How to Solve the Climate Change Problem for $100B

By Glenn Weinreb, Director, The Manhattan 2 Project

Nuclear power is inevitable, yet not everywhere

As we discussed in previous articles, decarbonizing most of electricity can be done by building more PV solar farms and more land-based wind farms, at a consumer price increase of ≤ $0.020/kWh. However, this still leaves manufacturing to be decarbonized. This includes making chemicals (e.g. hydrogen gas, liquid ammonia), metals, plastics, and materials (e.g. glass, cement).

With manufacturing, the cold electric options are costly (e.g. solar, wind, and hydro) and the lowest-cost hot option is high temperature nuclear. For this reason, nuclear power is inevitable, yet not everywhere, since nations averse to nuclear will import before building nuclear reactors at home.

In summary, nations that are averse to nuclear power will probably use solar, wind and hydro to decarbonize most of their electricity; and use someone else's nuclear reactors to decarbonize their manufacturing.

For details, see Nuclear power is inevitable, yet not everywhere.

The USA and Europe Could Reduce Nuclear Costs if Desired

USA and European nuclear costs are currently high due to designing and building one reactor at a time. However, if a standard design was mass produced, in a streamlined process, these costs would be different.

We Still Need Green Manufacturing to Cost Less than Non-Green

The lowest cost green method of making many things is via direct heat from a nuclear reactor. However, in order for this to be fully embraced on a global scale, it must cost less than making things with carbon-based fuels.

China's HTR-PM is the first and only commercial scale Generation 4 reactor in the world. However, it only produces electricity, not materials via heat. And this additional step is still in development.

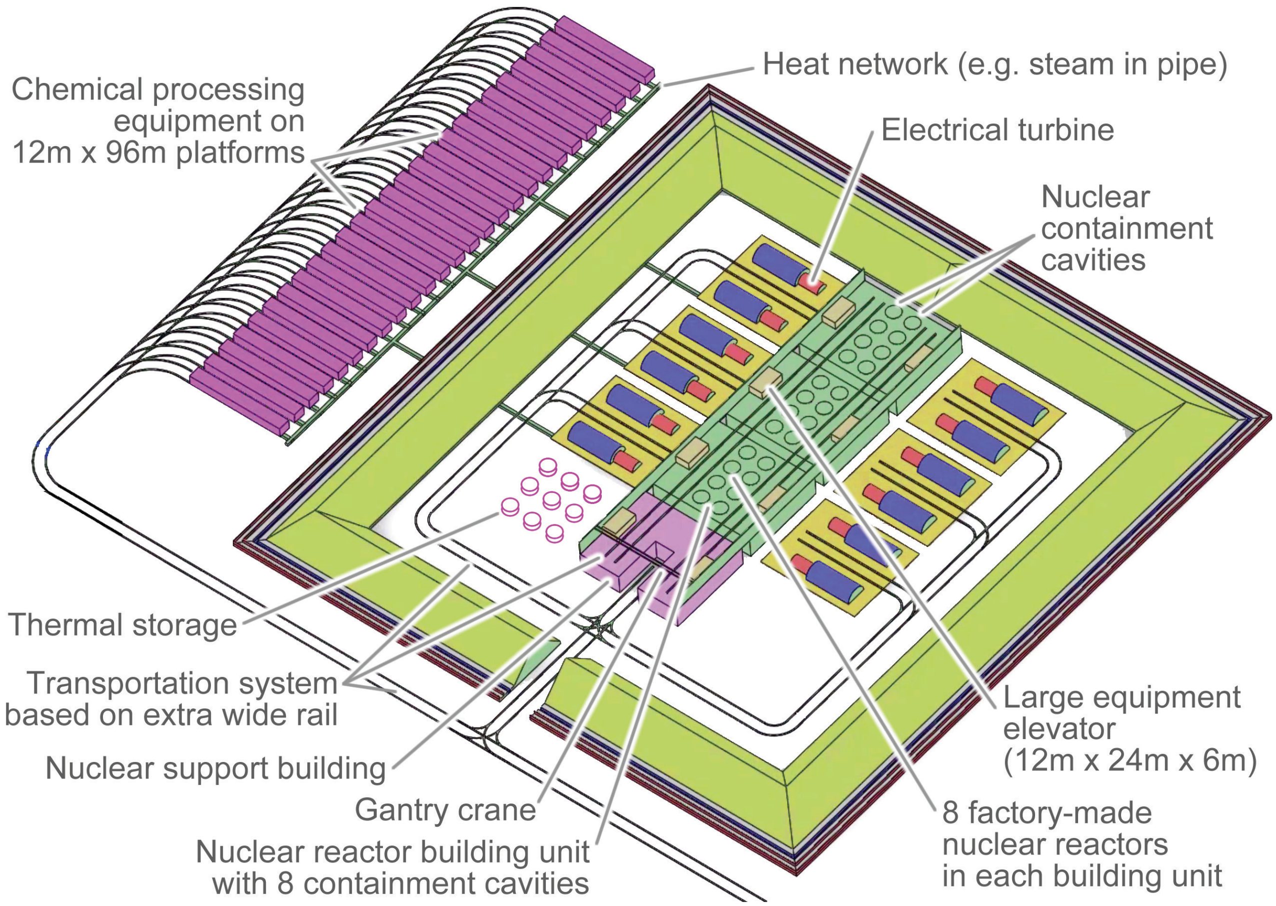
More R&D and cost reduction are needed to replace carbon-based manfacturing with nuclear power.

How to Make Green Manufacturing Cheaper Than Non-Green Given $10B/yr R&D

This article looks at what one might do to make nuclear-based manufacturing cheaper than carbon-based manufacturing given a $10B/yr budget. We will present concepts derived from an existing 50-page plan which is free and open (i.e. anyone can copy and modify at no charge).

Develop a Green Energy Production Facility

With a large R&D budget, engineers can develop a standardized green energy production facility that uses Generation 4 nuclear power to create: electricity, hydrogen gas, liquid ammonia, and other chemicals. An example of this concept is illustrated below:



After regulators certify one facility, copies are made within a streamlined regulatory process.

The equipment in the facility, including nuclear reactors, is mass produced in factories, to reduce cost.

Multiple nuclear reactors are installed at each site. For example, in the above concept, 24 factory-made reactors are plugged into concrete containment silos.

Platforms of chemical processing equipment, perhaps 12m by 96m in size, are positioned side-by-side, and utilize heat and electricity from the nuclear reactors to make things. These roll from factory, to ship, to power station; via 12m extra-wide rail. Standardized connectors at the end of each platform make it easy to plug into a network of heat pipes that carry heat from reactors (e.g. 500°C steam at 100 ATM pressure). Site-wide efficiency is maximized by capturing unused heat and redirecting it to make electricity, make chemicals, and increase temperature of thermal storage.

Replace Oil, Natural Gas, and Coal with Green Energy, Worldwide

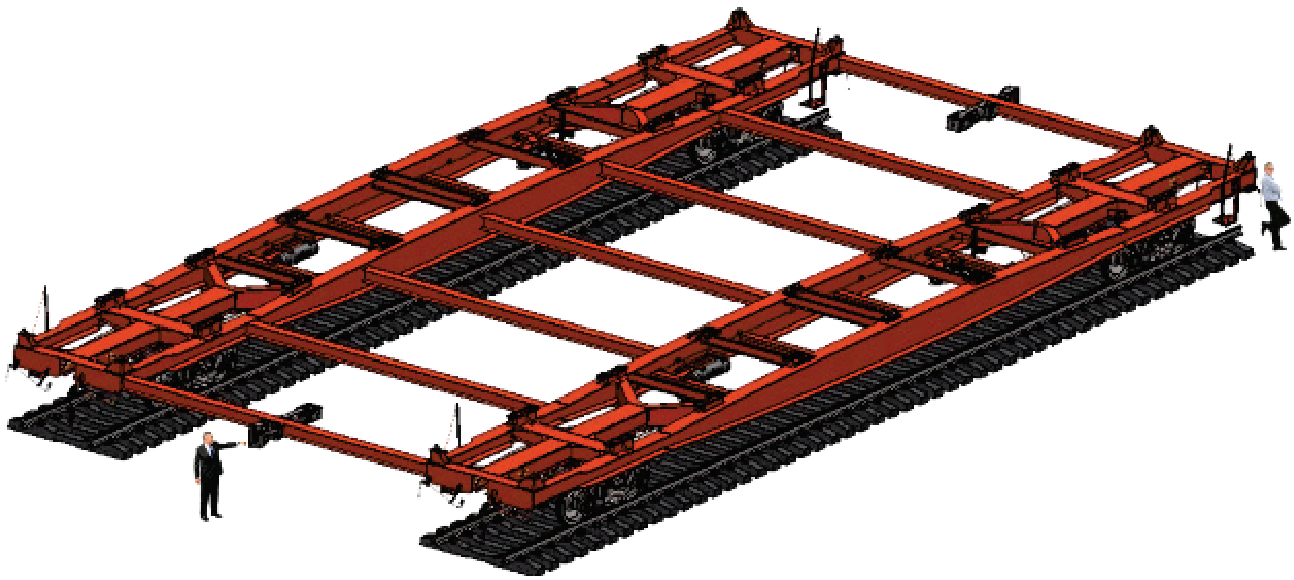
The above concept produces on the order of 2.5 GWe of power using today's technology, and perhaps two to four times more using newer technology, 10 to 20 years from now. To replace fossil fuels worldwide, we would need approximately 8,400 GWe of nuclear power, or 3,360 of these facilities (8,400 / 2.5). If they cost $1.50 per Watt and are built over 30 years, this works out to $420B-per-year worldwide, which is similar to what is spent on petroleum (8400 x $1.50 / 30yrs). These numbers are first order approximations and do not take into consideration details like energy consumption growth.

Develop Super-Sized Transportation System

The photograph below shows low-cost chemical processing equipment that was built in a factory-like shipyard, and placed onto a floating platform.

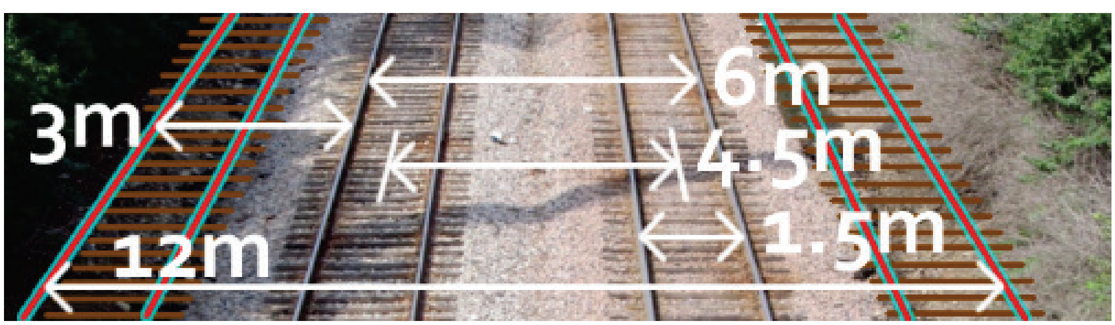
We need something similar, yet for land. More specifically, we need to assemble large platforms of equipment via robots, in a factory, and then move these to power stations, on land.

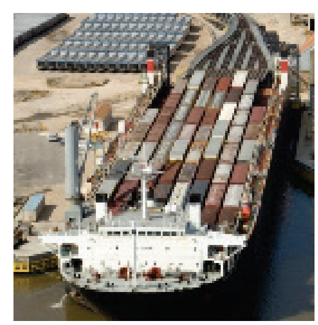
This requires a new super-sized transportation system, an example of which is illustrated below.



In this concept, railcars are sized at 12m by 24m and mount on double-tracks 12m apart. These railcars roll from factory, to dock near factory, to ship, to dock near power station, and then to power station.

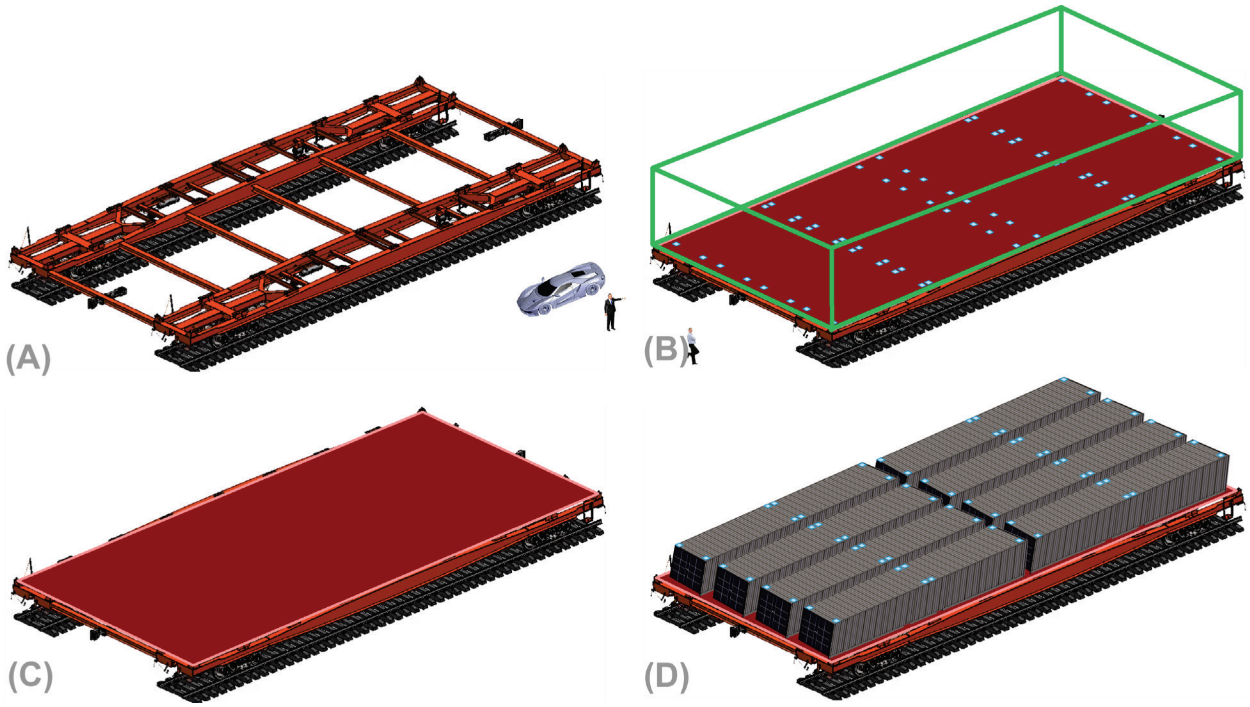
The distance between factory and water, and from water to power station, is short, and would typically range between 0.1 to 10 kilometers. In some cases, engineers rip up short segments of existing tracks, and rebuild with a total of four tracks, two for existing trains, and two for extra-wide railcars, as illustrated below-left.





Rolling between ship and shore is aided by ballast tanks on ship, which align height of ship to that of shore, an example of which is pictured above-right.

Illustration D below shows how one might place multiple standard-sized containers onto one railcar. Alternatively, one could transport 2-wide, 3-wide and 4-wide containers; or even a container that is 8-times larger than the standard container, as shown in image B.



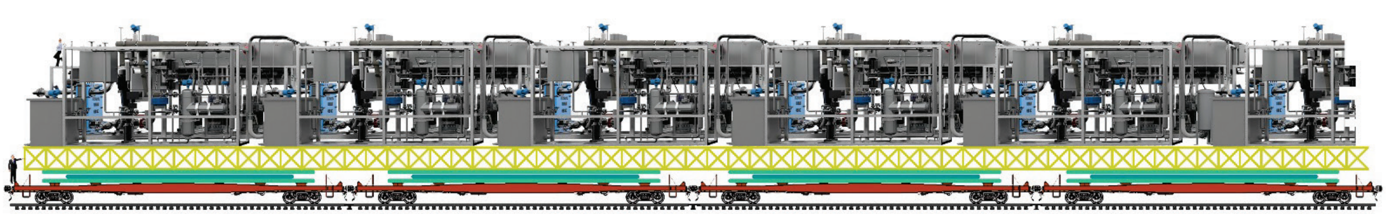
A new transportation system that moves large and heavy objects between factory and power station would have an enormous impact on nuclear power design, manufacturing strategy, and total site cost. And designing this would be easy since engineers can make use of existing rail, ship and crane technology.

Mass Produce Hydrogen and Ammonia Processing Equipment

One could potentially purchase the designs of equipment that make green hydrogen gas, and green liquid ammonia. And develop factories that mass produce this equipment. And, give the designs of the equipment, and the factories, away for free, to globally drive down the cost of green hydrogen and green ammonia.

Robots in a factory are positioned around a large platform for quick assembly. For example, 100 robots at $100K each would cost $10M total. And, if spread out over 1,000 platforms, would cost $10k per platform.

Below is an illustration of a factory-made 12m x 96m platform mounted on four 12m wide railcars. To get a sense of size, see person in lower-left corner.

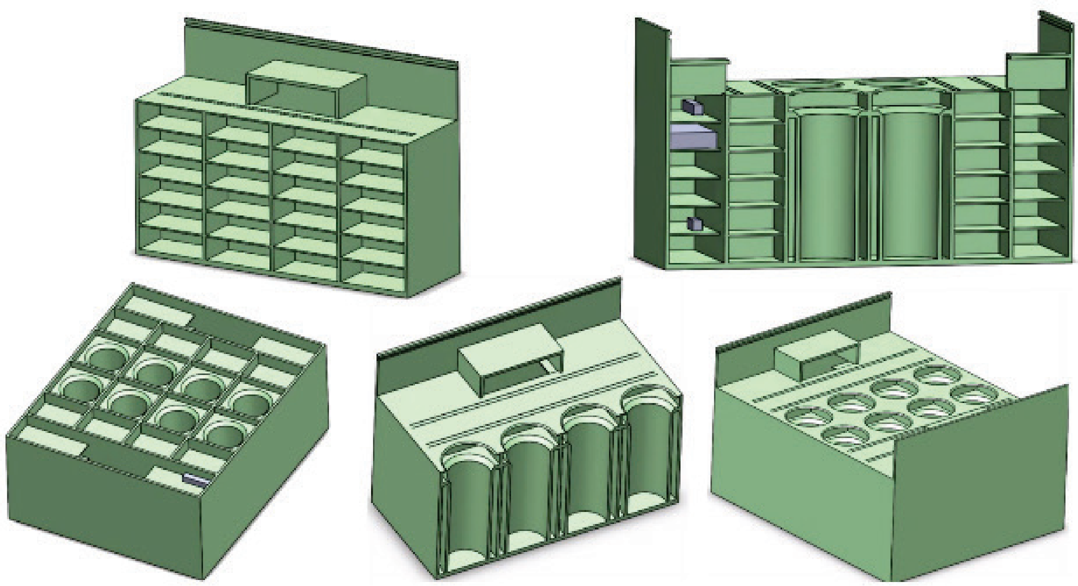


Commoditization of Green Energy Infrastructure Makes Decarbonization Easy

Competition among multiple global factories with no R&D costs drives down price to manufacturing-cost plus a little profit. This is referred to as "commoditization", and always results in low costs. And this is needed to make green energy cheaper than non-green. And we need cheaper green to get capital markets to pay for the factories, and the power stations. And if that occurs, governments do not need to pay for decarbonization.

Dramatically changing how we manufacture, transport, and handle intellectual property at green energy power stations requires sizable gov't funding. However, this funding can be justified in three ways: (a) it reduces the cost of the power stations by more than the cost of the funding, (b) it reduces the cost of harm from climate change by more than the cost of the funding, and (c) it enables governments to avoid paying for brute force decarbonization.

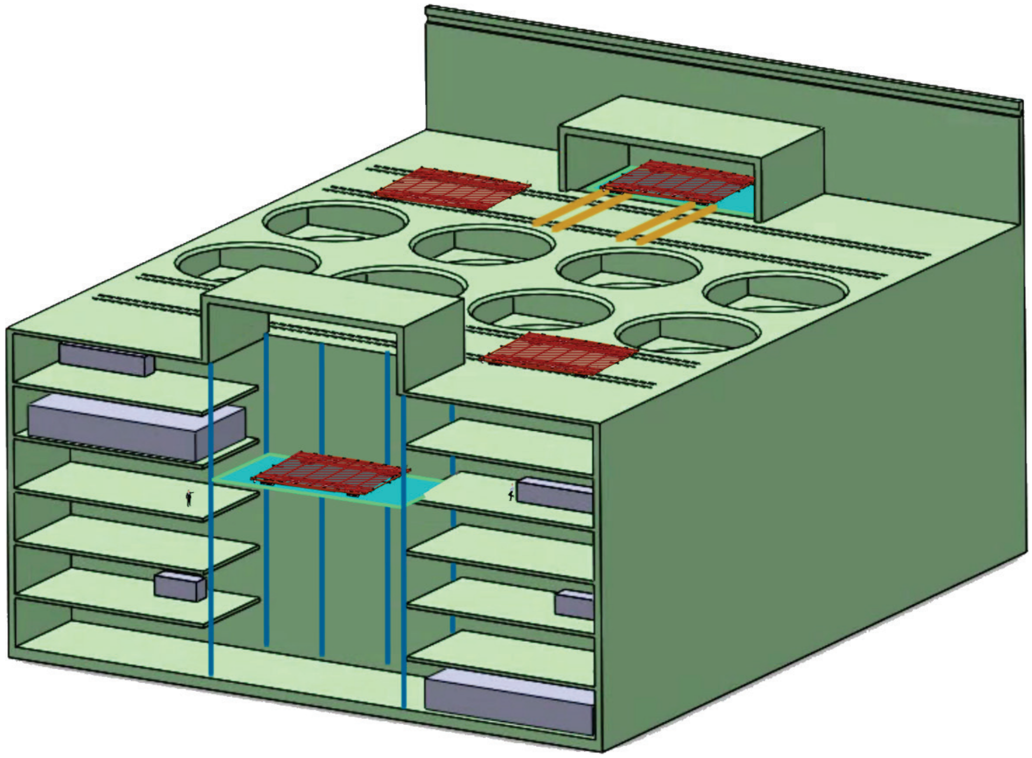
Develop Standardized Nuclear Reactor Building



Nuclear engineers can define a standard nuclear reactor building that supports all generation 4 nuclear technologies (e.g. gas cooled, molten salt, and liquid sodium). And automation engineers can then program machines to construct this building, under computer control, to reduce cost.

A standardized building and site allows nuclear engineers to focus on developing factory-made equipment; instead of developing non-automated costly buildings, thermal storage, and chemical processing equipment.

An example building concept is illustrated here. This contains eight standardized cylindrical containment cavities for factory-made nuclear reactors, where each cavity is a 14m diameter by 36m tall. And it provides many standardized rooms for equipment, each sized at 14m x 26m x 6m.



An elevator supports moving 12m x 24m x 4m sized equipment and machines into the building, as illustrated below.

Automate Site and Building Construction

Reactor buildings are mostly concrete and steel reinforcing rods ("rebar"), an example of which is shown here.

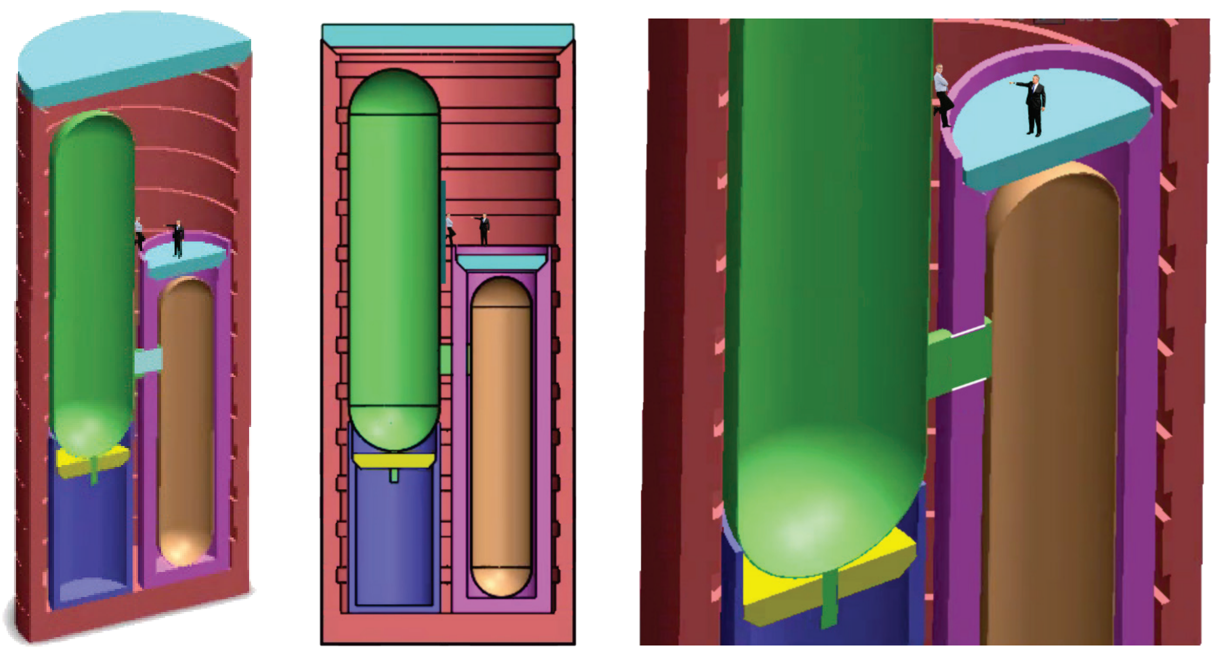
To reduce costs, robots in a factory place rebar and forms in a jig, and stack jig assemblies on a large railcar for transport to power station. The eight cavity building unit, shown previously, would require approximately 500 wall segments that are each 12m x 24m x 1m in size, for example. Specialized equipment, under computer control, bolt these together on-site, before receiving concrete.

The eight cavity building unit, shown previously, requires 232,000 tons of concrete, which is a lot. To reduce cost, the processing and dispensing of concrete is automated using specialized equipment, possibly mounted on 12m extra-wide rail.

To further reduce costs, excavation is automated using heavy equipment under computer control, illustrated below.

Factory-Made Nuclear Packages Both Install and Uninstall

Each nuclear reactor package includes a set of molded concrete inserts that drop into a cylindrical containment cavity via crane, to support reactor components. For example, engineers might place a steam generator into its own containment chamber, and place a reactor vessel onto a pedestal that surrounds pebble processing equipment, as illustrated below.



In some cases, reactor designers place one reactor into each containment cavity. However, in theory, one could place more than one into a cavity; or, spread out a large reactor among multiple cavities.

Factory-made packages both install and also uninstall; which means owners can upgrade, as needed.

Previously, nuclear power plants locked-in a technology for 60 years. However, with upgrade, owners make use of newer factory-made technology, as it becomes available.

Conclusion

If engineers had a large budget to cost-reduce nuclear-based manufacturing, they could potentially drive costs below carbon-based manufacturing.

Nuclear-based manufacturing would not need to be done everywhere, since nations adverse to nuclear could import.

Manufacturing via cold electricity (i.e. solar, wind and hydro), cheaper than carbon-based manufacturing, might be impossible; therefore, nuclear should be considered.

Further Reading -- Aspencore Climate Change Solutions Series

Summary	How to Solve the Climate Change Problem https://www.EETimes.com/how-to-solve-the-climate-change-problem/
	A Framework to Tackle Climate Change https://www.PowerElectronicsNews.com/a-framework-to-tackle-climate-change/
	10 Things You Need To Know to Solve the Climate Change Problem http://www.ma2life.org/g/10-things-you-need-to-know-to-solve-the-climate-change-problem.pdf
	Why COP Conferences are not More Productive https://www.PowerElectronicsNews.com/why-cops-conferences-are-not-more-productive/
Decarbonization Plan	A Plan to Get to Zero CO_2 Emissions https://www.PowerElectronicsNews.com/a-plan-to-get-to-zero-co2-emissions/
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