Nuclear Agro-Industrial Complexes for NAWAPA XXI

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This is the fourth in our series of articles from the 21st Century Science & Technology Special Report, "Nuclear NAWAPA XXI: Gateway to the Fusion Economy." See EIR, Sept. 13, Sept. 20, and Sept. 27 for previous coverage.

> 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.
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> —*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 thermonuclear fusion. Let the achievement of an economy based on the principle of fusion drive our transition, now, into an economy built on nuclear 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 of the new nuclear plants, as well as the most 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 purposes than as energy, will be a byproduct of preparing the foundation for a fusion economy (**Figure 1**).

Products of Fission

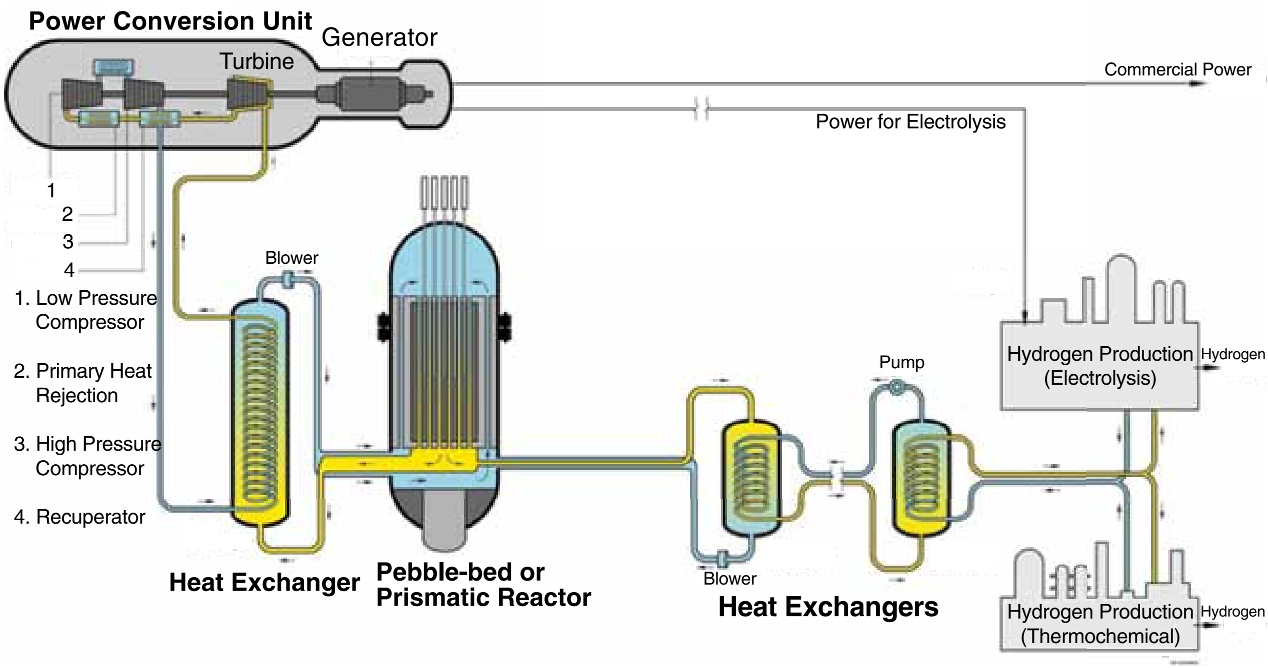
Nuclear agro-industrial complexes will be centered on an array of nuclear power plants designed to provide the products of the nuclear-fission reaction. Electricity, steam, heat, and fission products, all produced by nuclear power plants, can be directly fed into the industrial process.

Within nuclear reactors, there 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 atom, 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 usage 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 4 million pounds of steam per hour, at 200 to 600 pounds per square inch (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] According to the U.S. Department of Energy, "Nearly 49% of all fuel burned by U.S. manufacturers is used to raise steam. Steam heats raw mate-

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

FIGURE 1



Idaho National Laboratory

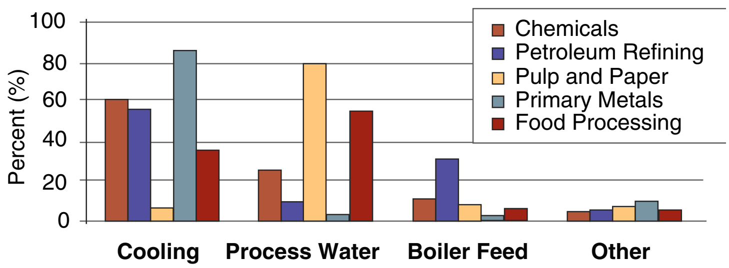
Heat transfer from a nuclear reactor

rials 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.

FIGURE 2

Water Use Type



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.

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 (**Figure 2**).

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 (**Figure 3**).

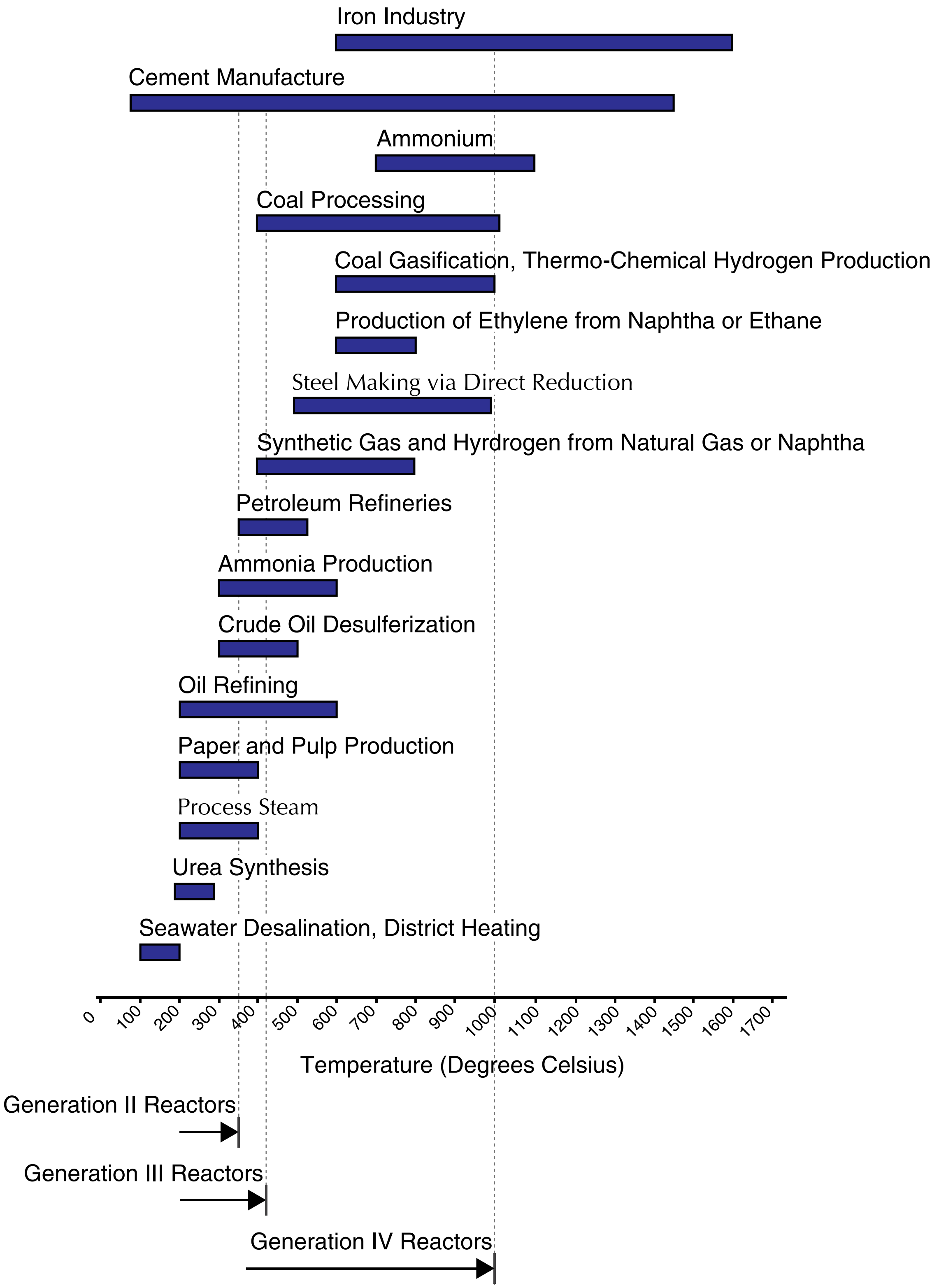
You can see that the second- and third-generation nuclear reactors of today are not able to meet the requirements of most of these common industrial processes. Fourth-generation reactors can meet a majority

2. U.S. Department of Energy Steam Systems

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

FIGURE 3



Comparison of common industrial-process heat-temperature requirements, with nuclear-reactor temperatures.[1]

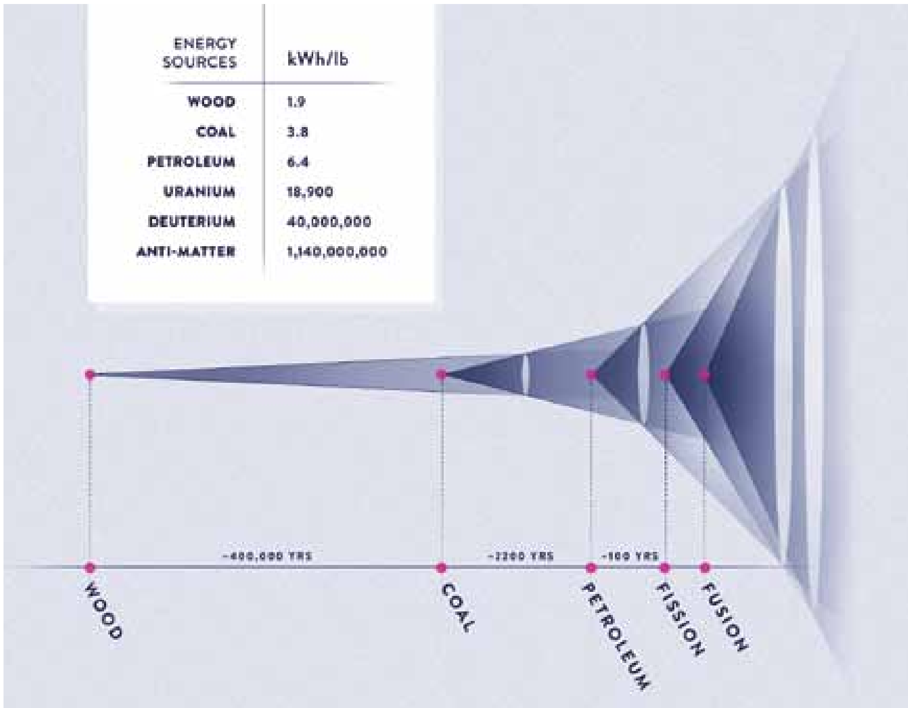
1. Produced from figures obtained from Majumdar, "Desalination and Other Non-electric Applications of Nuclear Energy," IAEA, Lectures given at the Workshop on Nuclear Reaction Data and Nuclear Reactors: Physics, Design and Safety, Trieste, 25 February-28 March, 2002.

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 they serve to replace low-energy-density coal, oil, and natural gas for many current industrial processes, but more importantly, they 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 hydrogen could replace two-thirds of the production cycle for ammonia (NH_3), one of the most widely 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, many methods of production evolve and many previously exotic products, such as more advanced specialty steels than can be produced today, will be integrated into mass production, providing the platform for a fusion economy.

FIGURE 4
Energy-Flux Density



LPAC

This progression of cones of increasing pitch show the natural progession of sources of fuels of higher energy density. Apexes represent 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.

Figure 4 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, 1 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 1 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 4, 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.

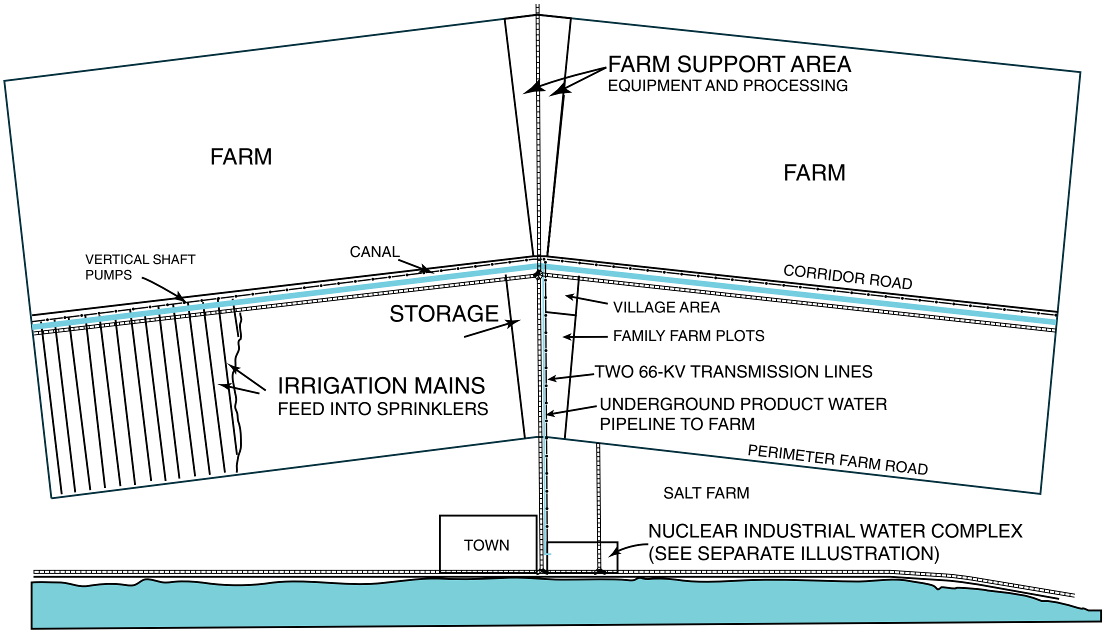
Advanced Industry and the Nuclear Platform

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

5. Eighty-three percent 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.

FIGURE 5
Nuclear-Powered Agro-Industrial Complex



Oak Ridge National Laboratory

This is a 1967 proposed 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.

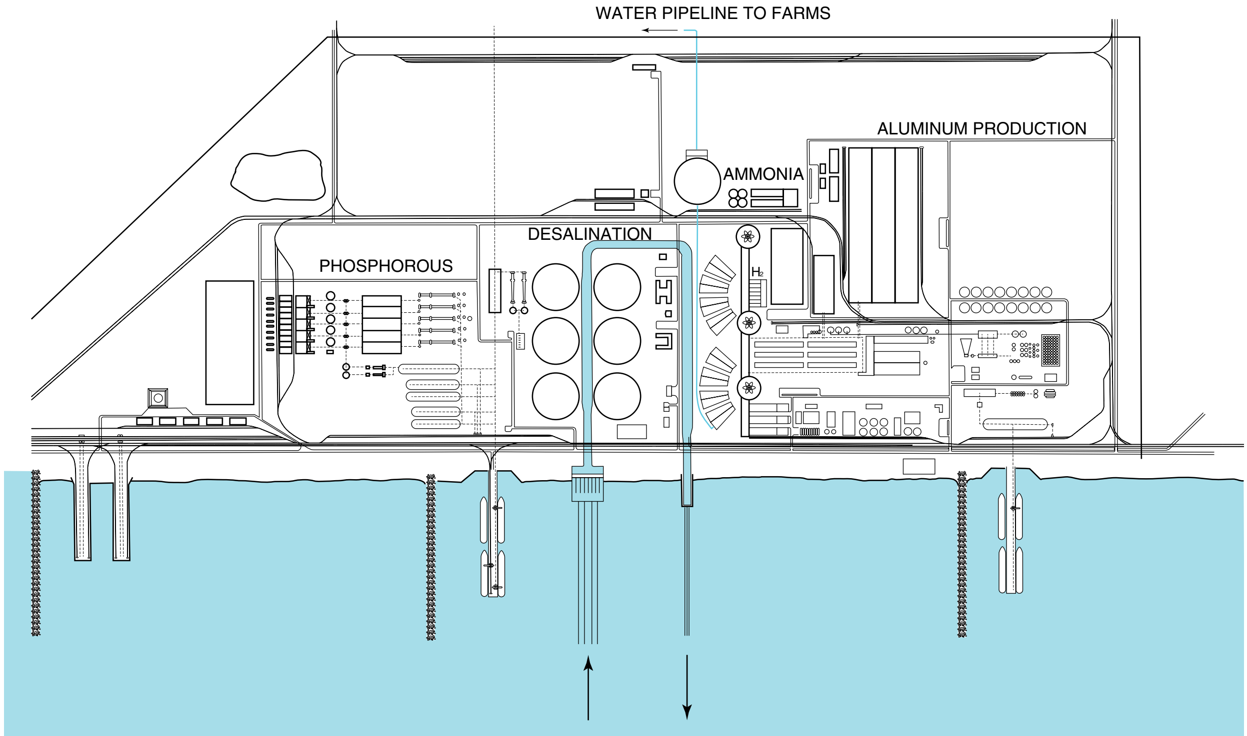
the tuned catalyzing of chemical reactions, will also drastically increase the rate and quality of production (**Figure 5**).[7]

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 will 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 decay product, technetium-99m, is used

7. See "The Nuclear NAWAPA XXI & The New Economy," Appendix 2 (http://larouchepac.com/nawapaxxi).
8. The plasma arc design is already in use today, though not widely.

FIGURE 6
Nuclear Industrial Water Complex



Oak Ridge National Laboratory

This bird's eye view of a 1968 Oak Ridge National Laboratory design of a prototype 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 (broken lines). Also included in the center are research facilities, fire station, machine shop, and administrative facilities.

widely for life-saving medical imaging, are already important factors in our standard of living (**Figure 6**).

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