DOE-FIU SCIENCE & TECHNOLOGY WORKFORCE DEVELOPMENT PROGRAM

STUDENT SUMMER INTERNSHIP TECHNICAL REPORT

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A Brief History of the Yucca Mountain Project

Principal Investigators:

Edgard Espinosa (DOE Fellow)
Florida International University

Edgardo Deleon, Mentor
Department of Energy Headquarters, Germantown Office

Acknowledgements: Hitesh Nigam

Florida International University Collaborator and Program Director:

Leonel Lagos Ph.D., PMP®

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ABSTRACT

Much hope was placed on the Yucca Mountain project. To many, it seemed the only viable solution for the final storage of spent nuclear fuel that has been in temporary storage for years at DOE sites and national laboratories across the complex. The Yucca Mountain Repository was the United States' designated deep geological repository storage facility for used nuclear reactor fuel and other radioactive waste. Its location was to be between the Mojave Desert and the Great Basin Deserts in the state of Nevada. Although the location was highly contested by environmentalists and residents, it was approved in 2002 by the United States Congress. In 2009, the Obama Administration stated that the site was no longer an option and proposed to eliminate all funding in the 2009 United States federal budget, which prompted inquiries from the Nuclear Regulatory Commission (NRC).This report provides a brief history of the project, its end point, and the continuing need for a long-term storage solution for used nuclear fuel.

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1. INTRODUCTION

The internship held by Mr. Espinosa was not a typical technical position at a national laboratory, DOE site, or with an authorized DOE contractor. Instead, Mr. Espinosa held a position at the EM-33 Office of Nuclear Materials Disposition where he received an awareness of the role that DOE Headquarters plays in governing the actions that are executed at the DOE sites. This experience allowed him to gain an understanding of the organization's structure allowed him to witness the internal processes and operations. Both mentors, Mr. Deleon and Mr. Nigam, provided Mr. Espinosa with information, advice and insights on many of the aspects of working for DOE.

The research topic for Mr. Espinosa's internship was one which had a great impact on the operations within EM. Much hope was placed on the Yucca Mountain project. To many, it seemed the only viable solution for the final disposition of used nuclear fuel that has been in storage for years at DOE sites and national laboratories across the complex. This report provides a brief history on the project and its end point. In addition information regarding the contributions Mr. Espinosa made to printed documents for the Office of Nuclear Materials Disposition is included.

2. EXECUTIVE SUMMARY

This research work has been supported by the DOE-FIU Science & Technology Workforce Initiative, an innovative program developed by the US Department of Energy's Environmental Management (DOE-EM) and Florida International University's Applied Research Center (FIU-ARC). During the summer of 2010, a DOE Fellow intern (Mr. Edgard Espinosa) spent 10 weeks doing a summer internship at DOE Headquarters with the EM-33 Office of Nuclear Materials Disposition, under the supervision and guidance of Mr. Edgardo "Gary" Deleon and Mr. Hitesh Nigam. Mr. Deleon is the Director of EM-33 and has a background in nuclear and materials engineering. The intern interacted on a daily basis with Mr. Nigam. The intern's project was initiated in June 1, 2010, and continued through August 7, 2010.

The internship held by Mr. Espinosa involved working directly with DOE Headquarters. At the EM-33 Office of Nuclear Materials Disposition, Mr. Espinosa was able to get a grasp of the role that DOE Headquarters plays in governing the actions that are executed at the DOE sites. The research topic for Mr. Espinosa's internship was one which had a great impact on the operations within EM. Much hope was placed on the Yucca Mountain project. To many, it seemed the only viable solution for the final disposition of used nuclear fuel that has been in storage for years at DOE sites and national laboratories across the complex. This report provides a brief history on the project and its end point.

3. YUCCA MOUNTAIN

Who is responsible in seeing that the used nuclear fuel is appropriately managed and receives proper handling and storage? What is to be done with all the used nuclear fuel from nuclear reactors and defense weapons programs generated long ago? For the summer of 2010, Mr. Espinosa was able to be part of the EM33 Office of Nuclear Materials Disposition (Office). The Office is part of the DOE framework and their main objective is dealing with the used nuclear fuel generated over the years. More formally, the Office's mission and objective is to perform analysis, develop and recommend program strategies for management and disposition of EM nuclear material, spent nuclear fuel (SNF) and other challenging materials (CM). In addition, the Office is involved with several partnerships with other agencies within DOE which attribute to the management and disposition of used nuclear fuel.

Interning at DOE Headquarter provided a different perspective to Environmental Management (EM) and its mission. While the national laboratories and DOE sites are at the forefront of EM activities, the work conducted at Headquarters provides a unique perspective on how the work is executed at the sites. Headquarters is where decisions are made. The directors and managers are constantly juggling priorities and funding to execute their mission. Before any task was planned, even if it was necessary and significant, the question "Do we have money in the budget for it?" was asked before "How much good will come from this?" The Yucca Mountain geological repository is a great example of this constraint.

Figure 1. Left to Right: Hitesh Nigam (EM33) Edgard Espinosa, Gary Deleon (EM33).

3.1 Yucca Mountain - Brief Opening Remarks on the Extinct Geological Repository

The Yucca Mountain Repository was the United States' designated deep geological repository storage facility for used nuclear reactor fuel and other radioactive waste. Its location was to be between the Mojave Desert and the Great Basin Deserts in the state of Nevada. Although the location was highly contested by environmentalists and residents, it was approved in 2002 by the United States Congress. In 2009, the Obama Administration stated that the site was no longer an option and proposed to eliminate all funding in the 2009 United States federal budget, which prompted inquiries from the Nuclear Regulatory Commission (NRC).

The purpose of the Yucca Mountain project was to comply with the Nuclear Waste Policy Act of 1982 and develop a national site for spent nuclear fuel and high-level radioactive

waste storage. The repository has a statutory limit of 77,000 metric tons (85,000 short tons). The Nuclear Waste Policy Act further limits the capacity of the repository to 63,000 metric tons (62,000 LT; 69,000 ST) of initial heavy metal in commercial spent fuel. The 104 U.S. commercial reactors currently operating will produce this quantity of spent fuel by 2014, assuming that the spent fuel rods are not reprocessed. Currently, the US has no civil reprocessing plant.

By 2008, Yucca Mountain was one of the most studied pieces of geology in the world with the United States having invested $9 billion on the project. DOE estimates that it has over 100 million U.S. gallons of highly radioactive waste and 2,500 metric tons (2,800 short tons) of spent fuel from the production of nuclear weapons and from research activities in temporary storage. The cost of the facility was being paid for by a combination of a tax on each kilowatt hour of nuclear power and by the taxpayers for disposal of weapons and naval nuclear waste. Based on the 2001 cost estimate, approximately 73 percent was funded from consumers of nuclear powered electricity and 27 percent by the taxpayers. The latest Total System Life Cycle Cost presented to Congress on July 15, 2008 by Director Sproat was $90 billion.

The reason that the Yucca Mountain repository was terminated without the possibility of ever being revisited remains vaguely expressed. The documented reasons are technical, including the repository not being adequate enough to accommodate the spent nuclear fuel inventory in the present and the in the near future. However, it is probable that the reason behind the termination has political advantages and commitments attached to it. The United States verges on a nuclear renaissance that relies on having a geological repository plan. Much preparation is needed to support a nuclear renaissance.

3.2 The Necessity of a Yucca Mountain-Like Geological Repository for the Future on Nuclear Energy

The United States is on the verge of a nuclear renaissance. U.S. demand for electricity is expected to increase by 40 percent over the next 25 years. The recent push to build new nuclear power plants in the United States is forcing some to consider alternatives to the Yucca Mountain geologic repository for spent nuclear fuel. These options include recycling nuclear fuel and opening interim storage facilities, such as the H-canyon at the Savannah River Site (SRS). Both options could play critical roles in any American nuclear power renaissance.

The United States is generating 20 percent of its electricity from 104 nuclear power reactors, and these reactors in turn have generated over 56,000 tons of spent nuclear fuel. Regarded as waste, this spent fuel in fact has the potential of being a valuable resource.

Although politicians and the public have begun to accept that nuclear power is a clean and affordable source of energy, questions remain about how to manage spent fuel. There are at least three solutions to this problem:

- First, the spent fuel could be put directly into Yucca Mountain for permanent storage. While politics has made this impossible to date, no scientific, safety, or technological reason prevents it.
- Second, the U.S. could recycle (reprocess) spent nuclear fuel, which still contains usable fuel that could be recovered and "used again" for future power generation. This could be achieved through numerous methods. Some technologies have already been commercialized abroad, and others are being researched and developed. These technologies will enable more efficient use of uranium resources and could drastically reduce the amount of high-level nuclear waste. In the end, however, some byproduct will still need to be placed in permanent geologic storage.
- Third, the spent fuel could be stored on an interim basis at shorter-term storage facilities. This option also has advantages. Simply allowing the spent fuel to decay over time decreases its heat load, making it easier to store for the long term. Shorter-term storage would also provide time to develop new technologies that would improve long-term management of spent fuel.

Both recycling and interim storage would provide flexibility, but geologic storage in Yucca Mountain will still be necessary.

3.2.1 The Role of Yucca Mountain

In every scenario, the Yucca Mountain repository is critical to the long-term success of nuclear power in the United States. The reality is that some of the byproducts of nuclear fission will last a long time. Therefore, the U.S. needs a place where it can be safely stored and remain under the control of an enduring institution like the U.S. government after the facility is closed. If properly managed, Yucca Mountain should be adequate for that purpose.

While the current direct deposit scenario, in which spent fuel will be taken directly from the reactor and placed into storage, dictates that numerous Yucca-like repositories be developed, other scenarios that include processing and recycling spent fuel could ensure that Yucca alone would be adequate to store America's nuclear waste indefinitely. Either way, the Yucca Mountain repository must remain the final destination for America's nuclear waste. Maximizing Yucca Mountain's potential requires that any new spent fuel management regime focus on minimizing waste volume and heat content.

Regrettably, the Yucca Mountain repository is already over a decade behind schedule and probably could not open until about 2020. The primary reason is politics. Opposition, especially from anti-nuclear activists and the Nevada congressional delegation, has slowed progress at Yucca. While the U.S. was not building new reactors, the need to open Yucca was not as pressing, but it is still critical in the long term, and the emerging recognition that nuclear energy is critical to meeting U.S. energy and environmental objectives has made the need even more urgent.

4. VISIT TO SAVANNAH RIVER SITE (SRS)

The General Accountability Office (GAO) staff visited SRS in an effort to examine and report on how the facility will be impacted now that the hopes of a geologic repository have been abrogated. In addition to GAO, members of EM-33 (Hitesh Nigam and Edgard Espinosa) visited the site as well. SRS presented the status of the SNF and high-level waste (HLW) Program and stated that there are no changes to any ongoing operations and no near term impacts to the site because of the changes in the geologic repository. SRS does not have any regulatory or state driven requirements, no milestones, or any penalties that would be assessed by changes to Yucca's future.

Figure 2. The Team : Left to Right - Dawn Gilles (SRS) , Hitesh Nigam (DOE -EM 33) , Eugene Gray (GAO), & Edgard Espinosa (DOE - EM 33).

Among the body of presentations by SRS officials and contractors, concerns on plutonium loading (897 g/m^3) and impact from spent nuclear fuel exchange between Idaho and SRS were discussed. There were concerns also regarding the aging of the facilities, primarily, how long the 50-year old facilities can operate safely. The GAO is still in the early stages of data collection and would like all available reference documents on this subject. The final GAO report is expected sometime late in 2010 or early 2011. As part of the site visit, the team had an opportunity to visit the Defense Waste Processing Facility, Glass Waste Storage Building, L-Basin, and H-Canyon Waste Tank Farm. The team was also fortunate to witness the unloading of a HFIR cask from Oak Ridge into the L-Basin wet storage.

Figure 3. The delivery of HFIR core, removing the cask for unveiling.

5. CONTRIBUTION TO DOE CIRCULATED DOCUMENTS

During the course of the internship, Mr. Espinosa provided input to Office documents. To accomplish this, he needed to gather, read, and understand the background information to provide substantial input to the documents. Below are excerpts from a document to which he contributed.

Source: ***Strategic Framework for the Management of Spent Nuclear Fuel***

Source Section 5. Expand efforts of Technology Development for disposition of SNF and other challenging materials

Success Indicators

DOE has over 2,400 metric tons of Spent Nuclear Fuel (SNF) and various inventories of nuclear materials. The Nuclear Materials Disposition Program Area is responsible for developing and deploying the technologies necessary to safely store and disposition these materials.

- Develop new technologies to assure long-term, interim safe storage.
- Develop robust technologies that can be applied to retrieval and stabilization of DOE fuels.

There are additional quantities of nuclear materials, dubbed "Challenging Materials" (CM) due to the diversity of the materials and the lack of clear stabilization paths. Many of these CM could be disposition through appropriate conditioning, processing, and /or repacking.

- Develop comprehensive cataloging and categorization of challenging materials and material fuels.
- Develop and demonstrate disposition paths and technologies.

Source: ***Strategic Framework for the Management of Spent Nuclear Fuel***

Source Section 6. Carry forward the efforts of the International Program ,

The International Program is devised and administered to advance and deploy technologies to meet identified environmental remediation, highly radioactive and waste management needs through continued communication, collaboration, and integration with international entities.

Success Indicators:

- Engage with multinational forums/agencies.
- Expand existing partnership and establish new collaborative international agreements.
- Engage with international visitors at EM and foreign sites providing the unique opportunity to facilitate information exchange and collaboration.

- Participate in international conferences to which would allow EM to promote the EM program to an international audience.
- Coordinate with other US agencies and programs.
- Engage with other DOE program offices which support and enhance the EM international program goals and objectives.

Source: ***Strategic Framework for the Management of Spent Nuclear Fuel***

Additional information was added to the section titled "Key Issues and Path Forward". It was an updated which provide the results of an investigation that was perform . The effort included EM 33s, Deborah Kula.

Issue 4: The path forward for disposition of EM's sodium-bonded SNF is not determined.

To address the issue of 56 metric tons heavy metal (MTHM) of sodium bonded spent nuclear fuel, a group of subject matter experts have gather from three Program Secretarial Offices (PSO): Environmental Management (EM), Nuclear Energy (NE), and National Nuclear Security Administration (NNSA). Collectively known as a Working Group, the group of experts seeks to provide a resolution to the long-term management and storage of sodium bonded fuel since the geological repository is no longer a viable solution. It has not been determined what protocol should be executed for long-term storage of sodium bonded fuel due to the limited understanding of the fuel and storage degradation. Near-term planned actions required amendments. The Working Group arrived at several recommendations for handling sodium bonded SNF:

- Evaluating the impacts of sodium on the material degradation of sodium bonded SNF and the safety basis of facilities storing this fuel over a long period of time.
- Evaluating the quality assurance programs under which the sodium-bonded SNF is managed.
- Evaluating alternatives for moving the FFTF driver fuel and EBR-11 driver fuel from their current storage locations.
- Maintaining status quo on the Fermi-1 blanket fuel.
- Proceeding with plans for the SNL sodium-debris bed material.
- Prioritization for funding of electrochemical treatment.
- Considering life-cycle costs when selecting the path forward for sodium-bonded SNF.

It's very difficult to know for certain the path of disposal and final destination for the SNF. Many intermediate processes may be used; the best option is not known for certain. The Working Group has presented a set of conclusions and recommendations to be considered when arriving at a final decision.

The Environmental Management Office was instructed to generate and have available a Strategic Plan. The Strategic Plan would provide a comprehensive outlook on current perspectives on the issues being addressed and future projections on the mission.

6. CONCLUSION

The opportunity to intern at a managing office within the DOE-HQ was enlightening and allowed Mr. Espinosa to gain an understanding of the overall management process. This process begins with the Presidential Administration and the needs of the country. The President has the power to determine the path forward for the country's issues. In regards to the nuclear renaissance the US would like to embark upon, a suitable geological repository is needed. The President approved loan guarantees of 8 billion dollars, which would increase to 54 billion dollars in the coming years, to allow contractors to developed nuclear reactor plants to increase America's energy contribution from nuclear power. American dependency on nuclear energy could increase from the current 20% to an unseen potential. However, the additional generation of electrical power from nuclear energy would increase the generation of spent nuclear fuel, adding to the 54,000 tons already stored at DOE sites. It seems impractical to create more spent nuclear fuel when the government is struggling to manage the current spent nuclear fuel in stock. In lieu of this, Dr. Steven Chu established the Blue Ribbon Commission (BRC). Due to the termination of the Yucca Mountain project, the BRC was commissioned to provide recommendations to DOE on the management of spent nuclear fuel. At the moment, the BRC is within the time frame given to generate these recommendations. We expect to hear final word soon. At the end, it is vital to have a geological repository to store the used nuclear fuel. Unless the government provides an amendment to the license to the geological repository, it would be tough to conceive a disposal plan for the used fuel.

7. REFERENCES

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