The Approach to Cleanup at West Cumbria's Nuclear Sites

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ABSTRACT

The cleanup of West Cumbria's nuclear sites is one of the most important and demanding managerial, technical and environmental challenges facing the UK over the next century. Considerable progress has already been made in cleaning up the Sellafield, Calder Hall, and Low-level Waste Repository (LLWR) sites but there remains significant challenge ahead.

There are more than 200 nuclear facilities at the sites including redundant fuel storage ponds, redundant chemical plants and silos of solid waste and sludge. These legacy buildings exist alongside commercially operating reprocessing and fuel fabrication facilities. They are all linked together by a complex network of services including gas supplies, water supplies, waste disposal routes, and chemical supply routes.

Many of the buildings requiring cleanup are very old and date back to the early years of the British nuclear industry. They were not designed with decommissioning in mind, and some require substantial improvement to provide a safe foundation from which to retrieve waste and decommission. The cleanup of these legacy facilities must be carefully balanced with the ongoing operations that provide services to commercial customers. Cleanup must be carried out safely and efficiently, without impacting upon commercial operations whose revenue is vital to funding the Cleanup organizations scope of work.

This paper will introduce the cleanup approach at West Cumbria's Sellafield nuclear site. It will provide an overview of what is being done in preparation to meet the formidable but rewarding challenge ahead.

INTRODUCTION - MANAGING THE BRITISH NUCLEAR LEGACY

In November 2001, the British Government announced its intention to make radical changes to current arrangements for nuclear cleanup funded by the taxpayer. The Nuclear Decommissioning Authority (NDA) was established as the owner of the nuclear sites formerly owned and operated by British Nuclear Fuels (BNFL) and the United Kingdom Atomic Energy Authority (UKAEA). This underlined the Government's commitment to improve cleanup at the nuclear sites it manages.

In April 2002, the Government's approach to managing and overseeing the nuclear cleanup was laid out in a policy proposal that outlined the new operating arrangements.

The policy reflects the scale of the technical and managerial challenges involved in nuclear cleanup and the Government's intention, through competition, to ensure the best available skills and experience from the public and private sector are utilized during cleanup. The proposal highlighted the Government's commitment to ensure cleanup is carried out safely, securely, cost effectively, and with environmental conscience to benefit current and future generations. The NDA was officially established in April 2005 and has taken up the role of managing the cleanup of the British nuclear liabilities.

With over 200 nuclear facilities, Sellafield (Fig. 1.) is the largest and most complex industrial nuclear cleanup site in the world. It comprises activities that cover the entire nuclear fuel cycle. British Nuclear Group is the primary contractor for this site, which includes a complete spectrum of redundant plants and waste streams to manage. Currently it represents:

- Scope-of-work valued at $49 billion, encompassing > 60% of the entire national cleanup program.
- A combined budget for managing and operating the sites during the three-year span of the initial contract of $5.437 billion.
- Over 200 individual nuclear facilities.
- Approximately 12,000 employees including subcontractors.
- Approximately 20 nuclear facilities currently being decommissioned, including first generation fuel reprocessing plants and redundant fuel manufacturing facilities.
- Legacy Ponds containing fuel and sludge where the activity of pond water ranges between 54 and 135 μCi/L, and the most radioactive stored waste form is in excess of 380 Ci alpha/m^3.
- Legacy Silos containing solid, liquid, and sludge waste streams with activity levels between 27 and 2,700 Ci beta-gamma/m^3.
- Management of the only Low-level Waste Repository (Fig. 2.) in the nation:
  - A disposal service for all LLW from NDA and Ministry of Defence sites, commercial organizations, hospitals, and universities. By 2050, the site is expected to have provided a total storage capacity of 1.7 million m^3 of LLW.
  - Until 1988, the LLW was placed into trenches cut in a clay layer up to 8 m below ground.
  - Since 1995 all LLW has been disposed of within containers placed in engineered concrete vaults.
  - The site was also used to store Plutonium Contaminated Material (PCM) during the legacy years. Removal of this legacy will be complete in 2006.
- Decommissioning of Calder Hall, the first commercially scaled graphite reactor in the world:
  - Four identical CO_2 cooled Magnox (natural uranium) reactors with eight turbo generators.
  - Net design output of 144 MW.
  - Net output prior to shutdown in 2003 of 200 MW. Station lifetime output of over 70 TWh.
- Operational facilities dedicated to the storage, evaporation, and treatment of significant quantities of liquid High Level Waste.
- A massive infrastructure network of steam, gas, air, chemical, and domestic service supply.

- An extensive network of road and rail services supporting the transport of nuclear fuel, radioactive waste, and other materials.
- Several operational facilities for the storage and reprocessing of Magnox, thermal oxide, and Advanced Gas Cooled Reactor (AGR) fuels.
- Operational facilities for the treatment and storage of wastes resulting from fuel reprocessing operations.
- Facilities dedicated to the storage, treatment, and discharge of operational liquid waste and storage pond water.
- Operational facilities used to treat and store other waste streams like LLW, Miscellaneous Beta Gamma Waste, and PCM.
- Dedicated medical, fire, rescue and emergency response teams and facilities.
- A large variety of administrative buildings, active changing facilities, transport housing, restaurant and welfare facilities, and plant/equipment and consumable stores.

Fig. 1. Sellafield is a 682-acre industrial nuclear site

Fig. 2. National asset – the UK's only Low-level Waste Repository

DELIVERY ACHIEVEMENTS AND FUTURE CHALLENGES

The cleanup of the Sellafield site is one of the most important and demanding managerial, technical and environmental challenges facing the UK over the coming decades. We have already made considerable progress over the past nine months during our first contract with the NDA:

Over 1,500 m^3 of radioactive flocculent waste has been successfully transferred from a fifty-year-old storage tank into modern, high integrity containment vessels. This has gained significant progress against a site-wide regulatory milestone concerning the transfer of sludge into modern containment.

Many safe and successful demolitions have been performed, freeing up valuable land for reutilization. Some of the buildings pre-dated the nuclear mission at Sellafield and were used for storing TNT explosives. Three buildings have recently been demolished in the historic Separation Area of Sellafield as part of site clearance work. The resulting land is of critical importance to the construction of new plants that will treat, package and export all ILW sludge from legacy pond facilities. Preparations are also progressing well to demolish the Uranium Purification Plant and the oldest PCM stores later this year.

Over 7,000 drums containing PCM from legacy storage buildings has been successfully transferred into modern, purpose-built and engineered drum stores. This particular project was successfully accelerated by redeploying workers from a commercially operating reprocessing plant.

Another recent key achievement has been the construction of the third Engineered Drum Store. This new plant maximizes the capacity for PCM storage at Sellafield and enables accelerated removal of PCM from aging legacy storage facilities.

Successful closure of waste tipping charge holes and demolition of the Waste Transfer Tunnel have been achieved at the Pile Fuel Cladding Silo. A major risk reduction achievement at one of the most hazardous working environments delivered safely ahead of schedule.

A redundant 55-ton crane has been successfully replaced at the Magnox Swarf Storage Silos using one of the largest mobile cranes in Europe. This was the most hazardous task at Sellafield over the past year, with fifteen lifts of up to 50-tons being performed above the silos, and was executed safely and precisely without incident – not even a cut finger! Work is progressing to commission the crane for its vital role in performing the removal of redundant equipment from the facility and supporting the retrieval of the silo waste contents.

Further progress has been achieved recently at this facility with the installation of new cavity sump emptying systems to two waste storage compartments, as part of a project to improve safety on the 1st Extension Silo. The new systems improve the management of potential liquor leakages from the silo into the secondary containment, providing robust capability to safely transfer leaked liquor back into the silo storage compartments. The fully integrated project team designed an innovative and fit-for-purpose solution that has cut two years off the original installation schedule, with direct savings of over $4.4 million and a collective radiation dose reduction of 350 rem.

Preparations to demolish the four redundant cooling towers at Calder Hall are progressing well. All of the internal materials have been safely removed from towers 1 and 2. The material removed includes asbestos-cement pipe, plastic packing and timber joists, beams and columns. A traffic management plan has been agreed with the Highways authorities to ensure traffic disruption is minimized when all four towers are demolished later in the year. This landmark demolition project will be the most visible demonstration that cleanup at Sellafield is truly happening. Preparations for reactor de-fuelling and plant decommissioning are progressing as planned.

Safe and successful retrieval of unpackaged PCM from a legacy brick-built storage building is now complete. 400-tons (3,700 drums) of raw PCM generated by the sites early military program have been removed using a mix of remote and manual techniques at a rate of twenty-six drums each day. The physical effort and determination of our highly skilled workforce has significantly cleaned up one of the oldest legacy storage areas associated with historical operations at Sellafield.

Outstanding performance by the Sellafield Waste Task Team has generated a cost saving of over $985,000 due to the effective decontamination of metals to free release status. Originally charged with completing twenty-five tasks during 2005/06, the team achieved their target three months early, enabling them to accelerate activities from next years NTWP.

An extensive survey using a submersible Remotely Operated Vehicle (ROV) has captured every inch of the First Generation Magnox Storage Pond. The purpose of the survey was to gain a better understanding of: the pond inventory, fuel skip status and position, pond furniture and miscellaneous waste, radiation profiles, and the quantity of sludge in the pond. As a direct consequence the volume of pond sludge has increased greatly compared to previous estimates.

Numerous plant experts have analyzed over 5,000 hours of footage, comparing visible items with plant drawings and databases, to create an accurate reality map of the pond. The analysis has already highlighted that pond retrievals need to be significantly different to previous assumptions. We have calculated that this fresh knowledge, combined with our new tactical plan for pond management, will have a dramatic effect on future plans to remediate this historic legacy pond, and our breakthrough thinking will generate environmental advantages while accelerating retrievals at reduced technical risk and cost. Reconciliation between the survey output and existing pond and materials accountancy databases is ongoing. It is anticipated that the results of the survey will facilitate future Physical Inventory Verifications (PIV's) by the safeguards regulator Euratom, who performed a successful PIV at the facility in early October.

Another key achievement at this facility has been the retrieval and export of one skip containing Magnox fuel; signifying the first such export from the plant in fifteen years. The fuel was safely transferred to another Sellafield facility for inspection and repackaging and has now been transported to another plant for reprocessing. If the reprocessing trial is successful this new approach has the potential to significantly accelerate the decommissioning of this legacy pond and could take up to ten years off the program.

We are meeting the challenge of contaminated land and groundwater at Sellafield. During 1941, prior to the nuclear mission at Sellafield, a Royal Ordinance Factory (ROF) was developed at the site for the production of trinitrotoluene (TNT). TNT production stopped after World War II and the site was cleaned, although residual contamination in the subsurface could consist of TNT and derivatives, acids, heavy metals, and organic solvents.

In 1947 the nuclear site was created. A number of leaks of radioactive liquors to the subsurface are known to have occurred in the Separation Area of the site over the past fifty years. Site characterization work to date has demonstrated that as a result of those leaks contaminated subsurface soils primarily exist below the Separation Area, but also outside it. Groundwater monitoring wells indicate that radioactive groundwater exists as several plumes within and outside the Separation Area. In addition to radioactive contaminants, organic and inorganic contamination is present in the form of salts of neutralized acids, petroleum hydrocarbons, heavy metals, and poly-nuclear aromatic hydrocarbons.

To be in compliance with Environment Agency (EA) and Nuclear Installations Inspectorate (NII) regulations governing contaminated lands, British Nuclear Group Sellafield Ltd must demonstrate to regulators and stakeholders that the contaminated land legacy at Sellafield is being managed in a safe, effective and timely manner. Toward that end, an overall program of work was initiated in 2000 that was split into two phases. Phase one covered site characterization of the subsurface outside the Separation Area along with work like numerical modelling and environmental risk assessment. The first phase was substantially completed by

March 2004. The second phase, Sellafield Contaminated Land & Groundwater Management Project (SCL&GMP), addresses site characterization of the subsurface beneath the Separation Area and is scheduled to start in late 2006. In addition, safety case documentation has been prepared to address risks and ensure a consistent approach to managing the day to day activities associated with excavations, leak detection and mitigation. Work to this point has demonstrated that risk to the public is minimal.

We face many challenges while conducting cleanup activities at the Sellafield Site. In order to manage these challenges we have structured the success of our mission around them, they include:

- Safety and environmental performance.
- Substantial transition from owner/operator to contractor – we now have a customer.
- Shift from manufacturing to cleanup culture.
- Project management focus including new systems, processes and reporting.
- Near Term Work Plans (NTWP) and Lifecycle Baseline (LCBL) discipline and opportunities.
- Demonstrating we are providing value for money to our taxpayers.
- Building our supply chain to support our program deliverables and provide open and transparent competition.
- Capitalizing on innovation and acceleration opportunities.

ORGANIZATION AND RESOURCE ENHANCEMENT

British Nuclear Group has an effective structure with a small central executive team providing strategy, policy, central focus, and direction for the four business areas: Management Services (Sellafield, Reactor Sites), British Nuclear Group Project Services, BNG America, and AWE Management Ltd (Fig. 3.).

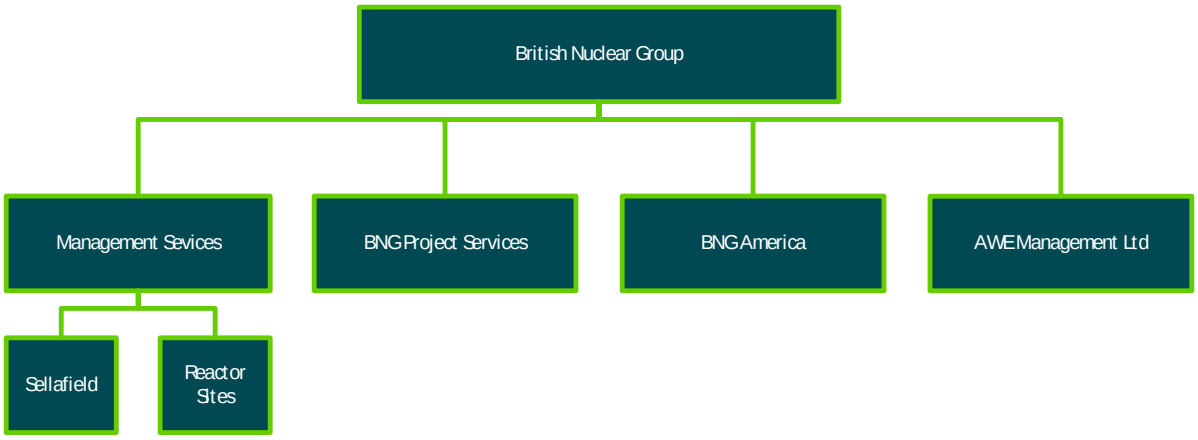

Fig. 3. British Nuclear Group organization.

Our mission is to redefine service excellence and best practice, based upon innovation and knowledge, while always maintaining the highest focus on safety.

Delivery of the cleanup at Sellafield is undertaken by a project based organization. A flat and lean organization that is focused on delivery, with clear lines of responsibility and complete accountability for delivery focused in the project line (Fig. 4.). Small functional teams support the projects in order to remove the burden and frustrations of business activities. Processes are removed from the day to day activities of the projects which are focused on the real cleanup work.

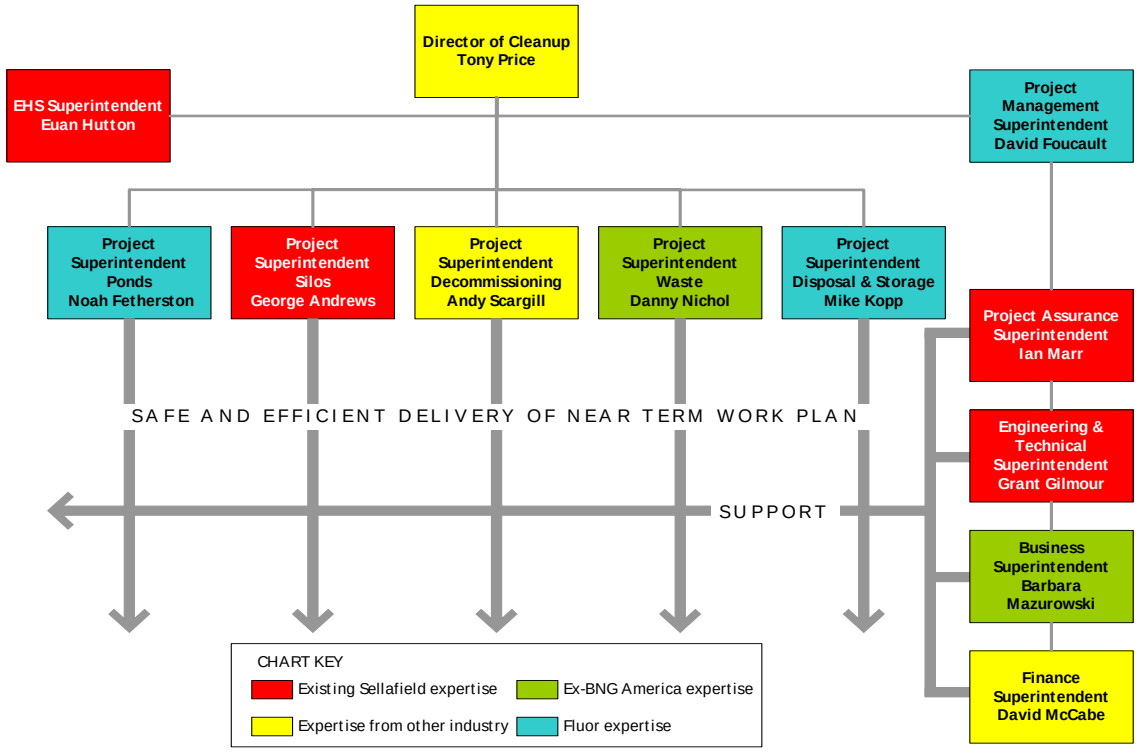

Fig. 4. British Nuclear Group Sellafield Ltd Cleanup organization.

The focus for the cleanup organization is to create a cleanup environment that unleashes all of our skills and resources to deliver time and time again to the satisfaction of our customers, building confidence and a solid foundation that recognizes nuclear excellence in West Cumbria.

The vision we want to paint for our workforce and community of the Sellafield cleanup, is that safe and successful delivery of cleanup builds a prosperous and secure future for West Cumbria and the nuclear industry.

In order to focus our workforce on the key challenges we face we have developed six priorities for the Sellafield Cleanup organization:

1. Safety and Environment.

2. Delivery.
3. Innovation.
4. Supply chain.
5. Customer satisfaction.
6. Leadership, workforce engagement and culture.

The organization is further strengthened and enhanced by a mix and influx of experts in their own field and in the area of decommissioning. This is a team that is highly focused and motivated by the challenge of the work. This team includes people from the oil and gas industry, other decommissioning projects, and Fluor who have recently made strides in cleanup and decommissioning at the Fernald site, and in sludge removal at the Hanford facility. We have taken the opportunity to build upon our strengths in ways which best serve our customer, regulators, the communities around the site, and the contracts we manage.

OPPORTUNITIES

The cleanup program at Sellafield represents not only the largest cleanup project today but also the largest opportunity for the British nuclear industry and for the area of West Cumbria.

Safe and Environmentally Sensitive, Successful Cleanup

Safety and environmental performance underpin everything. We have the opportunity to demonstrate to our regulators: the Nuclear Installations Inspectorate (NII) and the Environment Agency (EA) that cleanup of the ponds and silos, and hazard reduction, can and will occur using straightforward program management tools and good program management techniques. We will also be challenging long standing internal bureaucracy in order to streamline our work and allow our workforce to focus on safety and the cleanup mission.

Value for Money

By reducing complex bureaucratic systems, processes, and replacing them with proven decommissioning techniques, we have achieved significant project acceleration and cost reduction.

Successful Nuclear Decommissioning Authority

We have an opportunity to support the NDA and help them become responsible stewards of taxpayer money. This support will be in the form of delivery, time and time again on the annual work plans and even accelerating the delivery of cleanup. This demonstration of performance will build confidence in the British Nuclear Group Cleanup organization.

Foundation for the Future

By providing safe, efficient and effective cleanup, we are providing an opportunity for the future of our surrounding community in West Cumbria. Through well-planned and competitive procurements for major subcontracts in the cleanup arena, we are bringing new industry and cleanup opportunities to the community, and plan on supporting economic development throughout the cleanup process. This will enable us to make decisions that reflect the

community's goals while supporting jobs for the future. We will support the community in building and contributing to an infrastructure that welcomes new industry into the area. This is a two way initiative; we demonstrate support for the community, and the community has confidence that we can deliver cleanup and support new nuclear opportunities for the nation.

New Build/Repository
The cleanup of Sellafield represents an economic growth opportunity for the British nuclear industry; a prime location and skilled workforce for new nuclear Generation 4 power stations.

Workforce Engagement and Recognition
Our highly skilled workforce is our greatest asset. Our workers have transitioned from operators to decommissioning workers. We have provided training and jobs in the cleanup program. We have a flexible workforce willing to contribute to the cleanup mission, through their support of this massive culture change from owner/operator to cleanup contractor. In truth, the workforce has demonstrated that they are partners in these initiatives but also have led the way in supporting safety resource management. We recognize and reward our workforce through providing more and greater opportunity for continuing employment and skill retraining.

Support our Local Community in West Cumbria
With a reputation for providing support to the local economy and community, we are the recognized champions for social responsibility, committed to openness and transparency in dialogue with our stakeholders. We engage in extensive communication activities and we lead the way in engagement with local communities and stakeholder management.

It Has Been Done Before
There are many examples here in Britain where this kind of regeneration and invigoration of the local community has been beneficial. Aberdeen has been transformed from a small fishing village into a major city that is prosperous with new business and opportunities.

There is a Real Opportunity to Redesign Our Service Supply Chain
Align the procurement plan to the Life Cycle Baseline to allow us to effectively manage our subcontractors and future work at Sellafield. A robust procurement plan that matches our cleanup approach and strategy will allow us to get the most value out of our subcontracts. It will allow us to provide specifications and work scopes that will enable our contractors to achieve to our baseline goals. Provide the proper contract vehicle to enhance our subcontractor's delivery: incentive based, fee placed on end state/delivery, and turnkey projects so that we do not have to design/build/operate incongruities. This then allows our subcontractors to put together competitive bids. For example, the number of contracts we are competing has risen from 18% to 57% and will go to 75% in the near future. We have saved over $7 million this year as a direct result of our new competitive approach.

Innovation

We have the opportunity to think differently. Building confidence in delivery with our regulators will provide opportunities to focus on long term cleanup and defining end states, and national solutions to waste issues, rather then focus inwardly on short term regulatory issues. The diversity of our team provides us with opportunities to import tried and proven technology and techniques to improve our work plans and make significant gains in reducing hazard. Challenging long standing assumptions on how we can process sludge and fuel through existing operations rather than focus on expensive new build, provides us opportunities to make real progress in a safe and efficient manner. Identifying opportunities for utilizing fit-for-purpose solutions, instead of highly engineered technical ones that take an inordinate amount of time and money, will allow us to engage with our workforce to develop those simple straightforward tools and techniques that have proven to be the most effective in decommissioning.

CONCLUSION

Nuclear decommissioning and cleanup presents a significant challenge with expenditure of many billions of dollars and taking several decades to complete. Our values provide a framework for focusing on this challenge and getting the job done. Our objective is to continually and aggressively challenge cost and time targets, without compromising safety, security, or environmental standards. Cleanup at Sellafield is a massive task and significant decommissioning work on some plants has already been completed, with decommissioning activities on others well underway. These are some of our achievements to date and we have delivered them in less than one year working under contract to the NDA. Many of them illustrate the extent to which we have accelerated future work into our current NTWP. During this conference we will be presenting the details of a few more of our near term successes. But we have only just begun.

APPENDIX 1: HISTORY OF THE SELLAFIELD SITE

Sellafield began life in the Second World War. It was originally a Royal Ordnance factory manufacturing high explosives. To balance world power Prime Minister Attlee asked nuclear engineers and physicists to build Britain's first nuclear weapon.

In September 1947, work began on the construction of two air-cooled reactors. By March 1952, these reactors were in operation producing plutonium for military purposes. What the Sellafield site consisted of then was two reactors, known as the Windscale Piles. Their massive chimneys distinguished these. Between the two reactors was a water storage pond into which the fuel was submerged in its initial discharge from the reactors. Nearby was the fuel reprocessing plant, a ten-story building topped by a large ventilation stack.

In 1952 the world's first a commercial sized nuclear power station was designed by Christopher Hinton, later Lord Hinton. The Calder Hall reactor one was opened by her Majesty the Queen on October 17, 1956 just four years after construction began.

Three more reactors followed and these have now been operating successfully for over 40 years. They provide enough electricity to serve a city of 150,000 people along with providing a dedicated supply of electricity for the Sellafield site and constant steam supplies for the fuel reprocessing plant. In 1955, construction started on a virtually identical Power Station at Chapelcross in Dumfriesshire, southwest Scotland.

Calder Hall and its sister station Chapelcross became the forerunners of the eleven commercial sized Magnox Power Stations that came into operation throughout the UK between 1961 and 1971. During this period and up until 1990 the Magnox Power Stations were owned and operated by the Central Electricity Generating Board.

After ownership of the Site went through several company ownership changes, ownership of the Magnox fleet passed to BNFL plc following the merger of BNFL plc and Magnox Electric plc in 1998. Two additional Magnox stations were built overseas with one at Latina, Italy, and one at Tokai Mura, Japan. Both stations have now ceased operation. All Magnox Stations will close by 2010. Magnox Reprocessing on the Sellafield Site is forecast to end by the year 2012.

Magnox is the name given because the solid metal uranium fuel is encased in magnesium alloy cladding. Because of the increase in Magnox fuel needing to be reprocessed, it was soon realized that the original reprocessing plant could not cope, so a new reprocessing plant was built and came on stream in 1964.

Reprocessing Magnox fuel is a very simple chemical process. The uranium bar is dissolved in nitric acid; a solvent is added to separate the uranium which makes up 99.2% of the mixture. The uranium is drawn off and another solvent is added which separates the plutonium, about 0.3%. The 0.5% that remains is highly active waste products which are stored in stainless steel tanks inside concrete walls.

Another well-known landmark at Sellafield is the Windscale Advanced Gas Cooled Reactor (WAGR). This was a small prototype reactor, 30 Mega Watt (MW), used by the UKAEA, who owned and operated it. This was the second generation of nuclear fuel, Uranium oxide ceramic pellets encased in stainless steel. This cladding was valuable in two ways, firstly the fuel could be taken up to much higher temperatures so making the reactor more efficient and secondly, when the fuel is stored in water, there are no corrosion problems as with the magnesium alloy cladding of Magnox fuel. The Windscale Advanced Gas Cooled Reactor Power Station (AGR) began operating in 1963, closed in 1981, and is currently being decommissioned. The reactor was the forerunner to the UK's second generation of Power Reactors. Seven commercial sized AGR Power Stations came into operation between 1976 and 1988. The Power Stations are now operated by the privatized utility, British Energy plc.

WAGR was used as a test bed for decommissioning and has enabled British nuclear scientists to become world leaders in the decommissioning of nuclear plant.

In November 1985 the then Prime Minister, Margaret Thatcher, officially opened a new Fuel Handling Plant, costing £300 million. This building receives, stores, and decans (strips the magnesium cladding) from all Magnox fuel before reprocessing. It also has a storage pond for Commercial AGR fuel. Next to, it is SIXEP, the Sellafield Ion Exchange Plant. This single plant has had a tremendous impact in reducing radioactive discharges to the Irish Sea. It mainly treats water from fuel storage ponds, removing radionuclides before the effluent is discharged to the sea.