Supply Chain Management of the Nuclear Energy Industry

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Abstract

Nuclear energy generation facilities are created from a myriad of sources. Supply chain management for this industry requires someone who is adapt to global sourcing efforts. Each section of the industry falls under strict government guidelines and regulations from federal and national sources. The sourcing of nuclear energy consists of one of the most complex supply chains in the world.

Through an examination of the supply chain of the Nuclear Energy cycle, this paper incorporates a description of how a nuclear energy company achieves a strategic fit between its supply chain strategy and its competitive strategy as well as the major obstacles that must be overcome to successfully manage this unique supply chain. A brief examination of the various aspects of supply chain management for the nuclear energy industry, including the procurement of Uranium and Plutonium are discussed. Global methods are compared and contrasted. A cradle to the grave approach to nuclear energy plants and related facilities encompass construction to decommissioning of a facility as well as the disposal or recycling of nuclear waste.

Keywords: nuclear energy, supply chain management, transportation of hazardous goods

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Introduction

Nuclear Energy supply chains are an intricate interweaving of certified suppliers from a global marketplace. (Nuclear Energy Institute (NEI), 2010a) This highly complex supply chain can be a Supply Chain Manager's dream or nightmare. For those who appreciate a challenge and a global sourcing market, supplying the needs for the nuclear energy industry could be a dream come true.

The nuclear energy industry is under high scrutiny from the public in general as well as strict regulation from country governments, world organizations and the World Nuclear Association (WNA). All of this attention further adds to the complexity of the nuclear energy supply chain. In the United States, the government must certify suppliers who may contribute to this supply chain. An in depth study of the company and its products or services are conducted prior to the bidding process.

New reactor construction in the United States is under the oversight of the U.S. Nuclear Regulatory Commission (NRC). Procurement of supplies in the United States derives primarily from businesses certified by the Nuclear Procurement Issues Committee (NUPIC).

> NUPIC is committed to the future of commercial nuclear power. With a proven process for evaluating suppliers to high standards of quality, NUPIC is the NRC Licensee's preferred and cost-effective method of maintaining their Approved Suppliers List. NUPIC Members include all domestic U.S. nuclear utilities, and several international

members. If you, as a supplier, have as few as five customers who are NRC Licensees or international nuclear plant operators, you are eligible for a NUPIC Audit. Sponsorship by five NUPIC Members automatically enrolls suppliers into the NUPIC standard 30-month audit schedule. (NEI, 2010a)

Acquisition of Raw Materials

Nuclear plants are comprised of hundreds of components and subcomponents, whose construction will require a deep and diverse supplier base. Promoting the development of this supply chain has become one of the Nuclear Energy Institute’s (NEI) key strategic initiatives.

There are 104 nuclear reactors operating in the United States today, and the industry has submitted license applications to the Nuclear Regulatory Commission for multiple new reactors. Several billion dollars have already been spent on new plant activities, including the ordering of long-lead components

From the earliest stages of development, the successful construction of new plants depends on a robust supply chain to support nuclear manufacturing. Nuclear plants are comprised of hundreds of components and subcomponents, whose construction will require a deep and diverse supplier base.

Nuclear manufacturers supply the concrete, pumps, wires, instruments and many other components necessary to support current and future nuclear power projects. (NEI, 2010b)

On April 13, 2010, John Ritch, Director General of the World Nuclear Association released a brief detailing their initiative to standardize nuclear energy facilities. The concept of global standardization is a joint effort to improve safety as well as the raw material supply chain.

Obtaining Pu and U for the Creation of Energy

Plutonium (Pu) is a man-made element. The only evidence for naturally occurring plutonium is from a small source in South Africa where there once was a natural reactor. (Norbert Page, personal communication, August 1, 2006) Pu is created from Uranium (U). Uranium is the basic fuel of nuclear energy. Pu, a transuranic element, formed in a nuclear reactor through neutron capture, has several isotopes, some of which are fissile and some of which undergo spontaneous fission, releasing neutrons. About one third of the energy in a light water reactor comes from the fission of Pu-239. This is the main isotope of value recovered from reprocessing used fuel. As is the case with uranium, plutonium can also be recovered from spent fuel and recycled to create fresh reactor fuel. (World Nuclear Association (WNA), 2005a)

Pu and U are recouped through recycling. Through recycling, the separated uranium becomes new fuel for commercial nuclear power plants. The long-lived radioactive elements, including plutonium, become fuel that is used in advanced reactors that are being developed commercially for the industry.

Recycling Technologies

Advanced recycling technologies would reduce the volume, heat and toxicity of used nuclear fuel, but not completely eliminate the byproducts. The recycling byproducts would require disposal in a permanent repository. (NEI, 2010c) If true recycling were followed, as per our French counterparts, the radioactive materials would be converted into a glass ball about the size of your fist. Implementing their technique would reduce waste to approximately 3%. (Sutherland, 2003) The American version of waste burial, without recycling, produces mass quantities of radioactive waste requiring long-term disposal facilities and promotes the need for more breeder facilities.

> France chose the closed fuel cycle at the very beginning of its nuclear program, involving reprocessing used fuel so as to recover uranium and plutonium for re-use and to reduce the volume of high-level wastes for disposal. Recycling allows 30% more energy to be extracted from the original uranium and leads to a great reduction in the amount of wastes to be disposed of. Overall, the closed fuel cycle cost is assessed as comparable with that for direct disposal of used fuel, and preserves a resource, which may become more valuable in the future. Back end services are carried out by Areva NC. (Réseau de Transport d'électricité (RTE), 2010)

Breeder Reactors

Globally, the further development of breeder reactors is constantly growing. Japan, China, Korea, Russia, France, India, Germany, South Africa, Iran and the UK are advancing their technologies. These advancements are very controversial due to the potential, but unlikelihood, for nuclear energy waste to be transformed into a nuclear bomb. (Dickerson, 2006)

There are several types of breeder generating plants. There are High Temperature Gas Cooled Reactors, Fast Breeder Reactor (FBR), Liquid Metal Fast Breeder Reactor (LMRBR), Thermal Breeder Reactors, Pressurized Heavy Water Reactor (PHWR), Advanced Heavy Water Reactor (AHWR), Sodium Cooled Fast Reactor, Liquid Fluoride Reactor and the Light Water Reactors; advanced boiling water reactor (ABWR) and advanced pressurized water reactor (APWR). (WNA, 2005b) All of these facilities and technologies can breed Pu but through different processes.

Delivery of Radioactive Material to the Generation Facilities

Pu and U are transported to the generation facilities under strict government and global guidelines. International shipping standards are enforced in the packaging, transport and markings of said shipments. Enriched Uranium arrives at nuclear power sites in containers that are weighed to comply with the requirements of the International Atomic Energy Agency (IAEA) and the country's government associations such as the European Atomic Energy Community (Euratom) or the Nuclear Regulatory Commission (NRC). Deliveries to customers are made in containers that are transported in a licensed protective casing, referred to as casks, meeting international shipping standards. (URENCO, 2010)

Regulation of the Nuclear Energy Industry

Governmental Regulation: Domestic and Global

Radioactive properties of nuclear energy can take up to 500 years to decay excluding Pu which has a half life of up to 25,000 years. About 95 percent of all other radioactive properties decay to background levels within 100 years or less, according to the NEI (2010d). Due to the long life span of these properties and the potential for weaponry construction, the industry is highly regulated. Regulation of the industry, in the US, falls under the long arm of the Atomic Energy Act of 1954, which incorporates the Environmental Protection Agency (EPA), NRC, Federal Emergency Management Agency (FEMA), Department of Transportation (DOT) and other regulatory bodies. International regulations befall upon the WNA, IAEA and other global agencies including the United Nations (UN).

Yucca Mountain: US Nuclear Waste Burial Site

Unlike the Russian Federation, France and other countries who recycle their nuclear waste thereby recouping 95-97% for re-generation, the US has opted to bury the spent fuel rods in a long-term repository. Despite much opposition, Yucca Mountain was built and designated as this repository. (Sitler, 2009) The Energy Policy Act of 1992 along with recommendations for the National Academy of Sciences updated the regulations of 1954. In doing so, they included the addition of regulations for the transport and storage of nuclear waste through the Nuclear Waste Policy Act of 1982 (42 USC10141(a)), section 161b. of the Atomic Energy Act of 1994 (42 USC2201(b)), and any other authority of the Administrator of the Environmental Protection Agency setting generally applicable standards for the Yucca Mountain site. (*Energy Reorganization Act*, 1974)

Vendors

Security is high at these facilities. Nuclear energy generation facilities grant entrance only after a through vehicle search. Any non-employees must be escorted at all times while on said facility. Facility workers are subjected to strict hiring regulations and must pass comprehensive background checks. Transportation workers must now pass Transportation Security Administration (TSA) background checks, including finger printing and work history, prior to hauling hazardous goods or entering related facilities. All vendors: water delivery, office supplies, uniforms, diesel fuel, vending machines and so forth are all subject to the same strict criteria when their products enter a nuclear energy generation plant.

Delivering Energy to the Consumer (electricity)

Once all the components are in place, the generation of electricity can commence. Though Tesla experimented and theorized with wireless transmission methods, electricity is transferred to homes and businesses through a series of high-tension wires and stations. Wires can be buried or overhead transmission lines. Receiving and distribution stations relay the electricity along its path to the end customer. High voltage lines directly from a generation plant transfer electricity at 230,000 volts. Sub-transmission lines handle 69,000 volts and distribution lines near homes have their voltage reduced to 12,000 volts. Transformers help to regulate the voltage received in your home or business. (Salt River Project (SRP), 2010)

Decommissioning of Plants and Transportation of Radioactive Waste in the US

Decommissioning Process

Nuclear power plants are built with the presumption of an approximate 20-25 year life span. During that life cycle, plants are required to set up a fund that will cover the costs of decommissioning. The decommission process can consume twenty or more years therefore adequate funding is required by the government. Superfund monies have been used for this purpose but it is not their intended recipients.

Plant decommissioning is a multi-step process. This entails the removal and disposal of radioactive components and materials such as the reactor and associated piping and the cleanup of radioactive or hazardous contamination that may remain in the buildings and on the site. Radioactive materials must be handled in a fashion to reduce risk. The entire facility is sealed off to allow the grounds to return to a radiation safe zone. The energy generation room is sealed for a pre-determined time after the rods are removed. Hot rods from working plants are not immediately shipped upon decommission. Instead, there is a long-term process taken to further reduce the risk of contamination during transit.

Transport of Nuclear Waste

The Energy Reorganization Act of 1974 set standards including specific routing and mode of transport to the final burial site. Spent fuel rods are transported via rail and truck. They must be transported in cement casks manufactured specifically for this purpose. The DOT and NRC has designated an ultra strict set of rulings addressing everything from pre-trip to post-trip including the placarding and paperwork of any shipment containing nuclear waste. In-transit specifics are stated, including required escort services as well as unmarked escorts, in 49 C.F.R.

Risk reduction methods entail rods being placed in water pools to cool for 5-25 years before being transported to their first intermediate storage facility where they will remain for 30-100 years. During this stay, radiation levels with reduce significantly. Radioactivity from cobalt-60 will be reduced to 1/50th of its original level after 30 years and will be about 1/1,000th of its original level after 50 years per NEI (2010e) findings. They are then casked and taken to Yucca Mountain for burial. (Sitler, 2009) Eventually the entire plant can be leveled and the ground reused once it is determined safe from radioactive matter.

Origin of the Nuclear Energy Industry and the Need for Recycling of Its Fuel

The Soviet Union began creating nuclear energy in 1954 at the world's first nuclear power station, Обнинская АЭС (APS- 1 Obninsk) (WNA, 2010). Approximately 20 years later, the first civilian nuclear power plant became operational. At this time, other nations began producing nuclear generated electricity. Today the UK is experimenting with a third nuclear generation option; hybrid fusion, which will create a nuclear fusion reactor for energy generation. (The Times, 2010)

The Uranium Information Center (UIC) in Australia explains what has been achieved in their 35 years of nuclear energy generation and over 55,000 tons of spent fuel recycling in France and the UK.

> Arising from a year's operation of a typical l000 MWe nuclear reactor, about 230 kilograms of plutonium (1% of the spent fuel) is separated in reprocessing. This can be used in fresh mixed oxide (MOX) fuel (but not weapons, due to its composition). MOX fuel fabrication occurs at five facilities in Europe, with some twenty years of operating experience. The first large-scale French and UK plants started up in 1995 and 2001 respectively. Across Europe, over 35 reactors are licensed to load 20-50% of their cores with MOX fuel. (Uranium Information Center (UIC), 2006)

Recycling consists of dissolving and chemically separating uranium, plutonium and high-level waste. Through recycling, nuclear energy would truly be a viable renewable source of clean energy. The UIC explains, "[a]bout 97% of the spent fuel can be recycled leaving only 3% as high-level waste. The recyclable portion is mostly uranium depleted to less than 1% U-235, with some plutonium, which is most valuable." (2006) The 3% of the spent fuel, which is, separated high-level wastes amounts to 700 kg per year and it needs to be isolated from the environment for a very long time. These liquid wastes are stored in stainless steel tanks inside concrete cells until they are solidified. (UIC, 2006) Global adaptation of this recycling program would strength the nuclear industry.

Overcoming Obstacles in Nuclear Energy Proliferation

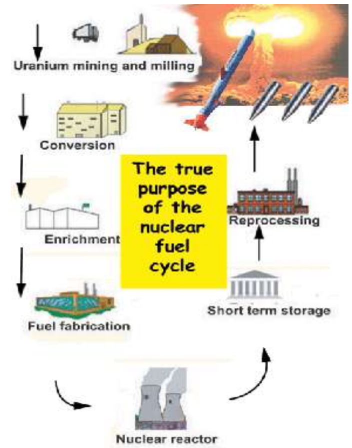
Nuclear Energy has some strong contenders in the clean energy generation arena. Solar and wind energy generation methods are fast risers. Hydroelectric energy generation remains a contender. Unlike solar and wind energy, hydroelectric and nuclear energy generation still require some fossil fuel usage in their generation processes.

It is "fiction that conservation, solar panels and windmills alone can meet human needs. Sustainability requires nuclear energy; and the path of sound environmentalism today is to embrace, fight for - and finance - a future in which nuclear power and "new renewables" function as clean-energy partners in a transformed global economy," states Director General Ritch (2004).

Views on Nuclear Energy

Nuclear energy is viewed by many as a heaven sent, global warming cure all. Supporters of nuclear energy sing its praises as a form of pure, clean, recyclable energy with less than 3% waste. Opposers of energy generation through nuclear means, view the power plants as an eyesore on the horizon and a ruse for nuclear weapon proliferation. Which do you see?

Vs.



(Publitek, 2010)

(Thorpe, 2008)

Acceptance of Nuclear Energy Proliferation is on the Rise

Despite the distrust for the industry from many world citizens and corporations, Nuclear Energy is on the rise. Over 74% of the American population support energy through nuclear generation methods. (Clear Skies News, 2010) President Obama supports alternative energy sources and comments on nuclear energy as "safe nuclear power".

> The Department of Energy (DoE) is currently promoting the early deployment of the most modern power reactors by administering loan guarantees for certain new plant projects, sharing planning costs and reinvigorating advanced reactor programs under various initiatives. It is responsible for the Global Nuclear Energy Partnership under which many nations discuss employing closed nuclear fuel cycles with advanced reactors and recycling. (World Nuclear News, 2008)

France generates 75% of its energy from nuclear power. India, Russia, the United Kingdom (UK) and many other nations are strong supporters of the nuclear energy industry. With Canada and Australia being the leading suppliers of uranium, it only makes sense that the UK is a strong supporter of this energy source. Adaptation of the French recycling method would further lead to the sustainability of this supply chain.

Conclusion

Obtaining a strategic fit between the supply chain strategy and the competitive strategy of the nuclear energy industry is still a tough battle in the US. Former President Bush showed his support for the nuclear industry and a recycling program by earmarking a $250M budget for nuclear fuel reprocessing. (Bellona, 2006)

Acceptance of nuclear energy is at its highest level. With this current increase in support and standardization of building methods, the supply chain complexities will decrease. Ease of regulations and constraints creates a more lucrative industry. Yucca Mountain is now operational and old facilities can finally be cleared and reopened. These new and upcoming changes in the industry will open a new playing field for the nuclear energy industry. Cost reductions are logically on the horizon. The renewed interest in nuclear energy proliferation places the nuclear energy industry as a prime candidate for the seasoned global supply chain professional.

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