A Green Complex: Setting the Stage for a Future Mission
New Mexico and Texas Energy Initiative - 11354

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ABSTRACT

As the Environmental Management (EM) Department of the United States Department of Energy (DOE) moves toward the goal of an environmentally clean North American DOE complex, capital assets such as land and facilities will become available. The Department of Energy's reduction in the environmental footprint brought about through the history of nuclear weapons development and production gives birth to an opportunity for the DOE to leverage assets and help the United States secure its energy future. In parallel with this mission, President Barack Obama and the Secretary of Energy, Dr. Steven Chu, made commitments to reduce greenhouse gas emissions 28 percent by 2020 and deploy renewable technologies across the nation in order to lessen the dependence on foreign oil, address the global climate crisis, and facilitate job creation.

As a result of greenhouse gas reduction measures and the DOE's goal of 90 percent footprint reduction by 2015, the Energy Parks Initiative was developed to utilize available physical assets to further advance the goal of energy security. In response, the New Mexico and Texas Energy Initiative was developed, consisting of a three-phased approach that begins at the Waste Isolation Pilot Plant (WIPP) and then expands into the statewide region.

The first phase will focus on augmenting the WIPP with clean energy, including both solar and wind technologies. The existing infrastructure, workforce, and locally established relationships form an opportunity to be utilized in the future use planning for this DOE site. Phase II is focused on collaboration with national laboratories to integrate with their renewable energy initiatives and Phase III is geared toward the expansion of clean energy production that has a national impact. This approach to the future use planning of DOE sites will establish renewable energy zones that will set the stage for a green complex.

INTRODUCTION

"The transition to clean energy has the potential to grow our economy and create millions of jobs – but only if we accelerate that transition. Only if we seize the moment. And only if we rally together and act as one nation – workers and entrepreneurs; scientists and citizens; the public and private sectors." -President Obama, June 15, 2010

President Barack Obama and the Secretary of Energy, Dr. Steven Chu, made commitments to reduce greenhouse gas emissions 28 percent by 2020 and deploy renewable technologies across the nation in order to lessen the dependence on foreign oil, address the global climate crisis, and facilitate job creation. The Secretary of the Department of Energy (DOE) is also committed to continued research and development in support of further advancement in solar and wind technology. The DOE's Office of Environmental Management (EM) has an objective to convert liabilities (e.g., land, facilities, and materials) into reusable assets that are focused on providing solutions to energy and environmental issues. The following are the primary drivers for clean energy and greenhouse gas reduction:

- Energy Policy Act of 2005 - Established renewable energy goals of 5.0 percent by 2012, 7.5 percent by 2015.
- Executive Order 13423 - Implement renewable energy generation projects.
- Executive Order 13514 and DOE Sustainability Performance Plan - Greenhouse Gas (GHG) reduction targets of 28 percent reduction from 2008 baseline levels by 2020. Includes reductions in GHG's from purchased power for DOE facilities [1],[2].
- Renewable Portfolio Standards (RPS) – Sets requirements for each state within the next five to ten years.
- DOE EM Office Energy Parks Initiative (EPI) – Objective to convert liabilities into usable assets.

Purpose and Scope

The convergence of initiatives aimed at clean energy and greenhouse gas reduction set the stage for the development of the New Mexico and Texas Energy Initiative. There is interest from communities in the exploration of clean energy, energy efficiency, technology optimization, and future development toward commercial-scale capabilities. As a result, the scope of the New Mexico and Texas Energy Initiative has developed into a three-phased approach (Fig. 1):

- Phase I will enable the WIPP to become a model site for net zero greenhouse gas emissions and a center for research and development. These activities will also involve collaboration between New Mexico and Texas.
- Phase II will focus on collaboration with the national laboratories to integrate clean renewable technologies within the state of New Mexico.
- Phase III will expand efforts in New Mexico and Texas to augment power on the national grid.

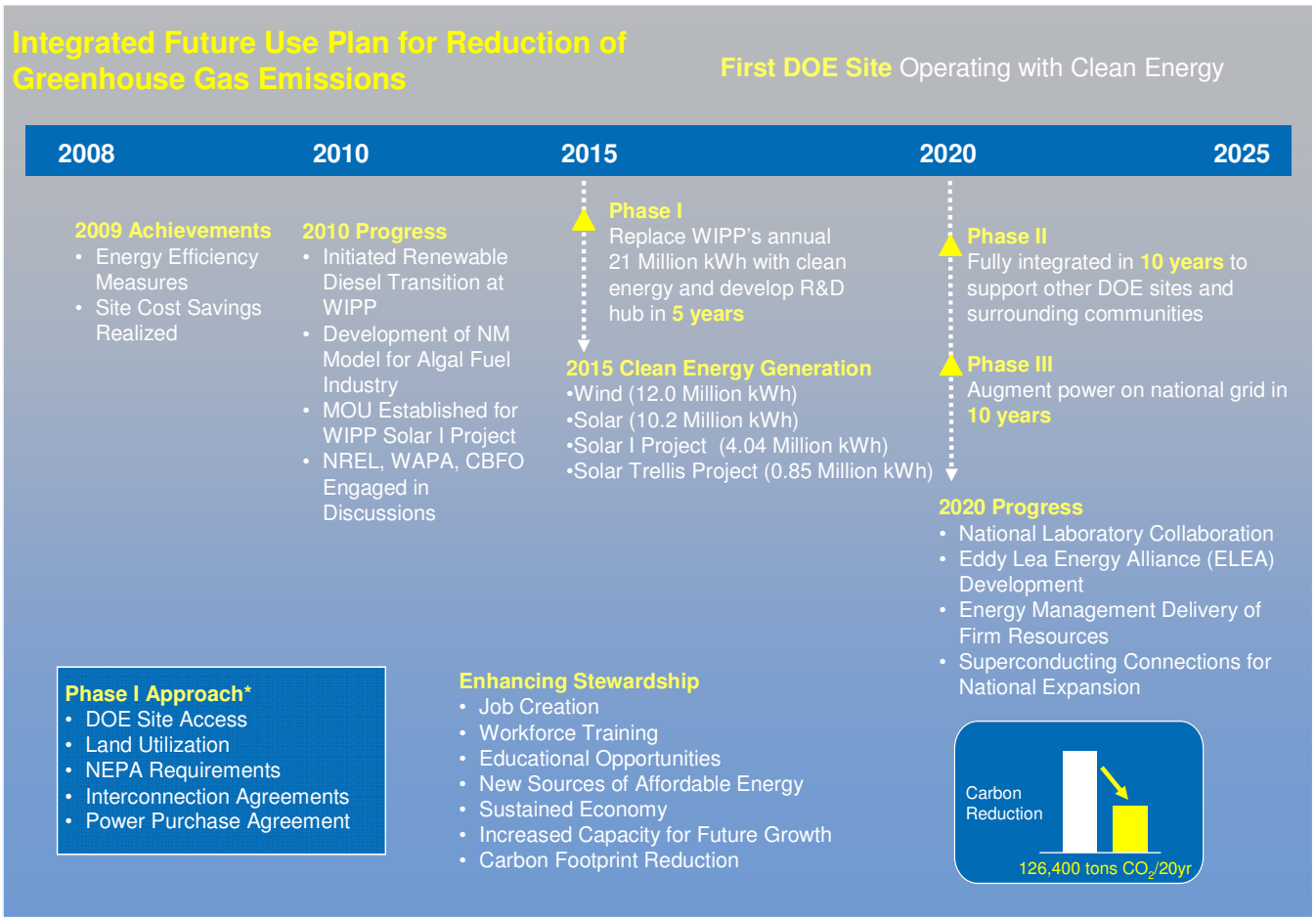

Fig. 1. Integrated Future Use Plan for Reduction of Greenhouse Gas Emissions

WASTE ISOLATION PILOT PLANT SITE

The Waste Isolation Pilot Plant (WIPP) (Fig. 2) is located in Eddy County in the Chihuahuan Desert of southeastern New Mexico, 26 miles east of Carlsbad. WIPP is a critical link in the DOE complex and the nation's nuclear waste disposal system. The WIPP is the nation's only geological disposal facility that safely disposes transuranic radioactive waste (TRU) 2,150 feet underground in a stable salt formation. The WIPP is a DOE facility that is managed by Washington TRU Solutions (WTS).

In 1992, management of the WIPP land was transferred from the United States Department of the Interior to the DOE. The WIPP is situated on a 16 mi^2 (41.4 km^2) tract of federally withdrawn land that is available for utilization and has been identified for the beginning development of the New Mexico and Texas Energy Initiative. Supporting future expansion, the WIPP is located within close proximity of the three national power grids: Western Electricity Coordinating Council, Electric Reliability Council of Texas, and the Eastern Interconnection.

Fig. 2. Aerial View of the WIPP

The WIPP has an annual electric consumption of approximately 21 million kWh with an annual aggregate cost of approximately $1.1M. Recently, the average instantaneous energy demand was approximately 3.2 to 3.4 MW.

Refer to Fig. 3 for the WIPP diurnal power demand for the Summer versus Winter.

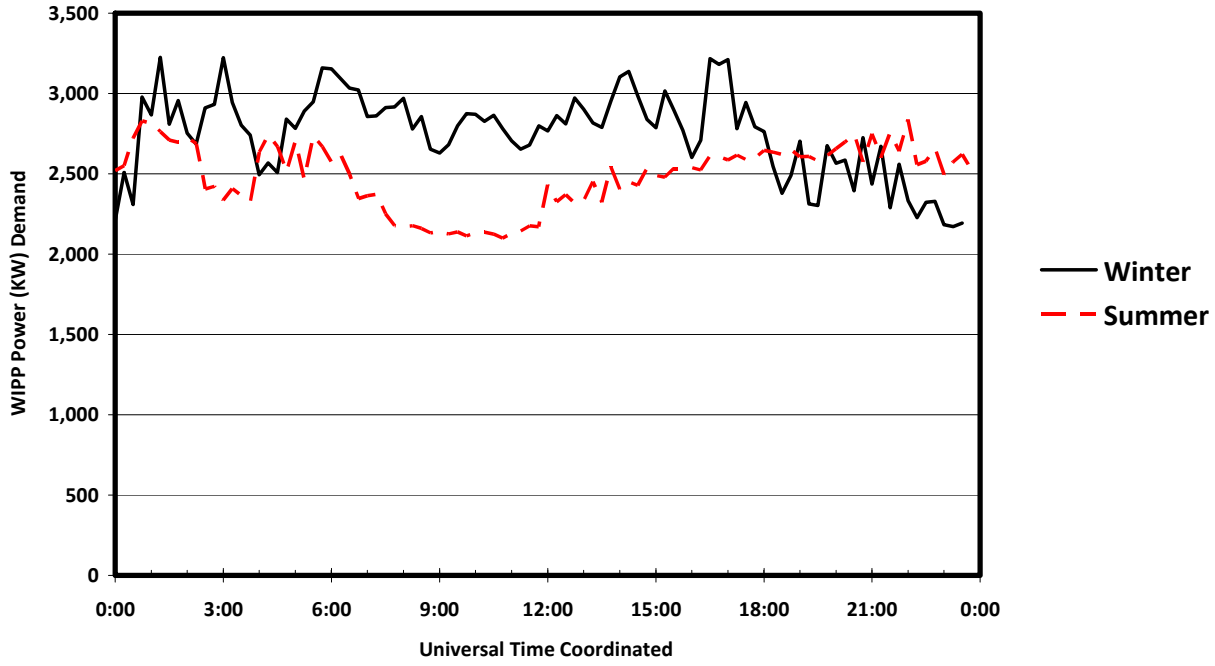

Fig. 3. WIPP diurnal power demand for the Summer versus Winter

The chart demonstrates the constant energy demand at the WIPP. While there is some variability, the primary electrical consumption is from the constant (24/7) ventilation fans. This and the other WIPP site characteristics lend to the feasibility and uniqueness for the clean energy siting and future use planning in Phase I of the New Mexico and Texas Energy Initiative. For example, any power supplemented by a solar array at WIPP will occur during daytime peak loads. This then allows the regional utility to sell the displaced capacity (that otherwise would have been consumed at WIPP) to other customers at higher peak load prices, thereby making WIPP's solar contribution more cost effective for the utility.

PHASE I: CLEAN ENERGY EFFICIENCY, GENERATION, & RESEARCH

Phase I will apply a multi-component approach at the WIPP site to implement energy efficiency measures, deploy clean energy technologies, and conduct research and development. It is envisioned that because of the region's growing interest and eagerness to embrace alternative energies, and in collaboration with New Mexico and Texas, the WIPP site will become a centralized hub for demonstrating how energy efficiency and clean energy generation is accomplished. The goal for Phase I is to enable the WIPP site to become a model site for net zero greenhouse gas emissions and become the first site operating with 100 percent clean energy.

Clean Energy Efficiency

The WIPP has an Energy Management Program that educates personnel and the community regarding energy management practices and how to implement practical approaches to reducing energy consumption. In conjunction with the DOE-Carlsbad Field Office (DOE-CBFO), the DOE, and the State of New Mexico, this program also implements funded or partially funded projects at the WIPP to reduce energy consumption.

The WIPP has identified energy conservation goals and opportunities for managing and reducing energy consumption in the Consolidated Energy Data Report (CEDR) and as further detailed in the *FY2009/FY2010 (Initial) Executable Plan* [3]. To-date, the WIPP has effectively realized energy efficiency and an ongoing annual

savings $50K. The projects implemented to achieve these goals include installation of environmentally friendly refrigeration and chiller equipment; low flow shower heads and other water conservation practices; digital electrical metering for monitoring performance and usage; recirculation versus once-through air in the heating, ventilation, and air-conditioning (HVAC) system; replacement of inefficient lighting (e.g., high pressure sodium lighting) and fixtures; and shelter for the shipping casks/containers.

Energy conservation measures at the WIPP have allowed constant energy consumption over time even as throughput has increased from zero shipments per day to a high of 1,128 shipments in fiscal year 2006. These measures demonstrate the energy leadership at the site and commitment to the continued endeavors on the road to sustainability. As part of Phase I, the New Mexico and Texas Energy Initiative will include additional energy efficiency measures such as 'Test and Conversion of WIPP Site Vehicles to Synthetic Hydrocarbon Fuel' and the 'Variable Frequency Drive Motors Conversion to Reduce Site Energy Demand'.

Clean Energy Efficiency & Research and Development

The Phase I generation of clean energy will consist of a five-year plan that augments the supply from the current energy provider. Through a collaborative effort, Texas Tech University (TTU) and New Mexico State University (NMSU) have provided a recommendation for deployment of an integrated technology system comprised of wind and solar energy. Research and development will be performed concurrently to support technology optimization for future development and energy distribution at regional and national levels. In Phase I, the main areas of development include "TTU Wind Technology Development in a Less-Than-Optimal Setting" and "NMSU Solar Technology Development and Use of Brackish Water for Cooling".

The TTU research emphasis of the initiative will focus on reducing the cost of wind power generation through enhanced siting and studies to mitigate the impact of turbulent wake dynamics in commercial wind farm deployments. As a component of the research, the project will employ new certification turbines to introduce new technologies into the United States market and also deploy a new technology to store the energy generated by the research wind farm. Additionally, TTU will partner with community colleges to launch a wind training and certification program which provides educational access to students.

NMSU will prove a test-bed for researching each solar technology as well as research involving conventional and emerging energy storage technologies at the WIPP. The principal research theme will address the potential for developing a hybrid system that serves both the goal of solar energy production and brackish water desalination. This is essentially a cogeneration process in which brackish water serves to cool a combined heat and power (CHP) system and in the process is also desalinated using CHP waste heat as well as a small amount of electrical energy. Additionally, NMSU will provide a training environment for solar technology installer training through local community colleges and branch campuses.

The following discussion will further explore the Phase I components (Table I) that encompass the areas of clean energy efficiency, clean energy generation, and research and development.

Table I. Phase I Components

Clean Energy Efficiency	**Clean Energy Generation / Research and Development**
Test and Conversion of WIPP Site Vehicles to Synthetic Hydrocarbon Fuel	TTU Wind Technology Development in a Less-Than-Optimal Setting
Variable Frequency Drive Motors Conversion to Reduce Site Energy Demand	NMSU Solar Technology Development and Use of Brackish Water for Cooling

Test and Conversion of WIPP Site Vehicles to Synthetic Hydrocarbon Fuel

Cetane Energy, LLC is engaged with Los Alamos National Laboratory's (LANL) Carlsbad Program Office in unique research focused on catalyst matching with high acidic oils produced through flash pyrolysis. Cetane Energy, LLC has developed a renewable diesel technology facility that will "remove the oxygen components in tallow sources, which stabilizes the fuel and modifies the chemical structure to produce a long chain hydrocarbon so that it is indistinguishable from on-road diesel fuel produced from petroleum refineries"[4]. Cetane Energy's renewable diesel in Carlsbad, NM is the *first* facility in the United States to produce renewable diesel from a standalone unit and has received EPA fuel registration approval and meets ASTM standards.

This research will lead to expansion of amenable feedstocks to include almost any biomass without oil or lipid extraction. The production technology for renewable diesel uses a Thermal Depolymerization process to co-process animal fat with hydrocarbon feedstock. The process design also has the flexibility to use other feedstock such as vegetable, soy, or algae oil. The process produces a renewable diesel product that is chemically equivalent to the diesel produced from hydrocarbon feedstock and can be transported directly through existing infrastructure to distribution terminals.

Based on Cetane's completion of its pilot level processing plant and demonstrated production of high quality diesel (higher cetane number, cleaner burn, lower exhaust emissions), DOE-CBFO and WTS have agreed to transition all diesel usage, surface and underground, at the WIPP to renewable diesel. The transition plan for the use of renewable diesel fuel at the WIPP includes an initial evaluation of the impacts and benefits. The evaluation program has been established and is expected to occur over the next six months to one year. During the evaluation of alternative fuels, consideration will be given to the recommendations of various diesel engine manufacturers regarding the use of non-petroleum-based fuels. Direct comparison evaluations of the fuel types will be performed on surface operated vehicles. After the impacts and benefits are evaluated, the implementation of the conversion will occur. This conversion will make the WIPP the only DOE or federal facility in the nation running 100 percent on renewable hydrocarbon fuel.

Variable Frequency Drive Motors Conversion to Reduce Site Energy Demand

The main ventilation fans for the WIPP site consume approximately 28 percent of the total energy. Installation of variable frequency drives (VFDs) will provide an overall reduction for the energy demand and kWh consumption requirements.

A full evaluation for incorporating VFDs at the WIPP has already been performed. In April of 1995, the fan system was analyzed to determine requirements for a third fan and optimal control opportunities. Additionally, the impacts to equipment were evaluated by adding VFDs to provide a "soft-start" vs. the existing "hard-start" 4,360V (medium-volt) kick. Due to funding limitations at the time and the expense of medium voltage drives, conversion to the VFDs was not feasible.

Since the initial evaluation, the technology has improved and price point has dropped making the value more cost effective. By 2009, there was a hardware cost reduction of over 50 percent and a more inclusive technology package available for a reduced price. The total cost for installation of VFDs on main underground fans will be approximately $1.5M which includes an enclosure (substation sized box) for three motors and the main drive components for each motor. Installation of VFDs with direct digital controls (DDC) on HVAC equipment at the WIPP has contributed to a realized cost savings and return on investment for implementing this technology is approximately three to five years.

TTU Wind Technology Development in a Less-Than-Optimal Setting

Texas Tech will deploy research wind facilities in close proximity to the WIPP, providing power to the WIPP and selling excess power to other off-takers. This work will be completed in coordination with National Institute of Renewable Energy (NIRE) and National Wind Resource Center (NWRC). Based on the *1999-2008 WIPP Annual Site Environmental Reports*, the predominant wind directions at 10 meters are generally from the southeast [5]. Mesonet wind data in the vicinity also confirm that the general wind direction is from the south. Preliminary analysis of available maps indicates average annual wind speeds of 7.25 to 7.5 m/s on the east side of the WIPP site at a height of 80 meters above ground [6].

Based on this information, Texas Tech has determined that the use of Class II type turbines (i.e., longer blades for lower wind speed regimes) would have a net capacity factor in the range of 38 to 40 percent. To produce about 50 percent of the WIPP site load or about 12 million kWh per year, wind capacity would need to be 3.4 to 3.6 MW. To achieve the required capacity, two 1.80 MW turbines will be deployed for the wind power generation.

The two wind turbines will be located at an outcrop approximately 1.75 miles to the east of existing structures on the WIPP site. USGS topographic maps show that this outcrop has elevations in the range of 3,550 to 3,570 feet above sea level, compared to the remainder of the WIPP site which has elevations between 3,330 feet to 3,550 feet above sea level. The turbines will be situated approximately 1,740 feet apart to optimize wind energy collection for any variation in the wind direction at higher elevations.

It is expected that the deployment of the wind turbines would occur by the end of 2011. To realize this schedule, milestones include completion of site planning by the third quarter of 2010; permitting and transmission construction in the second quarter of 2011; and early site construction by the end of the third quarter of 2011 that includes turbine assembly and initial operations. Additionally, TTU has included in Phase I an optional component to incorporate super compressed air energy storage that can be located on the WIPP site or the energy distribution site.

NMSU Solar Technology Development and Use of Brackish Water for Cooling

New Mexico State University (NMSU) has identified an integrated portfolio of solar technologies (Table II) for deployment to meet 50 percent, or 12 million kWh, of the present annual site load at the WIPP. NMSU will also provide performance data from the solar technologies for identification of replication potential in future phases of this initiative.

Table II. Solar Technology Deployment

Technology	Plant Size (MW)	Land Needed (Acres)	Total Installed Cost ($M)	Annual Energy Production (MWh)
Flat Plate PV	1.0	5	$5.0	2,263
Concentrating PV	1.5	8	$9.0	3,395
Solar Dish Stirling	1.0	5	$5.5	2,263
Parabolic Trough CSP	1.0	5	$4.5	2,263
Totals	**4.5**	**23**	**$24.0**	**10,184**

Flat Plate Photovoltaics (PV) is a mature technology used throughout the world for energy production in both large and small arrays that do not require the use of water. As of 2009, the largest PV array in the United States is the DeSoto Power plant in Florida with a rating of 25 MW. The majority of large, ground mounted PV arrays are deployed on one-axis trackers which result in approximately 30 percent more energy production than fixed arrays of the same size. NMSU recommends an array of 1.0 MW of PV on one-axis trackers for the WIPP site.

Concentrating Photovoltaics (CPV) uses optics on two-axis trackers to focus sunlight from horizon to horizon onto PV cells. DOE demonstration efforts with ultra-high-efficiency concentrator solar cells are beginning to show advantages over flat-plate equivalents for lower land use and increased power density. Like flat-plate PV, CPV systems require no water for operation. Promising high efficiency, low cost CPV technologies are accelerating solar towards grid parity with conventional generation. NMSU recommends an array of 1.5 MW of CPV collectors is recommended for the WIPP site.

2010 has seen the deployment of the first, large Solar Dish Stirling Plant: 1.5 MW Tessera Solar plant in Maricopa, Arizona. Innovative and highly-efficient, Solar Dish Sterling Technology, designed and developed at Sandia National Laboratories (SNL), is modular and uses no water. The maturation of this technology could result in greater efficiency of energy production. NMSU recommends an array of 1.0 MW of Solar Dish Stirling Engines is recommended for the WIPP site.

Parabolic Trough Concentrating Solar Thermal Electric Systems have undergone new developments to reduce weight, cost, and maintenance requirements. However, the technology is reliable and proven and NMSU recommends installation of 1.0 MW of Parabolic Trough systems with a research component for the demonstration of cooling options that allow direct comparison of the strengths and weaknesses of water-requiring and non-requiring solar technologies. The conventional Parabolic Trough system uses a Rankine cycle steam engine to generate electricity and requires 1,000 gallons/MWh water for cooling. The underground water formation located near the WIPP site has enough water capacity to support this requirement. Intrepid Potash utilizes several wells in the area for their mining operations that have high enough capacity for the concentrating system.

The research component would include the cooling portion provided by remediation of brine water (brackish) shallow water that is readily available in the area. Success with the brine water would demonstrate an economical way of deploying this technology in water resource challenged areas. If sufficient water is not available for this plant, other technologies offering dry cooling of solar thermal plants are available. The typical dry cooled plant routes turbine exhaust steam to finned tubes on air-cooled condensers. The performance penalty associated with dry cooling is typically an overall generation reduction of about 5 percent than for the water-cooled plant and an increase in the cost of electricity of from 7 to 9 percent.

PHASE II: NATIONAL LABORATORY INITIATIVES INTEGRATED

The local community is anticipating growth in the upcoming decades that will require an additional energy supply to meet the demand. As such, developing an energy expansion plan during Phase II is the key to accommodating future growth. Phase II will expand the clean energy resources and technologies to other DOE sites and surrounding communities in New Mexico and Texas.

Los Alamos National Laboratory (LANL) and Sandia National Laboratories (SNL) reflect the synergy that exists among the other sites in the DOE complex. The New Mexico and Texas Energy Initiative provides the opportunity to collaborate and expand the development of these technologies throughout the greater New Mexico and Texas region. The following provides discussion for a selection of current projects at both LANL and SNL that have potential for integration with this initiative.

LANL, Los Alamos County, and New Energy and Industrial Technology Development Organization (NEDO) finalized plans in August 2010 for a 15-acre solar panel array. The project includes three structural components including a 2 MW photovoltaic facility built over a landfill located on DOE land, a 10 MWh utility scale battery storage system, and a “smart house” demonstration home built using green construction techniques that includes meters and appliances to optimize power conservation. This project provide power to over 600 residential home and store energy to provide energy to 3,300 houses for an hour. This $27M project is being funded by the county ($10M) and NEDO ($17M).

SNL manages the Energy Storage Systems (ESS) Research Program which is part of the Office of Electricity Delivery and Energy Reliability at DOE. The goal of the ESS program is to develop advanced energy storage technologies and systems in collaboration with industry in order to increase the reliability, performance and competitiveness of electric generation, transmission and use in utility tied and off-grid systems. SNL continues to demonstrate the ongoing work to improve the Nation's electrical grid reliability as solar energy technologies reach cost-competitiveness with conventional sources of electricity and increasing amounts of photovoltaic (PV) solar electricity flow into the Nation's electrical grid. SNL is investing $8.5 million for four projects that have reached Stage III of the Solar Energy Grid Integration Systems (SEGIS) program. Initiated in 2008, the SEGIS program is a partnership that includes DOE, SNL, industry, utilities and universities. Projects that are part of this program are emphasizing complete system development for solar technologies, for instance, how to move designs of intelligent system controls towards commercialization and how best to integrate expanded solar resources onto the grid while maintaining or improving power quality and reliability.

PHASE III: EXPANSION WITH A NATIONAL IMPACT

In Phase I and II of the New Mexico and Texas Energy Initiative, the establishment of clean energy sources in the area brings a tremendous advantage to having access in the three national markets. The WIPP is located within close proximity to the three power grids consisting of Western Electricity Coordinating Council, Electric Reliability Council of Texas, and the Eastern Interconnection, ultimately supporting future expansion. Phase III includes the continued expansion of the clean energy technologies to have not only a regional but a national impact. In order to move in that direction, the planning for the future has to begin now. As such, the team has initiated discussions with companies such as Viridity Energy and Tres Amigas, LLC. The following discussion provides more information about these companies and how their involvement can facilitate clean energy expansion at a national level.

Viridity Energy will manage resource integration and injection into the grid through utilization of advanced decision-making tools taking into account factors including but not limited to prices in the market, load control, storage, and generation in order to optimize the economics. With sufficient capacity to meet the demand and maintain a reserve margin for the zone, Viridity delivers a 'firm resource' that is focused on the end-user by converting the demand (static) to something predictive and 'price-elastic.' The ability to make buy and no-buy decisions based on forecasts for real-time consumption establishes a balance within the grid. Viridity provides the benefit of an economic advantage and the minimization of carbon in the atmosphere. "Viridity Energy's platform enables customers to dynamically shift and balance energy load, integrate advanced energy technologies and convert existing energy investments into lucrative new revenue streams."

Tres Amigas, LLC has partnered with superconductor companies, American Wind Energy Association (AWEA), and Alt. Energy, LLC. The New Mexico State Land Office has granted Tres Amigas the right to lease 14,400 acres of land for the superstation that would interconnect the three power grids. The initial superstation would include a 5GW DC superconductor cable with the potential to be expanded to 30GW. The Commisioner of Public Lands, Patrick Lyons stated, "One of the biggest constratints on wind and solar power growth is the reduced capacity of the transmission grid to deliver energy to customers" and "[t]his new transmission infrastructure will allow half of the United States to access vast wind and solar energy resources." The superstation will shore up the transmission systems and strength the grid. Tres Amigas has two years to conduct an environmental analysis, various surveys, pursue power purchase and sales agreements, and interconnect agreements with utilities. Tres Amigas already has FERC approval and anticipates to be operational by 2013. The Tres Amigas development of a superstation located in Clovis, NM is a natural tie to the New Mexico and Texas Energy Initiative for the inclusion of additional clean energy sources to be brought onto the grid.

SUMMARY

There is a growing interest across the nation to employ energy efficiency measures and utilize renewable energy technologies. The Administration and the Department of Energy goals drive the continued efforts to boost the environmental stewardship of the nation and ultimately to lessen the dependence on foreign oil, address the global climate crisis, and facilitate job creation. The economic ripple effects of the New Mexico and Texas Energy Initiative are unlimited. In a scenario with 8 MW wind and 8 MW solar, the economic impact results in millions of dollars and hundreds of jobs (Fig. 4).

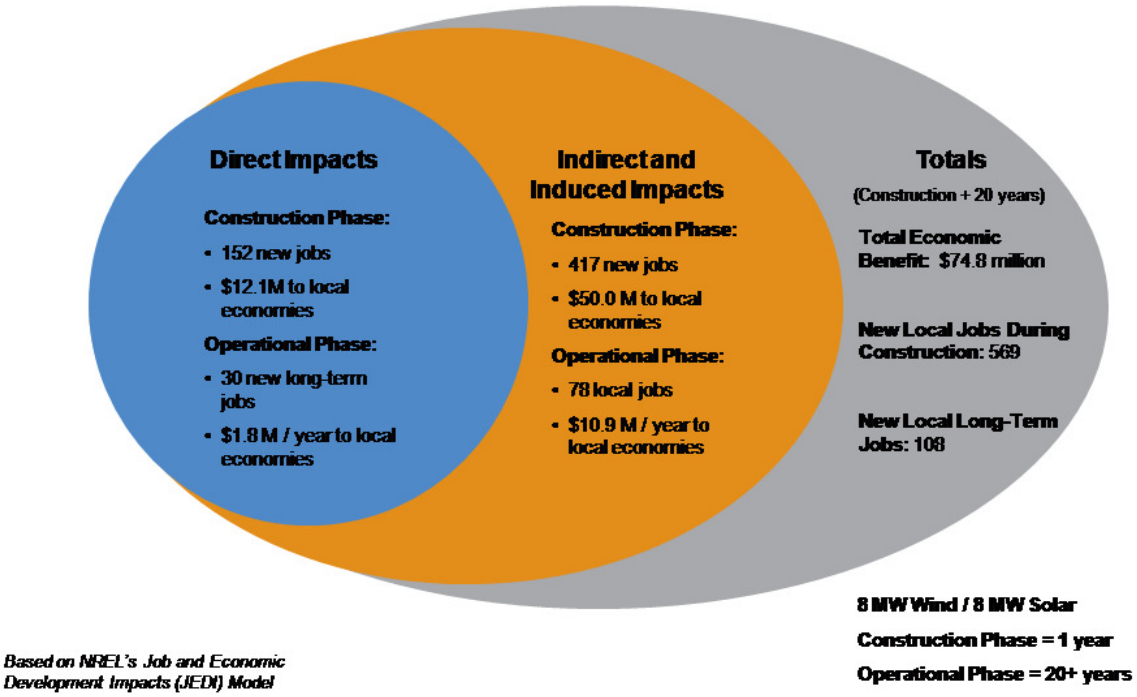

Fig. 4. New Mexico and Texas Energy Initiative Economic Ripple Effect

The New Mexico and Texas Energy Initiative's integrated three-phased approach identifies opportunities for future use planning and reduces greenhouse gas emissions. This approach has the flexibility to be applied at other DOE sites as well as meet the needs of other regions throughout the country. In conclusion, the New Mexico and Texas Energy Initiative is meeting the energy demands of the community and region today and providing technology optimization to meet the needs of the nation and the world tomorrow.

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