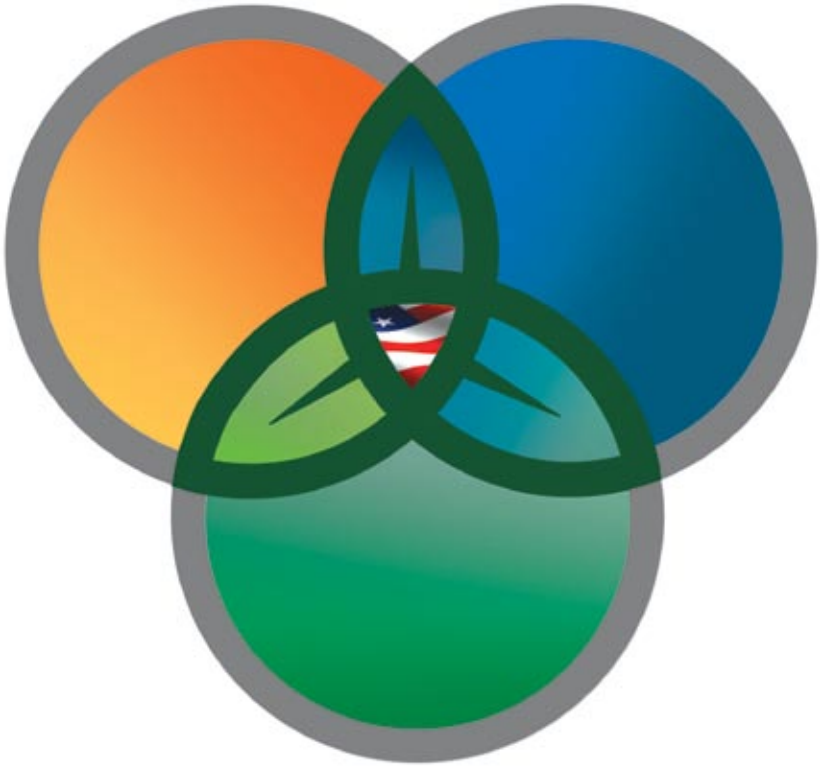

U.S. EnergyFreedomCenter™
Concept Paper

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PREDECISIONAL DRAFT

Today We Can Start To Unshackle America

Decades of debate for ending America's dependence on foreign fossil fuels, climate change and environmentally positive energy has produced a myriad of technologies that independently offer a partial solution. Applying existing technologies in concert at one unique location can be the catalyst for real change.

"I am convinced that whoever builds a clean energy economy, whoever is at the forefront of that, is going to own the 21st Century economy. I'm convinced America can win the race. Let's get it done."
President Barack Obama
February 3, 2010

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OUR CURRENT STATE

Today, the U.S. imports 70% of its petroleum. Foreign oil is responsible for most of our huge trade deficit ($9.6 trillion since 1976), which has driven the purchasing power of the U.S. dollar to an all-time low. Most of the dollars we trade for oil support governments who do not share our commitment to personal and governmental freedoms. Clearly, the time for change is now.

Can the U.S. really achieve energy independence?
ABSOLUTELY.

The U.S. is already self-sufficient in electricity production. More than 95% of the electricity we consume is produced within our borders. Obama Administration objectives are aggressively augmenting our electrical grid with renewable wind and solar sources.

We are also in the early stages of a nuclear renaissance under which many new nuclear power stations are planned. Beyond this, the U.S. is making greater use of its plentiful biomass, coal and natural gas.

So what's the problem?
TRANSPORTATION FUEL

The real energy security problem confronting the U.S. is transportation fuel. The consensus of energy experts to this limited problem is converting our abundant and inexpensive energy sources (coal, wind, solar, nuclear, biomass) to synthetic "drop-in" transportation fuels (gasoline, diesel, jet fuel).

The technologies needed to wean ourselves from foreign sources of oil already exist in the U.S. today. Better yet, with this technology and the right policy decisions today, the experts believe we can break our dependence on foreign oil by 2030 and, in the process:

- Put tens of thousands of Americans back to work in jobs that cannot be exported.
- Revive the dying manufacturing sector and restore American global competitiveness through global clean energy leadership.
- Drastically cut the national carbon footprint.

Which U.S. technologies offer the most promise?

The convergent energy security and climate change crises compel us to look for sustainable solutions. The need for an integrated approach is apparent since no single energy resource or technology can meet all of the energy and environmental demands.

Nuclear Fossil Fuels

Biomass

It's not a matter of available energy resources and technologies. It is a matter of delivering ample, reliable, economical, and clean energy in the form and location needed.

Hybrid energy conversion systems designed to efficiently and synergistically produce energy in the form needed by the end user are the logical choice. In particular, hybrid energy systems that convert our most abundant energy resources (coal, nuclear, biomass, wind, solar, hydro) to useful, but scarce, liquid and gaseous fuels offer the most practical and sensible solutions.

One such hybrid energy system is the **U.S. Energy Freedom Center™ (USEFC).**

What IS the U.S. Energy Freedom Center™?
A SMART CHOICE.

The USEFC™ is an innovative solution to national energy security, climate change, and nuclear nonproliferation challenges. Developed through the collaboration of SRNS leadership and researchers at the Savannah River National Laboratory (SRNL), USEFC™ would close the nuclear fuel cycle and convert surplus plutonium and used nuclear fuel to valuable, carbon-free electricity and hydrogen. USEFC™ would concurrently close the carbon loophole and break the nation's dependence on foreign oil by manufacturing synthetic transportation fuels from CO_2 and other renewable carbon sources.

The American Recycling Initiative

Elements of the USEFC™ are already underway at Savannah River Site. Since the Site was a primary producer of plutonium during the Cold War, a national center for plutonium weapon pit disassembly is planned at the Site and a plutonium mixed oxide (MOX) fuel recycling and fuel production facility is under construction. The resulting fuel will be used for peaceful electric power production.

Why Is The Energy Freedom Center Right For America?

4 REASONS

CARBON-NEUTRAL FUEL

RECYCLE CO_2

ELIMINATE SURPLUS NUCLEAR WEAPONS MATERIAL

THE YUCCA MOUNTAIN ALTERNATIVE

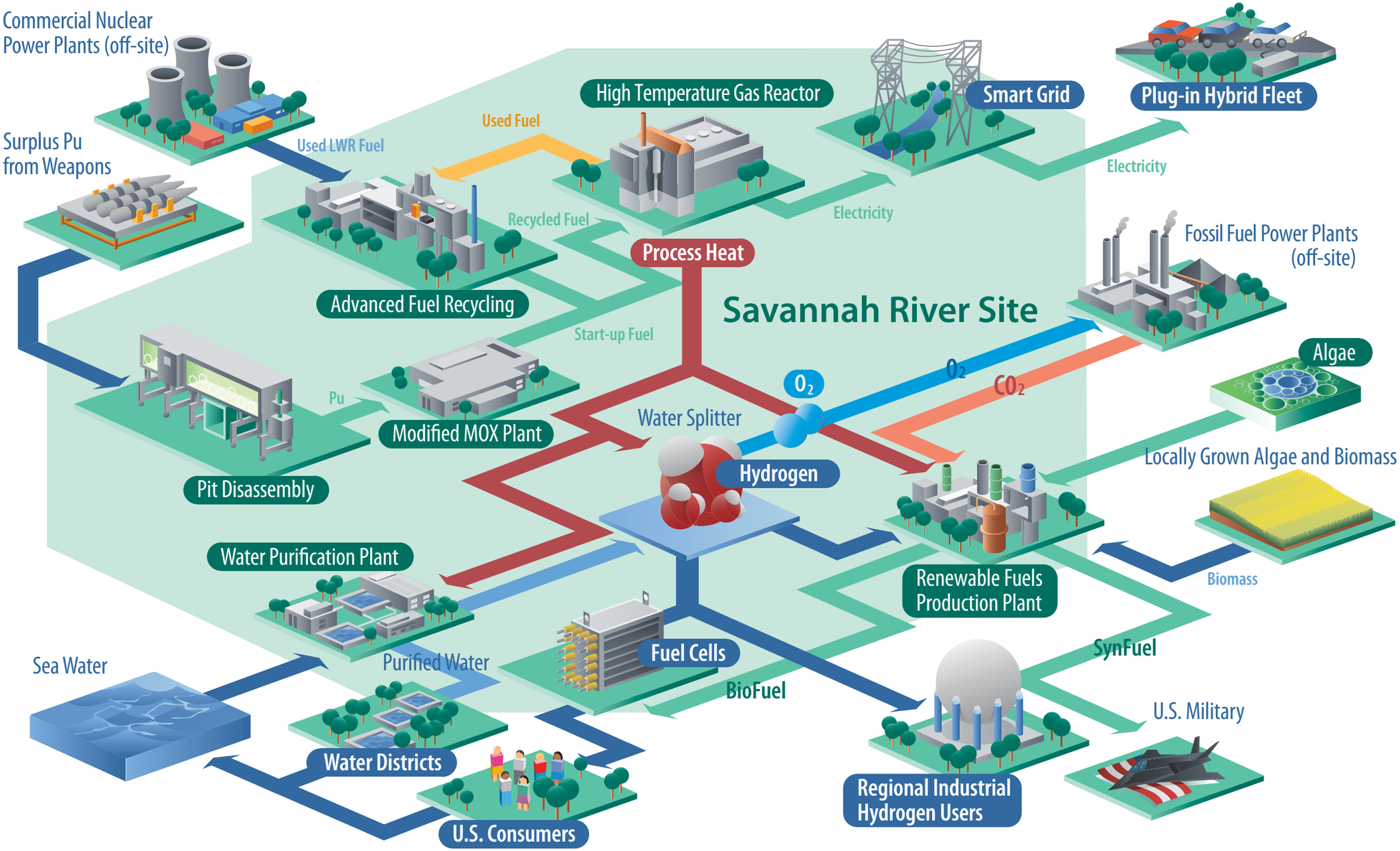
The USEFC™ harnesses CO_2-free nuclear energy to power a synthetic fuels plant that converts biomass, CO_2, and/or coal to liquid and gaseous "drop-in" fuels. A relatively abundant and inexpensive energy source (nuclear) provides abundant process heat and power to replace scarce and expensive transportation fossil fuels (gasoline, diesel jet fuel). Until now, the combustion of coal, oil, gas, or biomass has been used to produce synthetic fuel – generating too much CO_2
As illustrated on the next page, the USEFC™ is specifically designed to:

1. **Synthesize carbon neutral hydrocarbon fuels from a wide range of inexpensive, abundant, and entirely domestic carbon feedstocks** (switchgrass, sorghum, algae, coal, and carbon dioxide); providing inherent predictability and stability of supplies and production costs without the adverse impacts on food prices attendant to corn ethanol.

2. **Recycle CO_2 captured from industrial sources** (coal-fired power stations, cement kilns, etc.); significantly reducing net greenhouse gas (GHG) emissions.

3. **Beneficially eliminate surplus nuclear weapons materials**; promoting nuclear nonproliferation and President Obama's vision of a world free of the threat of nuclear weapons.

4. **Recycle used commercial nuclear fuel**; helping to expand the safe civilian use of nuclear power needed to combat climate change, while providing a viable alternative to Yucca Mountain.



U.S. EnergyFreedomCenter™

Hybrid Nuclear-Synfuels Platform for Sustainable Energy Independence

Applying existing technologies synergistically in one location can provide America with a quantum leap in global clean energy leadership.

SASOL. A WORLD WAR II PROCESS. A DIRTY BUSINESS WITH PROMISE.

Several countries operate synthetic fuels plants based on Fischer-Tropsch (F-T) technology pioneered by the Germans during World War II. In South Africa, Sasol has operated F-T synthesis plants for 50 years. Today, Sasol produces 160,000 barrels per day (bpd) of liquid fuels and chemical feedstocks from coal and natural gas - enough to fuel all of that country's vehicles—from buses to trucks to taxicabs at costs of $10 to $20 per barrel.
Despite the record of the past 50 years, Sasol cannot sustain its success in a carbon-constrained future for the following reasons:

- Sasol's principal feedstocks are fossil fuels--coal and natural gas.
- The F-T process is energy intensive and has an exceedingly low thermodynamic efficiency.
- The F-T process has an enormous CO_2 footprint, emitting 7 metric tons of CO_2 for every metric ton of fuel produced.

Powered by nuclear process heat, F-T technology can work for America.

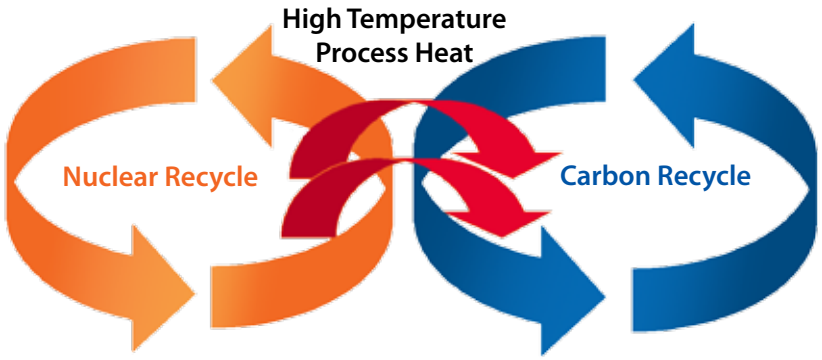
So Does Synthetic Fuel Production Have To Be Dirty?
USEFC™ IS DIFFERENT.

Clearly, the U.S. will have to make substantial improvements to the process of making synthetic fuel to make it a sustainable solution to national energy security. SRNL researchers have explored process solutions for more than a decade.
Here are the findings:

- **Hybrid energy conversion systems that tap clean energy resources** (e.g. wind, geothermal, hydro, solar, nuclear, and biomass) to provide process heat and hydrogen to the fuel synthesis operation are practical and sensible.
- **High temperature nuclear energy offers the best combination** of reliability, thermodynamic efficiency, and overall economy.
- **Biomass and simple carbon forms, including CO_2,** can be used as supplemental F-T feedstock.

SRNL has, thus, woven the following features into the hybrid flowsheet of the USEFC™:

- **Alternative feedstocks** which include alcohols, oils, lipids, and syngas produced via algal photosynthesis of CO_2, enzymatic cellulolysis of switchgrass and sorghum, and pyrolysis of biomass.
- **A high temperature nuclear process heat source.**



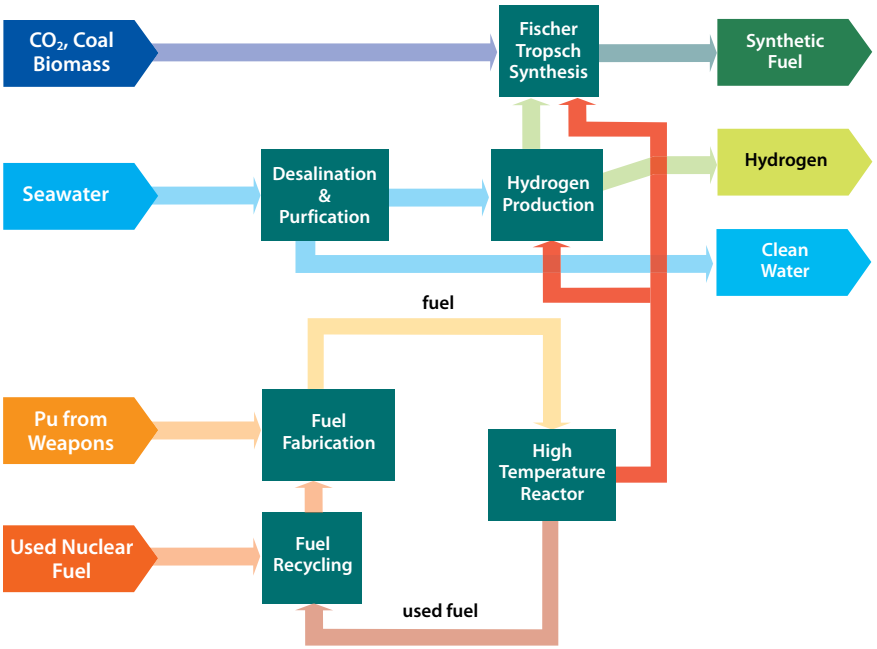
Closing The Nuclear, Fossil, Biomass Cycles.
INTO ONE SOLUTION.

The USEFC™ simultaneously intersects and closes the nuclear, fossil, and biomass fuel cycles. This enables the capture of synergies between fuel cycles that would otherwise be wasted (i.e., use of nuclear process heat in biofuel synthesis), resulting in better overall energy efficiency and an amplification of the carbon neutrality of the USEFC™. As a result, the USEFC™ is a giant leap toward…

- Truly sustainable independence from foreign oil.
- Reversal of the adverse effects of GHG on the global climate.

Central to the USEFC™ concept is high temperature process heat (>800 °C) on the boundary of the intersected fuel cycles, which enables **quantum improvements in the thermodynamic efficiencies of hydrogen and synthetic fuels production. This operating feature of the USEFC™ also completely eliminates the emissions of CO_2 from the hydrogen production and fuel synthesis processes.**

A SYNERGISTIC SOLUTION?
ABSOLUTELY.

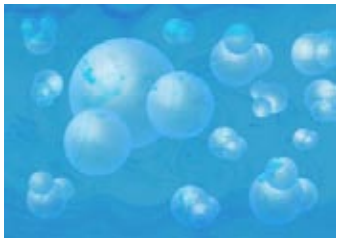


*"If you take a bale of **hay** and tie it to the tail of a **mule** and then strike a **match** and set the bale of hay on **fire**, and if you then compare the energy expended shortly thereafter by the mule with the energy expended by yourself in the striking of the match, you will understand the concept of **amplification**."*
William Shockley

Why a nuclear process heat source?
TWO REASONS.

The nuclear process heat source enables amplification of the carbon neutrality of the USEFC™ in two ways. First, the high temperature process heat greatly improves the thermodynamic efficiency of the fuel synthesis process. This enables significant reductions in the cost and carbon footprint of fuel synthesis. Second, high temperature process heat provides a carbon-free route to the large quantities of hydrogen which are consumed in the fuel synthesis process.

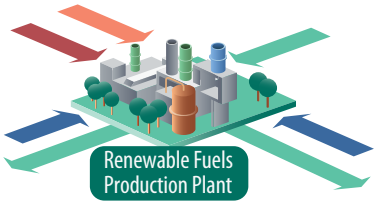
All hydrocarbon fuel synthesis involves the addition of large quantities of hydrogen to carbon. Most hydrogen is produced today via steam reforming of methane; a dirty process.



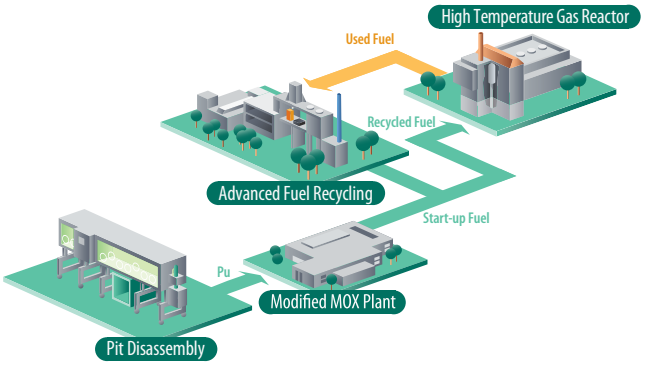
Conventional hydrogen production produces 11 tons of CO_2 for every ton of hydrogen. A high temperature nuclear heat source reduces the carbon footprint – completely.

High temperature process heat enables economical hydrogen production via electrolysis or thermochemical splitting of water. Neither of these processes emit CO_2. In short, the high temperature nuclear heat source reduces the cost of synthetic fuel production and completely eliminates its carbon footprint.

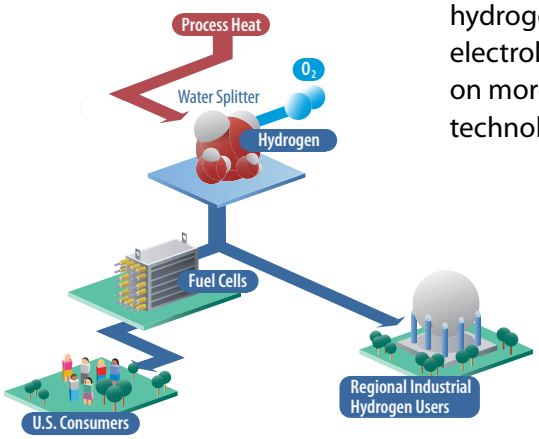
USEFC™ FLEXIBLE COMPONENTS.



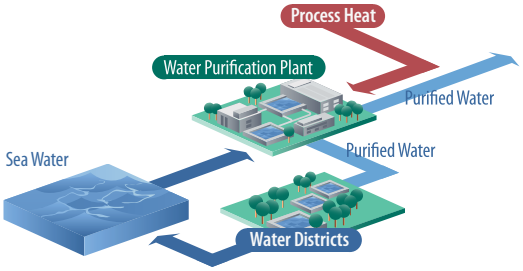
- **Flexible Renewable Fuels Manufacturing Complex.** A complex of facilities which synthesizes hydrocarbon transportation fuels from a variety of feedstocks, including coal, biomass, algae, and CO_2. This complex will ultimately produce 350,000 barrels per day (BPD) of hydrocarbon fuels; enough to meet all of the U.S. military's needs.



- **High Temperature Reactor(s) and Associated Fuel Cycle Facilities.** A closed high temperature nuclear fuel cycle consisting of the Mixed Oxide Fuel Fabrication Facility (MOX plant) presently under construction at SRS, the Pit Disassembly Facility presently under design at SRS, a new advanced fuel recycling facility, and a series of next generation high temperature nuclear reactors. Candidate reactor designs include the High Temperature Gas Reactor (HTGR) and Pebble Bed Modular Reactor (PBMR) being developed by Idaho National Laboratory (INL) and others under the next Generation Nuclear Plant (NGNP) Program and the Energy Multiplier Module (EM2) being developed independently by General Atomics.



- **Hydrogen Production Facility.** A nominal 20 million cubic feet per day (CFD) hydrogen production facility. Initial modules will likely use high temperature electrolysis to produce hydrogen from water. Later modules will likely rely on more efficient high temperature thermochemical water splitting technology which remains under development.



- **Sea Water Desalination Plant.** A 500 million gallon per day (500 MGD) sea water desalination plant which would supply approximately 100 MGD of cleanwater to the hydrogen production facility and the rest to municipal water systems throughout the region.

"So we have a choice to make. We can remain one of the world's leading importers of foreign oil, or we can make the investments that would allow us to become the world's leading exporter of renewable energy. We can let climate change continue to go unchecked, or we can help stop it. We can let the jobs of tomorrow be created abroad, or we can create those jobs right here in America and lay the foundation for lasting prosperity."
President Obama
March 19,2009

AMERICA Needs Energy Freedom.
STARTING NOW.

The USEFC is an energy security and climate change initiative the nation cannot afford to overlook. The following are a few of the many benefits the USEFC offers the nation:

- **Reduced dependence on foreign oil.** USEFC™ produces significant quantities of synthetic transportation fuels and chemical feedstocks at predictable prices. It also enables the production of low-cost supplies of hydrogen necessary for the nation's transition to the next generation of clean fuels**.**

- **Climate change.** USEFC™ reduces the nation's carbon footprint by producing synthetic fuels from biomass and carbon dioxide and hydrogen from water using carbon-free process heat.
- **Increased supplies of clean water.** USEFC™ charts a sustainable path to abundant supplies of clean water via nuclear-powered desalination of sea water.
- **Nuclear nonproliferation.** USEFC™ converts surplus nuclear weapons materials into clean water and carbon-neutral transportation fuels and chemical feedstocks, eliminating stockpiles of plutonium and highly enriched uranium and the attendant nuclear threat to global security.
- **Leadership of transformational science.** USEFC™ secures for decades U.S. leadership of research and development in high temperature materials, reactor physics, nuclear fuel recycling, carbon recycling, synthetic fuels, biofuels, hydrogen production, and climate change.
- **Medical isotope research.** Partnered with leading national and regional medical centers, such as the Medical University of South Carolina, Medical College of Georgia, research into the treatment and cures for exotic cancers and other diseases can result from the new nuclear reactors at SRS.
- **Jobs.** USEFC™ creates thousands of challenging and enduring "green economy" jobs in construction, manufacturing, and agriculture amid a region of the nation suffering from some of the highest unemployment rates.
- **Tritium production.** For the continuing needs of national defense and future international needs of ITER and fusion reactors. Through USEFC™, tritium production and purification at the SRS would eliminate further releases of tritium from the TVA Watts Bar Reactor.

Why at SRS?

IT MAKES SENSE.

- **The surplus plutonium stockpiles and the Mixed Oxide Fuel Fabrication Facility (MFFF)** required to fuel the USEFC™ are already located here.
- **The Site's 50+ year history of safe and effective nuclear operations**, well characterized geology and environment, and geographic location in the fast-growing Southeast make it the logical host site for the USEFC nuclear, hydrogen production, and synthetic fuels facilities.
- **The USEFC™ involves logical extensions of long-term SRS missions** in hydrogen, nuclear materials management, and nuclear nonproliferation.
- **The technology readiness levels (TRLs) are high.** Much of the remaining technology development is scaling through pilot demonstration to industrial-scale deployment--the strong suit of SRNL.

- **The Recovery Act invested $1.6 billion for environmental legacy footprint reduction** to make SRS ready for new missions.
- **SRS has been the home for pioneering nuclear development for 60 years.** The community and its stakeholders welcome further development as the key economic engine for the Central Savannah River Area.

EXPECTED OUTCOMES AND BENEFITS

In addition to blazing a sustainable path to global energy security, the USEFC™ offers an impressive array of economic and environmental benefits. Some of these are highlighted in the table below.

EXPECTED OUTCOMES AND BENEFITS

Sustainable Energy Independence

- 340,000 bpd of carbon-neutral fuels.
  - Enough to fuel all of DOD
- Greenhouse Gas Reduction
  - 55 million metric tons CO_2 per year
- Technology roadmap to independence from foreign oil
- Jumpstart to the Green Energy Economy

Commercial Viability

- Plant reliability greater than 90%
- Low O&M costs
- Drop-in fuels compatible with existing storage and delivery systems
- Reliable and economic path to compliance with federal and state Renewable Fuel Standards

Economic Boost

- 25,000 new and enduring jobs
- Rebirth of American heavy manufacturing and agriculture

Leveraged SRS Assets

- Expanded mission for the MOX Plant
- Beneficial reuse of SRS land and infrastructure
- Long-term R&D mission in hydrogen and renewable fuels for SRNL

Closure of nuclear fuel cycle

- Used fuel volume reduced 94%
- No long-lived isotopes in final waste form
- Smaller, less complex geologic repository
- Surety to the nuclear renaissance

Rebirth of American global competitiveness

- Global climate stewardship
- Renewed interest in mathematics, science, and engineering
- Leadership of the Clean Energy economy
  - Renewable fuels
  - Water purification
  - High temperature materials, components, and reactors
  - Hydrogen and Fusion

IMPLEMENTATION

The USEFC™ has sufficient scope, complexity and national importance to require collaboration between government, industry, and universities. Moreover, it is clear that President Obama has set the challenge to our best minds to galvanize diverse parties behind the benefits of USEFC™.

"You cannot escape the responsibility of tomorrow by evading it today."
Abraham Lincoln

Accordingly, the SRNS "launch" strategy for the USEFC™ will have the following thrusts:

- Align the scope and implementation plan with the President's agenda for energy and the environment.

- Implement an effective program of communications with the public, industry, university, and government which accentuates the overwhelming national energy security and environmental benefits.

- Leverage the relationships of SRNS, SRNL, parent companies (Fluor, Northrop-Grumman, Honeywell), and partner companies (Lockheed Martin and Nuclear Fuel Services) to build a strong transnational coalition of support which compels the ***Presidential Challenge***.

- Segment the USEFC™ into discrete projects (high temperature gas reactor, renewable fuels plant, etc.) and begin developing the strategic alliances with technology providers and potential "owner-operators" required to execute each project.

- Transition ***ownership*** of the USEFC™, in short order, from SRNS to an inclusive public-private partnership whose single focus is industrial-scale deployment of USEFC™ by 2025.

IMPLEMENTATION

President's National Objectives	
Restore Science Leadership	√
Reduce Greenhouse Gas Emissions	√
Enhance Energy Security	√
Enhance Nuclear Security	√
Secretary's Threshold Criteria	
Significant impact on economic prosperity, GHG emissions, and national security	√
Meaningful science	√
Open to partnerships with other programs, industry, and/or international partners	√
Secretary's Major Priorities and Goals	
Transformation Science and Discovery	√
Clean, Secure Energy	√
Economic Prosperity	√
National Security and Legacy	√
Climate Change	
-Leadership position in global climate change	√
-Deploy technologies globally	√
-Advance climate science understanding	√

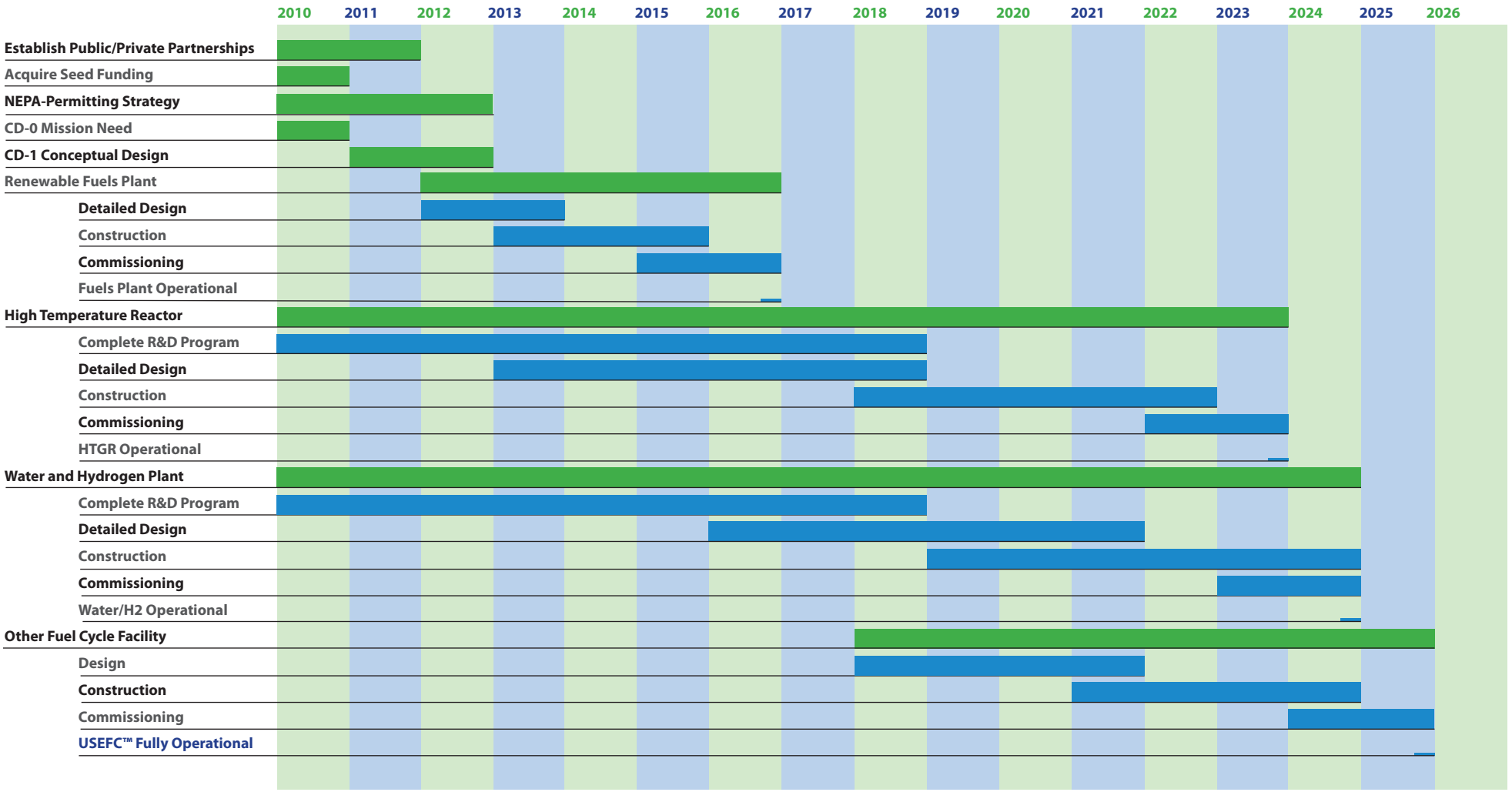
*Source: Goals and Targets to Direct FY2010 Budget and Stimulus, U.S. Department of Energy, Feb. 2009.

The major products of the USEFC™ are carbon-neutral transportation fuels. With this understood, the initial focus of the implementation approach will be the design and construction of the Renewable Fuels Plant. The focus will subsequently shift, in successions, to:

- **High Temperature Reactor**
- **Water and Hydrogen Production Plants (Seawater Desalination and Electrolyzer or Thermochemical Water Splitter)**
- **Advanced Fuel Cycle Facilities (Modification to MOX Plant and Advanced Fuel Recycling Plant).**

A high –level overview of the implementation schedule is provided on the next page.

USEFC™ implementation schedule



Start Date	01 Jan 10
Finish Date	04 Apr 25
Data Date	01 Jan 10
Run Date	01 Mar 10

Early Bar
Progress Bar
Critical Activity

U.S. EnergyFreedomCenter™

FINANCIAL CONSIDERATIONS

The USEFC™ will produce value to America well beyond the potential financial rewards. The business case for the USEFC™ includes a pro-forma analyses of cash flow point to returns on investment in the 10-15% range. Despite these projected returns,however, the biggest challenge will be acquiring the approximately $30 billion in capital needed to finance the design and construction of the entire complex of new facilities. A multi-faceted, multi-phased approach to financing will be needed. In the early stages, Government funding will be essential to establish the public-private partnership required to realize this extraordinary opportunity. Once the Government has established its commitment to realize some or all of the potential options, private sector investments can be confidently secured.

While a number of the potential facilities are purely Governmental, other projects raise significant prospects for private investment capital. One such project is the Renewable Fuels Plant which would likely be financed by a consortium of energy companies and venture capitalists. Still other projects, require mix of public and private funding. The High Temperature Gas Reactor, for example, will probably have to be financed by a public-private partnership involving DOE with one or more commercial nuclear companies furnishing its major components.

Extraordinary times present extraordinary challenges. The tools described above provide the United States with an extraordinary opportunity to use existing technologies in combinations that can lead to true energy independence, world leadership in the reduction of GHG, optimal control of nuclear wastes, and sound financial investment for our future.

U.S. EnergyFreedomCenter™

- **Creates 25,000 new and enduring clean energy jobs**
- **Produces 350,000 bpd carbon-neutral "drop-in" fuels**
- **Cuts CO_2 emissions by 55 million MT per year**
- **Restores American global competitiveness**
- **Establishes the road to sustainable energy security**

SUMMARY

SRNS has identified a promising opportunity to expand the SRS mission portfolio while helping the U.S. make giant steps toward sustainable energy independence, climate stewardship, and nuclear nonproliferation. This opportunity is the U.S. Energy Freedom Center.™

The U.S. Energy Freedom Center™ is a hybrid energy system that will utilize existing technologies and apply them synergistically to produce enough aviation fuel, diesel, and gasoline to meet all the U.S. military's demand.

It will demonstrate the commercial viability (high reliability and low cost) of integrated nuclear, biomass, and fossil fuel cycles. Its design and operation will set the stage for replication across the U.S.; blazing a path to sustainable national energy independence.

Likewise, the U.S. Energy Freedom Center™ will fulfill President Obama's challenge to be at the forefront in the development of a clean energy economy to own the 21st century global economy.

The estimated cost of the U.S. Energy Freedom Center™ is $30 billion. SRNS intends to establish within 18 months a public-private partnership to fund, design, build, and operate this complex of facilities critical to the future of America.