by fusing together two hydrogen isotopes – deuterium and tritium. These two isotopes are virtually inexhaustible.[3] Deuterium comes from ocean water, and tritium, though limited today, will be produced from lithium as a byproduct of the reaction. Fusion therefore holds the promise of complete energy independence. Fusion of the tiny amount of deuterium found in a quart of ordinary water yields energy equal to that in the combustion of 3 barrels of oil.

Fusion is secure. The only byproducts of the fusion process are helium and a fast neutron, which carries the heat to make steam, meaning there is none of the long-lived radioactive waste produced by conventional nuclear fission reactors. (Even the radioactive by-products are either short-lived (i.e. tritium gas) or low-level, and can be safely managed with relative ease.)

Fusion will spark monumental scientific achievements. The positive spillover effects of the U.S. fusion program are already being felt. Fusion scientists are making advancements in superconductors, which have a wide range of industrial applications. They are also developing super-power lasers and new high-efficiency semiconductor light sources, large and small-scale robotics, and pushing the progress of supercomputing and modeling.

With a major fusion initiative, America can regain the lead in developing world-class scientists and engineers, creating a workforce that will drive prosperity for future generations.

There is broad agreement in an 'all of the above' strategy on energy. We need new base load power that is carbon-free. Today, nuclear power can meet that – but we will also need research and development into new technologies. American leadership is on the line.

ASP Board Member
Gov. Christine Todd Whitman

We Need New Sources of Base Load Power

- Fossil fuels and climate change present national security threats to the United States
- Current energy technologies are not adequate
- Transformational change in energy technologies is needed to deal with the climate crisis

The U.S. relies upon a mix of energy sources to fuel its economy.

The current energy mix contributes to climate change, which presents national security concerns for the United States.

In order to adequately deal with the climate crisis, scientists believe emissions will need to peak and decline over the next few decades. Current technologies will contribute to emissions reductions, but fully scaling-up low-carbon technologies will require fundamental breakthroughs in technology.[4]

Incremental improvements will not solve the climate problem; phasing out greenhouse gas emissions from America's economy will require transformational change in energy technologies.

Fusion has the potential to meet the needs of tomorrow's economy by providing carbon-free base load power.

It emits zero greenhouse gases and is not variable like other renewable sources of energy. Fusion is the only source of energy that is clean, safe, secure and abundant. For energy and environmental security of future generations, fusion energy is critical. Because fusion power will be affordable, abundant, and 'always on,' base load energy provided by fusion power could be harnessed for many uses other than today's electricity; biofuels, desalinization, or fertilizer production could all be supported by fusion power.

It is not an exaggeration to say that fusion power would revolutionize America's economy.

Scientists have been working on fusion for decades and have made significant progress. If not for the short-sighted budget cuts of the 1990's, progress would have continued. Instead, progress in magnetic fusion has been delayed.

ASP Board Member
BGen Stephen A. Cheney, USMC (Ret.)

What is base load power?

Base load power is the minimum amount of power needed to supply customers with an uninterrupted supply of energy, without interruption. Currently, we rely upon power plants fueled by coal, natural gas, hydropower, and nuclear fission.

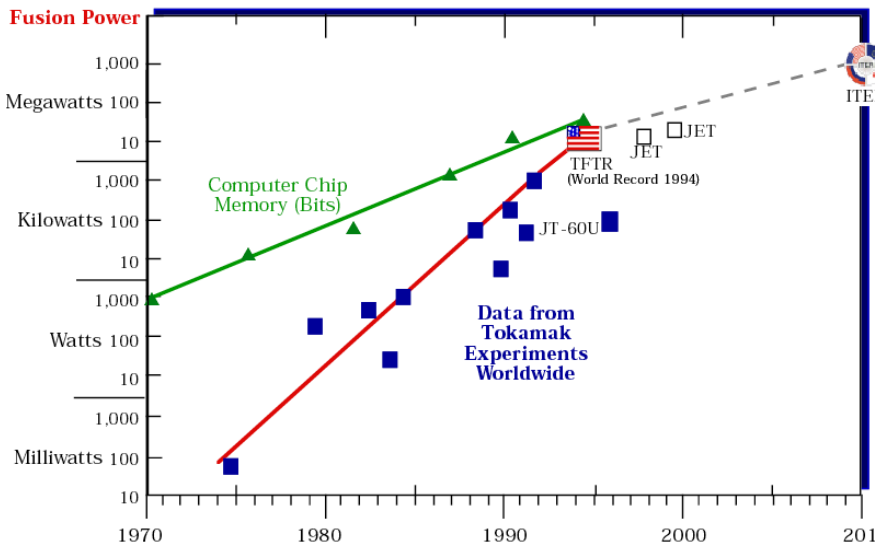
Fusion Works

- Fusion is already being conducted in laboratories all over the world.
- Scientists have achieved exponential progress in fusion energy.
- More progress would have occurred, but budget cuts have set back the program

Scientists have made extraordinary progress on fusion energy over the past few decades. Exponential increases in power generation have been achieved – from only a few watts in the 1980's to 16 million watts (16 megawatts) in 1997.[5] Further progress is possible, but budget cuts have caused significant delays.

The chart below depicts the progress fusion researchers were making until budget cuts in the 1990's.

Researchers were achieving exponential increases in power production, and it is safe to assume progress would have continued at a similar rate, but budget cuts slowed the effort.



The Approaches to Fusion Power

There is important progress being made towards this goal from the two main approaches to fusion energy – magnetic confinement fusion and inertial confinement fusion. Both approaches have plans to commercialize fusion energy in the coming years.

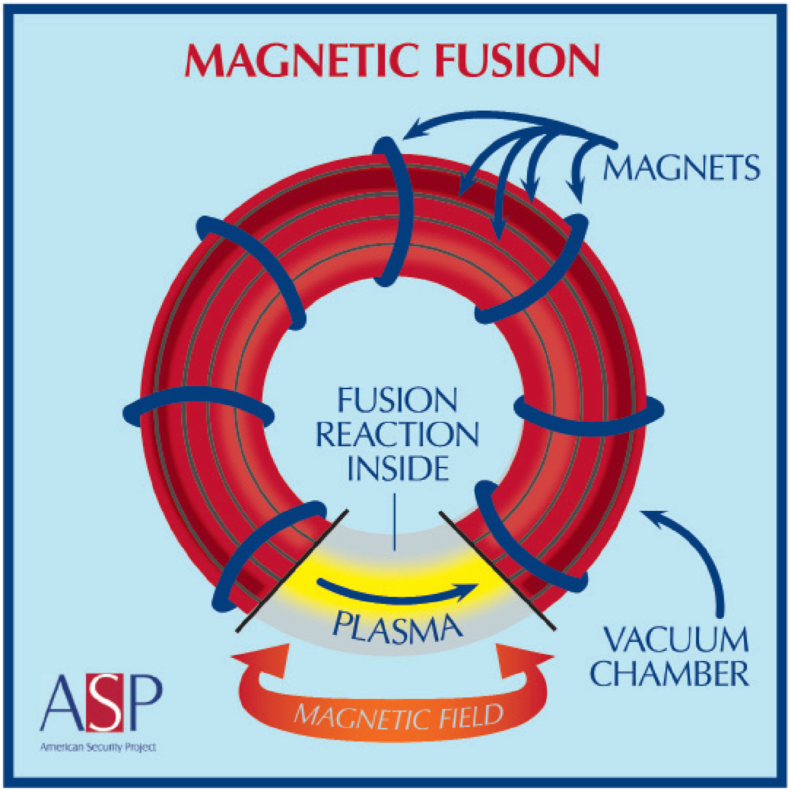
Magnetic Confinement Fusion

- The high temperatures of the plasma are needed to force the hydrogen atoms to fuse together – that releases massive amounts of power.
- Magnets are used to control very hot plasma.
- There are several leading magnetic fusion institutions in the U.S. making progress on fusion energy.

With magnetic confinement fusion, magnets are used to confine superheated plasma, within which, fusion is achieved.

The magnetic fields are produced by superconducting coils surrounding a vessel, creating a "torus" in which the plasma is contained.[6] The high temperatures of the plasma are needed to force the hydrogen atoms to fuse together (overcoming the natural electrostatic repulsion that exists for two positively charged atoms). The machines used for magnetic fusion are called "tokamaks."

Once the atoms fuse, energy is released, which can be captured to produce electricity.



Efforts at achieving fusion through magnetic confinement date back several decades.

In the U.S., there are several leading fusion institutions on fusion energy.

The Massachusetts Institute of Technology's Alcator C-Mod tokamak pushes the bounds of knowledge on magnetic fields and plasma pressure, more than any other facility in the world.[7] This research works to solve the key engineering challenges that remain before fusion energy can be commercialized.

General Atomics operates another critical fusion center on behalf of the Department of Energy, called DIII-D.[8] It is the third largest tokamak in the world, and focuses its research on plasma confinement and advanced tokamak designs.

The Princeton Plasma Physics Laboratory (PPPL) operates the National Spherical Torus Experiment (NSTX), constructed in collaboration with the Oak Ridge National Laboratory, Columbia University, and the University of Washington at Seattle. Because of its compact design, NSTX is a prototype for cheaper next-step fusion machines.[9] NSTX is also developing possible breakthrough solutions on the materials needed to handle plasma, a key engineering challenge that remains. Prior to its work developing the NSTX, PPPL was host to the first significant release of fusion power (10 megawatts) in 1994 at the Toroidal Fusion Test Reactor (TFTR).

Currently, the largest tokamak in the world is the Joint European Torus (JET), located in the United Kingdom.[10] After Princeton's TFTR breakthrough in 1994, JET set the record for fusion energy produced, generating 70% of input power.[11]

All of the tokamaks mentioned above have established the scientific foundation upon which the internationally-backed ITER experiment will build. The ITER experiment was originally agreed upon in the 1980's by the international community with the goal of developing fusion power for peaceful purposes.[12]

The European Union, together with the support of six other nations - the U.S., Russia, China, India, Korea, and Japan – the ITER magnetic fusion experiment will produce net power, providing definitive proof of the viability of fusion power. ITER is designed to produce 500 megawatts of fusion power for 500 seconds. ITER is currently under construction in the south of France, and the European Union, as host of the project, is financing 45% of the cost, with the other six nations contributing 9% each.[13] It is expected to be in operation by 2020.

What is Plasma?

Plasma is a hot gas that is used in magnetic fusion energy.

It has properties unlike those of liquids, gases, or solids – earning it the distinction of the 'fourth' state of matter. The heat from plasma is needed to overcome the natural inclination for hydrogen atoms to repel each other, allowing fusion to occur.

Inertial Confinement Fusion

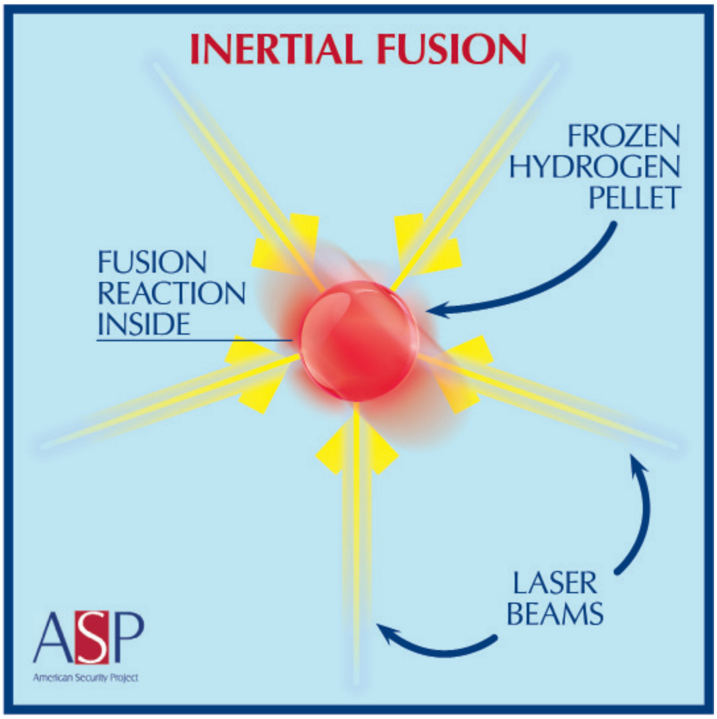
- Inertial confinement fusion uses lasers to heat and implode a very small fuel pellet.
- By crushing and fusing two atoms together using heat and pressure, energy is released.
- The National Ignition Facility (NIF) in California is conducting research to prove "ignition" - more energy out than is put in.

Inertial confinement fusion would create fusion energy by heating and imploding a fuel pellet, typically using lasers.

The National Ignition Facility (NIF), a lab housed within the Lawrence Livermore National Laboratory (LLNL) in California, is the world's leading institution working on inertial fusion. At the NIF, scientists are using the world's largest lasers in order to achieve fusion "ignition" – producing more energy out than is put in.

Alongside its national security mission, the NIF is designed to operate at a scale that could provide the scientific demonstration for a 1,000 megawatt electrical power plant.

By concentrating lasers on a pellet of hydrogen atoms, extreme temperatures and pressure cause the fuel pellet to implode, forcing the isotopes to fuse together and create energy.[14] Completed in 2009, the NIF has been making steady progress with inertial fusion.



"The potential benefits of inertial fusion energy justify it as a part of the long-term U.S. energy R&D portfolio."[15] – 2013 Report of The National Academies of Sciences.

In the summer of 2012, for a brief instant, the NIF's lasers delivered 520 terawatts of power, more than 1,000 times the amount of electrical output in the entire United States at one moment in time. This exceeded the design specification for the facility, and is believed to be sufficient to create the conditions necessary for ignition of the fusion fuel.

As with any approach to fusion, a precise timeframe to energy gain cannot be predicted accurately. What is important is to ensure that adequate resources and time are devoted to maximizing the timely realization of this goal.

When NIF reaches ignition, the next step will be to build a full-scale demonstration plant known as Laser Inertial Fusion Energy (LIFE). This is being designed as a fully operational power plant, able to sell electricity on a commercial scale.

Alternative Approaches

- There are other approaches to fusion energy than magnetic fusion and inertial fusion.
- These approaches use combinations of magnetic and inertial fusion
- Some alternative approaches hold promise to achieve fusion energy faster and cheaper than commonly believed

While magnetic fusion and inertial fusion are considered the two main approaches to fusion energy, there are alternative approaches in both the public and private sector that offer promising potential.

For example, the Naval Research Laboratory (NRL) is pursuing an alternative approach to the research being done at the NIF. Whereas the NIF uses "indirect drive" – shooting lasers at a capsule, which creates x-rays to crush the fuel pellet, NRL pursues "direct drive." This means that the NRL facility, known as 'Nike KrF,' shoots lasers directly at a fuel pellet to create fusion. There are some promising qualities about direct-drive fusion, such as simpler physics and more efficient use of laser energy.[16]

There are a number of teams researching Magnetized Intertial Fusion, or MIF, as a hybrid approach between the two traditional methods to fusion energy. These approaches have elements of both magnetic and intertial fusion. They use magnets to confine the fusion fuel, which is then imploded using some sort of outside force, ranging from pistons to lasers. A team at Sandia National Laboratory is reseraching "magnetized liner intertial fusion," or MagLIF, while a team at Los Alamos is researching Plasma liner-driven MIF, which would implode a target using supersonic plasma jets.

A nubmer of private sector firms have begun work to demonstrate a fusion power plant using one of these innovative designs. Companies researching this range from small start-ups like Gneeral Fusion, based in Vancouver, to large firms like Lockheed Martin.

There are many possible approaches to achieving a breakthrough in fusion energy. It is simply too early to down-select which approach is the most promising. Having multiple approaches competing for funding and investment improves the probability of success.

The U.S. continues to fall behind in its scientific competitiveness. As one major example, research into fusion power could lead to safe, affordable, clean, and sustainable energy, yet other nations such as China and South Korea are pushing much harder than we to commercialize fusion.

If we don't set it as a national priority ourselves, we are in danger of losing this race, too.

ASP Board Member
Norman R. Augustine

Fusion Industry Stretches Across the U.S.

- The fusion energy industry already supports thousands of jobs and businesses across the country.
- 47 out of 50 states support the fusion industry.
- The fusion industry consists of over 3,600 businesses and contractors.

The fusion industry consists not only of national laboratories, but also the thousands of businesses, contractors and research facilities that support fusion energy.

Through its research, the American Security Project found that the fusion industry supports over 3,600 businesses and vendors, in addition to 93 research institutions, which are located in 47 out of 50 U.S. states.[18] This strong vendor base supports thousands of jobs in both magnetic and inertial fusion.

It is time to get serious about the possibilities of fusion energy technologies. We should not allow short-term fiscal difficulties to cause us to lose our scientific leadership in the next generation of energy sources. Our leadership in areas like information technology and space travel is being challenged. Our energy systems present both opportunities and threats – and we know that investments in fusion technologies can help exploit these opportunities.

ASP Board Member
General Lester Lyles, USAF (Ret.)

The U.S. is Falling Behind

- Despite pioneering fusion energy research, a lack of commitment risks ceding leadership to other countries.
- While the U.S. has some leading fusion energy facilities, the capabilities of other nations are surpassing those of the United States.
- Other countries are moving ahead with more ambitious plans to develop fusion energy.
- This is a critical issue for our national security.

Despite the impressive progress that fusion scientists are making in American laboratories, the U.S. is ceding leadership in fusion energy to other countries. Although the National Ignition Facility currently leads the world in inertial fusion research, the magnetic fusion facilities in other countries have surpassed the technological capabilities of the best American labs.

International plans for power-plant deployment are also substantially more advanced in many areas.

Here is a quick look at a few of the superior labs around the world:

- China: completed construction of the world's first superconducting Tokamak in 2006, called the Experimental Advanced Superconducting Tokamak (EAST).[20] It is located in Hefei, Anhui Province.
- South Korea: completed construction on its superconducting Tokamak in 2007, called the Korean Superconducting Tokamak Reactor (KSTAR).[21] It is located in Daejon, South Korea.
- Japan: completed construction on a superconducting Stellarator (a type of magnetic fusion reactor) in 1998.[22] It is located in Toki, Gifu, Japan.
- Japan: a superconducting Tokamak is under construction in Naka, Japan.[23]
- Germany: a superconducting Stellarator is under construction in Greifswald, Germany, called the Wendelstein 7-X.[24]

Each of these machines is superior and more advanced than their counterparts in the U.S. This is a reflection of greater sustained national investments.

The Challenge

While the science of fusion has advanced dramatically through contemporary supercomputing techniques, there are several engineering challenges remaining before fusion energy can become a commercial reality.

So far, fusion reactors have required more energy than they have been able to create. To overcome this hurdle, advancements in three key areas are necessary.[25]

- Advanced Materials: Materials that are powerful enough to withstand extremely high levels of temperature from plasma must be developed.
- Controlling Plasma: A better understanding of how to control and confine plasma is needed in order to sustain a net-positive reaction. This is the goal of the ITER and the National Ignition Facility.
- Providing Sustained Electricity: Fusion engineers need an improved understanding of how to harness the energy from fusion into electricity capable of powering the grid.

The fusion science and engineering community has developed detailed plans to tackle each of these issues, given enough time and resources.

The Urgent Steps Needed to Commercialize Fusion Energy

- It is a national security imperative that America makes a dedicated commitment to fusion energy.
- The current situation lacks leadership and ambition, which will lead to the inability to commercialize fusion energy for many decades.
- A national commitment will require just $30 billion over 10 years, with the goal of producing demonstration levels of electric power within a decade.
- A national commitment to fusion energy will lead to energy and environmental security, and provide leadership in an emerging high-tech industry.

Absent steps to accelerate fusion development, current projections estimate that commercial-scale fusion power plants could be built in the 2040's. Scientists and engineers believe they are on the right path to development. Yet, a timeframe that always remains decades away lacks ambition and forecloses on domestic leadership.

Cutting down the time needed to develop fusion energy will require a national commitment for fusion energy coupled with an accelerated push to commercialization.

The American fusion community believes that given adequate resources, developing commercial fusion power can be achieved on an accelerated timeframe.

A National Commitment for Fusion Energy

It is a national security imperative that America develops commercial fusion power on an accelerated timeframe.

Our dependence on fossil fuels to power millions of homes, businesses, and automobiles exacts an economic toll, contributes to climate change, and distorts our foreign policy. Fusion energy can go a long way to addressing all of these problems.

Without a strong push towards fusion, our economy will still suffer from volatile fossil fuel prices as these resources continue to be depleted. The effects of climate change – drought, severe storms, flooding, reduced agricultural productivity – will ravage both rich and poor countries alike. Ensuring

oil continues to flow out of hotspots around the world saps our resources and weakens our foreign policy.
Moreover, other countries are moving ahead with fusion energy.

Currently, the United States has the strongest scientific and engineering workforce in the world, but that position will erode if the U.S. continues to scale back fusion investments and other countries forge ahead. Should we fail to adequately invest in fusion energy, we will not be able to train the next generation of scientific leaders or create the necessary industrial capacity.

Creating a new industry will give America a "first mover advantage" that will increase our global competitiveness. Being the first-mover in a new industry can have economic implications for generations. This has been illustrated time and time again with new technologies – from automobiles, to aviation and aerospace, to nuclear fission. The U.S. pioneered each of these industries and led them for generations, creating economic growth and employment as a result.

America can once again lead in establishing a cutting edge industry. Fusion promises to revolutionize the global energy system and the United States can help make it a reality.

However, it will take a national commitment.

What does a national commitment look like?

The United States would position fusion energy as a technology that is central to America's long-term energy and environmental security.

A true national commitment would include a sustained commitment to fusion energy development, instead of an annual budget fight over cuts and goals.

It would require a commitment of policymakers and the public to see fusion energy through to its commercialization, a process that will necessarily take many years.

A national commitment would require more investment; scientific innovations require significant financial resources.

More importantly, it is critical that funding levels are consistent and set for the long-term. Fluctuations and annual budget fights make it incredibly difficult to plan. As such, the main barrier to an aggressive plan to develop fusion energy is political will.

We know the payoff from the investment will be enormous – clean, safe, secure

Accelerated Push

We cannot wait decades; we must move swiftly to harness fusion energy.

Shortening the time to development is possible if there were a national commitment on fusion energy, strong leadership, and sufficient resources.

There are several actions that could accelerate its development.[26]

1. Appoint a Fusion Power Commissioner to streamline leadership
2. Begin construction of a "Component Test Facility" to accelerate progress in materials science
3. Pursue multiple and parallel research paths to fusion
4. Devote increased resources to existing fusion research facilities
5. Experiment with new and innovative power plant designs
6. Cooperate fully with the private sector

1. Appoint a Fusion Power Commissioner to streamline leadership

Expanding fusion power in a short time period will need a strong voice at the highest levels of government in order to overcome the inertia that grips large government programs.

Regulatory authority for fusion energy would currently fall to the Nuclear Regulatory Commission (NRC) by default, but the NRC lacks the capacity and resources to evaluate and license fusion reactors.

If fusion energy nears commercialization and a regulatory framework has not been developed, delays in design licensing, not to mention permitting and siting, could significantly push back the completion date of commercial reactors.[27]

RECOMMENDATION: A Fusion Power Commissioner should be appointed to coordinate all fusion research and to begin to establish a fusion regulatory regime. Authorities should be streamlined to allow the commissioner to consolidate overlapping entities in order to reduce delays.

Fusion science is also plagued by overlapping entities. Different approaches to fusion energy fall under different budget authorities. Fusion research is stove-piped into different science and engineering fields.
Therefore, appointing a "Fusion Power Commissioner" that would be given streamlined regulatory authority would facilitate the rollout of fusion energy and avoid delays.

The new commissioner could be responsible for allocating resources to fusion science facilities around the country in a streamlined fashion in order to overcome the inevitable regulatory and bureaucratic delays.

Strong leadership from a consolidated authority is needed to accelerate fusion development.

Budgeting for all fusion research would be streamlined under the Fusion Power Commissioner. This would greatly reduce regulatory red tape and bureaucratic delays.

2. Begin construction of a "Component Test Facility" to accelerate progress in materials science

One of the main engineering obstacles remaining is the use of materials to handle high temperatures required for confining plasma. Existing fusion research facilities are currently working on this issue and have made significant progress. However, the next few years are critical.

To accelerate progress in materials science, fusion scientists have proposed the construction of a Component Test Facility (CTF), which would allow key materials to be tested under extreme conditions. The research at the CTF would enhance understanding of materials science and may lead to technological breakthroughs. This would be similar to the experience of nuclear fission, in which 45 small test facilities at the Idaho National Lab in the 1950's and 1960's set the stage for full-scale commercialization of nuclear power..[28]

RECOMMENDATION: A Component Test Facility should move forward right away to improve the scientific and engineering understanding of materials science and plasma confinement.

The fusion community hopes to build the Component Test Facility after ITER in the 2020's. The Component Test Facility would build on lessons learned from ITER and increase the likelihood of success for the demonstration plant. America's national labs are ready to proceed with a Component Test Facility, but lack funding.

We do not need to wait until ITER is completed to build it. Instead of waiting until ITER is complete, it should be built as soon as possible.

3. Pursue multiple and parallel research paths to fusion

There are two main approaches – magnetic confinement fusion and inertial confinement fusion – and a variety of subcategories beneath those two. The most viable path forward for fusion energy will be informed by the results of National Ignition Facility, ITER and many other related experiments.

The community must pursue multiple paths to mitigate risks and increase the probability of success.[29]

Although some will not work, pursuing multiple paths would reveal superior approaches and increase the chances of success. This would require a tolerance for failure, but we could achieve net energy gain more quickly.

Similarly, building experimental facilities in parallel instead of staggering them would increase the probability of success. For example, instead of waiting until the mid-2020s to begin designing and planning a plant to demonstrate net energy gain, those preliminary steps could begin now.

RECOMMENDATION: It is too early to down select the best approach to fusion energy. Multiple paths should be pursued.

Undertaking the next steps in the fusion development plan on an accelerated timeframe, which have hitherto been planned to be spread out over decades, can shorten the eventual start date for full commercialization.

4. Devote increased resources to existing fusion research facilities

Expanding funding for fusion research at universities and national labs will accelerate discovery and innovation.[30]

Whether it is progress in plasma confinement, modeling, or developing and testing new materials, the current fusion facilities could accelerate their research. Due to funding constraints, facilities are not being operated at full capacity.

For years, researchers made exponential gains in power generated from fusion reactions, but progress stalled when budgets were cut. Given more resources, America's fusion laboratories and university programs could dramatically scale up experimentation and testing. Operating at a heightened level will accelerate fusion development.

RECOMMENDATION: Fusion research institutions are pushing the bounds of science and engineering and successfully developing fusion energy depends on them. More resources should be dedicated to these institutions. Fusion institutions need consistent funding and a base from which to build. This means annual appropriations for fusion must be sufficient to avoid cuts. Specifically, Congress should support $475 million for Fusion Energy Sciences in the FY-13 budget and $522 million in the FY-14 budget.

For example, research at MIT's C-MOD fusion laboratory is facing crippling budget cuts in the coming year, which would close the facility. The research being done at MIT is important for the success of ITER.

For fusion to become a reality, facilities like those at MIT deserve adequate funding. Similarly, the budget for National Ignition Facility is being scaled back just months after it has attained its full operational status.

Instead of shuttering or starving facilities to find budget savings, we should be opening new institutions to push the frontiers of fusion science forward.

Moreover, innovation requires multi-year and often multi-decade planning and investment decisions. Fluctuating budgets – with on-again, off-again funding – is damaging to scientific progress.

Fusion research needs consistent funding and a base from which to build. In the short-term, this means avoiding draconian cuts to institutions that are already reeling from years of operating on minimal budgets. Fusion researchers need certainty and budget stability to plan research and projects that span several years.

5. Experiment with new and innovative power plant designs

Advances in superconducting materials will likely open up new possibilities for fusion power plant designs.

Up until now, fusion scientists believed that further progress in performance required significant increases in the size of a fusion facility. However, according to a new MIT proposal, new superconducting materials may allow a doubling of magnetic field strength, and at the same time potentially reducing the size of the power plant by a factor of 5 to 10.[31]

RECOMMENDATION: Resources should be dedicated to developing alternative designs for fusion power plants. While some may fail, some may prove more cost-effective.

Moreover, by decreasing the size of fusion reactors and increasing the power of magnets, efficiency gains could be made. In other words, producing the same power with smaller reactors could be significantly cheaper. Also, through "modularization" – standardizing reactors and their components so they can be assembled – costs could be further reduced.[32]

These new "small fusion reactors" could also theoretically be opened up, with standardized parts dropped in when replacement is needed. By experimenting with creative new designs, fusion reactors could achieve enormous efficiencies and cost-savings.

6. Cooperate fully with the private sector

While fusion energy research has traditionally been the purview of national labs funded by government research dollars, there has been extensive involvement from industry throughout its history.

In order to move from scientific demonstration facilities to a fleet of U.S.-designed, American-built power plants, the role of industry will need to be further developed.

In particular, the design process for the power plants will need to take account of the owner/operator requirements of the utility industry, including the need to minimize costs and enhance maintainability by adopting a factory-based manufacturing approach wherever possible.

Commercializing fusion energy will not just affect the fusion community.

RECOMMENDATION: Fusion research institutions, vendors, and the government need to collaborate with the private sector to begin planning for the realization of fusion power plants.

Building fusion power plants and developing the sophisticated supply chain needed to service those plants, will provide economic opportunities for a range of products, including: turbines; semiconductors; gas processing; cryogenics; superconductors; vacuum systems; piping and boiler systems; advanced materials; remote handling technologies; and mass manufacturing and conventional construction.

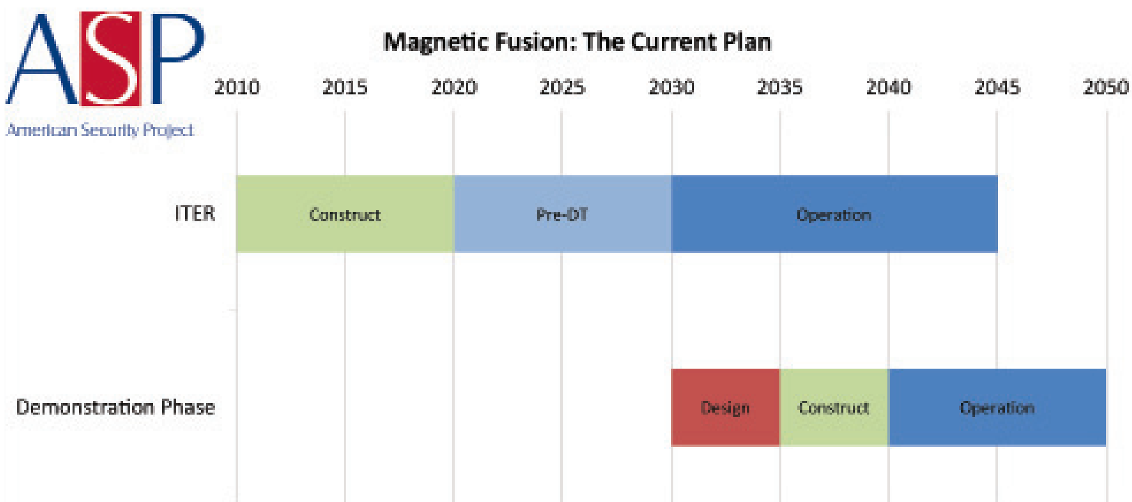
Incorporating these broad and disparate industries into a supply chain that can lower costs for future fusion power plants is critical.

Seizing the Opportunity – The Plan

By pursuing the above actions, the timetable for fusion commercialization can be accelerated. The below scenarios represent a conceptual idea of what can be done.

Magnetic Fusion: The Current Situation

Currently, the situation for fusion energy represents a lack of commitment and leadership. Given the current budget, the fusion community believes that ITER will be followed by a full-scale demonstration plant sometime in the 2030-2040 time frame, incorporating the lessons learned from ITER.

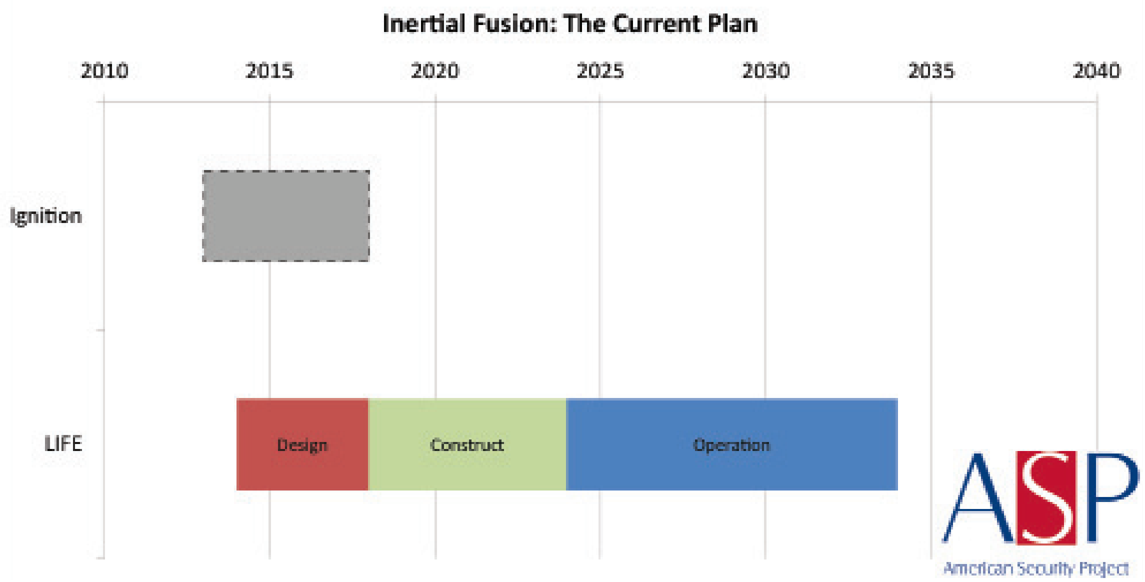


Only after the 2040's will commercial power plants be considered. The current situation means that fusion energy will not be commercially viable until mid-century.

Inertial Confinement Fusion: The Current Plan

To a large extent, research on inertial fusion is focused on the work at the National Ignition Facility, and the labs and contractors that support it. The National Ignition Facility is using lasers to compress a fuel pellet of deuterium and tritium to high pressure and density.

Inertial fusion at the National Ignition Facility has more of a coherent plan than fusion energy under magnetic fusion. A principal goal of the National Ignition Facility is to reach "ignition" and net energy gain in a mode consistent with power plant operation. Researchers continue to pursue ignition, but discussions over reducing resources for inertial fusion could delay ignition.



After ignition is proven, the inertial fusion community plans to build a demonstration power plant called Laser Inertial Fusion Energy (LIFE). Planning on LIFE is currently underway, but only at a low-level effort. The design and construction of LIFE is assumed to begin later this decade, with operation beginning in the middle of the next decade.

The present situation is unacceptable.

There is a national security imperative in developing clean base load power in the near-term.

Our energy dependence on fossil fuels presents national security risks, restricts our foreign policy, contributes to the threat of climate change, and saps our economy.

America must commit to develop fusion energy on an accelerated time frame.

Our Generation's "Apollo Program"

- An "Apollo Program" will significantly cut down the time required until commercialization. But, this will require a greater tolerance for risk.

- An accelerated push would achieve the goal of providing demonstration levels of electricity to the grid from a 'burning plasma' facility plant within ten years.

- This breakthrough Fusion Nuclear Science Facility will pave the way to commercial fusion power in a time frame that is relevant to America's national security.

What does an Apollo Program mean?

Just like when America committed itself to putting a man on the moon in the 1960's, America must rededicate itself to pushing the frontiers of science and engineering forward. America must commit to building a "burning plasma" facility within ten years, which will produce fusion energy. This will require $30 billion over that time frame, and would require several support facilities to test materials and push the technology forward. Under the Apollo Program, the six recommendations listed above are necessary to move quickly to the demonstration plant.

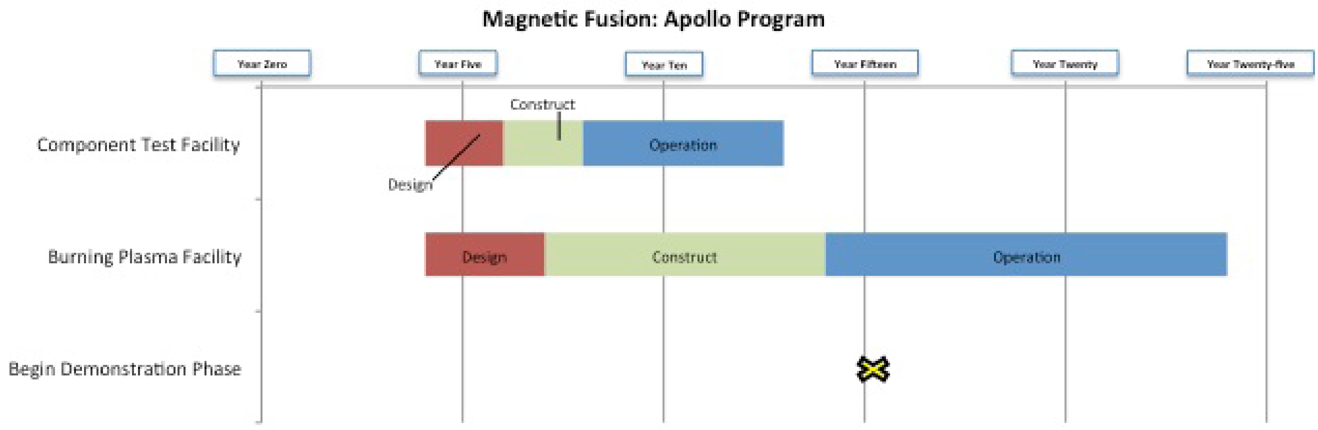
Magnetic Fusion: Apollo Program

There are two steps needed to get to commercialization within a decade.

First, a Component Test Facility would be a small-scale experimental facility that would test critical components and materials. Building the Component Test Facility would validate materials that could be used in future fusion power plants, and accelerate fusion energy development. The Component Test Facility would accelerate the development of key materials, allowing fusion researchers to overcome engineering challenges on a faster time frame.

Scientists and engineers are ready to build the Component Test Facility, but given funding constraints, there are currently no plans for it.

Second, a "burning plasma" facility, commonly called the Fusion Nuclear Science Facility (FNSF), is needed to scientifically prove positive net energy gain is possible from a science, technology and materials perspective. FNSF will build upon the projected achievements from ITER by further testing how to produce fusion energy from a technical and engineering perspective.



Burning plasma is the state at which the heat from plasma becomes self-sustaining. It has not yet been produced in laboratories, but is the major objective of the ITER experiment. America's FNSF program will build on ITER's scientific gains by proving that fusion power can be harnessed for energy production. The FNSF would prove new technologies like power-handling, tritium-breeding, and operation. It would be capable of operating plasmas for time spans measured in days and weeks – not the seconds and minutes currently envisioned by ITER.

This will drastically accelerate the progress towards a commercially viable demonstration power plant that would provide energy onto the grid just like any other power plant.

The recommendations listed in this report are required to accelerate fusion development. Given the funding necessary - $30 billion over ten years – fusion can reach real and significant milestones and begin the demonstration phase within a decade. The burning plasma facility will bring about the era of commercial fusion power, leading to the construction of full-scale demonstration power plants.

Inertial Confinement Fusion: Apollo Program

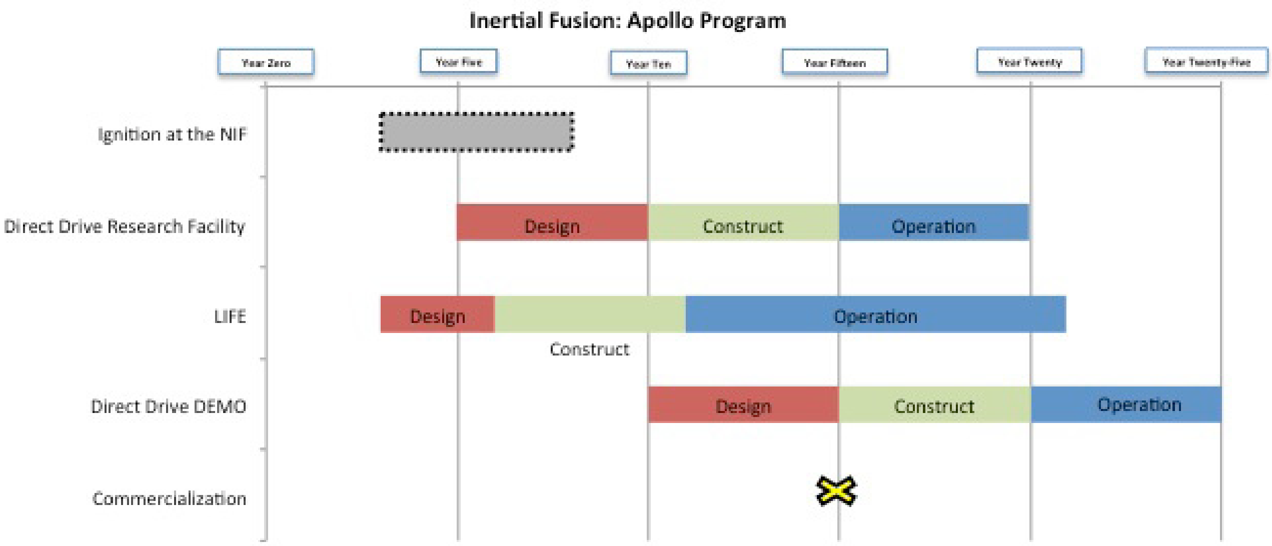
The timetable for achieving commercial energy from inertial fusion is a function of the resources allocated to R&D and the readiness of the vendor base and licensing regime.

Fusion energy could be obtainable on a faster timescale and it would require parallel design, development and construction.

This approach was adopted for the National Ignition Facility with success.

In the "Apollo Program," more resources are devoted to achieving ignition in the next few years and planning for the LIFE demonstration power plant would be accelerated prior to ignition.

The National Ignition Facility has already begun the planning process with utility executives, with the intention of optimizing the LIFE plant to demonstrate commercial viability. The LIFE plant would have a modular, factory-built design to facilitate supply-chain development. It would also reduce risk by allowing for replaceable parts as engineering improves. The LIFE plant will set the stage for inertial fusion commercialization.



Importantly, investments need to be made into the relevant industrial sectors (in particular, optics, semiconductor lasers, and mass manufacturing of the micro-scale fuel pellets). These lie on the critical path of the LIFE delivery plan.

Fortunately, there are many spin-off benefits to these types of lasers and manufacturing techniques, meaning that the industrial investment would pay substantial dividends irrespective of the success of the fusion program.

While the NIF pursues the more publicized "indirect-drive" approach, one alternative is "direct-drive." With direct-drive, lasers directly shoot a fuel pellet. This has received less attention because it is not useful for weapons research. However, several labs are working on direct-drive – including Sandia National Lab, the University of Rochester, and the Naval Research Laboratory.

The Apollo Program considers two additional facilities dedicated to researching direct-drive inertial fusion: a direct-drive research facility (much like indirect-drive's National Ignition Facility) and a direct-drive demonstration plant. This will require a significant increase in funding for fusion energy. The direct-drive research facility and the 'DEMO' plant do not accelerate commercialization of fusion energy, but they offer an additional option. It will likely result in one of the approaches not leading to commercialization, but it will also dramatically reduce risk and increase the probability of success for fusion energy.

Alternative Approaches

Several other facilities are trying innovative approaches to fusion, and they believe they may achieve net energy gain on a faster and cheaper timetable.

These approaches, by definition, have received far less time, investment and attention and are thus "high risk," but offer potential breakthroughs and so need to be funded in any balanced approach to the pursuit of fusion energy.

Fusion funding must focus on attempting to commercialize an energy technology. Private sector approaches offer intriguing opportunities to find a faster path to fusion energy, but funding for these innovative ideas often gets crowded out by the two main approaches.[33] The U.S. should offer opportunities to invest in promising alternative approaches to fusion energy, which have the potential to result in breakthroughs.

What the Fusion "Apollo Program" Will Give Us

A national commitment and an accelerated push can achieve fusion energy within ten years.

Fusion power is a laudable national goal because it will provide immense benefits to the United States and the world.

We know that failing to meet the 21st Century challenges that we face today will, justifiably, earn our generation the enmity of generations to come. However, if we realize that a relatively small investment today of $30 billion over ten years – less than American consumers lose every year from theft or misplacement of their cell phones – could achieve this goal.[34]

The Apollo Program for fusion energy will provide at least 10 monumental benefits to the United States:

1. A clean source of power that will revolutionize the energy system in an era in which fossil fuel reserves are diminishing.
2. New sources of base load power that can solve the climate crisis in a time frame that avoids the worst effects of climate change.
3. The establishment of a high-tech industry that will bring vast new streams of revenue to America's leading industrial companies, creating thousands of new jobs.
4. The creation of an exportable technology that will allow America to capture a portion of the $37 trillion in energy investment over the coming decades.
5. Spin-off innovations in high-tech industries such as robotics, supercomputers, and superconducting materials.
6. American leadership in pioneering new scientific and engineering frontiers. As other countries (like China, Russia and South Korea) have ambitious plans to develop fusion energy, being a first-mover in this emerging field will enhance American competitiveness.
7. Freedom from fossil fuels, allowing the U.S. to conduct foreign policy according to its values and interests, not according to commodity prices.
8. A clarion call to bright young Americans to enter into scientific education.
9. A new source of energy that will ensure America's economic vitality and global leadership in the 21st Century, just as America's vast resources helped us in the 20th.
10. The opportunity to finally divorce energy use from economic growth will bring untold economic prosperity.

Recommendations

- The United States must make a national commitment to develop fusion power because it will supply clean, safe, secure and abundant energy for the next century.
- The U.S. Congress should authorize an accelerated push to develop fusion power over the next decade. This will require a sustained appropriation of $30 billion over 10 years. The first step to this will be to approve adequate appropriations for Fusion Energy Sciences of $475 million in the FY-13 budget and $522 million in the FY-14 budget, enough to ensure the continued operation of the U.S. domestic fusion program and its international commitments.
- The U.S. government should challenge American scientists and engineers to build a burning plasma facility within a decade.

How the U.S. Government Can Implement Congress' National Commitment to Develop Fusion Power:

1. The President should appoint a Fusion Power Commissioner to organize, streamline and lead the research, development & deployment of fusion power.
2. Immediately begin construction of a fusion "Component Test Facility" to test and develop new materials needed for a fusion power plant.
3. Pursue multiple and parallel research paths (including inertial, magnetic, and alternative approaches) before down selecting to the most promising.
4. Devote increased resources to existing fusion research facilities, in order to fully utilize America's existing resource base.
5. Experiment with new and innovative power plant designs.
6. Scientists and researchers should actively collaborate with private businesses and vendors to ensure an accelerated path to fusion commercialization.

Conclusion

America faces a crisis in its declining support for Research and Development. The next generation of America is in danger of inheriting a country that is no longer the world's leader in science or engineering; the very skills we know will be the building blocks of 21st Century prosperity.

This crisis is paired with a coming crisis in energy: our economy depends on reliable sources of power, but over the next few decades, almost all of the power plants in the U.S. will need to be replaced, and America's dependence on fossil fuels presents serious national security concerns – they sap our economy, exacerbate climate change, and constrict our foreign policy.

America needs to produce energy that is clean, safe, secure and abundant. We see that energy from fusion has huge potential.

The next generation's "Apollo Program" should be new R&D into fusion energy. We need a national commitment to develop fusion power. This would mean committing $30 billion over the next ten years – with the goal of achieving practical fusion power within a decade. This will set the stage for full-scale commercial power that will drive American prosperity for the next century.

We can begin today. If we are serious about fusion development, the President should appoint a Fusion Power Commissioner, who would have the authority to organize and streamline the research, development, and deployment of fusion power. Any government program is plagued with overlapping entities and different budget authorities. A Fusion Power Commissioner could cut through the red tape and avoid bureaucratic delays.

With new authorization from Congress, America's scientists could begin today to build the next-generation of facilities that will develop and prove the feasibility of fusion power. Our scientists are ready today to begin constructing a fusion "Component Test Facility" to drive innovation. In short order, they could begin construction of new facilities, like a Fusion Nuclear Sciences Facility or a Laser Inertial Fusion Energy facility that would show how to build and operate a real power plant operated by fusion. We know that our competitors in China and Russia have begun work on these facilities. Our superior scientific expertise means that we can beat them: but we first need to get to the starting line.

Commercializing fusion energy would revolutionize America, bringing us monumental benefits.

Developing fusion energy will provide a clean source of power that can fully break America's dependence on fossil fuels. This will provide untold national security benefits.

Second, pioneering a new high-tech industry will bring vast new streams of revenue to America's leading industrial companies, creating thousands of new jobs.

Third, developing fusion energy will lead to countless spin-off innovations in robotics, supercomputing, and superconducting materials.

Fourth, pursuing fusion will be a clarion call to bright young American minds to enter the critical fields of science, technology, engineering and mathematics (STEM).

Finally, achieving practical fusion power will cement American leadership in solving some of the world's critical problems, and drive American competitiveness in the coming decades.

Other countries (like China, Russia and South Korea) already have ambitious plans to develop fusion. The U.S. will be left behind if Congress and the President fail to make the smart investments we know are necessary.

Fusion power is possible and America can do it. The payoff will prove to be a revolution in America's energy system.

Epilogue: Is the U.S. Ready For An Aggressive Program To Develop Magnetic Fusion Energy?

"Assuming a well-funded and aggressive program of development in magnetic fusion, how close can the U.S. come to a working fusion power plant in 10 years?"

Answer: *The scientific basis now exists to support greatly accelerated magnetic fusion energy development. With adequate resources and appropriate program structure, a device that would test key fusion technologies and ultimately produce demonstration levels of electric power could begin operations about 10 years from now***.**

Such a facility is called a Fusion Nuclear Science Facility (FNSF). It will produce fusion power continuously (for days or weeks at a time), produce its own fusion fuel, and qualify the material components that surround the fusion plasma. This facility, combined with a supporting R&D program and participation in fusion burning plasma experiments in ITER, would provide the basis for construction of a full-scale demonstration plant (DEMO) and ultimately for commercialization of fusion energy. The result would be U.S. leadership in a critical new energy technology.

Execution of research and development activities leading to an FNSF will close the majority of remaining technical gaps in establishing the readiness to initiate development of a fusion demonstration plant. Maintaining an aggressive schedule will require a well-funded and administratively optimized program that would manage well-known risks in magnetic fusion development via an accelerated, robust and parallelized program of scientific and technological advance.

What needs to be done to meet this schedule?

The technical challenges to developing practical fusion energy have been studied extensively and catalogued along with the research and development needed to overcome them. Hence, the elements of an aggressive program to meet those challenges are largely known and can be carried out roughly in parallel with the development and operation of FNSF. FSNF will be accompanied by the international experiment ITER, which will produce and study burning (self-heated) plasmas, and an R&D program consisting of: developing steady-state plasma scenarios; using test stands to address "single-effects" technology and science issues including materials, plasma-wall interactions, plasma-facing components, joining technologies, superconducting magnets, tritium breeding, fueling, heating and current drive systems; increased capabilities for simulation of plasmas and materials, coupled to a rigorous validation program; a materials qualifications and nuclear component research programs; and preparatory experiments on plasma-wall interactions and plasma facing components.

At the end of 10 years, what will have been delivered?

Operations will have also begun on ITER, a device which will explore high gain burning plasmas. The FNSF would begin operation, and would produce hundreds of megawatts of thermal power for days or weeks at a time (possibly at low fusion Q), test critical materials and components, make all or most of its own tritium fuel, and eventually produce demonstration levels of electric power (i.e., relatively low levels of electricity from individual test blanket modules). The supporting R&D program would be sufficiently mature to validate that machine's design, materials, construction and operation, and would provide the scientific and technical basis for upgrades or follow-on experiments. In addition, the U.S. would have the trained workforce and industrial base required to complete the final steps to fusion commercialization.

How will the risks be managed and why is there confidence that this effort can be successful?

The principal risk mitigation strategy will be to follow parallel development paths in all critical areas. This differs from the current serial approach but must come with the acceptance that some of the paths will be abandoned when superior paths are selected based on merit from the parallel set.

The program would draw broadly on the highly capable American science and technology communities, as well as industrial partnerships with first-rate suppliers, and would make full use of advances realized during the design, R&D, and construction of ITER. Overall management practices would need to stress processes that augment project success while eliminating lower-value administrative burdens. Historic successes in the U.S. fusion program, including DT operation on the TFTR device, coupled with recent advances in understanding and control, lend a high degree of confidence in the ability to achieve high gain plasmas in more capable next generation facilities.

How would this program be integrated with the current fusion program including ITER?

ITER will address the science of high gain burning plasmas, whereas FNSF is focused on the complementary issues of the science, technology, and materials of energy production, all of which can be initially addressed at relatively lower fusion gain. Together, ITER and FNSF put the US fusion program on the doorstep of demonstrating practical fusion energy production. The work required would build on and add substantially to the existing fusion energy sciences program, which would need to be dramatically enhanced to meet the accelerated schedule. In addition, the U.S. would meet all of its obligations for the construction, operation and participation in ITER which will produce 500 megawatts of fusion power for 400 seconds. ITER is under construction, with high-tech components being developed and fabricated by the ITER Members (China, European Union, India, Japan, Korea, Russia, and the United States).

Partnerships with industry developed as part of the ITER project would be particularly helpful in ensuring the success of the aggressive plan described here.

What will this program cost?

Roughly $20B over 10 years, which includes the cost of constructing the FNSF, accompanying fusion R&D, full and timely U.S. ITER contributions, and initial design activities for the follow-on fusion power demonstration facility (DEMO). A more refined cost estimate awaits more detailed analysis.

When will the next step – DEMO – be operational and what are its characteristics?

Assuming a successful FNSF campaign and other elements of the program including US participation in ITER operation and its results, a DEMO could be operational in 10 to 15 years after the start of FNSF operation depending in part on the level of funding provided. DEMO would be a full-scale prototype (about 1 GW) having many of the characteristics of a commercial fusion plant.

In addition to U.S. leadership in a vital new energy technology, what are some likely benefits to U.S. technology and competitiveness (spinoffs)?

- *Materials in extreme environments:* Fusion materials development will spur advances in materials that can withstand environments with high radiation and high heat flux. These materials have major applications in advanced fission reactors, satellites, and defense applications.
- *Plasmas to process materials:* The plasma physics and technology of the fusion energy sciences program will lead to ways to use plasmas to produce new materials, from computer chips to nano-materials.
- *Understanding the plasma universe:* Plasmas make up most of the visible universe. Fusion plasma physics will teach us about astronomical plasma behavior at all sizes - from our sun to large clusters of galaxies.

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Glossary

Apollo Program – Just like the original program, ASP's plan for an Apollo Program for fusion energy calls for a national commitment to push the frontiers of science and engineering forward.

Alcator C-Mod – a fusion facility operated by the Massachusetts Institute of Technology

Base load power – power that is "always on," as opposed to power generated to meet "peak" demand.

Burning Plasma facility – the burning plasma facility would demonstrate a 'sustained' burn of plasma – plasma that generates self-sustaining heat.

Burning Plasma facility vs. Demonstration plant – a burning plasma facility achieves a sustained 'burn' of plasma, producing demonstrable levels of fusion power. This proves fusion power is viable. A demonstration power plant would follow, putting utility-scale power onto the grid.

Component Test Facility (CTF) – a facility that would test key materials used for confining plasma. Building this would accelerate the development of fusion energy.

Deuterium – a hydrogen isotope used in a fusion reaction. It can be sourced from ocean water

DIII-D – a fusion facility operated by General Atomics.

Fusion – when two atoms fuse together they release enormous amounts of energy

Fusion Power Commissioner – ASP's 10-year plan calls for a fusion power commissioner who will be responsible for streamline authority over the U.S. fusion research program.

Fusion Nuclear Sciences Facility (FNSF) – the common name for a burning plasma facility, or a facility that will produce demonstrable levels of fusion power. ASP calls for the construction of an FNSF in the U.S. within a decade.

General Atomics – hosts the DIII-D fusion facility in San Diego, CA.

Ignition – the point at which more power is produced than is consumed. This is a key goal for inertial confinement fusion.

Inertial confinement fusion (ICF) – one approach to producing fusion energy. Using lasers, hydrogen atoms can be crushed with extreme temperatures and pressure, forcing them to fuse together. The NIF is the leading ICF facility in the world.

ITER – an experimental burning plasma facility under construction in the south of France. Led by the European Fusion Development Agreement (EFDA), but backed by six other nations including the U.S., ITER has the goal of achieving net energy gain.

Joint European Torus (JET) – the largest fusion facility in the world, JET is located in the United Kingdom.

Laser Inertial Fusion Energy (LIFE) – a full-scale ICF power plant that will set the stage for ICF commercialization.

Magnetic confinement fusion (MCF) – one approach to producing fusion energy. With this approach, magnets are used to confine a plasma, which creates the conditions for fusion.

Magnetized Liner Inertial Fusion (MagLIf) – a hybrid approach to fusion, using elements of both ICF and MCF.

Massachusetts Institute of Technology (MIT) – a major fusion research institution that hosts the Alcator C-Mod fusion machine.

National Ignition Facility (NIF) – the leading inertial fusion facility in the world. The NIF is hosted by the Lawrence Livermore National Laboratory.

National Spherical Torus Experiment (NSTX) – a fusion facility operated by the Princeton Plasma Physics Laboratory (PPPL)

Naval Research Laboratory (NRL) – a facility working on "direct-drive" inertial fusion.

Plasma – one of the four fundamental states of matter, plasma is a hot gas. It is needed to heat hydrogen atoms to the point that they fuse.

Plasma-material interface – a reference to one of the key engineering challenges that remains for fusion energy – the interaction between plasma and a solid wall.

Princeton Plasma Physics Laboratory (PPPL) – a major fusion research facility at Princeton University. PPPL hosts the NSTX and TFTR facilities.

Stellarator – an alternative design to the tokamak for magnetic fusion.

Tokamak – a machine that uses magnets to confine plasma to achieve fusion. The tokamak confines plasma using a magnetic field.

Toroidal Fusion Test Reactor (TFTR) – a fusion facility hosted by PPPL. It's release of 10 megawatts of power in 1994 is considered the first significant production of fusion power.

Torus – the donut-shaped magnetic field used in a tokamak.

Tritium – a hydrogen isotope used in the fusion reaction. Can be sourced from lithium.

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Andrew has served on Capitol Hill as a Legislative Assistant on Energy, Environment, and Infrastructure for United States Senator Chuck Hagel of Nebraska from 2006 through 2008. He also has experience working in the US House of Representatives for the House Ways and Means Committee and the Office of Congresswoman Roukema.

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Further Reading

White Papers:

America's Energy Choices - 2014

Five Choices on Energy that We Need to Make

Critical Energy Choices for the Next Administration

Technology from Fusion Research, Benefits Today

International Progress on Fusion Energy - How American Leadership is Slipping

Fusion Power and U.S. National Security

Fusion Energy: An Opportunity for American Leadership and Security

Fact Sheets:

Fusion Fact Sheet

Fusion's Reach Across America

What is Fusion Power?

Intertial Confinement Fusion at the National Ignition Facility

Opinions and Editorials:

America's Fusion Race with China is Heating Up, So Why is Washington Going Cold?

George Will: The Fusion in our Future

A Challenge to America: Develop Fusion Power Within a Decade

Through Innovation and Investment, the U.S. Can Lead in Next-Generation Energy, Nuclear Fusion

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The American Security Project (ASP) is a nonpartisan organization created to educate the American public and the world about the changing nature of national security in the 21st Century.

Gone are the days when a nation's security could be measured by bombers and battleships. Security in this new era requires harnessing all of America's strengths: the force of our diplomacy; the might of our military; the vigor and competitiveness of our economy; and the power of our ideals.

We believe that America must lead in the pursuit of our common goals and shared security. We must confront international challenges with our partners and with all the tools at our disposal and address emerging problems before they become security crises. And to do this we must forge a bipartisan consensus here at home.

ASP brings together prominent American business leaders, former members of Congress, retired military flag officers, and prominent former government officials. ASP conducts research on a broad range of issues and engages and empowers the American public by taking its findings directly to them via events, traditional & new media, meetings, and publications.

We live in a time when the threats to our security are as complex and diverse as terrorism, nuclear proliferation, climate change, energy challenges, and our economic wellbeing. Partisan bickering and age old solutions simply won't solve our problems. America – and the world - needs an honest dialogue about security that is as robust as it is realistic.

ASP exists to promote that dialogue, to forge that consensus, and to spur constructive action so that America meets the challenges to its security while seizing the opportunities that abound.

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