EM-5.22 Lessons Learned Bulletin	**May 2017**
	Sellafield MOX Plant Lessons Learned

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Statement:

The Office of Environmental Management provides Lessons Learned applicable to EM projects. Lessons Learned, from Federal and private sectors, are referenced as examples to further bolster EM's knowledge base in the execution of successful work. This month's bulletin focuses on lessons learned from the design and planning of the Sellafield MOX Plant.

The Sellafield MOX Plant is located in Cumbria, UK and is awaiting decommissioning and demolition. This facility ceased operations due to lack of production capacity to meet its goals and loss of the primary Japanese customer. The UK Nuclear Decommissioning Authority (NDA) deemed it in the best interest of the taxpayer to close the plant. Other factors that contributed to closing this facility were lack of management strategy, design, and poor nuclear site culture.

Discussion:

BACKGROUND

British Nuclear Fuels Ltd (BNFL), a government owned entity, had successfully proven that MOX fuel could be produced on a small scale through the success of their MOX Demonstration Facility (MDF). The British government approved the construction of the Sellafield MOX Plant (SMP) and awarded a contract to BNFL for the design, construction, and operation of this facility. The British Government approach for funding this project was based on generating income through processing their plutonium stockpile and subsequent sale of the created MOX fuel to utilities. This project also intended to support the development of BNFL's reprocessing business and expertise. In 1997, the Sellafield MOX Plant completed construction and produced its first MOX fuel in 2001.

The SMP operated for 10 years before shutting down due to inherent issues with the design and operation of the plant, which affected profitability. Shortly before the decision to shut the plant down, the UK government partnered with Japan to use the SMP to process some of the Japanese plutonium inventory. In 2011, the Fukushima earthquake and tsunami impacted the global nuclear industry, which led to the decision to discontinue with MOX fuel. The Nuclear Decommissioning Authority (NDA) announced that the plant would be closed "at the earliest practical opportunity" to "ensure that the UK taxpayer does not carry a future financial burden from the SMP". (Nuclear Decommissioning Authority, 2011). This lessons learned references a 2012 report which was developed to address lessons learned from the lifecycle of the SMP. This report includes the key issues contributing to the early closure of the SMP.

Management Strategy

Having successfully demonstrated MOX production on a small scale, BNFL was awarded the SMP design and build contract. BNFL developed a business case for constructing this facility. The original business case assumed that BNFL would acquire Siemens, including its MOX expertise. When the Siemens acquisition was abandoned, BNFL proceeded with SMP nevertheless, and relied on its relatively limited in house expertise. As a result, SMP had very significant gaps in both its design and operating capability. This meant that the plant, as built, was not capable of meeting requirements and struggled from the start with a wide range of operational problems. Construction of the plant before it had been

justified resulted in a significant hiatus between completion of construction and the plant entering operations. In addition, the SMP culture (as part of the Sellafield site) was not well suited to a precision manufacturing production facility, and for much of its operating life there was an unwillingness to face up to the scale of the problems facing the plant.

UK law required that BNFL provide viable justification that the project would benefit the taxpayer before commencing work. However, BNFL proceeded through design and construction without ever providing justification of benefit of the project and the expected revenue of the plant. Although SMP construction was completed in 1997, the plant didn't begin operations until 2001 and was closed in 2011 with a poor performance record. The plant delivered only 13.8 tons of MOX in 5 years, even though it was designed for a capacity of 120 tons per year, and the construction cost was overrun by 360%. The SMP was intended to be a source of revenue to the government and now that operations have ceased, the lifecycle cost of the project was estimated to have a £2.2B impact to the UK taxpayer. BNFL's management strategy did not safeguard the UK taxpayer against unnecessary risks. Had BNFL followed the legal process, a justification would have been provided to the government, which would have saved the project time. Had the government understood the limitations of BNFL to design the project, the project may have been avoided and spared the UK taxpayer £2.2B.

Design

BNFL had successfully designed, constructed, and operated the MDF; however, they lacked the right experience in scaling the project to a large-scale production facility. The major area of concern for the design team was the increase in the amount of radioactive material, 120 tons of heavy metal throughput per year. Additional measures were required to address worker safety through automation and the increased heat impact on the system. BNFL lacked capability and expertise to address these issues. The design team relied heavily upon theoretical computer modeling to bridge their gap in expertise, and to address the heat related issues. (Elliott, 2012) BNFL had not validated their design nor conducted independent reviews. This resulted in a plant that was not able to achieve the functionally required plant production, and as a result the MOX product. In order to physically test the functionality, BNFL would need to use a simulant with characteristics of plutonium oxide. Because no simulant exists for plutonium oxide, uranium dioxide was chosen, the closest simulate. This simulant had a much cooler heat characteristic, and thus did not provide the exact behaviors in tests. The plant design also required a higher level of automated operations. Particular emphasis was placed on remote welding equipment for fuel rods and automated inspection techniques, including the use of automated real time CCTV imaging and laser surface inspection all intended to protect the worker from high dose counts. SMP was constructed per design and struggled to operate to meet the UK Government expectations.

BNFL did not have a systematic approach to address their lack in experience. Though they used valuable tools to aid in design, such as theoretical computer modeling and simulant materials, their knowledge gaps could not be overcome without experience. BNFL did not use the incremental development of the MOX technology, increase their working knowledge, which would ensure success. Because they didn't use a systematic approach in proving their scaled up design, once completed, the design was not able to perform as anticipated.

Site Culture

The Sellafield site had undergone several transitions and reorganizations since opening in 1956. The management and oversite contracts for the site failed to provide enough fiscal protection to the UK taxpayer in the site's life cycle activities. The UK government's response was to develop new agencies and implement new management structures, which would give them more control over risk and financial impact. The SMP Lessons Learned stated that the site culture was not well suited for the production of MOX fuel. MOX fuel production required a high level of automated processing and precision manufacturing, which was outside of BNFL's operational skill set. A mixture of inexperience and the lack of focus on protecting the taxpayer, resulted in a site culture that did not embrace currently accepted methodology of validating design, conducting technical readiness assessments and technical readiness levels, and accountability for meeting mission objectives and cost targets. The SMP Lessons Learned stated that Sellafield was "*unwilling to face up to the scale of the problems facing the plant*". (Lessons Learned from SMP, 2012) The lack of expertise in MOX production affected the ability of the team to estimate, schedule, and plan this type of work.

Inaccurate performance reporting was identified as a contributing factor as well as BNFL's lack of significant experience in operating Sellafield plants, and the reprocessing of fuels for the reactors. The production of plutonium did not provide BNFL with the right experience or culture for a new business line of fuel production for profit.

Recommended Actions:

The following Lessons Learned derived from SMP should be used to inform decision-making, planning and execution of the project covering areas including:

- Having the right skills and capability which may involve making use of appropriate third party experience
- Ensuring there is a good design in place and early resolution of any design issues
- Realistic costing and planning
- Avoiding imposition of artificial time and cost constraints
- Safeguarding value for money (VFM) by seeking to minimize risk exposure of the US taxpayer through, inter alia, a robust contractual framework;
- Ensuring fit for purpose, consistent operational / safety design criteria that are as far as possible, not modified over time
- Not carrying-on when issues arise until there is clarity on the cost implications and scale of the correction that is required
- Clarity and consistency in the basis of VFM analysis
- Ensuring good quality project management including realistic targets, performance metrics and a gated process
- Ensuring appropriate phasing in the project plan, for example, only building the plant and entering into contracts with customers after justification is in place
- Ensuring there are robust governance arrangements in place, both with government and with the responsible corporate board, an appropriately qualified governance team with the necessary commercial and financial skills and that government has appropriate levers over its funding commitments and a clear monitoring framework
- Addressing cultural issues, including openness, honesty and realistic reporting.

Critical Decision(s):	CD-0 to CD-4
Facility Type(s):	All
Work Functions(s):	Project/Program Management
Technical Discipline(s):	Contracting, Design, Operations

References

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