NUCLEAR NAWAPA XXI
GATEWAY TO THE FUSION ECONOMY

21st CENTURY SCIENCE & TECHNOLOGY · SPECIAL REPORT

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Special Report: Nuclear NAWAPA XXI: Gateway to the Fusion Economy

Contents

21st Century Science & Technology (ISSN 0895-6820) is published 4 times a year by 21st Century Science Associates, 60 Sycolin Road, Suite 203, Leesburg, Va. 20175. Tel. (703) 777-6943.

Address all correspondence to **21st Century**, P.O. Box 16285, Washington, D.C. 20041.

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Electronic subscriptions are $35 for 4 issues, $60 for 8 issues, and $80 for 12 issues. Back issues (1988-2005) are $10 each ($20 foreign). Electronic issues from 2006 on are $10 each.
Payments must be in U.S. currency.

A New Economic Platform:
The Nuclear-Thermonuclear NAWAPA XXI

Man is profoundly distinguished from the other organisms by his action on the environment. This distinction, which was great from the beginning, has become immense with the passage of time. . . .

Reason changes all. Through it, man utilizes material in the environment—inanimate or living—not only for the building of his body, but also for social life. And this usage has become a great geological force.

Thought, by its existence, introduces into the crustal mechanisms a powerful process having no analog before the appearance of man.

— Vladimir Vernadsky, "Human Autotrophy"[1]

The Context

This planet can no longer tolerate environmentalists.

The time has come to make a tremendous step forward in our relationship to nature, by making the development of a fusion-based economy—bringing the power of the stars under our control—our primary long-term physical economic goal. Not a goal to be pursued in isolation, the mental outlook coherent with such an objective demands immediate action on both political and physical-economic fronts.

A new international order must be secured, based not on maintaining hegemony in a static world, but on scientific and technological cooperation for the benefit of all nations.

The failing and flailing trans-Atlantic financial system will take down the physical economies of the world with it, unless a break is made. That break is Glass-Steagall, which would restore national sovereignty by breaking the hold of Wall Street, the City of London, and kindred interests over policy-making. With Glass-Steagall in place, the primary financial obstacle to progress will be removed, and future-oriented projects can be funded.

Foremost among these must be an updated North American Water and Power Alliance (NAWAPA XXI), a civil works project of truly geological magnitude. This program would redirect water from river basins in Canada and Alaska to the parched regions of the continent, providing a secure water supply that will triple the acreage of irrigable farmland in the Southwest. Its construction will involve some of the first civilian use of nuclear technology for purposes other than electricity. By providing a drought- and flood-resistant, stable water supply, and improving the atmospheric moisture system of North America, NAWAPA XXI is essential for the continued survival and flourishing of human life on our continent.

With both monetarism and radical (anti-human) environmentalism out of the picture, we can make the next leap in our power: the development of a new form of *fire*.

Fire, the fabled gift of Prometheus to man, separates, absolutely, the human species from all others. From its initial form as wood fire for heat and cooking, fire progressed to charcoal to allow basic metalworking, then to coal and coke to further expand the materials available to us and allow steam-engines to replace muscle-power. Petroleum fire enabled the internal combustion engine. Electrical "fire" transmits our power to act by metal wire to motors, rather than by railcars of coal and large steam engines, and allows entirely new fields of materials, such as aluminum.

But this natural process has been halted. Nuclear fission, a qualitatively new form of fire, saw its application stunted, and its only commercial applications in electricity and some limited use of medical isotopes. Fusion, currently languishing from chronic underfunding, will set us free from limited energy and limited resources, enable us to control errant asteroids, and bring the outer planets and stars within our reach; but this breakthrough is being prevented.

The economic *platform* encompassing fusion power and our mastery, through NAWAPA XXI, of the very geology of our planet—our river systems and our weather—is a coherent goal, one that binds together our greatest aspirations.

While breakthroughs in fusion (given adequate funding) have been possible for decades now, the present historical context does not present fusion as an option, but rather as a necessity.

Any civilization which systemically rejects man's natural development as an increasingly powerful force in nature, will simply be unable to exist.

1. Vernadsky, VI., "Human Autotrophy", 1925, full translation to appear in the Fall 2013 issue of *21st Century Science and Technology.*

This Report

The report lays out the new economy to be developed with a nuclear NAWAPA XXI driving towards a fusion economy as its driver. We begin with fusion, covering the current state of fusion research and nuclear applications besides electricity, such as peaceful nuclear explosions for earth-moving, and the ultimate in resource extraction: the plasma torch, which can break up any material into its elemental components. These technologies are within reach: the past few decades have seen a 10,000-fold increase in a key fusion parameter, which requires only another 10-fold increase to achieve controlled fusion. Appendices expand on the concept of energy flux density and breakthroughs to be made in the field of high energy-density physics.

The next article introduces the North American water cycle, the current water challenges we face, and how nuclear power will transform the NAWAPA XXI system. Water which currently plays no role in the biosphere or human economy will become more productive, and thus more valuable. And by making use of the evapotranspirative multiplier provided by plant life, every unit of water introduced by the system will have a greater effect. This project can change the fundamental character of the climate of the Western states.

With an understanding of the continent's hydrology, we then jump into the implementation of solutions: desalination and NAWAPA XXI. During the decades required to bring the full system online, immediate mass-production of nuclear desalination plants can provide immediate relief and water security to coastal areas as well as inland areas suffering from saline intrusion.

Nuclear agro-industrial complexes, which demonstrate many of the non-electrical uses of nuclear processes, are taken up next. A past breakthrough, coal, provided more than an improvement over wood for home heating, by allowing for new metallurgical processes as well. So too will economic planning incorporating nuclear complexes make use of the high-temperature process heat and unique isotopes of nuclear power.

We conclude with a proposed Pacific Development Corridor, based on high energy-density development, including high-speed magnetic levitation transportation. Rather than pursuing a military and economic encirclement of Russia and China, this concept is an example of what international relations should be.

Be Fruitful!

This report provides a full basis for scientists and policy-makers to conceptualize the inspiring future that can be ours, if we grasp it. Doing so will, of course, require some financial housekeeping, including the immediate re-implementation of Glass-Steagall, to free our physical economy from the political (rather than economic) control by money. This proposal is fiercely opposed by the same groupings that have held back fusion, fostered the cult-like environmentalist movement, and who teach our children that their goal in life is to have as little impact on their surroundings as possible. This is a goal of extinction!

We are past the point of being able to tolerate this pathological anti-human outlook. Let us now overthrow the stasis demanded by these forces, and be beautifully human, enjoying the thrill of discovery as we do things that are truly new!

Jason Ross
Editor in Chief

A member of 21st Century Science and Technology's *Scientific Advisory Board, economist Lyndon LaRouche has been a strong advocate of fusion power throughout his career. His proposal for revisiting NAWAPA from the standpoint of a fusion economic platform provided the inspiration for this Special Report.*

A Call for an International Crash Program

Creating the Fusion Economy

by *21st Century Science and Technology* Staff

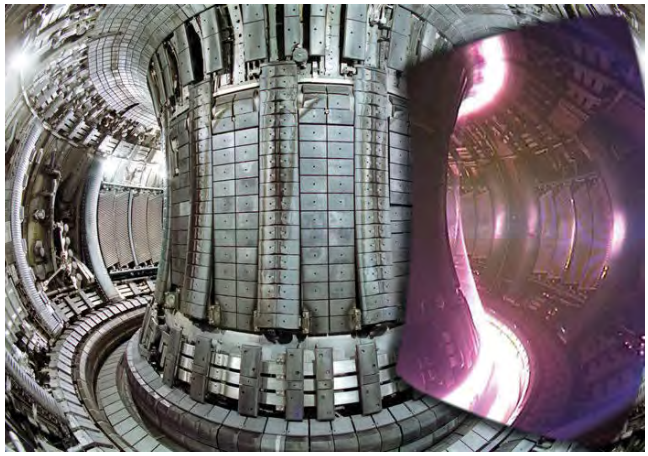
We have reached the point that not only is man's power to harness the processes of the Sun an emerging reality, it is in fact an existential necessity.

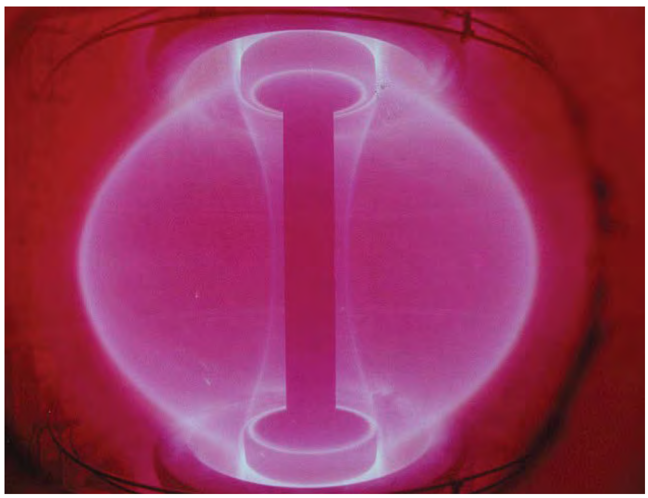
We must now direct our creative faculties and physical resources, in an international collaboration reaching from Eurasia to the Americas, towards achieving critical breakthroughs in the domain of thermonuclear processes. This is the already-delayed next step in the willful process of human evolution, illustrated by the previous successive transitions from a wood-based society, to a coal economy, then to petroleum and natural gas, followed by the higher potentials of nuclear fission power (see Appendix 1: Energy Flux Density).

By increasing what the American economist Lyndon LaRouche has defined as the *energy flux density* of the economy, we gain control over processes of higher energy throughput per unit of area, as expressed in a wide range of technologies, infrastructure projects, and production methods. With the fusion economy energy supplies become relatively limitless, since the fusion fuel contained in one liter of seawater provides as much energy as 300 liters of petroleum.

But this is more than limitless power. The fusion economy brings mankind into the domain of "high energy density physics,"[1] dealing with thermonuclear reactions and plasmas with energy densities on the order of 10^{11} joules per cm^3—a billion times the energy density of the battery in your smart phone—and the dynamic interrelationship between plasmas, lasers, fusion, and antimatter reactions. For example, ultra-high powered, petawatt, lasers are capable of producing extremely brief pulses of laser light 1,000 times as powerful as the energy coursing through the entire U.S. electrical grid (see Appendix 2: "The High Energy-Density Physics Platform").

This new platform brings a wide range of fusion-related technologies and experimental capabilities, from high-powered lasers, to particle accelerators, to high-temperature plasma generators, to directed energy explosions, all working in a dynamic relationship, complementing each other to transform mankind's entire economic system, eliminating any concerns over limited power or limited resources. Given the crises both in the United States and globally, this is an absolute necessity, and requires a global crash program, comparable to the Manhattan Project or the Apollo Program, but on an international scale.





Top: EFDA-JET; Bottom: U.K. Atomic Energy Authority:

Above, the Joint European Torus, below, superheated plasma.

1. For example, see "Frontiers in High Energy Density Physics," by the Committee on High Energy Density Plasma Physics, Plasma Science Committee, National Research Council, 2003. http://www.nap.edu/catalog.php?record_id=10544

What is Fusion?

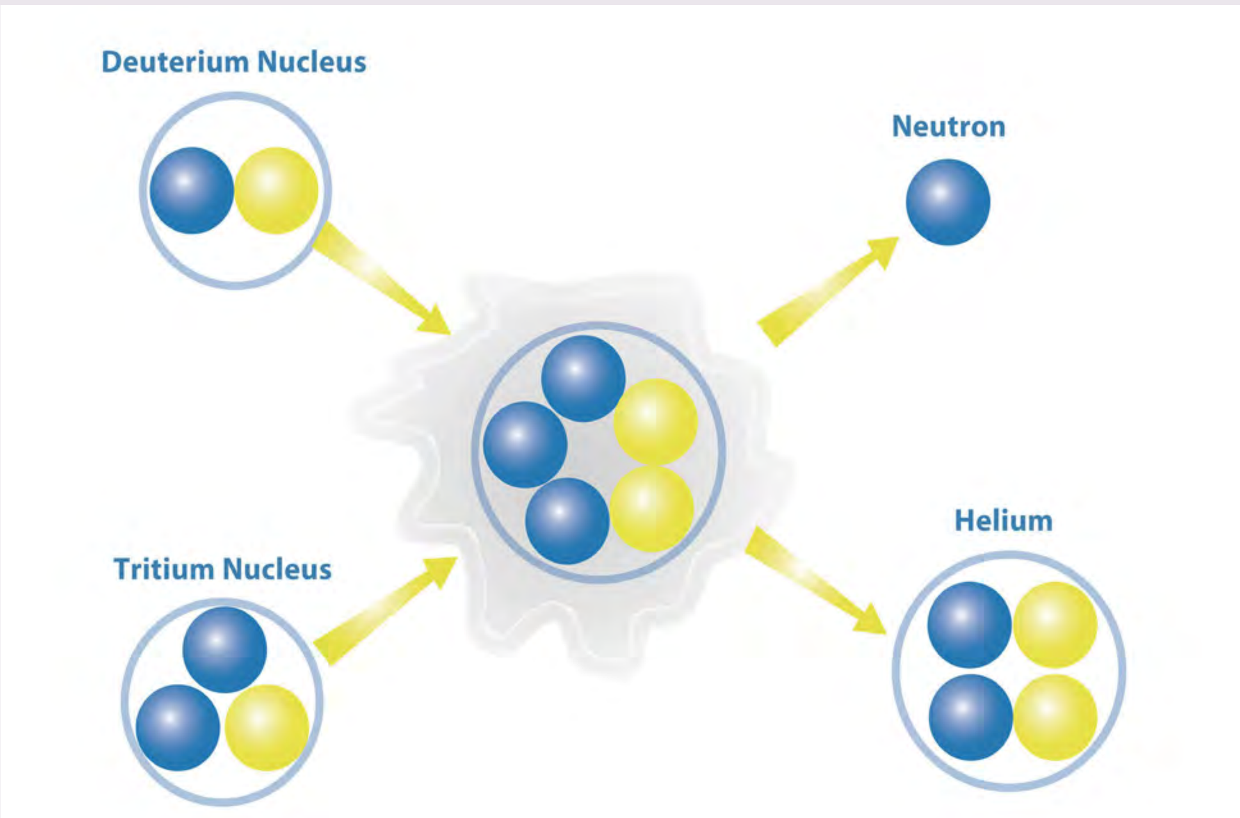
As opposed to fission, the breaking apart of the heavier elements (uranium, plutonium, thorium, etc.), thermonuclear fusion is the bringing together of the lightest elements (hydrogen or helium isotopes for example). When two isotopes of hydrogen are fused, the process produces helium and a free neutron (together weighing less than the sum of the two original hydrogen isotopes) plus the release of energy in accordance with Einstein's famous discovery that small amounts of mass can be converted into large amounts of energy (in proportion to the speed of light squared, $E = mc^2$).

These fusion reactants have energy densities millions of times greater than coal, oil, or natural gas, resulting in orders of magnitude less fuel required to generate comparable amounts of energy. For example, the same amount of electricity can be generated from either two million tonnes of coal (21,000 rail car loads), 1.3 million tonnes of oil (ten million barrels), 30 tonnes of uranium oxide (one rail car load), or one half tonne of the hydrogen isotope of deuterium (one pickup truck load).

Since ocean water contains deuterium, a fuel for fusion, the energy available with fusion is relatively limitless.

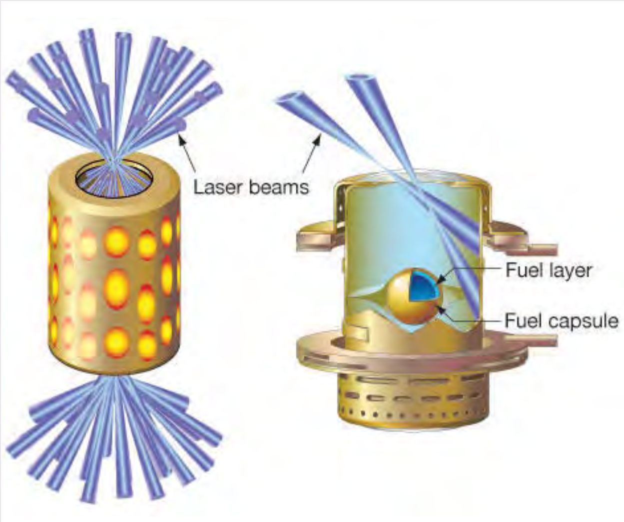
Fusion is the process that goes on in the Sun and the stars, as the light elements collide at high speeds and high densities. In both the Sun and the laboratory, ultra-high temperatures (50–200 million degrees) strip the negatively charged electrons from the nuclei, resulting in a highly charged state of matter called a plasma, in which any material can be manipulated at its atomic level. To fuse atoms in the laboratory requires not only ultra-high temperatures, but also a means of containing and controlling the reaction, sustaining it at a steady rate over a long period of time.

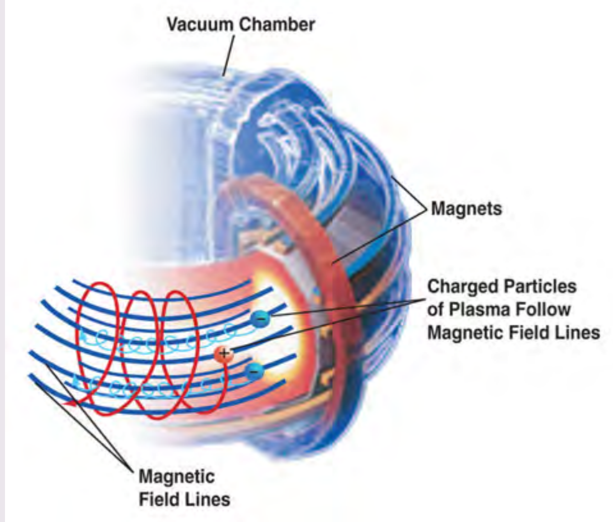
Since the 1950s, scientists have explored different ways of heating and confining hydrogen nuclei to fuse atoms of the heavier hydrogen isotopes, deuterium (^2H) and tri-



"The Surprising Benifits of Creating a Star," U.S. Department of Energy, 2001.

One type of fusion reaction: two isotopes of hydrogen, deuterium and tritium, combine to form a larger helium nucleus and a neutron, releasing energy in the process. Conditions of at least 100 million degrees under sufficient pressure are required to produce fusion.





Left: Lawrence Livermore National Laboratory; Right: "The Surprising Benefits of Creating a Star," U.S. Department of Energy, 2001

Left: This schematic of the National Ignition Facility shows its array of laser beams focussed on the tiny pellet of fusion fuel encapsulated in beryllium and carbide. The laser beams compress and heat the fuel pellet in a billionth of a second, so that the deuterium and tritium fuse before the pellet flies apart. The term "inertial" refers to the fact that the atoms must have enough inertia to resist flying apart before they combine. Right: This diagram of a fusion tokamak shows the magnets, the magnetic field lines, and the charged particles of plasma that follow the magnetic field lines, spiralling around the tokamak. The magnetic fields "contain" the plasma.

tium (^3H). Many proposals for devices and processes have been explored (tokamaks, stellarators, the ELMO bumpy torus, the z-pinch, to name a few). The two prevailing methods to control fusion are known as magnetic confinement and inertial confinement, both of which are embodied in the fusion research continuing today.

Progress in fusion research can be expressed in terms of increasing the "Lawson criterion," the product of plasma density, confinement time, and plasma temperature. The past several decades of research, despite chronic underfunding, have seen a 10,000-fold increase in this parameter. To make the breakthrough to commercial fusion requires a further increase of only about 10 times.

Full transformation will take some time, but certain fusion technologies can provide economic benefits in the relatively short term.

Already at the beginning of the fusion age, such visionaries as the co-founder of Lawrence Livermore National Laboratory and leading proponent of the Strategic Defense Initiative (SDI), Dr. Edward Teller, supported the utilization of the immense energy density made available with fusion reactions, in the form of Peaceful Nuclear Explosions (PNEs). It was demonstrated that this could revolutionize canal building, port construction, mining, aquifer creation, tunneling and other requirements of bulk earth moving. Today, PNE technology can be improved and applied for rapidly accelerating and cheapening the construction of vital projects, like NAWAPA XXI.

For materials processing and natural resources, the plasma torch, operating at temperatures below that required for fusion, can break down and separate many materials into their constituent elements and isotopes, meaning that chemical and nuclear "waste" can be processed into valuable resources. Such plasma torches can be a driver towards the higher densities of power achievable with a self-sustaining fusion reaction, at which point we could theoretically extract many times the current annual U.S. production of iron, copper, aluminum, and many other resources from virtually any cubic mile of dirt, and reprocess the valuable concentrations of materials in landfills.

Beyond separation and concentration of resources, a fusion economy allows for the creation of completely new materials with new properties, and even the transmutation of one element into another. For example, petawatt lasers have already demonstrated the ability to transform gold into platinum, and future transmutation potentials are much broader. Thus, the fusion economy demonstrates beyond a doubt that, for an advancing mankind, there are no limited resources, and no limits to growth.

While the broad-based implementation of some of these systems will require a generation or more of work, their future realization depends upon getting started now, and the first steps of a fusion economy are closer than you may think.

1. A Call for An International Manhattan Project

The slow progress in developing fusion power over the past four decades has been the result of political decisions, not scientific impossibilities. For example, in 1980 the U.S. Congress passed Congressman Michael McCormack's "Magnetic Fusion Energy Engineering Act," calling for a crash investment in fusion, and for the construction of a prototype magnetic confinement fusion reactor by the year 2000. However, the breakthroughs were never made because the program was simply never funded, as is indicated in the following graph of the annual fusion budget.

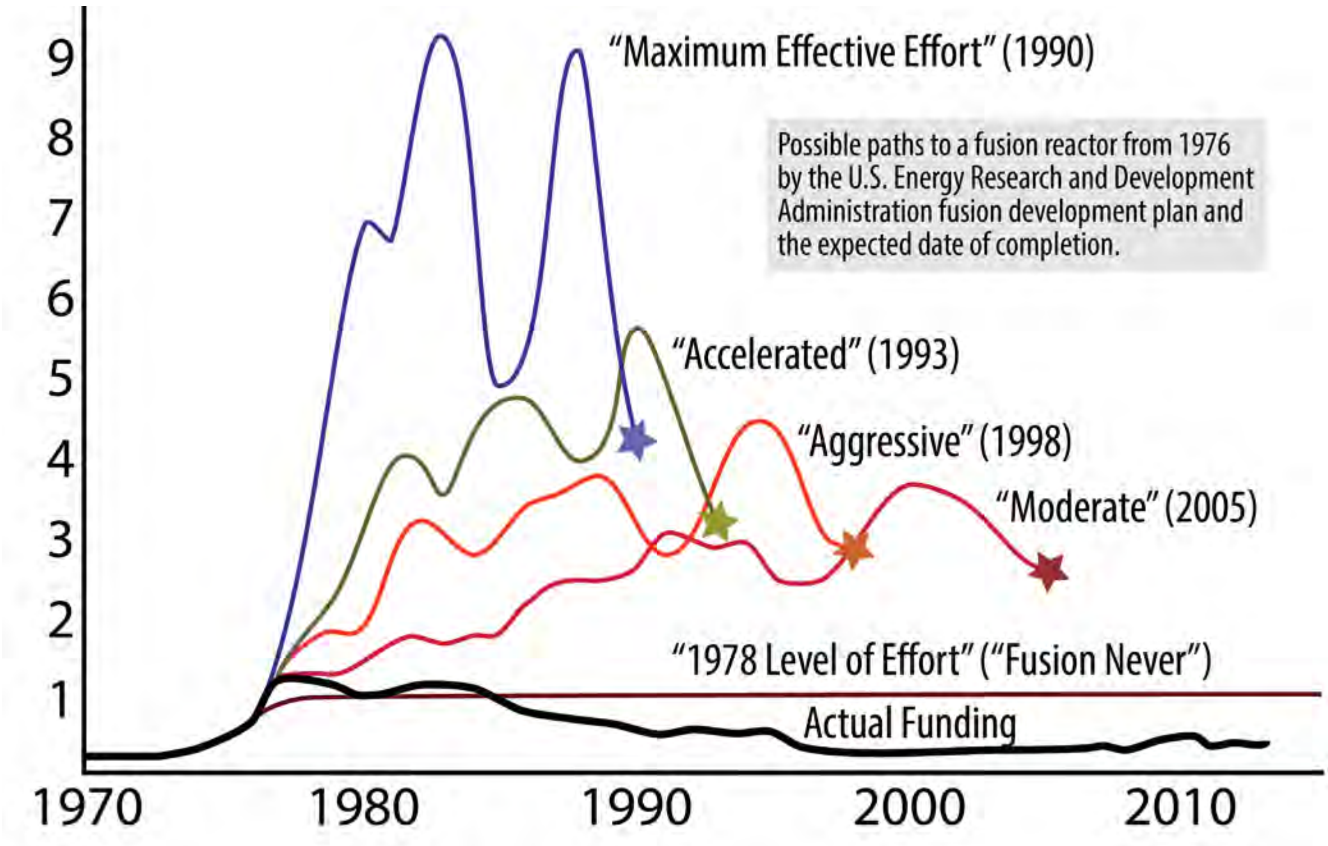
Thus, the challenge today is as much political as scientific. The *decision* must be made to develop the fusion economy; with this commitment, and with full funding and support of key governments, an international crash effort can make this a reality.

Fusion scientists from around the world (and especially the remaining veterans of the fusion efforts going back to the 1960s) must be pulled together to properly plan a serious crash program. The purpose of such a scientific gathering is clear: move the accountants out of the room, get the bureaucracy out of the way, and let the scientists hammer out what must be done from a scientific standpoint. No options should be off the table, including the revival of alternative fusion reactor designs which were shelved for political or budgetary reasons.

With the scientific, technical, and engineering considerations placed clearly on the table, a crash program can begin, pulling together the fusion and high technology resources of the United States, Russia, China, Japan, South Korea, the nations of Europe, and other countries, along with support from existing bodies such as the International Atomic Energy Agency (IAEA).

While this new crash program is being developed and implemented, an array of existing fusion programs can be fully supported and accelerated, including the large international project, the International Thermonuclear Experimental Reactor (ITER), which has been delayed because of lack of funding and poor coordination.

In the United States, greatly increased funding must be supplied to domestic fusion programs, reversing the



Credit: graphic design by Geoffrey M. Olynyk, incorporating 1976 projections from the U.S. Energy Research and Development Administration, "Fusion power by magnetic confinement: Program Plan," by S. O. Dean.

Four possible funding paths to create a magnetic confinement fusion reactor from 1976, measured in billions of dollars (adjusted to 2012 values). Actual funding falls below all projections, even a steady funding from 1978 levels (which was known to be too little to ever make the breakthroughs needed).

Obama administration's slashing of the fusion budget. This includes saving the Alcator C-Mod research facility at MIT (the largest U.S. training facility for students studying fusion) and funding the expansion of the fusion research going on at the nation's various national labs, universities, and industries.

Other nations can do the same, as with the advanced work going on in China with their Experimental Advanced Superconducting Tokamak (EAST), in South Korea with the Superconducting Tokamak Reactor (K-STAR), and the joint Russian-Italian IGNITOR project, among others.

These are only a few examples of ongoing work. A full survey of currently existing programs and past proposals must be done from the standpoint of an open-ended international crash program effort. This will lead to a selection of new demonstration and experimental systems to be constructed. (See Table 1 below.)

While effectively unlimited electricity is critical to the future, it is not the only benefit of a fusion economy. The international crash program will also focus on the applications of the great energy densities and unique physical properties of the fusion process, as applied to materials processing, industry, and manufacturing, for example. Put simply, a fusion economy completely revolutionizes man's relationship to the periodic table of elements, and what are considered "natural resources."

2. Fusion Technology for Production and Industry

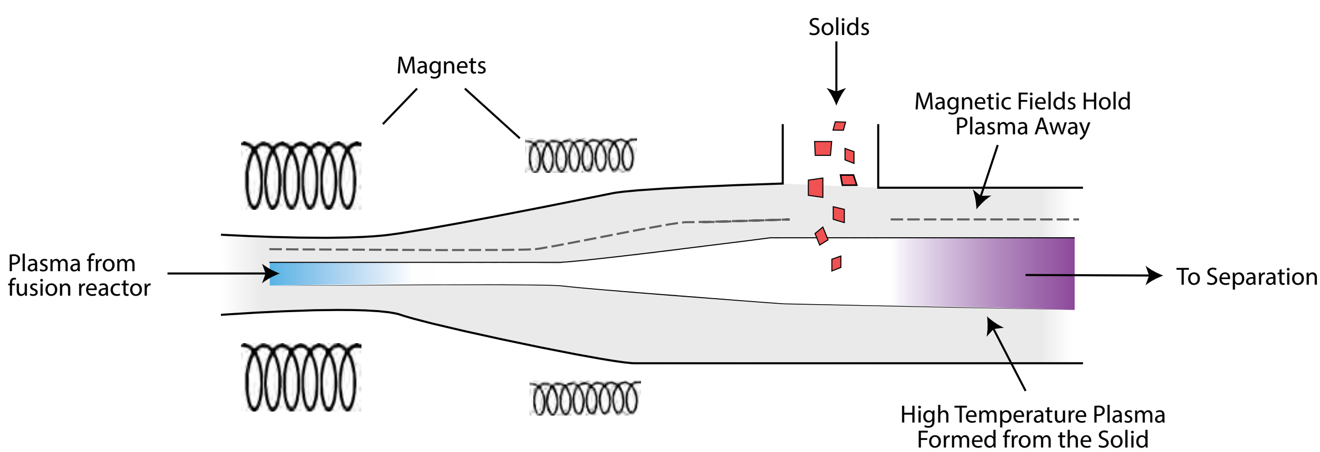
With fusion, we will be able to create plasmas at temperatures of tens and hundreds of millions of degrees. At these temperatures, any known substance can be easily broken down into its constituent elements. However, even low-temperature plasmas (tens of thousands of degrees) are already in use in certain industries today, and their use must be expanded. For example, so-called "arc plasmas" are used in welding and in specialty steel making, and a plasma separation process has been used to isolate desired isotopes for medical and other purposes. While these lower-temperature plasmas do not exhibit the full potential of what we will be able to achieve with a fusion reactor, they show the promise of what is to come when man has full access to controlled thermonuclear processes as the basis of his economic platform.

Continuing to broaden our use of plasma technologies today will serve to (1) improve our knowledge of plasmas in general, (2) aid in the development of technologies to handle them and put them to work, (3) train a new generation of scientists and industrial workers in the use of plasmas and fusion-related technologies, and (4) produce specialty materials which could overcome materials challenges arising in fusion research, such that the advances in productivity made today will contribute to accelerating the realization of fusion.

2.1 The Fusion Torch

The "fusion torch" design, first proposed in 1969 by Bernard Eastlund and William Gough of the U.S. Atomic Energy Commission, uses an ultra-high temperature fusion plasma, diverted from a fusion reactor core, to reduce virtually any feedstock (low-grade ore, fission by-products, seawater, garbage from landfills, etc.) to its constituent elements. Once the feedstock has been injected into the plasma, the elements become dissociated into electrons and ions, and the desired elements (or isotopes) can be separated from one another by atomic number or atomic mass, creating pure, newly synthesized mineral "deposits" from virtually any substance.

To make the point, an average cubic mile of dirt contains approximately 200 times the amount of annual U.S. aluminum production, 8 times the iron production, 100



Schematic of Fusion Torch Processing of Solid Waste

Table 1: Selected Fusion Experimental Designs

		Country	Reactor	Status	Features
Magnetic Confinement	Tokamak	International (being built in France)	ITER	Construction phase, first plasma expected in 2020	Utilizes superconducting magnets
		France	Tore Supra	Operational since 1988	Longest plasma duration for a tokamak (6.5 sec)
		Russia and Italy	IGNITOR	Under construction in Troitzk, Russia, expected to be completed in 2014, first plasma by 2016	Designed to demonstrate feasibility of ignition
		South Korea	K-STAR	Operational since 2008	Utilizes superconducting magnets
		United States (PPPL)	NSTX	Operational since 1999	
		United States (MIT)	Alcator C-Mod	To be shut down in October 2013 due to budget cuts, operational from 1991-2013	Reactor with the highest plasma pressure in the world
		China	EAST	Operational since 2006	Utilizes superconducting magnets
		Europe	JET	Operational since 1983	
		Japan	JT-60SA	Under construction, to be completed in 2016	Utilizes superconducting magnets
	Stellarator	United States (PPPL)	NCSX	Canceled in 2008. Constructed, but never assembled for budgetary reasons.	
		Germany (MPG)	Wendelstein 7-X	To be completed in 2015	
		Japan	LHD	Operational since 1998	Largest superconducting stellarator in the world
	Reversed Field Pinch	United States (University of Wisconsin)	MST	Operational	
	Tandem Mirror	United States (LLNL)	MFTF	Built in 1986 and promptly shut down due to budget cuts. No experiments were ever performed.	
	Dense Plasma Focus	International (AAAPT)	UNU/ICTP PFF Network	Operational, 12 systems in 9 countries	
	Magnetized Target	Canada (General Fusion)	General Fusion Reactor	Prototype expected by 2015, reactor by 2020	Combines features of magnetic and inertial confinement techniques

		Country	Reactor	Status	Features
Inertial Confinement	Laser	United States (LLNL)	NIF	Operational since 2003	
Inertial Confinement	Laser	Japan (Osaka University)	GEKKO XII	Operational since 1983, currently being upgraded by the addition of a second laser.	Upgraded apparatus will be part of an experiment for "fast ignition"
Inertial Confinement	Laser	Russia (VNIIEF)	ISKRA-5 and ISKRA-6	ISKRA-5 operation since 1989. ISKRA-6, proposed for construction, would be a NIF-class laser	
Inertial Confinement	Laser	France (CEA)	LJM	Prototype operational since 2003, full operation expected in 2014	
Inertial Confinement	Laser	European Union	HiPER	In design stages, construction expected to begin in 2014	
Inertial Confinement	Non-Laser	United States (SNL)	Z Machine	Operational since 1996	Largest X-ray generator in the world, has achieved temperatures of >2 billion degrees (theoretically high enough for fusion of heavier elements)
Inertial Confinement	Non-Laser	United States (LANL)	Project PACER	Under research until 1975 under Project Plowshare	Utilizes fusion bombs exploded in a cavity

times the tin, and 6 times the zinc, though most of it is not in a concentrated form, making it impossible to effectively mine and process with current technologies.[2] Even with the fusion torch we will likely not need to mine random plots of dirt, but this indicates how extensive the available resources are when we move to more energy-dense processing techniques. Lower-grade ores and lower concentrations (which are currently useless to us) will suddenly become readily available resources. *Dirt* becomes *ore*. Scrap materials which already contain concentrated elements, can also be efficiently reprocessed as new, vital raw materials. Urban landfills, containing disorganized forms of most all the elements we already use, become one of the most potentially valuable concentrations of materials waiting to be processed. According to Eastlund and Gough, with the wide availability of commercial fusion, the fusion torch will become an efficient method of generating whatever bulk raw materials are necessary to meet humanity's industrial and other needs.

Even before mastering a self-sustaining fusion reaction, a high temperature plasma torch can be created with today's technology. By the 1980s the company TRW had patented and was promoting the commercial construction of a plasma torch design fully capable of processing spent nuclear fission fuel, and retrieving valuable isotopes.[3] Already then, what some still today call "nuclear waste" or "chemical waste" had become a potential resource, with the application of the available processing technologies.

Beyond accessing existing resources, the ability to select and harvest very specific ratios of isotopes and elements in substantial quantities creates the potential for a revolution in the qualities and properties of materials. For example, specialty steel can be isotopically tuned, improving the capabilities for handling high energy processes ranging from industry, to fusion reactors, to space travel.

Claims of crises caused by "limited resources" fly out the window with the fusion torch and a fusion economy.

2.2 Chemicals Processing

Another use for the fusion torch design will be the transformation of the energy from the plasma into a radiation field for processing industrial materials and chemicals.

By injecting selected "seed" materials into the fusion torch, the emission frequency and intensity of the radiation can be finely modulated by the amount and type

2. See "The Fusion Torch: Creating New Raw Materials for the 21st Century," *21st Century Science & Technology*, Fall-Winter 2006.

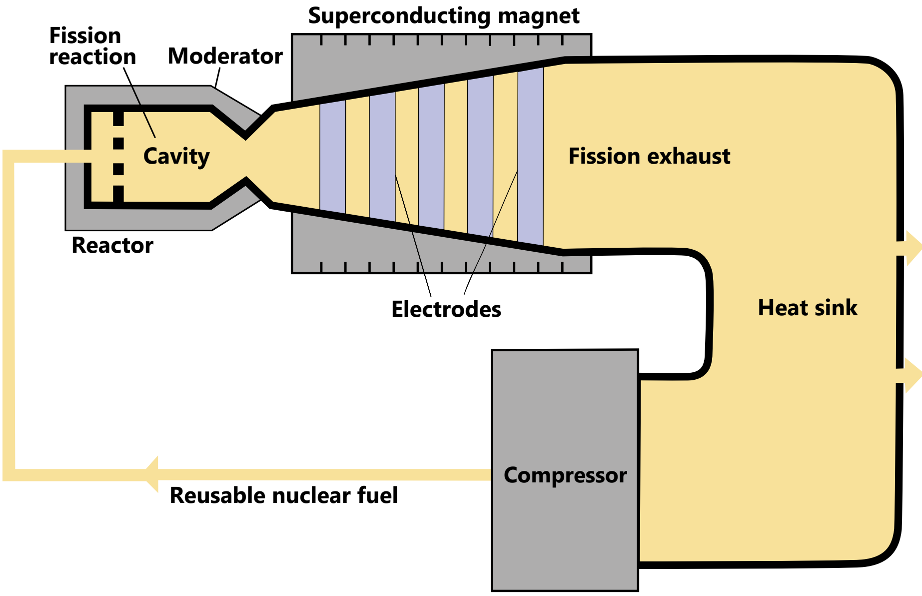
3. See "Plasma Separation Process for Generic Isotope Separation," by Steven N. Suchard, from the *1983 Waste Management Symposia*, and "The Status of the Isotope Separation by PSP," by Yuri A. Muromkin, February, 2013, *Journal of Energy and Power Engineering*.

of materials chosen. With a fusion plasma, as opposed to lower-temperature plasmas, it is possible to maximize the energy within specified, narrow bands of the spectrum.[4] This radiation can then be transmitted through a "window" material to a fluid or other body. Because the frequency of the radiation can be tuned to the material being processed, the existing limitation placed on bulk processing by the limits of surface heat transfer is greatly overcome. For example, ultraviolet radiation could be generated to sterilize industrial process water and drinking water.[5]

The neutrons from the fusion reaction can be used for direct or indirect heating of process materials to temperatures ranging from 1,000°C to more than 3,000°C.[6] They can also be used themselves, or converted via a blanket material into high-energy gamma rays, for catalyzing chemical reactions, thus directly converting the fusion energy into chemical energy. This could greatly increase the efficiency of the production of industrial chemicals requiring high heats or high activation energies, such as hydrogen, ozone, carbon monoxide, and formic acid. This increased power over materials and chemicals processing opens up a scale of production never before possible.

With the use of high-temperature plasmas the quality and quantity of available resources is completely transformed. As was said in 1969 by Eastlund and Gough, "the vision is there; its attainment does not appear to be blocked by nature. Its achievement will depend on the will and the desire of men to see that it is brought about."

Nuclear Cavity Reactor with MHD Conversion



From "Magnetohydrodynamics: Doubling Energy Efficiency by Direct Conversion," by Marsha Freeman, *Fusion*, April 1980

An externally moderated or cavity reactor would use the exhaust from the nuclear fission process in a closed cycle as the working fluid for MHD direct conversion. In this simple 1968 design, heat from the MHD generator's exit plasma could be could still be used to run a steam turbine. The design provides for the reuse of the nuclear fuel.

3. Magnetohydrodynamics (MHD) For Direct Conversion

For the generation of electricity from fusion power we will have to revive and advance the science of magnetohydrodynamics (MHD), a technology which can be used with virtually any source of energy to generate electricity directly from a high-temperature plasma. As a "direct conversion" process it eliminates the need for large steam turbines, and has the potential to *double* the amount of electric power generated from every unit of fuel used.

While in the 1980s some of the basic technologies were under development in the United States with coal powered systems, in the USSR with natural gas based systems, and in Japan using petroleum, the ultimate goal is the application to fusion power generation, with a possible role for utilization in fission power systems along the way.

The basic principle in MHD conversion is to pass a high-temperature plasma through a magnetic field. The magnetic field creates an electrical current in the plasma, which is drawn off by electrodes along the length of the channel through which the plasma flows. There are essentially no moving parts, since the plasma is itself moving through the magnetic field.

In a standard power plant (coal or nuclear), only 30% to 40% of the energy released by the fuel gets converted into electricity through the heating of steam used to

4. "The Fusion Torch: Closing the Cycle from Use to Reuse," Eastlund and Gough, 1969.

5. The absorption depth of ultraviolet radiation in water is about 1 meter. With the fusion plasma torch, energy fluxes of ultraviolet radiation on the scale of megawatts per m^2 can be generated and transferred to the water with very little loss, thus permitting a scale of bulk processing not possible before.

6. "A Survey of Applications of Fusion Power Technology for the Chemical and Material Processing Industries," Steinberg, Beller and Powell, *Energy Sources*, 1978.

then spin a turbine, while the rest of the energy is lost as "waste heat" (this is the efficiency of the power plant).

In basic MHD systems the direct conversion can nearly double the electricity generated without changing the amount of fuel, with the 50% efficiencies of simple MHD systems. Adding a steam turbine (to take advantage of the remaining heat) can increase the efficiency to 60%.

These are more than theoretical concepts: in the late 1970s, researchers at Argonne National Laboratory succeeded in achieving a 60% efficiency with a nuclear fission-powered MHD system, and the experimenters were confident they could reach a level of 80% with future developments.[7]

However, despite these exciting studies and results, serious MHD direct conversion research basically ended in the 1980s (along with many other areas of promising research).

MHD must be revived for the generation of power with fusion (with the possible application for more efficient fission systems as well). Using advanced fusion fuels, such as deuterium and helium-3, in a magnetically confined system, the charged particles of the fusion product can be continuously run through a magnetic field to directly generate electricity at efficiencies of 70%.[8]

4. Plowshare and Engineering with Nuclear Explosions

An important and relatively short-term application of thermonuclear power is the use of peaceful nuclear explosions (PNEs) for construction, the general precedent for which has already been well established by the 1960s–70s U.S. Plowshare Program, which took its name from the book of Isaiah: "And he shall judge among the nations, and shall rebuke many people: and they shall beat their swords into plowshares, and their spears into pruning hooks: nation shall not lift up sword against nation, neither shall they learn war any more."[9]

Although detailed plans for their application in the construction of the NAWAPA project are not known to the authors of this report, in 1968, Ralph Parsons (the head of the company which originally designed NAWAPA) did raise the general possibility of using nuclear explosives for its construction in a letter to a leading proponent of the project at the time, Senator Frank Moss.[10]

Today such considerations must again be put up front, to fast-track the construction of NAWAPA XXI and similar projects.

To bring some of the abundant northern waters down into the water-starved regions of the continent (from the Mississippi River to the Pacific Coast, and from the Canadian Prairies to Northern Mexico), NAWAPA XXI requires that an immense amount of earth be moved, totalling around 725 billion cubic feet (about 5 cubic miles), including 39 tunnels (totalling 1,200 miles) and 5,400 miles of canals. PNEs could be used for the construction of these new tunnels and canals, for widening or deepening existing rivers and reservoirs involved in the system, and even for the construction of new deepwater ports if needed.

Peaceful nuclear and thermonuclear explosions can be used to sculpt terrains on scales difficult or impossible with conventional methods, dramatically decreasing both the construction time, and the physical costs, based on the higher energy density unique to nuclear and thermonuclear reactions.

For example, according to the 1960s Atomic Energy Commission's informational videos on Plowshare, a 10-kiloton nuclear explosive could, at the time, be as small as a cylinder three feet long and fifteen inches in diameter. To release an equivalent amount of energy from conventional explosives would require 10,000 tons of TNT (hence the "10 kiloton" measure of the yield of the nuclear explosive), which would form a cylinder 200 feet long and 36 feet in diameter—that is equivalent to comparing the size of about 36 semi trucks to the size of your chair.

Over two decades, Project Plowshare completed 27 test nuclear explosions, and proposed using the technique for projects ranging from creating an artificial harbor at Cape Thompson, Alaska, to creating a new, sea-level Panama Canal, where studies showed that the excavation costs could be reduced by up to an order of magnitude with the usage of PNEs.[11] This reflected the general optimism around the "Atoms for Peace" outlook outlined by the Eisenhower Administration and promoted by Kennedy.[12]

7. See "Magnetohydrodynamics: Doubling Energy Efficiency by Direct Conversion," by Marsha Freeman, April, 1980, *Fusion*.

8. See "Direct Energy Conversion in Fusion Reactors," by Ralph W. Moir, *Energy Technology Handbook*, McGraw Hill, 1977, pp. 5150 to 5154.

9. Isaiah 2:4.

10. In a May 10, 1968 letter to Senator Frank Moss discussing NAWAPA, Ralph Parsons said, "In the past five years great advances have taken place in tunneling, for example, in earth moving, and in transmission of electric power. One construction factor which could very drastically change both the design and economic basis is the prospect of using nuclear explosives to create deep artificial aquifers for both storage and transfer underground." This was five years after the original NAWAPA design was proposed by Parsons' company.

11. "Major Activities In The Atomic Energy Programs," U.S. Atomic Energy Commission, 1965.

12. President Kennedy appointed Leland Haworth to the Atomic Energy Commission in 1961. An avid proponent of Project Plowshare, Haworth studied the proposal for a harbor in Alaska, Project Chariot in July of 1961. In March 1962 President Kennedy requested the AEC, to "take a new and hard look at the role of nuclear power in our

Kra Canal: PNE Case Study

In 1983 and 1984, the Fusion Energy Foundation (FEF) and *Executive Intelligence Review*, together with the Thai Ministry of Communication, held two conferences on the Kra Canal Project. The FEF updated an earlier feasibility study and further developed the project's economic and industrial benefits.

The 1984 conference included a presentation by *EIR*/FEF researchers on the use of PNEs, as the fastest, most efficient and most cost-effective method of construction. It was during this same period that Lyndon LaRouche and the FEF were involved in another program calling for the peaceful use of nuclear technology: the Strategic Defense Initiative.

Milo Nordyke of Lawrence Livermore National Laboratory in the U.S. and Harry Ekizian of TAMS engineering firm, both of which groups were involved in the 1973 feasibility study for the canal, presented the physical parameters for building the 30 mile long canal using both nuclear and conventional methods, with the nuclear methods roughly halving both the cost and the construction time.

Mr. Samak Sundaravej, then Minister of Communications and later Prime Minister, addressed the 1984 conference, stating, "The question is can we do it, how and which way?... If we use TNT, it will take 10 years, but if we use atomic energy for peace, it will shorten the excavation time by 5 years."

A spokesman from Lawrence Livermore suggested that a major nuclear isotope separation plant could be constructed as part of the Kra Canal complex of industrial centers constructed at both ends of the canal.

A later Japanese plan also advocated for the use of nuclear technology in the construction of the canal in a 1985 report. This plan would have used over twenty nuclear devices each roughly 30 kilotons—fulfilling the quote from Isaiah, by turning the former weapons of war into a tool for the betterment of all mankind.[1]

1. See "Kra Canal: Gateway to Asia's Development," in *Fusion*, July–August, 1984, and "International Conference Puts Kra Canal Back on the Agenda in Thailand," in *Fusion Asia*, January, 1985.

While the official U.S. program ended in the 1970s, the concept has continued to be discussed and considered. For example, another well-known case for the use of PNEs is a project which currently has renewed momentum: the construction of the Kra Canal across Thailand, providing an alternative to the congested straits of Malacca. While also designed for construction with conventional methods, this project attracted the interest of scientists at Lawrence Livermore National Labs for the application of PNEs (See box, Kra Canal: PNE Case Study). In fact, to dispel unjustified fears of radiation release, Lawrence Livermore scientist Dr. Edward Teller promised that he would move his entire family to Thailand after the construction of the Kra Canal, if they built it with PNEs.

While the original Plowshare tests were dealing with the very early stages of nuclear and thermonuclear technology, the tests allowed them to figure out how to contain the radiation release from the explosions, and by the end of the program the scientists involved were confident that the most dangerous safety hazards posed by PNEs would be the same as in any conventional explosion—the groundshock, air blast, dust cloud, etc.—and not the radiation.

If a PNE program is restarted today, the development of newer technologies can guarantee the radiation issue will pose no problem whatsoever.

This includes the prospect of "non-nuclear triggers" for thermonuclear explosions. Currently fusion explosions require a fission reaction to trigger the fusion, meaning the fission products are involved in the explosion (although they can be contained).[13] However, other methods can trigger fusion reactions as well, including inertial

economy," and Haworth led the writing of the report "Civilian Nuclear Power–A Report to the President–1962". In 1963, President Kennedy asked Haworth to direct the National Science Foundation.

13. Unlike fusion, which creates a very limited number of products, almost none of which are directly radioactive, fission creates nearly all the isotopes of the periodic table.

confinement (as with lasers for example) or even small amounts of antimatter.

Fulfilling the Thermonuclear Age

The fusion economy is not just a new way of acquiring power to be applied to the existing economy.

The entire history of the development of humanity has been characterized by the creation of *new economic systems*, with *new resource bases*, and *new technological capabilities*—a series of qualitative changes driven by increasing levels of controlled energy flux density. This is one of the purest expressions of the unique creative powers that separate mankind from any mere animal species.

The greatest economic revolutions have been driven by transitions to qualitatively higher levels of power sources. Fusion is now the imperative for mankind. By starting now, over the course of the next two generations the power and resource requirements of a growing world population can be met, and mankind can be set upon a new path, one actually befitting our true, creative nature.

Appendix 1: Energy Flux Density

The first evidence of a distinction between mankind and the apes comes with first appearance of ancient fire pits, used to control the power of fire for the betterment of the conditions of life of those wielding that new power.

From that time onward, mankind could no longer be characterized biologically or by biological evolution—the evolution of the creative mental powers unique to the human mind became the determining factor. Biology took a backseat to the increased power of thought wielded by the human species.

This is the secret—and science—of economic growth, and is expressed in the control over successively higher forms of fire. This started with transitions to more energy-dense forms of chemical combustion, from wood burning (and charcoal), to coal (and coke), to petroleum and natural gas. The developments around the end of the 19th century showed mankind an immense potential beyond chemical reactions: the fundamental equivalence of matter and energy, as expressed in the domains of fission, fusion, and matter-antimatter reactions, each with qualitatively higher energy densities.

Control over higher energy densities drives the increase in what Lyndon LaRouche has identified as the energy flux density of the economy, as can be measured by the rate of energy use per person and per unit area of the economy as a whole. As is illustrated in the accompanying articles ("A Call for An International Crash Program: Creating the Fusion Economy" and "Nuclear Agro-Industrial Complexes for NAWAPA XXI"), this increasing power drives qualitative changes throughout the entire society—creating fundamentally new technologies, new resources bases, new levels of living standards, and, actually, new economies.

Table I: The Energy Density of Fuels

FUEL SOURCE	ENERGY DENSITY (J/g)
Combustion of Wood	1.8×10^4
Combustion of Coal (Bituminous)	2.7×10^4
Combustion of Petroleum (Diesel)	4.6×10^4
Combustion of H_2/O_2	1.3×10^4 (full mass considered)
Combustion of H_2/O_2	1.2×10^5 (only H_2 mass considered)
Typical Nuclear Fuel	3.7×10^9
Direct Fission Energy of U-235	8.2×10^{10}
Deuterium-Tritium Fusion	3.2×10^{11}
Annihilation of Antimatter	9.0×10^{13}

Fuel energy densities. The change from wood to matter-antimatter reactions is so great that progress must be counted in orders of magnitude, and the greatest single leap is seen in the transition from chemical to nuclear processes.

For example, start with the simple rate of biological energy usage for the human body, about 100 watts (as sustained by eating a standard 2,000 calorie diet). Assuming a hypothetical pre-fire civilization in which everything is done by human muscle, the power employed to sustain the "economy"—the power of labor—is only 100 watts per capita.

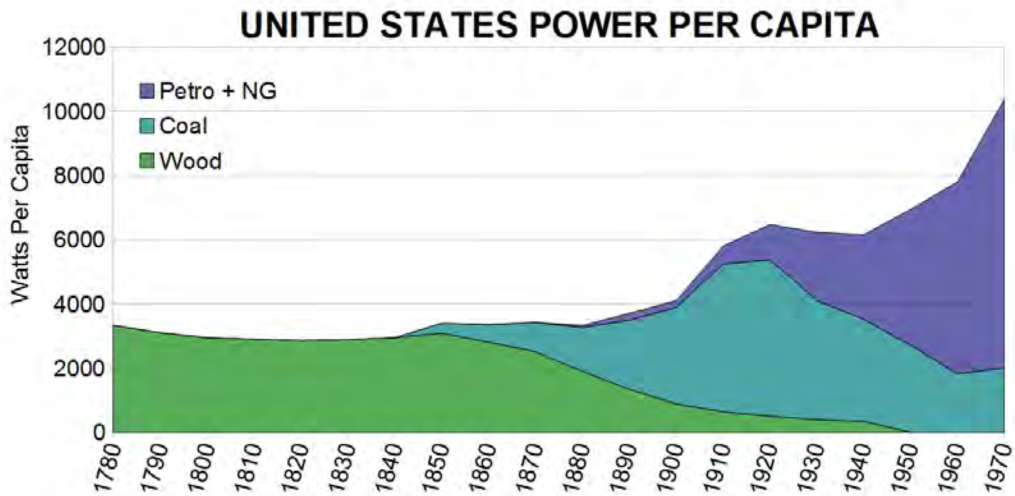
Compare this with the growing per capita power usage throughout the history of the United States. At the time of the nation's founding, the wood-based economy provided around 3,000 watts per capita, a thirty-fold increase over the muscle power of a fireless society. Then the widespread use of coal throughout the economy increased the power per capita to over 5,000 watts by the 1920s, and the implementation of petroleum and natural gas brought this to over 10,000 watts by 1970—100 times the per capita power of our hypothetical fireless society.

With each succession, the previous fuel base declines as a power source (allowing it to be used for things other than combustion, as wood is used for construction, and petroleum should be used for plastics and related non-combustible products of the petrochemical industry).

Following the post-World War II developments, nuclear fission power was fully capable of sustaining this growth rate into the 21st century. In a conservative estimate based upon previous growth rates and the potentials of nuclear power, this should have brought the U.S. economy to a level in the range of 20,000 watts per capita by some time before the year 2000.[14]

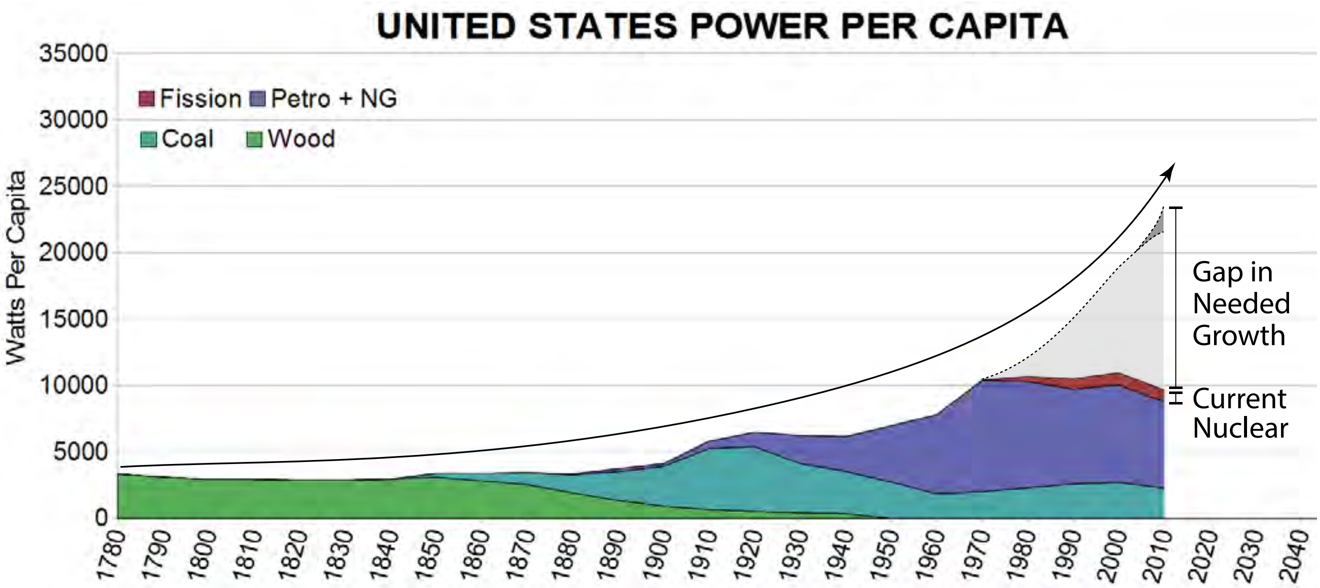
By then, assuming the nation had maintained a pro-growth orientation, as fission power was becoming the dominant power source, the beginnings of applied fusion power should have begun to emerge. With ocean water becoming an effectively limitless fuel source for fusion reactors, the U.S. economy would have been on a path to

14. If a serious economic policy had governed the nation following World War II (as was intended by Franklin Roosevelt, but reversed by the presidency of Harry Truman), a higher level could have been reached faster.



Per capita power consumption for the United States from 1780 to 1970. "Other" power sources, such as hydropower, or so-called renewables, have been left out because of their minimal impact on the total per capita values.

Based on data from the U.S. Energy Information Administration's "2011 Annual Energy Review."



Per capita power consumption for the United States from 1780 to 2010. The general growth trend is indicated by the long arrow on top, with the gray wedge representing what needed to happen with a fission economy and the beginning of a fusion economy. The lower arrow on the right shows the direction of the immediate path which must be started today to overcome the 40-year growth gap. This requires a crash program for the development of fusion.

an energy flux density of around 40,000 watts per capita, and beyond, in the first generation of the 21st century, four times the current value of 10,000 watts. Again, this would not simply be more power for the same economy, but a fundamentally new economy.

However, this natural growth process was halted with the takeover of the anti-progress environmentalist movement, a shift, then, which sent the economy on the direct path into the attritional collapse being experienced, now—a collapse process accelerated by imposing policies which lowered the energy flux density of the economy.[15]

15. This was not some happenstance change, but resulted from the top-down strategic intention of the Anglo-Dutch Empire, whose leaders have been explicitly and openly operating on a policy intention of reducing the world population to less than one billion people. For example, see "Behind London's War Drive: A Policy To Kill Billions," by Nancy Spannaus, *EIR*, November 18, 2011.

As is clear in the second graph shown, nuclear fission power was never allowed to realize its full potential, and the energy flux density of the economy stagnated and began to collapse.

While the actual implementation of nuclear fission is seen in the red sliver, the role it needed to play is indicated in the gray wedge above, a projected value which keeps with the natural growth rates of a progressing human economy, and includes the beginnings of a fusion economy as well.

The 40-year gap between the needed growth rate and the present levels expresses the source of the current economic breakdown, and demonstrates the immediate need for a crash program to develop and implement the next stage, the fusion economy, to overcome decades of lost time by creating a new economy at a higher level than ever before.

Appendix 2: Our Future in and of the Stars: The High Energy-Density Physics Platform—Plasmas, Lasers, Antimatter, and Fusion

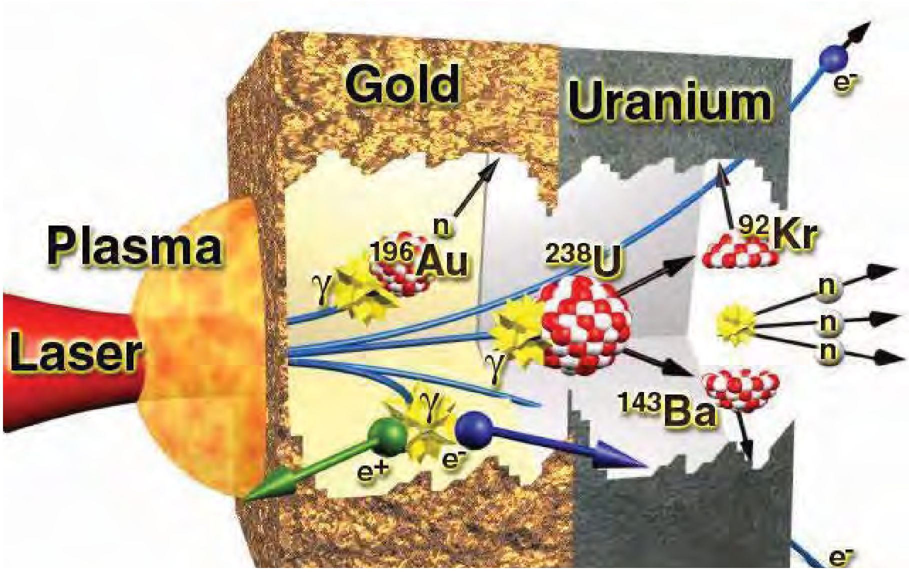
The next platform in the evolution of our human economy is the control of atomic processes like those found in our Sun, as this is to be applied to energy production, materials creation, and earthmoving, among other things. But this is not just for use here on Earth: the development of this power will be applied to conquering the entire domain of our Sun's influence, the Solar System, and will ultimately put us in range of our closest neighboring stars.

To achieve this will require the full exploitation of the dynamic relationships which currently exist between the fields of plasma, laser, antimatter, and fusion research, i.e., high-energy-density physics, where much of the work is already vectoring towards the next generation of space propulsion techniques. Only fusion propulsion can generate the 1-gravity equivalent acceleration, which is ideal for the human body, in that it both produces an Earth-like gravity environment, which mitigates some of the deleterious effects of microgravity, and reduces travel time, thus limiting exposure to harmful cosmic radiation. For example, at 1-G acceleration a trip to Mars could take as little as one week, achieving velocities of one-tenth the speed of light.

In addition to the space travel benefits of thermonuclear processes, the fields of high energy-density physics are furthering our understanding of processes occurring in stars and other cosmic phenomena, such as supernovas, widening our scope of understanding about the universe. This is opening up a renewed and necessary collaboration between astronomical, quantum, laser, and plasma physicists, where insights in one field quickly feed into the investigations of another. The physics of the lab and the physics of the stars are becoming more coherent.

Petawatt lasers, which operate on the order of 10^{15} watts of power, equal to 1,000 times the power of the entire U.S. electrical grid—a feat achieved by compressing mere hundreds of joules of energy (enough to light a 100-watt bulb for a few seconds) into pulses of trillionths of a second duration (femtoseconds)—are opening up vast new potentials for humanity. These lasers have thus far been directed towards the production of such things as: deuterium-deuterium fusion neutrons, the transmutation of gold into platinum, and the creation of anti-electrons (positrons), among other effects.

One such device is being operated by a group at the University of Michigan, where researchers have created what is being called the first table-top antimatter gun. The group has been aiming a petawatt laser at hydrogen gas, which in turn fires a stream of high-energy electrons at a thin metal foil, thereby producing quadrillions of antimatter particles (positrons). They have yet to develop



Lawrence Livermore National Laboratory

Interaction of the petawatt laser pulse with the gold and uranium target material. The laser forms a plasma plume at the target surface, in which electrons (e-) are produced with very high energies. Some of these electrons make gamma-rays (g) in the target, which in turn can knock neutrons out of the gold nuclei. Those neutrons cause uranium nuclei to fission. Some gamma-rays are converted into matter-antimatter electron-positron pairs (green e+).

the ability to trap and hold the antimatter, but that will be the next step they aim for.[1]

The other petawatt laser currently operating in the U.S. is at the University of Texas, where researchers have directed their efforts towards using the high-powered pulse for the creation of fusion reactions by blasting a plasma of hydrogen. Thus far they have been successful in generating neutrons from the fusion of deuterium-deuterium, and hope to increase the yield by adding a collapsing magnetic field around the plasma, further increasing the density.[2] This is a technique similar to that being developed by a group led by John Slough at the University of Washington. Slough proposes using a collapsing magnetic field around a plasma to rapidly contract a metal casing upon fusion fuel, triggering fusion, and then being ejected along with the fusion products for space propulsion.[3]

Continuing with the theme of antimatter's role in this new high energy-density paradigm, and the dynamic that exists between these different paths of pursuit, antimatter has the potential to be used as a trigger for fusion reactions. One application being explored is the antimatter triggered fusion propulsion system for rockets. To this end, a study was recently put out by a joint group from Pennsylvania State University and NASA Johnson Space Center which demonstrates the feasibility of two different models for antimatter-catalyzed propulsion, based on existing production rates of antimatter and methods for its application, as this would be applied for deep space exploration.[4]

Various proposals are being floated for antimatter triggered fusion propulsion systems, but they will all necessitate significantly more physical and intellectual investment to achieve the breakthroughs required.

The designs for rockets run all the way from antimatter triggered fusion propulsion, up to pure antimatter fuel propulsion. As things currently stand, the main road-block to making these systems a feasible reality are the limits in antimatter production and containment of the fuel, along with some engineering challenges. All of these are really a matter of proper rates of investment, as opposed to theoretical challenges. In addition, laser cooling techniques may be the key to efficiently generating Bose-Einstein condensates of anti-hydrogen, which are orders of magnitude more dense than simple anti-hydrogen gas or liquid. These condensates would make antimatter storage a real possibility for deep space flight, since (charged) anti-protons cannot themselves be packed densely, and (neutral) anti-hydrogen is difficult to contain otherwise. The proposed system would achieve velocities of just over half the speed of light and get within the range of our nearest star beyond the Sun in about 18 years.[5]

Another option for the use of antimatter triggered explosions is their use as shaped charges for large scale earth-moving and tunnel boring purposes, along with other applications as proposed in operation Plowshare,

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1. Center for Ultrafast Optical Science, Michigan Engineering, http://www.engin.umich.edu/research/cuos/ResearchGroups/HFS/Experimentalfacilities/HERCULESPetawattLaser.html; Bob Yrka, "Physicists Create Table Top Anti-matter Gun," June 25, 2013, http://phys.org/news/2013-06-physicists-tabletop-antimatter-gun.html.

2. The Texas Petawatt Laser, The Center for High Energy Density Science, http://texaspetawatt.ph.utexas.edu/overview.php.

3. See: John Slough, "Developing Fusion Rockets to Go to Mars," *21st Century Science & Technology*, Fall-Winter, 2012-2013.

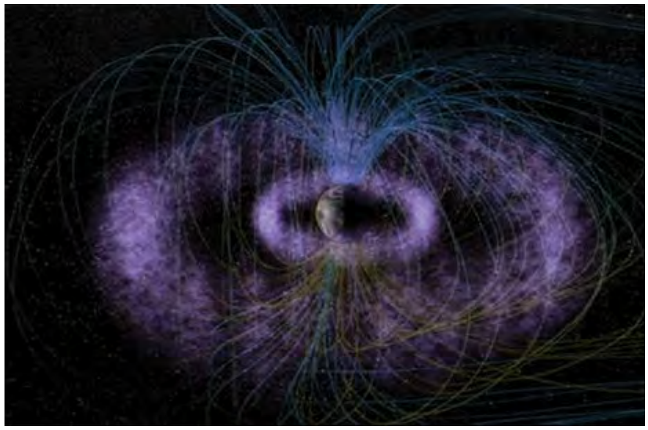
4. Schmidt, G. R., et al., "Anti-matter Production For Near Term Propulsion Applications," http://www.engr.psu.edu/antimatter/papers/nasa_anti.pdf.

5. Turyshev, Slava G., et al., "Controlled Anti-hydrogen Propulsion For Nasa's Future In Very Deep Space," October 21, 2004, http://arxiv.org/pdf/astro-ph/0410511v1.pdf.

for example. Anti-matter fusion explosions do not produce the radioactive fall-out associated with the PNEs of earlier designs.[6]

Regarding plasmas, the fourth state of matter, around which much of this new scientific paradigm revolves, in addition to those being developed in the tokamak fusion reactors and plasma torches discussed above, there is the potential for the controlled use of plasmas in fusion propulsion systems and petawatt lasers. One design for a propulsion system being developed by a group at the University of Alabama in Huntsville, utilizes the plasma pinch approach to create the densities for fusion reactions. The plasmas themselves are generated by electric pulses equivalent to 20% of world power output, which then go through a process of magnetic self-compression (the pinch), towards densities of action capable of igniting fusion reactions.[7]

The importance of the plasma state cannot be overemphasized, as it is a key aspect of all these interacting lines of development, for it seems to always accompany processes moving towards fusion. More to the point, the majority of observable phenomena in the universe seem to exist as some form of plasma, and as such, are better understood in terms of electromagnetic fluid dynamics, with its various non-linear qualities. This means changing our emphasis away from simple mechanics and thermodynamics, and towards the kind of non-linear evolutionary dynamics found in living processes, for example. This means broadening the scope of what we mean by astrobiology. This can already be seen clearly in the immediate Earth domain where lightning (a plasma) has been found to generate antimatter, and NASA has just discovered that the Van Allen (plasma) Belts that surround the globe, bear a functional resemblance to particle accelerators. Both processes are the product of life's effects and its interaction with cosmic processes.



NASA

The Van Allen Belts. NASA studies have shown a particle accelerator effect acting within the belts.

6. Gsponer, André, et al., "Anti-matter Induced Fusion and Thermo-Nuclear Explosions," February 2, 2008, http://arxiv.org/pdf/physics/0507125.pdf.

7. "UAHuntsville student seeking 'Holy Grail' of rocket propulsion system", http://www.uah.edu/news/research/3855-alpharetta-graduate-seeking-holy-grail-of-rocket-propulsion-system#.UiYc3TYkJ8E.

Increasing the Productivity of the North American Water Cycle

by Benjamin Deniston

America does not need a "recovery," but a *new economy*. This means not simply rebuilding what was lost, but *leapfrogging to qualitatively higher levels*. Higher conceptions of economy, including understanding the true role of mankind in managing and improving the biosphere—as by the massive control and direction of water—are demanded in order to solve the continental agricultural and food crises, while improving the overall territory of the West.

To do this effectively, the original 1964 design for a North American Water and Power Alliance (NAWAPA) must be upgraded from the standpoint of a nuclear-thermonuclear economic driver, providing not only *more* desperately needed water, but doing so *faster*, with *less loss*, and with an international commitment to the development of a new nuclear-thermonuclear global economy.

The point is that water is not an object that gets "used up." The newly designed NAWAPA XXI increases the productivity of the existing continental water cycle, by redistributing wasted freshwater and utilizing the unique power of plant life itself.

The original 1960s design would have made significant progress in this regard, but by being based on hydropower, it had a 40–45% loss factor built-in. However, a nuclear-powered NAWAPA XXI changes that.

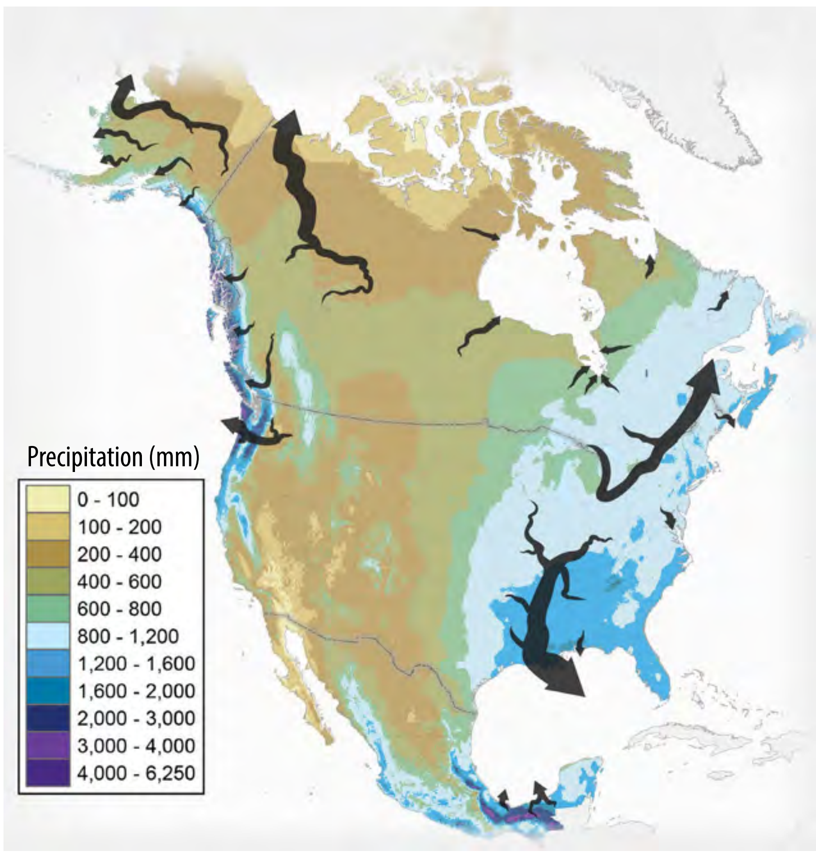
For the original NAWAPA to generate roughly 0.25 GW of electricity through hydropower, one million acre feet (or 1.23 billion tons) of freshwater per year must be released from the system, whereas the same amount of electricity can be generated using nuclear power with 600 million times less "fuel" (by weight), 2 tons of uranium per year – dramatically increasing the efficiency, potential, and size of NAWAPA XXI.

To fully understand the significance of this, it must be recognized that the value of water is never measured in its quantity alone, but defined by its contribution to the growth of the biosphere and the economy.

Why NAWAPA XXI Will Work

There are no isolated water basins on the North American continent (or any continent for that matter). The Earth has a single global hydrological cycle, which can then

Figure 1



NEGI, NR-Can, USGS, North American Environmental Atlas of the Commission for Environmental Cooperation

Precipitation map of North America, with major river runoff overlaid. The thickness of the arrows roughly corresponds to average annual runoff.

be sub-divided into continental components. Any serious discussion of the water issues in a region of North America requires addressing the whole continental system.

Start with the entire continental input and output of freshwater (e.g., rainfall and river runoff), and compare the resulting amount of plant growth. For the most accurate representation, the values should be examined in per-area terms, and the rising productivity for the continental system will be seen in the increasing photosynthetic activity per unit of water input. This becomes a reciprocal process, as the development of more plant life (enabled by the water) will then drive an even greater increase in the rate of re-utilization of the water while it remains on land.

This reveals the secret beauty of NAWAPA. Currently, a huge density of precipitation falls along the coastal region of Alaska and British Columbia, which very quickly rushes back into the Pacific Ocean to become saltwater—losing any potential to be productive. Another massive input of precious freshwater flows north into the Arctic Ocean through the Yukon and Mackenzie basins, featuring two of the longest and largest rivers of the continent (with the Yukon and Mackenzie rivers together matching the flow of the mighty Mississippi).[1] (See Figure 1.)

This intense concentration of coastal precipitation is a peculiar consequence of the relationship between the geography of North America, and the Coriolis-driven wind patterns in the northern latitudes (the "anti–trade winds" or the "Westerlies"). The northern west-to-east wind pattern carries with it evaporation from the Pacific Ocean, bringing an immense store of water vapor. However, instead of this moisture delivering its benefits across the land mass (as is done in the west-to-east delivery of Atlantic moisture across similar latitudes in Eurasia), this Pacific moisture hits the massive block of North America's western coastal mountain ranges, pushing the moist air to higher altitudes where it condenses and much of it falls on the Pacific side of the mountains, running back into the ocean before it can get much work done.

This is a terrible waste of all the work the Sun had to do to evaporate all that ocean water, producing the freshwater needed for the survival of life on land.

Compare this unfortunate scenario with South America, where there is also a major mountain range along the western coast, but, being at a lower latitude, the Coriolis-driven winds flow in the opposite direction (the "trade winds" running from east-to-west). (See Figure 2.)

This results in the exact opposite effect, preventing the water from leaving the landmass. When combined with the power of the Amazon rainforest, this water ranks among the highest rates of productive use *and reuse* (through repeated cycles of evaporation, transpiration, and rainfall) of any continental water system on the entire globe.

Figure 2

North and South America, with the coastal mountain ranges and moisture-carrying wind patterns indicated.

In the unfortunate situation of North America, despite the major block of the coastal mountain ranges, some of the water in the northern regions does make it farther inland (over the continental divide), but only to then flow north, into the Arctic Ocean. The biospheric productivity of this northern territory is not limited by any shortage of water, but by lack of sunlight and the resulting frigid cold. For example Canada's Mackenzie basin has a -10°C mean annual temperature, with widespread permafrost in the north (where the land transitions to tundra), and nutrient-poor forest soils in the south.

Contrast this with the lower half of western North America. In the southwestern United States, where there is significant farming, agriculture, industry, population centers, and the potential for much, much more, the amount of freshwater runoff available is very small, ten times less than the north—only 91 million acre feet per year (113 km^3), compared with the 1,220 million acre feet per year (1,494 km^3) of the northern basins (see box: The Great Western Discrepancy).[2]

1. Also take note that Canada's Yukon and Northwest Territories have populations of 34,000 and 41,500, and population densities of 0.07 / km^2 and 0.04 / km^2, respectively. Alaska almost appears like an urban center in comparison, with its population of 731,500 and population density of 0.49 / km^2.

2. Unless otherwise noted, the freshwater runoff figures in this article are from John D. Milliman and Katherine L. Farnsworth, *River Discharge to the Coastal Ocean: A Global Synthesis*, May 2013.

The Great Western Discrepancy

The entire North American continent suffers from the lack of productivity created by the "Great Western Discrepancy."

In the north, there is excessive rainfall and runoff found in the Mackenzie, Yukon, Fraser, and Columbia River basins, plus the Pacific Seaboard, from Bristol Bay, Alaska down to about the northern border of California (42°N latitude).

In the south there is relatively little water throughout the remainder of the Pacific Seaboard down to the Tropic of Cancer (at just about the southern tip of Baja California Sur), and in the Rio Grande and Colorado River basins, along with the landlocked Great Basin.

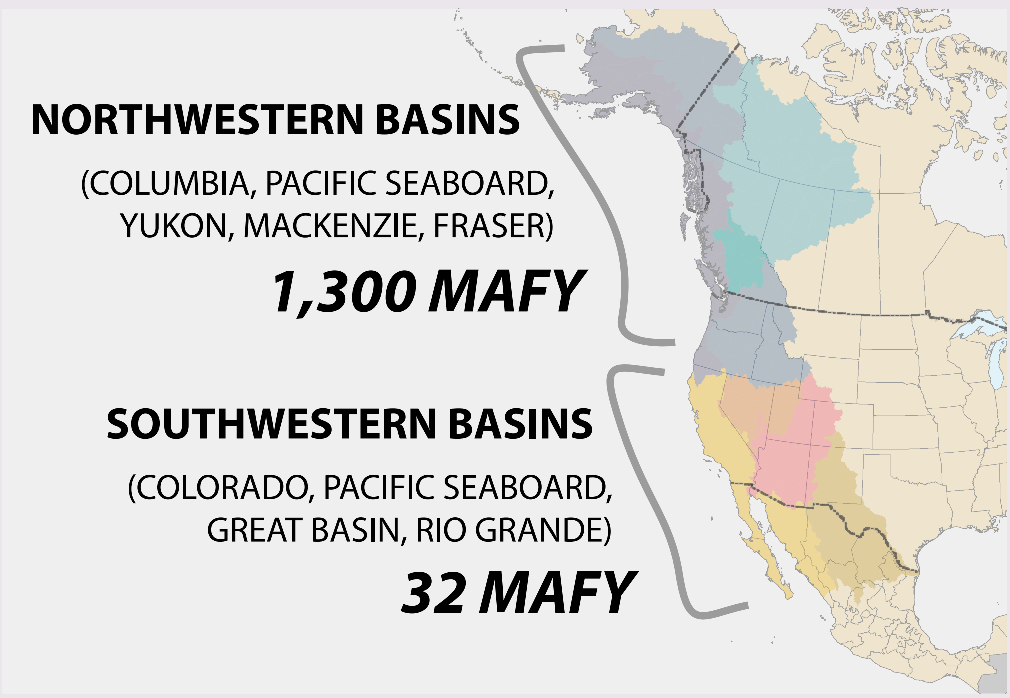
The precipitation into these basins, and the freshwater runoff leaving them, provides the water input and output of the two areas, and the comparison is improved when the values are considered relative to the size of the basin areas—showing that the northwest runoff per area is an order of magnitude higher than the southwest. Comparing these values against the average for the entire continent further illustrates the point, with the Northwest being about a factor of 2.5 times above the continental average, and the Southwest being about a factor of 3.5 times below the continental average, when considered in per-square-kilometer terms, as seen in Table 1.

Table 1

	Runoff (MAFY)	Area (Million km^2)	AFY/km^2
Northwestern Basins	1,220	4.42	276
Southwestern Basins	91	3.11	29
North America	2,554	23.1	110

This defines the physical framework for determining how the entire continental system can be improved by NAWAPA XXI.

The general question is the following: given the average continental yearly freshwater input-output cycle (i.e., the net annual continental hydrological flux), how productive is the water?



Division of the Northwestern water basins from the Southwestern

The total freshwater runoff for each set of basins is provided in million acre feet per year (MAFY), and the averaged acre feet per year (AFY) per square kilometer is provided. The total runoff values are what would leave each basin, assuming no withdrawals for other purposes; for example, the value used here for the Colorado is 16.2 MAFY, which corresponds to how much precipitation the basin receives, even through the actual amount that currently runs into the ocean is only 0.2 MAFY, since most of the river is used along the way for agricultural and economic activity.

In the Southwest, stretching from California to Texas, the climate is excellent, and the soils are fertile, but the limiting factor is the lack of water. The water challenges extend as far north as the Canadian Prarie Provinces, and south to Mexico, where entire regions of agricultural land are being lost, towns are running dry, and finite groundwater stores are being depleted, threatening an imminent and deadly food and water crisis.

Taken together, this north-south disparity in the West lowers the productivity of the water cycle of the entire continent.

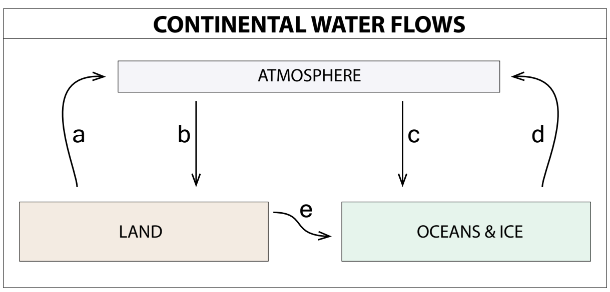
NAWAPA XXI is designed to take a fraction of some of these northern rivers (about 10% of the total runoff, by taking 20% of the runoff from a select set of rivers), and redirect the water south, both down into the Southwest and into northern Mexico, and also southeast, into the drought-prone Canadian Prairie Provinces and to the Great Lakes (where the water level has been steadily falling since the late 1990s), a more equitable distribution that will vastly improve the productivity of the continent as a whole.

Input and the Multiplier Factor

To measure the increased productivity, we have to first know more about the nature of North America's freshwater cycle.

In the most simple terms, Figure 3 illustrates a basic continental hydrological system. Rainfall (***b***) provides a freshwater *input*, while rivers releasing freshwater into the ocean provide an output (***e***).

Figure 3

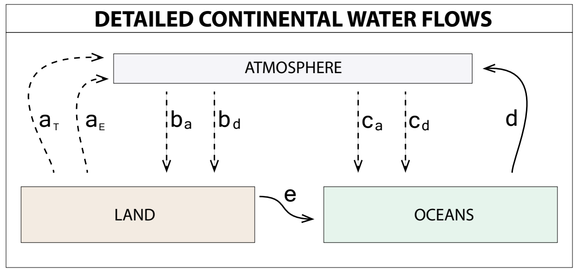


General flows of a continental hydrological cycle.

However, we must note that some of the atmospheric moisture which falls on land as rain *(**b**)* comes from the evaporation of water that was *already* on the land *(**a**)*.

So, to properly define continental freshwater input requires *knowing where the rain actually comes from*. True "input" is only new freshwater that is introduced onto the continental system: evaporated ocean water that then falls as precipitation over the continent. Simply measuring precipitation without investigating the source would lead to double counting when strictly defining input.

Figure 4



*Detailed schematic of a continental water cycle with precipitation subdivided by the source of the moisture (either from **a**, the continent, or **d**, the ocean), and evaporation from land subdivided into general evaporation (**E**) and the transpiration of plants (**T**).*

As seen in Figure 3, actual input is the amount of water evaporated from the ocean (***d***) which falls over the land (***b***). This is indicated in Figure 4 as b_d (a value that is different than simply the total precipitation).

While this may seem like a rather peculiar challenge, a team at Delft University of Technology, Netherlands, has investigated precisely this question.[3] Using new methods for modeling the transfer of water between the atmosphere, oceans, and land, they were able to estimate *where rainfall comes from*.

For example, according to their simulations, on average for the entire globe, only 60% of the rainfall over land would be considered fresh input (originating from moisture that evaporated from the oceans), while the remaining 40% comes from evaporated water *that was already on the land*. However the percentage varies significantly for different landmasses.

For China, they estimate that *only 20%* of its precipitation comes from ocean water, and about 80% comes from the Eurasian landmass. But for North America, the ratio is inverted, with 70% of the precipitation originating from the ocean, and only 30% coming from the land.

This analysis of the different sources of precipitation can be used to define the *rainfall multiplier factor* for any continental water cycle. For water that falls on a particular continent, how many times will it evaporate, and then rain back onto that continent again, before returning to the ocean? For North America the multiplier factor is about 1.45, below the global average.[4]

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3. See, Rudi van der Ent, Hubert Savenije, et al., "Origin and fate of atmospheric moisture over continents," *Water Resources Research*, September 2010.

4. Of all the water falling on North America, only 70% is fresh input, while the remaining 30% is input that has been re-cycled or re-utilized (in the form of precipitation). Since 70 is to 100 as 1 is to 1.45, the

Not surprisingly, when discussing this lower multiplier factor for the North American continent, the authors of this study repeatedly point to the role of the Western coastal mountain ranges in blocking moist air from moving inland, correctly noting that this lowers the cycling potential from the very start by causing a large amount of precipitation to immediately return to the Pacific Ocean before it has a chance to evaporate (let alone participate in plant life). For the precipitation (input) that is lucky enough to remain on land long enough to re-enter the air, they note that 60% of the land evaporation from the West returns to the continent again as rain. So while most water falling along the West Coast does not get a chance to evaporate, that which does has a multiplier factor of 1.67 (higher than the continental average of 1.45).

Now, in this context recall the specifics of the Great Western Discrepancy. In the northwestern basins, 1,220 MAF of water runs off every year, averaging 276 acre-feet of yearly runoff per square kilometer (as compared with the continental average of 110). When considering its scant participation in plant life, and the limited evaporation for inland transport, *this is among the least productive concentrations of precipitation globally*!

NAWAPA XXI's redirection of the northern water inland automatically increases the multiplier effect of the continental water input (again note that water evaporating from the West has a higher multiplier factor than the continental average). NAWAPA XXI's delivery of freshwater throughout the Canadian Prairie Provinces, the 17 western U.S. states, and northern Mexico, will ensure that more of this northwestern water will not only get a chance to be productive, but also to re-enter the atmosphere, increasing the rainfall throughout the Western and Central regions.

The benefits don't end there. The development of more plant life (supported by this new water) provides an additional feedback on the multiplier factor.

The Delft University team did a follow-on study examining a few specific regions which are highly dependent upon land evaporation for their rainfall, such as China. Specifically they studied the effects on rain patterns created by irrigation and plant life changes in the neighboring lands from which the moisture originates. For example, in one case they concluded that irrigation, agriculture, and water management systems in India have led to an increase in rainfall for China.[5]

NAWAPA XXI will take advantage of similar effects for North America.

precipitation value of rainfall over North America is increased by a factor of 1.45.

5. See, P.W. Keys, R.J. van der Ent, et al., "Analyzing precipitation sheds to understand the vulnerability of rainfall dependent regions," *Biogeosciences*, February 2012.

The Great NAWAPA XXI Forests

While plants use some water directly for photosynthesis, they also release much more water vapor directly into the atmosphere, through a process called *transpiration*. Adding to existing evaporation, plant transpiration can significantly increase the moisture delivered into the atmosphere, meaning the introduction of large amounts of new vegetation can directly affect the water cycle, weather, and even local and regional climates. While all plants reintroduce additional moisture back into the atmosphere, trees and forests are the most effective in this process. For example, a 70-foot-tall sycamore tree can bring 100 gallons of water per hour from its roots to its leaves, 90% of which transpires into the atmosphere. This takes water from the subsurface water table—which would not otherwise evaporate, but would instead follow the underground water table toward streams and rivers—and lifts it into the atmosphere.

Within forests, certain angiosperms, such as oaks, transport water at a much faster rate then their less biologically advanced cousins, the gymnosperms, e.g., pine trees (although it should be noted that oaks are much slower growing than pines, so they would take longer to get going).

A 2012 review of decades of studies on the effects of plant life and forestation on the water cycle notes that, in general, forests release 1.4 to 1.75 times more water per square kilometer into the atmosphere than grass or croplands.[6] The authors note that plant life plays a critical role in strengthening the inland transport of water inland, and promoting more rainfall.

NAWAPA XXI will provide desperately needed water not only for existing farming, municipal, and industrial needs, but for additional economic growth, potentially tripling the agricultural land, for example—and it can also do more. For the multiplier power of plant life to be fully realized, additional water can go toward significant greening of strategic regions as well.

As discussed above, the atmospheric-hydrological system covering much of North America has an overall west-to-east directionality, a characteristic that can be utilized to increase the multiplier factor provided by plant life. For example, consider using NAWAPA XXI water to create dense strips of forest running north-south along the main NAWAPA XXI distribution trunks running from Idaho, through Utah, and into Arizona and Mexico, as well as the western branch from Utah, through Nevada, and along the California-Arizona border. A third north-south strip could follow the Colorado aqueduct, and/or the High Plains ex-

6. See, David Ellison, Martyn Futter, and Kevin Bishop, "On the forest cover-water yield debate: from demand to supply-side thinking," *Global Change Biology*, 2012.

tension (see Figure 5).

Such forests could rapidly accelerate the return of water into the air, as moisture for more rainfall. Additional elements can be considered, including ionization-based weather modification systems, designed to induce existing atmospheric moisture (provided by the trees) to condense and fall as rain.[7]

Figure 5

Map of NAWAPA XXI with four extensions indicated. Three sets of river basins are also identified, the northwest basins (blue) involved in collection, the southwestern basins (red), and the High Plains basins (green).

The Nuclear Driver

Although impressive for its time, the original 1960s NAWAPA design was limited by its hydropower constraints. This resulted in an inherent 40–45% loss factor, in terms of water utilization. Water would have to be collected within the system, only to then be released into the ocean to generate enough power to pump the rest of the water throughout the Southwest. With a higher level of energy-flux density, the power of NAWAPA XXI increases.

Key pump-lift stations in the northern regions raise the elevation of the water to allow it to flow by gravity throughout most of the rest of the system.

To deliver water into the Southwest, a hydropower NAWAPA depended upon collecting around 200 MAFY,[8] and then releasing around 130 MAFY of that collected freshwater into the ocean, solely to generate the power needed to pump the remaining 70 MAFY into the Southwest.

With a series of nuclear power plants to drive the pumping, NAWAPA XXI solves this issue, allowing more water to be delivered to the Southwest.[9] With more water available, critical extensions expand the distribution to new regions, beyond the scope of the original NAWAPA design.

7. Or even modulating the systems to keep existing moisture from raining down where it is not desired. See, Benjamin Deniston, "Expanding NAWAPA XXI: Weather Modification To Stop Starvation," *EIR*, Aug. 9, 2013."

8. This number does not include the amount collected and distributed along the Prairie Canal, since that portion of the project on the other side of the continental divide does not have the same pumping requirements. It also does not include the large amount collected in the 1960s design for the purposes of generating excess hydropower.

9. Recall that only 2 tons of uranium provide the same electricity (needed for pumping) as 1.23 billion tons of freshwater runoff.

Table 2

	North America	Northwest	Southwest	High Plains	Southern Mexico
Area (km²)	23.1 million	4.4 million	3.1 million	3.3 million	0.42 million
Runoff (AFY)	2,554 million	1,220 million	91 million	238 million	177 million
"Natural" Runoff (AFY/km²)	110	276	29	73	419
NAWAPA (Hydro) (AFY/km²)	110	248	52	82	–
Nuclear NAWAPA (AFY/km²)	110	242	61	82	–
PLHINO & PLHIGON (AFY/km²)	110	–	39	–	350
Complete Program (AFY/km²)	**110**	**242**	**71**	**82**	**350**

This table shows the freshwater runoff relative to the size of different land areas, and compares the results of the original NAWAPA, the Nuclear NAWAPA XXI, the PLHINO and PLHIGON, and the complete program (Nuclear NAWAPA XXI, PLHINO and PLHIGON), in these terms.

The High Plains extension provides water to the region of the Ogallala Aquifer, where the agriculture of western Texas, Oklahoma, and Kansas; most of Nebraska; and parts of New Mexico, Colorado, and Wyoming depends upon the overdrawn aquifer.

The California-Oregon (CA-OR) extension provides existing river and water systems in those states with much-needed reinforcements, securing and strengthening the existing capabilities.

Nuclear power can also drive a pair of coastal water projects for Mexico, the PLHINO and PLHIGON, bringing significant additional supplies of water from the *southern regions* of Mexico into the north, connecting into the NAWAPA XXI system.[10]

Thus, higher levels of energy-flux density enable what the original NAWAPA did not. Nuclear systems power the increased productivity and reuse of the entire continental water system, overcoming the arbitrary block of the coastal mountain ranges and bringing the biosphere to levels of activity impossible without man's governing hand.

This more equitable distribution is summarized in Table 2, showing the changing freshwater runoff per area.

This is not just redistribution, and is certainly not simply "using up more water." There is a continuous continental input, but the questions is, "what does the water do?"

Directing more water throughout the water-starved regions of the continent with the nuclear NAWAPA XXI allows for more plant life, more agriculture, and more economic activity generally, dramatically increasing the productivity of the existing continental water cycle.

The key to the future survival of North America is the direct interrelationship among energy-flux density, plant life, and water re-utilization per cycle without changing the actual input.

It is time for man to improve the biosphere in a way only he can do.

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10. See the discussion of the PLHINO and PLHIGON Mexican water projects in Dennis Small, "Make that Which Is Reasonable, Possible—U.S. and Mexico: Cooperate on Great Water Projects," *EIR*, Dec. 7, 2007.

The Nuclear NAWAPA XXI and the New Economy

by Michael Kirsch

An economy is an integrated process, whose character is to constantly evolve as such. Today, that evolution must be spearheaded by a 21st century North American Water and Power Alliance (NAWAPA XXI), driven by fission, with a fusion economy on the horizon.

The completed NAWAPA XXI will be more than delivery corridors of freshwater: it will be the bounding infrastructure network of a more advanced economy and society, and a scientific resource management of a new kind.

With the widespread application of fission for electricity, heat, and desalination, combined with a system of continental water resource management, the several crises in water, food, energy, transportation, jobs, etc., all merely symptoms of the failure to implement these measures decades ago, will be solved.

For this, a complete dedication of human and productive resources currently existing in the U.S., Canada, and Mexico, will be required. Their economies will be put into high gear, requiring assistance from China, South Korea, and Japan for the mass-production of the latest nuclear power plants and machine tools. A rapid training program of the necessary skilled labor will be initiated. These include construction crafts, machine toolists, engineers, and scientists of all kinds.

Even before construction of a full NAWAPA XXI system begins, coastal desalination, desalination of irrigation wastewater, groundwater, and Southwest river water, through the mass production of fission reactors, will raise the level of productivity of our lands and cities and halt the collapse. Food production will be maintained, coastal cities will be sustained, and large areas of agricultural land will increase yields in the short term, supporting the growth process.

Drawing upon the built-up skilled labor and industrial capacity associated with this process, construction on the core trunk line of NAWAPA XXI will begin to take place. The higher quality of concentration, skill, and foresight of engineers and the labor force will shorten the time table. Scientists will have been using these new nuclear plants as locations for research and application of the most advanced technologies available, including those associated with fusion and plasma processing and power. Commercialized fourth-generation reactors and nuplexes will be introduced into the early phases of NAWAPA XXI construction and planning.

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Plasma Thermal Spraying: a plasma torch shoots a jet of plasma (on the order of 10,000°C) into which materials are introduced, melted, and sprayed onto a substrate.

New mining technologies will be developed, and new types of minerals will be processed and available to industry. Cutting-edge technologies will be applied throughout the machine tool sector and manufacturing and transportation process. New careers in sciences of all kinds will be needed for the exploration, designing, constructing, manufacturing, and management of an integrated water and power system, and the establishment of infrastructure and cities at higher levels of technology than ever before.

In short, as the system is built, an economy unrecognizable from today will emerge, making possible the most productive relationship between mankind and the biosphere yet achieved.

This process of development is described in what follows, beginning with the wide application of Kennedy-era nuclear desalination plans.

Phase 1: NAWAPA XXI Treaty and Application of Nuclear Desalination

The Model for Nuclear Desalination

The most advanced research for large-scale desalination was launched under John F. Kennedy, but was never implemented. To this day, these designs are the most ambitious, rational, and scientific, and are therefore the model for today.

In January 1963, Kennedy formed a task group with the Executive Office of Science and Technology to investigate the use of large nuclear reactors for desalination. Working closely with the Atomic Energy Commission (AEC) and the Department of Interior, the task group issued its report in March 1964, five months after his assassination. Their report estimated that if an appropriate research and development program were actively pursued, large-scale dual-purpose installations could produce 1,000 to 1,900 megawatts of electricity and 500 to 800 million gallons of water per day (.6-.9 million acre feet per year (MAFY). The report also suggested a program to develop and demonstrate a plant operating with an 8,300-MWt reactor,[1] producing approximately 1,400 megawatts of electricity and 600 million gallons of water per day (.7 MAFY).[2]

This 8,300 MWt reactor was the 1975 goal. The 1970 goal was set for plants of intermediate size.

The task group proposed producing a half dozen intermediate sized units, two in southern California, one in the greater New York area, several for the Gulf Coast, and one in Florida.

The Metropolitan Water District (MWD) of southern California was the first site for such nuclear desalination, and entered into a contract with the Department of the Interior and the AEC in 1964 for a detailed economic and engineering study of dual-purpose nuclear desalination plants with 50 to 150 million gallons per day (mgd) production capacity, to be in operation by 1970.[3] James Ramsey of the AEC remarked, "Such a project could convert more water from the sea than all the other sea water conversion units currently operating in the world." The 150 mgd plant was to produce enough water for a city of about 750,000 with a power output of 1.8 GW, exceeding that of the Hoover Dam, or enough for a city of about 2 million. Two large conventional light-water nuclear reactors, of about 3000 thermal megawatts each, were to be the energy source, and the water plant was to consist of three large multistage flash distillation sections, each producing 50 million gallons of water per day. The plant would have been 30 times larger than the largest existing water-desalination plant at that time.

Other plans were underway for Texas, Arizona, New York, and Florida. For example, in July, 1964, Glen Seaborg, chairman of the AEC, proposed dual-purpose plant for Key West, FL, of intermediate size, up to 1.5 GWt producing 150 mgd.

In a 1966 AEC report, an even larger reactor was illustrated in a drawing, showing a nuclear-powered seawater-conversion plant that would produce 1 billion gallons of fresh water per day and 4.5 GW of power. The report continued, suggesting that "by the 1980s, plants embodying several nuclear reactors in a single installation, with a total capacity as high as 25,000 thermal megawatts, could be in operation. A plant like this would produce 5,950 electrical megawatts at 1.6 mills per kilowatt-hour and 1,300 mgd at 19¢ per thousand gallons."[4]

Kennedy and Eisenhower's Atoms for Peace created a dynamic of creativity throughout government institutions, where what was practical and possible was of a qualitatively different nature than today.

By cutting out nuclear, water shortages were guaranteed. Since the 1960s, there has not been a water shortage, but rather a nuclear shortage.

Today, in the short term, the "interim sized" 150 mgd desalination plants of the Kennedy era should immediately be built. Coastal desalination for industrial and municipal use will provide for cities, offset demands on limited water for agriculture, and solve the problem of saltwater intrusion. Agricultural wastewater desalination combined with groundwater desalination will increase crop yields, and reclaim land abandoned due to high salinity levels and lack of water. Saline river water, a major problem in nearly every western river, can be treated.

1. MWt denotes thermal power produced by a reactor, which is compared with MWe, which is the electrical power it produces.

2. The AEC contract was with E.I. Du Pont de Nemours and Co.: Contract AT (07-2)-1; Scope: To evaluate the feasibility of building and define the major engineering problems in the design and construction of heavy water moderated power reactors of 3,500 MWt and 8,300 MWt.

3. For scale, a desalination plant producing 150 mgd, would provide two times the current water use of San Francisco. Four of these plants, or one 8,300 MWt plant, would provide the current water use of Los Angeles.

4. 1966 AEC pamphlet, "Nuclear Energy for Desalting" Report, by Grace Urrows, part of the Understanding the Atoms Series.

Water quality in thousands of inland cities can be improved. As the larger size desalination plants become available, in addition to increasing the amount of all of the above, sufficient quantities of water could be made available for new agriculture.

Coastal Water

In places like the southern California coastal area, desalination plants could meet all or part of its demand from the Colorado River thereby physically freeing the river water to meet municipal and industrial deficiencies of inland areas in the region. The added coastal water would be an indirect addition to the normal river flow, since through appropriate agreements, less would be drawn from the river for southern California than at present. In addition, the present, disastrous agricultural situation, where large areas of California agriculture are shutting down due to water demands by municipal areas, could be relieved.

Other coastal areas require desalination plants, such as the industrialized section of the Texas Gulf coast. The area from Houston to Corpus Christi has long experienced critical shortages for lack of supply.

Saltwater intrusion is also a problem requiring the widescale use of desalination plants. In coastal areas throughout the United States, pumping of fresh groundwater supplies frequently causes saltwater intrusion when the fresh water is pumped to the surface before it can be naturally recharged. When seawater fills the void, the usual result is groundwater that is too brackish for most uses. Already in 1979, this problem was a subject of Congressional study.

One such coastal desalination plant is finally under construction. In 2016, the Carlsbad desalination project in San Diego County, California, is expected to be completed. This plant, driven by natural gas, will produce 50 mgd (.056 MAFY) of desalinated seawater and provide ten percent of the total drinking water needed by San Diego, sufficient for about 300,000 people. While this plant will be the largest desalination plant in the western hemisphere, and the first large-scale desalination plant on the West Coast, its production is only one-third the capacity of the 150 mgd plants, planned by the Kennedy administration for operation in 1970.

Nuclear desalination plants should be built to offset groundwater usage causing saltwater intrusion, as well as to create large supplies for municipal and industrial use. Areas reporting high impact of intrusion and where supplying municipal demand could augment normal river supplies are: San Diego and Los Angeles, California; Houston to Corpus Christi, Texas; Louisiana; Key West and southern Florida; Georgia; and South Carolina.

Agricultural Wastewater

Agricultural wastewater is a resource currently being wasted, and could be desalinated and reused. This is particularly necessary in California's Central Valley, which produces 30-40% of the nation's produce.

In the California water system, and other irrigation canals in the Southwest, the increasing salinity of the water through reuse and evaporation causes less agriculture yield further along the canals and aqueducts. This water should be recycled through nuclear desalination plants built along the aqueducts, with the irrigation wastewater serving as coolant. After desalination, the agricultural wastewater could then be put back into the canal.

As an example, irrigation wastewater in parts of the western San Joaquin Valley has risen to the point that it has poisoned the crops in a part of the Westlands Water District, so that there are now nearly a half million acres of unusable land. In addition, a large accumulation of selenium, boron, and salts from the natural drainage in the Kesterson National Wildlife Refuge to the north of Los Banos on the east side of the San Luis Reservoir, has poisoned the ability to grow crops.

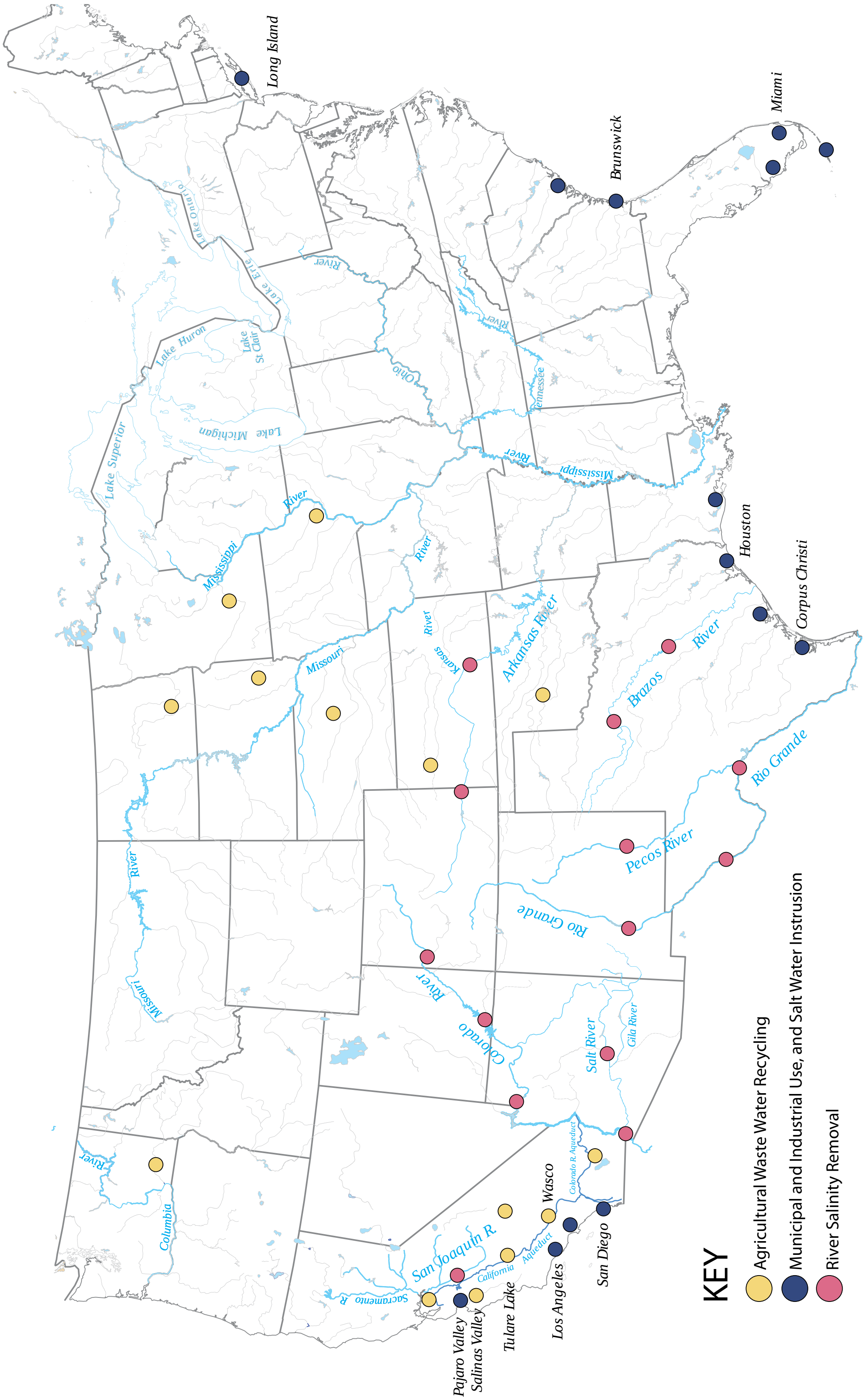
A series of nuclear power plants could be built along the California Aqueduct to produce both fresh water and electricity for farms and cities. The new system of desalination plants would begin with one at the southern end of the San Francisco Delta, where salts accumulate in the Delta sloughs. Salts would be removed before the water is pumped into the aqueducts. More reactors would then be built along the west side of the San Joaquin Valley in parallel to the aqueduct of fresh water flowing to the south through the so-called San Luis Drainway in order to remove the partly saline irrigation wastewater so that it would not accumulate in the soils. Contaminated irrigation wastewater and groundwater would be pumped from the aquifers and passed through treatment systems for boron and selenium removal, and desalinated to remove and recover the salts. Desalinated water could then be returned to the California Aqueduct canals.

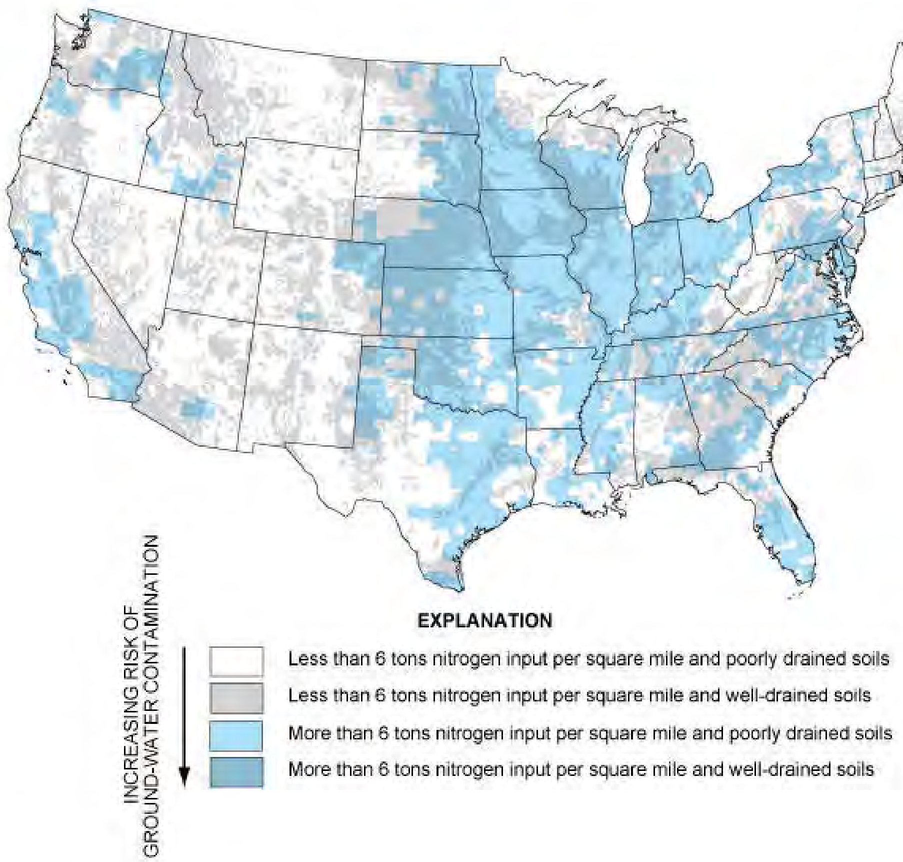
Nuclear reactors built in the San Joaquin valley could use an annual supply of over 750,000 acre feet per year of irrigation wastewater for cooling, plus the large volumes of brackish water now sitting under the Westlands Water District and elsewhere in the San Joaquin Valley. The earlier proposal for a five-unit plant of 5GW at Wasco, CA in the southwestern part of the San Joaquin Valley is one such candidate.

River Water

All western rivers have salinity problems, with the chief factors being an arid climate, natural saline springs, erosion of geologic formations, and runoff; and the sec-

Proposed Locations for 42 Nuclear Desalination Plants





United States Geological Survey, January 2013

Areas in the United States with the highest risk of nitrate contamination in ground water.

ondary factors being the return flows from agricultural use and reservoir evaporation.[5]

Increasing salinity in the Colorado River, as well as the Rio Grande, Pecos, San Joaquin, Brazos, and Arkansas Rivers could immediately be relieved by building dual purpose nuclear desalination plants along the most saline regions of the river. Proposed locations in the map on the previous page are based on reported salinity levels. The Yuma, Arizona desalination plant (YDP), belatedly completed in 1992, could be expanded as required.

Agricultural and Industrial Land

While numerous areas of agricultural land are unusable due to the dropping of aquifers, vast areas of shallow groundwater, though annually replenished with rain water, are saline or contain other contaminants and are thus unusable simply due to lack of desalination.

Lawrence Livermore National Laboratory discussed an example of this problem for California in 2004, stating that "many wells closed by nitrate contamination could be reopened if a cost effective treatment were found."[6] Similar areas of nitrate contamination exist around the country, concentrated in agricultural areas, especially near the High Plains, and restoring such groundwater could salvage a large area of agricultural land in the short term. Tulare Lake Basin, Salinas Valley California, Suffolk County (Long Island) New York, are all regions highly in need of nitrate removal through nuclear purification plants. Northern Nebraska, southern Minnesota, eastern North Dakota, western Kansas, western Oklahoma, and eastern Iowa are also areas of high nitrogen input and high aquifer vulnerability.

In addition to agriculture, numerous inland cities, far from the coast, could immediately be maintained through use of dual-purpose nuclear powered desalination plants. In urban areas, populations add large amounts of wastes, including salts, to surface and ground waters, making downstream waters less and less potable. Thousands of communities throughout the United States are now depending on brackish water, and could use nuclear desalination to meet current demands, before

5. http://www.usbr.gov/uc/progact/salinity/pdfs/PR23final.pdf

6. Arnie Heller, Lawrence Livermore National Laboratory, 2004, *S & TR Magazine*, https://www.llnl.gov/str/JulAug04/Newmark.html.

greatly augmenting their supply as the larger continental runoff system comes online.

Large Scale Agricultural Supply

While the above applications of nuclear desalination would mostly indirectly supply agricultural use by offsetting demand and restoring groundwater supplies, larger desalination plants, such as the proposed 8,300 MWt reactors capable of producing 800 mgd, could produce water directly for agriculture during the construction phase of the larger system.[7] For example, the San Joaquin and Imperial Valleys, which are in terrible drought, could be supplied by coastal desalination, pumped to the California Aqueduct System, which could then be brought directly into the California Water System.

Harvesting Resources from Seawater

A 1966 AEC report on nuclear desalination, discussed plans for harvesting resources from seawater, giving as their chief example the chemical removal of scale accumulation in pipes and vessels of desalination plants,[8] which would not only increase the efficiency of sea water distillation, but would also convert the separated scale-forming material to high-grade fertilizer. Scientists working with the Office of Saline Water in North Carolina in the 1960s estimated that about 37 tons of fertilizer could be produced for each million gallons of seawater processed.

Additional mineral by-product development and utilization plans have developed, such as creating magnesium ammonia phosphate from seawater, which can be used as fertilizer for many plants including tree seedlings, grasses, and vegetables. By fully exploiting nuclear heat for desalination, trillions of gallons of seawater a year will be processed, and it will become efficient to concentrate minerals from the water, in addition to making use of the salt itself. Instead of waste, the byproducts of desalination will become valuable resources.

In the next section, we investigate in detail the NAWAPA XXI distribution system itself, and then the requirements of Phases 1 and 2 for mass-producing nuclear power plants and other materials.

Mineral Content per Cubic Mile of Seawater

Mineral	Weight, in tons
Sodium Chloride	120,000,000
Magnesium Chloride	18,000,000
Magnesium Sulfate	8,000,000
Calcium Sulfate	6,000,000
Potassium Sulfate	4,000,000
Calcium Carbonate	550,000
Magnesium Bromide	350,000
Bromine	300,000
Strontium	60,000
Boron	21,000
Fluorine	6,400
Barium	900
Iodine	100 to 1200
Arsenic	50 to 350
Rubidium	200
Silver	up to 45
Copper, Manganese, Zinc, Lead	10 to 30
Gold	up to 25
Radium	About 1/6 (ounce)
Uranium	7

Source: "Saline Water Demineralization and Nuclear Energy in the California Water Plan," Bulletin No. 93, State of California Department of Water Resources, Dec. 1960.

7. As an example of needed capacity for agriculture, California applies 34 million acre feet of water per year to produce 9.6 million acres of crops.

8. Scale is composed primarily of calcium carbonate, magnesium hydroxide, and calcium sulfate present in seawater. It gradually deposits on heated surfaces, clogs the equipment, and must be periodically removed.

Phase 2: The Runoff Distribution System

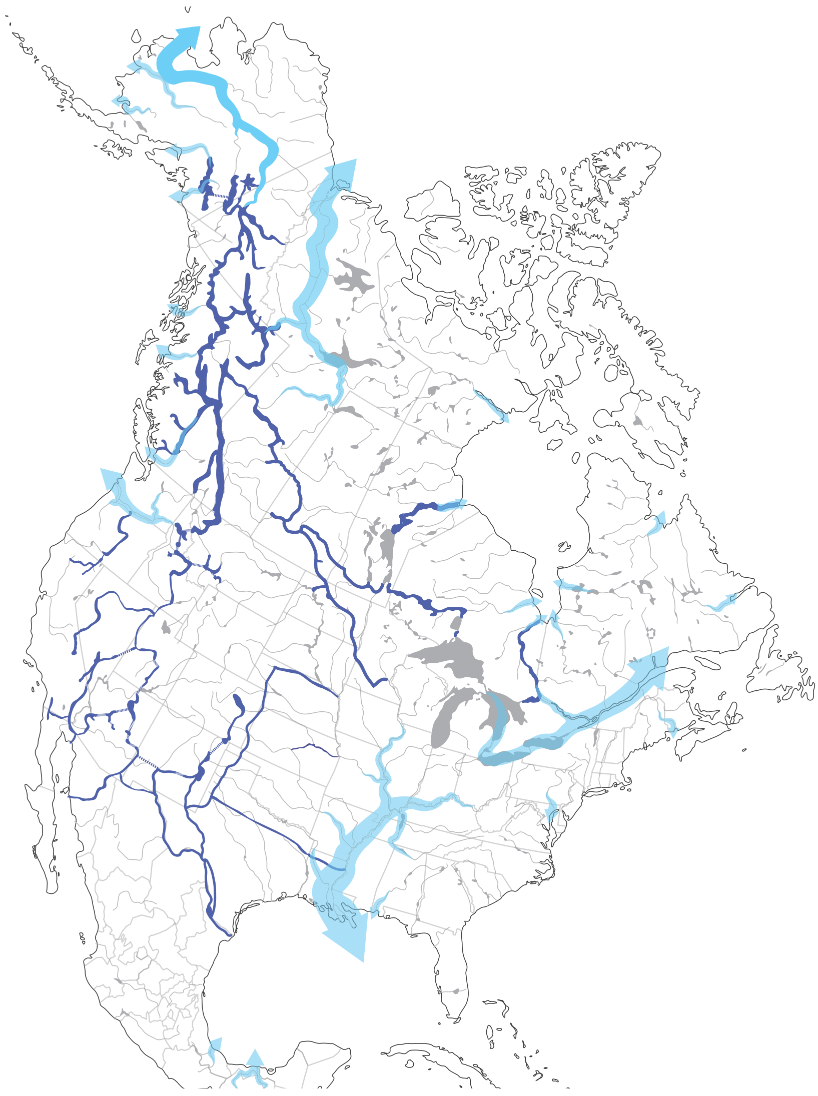
While the above measures are taken, the three nations will simultaneously be gearing up for the larger continental system, designed to yield the greatest results in the process of its construction. Once the design phase is completed and construction begins, it is feasible with an accelerated timetable and the application of new technologies, that pieces of the system could begin coming online only years after it begins, and the main trunk line completed in 10 to 15 years. What follows is the description of the completed system and the amounts of water to be distributed.

The western part of the North American continent has a wide discrepancy of rainfall distribution due to the particularities of the Pacific Ocean weather system. The area stretching from Alaska and Yukon down to Washington State has 40 times the annual river runoff of the Southwest and northern Mexico. Through utilization of continental topographical characteristics, a 2,000-mile reservoir system can collect and distribute runoff in the most efficient manner possible.

As a first approximation for the design, it is proposed that 20% of the runoff of each northern river to be incorporated into the system be collected for distribution. By utilizing nuclear power for the required pumping systems, described below, all of the water collected will be available for delivery, rather than being used to generate hydropower to drive the pumping systems, as the original design required.

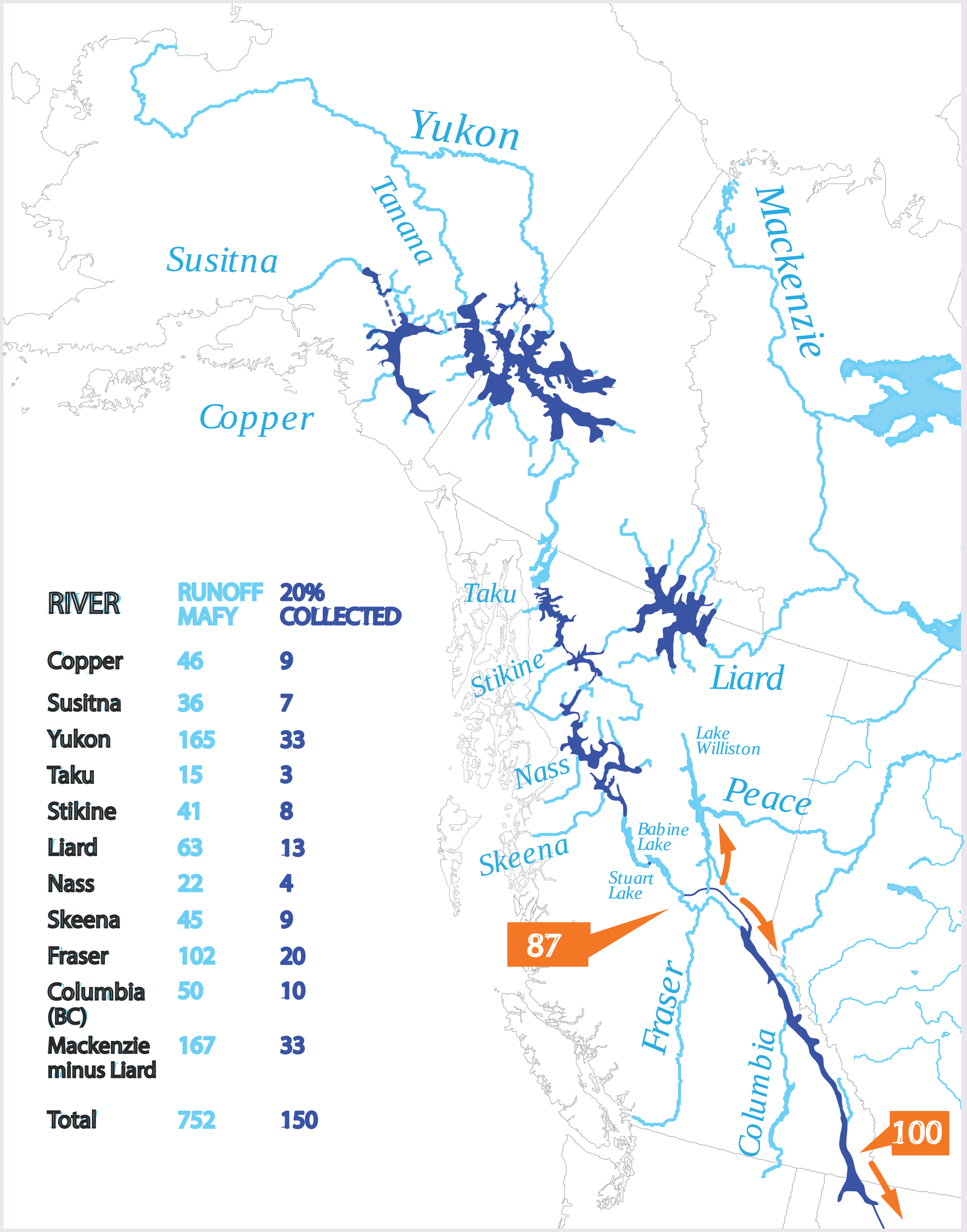
The collections from the Susitna, Copper, Yukon, and Taku Rivers are pumped from 2,100 to 2,400 feet into the Stikine Reservoir, which receives collection from the Liard Reservoir, before joining with the Nass and Skeena Reservoirs, themselves flowing into Babine and Stuart lakes at 2,330 feet elevation (see box on following page). If 20% of each river's annual mean runoff is collected, approximately 87 MAFY on average would flow out of Stuart Lake into a man-made canal.

Of the 87 MAFY flowing out of Stuart Lake, some 70 will be pumped into the Rocky Mountain Trench Reservoir, while around 17 will be diverted into Lake Williston for the Prairie Canal, where it will join the 33 collected from the Mackenzie basin streams (see "Great Plains Canal" box). In the Rocky Mountain Trench, 20 will be added from the upper reaches of the Fraser River, and 10 will be added from the upper Columbia. The 100 MAFY flowing out of the Rocky Mountain Trench will be pumped through the Sawtooth Lift and diverted multiple ways throughout the Southwest and northern Mexico (see boxes on following pages).



Continental NAWAPA XXI Runoff Collection and Distribution System

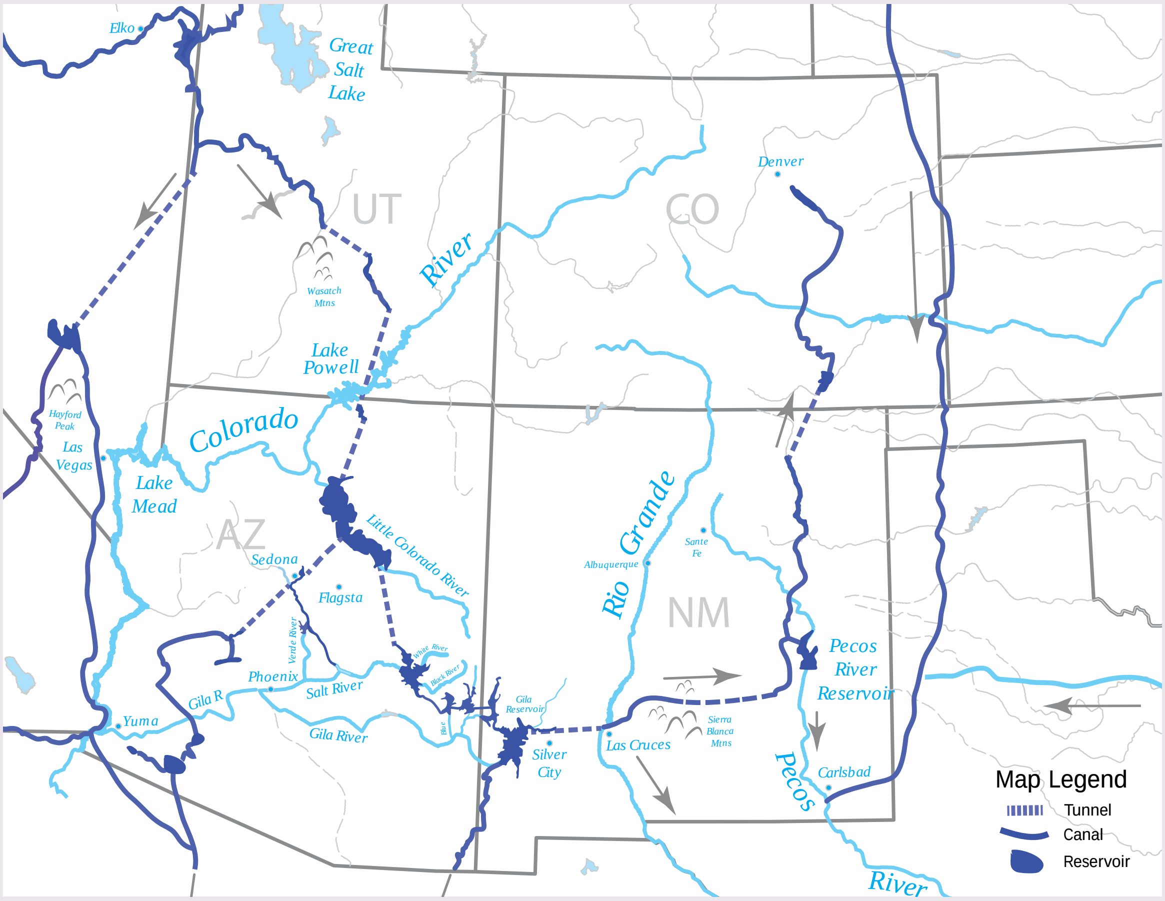
Northern Collection System



RIVER	RUNOFF MAFY	20% COLLECTED
Copper	46	9
Susitna	36	7
Yukon	165	33
Taku	15	3
Stikine	41	8
Liard	63	13
Nass	22	4
Skeena	45	9
Fraser	102	20
Columbia (BC)	50	10
Mackenzie minus Liard	167	33
Total	752	150

The runoff of the rivers shown here in Alaska, Yukon, the Northwest Territories, and British Columbia is a portion of the total annual runoff flowing into the Arctic and Pacific. Adding the runoff of several Alaskan rivers, including the Nushagak, Kenai, Alsek, and Kusokwim, along with other coastal runoff of British Columbia, brings the total from 752 to approximately 1,300 MAFY of annual runoff for the region.

Colorado–Rio Grande Distribution System



NAWAPA XXI will tunnel into the Great Basin, and into the Colorado Basin, creating reservoirs on the tributaries of the Colorado River, which will feed water into its main stem.

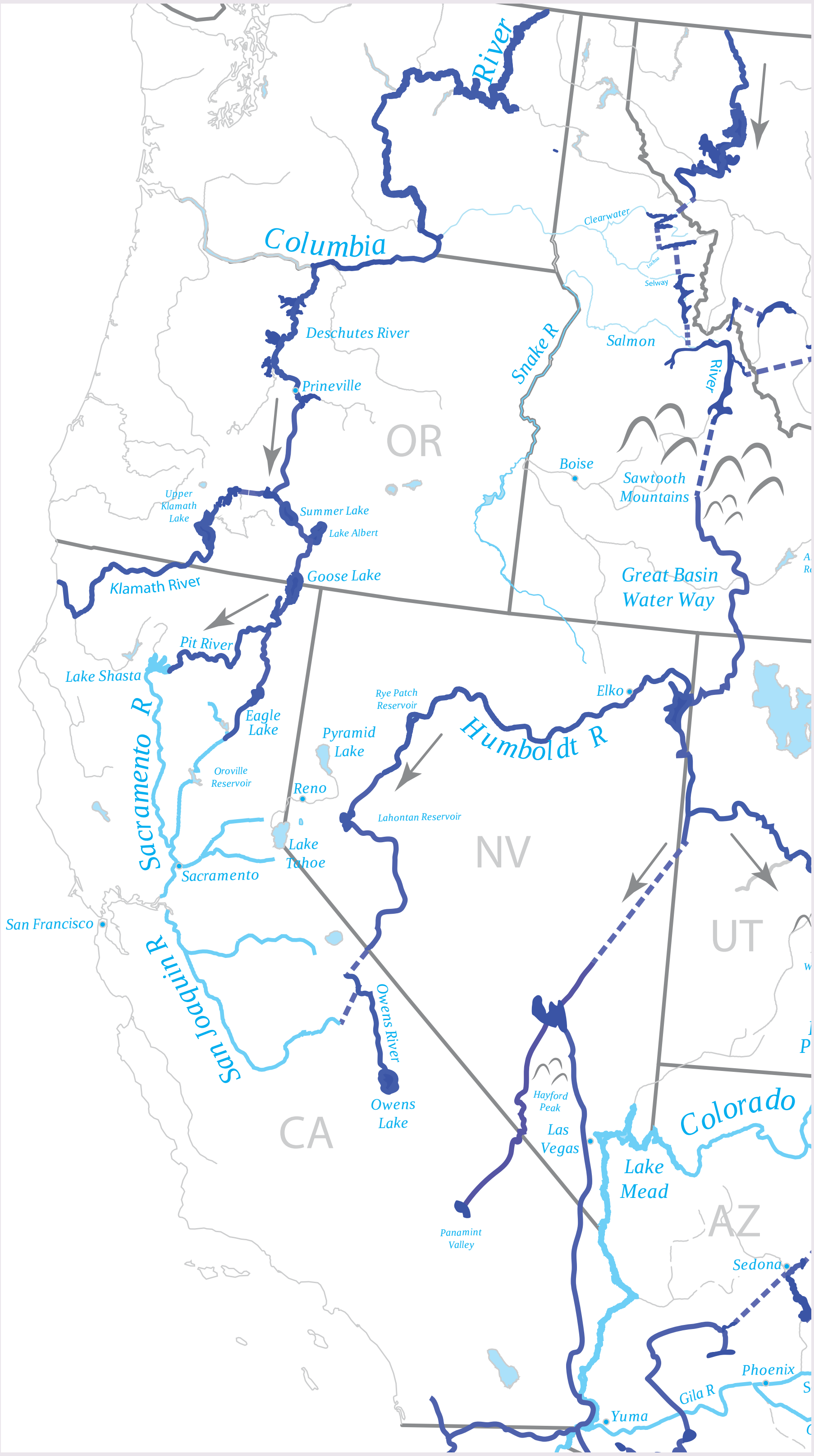
A large distribution reservoir, up to four times the size of Hoover Dam's Lake Mead will be formed in the Little Colorado River Valley. Out of this central reservoir, tunnels and canals will form three reservoirs on the tributaries of the Salt River, three reservoirs on the tributaries of the Gila River, and a large reservoir on the headwaters of the Gila River itself. A tunnel will connect a reservoir formed on the Gila River to the Rio Grande Basin, crossing and supplying water to the Rio Grande River, and forming a large reservoir on the Pecos River, which will supply West Texas, and Mexico, and connect to eastern Colorado.

Throughout the Colorado and Rio Grande basins, groundwater pumping costs will be eliminated and farmland restored, and with the water added to Utah, Arizona, New Mexico, and West Texas alone, 14 million acres of farmland could be opened up. The average 11 MAFY currently flowing through the Colorado River will be increased over 100% through these added reservoirs; the Pecos and Rio Grande rivers will become full and flow year round.

Approximately 30 new reservoirs will be formed in NM, AZ, NV, UT, and CO, changing local climates and expanding recreation. The storage capacity of the Rio Grande Basin will be more than doubled, from 20 MAF up to 54 MAF. The Colorado Basin storage will be increased from 61 MAF, largely from Lake Mead and Lake Powell, up to 230 MAF.

A 7-MAF reservoir will also be formed 50 miles north of Las Vegas just north of Hayford Peak, in the Sheep Mountain range, distributing water to Southern Nevada and paralleling the Colorado River, supplying water to farms before continuing south to Mexico, and the Imperial Valley.

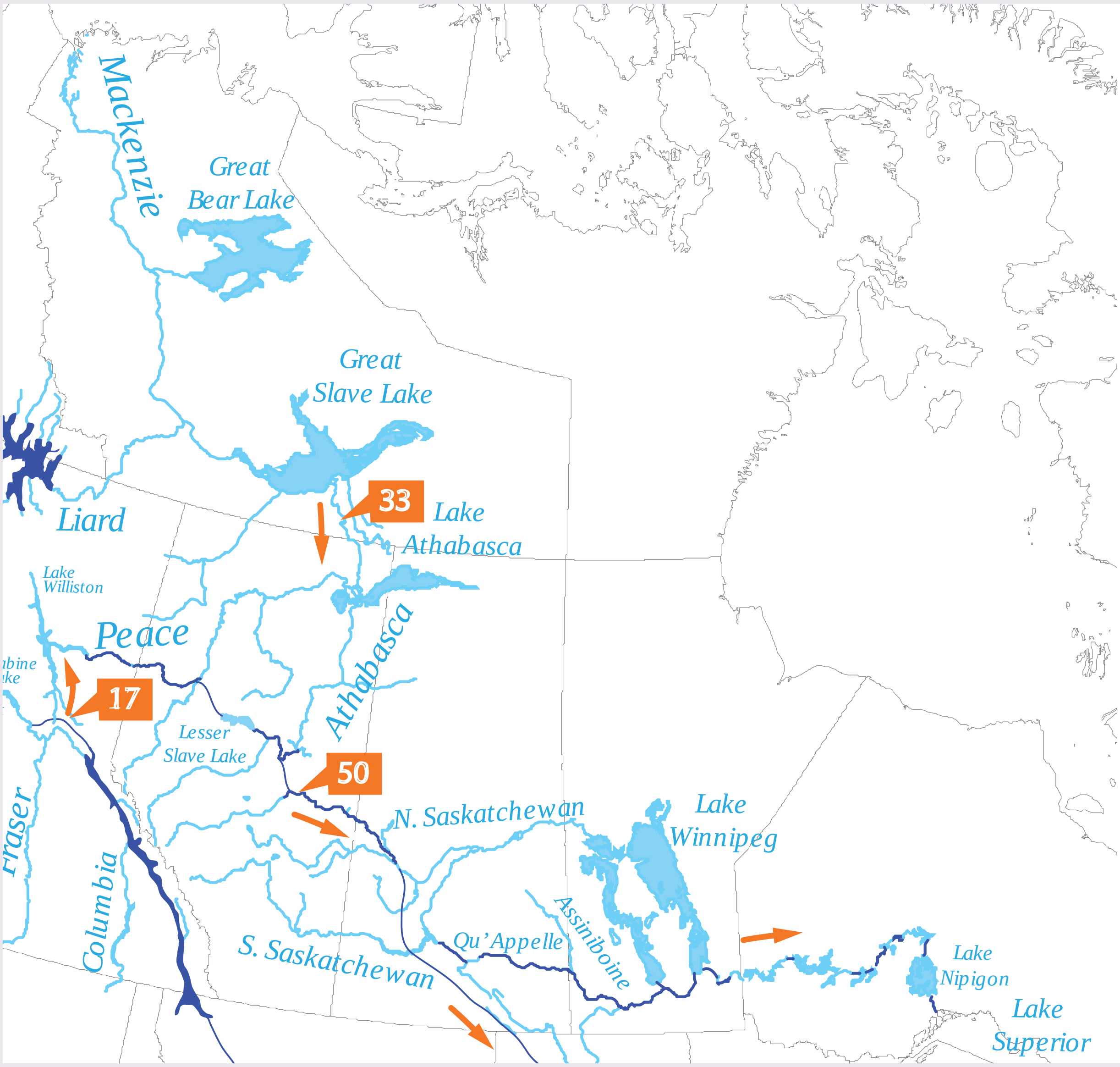
California Distribution System



Fifty miles east of Elko, Nevada, a 7-MAF storage reservoir will be created between Murdoch and Bald Eagle Mountains. A 30-mile canal will connect to the Humboldt River, in which water will then be diverted across the state, ending at the Humboldt Sink, and from there, can be linked to Lake Lahontan, of the Truckee Carson Irrigation District, serving Northern Nevada, before continuing south and tunneling into the Owens River Valley, refilling Owens Lake over time, and reviving farmland. Upon entering Owens Valley, an additional tunnel can connect the the flow to the San Joaquin distribution system, delivering water to most of the San Joaquin Valley.

An alternative plan, requiring more power and complexity, is capable of delivering water directly to southern Oregon, the parched Klamath River, and Lake Shasta. By releasing a portion of the water collected in the Rocky Mountain Trench into the Columbia River reservoir formed by Mica Dam, in British Columbia, water would be pumped out of the Columbia River further south at the Dalles Dam, into a series of reservoirs on the Deschutes River, continuing through Central Oregon, and connecting with the Klamath and Pit Rivers, the latter supplying water to Lake Shasta, one of the key storage reservoirs of the Central Valley Project.

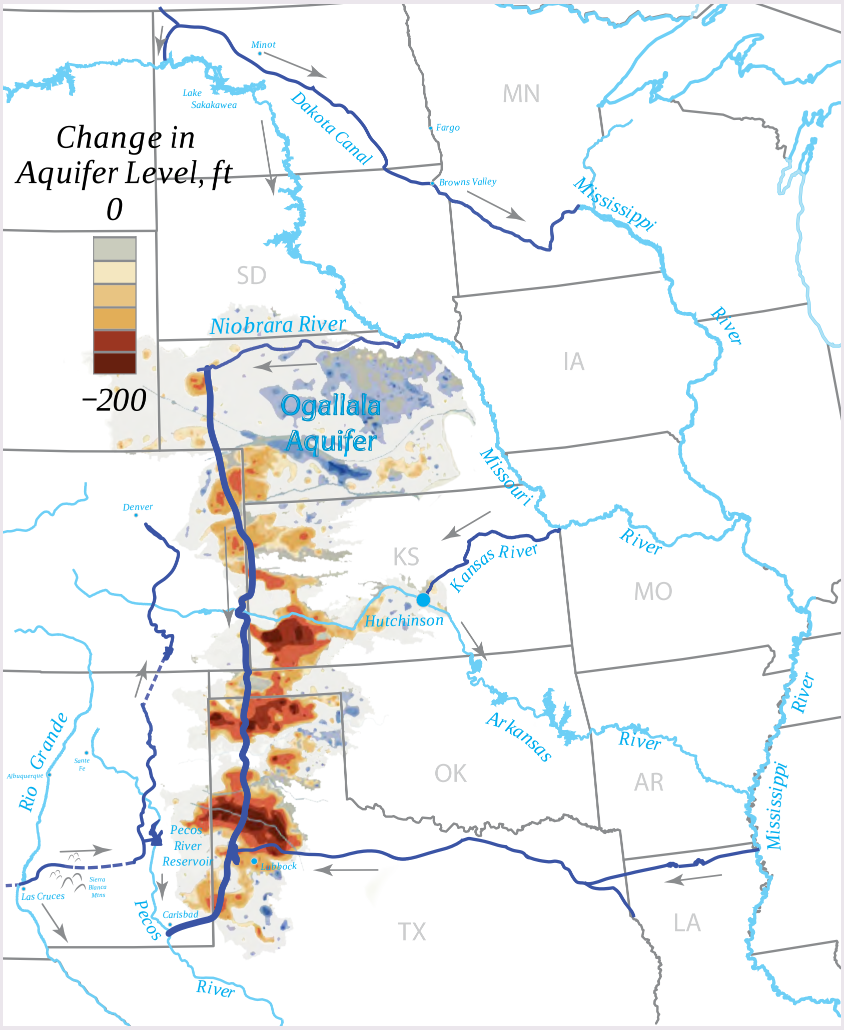
Great Plains Canal



The 17 MAFY diverted from the northern flow into the Peace River will be joined with 33 MAFY collected from the Peace, Athabasca, and other tributaries of the Mackenzie River Basin or the Mackenzie itself, whose total annual runoff is 230 MAFY. This 50 MAFY will be delivered to the Prairie Provinces, the Missouri river, the Mississippi, and Great Lakes.

Canals will connect the Peace River to Lesser Slave Lake, to the Athabasca, Saskatchewan and Qu'Appelle Rivers. Sufficient water supplies of 20 MAFY will be drawn from the canal for the needs of Alberta, Saskatchewan, and Manitoba; the canal will also be capable of diverting flood waters in the region to areas of drought. Off of the Qu'Appelle River, a branching canal will connect with the Missouri River's Lake Sakakawea, as well as the Mississippi River. The main canal will continue to Lake Winnipeg, and Lake Superior, delivering up to 20 MAFY. Additional plans, such as one proposing diversion of 20 MAFY of runoff from Quebec into the Great Lakes, could be incorporated into the final design.

Great Plains Distribution System



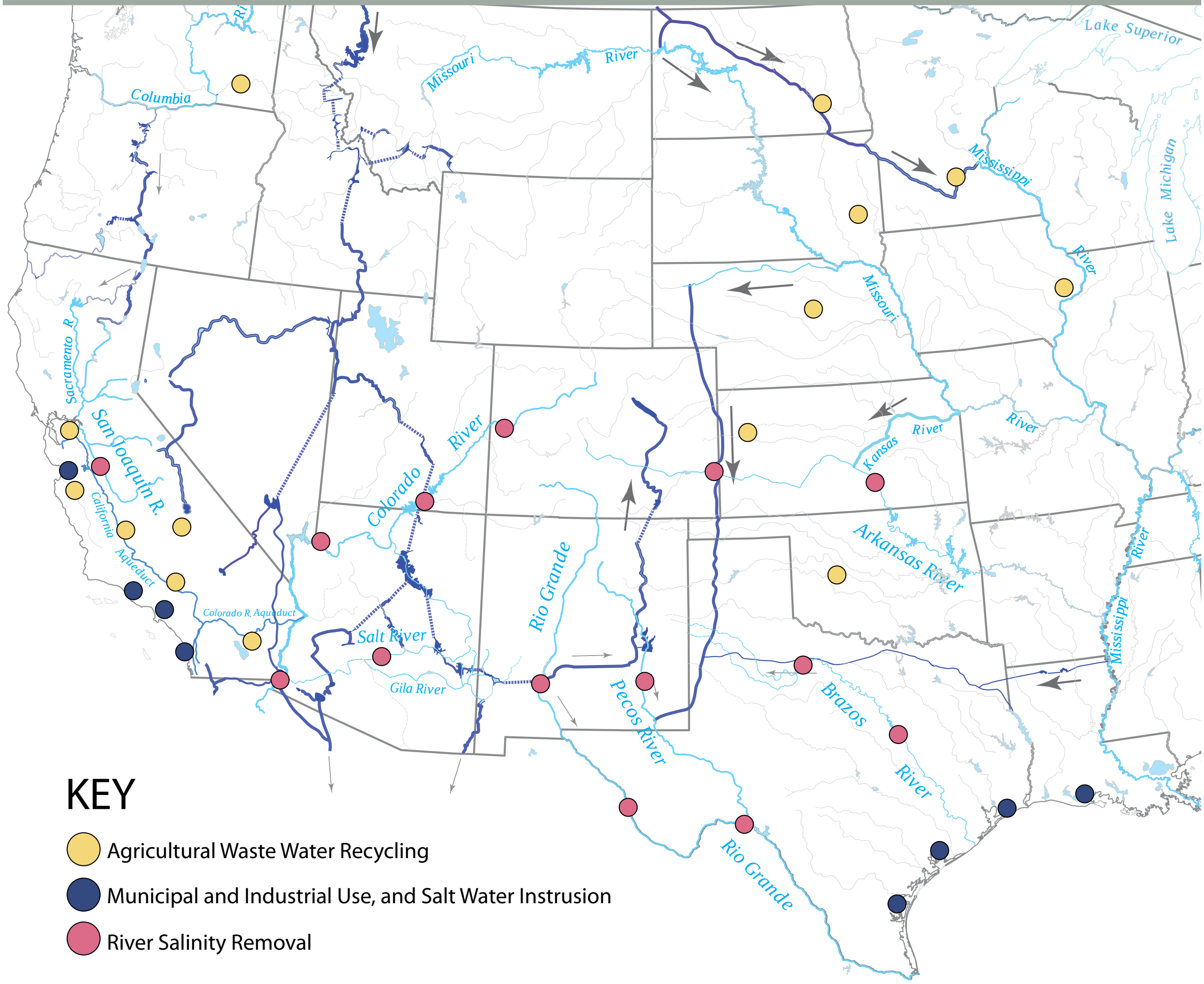
Water in the Canadian Prairie Canal will link up with the Missouri River at Lake Sakakawea, as well as running along the Laurentian Continental Divide through the Dakotas, before connecting with the Mississippi River.

Approximately 10 MAFY will be delivered Lake Sakakawea by way of the Prairie Canal. In addition, 10 MAFY of Missouri River flood water could be added to an amount to be diverted just downstream of the Fort Randall Dam, on the Nebraska and South Dakota border, and pumped up a series of reservoirs on the Niobrara River. From there, water would run through a canal engineered to intersect key locations dependent on the Ogallala Aquifer for irrigation.

Missouri River flood water would be back pumped from the north side of Kansas City, Kansas along the Kansas River before being piped to Hutchinson, Kansas, where a purification plant could be built to discharge water into the Ogallala Aquifer. Water could also be added to the Arkansas River, along with any other programmed flow of water into the river from other elements of the system.

If excess water was available in years of Mississippi drought, water could be delivered via the Minnesota River into the main stem. In years of flooding, Mississippi River water could be diverted according to specific elements of the Texas Water plan, intersecting other plans.

Desalination and Distribution



Once the completed NAWAPA XXI system is built, water will be able to be delivered to every major river system and region of the continent, west and north of the Mississippi. All of the plans will form an interconnected grid across the continent which will be managed as a single system.

Nuclear desalination facilities along the completed NAWAPA XXI irrigation systems will augment the effect of the canals by recycling water more quickly, as well as increasing the total amount of water available.

Phase 3 begins when NAWAPA XXI comes into operation, where the completed system will allow for wide-scale biospheric engineering and directed water recycling, creating a broader hydrological effect than the direct water contributions from the distribution system itself.

Scientific institutions which study the effect of moisture in arid regions toward effecting changes in local climate and weather patterns, will collaborate in planning specific types of land cover for specific regions, and enacting other techniques of weather modification. Reservoirs will also be maintained to maximize aquaculture.

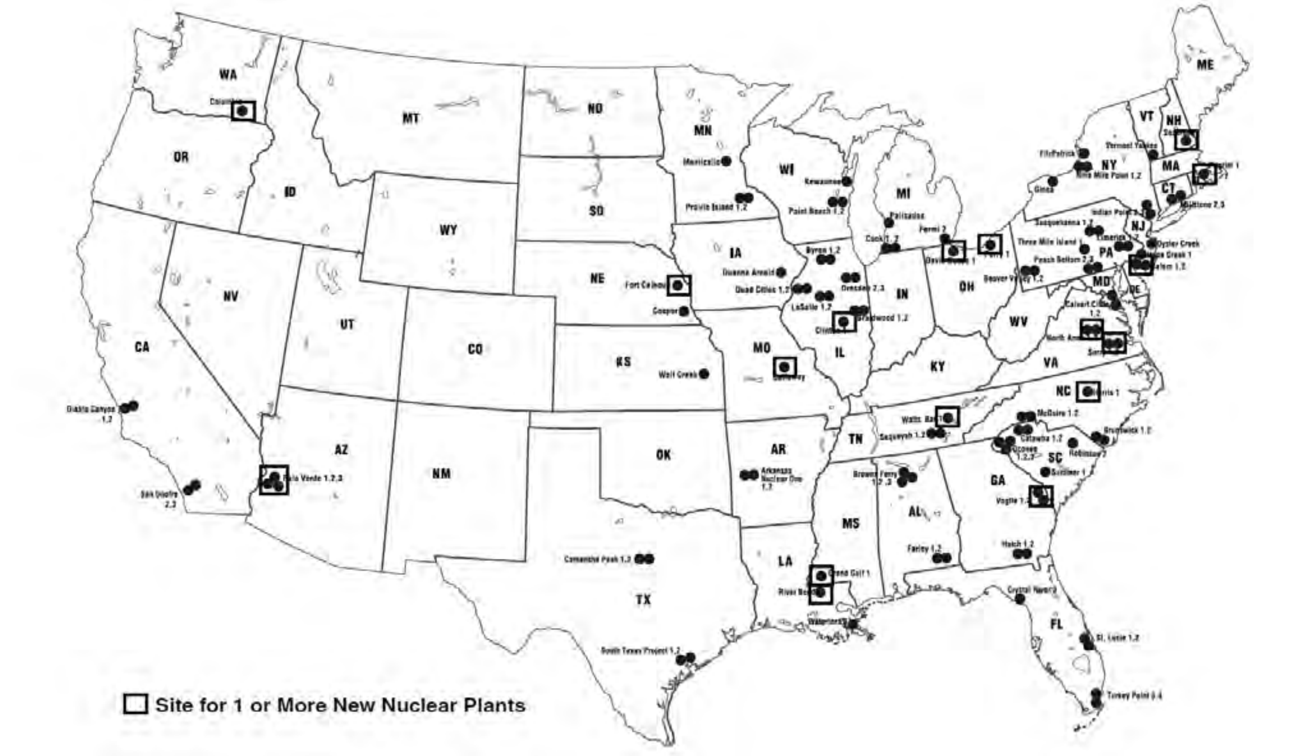
Potential MAFY Distribution

Oregon	5	N. Mexico	22
Utah	4	Alberta	4.5
Nevada	8	Saskatchewan	7.5
California	22	Manitoba	7.5
Arizona	14	High Plains	20
New Mexico	11	Great Lakes	20
Texas	14	Total	160

Phase 1 and Phase 2 Requirements

For the mass-production of nuclear power plants for desalination, industry, and pumping systems, an industrial gear-up will be required like that for World War II, and will include agreements with other nations. The thrust of this will be the conversion of our remaining machine tool capacity, largely centered in auto plants.

In addition to the already severe deficit of electricity production,[9] were the U.S. to become a productive society, the demands of the evolution of our economy, spearheaded by the 42 nuclear desalination plants proposed for water management, will make this deficit all the more severely felt. Since there is a shortage of electricity everywhere, the quickest route to putting new nuclear power production online will be to make use of the 17 "brownfield" sites around the country, where there is already an operating reactor, and where the site has been prepared for additional units, giving a head start on the infrastructure, manpower, and experience. These sites will be capable of housing 28 new nuclear plants in short order, for the industrial requirements of further mass producing plants and other equipment. Manufacturing plants will be established for an assembly line, standardized, mass production of modular nuclear plants. Pump, piping, electronic controls, and other nuclear plant components can be produced in upgraded auto parts factories.



Source: Nuclear Energy Institute

Ready Sites for 28 New Nuclear Plants, at 17 Current Nuclear Power Locations

Among the 104 nuclear power plants that were cancelled 30 years ago, approximately one third were to be additional units at sites already housing at least one operating nuclear power plant. At these "brownfield" sites, where there is at least one operating plant, a skilled workforce is available, and site preparation work was already done. The overall transportation, energy, and other infrastructure is in place. In some cases, the infrastructure for the additional unit was also in place, and construction of the reactor had begun. When the price of oil quadrupled in 1973, the utilities accelerated their nuclear plans, so they could stop importing expensive oil. As a result of the economic collapse, from Nixon's 1971 policy, and then the dramatic economic contraction afterwards, energy prices zoomed. When demand for electricity went to almost zero, more than 100 nuclear plants were canceled.

The auto sector represents a highly developed capability of the most advanced machine tooling, which can produce the most developed products if it is retooled to

9. A doubling of the capacity of the electric grid over the next ten years to meet the current deficit is a low-end baseline estimate. See Appendix 1 of "Creating the Fusion Economy."

Large-Volume Components for One Nuclear Plant

Equipment	Number	Comments
Pumps, large	70–100	
Pumps, small	80–484	
Tanks	50–150	600–150,000 lbs
Heat Exchangers	12–26	2,100–250,000 lbs
Compressors, vacuum pumps		
Fans	60–120	600–45,000 lbs
Damper/louvers	730–1,170	
Cranes and hoists	25–50	
Diesel generators	2	10 MWe
Prefabricated equipment	65–135	
Instruments	1,850–3,440	
Valves	9,630–17,900	

Bulk Materials for One Nuclear Plant

Concrete, (cubic yards)	423,000
Structural steel, (tons)	19,000
Pipe, more than 2" diameter, (feet)	370,000
Tray/conduit, (feet)	206,000
Cable (feet)	6,980,000

that purpose. An auto plant is primarily an arrangement of between 500 and 2,000 machine tools, in a configuration that passes a work piece from one machine to the next, as well as scores of robots. Auto plant conversion will mean not only replacing old assembly lines, but putting in place new machine tools, incorporating the most advanced scientific design.[10]

In addition to the needs for industry in the East and Midwest regions, modular reactors, to be put together in pieces, will be shipped across the country on rail lines to supply desalination plants required for the West.

The industrial capacity built up to produce 42 nuclear desalination plants, and the 28 plants at the brownfield locations, and other industrial demands of Phase 1, will

Nuclear Requirements

Pump System	MAFY Lifted	Lift (ft)	Shaft Power (GW)
Taku	52	300	2.5
Fraser	70	670	6.5
Sawtooth	100	2450	35
Niobrara	20	2800	8
Total			52

Gigawatts of Nuclear Power Required for NAWAPA XXI's pump lifts.

then be applied, at a higher level of technology, and integration, to the requirements of Phase 2.

The NAWAPA XXI collection and distribution system described in the previous pages will require the digging and lining of 5,400 miles of canals, 1,200 miles of tunnels, 60 dams, pumping stations, and new rail lines. To drive the pumping systems with nuclear power—thereby augmenting the water available, adding a degree of freedom to the whole system, and requiring fewer overall dams and projects—about 52GW of capacity will be needed once the system is running at maximum capacity.

At least 25-30 large 30′-diameter tunnel boring machines will be needed, and perhaps those larger in size for the various 50′ diameter tunnels. The pumping systems required to pump the large volumes of water at the Sawtooth Lift and other large lifts of the system will be the largest ever made in terms of head and volume, and on the order of 100,000 to 125,000 HP each.

The steel and cement production needs, totaling 300 and 540 million tons, respectively, will require a massive increase in steel and cement mills. Cement production will need to be developed in areas where little or none currently exists, which will require new sources of limestone, clay, and iron. Moving some 30 billion cubic yards of earth will require an enormous array of heavy cranes, numerous excavators, some specially built for the specific areas. While our mining and milling capacity is large, the U.S. has lost over 80% of its foundry capacity since the 1980s. Most forming and casting of metal is done in foundries abroad. They will need reviving. This will include heavy rolling, forming, casting houses for large components, and metallurgy components.

The hundreds of thousands of auto and aerospace jobs lost since 2005 with the shutdown of industry, and millions of other useful jobs, can be reclaimed. The production of 100 nuclear plants will create 10 million jobs, and the building of Phase 2 will create at least another 7 million jobs.

Throughout the process, in addition to those technologies applied to the machine tool sector and manufacturing process, other technologies will transform the con-

10. The mass production of nuclear plants will be akin to Frank Roosevelt's war mobilization, where the whole economy was mobilized to turn out planes as fast as they could be produced. In the three years of war production, the re-tooled auto industry built 27,000 planes, 455,000 airplane engines, 25,000 propellers, and more, all at higher tolerances and greater reliability than automobiles.

NAWAPA XXI Production Requirements

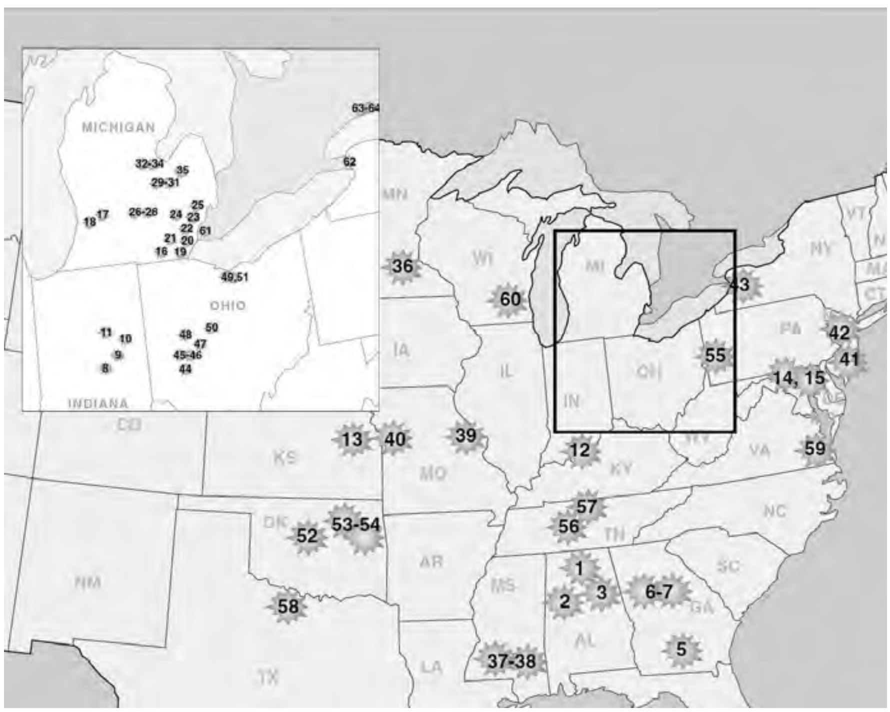
	Steel (mil. tons)	Cement (mil. tons)	Earth Moved (mil. cu. yd)	Number	Miles
Pumping Systems	3	4		8	
Dams	300	490	18,570	60	
Tunnels	0	4	670	40	1,200
Tunnel Boring Machines			30		
Canals	0	36	8,280		5,400
Nuclear Plants for Pumps and Desalination	2	8		94	
TOTALS	306	546	27,520		

struction and management process of the system, such as: maglev technology for rail transportation; LIDAR technology in geological mapping for precision of design; roller compacted concrete for quicker and more efficient dam construction; new composite concretes for optimal flow; permafrost engineering advancements for construction in northern British Columbia, Yukon, and Alaska; anchor bolt technology for rail lines in mountainous areas; use of peaceful nuclear explosives for tunneling.

The infrastructure used to build the more advanced economy, will also establish new corridors of agricultural and industrial development. Along the new corridors, new population centers will be formed around the new routes of resource management and industry. The system will create new cycles of trade and production throughout the continent. The water routes, by canal and reservoirs, and rail lines, will link the states through new water and transportation connections. Individually, each state will not only become specialized in new industrial and agricultural products, but the relations between each state will become transformed by the new infrastructure system. Every state and province will be going from a currently dying direction, to one of increasing the populations living there, and the living standard. The growth rate will increase as the future becomes possible and realized.

For all of the construction needs described here, the plants will incorporate the nuclear agro-industrial model, as described in the following article, "Nuclear Agro-Industrial Complexes for NAWAPA XXI." Later, the introduction of fusion economy elements will bring the whole economy to a higher order platform.

Let us reverse the four decades of cultural and economic decay that we suffer today, and defeat the malthusian efforts of population reduction by creating an economic system capable of defeating their intention. We must pick up where Kennedy left off, and turn our generation of youth and young adults from being a wasted generation into the generation that built NAWAPA XXI.



Source: EIR

Retooling Locations for the Mass Production Nuclear Power Plants

This map shows 64 specific locations for the mass production of nuclear plants, where idle auto capacity existed in 2005, which may still be potential locations for such conversion. Such plants could produce nuclear fuel rods, cranes, pumps,valves, pipes, and other components of nuclear power plants, electric locomotives, high speed railroad stock aluminum, plastic injection molding presses, mitre gates for locks and dams, parts for large earth moving machines, pumping stations, and other infrastructure.

Nuclear Agro-Industrial Complexes for NAWAPA XXI

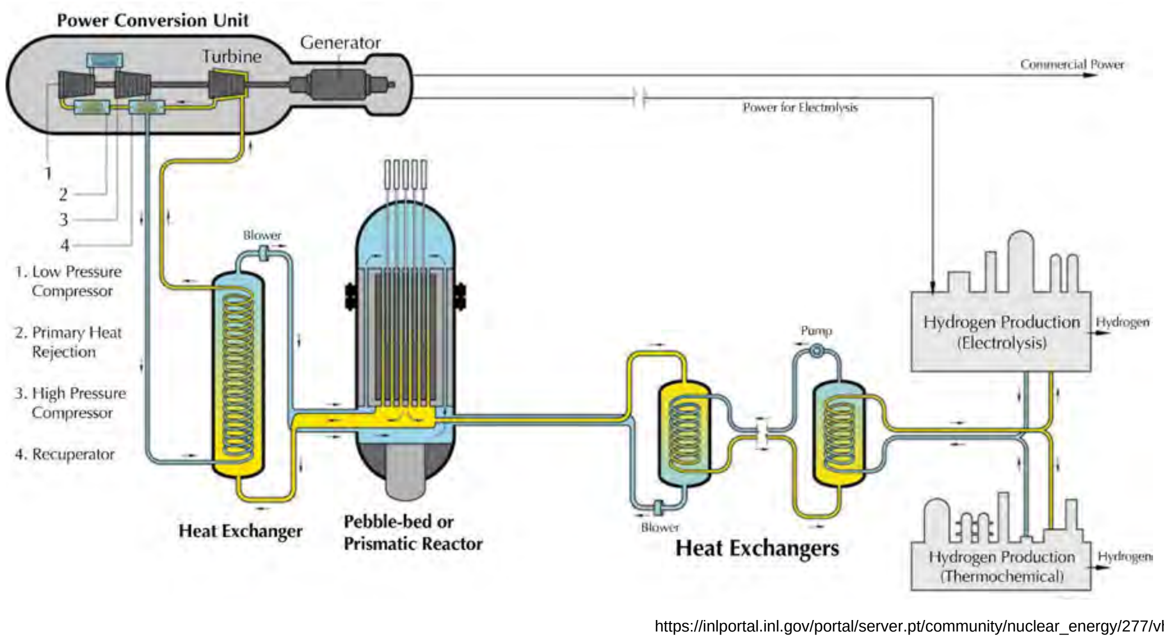
by Liona Fan-Chiang

In my judgment, the real economic potential of nuclear fuel is no more captured in its substitution for fossil fuels in large scale electric power stations, outstanding technological accomplishment though this is, than was the economic potential of petroleum realized when kerosene replaced whale oil in lamps used in the home.

— *Sam H. Shurr, "Energy and the Economy,"* Energy: Proceedings of the Seventh Biennial Gas Dynamics Symposium, *1968*

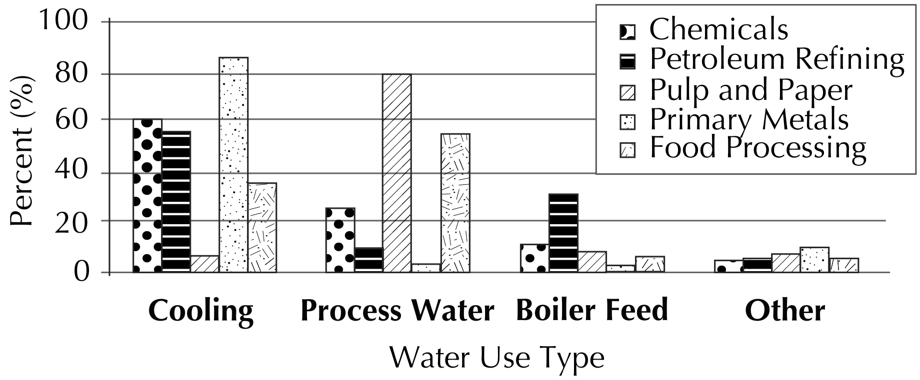
NAWAPA XXI requires an intensification of productive output, more important than quantitatively, qualitatively. This will be achieved by applying a more powerful principle across the board, from raw material extraction, to the processing of the end product. The horizon which guides us today is fusion. Let the achievement of an economy based on the principle of fusion drive our transition, now, into an economy built on fission.

Begin this transition at NAWAPA XXI's new productive powerhouses—nuclear-driven agro-industrial complexes which are centers of mass industrial and agricultural output. Since we will be building many industries anew, we have the opportunity to pre-plan these centers of output to make the most out of the new nuclear plants, as well as the most out of those new and retooled industries. These industrial centers will be fully integrated, driven by nuclear power plants, and flexible enough to assimilate new technologies at all levels, especially upstream. Integration will allow efficient application of both the secondary products of fission, namely heat, steam and electricity, as well as the primary products, namely radioactive elements. The use of coal, petroleum, and natural gas for more efficient uses than energy, will be a byproduct of preparing the foundation for a fusion economy.



https://inlportal.inl.gov/portal/server.pt/community/nuclear_energy/277/vhtr/2251

Heat transfer from a nuclear reactor.



Source: Ellis, Industrial Water Use and Its Energy Implications

Breakdown of how each type of industry uses water. Boiler feedwater is water used to supply a boiler to generate steam or hot water.

Products of Fission

Nuclear agro-industrial complexes will be centered around an array of nuclear power plants designed to provide the products of the nuclear fission reaction. Electricity, steam, heat, and fission products, all produced by nuclear power plants, can be directly fed into the industrial process.

Within nuclear reactors, occurs the amazing process of altering elements by splitting atoms, not to create waste, but to create multiple other atoms, which are not the same element as the first, or even as each other. As a byproduct, large amounts of heat are created. In the most common reactors today, this heat is used in the same way as is heat from the burning of coal and natural gas. The heat is eventually used to boil water, creating steam that can be funneled through a turbine to generate electricity. This electricity contains approximately 30–40% of the energy that came out of the fission reaction as heat. What happens to the rest of the heat energy, and the newly created atoms? Today, they are wasted—rejected as "waste heat" and "nuclear waste."

The U.S. industrial sector, as dilapidated as it is, currently accounts for one-third of the total energy use of the United States. Much of this energy is consumed in the form of process heat and for producing steam. For example, the steam requirements of the largest chemical plants are around four million pounds of steam per hour at 200 to 600 psi. Similarly, for a 500,000-barrel-per-day oil refinery, roughly half of the 4,000 MW (thermal) of energy input required could be steam, while the balance is high-temperature process heat and electricity.[1] "Nearly 49% of all fuel burned by U.S. manufacturers is used to raise steam. Steam heats raw materials and treats semi-finished products. It is also a power source for equipment, facility heating, and electricity generation."[2]

Nuclear-powered industrial complexes, with their array of reactors,[3] can be designed to supply the heat needs of many different industries—industries which require steam at different temperatures and pressures, as well as direct heat at a higher range of temperatures.

Steam from nuclear plants, paired with the nearby coolant water source provided by NAWAPA XXI, and supplemented by desalinated water from desalination plants, can meet many of the intense water requirements of industry and agriculture.

While steam temperature requirements are typically in the range of 120–540°C (250–1,000°F), direct heat temperature requirements are often much higher, at 800–2,000°C (1,500–3,600°F). NAWAPA XXI will require approximately 300 million tons of steel,[4] requiring temperatures up to 1,370°C (2,500 F) with current technologies, and approximately 540 million tons of cement, which require temperatures up to 1,450°C (2,640°F). Below is diagram of a few industrial processes and their temperature requirements.

You can see in Figure 1 that the second- and third-generation nuclear reactors of today are not able to meet the requirements of most of these common industrial processes. Fourth-generation reactors can meet a majority of these needs, and these will have to be fast-tracked, out of the testing phase they are in today.

The broad use of high-temperature fourth-generation nuclear reactors in these production units will change the whole industrial landscape. Not only will it serve to replace low-energy density coal, oil, and natural gas for many current industrial processes, but more importantly, it will create new types of industries and products, while reshaping and multiplying the productive output of existing industries. For example, among many other uses, the centralized mass production and delivery of hy-

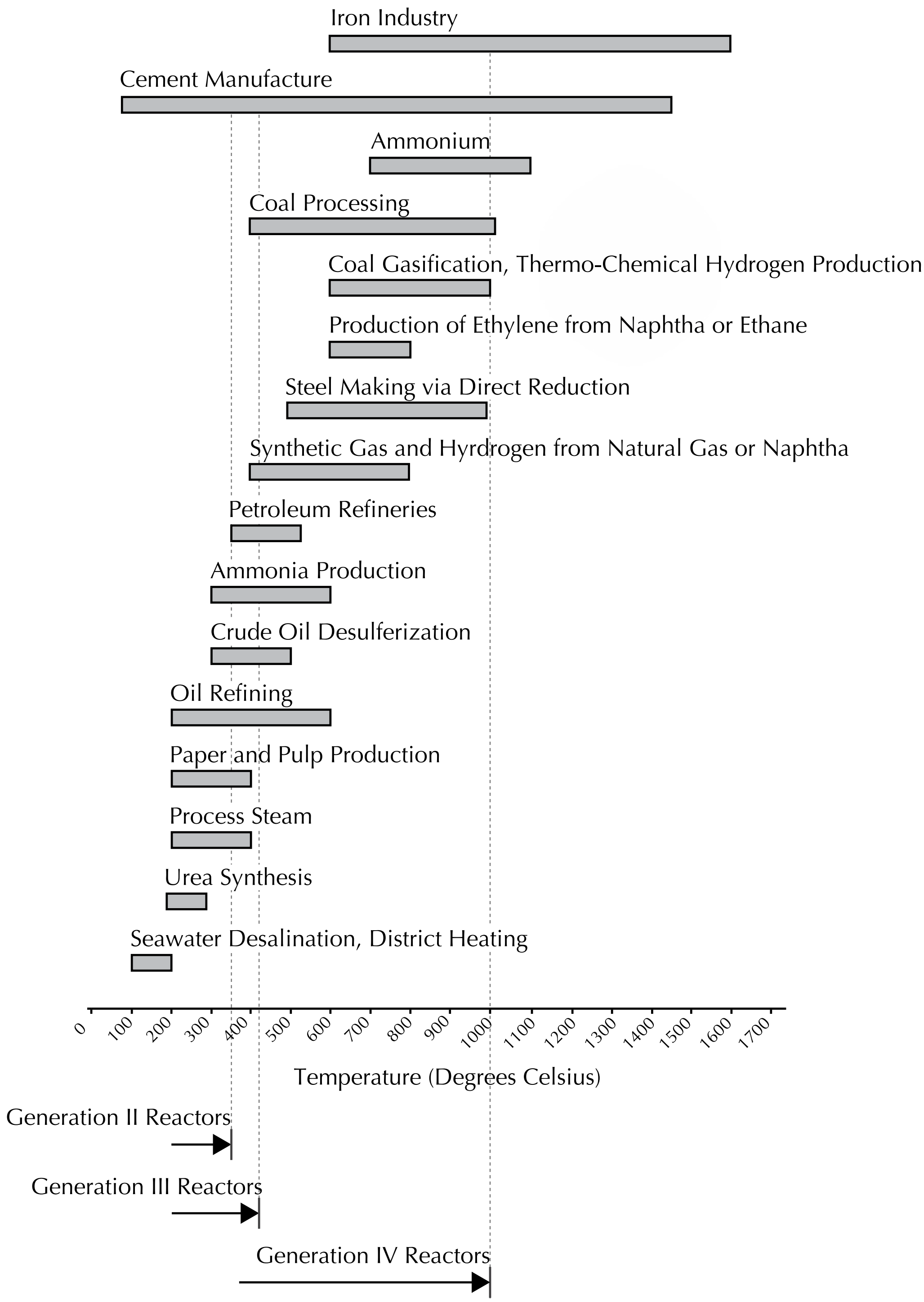
1. Oak Ridge National Laboratory, "Nuclear Energy Centers: Industrial and Agricultural Complexes," 1968.

2. U.S. DOE, Steam Systems, http://www1.eere.energy.gov/manufacturing/tech_assistance/steam.html.

3. Besides having more flexibility to add reactors, the arrangement of reactors in a bundle, all feeding into the same set of steam, electricity, and heat infrastructure, allows the freedom to have one or two in maintenance at any one time, without affecting the supply to industries, many of which run continually. Since steam and process heat are not as easily transported as electricity, this will all have to be preplanned into reactor designs.

4. The present annual U.S. steel production for 2013 is estimated at 65 million tons. http://www.steel.org/About%20AISI/Statistics.aspx

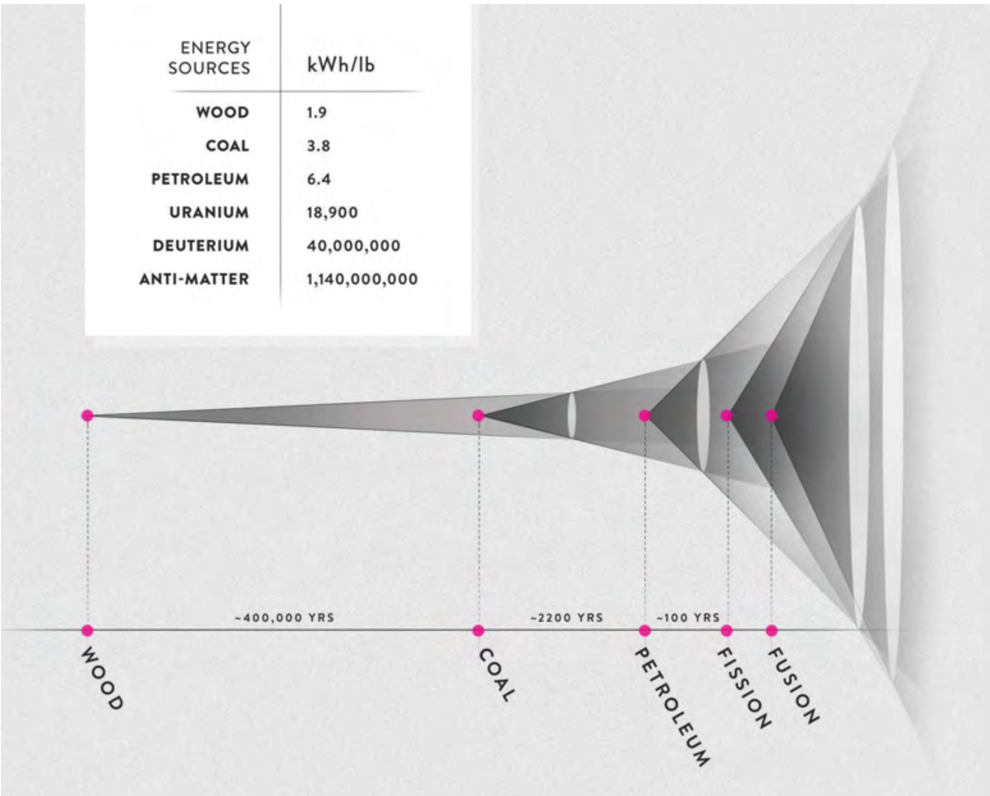
Figure 1



Comparison of common industrial process heat temperature requirements with nuclear reactor temperatures.1

1. Produced from figures obtained from Majumdar, "Desalination and Other Non-electric Applications of Nuclear Energy," IAEA, Lectures given at the Workshop on Nuclear Reaction Data and Nuclear Reactors: Physics, Design and Safety, Trieste, 25 February–28 March, 2002.

Figure 2: Energy Flux Density



This progression of cones of increasing pitch show the natural progession of sources of fuels of higher energy density. Apexes respresent the time of their discovery. As a new cone reaches the previous one, the old technology becomes eclipsed in its use in the economy. Both the rate of discovery, and the relative energy ratios are increasing dramatically. Deuterium is used here as the fuel for fusion reactions.

drogen could replace two-thirds of the production cycle for ammonia (NH_3), one of the most-produced inorganic chemicals in the world.[5]

Many more technological breakthroughs will need to be made to eventually replace the higher heat requirements currently being supplied by fossil fuels. Once abundant electricity, steam and heat at increasingly higher temperatures are available, we will see many methods of production evolve and many previously exotic products, such as more advanced specialty steels than can be produced today, be integrated into mass production, providing the platform for a fusion economy.

Figure 2 shows the energy content of different fuel sources. One pound of petroleum produces 6.4 kWh of energy, while, with breeder reactors, which breed not-yet-fissile fertile fuel into burnable fissile fuel during operation, one pound of uranium can potentially produce 18,900 kWh.[6] If you have ever been stopped at a railroad crossing to wait for a coal train to pass by, then you have seen a part of the vast amount of infrastructure, time, and manpower consumed by the use of approximately one billion tons every year in the United States alone. In contrast, breeder reactors can be designed to burn the initial fuel for the lifetime of the plant, eliminating the fuel transportation cost after installation altogether.

As can also be seen in Figure 2, human economy has always been based on progressing toward use of fuels of higher energy density. However, fuel is only a reflection of the underlying principle in operation at any one time. This type of progression must occur at all levels, not just at the fuel source.

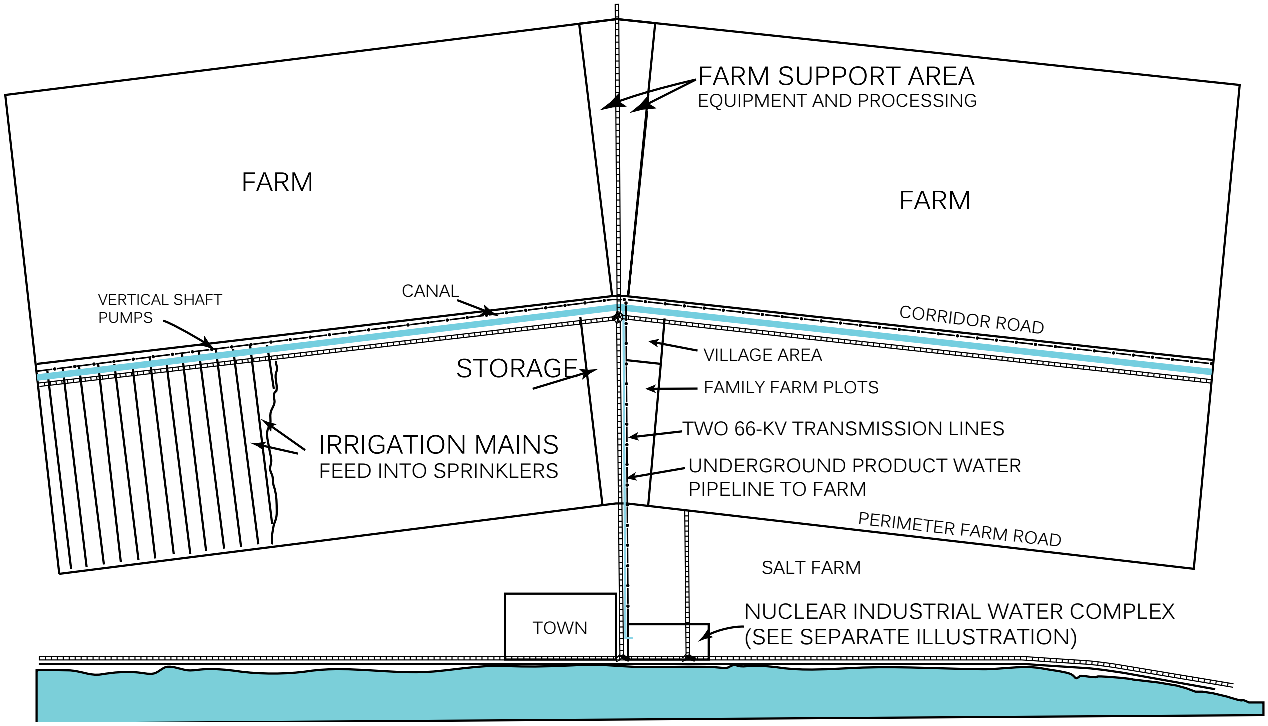
Advanced Industry and the Nuclear Platform

Nonlinear increases in productivity will not come from better integration alone. Replacement, as much as possible, of machine tools with already available computer numerical control (CNC) laser machine tools, is a way to introduce the high energy flux density of laser technology into all the processes downstream. Many other uses of lasers throughout the economy, such as the tuned catalyzing of chemical reactions, will also drastically in-

5. 83% of ammonia is used for fertilizer. Currently, the constituents of ammonia, hydrogen and nitrogen, are obtained from natural gas (or liquified petroleum gases such as propane and butane), air, and high-temperature steam (700–1,100°C). The process creates carbon dioxide and water as byproducts.

6. In breeder reactors, non-fissile Th-232 and U-238 absorb neutrons to eventually become fissile U-233 and Pu-239, respectively.

Nuclear-Powered Agro-Industrial Complex



This is a 1967 example design of an agricultural-industrial nuclear-powered complex by Oak Ridge National Laboratory. The image shows that industrial centers can be embedded into agricultural areas which benefit from both the industrial output, including electricity and fertilizers, and the desalinated water supplied by the complex. Underground piping takes water through irrigation mains to a sprinkler system. Storage and processing equipment is on site. These agricultural units will use the locally supplied desalinated water—or water newly derived from NAWAPA XXI—for irrigating soil, for hydro- and aquaculture, and for growing trees and other vegetation for both food, and for land, water, and weather reclamation. Advances in the industrial sector will feed into agriculture's goal of continually increasing the technology density per area of land.

crease the rate and quality of production.[7]

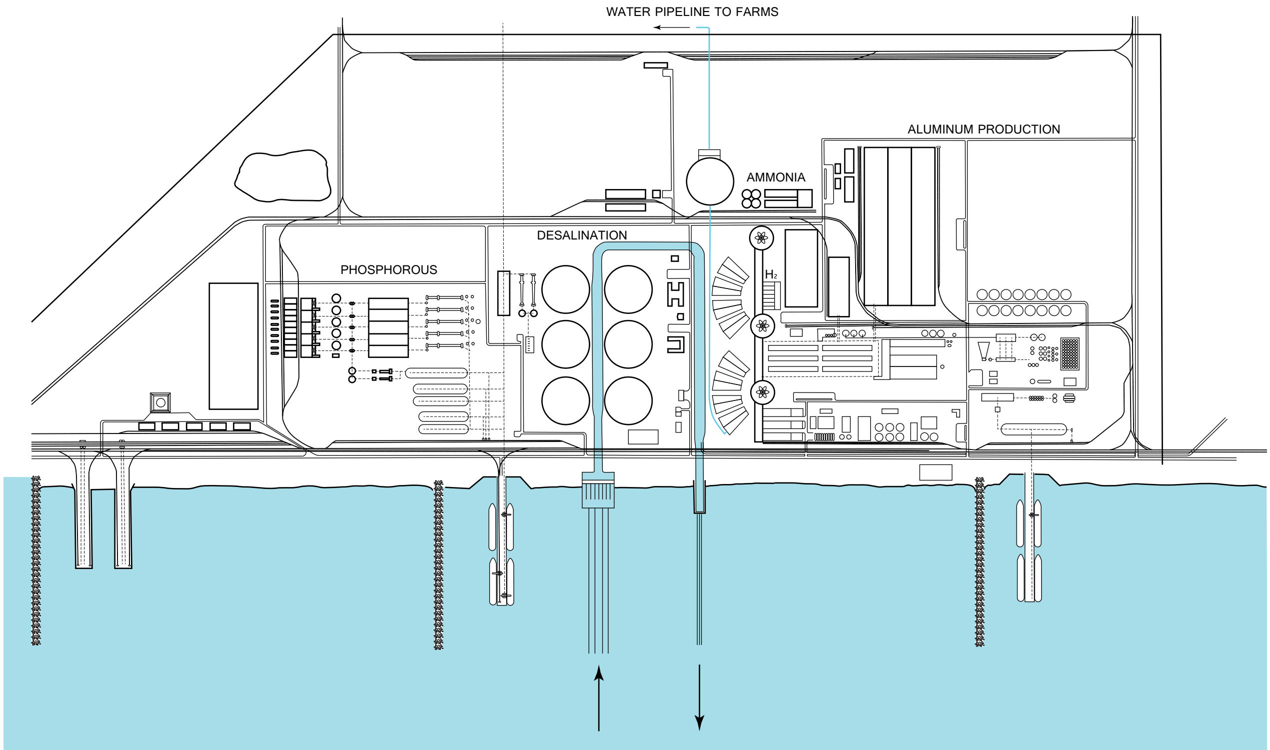
The use of low- and high-temperature plasmas for processing material such as steel will also have a large impact on the productive process. Requiring some of the highest temperatures of common industrial processes, steelmaking can largely be transferred over to furnace designs which would utilize the very high temperatures and other properties of plasmas to process the iron ore into any desired steel alloy.[8] Ultimately, besides the coolant, the temperature limit of fission reactor designs will be determined by materials increasingly capable of handling high heat, corrosion and neutron degradation. These limits, however, are not inherent to magnetically confined plasmas. High temperature plasmas, and ultra-high temperature plasmas of controlled thermonuclear fusion, can reach millions and tens of millions of degrees Celsius. With them humans will be able to interact with and control matter the way the Sun does. With fusion plasmas, humans will even be able to synthesize needed bulk raw materials from the contents of landfills.

Yet another upgrade in the productive process comes from the most valuable product of the fission reaction. The remnants of the fission reaction are high-grade ores, which not only contain elements which we commonly use, but also isotopes which cannot be, or are not easily, found in nature. Breeder reactors, which "breed" more fissile fuel during operation, can potentially use up all the larger, more radioactive elements (the actinides, having atomic numbers 89–103), leaving behind neutron-absorbing fission products. Like "waste heat", it is also now called "nuclear waste," and considered a hindrance to the fission process. Rather than a hindrance, fission products must be a primary product of specialized reactors, designed specifically to create, collect, and deliver these valuable resources. Fission products, such as molybdenum-99, which is not found in nature, but whose

7. See Appendix 2.

8. The plasma arc design is already in use today, though not widely.

Nuclear Industrial Water Complex



Nuclear Industrial Water Complex. This bird's eye view of a 1968 Oak Ridge National Laboratory design of an example nuclear-powered industrial complex shows six main industrial processes: aluminum, ammonia, hydrogen, phosphorous, and desalinated water, all feeding off of the electricity, heat, and steam from the three nuclear power plants near the center. A small channel brings in ocean water for cooling and desalinating. A pipeline runs desalinated water out to farms. Oak Ridge designed the complex so that material would be mostly transported within the complex by conveyor belt (dashed lines). Also included in the center are research facilities, a fire station, machine shop, and other administration.

decay product, technetium-99m, is used widely for life-saving medical imaging, are already important factors in our standard of living.

Well-funded research into the nature and uses of the controlled transmutation of elements, especially into natural transmutation within the biological realm, is long overdue. In addition, the full ability to make and manipulate isotopically pure materials by exploiting their particular resonance frequencies will define a completely new degree of freedom, of which we see only a glimmer in the current uses of isotopes (primarily as radioisotopes).[9]

Conclusion

During the construction of NAWAPA XXI, nuclear industrial complexes would be ideal for new industries in the Great Lakes area, where the raw materials for steel production are in close proximity. Plants producing over 50 GW of electricty will be located in and around Idaho for the most demanding of the water pumping requirements of the NAWAPA XXI water distribution system. These plants provide much more than electricity, if used to produce more nuclear plants as well as other materials needed for the construction of NAWAPA XXI. Nearby will be medical research facilities, as well as plasma research facilities, preparing the way to a fusion economy. Units in Alaska can be specialized to produce warm working environments, and supply nearby emerging cities. Agricultural units, with embedded industrial units, could be placed in the Southwest, along the NAWAPA XXI route or along its tributaries. Each will be tailored to the specific required industrial or agricultural cycles. These units will be crucial for developing the Pacific Development Corridor, strung along the corridor like the cities which connected the east and west of the United States during the construction of the transcontinental railroad.

9. 40% of the world radioisotope supply comes from Chalk River Laboratories in Ontario, Canada. Only laboratory amounts are produced in the United States

The Pacific Development Corridor:

Maglev Across The Bering Strait

by Benjamin Deniston

The construction of the northern components of NAWAPA XXI in Alaska and Canada makes possible development programs with massive international implications, linking the United States with East Asia in the creation of a high-technology, fusion and fission powered backbone for a new world economy.

A major geopolitical shift towards the Pacific is already underway, with a strong pro-growth orientation in Asia, centered around pro-development factions in China, Russia, South Korea, and Japan. This directionality stands is stark contrast with the stagnation and collapse of the trans-Atlantic sector. In line with this Pacific orientation, Arctic development is increasingly becoming an area of focus, with major untapped resource deposits lying in wait, while the melting of Arctic ice is opening up northern shipping routes.

The development of the nuclear-thermonuclear NAWAPA XXI system links the United States, Canada, and Mexico into this Pacific-Arctic perspective. However, the critical factor must be continually emphasized and underscored: *the success of the effort fully depends upon the highest levels of technology and energy flux density achievable.*

The present physical-economic collapse of the United States is the result of four decades of stagnation and attrition. Living standards have collapsed, industry has been shut down, power per capita has decreased, and aging infrastructure systems are breaking down. The only way to overcome the accumulated physical collapse in the United States (let alone the entire world) is to create greater leaps to higher levels of progress.

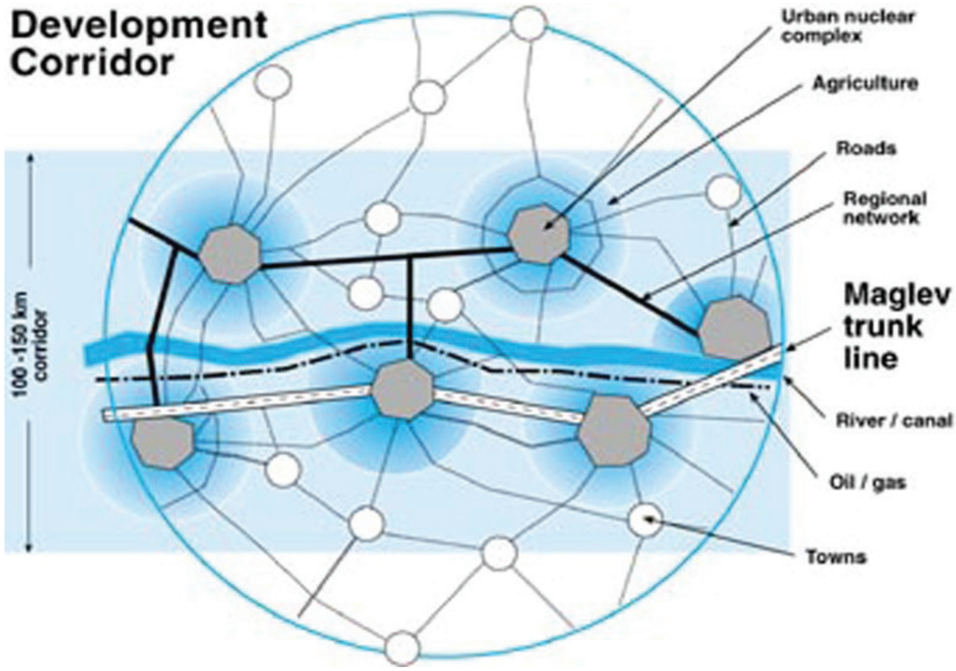
The United States will already need to partner with these Asian nations for the development and implementation of the fourth-generation nuclear requirements of the NAWAPA XXI system itself,[1] but the implications of the construction and development of the project take the connection deeper, and connecting the North American and Eurasian landmasses across the Bering Strait with high speed magnetic levitation rail is a keystone.

The gap between Alaska and Siberia—the Bering Strait, stretching a mere 50 to 60 miles—can be connected by a set of tunnels, linking the transportation systems of both

1. The basic pumping requirements of the NAWAPA XXI system will require over 50 gigawatts of power. Additional requirements for desalination systems (up to 42 systems) and power for industry increase the requirement, all in addition to the need to replace existing aging systems. When the requirements of the world population are considered, it becomes clear very quickly that mankind needs a lot of nuclear power, and fast. See "The Nuclear NAWAPA XXI and the New Economy," by Michael Kirsch.

continents for the first time.[2] To support the greatest leap in the productivity of the nations and people involved, the most advanced magnetic levitation (maglev) rail systems are required. Unlike trains with wheels, maglev trains float above the track, allowing for travel at well over 300 miles per hour, smoother rides, less wear on the track, and an improved ability to handle steep grades.

These maglev systems are a critical element of the new Pacific Development Corridor, connecting the United States with East Asia through a density of high-technology infrastructure, supporting the advanced development of the entire Pacific coastal basin, including resource development, new agricultural lands, new cities, and new nuclear agro-industrial complexes (nuplexes).[3]



A development corridor, as illustrated in the 1997 EIR Eurasian Land-Bridge report.

Because of the density of high-technology development, centered around advanced infrastructure and a high density of power, this corridor can uniquely enable massive leaps in the productivity of the high-technology space, fission, fusion, machine tool, and related industries and manufacturing centers needed to support the creation and implementation of a global fusion economy.

From this Pacific trunk line, development corridors can branch off to the rest of the world, completing the world land-bridge as envisioned by Helga Zepp-LaRouche and Lyndon LaRouche. Thus the Pacific Corridor is now to be the start of a new global economy, both in geographical terms, but also in physical economic terms, because the growth factor provided to these Pacific Rim populations and territories is what will make the extensions physically possible.

The Pacific Trunk Line

The program starts with a focus on the development of the Pacific basin territory. This includes supporting and expanding the already extensive shipping routes, but the end goal of an initial generational investment cycle must guide the policy from day one.

On one end, the manufacturing centers of the Midwestern United States and the critical Pacific ports in California and Washington, can be connected north into the Canadian and Alaskan regions of NAWAPA XXI, and from there on to the Alaska side of the Bering Strait, all with maglev rail.

This is premised on the role of the Pacific ports in existing trade relations (and their physical economic implications), and the future role of the Midwest as a new high-technology industrial base in America.

At the other end, the high technology regions of China, South Korea, and Japan can be linked up on the Asian side, with maglev lines traveling from southern China to create a loop connecting China, North Korea, South Korea, Japan (through Hokkaido), Russia's Sakhalin Island, the Russian mainland, and back down to China. From this, a connection runs north, through Eastern Siberia and the Russian Far East, meeting the maglev Bering Strait connection from Siberia.

This East Asia side links the relevant ports, along with the high-technology and industrial centers of South Korea, Japan, and China, including existing Russian proposals for an advanced Space Industry complex (along the Svobodny-Komsomolsk corridor) in the region, anchored by the new Vostochny Cosmodrome (see box, "Update on Russia's Vostochny Cosmodrome and the Space Industry Cluster").[4]

2. This project has been discussed as far a back as the 19th-century railroad revolution. See "Origins of the Bering Strait Project," by Richard Freeman, *EIR*, May 4, 2007.

3. See "Nuclear Agro-Industrial Complexes for NAWAPA XXI" by Liona Fan-Chiang.

4. See "Space Industry Cluster in Russia's Amur Region," submitted by Yuri V. Krupnov (then director of the Institute for Demography, Migration and Regional Development) and presented by his associate,

Taken together this defines an initial functional system, in which high-speed maglev rail and a nuclear-thermonuclear driver can support the development of the Pacific rim, connecting the high technology and industrial centers of the United States and East Asia, through the NAWAPA and Siberian territories.

However, the key is that the connecting route will not just be an empty transport line. Fast transportation, water, high densities of nuclear power, and abundant untapped resources enable the creation of *the most advanced and productive strip of territory the Earth has ever seen*. New cities and industries can be constructed along the way, featuring upgraded nuplex systems designed to work with fourth-generation fission reactors and thermonuclear fusion technologies (see "Nuclear Agro-Industrial Complexes for NAWAPA XXI"). The extensive resources available in the Arctic can be developed with the most advanced nuclear and thermonuclear technologies, and raw, semi-processed, and processed goods can be rapidly delivered to the high-technology industrial centers at each end in Asia and North America, radiating the effects of a higher level of productivity throughout the global economy.

The key is achieving the highest level of energy flux density accessible, integrated with the most advanced infrastructure systems, concentrated to create a revolutionary leap in the physical economic productive powers of labor throughout the region (see "A Call for An International Crash Program: Creating the Fusion Economy").

Ilnur Batyrshin, at the September 15–16, 2007 conference held in Kiedrich, Germany, "Reconstruction After the Financial Crash," *EIR*, September 28, 2007.

Update on Russia's Vostochny Cosmodrome and the Space Industry Cluster

In August, 2013 Russia's Deputy Prime Minister, Dmitri Rogozin, visited the construction site of Russia's new space center, Vostochny Cosmodrome. He took the opportunity to formulate a perspective for development of their space industry, linking it with measures to revive and develop the region as strategically crucial to Russia's future.

RIA Novosti reported that Rogozin said, "We are only just beginning to reform our space launch industry in accordance with the President's decision on the consolidation of all industry, and this means that the entire, enormous machinery of [the Russian Space Agency] will go into motion. It may well be that this motion will be toward the East. There should be a second geopolitical center here." Rogozin elaborated the idea as follows: "If the Cosmodrome is here in the Amur Region, then why is all of our industry in Western Russia? It is risky and very expensive, for example, to haul heavy craft by rail. The real situation forces us to shift production capacity and manpower to Siberia and the Far East."

Rogozin said that a Presidential decree is being prepared on these matters, and SpaceDaily.com reported that in April President Putin said, "the site will become a major link in Russia's aviation and space sector and a powerful innovation center for developing the whole country and the Far East."

The online publication Nakanune.ru, in reporting Rogozin's remarks, noted that "experts have been saying for a long time that you can't just build something like a cosmodrome by itself, without a production, scientific and technological, manpower and industrial base. The Cosmodrome construction project should become a breakthrough point for the country and the world."

One of those experts is Yuri Krupnov, leader of the Development Movement, who worked intensely in 2006–2007 to get the decision made to build the Vostochny Cosmodrome. Nakanune.ru quoted him following Rogozin's visit, saying, "We should create a world-class national space center there. The city nearby the Cosmodrome should be built not merely in order to provide square meters of living space for [guest workers], but those square meters should be allocated to the best youth in our country. This city should have the best possible planning and architecture in the world. As of today, we don't have anything of the kind. Five years ago we had no strategic program for developing the space program, and we still don't have one, although a state program has been formally adopted and approved."

-Rachel Douglas

As the world shifts to a Pacific orientation, the Pacific Development Corridor will be the ultra-high productivity backbone of the new world economy, and NAWAPA XXI with the Bering Strait connection can be the critical driver to initiate the entire program.

Maglev Systems

Both Germany and Japan have already developed magnetic levitation train systems, while other designs have been proposed by U.S. engineers. While there are variations in the designs, the general principle is to use the power of magnetism to create a continuous gap between the entire train and the track, allowing the floating train to be smoothly propelled electromagnetically at very high speeds. This is powered by the electrical grid (eliminating the need for separate engines and fuel supplies for each train), and because there is no direct contact on the track, there is no mechanical wear and tear, allowing for longer-lasting tracks with less maintenance. And difficult weather conditions (such as iced tracks) do not pose a problem to electromagnetic braking and acceleration.

Maglev can also travel up and down steeper grades than conventional rail, allowing for much easier travel through mountainous terrain—as encountered in the NAWAPA XXI regions and the Pacific Development Corridor.

The German system is called Transrapid, and it utilizes electromagnets to lift the train. Transrapid created a test facility back in 1987, but after years of successful demonstrations, the only construction of an operational line has been in China, with the Shanghai Transrapid running since 2004, achieving a maximum speed of 311 miles per hour.

In Japan, maglev systems are being developed which utilize a different technology, superconducting magnets. Although they have to be cooled and are heavier systems, the superconductivity allows for a much stronger magnetic lift, creating a larger gap between the train and the track, and the ability to handle heavier loads. In June of 2013, officials at Central Japan Railway unveiled their latest prototype, the "Lo" model, which is planned to begin operations between Tokyo and Nagoya in 2027, operating at 360 miles per hour.[5]

While much of the discussion has focused on the applications for passenger transport, the systems can also revolutionize freight and cargo transport. Even the ex-

5. "Commercial Superconducting Maglev Train On Tracks in Japan," June 10, 2013, LaRouchePAC.com/Node/26901

Full World Land-Bridge as proposed by Helga and Lyndon LaRouche

isting Transrapid systems could be quickly altered for freight, while additional investments could produce faster and more advanced second generation systems.[6] The more powerful superconducting magnets involved in the Japanese design can carry heavier loads, further increasing the possibilities for maglev freight transport.[7] Again, the faster speeds and ability to handle steeper grades and cold climates make these systems far superior to existing wheel-based rail, especially for the terrain of NAWAPA XXI, accessing Arctic resource deposits, and traversing the length of the Pacific Development Corridor.

With maglev, the top speeds are limited not by the magnetic levitation technologies, but by wind resistance as speed increases. While it will not be worthwhile for freight, ultra-fast passenger transport can take full advantage of the magnetic levitation capabilities by utilizing enclosed vacuum or semi-vacuum tubes, removing the air resistance factor (and trouble with sonic booms), and allowing for speeds of thousands of miles per hour.[8] Special ultra-fast passenger transport could bring people from American urban-industrial centers to those in East Asia in a matter of hours.

The Nuclear-Thermonuclear Driver

The highest levels of energy flux density are required to power this development corridor. While significant amounts of electricity will be needed to support the development of this entire territory, including the maglev lines and advanced industrial sectors on both ends, power sources with higher temperatures and greater heat densities have broad applications beyond electricity generation.

The decades-old concept of nuclear-powered agro-industrial complexes must be revived and upgraded. Fourth-generation nuclear fission reactors provide higher levels of process heat allowing for direct applications to chemical, industrial, and agricultural requirements, ranging from the production of metals, to fertilizers, to synthetic fuels. Centralizing these processes in a dense cluster maximizes the productivity and efficiency (see "Nuclear Agro-Industrial Complexes for NAWAPA XXI").

Additionally, nuclear desalination and water purification can provide abundant water where needed along the corridor as well (see "The Nuclear NAWAPA XXI and the New Economy").

Even more advanced options are available, with the use of fission-fusion hybrid systems, controlled high temperature plasma-based systems, and full-scale controlled

6. "Maglev Trains—Even More Powerful as Freight Carriers," October 1, 2007, LaRouchePAC.com/Node/4225

7. "Maglev: Transport Mode for the 21st Century," by Drs. James Powell and Gordon Danby; *EIR*, September 21, 2007.

8. Ibid.

thermonuclear fusion (see "A Call for An International Crash Program: Creating the Fusion Economy").

High energy flux density processing of raw materials closer to the extraction site enables the transportation of higher quality goods, translating to a greater value per ton transported. It also enables the more efficient processing of ores, cheapening the process and making lower grade and lower concentration deposits valuable, economically viable resources.

These considerations must be placed up front when considering the development of the vast Arctic resource deposits, including the role of strategic Arctic fusion-fission nuplex power and processing systems along the Pacific Corridor.

For these reasons, it will be critical to locate demonstration and experimental fusion systems specifically along this corridor, with the goal of developing a broad range of fusion technologies.

This includes such technologies as high temperature controlled plasma technologies such as the plasma torch, capable of separating any substance (from nuclear "waste," to chemical waste, to dirt, to basic city trash) into its constituent elements, turning virtually any input into useful material. The resulting resources can even be tuned to the isotopic level—providing higher quality materials than were possible before.

To maximize the benefits received from the surrounding infrastructure, and contributions delivered back to the integrated productive processes, the initial experimental investigation and development of high-temperature plasma and fusion-related systems should be strategically constructed as part of the Pacific Development corridor, and within proximity to the advanced industry on both ends, and the resource development along the corridor when appropriate.

Bering Strait & The World Land-Bridge

Integrating the NAWAPA XXI, Bering Strait, Arctic Development, and Pacific Corridor projects will provide the needed economic *leaps* for the nations involved, creating a density of productive potential that will drive the growth of the entire world.

Done properly, this can literally be the physical-economic backbone of a new global economy.

Branching off the East Asian side, the northern, central, and southern corridors of the Eurasian land-bridge can be upgraded to maglev and high energy flux density development corridors, reaching back into Europe, where the Paris-Berlin-Vienna productive triangle can become the high-technology center of western Eurasia. Through Spain and the Middle East, two branches reach down into Africa, bringing the same density of development and advanced infrastructure throughout the continent.

On the North American side, branches from the main Pacific Development Corridor can expand across the rest of the continent, integrating national and international high-speed maglev rail grids throughout the United States, Canada, and Mexico. From Mexico, the lines continue into South America across the Darien Gap, connecting the tip of Argentina with the tip of South Africa in a single high speed maglev network.

The first stage is the development of the Pacific Development Corridor, with NAWAPA XXI and the Bering Strait connection being the critical driver. Done with a fusion-fission driver applied to the most advanced infrastructure, industry, and resource development, this high density of high-technology development is the only way to provide the needed physical-economic leaps, overcoming the past four and a half decades of attritional-collapse by reaching farther and faster into the future.

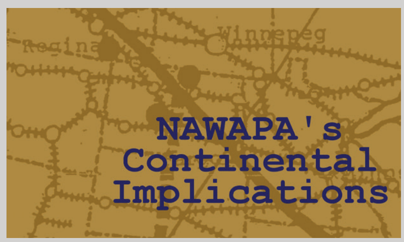
These are requirements, not options.

This 2012 NAWAPA XXI feature is the most in-depth animated tour of the water collection and distribution system produced to date, reviewing in detail every river basin, reservoir, tunnel and geographical feature of the plan.

larouchepac.com/nawapaxxi/feature

This 2011 video documentary presents the true story of the fight for NAWAPA, consisting entirely of letters to and from Senator Frank Moss, the original champion of the project, along with news reports from 1962–1973.

larouchepac.com/nawapa1964



This 2010 video presents the rail lines needed for the original NAWAPA system, needed steps for completion of the Alaska-Canada and Bering Strait rail systems.

larouchepac.com/continentalimplications

For the 'Common Aims of Mankind'

A Strategic Defense of Earth

by Benjamin Deniston

The surprise Chelyabinsk asteroid impact on February 15, 2013 was a warning to mankind: *either progress, or face extinction.*

Today we have discovered fewer than 1% of the near-Earth asteroids orbiting the inner regions of the Solar System, and we know far less about the long-period comets lurking in the farther depths of space.[1] Since it is a certainty that the Earth will be struck again in the future, the only real questions are two:

First, when might the next major impact occur?

Second, will mankind be prepared to stop it?

In 2011, high-level officials of the Russian government addressed this challenge in a critical offer to the United States, proposing the two nations move beyond the dangerous standoff over the forward placement of anti-ballistic missile systems by pursuing a joint program in which both nations could openly collaborate to overcome common threats: both defending against thermonuclear missiles and protecting the entire planet from asteroids and comets.[2]

Carrying the name "Strategic Defense of Earth," this Russian proposal clearly implied an upgraded re-offer of Lyndon LaRouche's Strategic Defense Initiative (SDI) proposal of the 1980s (a program which was avidly promoted by both President Reagan and Dr. Edward Teller at the time).[3]

The Strategic Defense of Earth is one of the most important issues facing humanity at this historical juncture.

The Fusion Driver

To achieve this, a shift in the strategic relations among leading nations is required. With the development of thermonuclear weapons, mankind can no longer tolerate even the possibility of global conflict among major powers. Policy must be based on the shared interests and the shared defense of all involved.

Since no one nation currently has the ability to defend the Earth from future asteroid or comet impacts, a global effort is needed. The United States, Russia, and China are the critical powers that must come together in a joint effort, sharing existing scientific and related resources, while initiating a crash program for the development of new capabilities.

It is an easily recognizable fact that the comprehensive defense of Earth requires a controlled use of thermonuclear power.[4] Whether in the form of explosives to blow apart or push away an asteroid, or in the more elegant form of advanced propultion systems enabling faster intercepts, the energy flux densities made possible with controlled fusion reactions raise mankind above the critical plantary threshold, moving from a class of helpless inhabitants of a planetary body, to active defenders and organizers of the entire territory of the inner solar system.

1. For a detailed overview see the Fall-Winter 2012-2013 issue of *21st Century Science & Technology*, dedicated to Planetary Defense.

2. See "The Thermonuclear Option: Extinction or Existence," *EIR*, May 25, 2012.

3. See "The Power of Ideas: SDI Changed the World," by Jeffrey Steinberg, *EIR*, February 16, 2007.

4. See "Planetary Defense: Deflection and the Energy Flux Density Factor," in the Fall-Winter 2012-2013 issue of *21st Century Science & Technology*.

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