



*Maximizing Value Through Innovation & Collaboration
The Radford Army Ammunition Plant and the New River Valley*

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*Economic Development Studio @ Virginia Tech
December 2010*

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Foreword

The Economic Development Studio @ Virginia Tech is a resource for communities throughout the Commonwealth of Virginia. The research conducted in the Studio includes a broad range of economic development issues to empower decision makers with technically sound recommendations for economic development strategy and implementation.

The studio is a collaborative effort between Virginia Tech's Office of Economic Development and Virginia Tech's Urban Affairs and Planning Department. Graduate students work under faculty supervision on behalf of real-world clients and deliver actionable applied research projects. The students design and shape the implementation of the project, which typically provides a sheltered work experience before they embark on professional careers.

This year's Studio team is comprised of six students from the Masters of Urban and Regional Planning program. I am proud to have worked with this fine group of skilled pre-professionals. I commend to you both their work that follows and their potential to make future contributions to the welfare of communities across the Commonwealth, the nation, and the world.

On behalf of the team I would like to express my sincere thanks to this year's clients, the New River Valley Economic Development Alliance (NRVEDA). They have been excellent partners to the Studio, opening their organization to the students and facilitating important interactions with their members including ATK, Montgomery and Pulaski County and the City of Radford. I would especially like to thank Aric Bopp, Basil Edwards, Brian Hamilton, Shawn Utt, Kent Holliday, Dara Glass and all the staff at ATK who were generous in taking time to engage in a sincere and open discussion about ideas. While we could not have undertaken this project without the support and guidance of all of these individuals it should be noted that any errors or omissions in this report are the sole responsibility of the authors.

Sincerely,

John Provo, Ph.D.
Director, Virginia Tech Office of Economic Development
Instructor for the Economic Development Studio @ Virginia Tech

Executive Summary

The Radford Army Ammunition Plant occupies a unique position in the New River Valley, both physically and symbolically. Situated along the New River in both Montgomery and Pulaski Counties, the plant has a prominent history in the region. However, like much of the manufacturing sector in Southwest Virginia, changes in technology and policy have caused significant restructuring. Employment at the base has receded from over 20,000 at its peak during WWII to below 2,000 today and many of its industrial facilities are outdated or under-utilized. The apparent decline, however, is a misleading indicator of the future potential of the base. Many in the region do not realize the critical importance of products manufactured at the RFAAP to the U.S. Army supply chain and the renewed attention to creating economic opportunities from the wealth of assets available.

The New River Valley Economic Development Alliance, a regional group of local economic developers, business leaders, and universities and the Economic Development Studio @ Virginia Tech collaborated on this project to explore new avenues for leveraging opportunities at the base. The Studio worked closely with base operator ATK and local economic development officials to create a framework for understanding the unique context surrounding the potential for new development. Applying best practices in contemporary economic development, the Studio based its recommendations on three primary considerations. First, generational change is coming to the base in the form of a new government contract. The Army is requesting significant changes to operations that could open a critical window of opportunity to expand the portfolio of economic activities on base. Second, opportunities exist to enhance collaboration between the base and the surrounding community to attract new businesses and develop new ones from within. Third, as witnessed time and again over the last half-century, the future will bring technological and political changes that will disrupt business-as-usual. The base must be positioned to hedge against these inevitable shifts and prepared to reinvent itself in the face of a dynamic economy.

Our primary recommendations include increased marketing and collaboration between the base contractor and local economic developers, enhanced relationships with local universities to encourage innovative research and development activities on base, and building a foundation for a clean energy economy through the pursuit of renewable energy technologies. Each of these recommendations are interrelated and supported by research and examples. We are confident that the information in this report will serve as a practical roadmap for the Alliance as it works to maximize the value of the RFAAP to the New River Valley.

Introduction

The Radford Army Ammunition Plant (RFAAP) is a government-owned, contractor-operated (GOCO) facility located in Southwest Virginia. The entire facility encompasses 6,901 acres and is contained within Montgomery and Pulaski counties. The plant was built in 1941 to provide military ammunition requirements during WWII. The operator and main tenant, Alliant Techsystems (ATK) is contracted to produce propellants and energetics.

While the short-term prospects for growth at the RFAAP are promising, the future holds many uncertainties. The recent Base Realignment and Closure Process (BRAC) closed several arsenals under Joint Munitions Command (JMC) and shifted additional production of propellants, acids, and explosives to the Radford facility. In addition, ATK and the Army have made significant investments in infrastructure improvements at RFAAP with approximately \$400 million more earmarked over the next five years¹. Although this mutual commitment is reassuring, infrastructure improvements depend highly on available funding from the Armament Retooling Manufacturing Support Program (ARMS). ARMS offers government-issued financial incentives to base tenants who invest in buildings, infrastructure, and/or equipment as part of their own business development. The base operator, ATK, acts as an intermediary between the Army and the base tenants. Reduction of ARMS funding would potentially reduce the operator's marketing and advertising budget as well as its overall capacity to attract new tenants.

While much has changed external to the base, many constants remain in place from the original plant. Many of the same types of propellants and explosives are produced there, and ATK acquired the contract to operate the base when it merged with original contractor Hercules in 1995. Much of the infrastructure for essential services, such as power and water, has never been replaced and the footprint of the base, including the layout of facilities, has gone virtually unchanged. It is clear, however, that many of these facilities will not survive the modernization process necessary to maintain the plant's relevance in the 21st century. Technological advancements, globalization, changes in the nature of defense, and a possible change in management are each major barriers to the status quo at the RFAAP. Identifying and preparing for these changes is critical to its survival and important for the economy of the New River Valley.

Base Description

CURRENT STATUS

Plant Infrastructure

The plant is separated into two facilities. The Main Manufacturing Area, located near Radford, VA, is used for energetics manufacturing as well as storage and is contained within 4,080 acres. The second facility, or the New River Unit, located near Dublin, VA, is a storage facility and consists of 2,821 acres. These facilities contain 2,754 buildings, 132 roadway miles, 26 railroad miles, 21 miles of security fence and 60 miles of piping. With an on-site coal-fired power plant, as well as a water treatment plant, the facility is capable of producing 3 million gallons per day of drinking water, 580,000 kilowatts per hour/day of electricity and 23.5 million pounds per day of steam².

¹ ATK Competition Slideshow, 2010.

² Radford Army Ammunition Plant Fact Sheet. Joint Munitions Command, U.S. Army. Retrieved 3/4/11 from <http://www.rfaap.army.mil/Docs/RFAAP%20Fact%20Sheet%202009.pdf>

Operations

ATK is the main tenant and contractor at the RFAAP. The energetics systems division of ATK currently utilizes approximately 50 percent of the 2,754 buildings. It is the only North American manufacturer of military-grade nitrocellulose and TNT. While the aforementioned processes refer specifically to energetics systems production, ATK also produces integrated weapon systems as well as commercial ammunition products.

ARMS Tenants

Currently there are 15 tenants including ATK at the RFAAP. The table below provides tenant name and activity.

Table 1: ARMS Tenants at RFAAP

Tenant	Activities
Alliant Energetic Systems	Explosives and Propellants
Alexander Arms	Manufacturing & Sales
Alliant Painting	Residential Painting
Belmont Machine	Machine Tools
Commonwealth Explosives LLC	Distributor of Commercial Explosives
General Dynamics	Field Rep Office
Grucci	DoD and Commercial Fireworks
Montgomery County PSA	Drinking Water Sales
New River Energetics	Commercial Gunpowder
Salem Tools Inc.	Supplies Sales and Distribution
Valley Turf Inc.	Mowing Maintenance
Virginia Tech	Coal Storage
York International	HVAC

Source: RFAAP Fact Sheet³

Contract Dollars

ATK Defense Contract Totals since 2007⁴:

- Facilities Operations, including production equipment: \$272,159,096
- Bulk Explosives/Ammunition: \$58,416,994

³ Radford Army Ammunition Plant Fact Sheet. Joint Munitions Command, U.S. Army. Retrieved 3/4/11 from <http://www.rfaap.army.mil/Docs/RFAAP%20Fact%20Sheet%202009.pdf>

⁴ Alliant Techsystems Government Contracts at RFAAP. Proprietary Report Retrieved 9/26/10 from www.governmentcontractswon.com

Major Contracts:

- \$130 million pledged in 2005 (disbursed over several years) for state-of-the-art nitrocellulose production facility
- \$63 million contract in 2008 as primary funding for new nitric acid concentrator/sulfuric acid concentrator facility (NAC/SAC)

Table 2: Profile of government contracts at RFAAP (2006-2009)

Product/Service Category	2006	2007	2008	2009
Operation of GOCO Facility	n/a	\$40,205,466	\$180,046,876	\$16,568,822
Bulk Explosives	n/a	\$31,454,786	\$24,534,239	n/a
Pyrotechnics	\$3,641,171	\$4,753,642	\$27,043,813	n/a
Contracting Agency Purchases				
Department of the Army	\$30,869,312	\$113,715,351	\$286,791,574	\$28,887,666
Contractors				
Alliant Techsystems, Inc. (ATK)	\$2,858,384	\$73,813,327	\$211,534,058	\$16,568,822
Pyrotechnique by Grucci, Inc.	\$3,641,171	\$4,753,642	\$27,261,093	n/a

Source: GovernmentContractsWon.com

CHALLENGES AND DEVELOPMENTS

Change at RFAAP

In the post-Cold War era, U.S. military bases face periodic review under the base realignment and closure (BRAC) process. The country's original 34-facility network of ammunition plants dwindled to 14 before the latest BRAC round in 2005. The most recent round recommended the closure of four additional plants, with one plant being transferred to the National Guard. Consequently, nine Army ammunition plants remain, six of which are GOCO facilities such as the RFAAP.⁵

The capacity to produce nitrocellulose at the RFAAP is unquestionably critical to the U.S. military supply chain. A recent report on the U.S. Army ammunition supply chain, issued by the Lexington Institute, predicts that "the inability to produce nitrocellulose would cripple the domestic production of ammunition, placing the war fighters in combat situations at risk and making the United States completely dependent on limited foreign sources."⁶ In its 2009 Weapons Study, the National Defense

⁵ Goure, D. (2009a). Radford Army Ammunition Plant: The Heart of the US Ammunition Supply Chain. Arlington, VA: Lexington Institute.

² Alliant Techsystems Government Contracts at RFAAP. Proprietary Report Retrieved 9/26/10 from www.governmentcontractswon.com

⁶ Goure, D (2009b). You Can't Fight a War without Nitrocellulose. United Press International. Retrieved 3/4/11 from http://www.upi.com/Business_News/Security-Industry/2009/05/12/You-cant-fight-a-war-without-nitrocellulose/UPI-78041242147842/

University questions the wisdom of depending solely on the RFAAP and issues several recommendations for change: 1) produce a surplus stockpile of nitrocellulose in the event of system failure; 2) Develop an alternate manufacturing line at RFAAP or another government location as a redundant safeguard; and/or 3) Develop an alternate commercial source of nitrocellulose.⁷ With respect to the latter, the NDU argues that the military could potentially secure nitrocellulose from commercial counterparts that input the chemical compound into goods such as varnish removers, golf balls, piano keys and nail polish. Nevertheless, nitrocellulose currently remains critical to the production of ammunition that is used in all branches of the military. As stated in an analysis prepared by the Army Logistics University, “all ammunition roads lead through the Radford Army Ammunition Plant.... [T]he Army and its sister services cannot afford to lose this plant’s ability to produce nitrocellulose.”⁸

Although the facility has not witnessed any long-term inefficiency with respect to nitrocellulose production, it experienced seventy production failures in 2008.⁹ These breakdowns, primarily caused by faulty or outdated equipment, can be reduced or eliminated through modernization of the plant’s facilities. To date, much of this work has been completed while other updates are underway or scheduled to begin within several years.

ATK’s recent strategic agreement with Rheinmetall Nitrochemie of Germany/Switzerland presents an additional manufacturing opportunity for the RFAAP facility. Specifically, the agreement enables both companies to create new surface coating and impregnating capabilities at the Radford Arsenal¹⁰ This production expansion will likely bring additional jobs to the RFAAP and enlarge the facility’s economic impact on the region.

Aging Facilities

RFAAP was built during World War II and a surprising amount of the original infrastructure remains today. The Army and RFAAP’s contractor-operator have made some improvements over time, but the surge in military activity after 9/11/01 tested the plant’s capacity and raised awareness of the need for comprehensive modernization.¹¹ Between 2000 and 2005, the military’s requirements for ammunition jumped dramatically; for medium-caliber ammunition (a product in which RFAAP specializes), demand nearly doubled from 11.7 million rounds to 22 million rounds.¹² The Department of Defense (DoD) recognized that its supply plants were ill equipped to meet this increased demand and embarked on a facility modernization program.¹³

The Army’s recent investments at RFAAP include \$100 million for power plant upgrades and maintenance of the water treatment facility and other infrastructure.¹⁴ Another \$148 million in Army modernization funding supported the construction of RFAAP’s new acid concentrator facility, a new solvent recovery system, and repairs to the water distribution system and powerhouse for modernization

⁷ The National Defense University (2009). Industry Study Final Report: Weapons Industry. Retrieved 3/4/11 from <http://www.ndu.edu/icafe/programs/academic/industry/reports/2009/pdf/icafe-is-report-weapons-2009.pdf>

⁸ Siekman, M. W., Anderson, D. A., & Boyce, A. S. (2010). Small-Arms Ammunition Production and Acquisition: Too Many Eggs In One Basket? Army Sustainment, 42 (5). Retrieved 3/4/11 from http://www.almc.army.mil/alog/issues/SepOct10/spectrum_smallarms_ammunition.html

⁹ Kirnes, A. (January 15, 2009). Joint Services Overview. Brief to the Industrial College of the Armed Forces. Washington, DC

¹⁰ ATK (2009). ATK and Rheinmetall Nitrochemie – Technology Transfer Agreement. Retrieved from http://www.defensefile.com/Customisation/News/Weapons_Ammunition_and_Explosives/Ammunition_detonators_Primers/ATK_and_Rheinmetall_Nitrochemie_-_Technology_transfer_agreement.asp

¹¹ Goure, 2009a

¹² Government Accountability Office (GAO). (2005). Defense Ammunition: DOD Meeting Small and Medium Caliber Ammunition Needs, But Additional Actions Are Necessary (GAO-05-687). Retrieved 3/4/11 from <http://www.gao.gov/products/GAO-05-687>

¹³ GAO, 2005

¹⁴ Goure, 2009a

at RFAAP.¹⁵ In addition, substantial modernization funding—\$400 million—will be available to the winning bidder in the Army’s current competition for the new five-year contract for managing the Radford base.¹⁶

As RFAAP’s contractor-operator, ATK has made modernization improvements of its own, spending \$40 million over five years on projects at the base including a modernized energetics facility.¹⁷ However, the short-term nature of its current five-year contract has provided the contractor with little incentive to make substantial investments in improvements with longer-term payback periods.¹⁸

In conjunction with the recommendations above, the National Defense University also suggests the possibility of privatizing nitrocellulose facilities at the RFAAP. Private ownership would incentivize investment in modernization and technology and eliminate the need for government-appropriated funds.¹⁹ Under the RFAAP’s current conditions, this action would help ATK develop a stronger sense of ownership, thus encouraging investments in modernization and optimization.

Defense Budget Cuts

The recent economic downturn and the subsequent reduction in government funding have exerted significant influence on the Department of Defense’s expectations of its industrial base performance. The Industrial Base Strategic Plan: 2015 contains nine goals, several of which are aimed at streamlining operations and reducing costs:

- Implement Base Realignment and Closure Process (BRAC) actions
- Reduce ownership cost
- Reduce excess physical capacity and infrastructure
- Identify and complement opportunities for greater joint service activity
- Maintain out-loading capability to support joint strategic readiness
- Aggressively pursue public, private partnership and other tenant/3rd party revenue generating activities (i.e. ARMS) to support base operations and expertise, and offset ownership costs
- Utilize lean six-sigma
- Implement Integrated Logistics Strategy to optimize out-loading, storage, and networking (transportation) requirements in the depot logistics industrial base.
- Coordinate JMC Integrated Logistics Support Strategy with PM DEMIL to insure optimized investment in facilities and correct positioning of retrograde DEMIL stocks.²⁰

The Changing Nature of Warfare

The Department of Defense’s most pressing priorities for RFAAP are facility modernization to meet the military’s ammunition needs and operational efficiency to cut costs, but other changes are on the horizon with potential to affect the core production work at RFAAP. A study by the Lexington Institute on RFAAP recommends that the Army expand its goals for its ammunition sector of the defense industrial base to incorporate production of “the next generation of products such as advanced energetics materials, IM [insensitive munitions], and even ‘green ammunition.’”²¹ The report explains that advanced energetics

¹⁵ Ibid

¹⁶ Competition slideshow

¹⁷ Goure, 2009a

¹⁸ Per ATK site visit meeting

¹⁹ NUD, 2009

²⁰ Single Manager for Conventional Ammunition (SMCA). (2009, January). Industrial Base Strategic Plan (IBSP): 2015. Retrieved 3/4/11 from

<https://peoammo.army.mil/PMJointServices/Divisions/IndustrialBase/IndustrialBaseStrategicPlan.aspx>

²¹ Goure, 2009a, p. 10

offers more power per unit; IMs are safer because they will not accidentally detonate; and green ammunition contain and emit fewer toxins.

Although TNT has historically been a critical explosive for the U.S. Armed Forces, its presence in artillery munitions may soon be replaced by a new family of explosives called Intensive Munitions eXplosives (IMX). BAE's IMX-101, heralded by TIME magazine as one of the top 50 inventions of 2010, and developed at the Holston Army Ammunition Plant, is a safer, more chemically stable alternative for large-caliber munitions. While certainly not supplanting the products generated at the RFAAP, the IMX-101 represents innovation and advancement in modern warfare. As the U.S. military supply chain evolves, the RFAAP contractor must attempt to modernize its products, and in most cases, modernize the facility.

The draw down in Iraq and the proposed draw down in Afghanistan will also result in lower demand for ammunition. Over the long term, strategic military choices will determine the level of demand and for the type of products made at RFAAP. The U.S. Army, seeking to leverage base assets and diversify production and business development, encourages adaptive re-use of its extensive network of ammunition facilities.

The Competition

A consistent environment of uncertainty regarding improvements at the RFAAP results from the short-term nature of the government owned, contractor operated (GOCO) arrangement. As noted earlier, the five-year contract provides little incentive for the contractor to make investments from which it may not fully benefit. This has implications for facility modernization but also for the plant's subsequent relationships with counties and cities surrounding the base: if the contractor does not consider itself a fixture in the community, it is unlikely to make non-mandatory improvements that could, for example, reduce the base's environmental impact or to provide necessary infrastructure for new tenant attraction and retention. The competition for the new RFAAP contract indicates that this could change. After over 60 years of contracting with ATK, the Army has created a competition for future ammunition manufacturing at the RFAAP. The request for proposal for the new contract clearly states that a minimum five-year contract with an optional 5-year extension will be provided upon being awarded the grant. Additional contracts may be available, as language in the "Requirements Summary" states: "should the successful offeror meet the Award Term thresholds, the contract MAY be extended up to a total of 25 years."²²

The RFAAP responses to some of the challenges identified above will depend in large part on the outcome of the current competition for the new facility operation contract. The competition's overarching goal is optimizing use of RFAAP's facilities to reduce the gap between costs and revenue.²³ Bidders must present "innovative, achievable ideas" to reduce costs and improve revenue generation in the Optimization Plan component of their proposals. The RFP uses a specific 2-step acquisition strategy that requires interested parties to show competence in manufacturing, management and modernization as well as best value selection in regards to proposal areas.

At stake in the competition are substantial revenues from product lines and tenant rents, with potential for enhanced operational efficiency from significant modernization funding provided by the Army. Three contracts will be awarded to the winning bid, including facility use, production, and service (modernization is included within this contract).

²² RFP solicitation. Retrieved 3/4/11 from http://www4.osc.army.mil/padds_pdf/W52P1J09R0015/0000.pdf

²³ Rock Island Contracting Command (2009). Briefing to Industry: Radford AAP Competition Project. Retrieved 3/4/11 from http://www.afsc.army.mil/ac/aa/is/ioc/Radford/Industry_Days/February_Industry_Day/633761012370571484.pdf

Below are the specific opportunities for the winning bidder:

- A five-year contract with a five-year option, as well as potential additional contracts
- \$430 million in potential product work over five years
- \$400 million in modernization funding over five years
- \$10 million in ARMS tenant revenue over five years²⁴

Two bidders are involved in the RFP: RFAAP's present contractor-operator, ATK, and British aerospace and defense corporation, BAE Systems. BAE currently operates the GOCO facility of Holston Army Ammunition Plant in Kingsport, TN.²⁵

It is important to note that the competition at RFAAP is integral to the recommendations made in this document. The effects of the competition could lead to a number of possible outcomes with important implications for the community. First, the potential modernization of facilities would result in increased production efficiency with fewer disruptions and safety concerns. An ancillary benefit of modernization is a heightened ability to attract new businesses and processes to the plant, as tenants may be attracted to locate in a place with state-of-the-art energy, water, waste, and production facilities. The second major possible outcome is the restructuring and optimization of resources. As the base operator is expected to avoid costs and complications of managing environmentally hazardous materials as much as possible, and as research yields new uses for waste materials and new methods for storage and destruction, opportunities exist to engage in new industrial practices that leverage waste outputs as inputs in other processes. This could lead to innovative clusters of compatible manufacturers in the region and possibly attract new tenants to the base itself. The third outcome is a change in employment at the base. While capital investments in base infrastructure may improve efficiency and production capacity, it is yet to be seen what effect this may have on existing jobs. The contractor selected to operate the base may also handle personnel decisions in a way that breaks from the past. The fourth and final outcome considered as a result of the competition is a change to the base footprint, notably a reduction in the amount of land and infrastructure utilized for manufacturing. This could lead to new land use opportunities discussed in more detail in the recommendations. By understanding the outcomes and implications of this competition, the contractor and surrounding communities can better leverage assets, as well as prepare for the impending competition results.

Environmental Concerns

The environmental impacts derived from the manufacturing processes at RFAAP are varied in nature and significant relative to other industrial facilities in the state. According to the 2008 Virginia Toxics Release Inventory (TRI) Report, ATK was ranked as the largest toxic emitter in the state releasing 14.30 million pounds of TRI chemicals on-site.²⁶ Toxics emission at RFAAP primarily affects groundwater, soil, sediment, and surface water. The primary contaminants of concern include explosives, metals, pesticides, polychlorinated biphenyls, semi-volatile organic compounds, and volatile organic compounds.²⁷ As part of the Army's Installation Restoration Program (IRP)²⁸, there are ongoing evaluations to determine the extent of the environmental impacts on the base. The IRP, a component of the Army's Defense Environmental Restoration Program, is responsible for the "Identification,

²⁴ Ibid

²⁵ Data for GOGO Army Ammunition Plants. Retrieved 3/4/11 from www.osc.army.mil/ac/aaais/ioc/data-for-goco-army-ammunition-plants.doc

²⁶ Virginia Department of Environmental Quality (DEQ) (2010). 2008 Toxics Release Inventory Report. Retrieved 3/4/11 from <http://www.deq.state.va.us/export/sites/default/sara3/documents/2008trireport.pdf>

²⁷ Radford Army Ammunition Plant (RFAAP) (2010). Army Defense Environmental Restoration Program : Installation Action Plan. Retrieved 3/4/11 from http://www.radfordaapirp.org/invest/IAPs_previous_years/2010_Radford_IAP.pdf

²⁸ Ibid

investigation, and clean-up of contamination resulting from past operations at the base”.²⁹ IRP activities are carried out in both the Main Manufacturing Area (MMA) and the New River Unit (NRU); however, they are conducted and managed separately.

Within the MMA, the IRP has identified five different site types in need of remediation:

- Burn Area
- Chemical Disposal
- Landfill
- Storage Area
- Surface Impoundment/Lagoon

Each site type or classification encompasses multiple sites, for a total of 79 different locations within the MMA that either have remediation phases underway or will undergo remediation in the future.³⁰ The IRP at RFAAP-MMA was initiated in September of 1984 and has an estimated end date of December 2035.³¹ Prolonged duration of the IRP is related to initial facility investigations, sites identification, sites testing, implementation of remedial actions, and the need for Long Term Management (LTM) for various sites. From 1988 to 2009 there were six Completed Remedial Actions in the MMA.³²

Recent actions of the IRP are most noticeable in the New River Unit in which the identification and investigation processes have been completed. A comprehensive plan for remediation has been developed and is currently available for public revision and input. The IRP activities in the NRU are being managed and performed according to the requirements outlined by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).³³

The NRU is located approximately six miles west of the MMA and consists of approximately 2,800 acres. Between 1940 and 1945 the NRU was used to load propellants and igniter charges and to manufacture igniter charge bags. From 1943 to 1945 operations were expanded to include an additional bag-loading line, rolled powder operations, flash-reducer loading lines, and black powder drying facilities.³⁴ All active manufacturing operations ceased in 1945 at the end of World War II. Since then the NRU was officially consolidated with the RFAAP-MMA and has served primarily as a storage facility for the ongoing propellant and explosives manufacturing operations carried out at by ATK. Within the investigations conducted at the NRU, six study areas were identified.³⁵

- The Bag Loading Area
- The Igniter Assembly Area
- The Building Debris Disposable Trench
- The Western Burning Ground
- The Northern Burning Ground
- The Rail Yard

²⁹ Radford Army ammunition Plant: Installation Restoration Program. Retrieved 3/4/11 from <http://www.radfordaapirp.org/>

³⁰ RFAAP, 2010

³¹ Ibid

³² Ibid

³³ RFAAP, 2010

³⁴ Ibid

³⁵ Final Proposed Plan for the New River Unit (RAAP-044). Radford, Virginia (September, 2010). Obtained at Public Meeting on October 19, 2010.

In addition, groundwater beneath the NRU was tested for different TRI chemicals. Based on the findings of the comprehensive environmental investigations conducted at the NRU, several study areas were identified as requiring clean-up action or restriction on land use for the protection of human health and the environment. The following table provides an overview of each site, along with the corresponding remedial actions.

Table 3: Summary of Proposed Plan for the RFAAP-NRU³⁶

Site	Formal Use	Cause/Source of Contamination	Main Contaminants	Remedial Action
Bag Loading Area (BLA)	Powder bag production (1941 – 1943) 7 buildings	Metallic conductive flooring was exposed to weathering when roofs and walls were removed from the buildings	Lead, copper, asbestos, Aroclor 1254 and benzo(a)pyrene [B(a)P]	Removal of conductive flooring and the excavation and off-site disposal of soil containing metals and asbestos.
Igniter Assembly Area (IAA)	Assembly of igniter chargers for artillery, cannon, and mortal projectiles (1941-1943) 36 buildings	Metallic conductive flooring was exposed to weathering when roofs and walls were removed from the buildings	Lead, copper, asbestos, Aroclor 1254	Removal of conductive flooring and the excavation and off-site disposal of soil containing metals and asbestos.
Building Debris Disposal Trench (BDDT)	Originally a natural surface water drainage channel Later used as a disposal site for construction debris	Concrete, wood, and rusted/broken drums of a black, tarry substance believed to roofing tar	Benzo(a)pyrene	Restoration activities were completed in 1998. Mitigate erosion of soil to the adjacent stream.
Western Building Grounds (WBG)	Decontaminate explosives contaminated materials and dispose of off-spec energetics	Burning operations were conducted directly on ground surface or in a portable burning cage	Chromium and lead	Excavation and off-site disposal of sediment at edge of the pond

³⁶ Ibid

Site	Formal Use	Cause/Source of Contamination	Main Contaminants	Remedial Action
Northern Burning Ground (NBG)	Decontaminate explosives contaminated materials and dispose of off-spec energetics		Chromium and lead	Removal Action was completed in 2009.
Rail Yard	Former loading/unloading area		Isolated detections of PHAs and Aroclor 1254 below industrial levels and metals within background limits	No action
Groundwater	11 ground water monitoring wells and several springs		Arsenic, iron, lead, manganese – metals appear to be naturally occurring	No action

The extent of environmental impacts in both the MMA and the NRU indicate that any possibility of a reduced footprint in terms of a reduction in RFAAP’s acreage by moving the fence line is highly unlikely, particularly in the MMA. What is more likely to occur (as stated in the previous section) as a result of modernization and optimization efforts is an internal reduction of footprint as active production buildings and machinery are retrofitted, idle buildings are torn down, and liabilities are turned into assets through innovative solutions. This assumption is also supported by the notion that much space is needed on site for the safe storage of TNT and propellants. Thus, the continued availability of land was an important factor that influenced the selected recommendations for this report, specifically within the chosen industry targets.

RFAAP IN THE REGIONAL CONTEXT

Employment

According to Alliant Techsystems Inc. (ATK), RFAAP directly accounts for roughly 1,300 jobs. As a result, ATK represents the 5th largest employer in the region.³⁷ Most of these employees reside within the Blacksburg-Christiansburg-Radford (BCR) MSA due to the availability of affordable housing and a high quality of life. The total employment of the arsenal has been decreasing steadily since its WWII peak of about 23,000 employees. Since RFAAP supplies its products for military use, base employment inevitably depends on the level of U.S. military involvement around the world. Although owned by the Army, the base supplies ammunition and propellants to other branches of the U.S. armed forces.³⁸

³⁷ VEC, 2010

³⁸ Goure, 2009a

Income

According to ATK, the RFAAP injects \$85 million annually into the local economy through employee wages. This signifies an average salary of about \$65,000 for RFAAP employees. When compared to the average salary in the metropolitan region, RFAAP appears to be a pivotal contributor of strong-paying jobs in the BCR MSA. Manufacturing as a sector has above average weekly wages at \$883 and low turnover rates (6.8%). Fostering an economic portfolio strong in manufacturing could provide an excellent economic and fiscal foundation for the MSA, given the stability of employment and higher wages. See Table 4.

Table 4: Average Annual Incomes^{39 40}

	Per Capita Incomes
RFAAP Employees only	\$65,384
BCR MSA Manufacturing Sector (2009)	\$46,697
BCR MSA Total (2009)	\$36,032

Economic and Fiscal Implications of Base Optimization

As previously discussed, the base is currently in the midst of a competition to determine the next facilities-use contractor. An important part of the competing bids are proposals to optimize the base assets and operations, including offsetting overhead expenses by attracting private tenants to the base.

Infrastructure is an important piece of the current relationship between the RFAAP and its surrounding communities. Both Montgomery and Pulaski counties have agreements with the RFAAP to purchase water from its treatment facility, which could be further developed in the event that base modernization funding is used to repair and enhance water treatment capacity. As infrastructure projects are often difficult for local governments to finance given the uncertain nature of growth and commerce, this relationship has significant implications for the region. For example, the Pulaski County PSA is set to issue a \$3,812,000 Water and Sewer Revenue Bond for improvements to its pipes and pump stations. Since several areas of Pulaski are already serviced by water from the RFAAP, modernization and increased capacity to the water system at the base could reduce the need for Pulaski to incur additional debt to finance such a large capital expenditure. Another potential noteworthy fiscal impact would be capital improvements to transportation infrastructure such as roads and rail if production on the base were to ramp up or change in nature. If increased capacity on state or county roads were necessary due to changes on the base, this could become an unfunded capital improvements problem for local governments to tackle.

Regarding the economic impacts of employment on the base, the future scenario depends on the type of economic activities resulting from optimization and modernization. If additional tenants were to locate on the base, the composition of employment would depend on the nature of business (e.g. manufacturing, service, warehousing, etc.) and the degree of automation those tenants employ in production or service delivery. Given the industrial nature of the plant, industrial tenants are more likely to locate on the base and engage in a higher degree of automated production processes than service-based tenants. This is not to say that new businesses on the base would not contribute to increased employment, but it is unlikely that the base will return to the days of 20,000+ employed. The fiscal implications of such process-oriented growth are relatively insignificant for local governments, particularly with regards to schools and land development because fewer workers are attracted to the area. Also, because the base is isolated and restrictive, it is unlikely that cottage industries- particularly in the service sector- will spring up and

³⁹ Holiday, Kent. (2010). The Radford Army Ammunition Plant. ATK Energetic Systems ppt, Sept., slide 9.

⁴⁰ Bureau of Labor Statistics. (2010). Quarterly Census Data. BCR MSA.

provide much additional tax revenue for local governments. This could change in the event of a base footprint reduction and the transfer of land for private development, but the current situation is not conducive to growth.

Recommendations

The following recommendations for RFAAP and the New River Valley Economic Development Alliance (NRVEDA) stem from identifying RFAAP and community assets, examining comparable ammunition plants in the context of their surrounding communities, and understanding the environmental impacts of the base. These recommendations represent opportunities to enhance the level of synergy and collaboration between RFAAP and the NRVEDA and to leverage the value of RFAAP to the communities. However, certain assumptions are granted particularly regarding the future outcomes of the RFAAP contract contest. The three target areas of opportunity include:

- Marketing
- Industry Targeting
- Higher Education

MARKETING

The NRVEDA, a public-private regional marketing entity, highlights thirteen target industries for further development in the area. As the RFAAP attempts to modernize and increase its tenant-base, the NRVEDA should adapt its website and marketing strategies accordingly to distribute valuable information about updates and new opportunities for business. There is also an apparent communication gap between the RFAAP and the NRVEDA that precludes timely updates to marketing materials and results in suboptimal presentation of the base as a viable industrial site for potential tenants. While the NRVEDA mentions ATK and the base under the government and defense industry in its literature, it provides an outdated or incorrect website link to the RFAAP. The NRVEDA and the facility itself should also examine the marketing strategies used at other bases.

In order to remain competitive, the RFAAP should look to more effective marketing campaigns. The Holston Army Ammunition Plant (HAAP), the Milan Army Ammunition Plant (MLAAP), the Mississippi Army Ammunition Plant (MSAAP), the Rock Island Army Arsenal and others all employ advertising and marketing tools on their respective websites. Holston's Business and Technology Park website⁴¹ describes the ARMS initiatives, outlines the base assets, illuminates favorable news articles and enables users to search for available properties. The Iowa Army Ammunition Plant (IAAP) and its associated Commerce Center of Southeast Iowa markets selective assets: infrastructure, laboratory facilities, engineering expertise, research and development, testing facilities, fire protection and security. In addition, the Commerce Center provides descriptions, photos and potential uses for its available properties. Meanwhile, the MLAAP website⁴² highlights the existence of reliable utilities, accessibility to transportation and a "unique business climate" as reasons for choosing its Milan Commercial Complex. Although recently closed due to 2005 BRAC, the MSAAP is reinventing itself as a secure, competitive Industrial Complex within a Foreign Trade Zone.

The Rock Island Arsenal, a government-owned, government-operated (GOGO) facility, emphasizes affordability, security and site amenities as reasons for relocating businesses to the base. Thanks to the

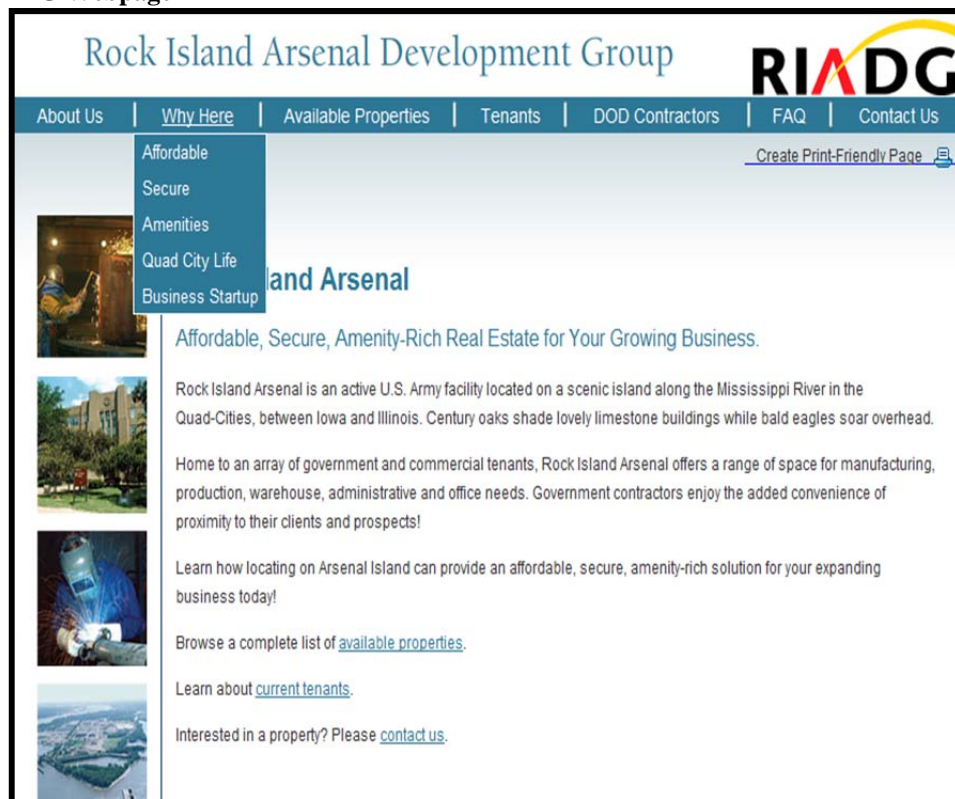
⁴¹ <http://www.holston2025.com/>

⁴² <http://milancommercialcomplex.com/>

Arsenal Support Program Initiative (ASPI), there are no buildout costs. As a result, tenants are free of engineering and architectural fees for structural renovations. If necessary, the government provides funds for remediation. Although the Radford facility is ineligible for ASPI funding (ASPI is only available for three specific facilities), ARMS funding can be leveraged along the same lines. The RFAAP and the upcoming winner of the contractor contest will allocate ARMS funding for facility renovations and optimization processes. In doing so, the RFAAP should work with the NRVEDA to advertise its relative affordability for potential tenants. Pat Nolan, Vice President and General Manager, Ordinance Business Unit, Conventional Munitions Group, remarked in 1998 that ARMS funding had brought 10 commercial tenants to the facility, resulting in more than 200 new jobs.⁴³ Nevertheless, the NRVEDA and the base contractor should look for methods beyond the ARMS program to expand the tenant base, including benchmarking of some of the successful communication technologies used at other bases.

The Rock Island Arsenal Development Group (RIADG) provides a comprehensive, navigable website. The site, displaying a horizontal array of drop-down menus, provides information on available properties, reasons for locating on the base, current tenants, FAQ and contact information. Figure 1 below illustrates the website's design and function.

Figure 1: RIADG Webpage⁴⁴



The Radford Army Ammunition Plant offers tremendous opportunities within a secure facility. Although the RFAAP's scrupulous security measures could be seen as a potential hurdle for new tenants, the precautions help create a safe work environment. In addition, activities within the fence(s) potentially allow for greater flexibility and fewer land use compatibility issues. Specifically, the base security helps circumvent NIMBYism (not-in-my-back-yard), a painstaking problem for many manufacturers. Future changes to the facility, such as a reduced footprint, could reduce complications associated with security

⁴³ Alliant Techsystems Submits Proposal to Manage Holston Army Ammunition Plant in Kingsport, Tenn. (May 15, 1998). Retrieved 3/4/11 from <http://atk.mediaroom.com/index.php?s=118&item=236>

⁴⁴ <http://www.riadg.org/>

by enabling tenants to operate “outside of the fence.”

The Holston facility, located in Kingsport, Tennessee recently created four acres of “outside of the fence” commercial development as part of its optimization process. Pendulum Management Company LLC, a consultant for BAE and the Holston facility, examined the possibility of moving fences and securing only what actually needed to be secured.⁴⁵ The 6,500-acre facility, roughly the size of the RFAAP, is burdened by greenfields and brownfields. In the last five years, BAE has taken the initiative to relocate the fences and transform 250 acres of greenfields into commercial space. One four-acre segment, shown in the figure below, is home to a new bank and strip retail center. Another large area was designated for the “Shoppes at Allandale,” a high end commercial shopping center, yet the project appears to be at a standstill. Although BAE is encountering some development setbacks, potentially due to the economic downturn, Pendulum offered another prudent marketing tool for the future.

While the Holston Business and Technology Park website enables a basic property search, it is not comprehensive or user-friendly. Pendulum, in its Special Study on “Security for Arms,” identified a survey template for potential tenants. One component of the survey, seen below, presents users with a series of criteria. In this fashion, tenants can select important attributes and essentially customize their requests.

Figure 2: Pendulum Energetics Prospective Tenant Survey

• Parcel Size	(Check One)
Under One (1) Acre	
1-5 Acres	
Over 5 Acres	
• Separated Fenced	Yes/No
• Building Size	
None	
1 – 10,000 SF	
10 – 25,000 SF	
Over 25,000 SF	
• Secure Storm Protection Required	Yes/No
• Drive In Doors	Yes/No
• Delivery Dock	Yes/No
• Ceiling Heights	_____ Ft
• Utilities	
- Electric	Yes/No
- Water	Yes/No
- Steam	Yes/No
- Sewer	Yes/No
- Fire Protection	Yes/No
• Rail	

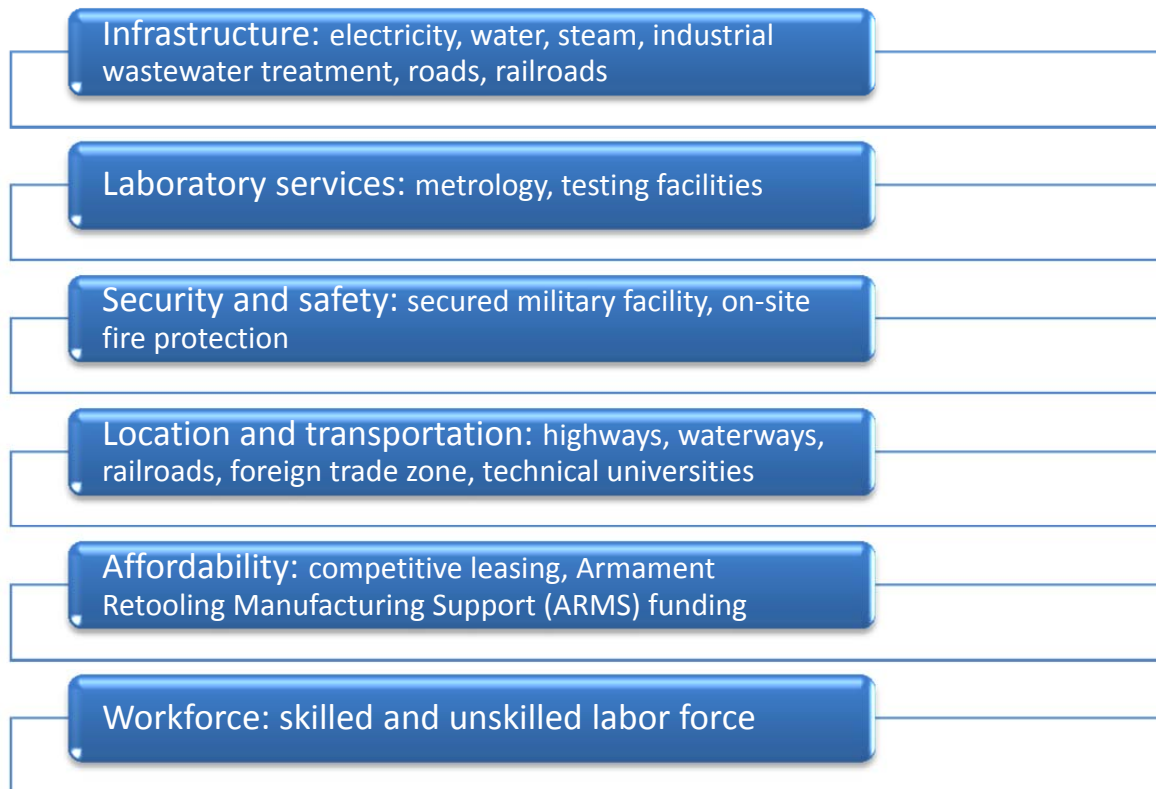
While the RFAAP’s assets are comparable to those of other major U.S. ammunition plants, the facility could more effectively market and advertise these strengths. In addition to revamping its own website, the base administrators should also broaden its marketing platform by teaming up with regional economic development organizations, such as the NRVEDA. This type of partnership, as seen with the Mississippi Army Ammunition Plant (MSAAP) and its local, regional and state economic development organizations, provides a much more dynamic illustration of the business opportunities available on the property. Furthermore, the RFAAP could establish its own version of a “Business and Technology

⁴⁵ Pendulum Management Company LLC (July 14, 2005). Special Study: Security for Arms.

Park.” Although the Radford Arsenal’s surrounding area is less developed than that of HAAP, Route 114 (Peppers Ferry Road) is a major artery through Montgomery County providing ample access to the facility. Despite the lack of commercial or residential development directly adjacent to the base, the communities of Radford, Christiansburg, and Blacksburg are each less than 10 miles from the main entrance. Finally, the facility operators and local economic developers could implement a survey to more aggressively pursue new tenants (see Figure 3).

Some of the highly marketable characteristics of ammunition plants throughout the United States can be examined in the figure below.

Figure 3: Marketability of Ammunition Plants in the U.S.



INDUSTRY TARGETING

In addition to creating a more effective marketing program, a goal of the Studio was to provide ideas and examples for new industrial development on the base. These recommendations are based on strengths and opportunities identified in the asset analysis phase of the project, as well as an understanding of client interests and larger economic trends. While several opportunities for economic development exist on the base, there also are many constraints and challenges that define the parameters of feasibility. This includes access and security issues, environmental contamination, and general uncertainty about the long-term or emergency needs of the Army. However, the Army has requested that competing contractors, ATK and BAE, include a plan to optimize the base footprint and offset operating costs with private tenants.

The industry targeting process started with an evaluation of existing tenants at the base. Several companies have located at the RFAAP to take advantage of similar products or processes, such as manufacturers of fireworks and small caliber ammunition. The connections between these tenants and the primary manufacturing function of the base are clear. Given the opportunity to apply a creative lens to the industry screening process, it was decided to search for industries without such an observable relationship to the core base functions. To avoid re-inventing the wheel, comparable Army ammunition plants were studied to determine if any innovative economic development efforts elsewhere could succeed at the RFAAP. Regional industries outside the base footprint were also examined to search for possible industry clusters and identify common inputs, outputs, by-products, or labor needs.

Several primary themes emerged from the industry screening process, including the concept of industrial ecology and leveraging the existing infrastructure assets.

Industrial Ecology

The term industrial ecology refers to an approach that recognizes the interactions between industrial systems and ecological systems and seeks to harmoniously integrate them. The concept is still evolving and has no single definition, but generally emphasizes the following:

- the study of material and energy flows and transformations
- a multidisciplinary approach
- an orientation toward the future
- a change from linear (open) processes to cyclical (closed) processes, so the waste from one industry is used as an input for another
- an effort to reduce the industrial systems' environmental impacts on ecological systems
- the idea of making industrial systems emulate more efficient and sustainable natural systems⁴⁶

RFAAP has made great strides in improving its environmental record over the decades but there is still room for improvement. With use of an industrial ecology approach it is possible to reduce the Arsenal's environmental impact even further by identifying industries that, when co-located with the current production work at RFAAP, allow waste products from one process to be used as inputs for another.

Following are discussions of the three target industries that may be integrated into a system of industrial ecology at RFAAP:

- Algae in biodiesel production
- Solar energy
- Wood products manufacturing

Target Industry: Algae in Biodiesel Production

Development in the field of renewable energy, a stated goal of the military and governments at all levels, is a solid possibility for the base given the abundance of underutilized land and the energy intensive manufacturing processes. The Air Force and Navy have already held successful testing of planes and boats using biodiesel, and each has expressed a goal to use renewable energy for half of their energy needs within a decade. The most efficient feedstock for producing biodiesel is algae, which can be grown in small ponds on non-arable land. Refined algae genetics and enhanced processing technology have

⁴⁶ Garner, A., & Keoleian, G. A. (1995, November). Industrial ecology: An introduction. Retrieved 3/4/11 from <http://www.umich.edu/~nppcpub/resources/compendia/INDEpdfs/INDEintro.pdf>

helped make biodiesel produced from algae cost competitive with petro-diesel, particularly if achieved on a large enough scale. Inputs to the process involve high volumes of water, cellulose or wastewater feedstocks, and CO₂ (including CO₂ sequestered from coal-fired power plants like the one at RFAAP). Open-air algae ponds must be heated in the colder months in this climate, which could be achieved through co-generation and distribution of steam from the base power plant. The start-up costs are high and vary depending on the type of system, but many algae start-up firms have either partnered with large energy companies for investment capital or received commercialization funding from the Departments of Energy, Agriculture, and Defense. Researchers at Virginia Tech have also found ways to utilize algae as a recycler of glycerol wastes resulting from biodiesel production, creating yet another opportunity for industrial symbiosis.

Target Industry: Solar Energy Production

Government at every level has adopted a goal of increasing the share of energy generated from renewable sources, including solar energy. The convergence of federal, state, and local government interests could lend valuable attention and effort to the implementation of this goal.

Federal Government

Various sources of federal authority, including the Energy Policy Act of 2005 and Executive Order 13423, direct federal agencies to source minimum amounts of the energy they consume from renewable sources. Most specific to the military is the 2007 Defense Authorization Act, which set a goal for the Department of Defense to “produce or procure not less than 25 percent of the total quantity of electric energy it consumes within its facilities and in its activities during fiscal year 2025 and each fiscal year thereafter from renewable energy sources.”⁴⁷

State Government

Virginia’s legislatively-mandated 10-year energy plan acknowledges that the state will need to expand its electricity generation infrastructure by more than 2,300 megawatts by 2017, using both conventional and renewable technologies. The energy plan requires the state to “encourage generation of electricity from new renewable sources” including biomass, wind, and solar, noting that these resources remain “significant[ly] untapped.”⁴⁸ The plan indicates that the potential installed new generating capacity for solar PV within the state exceeds that of all other renewable energy sources available to the state combined, except for offshore wind, at 11,000-13,000 megawatts.⁴⁹ In 2007, Virginia adopted a voluntary renewable energy portfolio standard (RPS) for utilities: 12 percent of base year electricity sales by 2022 minus the annual percentage generated from nuclear between 2004 and 2006. Wind and solar count double toward this RPS goal.⁵⁰

New River Valley Region

The New River Valley Planning District Commission’s Vision 2020 plan includes the goal of “develop[ing] alternative energy sources.”⁵¹ The New River Valley Economic Development Alliance’s website indicates that the region “has developed a strong cluster for renewable energy innovation.... New River Valley offers an attractive business climate for the renewable energy industry, including a world-class research university, low electric rates, excellent location, and a readily available, highly skilled workforce.”⁵²

⁴⁷ <http://www.gao.gov/new.items/d10104.pdf>

⁴⁸ The Virginia Energy Plan. (2007) Retrieved 3/4/11 from <http://www.dmme.virginia.gov/>

⁴⁹ Ibid

⁵⁰ Pew Center On Global Climate Change. VirginiaRPS. Retrieved 3/4/11 from <http://www.pewclimate.org/node/4683>

⁵¹ New River Valley Comprehensive Economic Development Strategy. (2009) Retrieved 3/4/11 from <http://www.nrvpdc.org/2020Update/CEDSVision2020report6-30-09.pdf>

⁵² http://www.nrvalliance.org/put_it_all_together/for_your_industry/energy.html

The compatibility of these various energy goals provides RFAAP and the region with an opportunity: not only does the plant stand to meet DoD goals by adopting solar energy technology, there is potential for RFAAP to profitably lend one of its greatest resources—land—for development of a solar energy project to serve the surrounding communities.

Background on Solar Energy Production at U.S. Military Installations

The U.S. military’s goal of increasing the share of renewable energy used in its operations has led to several major solar energy projects. Table 5 summarizes major features of several of these.

Table 5: Summaries of Major Solar Energy Projects at U.S. Military Installations

Project Features	Public and Private Partners	Construction and Operations
Nellis Air Force Base (NV)		
Status: operational as of December 2007	Air Force	Nellis AFB leases land to MMA Renewable Ventures, LLC
Capacity: 14 MW (over 30 million megawatt-hours of electricity/year)	SunPower Corporation Nevada Power Company	SunPower Systems designed and built the PV power plant
72,000 ground-mounted, tracking PV panels, with 6 million solar cells	MMA Renewable Ventures, LLC (subsidiary of Municipal Mortgage and Equity)	MMA Renewable Ventures financed and operates the solar plant, selling electricity to Nellis AFB at a guaranteed fixed rate for 20 years
Located on 140 acres, 33 of which are capped landfill	Four companies produced and supplied panels for the array	Nevada Power Company purchases renewable energy credits generated by the array to meet compliance goals of Nevada’s mandatory renewable energy portfolio standard
Supplies 28% of base electricity needs		
Cost savings: \$83,000/month, or \$1 million/year		
CO2 savings: 24,000 tons/year		
Fort Carson (CO)		
Status: operational as of winter 2008	Army	Fort Carson leases land to group of utilities investors
Capacity: 2 MW (3,200 megawatt-hours of electricity/year)	Dept. of Energy Western Area Power Administration (WAPA)	WAPA wrote two contracts allowing Fort Carson to buy power generated by the array from Colorado Springs Utilities for low fixed cost over 20 years
Located on 12 acres of closed (not even capped) landfill	Colorado Springs Utilities Investors	Lead contractor sells the renewable energy credits generated by the array to Denver utility company Xcel Energy, which applies these credits to compliance with Colorado’s mandatory renewable energy portfolio standard
Supplies 2.3% of base electricity needs (enough to power 540 Fort Carson homes)		

Project Features	Public and Private Partners	Construction and Operations
Stewart Air National Guard Base (NY)		
<p>Status: under construction; expected completion in 2011</p> <p>Will supply nearly 100% of base's daytime electricity needs (enough to power 100-150 four-bedroom houses)</p> <p>Will occupy up to six acres</p>	<p>Air National Guard</p> <p>The Solar Energy Consortium (TSEC)</p> <p>Applied Materials</p>	<p>Funded by \$4 million in federal defense funds appropriated in 2010</p> <p>In 2007, NY Congressman Maurice Hinchey organized TSEC, an industry-driven nonprofit, to help establish a major solar energy cluster in New York; TSEC (with \$31 million in federal funds) has partnered with 70+ companies that aim to create 1,000 solar jobs upstate</p> <p>Will be constructed using Applied Materials' thin-film solar PV technology</p> <p>New York has a mandatory renewable energy portfolio standard</p>
Edwards Air Force Base (CA)		
<p>Status: construction to start in 2013</p> <p>Capacity: up to 500 MW</p> <p>Will occupy 3,288 acre parcel</p>	<p>Air Force</p> <p>Fotowatio Renewable Ventures</p>	<p>Air Force Real Property Agency will lease land to Fotowatio, which will have exclusive access to site for environmental and transmission studies and first option to lease parcel after completion of studies</p>
Fort Irwin (CA)		
<p>Status: under construction; expected completion of first phase in 2014</p> <p>Capacity: 500 MW (approximately 1,000 Gigawatt hours/year), with potential expansion to 1,000 MW—the largest installation in the United States</p> <p>Concentrated solar thermal and PV technology</p> <p>Will be located at five sites across 14,000 acres</p> <p>Will meet 100% of Fort Irwin's energy needs</p> <p>Cost: \$2 billion</p>	<p>U.S. Army Corps of Engineers</p> <p>Irwin Security Partners (joint venture of ACCIONA Solar Power of Henderson, NV, and Clark Energy Group of Bethesda, MD)</p>	<p>Army will lease about 14,000 acres at Fort Irwin to Irwin Energy Security Partners</p> <p>Irwin Energy Partners will finance and develop the project and provide in-kind services (operation and maintenance) to the Army in exchange for lease of landholdings</p> <p>Any electricity generated by the project and not used by Fort Irwin can be sold on the commercial grid</p> <p>California has a mandatory renewable energy portfolio standard</p>

Some patterns emerge from a review of these solar energy projects at military installations, suggesting possible lessons for RFAAP and its New River Valley partners.

Large-scale innovation

All of these projects are (or were, during initial planning) groundbreaking, usually in terms of sheer size for U.S. solar production. This routinely innovative nature of solar energy projects for military purposes suggests that RFAAP and its partners may want prepare themselves to take on a project of unprecedented scope, at least in this geographic area.

Creative reuse of contaminated land

The Nellis AFB and Fort Carson solar projects were both at least partially sited on closed landfills—land that would require expensive clean-up for any other productive use. A solar project at RFAAP might be an ideal way to earn income from land where remediation poses an economic barrier.

Public-private partnerships

Each project involves a mix of public and private partners, which can include venture capitalists, utility companies, and other governmental entities. In addition to creating linkages in the region and providing a greater breadth of technical expertise, this mix can supply crucial funding. Indeed, the Government Accountability Office (GAO) notes that in cases where renewable energy is more expensive than conventional sources, the military can often share the cost burden with private industry (e.g., a local electric utility) for mutual benefit.⁵³

Mandatory Renewable Energy Portfolio (RPS)

It might not be a coincidence that all the military solar projects in the table above were located in states with mandatory renewable energy portfolio standards. The targets of a mandatory RPS can powerfully reshape the energy marketplace and create new business opportunities. For example, both the Fort Carson and Nellis AFB solar projects sell renewable energy credits to utilities subject to a mandatory RPS; without this mandate, there would be no need for the transaction. Virginia's RPS is only voluntary, and thus lacks the imperative to force real change. If it is serious about making renewable energy a part of its regional economic development strategy, the New River Valley Economic Development Alliance should consider lobbying the state for a mandatory RPS.

See the Appendix to this report for calculations that estimate the sizing of photovoltaic arrays necessary to meet half of RFAAP's current electricity needs.

Industry Target: Wood Products Manufacturing

Wood is one of the region's most abundant renewable energy resources and among the leading candidates to displace the supremacy of fossil fuels. If sustainably managed, Southwest Virginia's forests can contribute significantly to regional energy demand for heating and electricity generation. Export markets for wood pellets have also grown substantially in the past five years, creating an opportunity to increase local employment while diversifying the regional industry base. Exports to Europe alone have increased five-fold since 2006, and regulations imposing more stringent efficiency standards for wood stoves indicate the market will continue to expand into the reasonable future.⁵⁴ In addition to heating fuel, wood products can be co-fired with coal in conventional power plants to a ratio as high as 15% without requiring extensive equipment modification.⁵⁵ Typically referred to as wood brick, this product is not feasible for export, but has potential to satisfy demand for biomass co-firing at regional coal plants. Utilizing locally-sourced woody biomass to offset 15% of coal use in local power plants would be an impressive demonstration of the state's alternative energy goals and would bring valuable attention to

⁵³ <http://www.gao.gov/new.items/d10104.pdf>

⁵⁴ Wahl, A. Wood Market Trends in Europe. Report for Natural Resources Canada, 2008.

⁵⁵ Bain, R. & Amos, W. (2003). Highlights of Biopower Technical Assessment: State of the Industry and Technology. National Renewable Energy Laboratory, TP-510-33502.

the region. As prices for fossil fuels often fluctuate and are certain to increase in the long-term, wood products have a promising opportunity to emerge as a major source of reliable, carbon-neutral energy without the negative environmental consequences.

The RFAAP offers many of the necessary resources to support a wood products manufacturing facility on its premises. Land, water, energy infrastructure, and major rail access are essential assets for the industry, as well as proximity to inexpensive raw material. The region contains over 4 million acres of National and privately-held forests, much of which (79%) is comprised of hardwoods considered preferable for use as biofuel.⁵⁶ Of those 4 million acres, over 80% are privately-held and thus have fewer restrictions on economic uses. Despite containing over 25% of Virginia's total forest land, the region only accounts for roughly 17% of forest-related economic output, suggesting under-utilization of the region's resources and a deficiency in the creation of value-added forest products.⁵⁷ Beyond local timber harvesting to supply inputs for a woody biomass facility, the thriving logging industry in West Virginia could supply raw timber or sawmill byproducts via Norfolk Southern rail lines. Furthermore, the furniture industry cluster that exists throughout Southwest Virginia could be leveraged to supply sawdust as an input. On the other end of production, the Heartland rail corridor connects the RFAAP with the Port of Virginia at Norfolk for access to international shipping routes, while regional distribution needs can be met through nearby access to major interstates and local arterials. The base's exemption from local land use regulations is also an attractive feature for potential manufacturing industries, as zoning, permitting, and nuisance concerns often complicate or derail proposed industrial projects. However, should the base constrict its footprint in the upcoming optimization process, local governments should move to zone reclaimed land for industrial use to capture agglomeration effects and prevent the encroachment of incompatible land-uses on the primary base functions.

While a specific study to determine the feasibility of a woody biomass production facility in the area is yet to be initiated, several feasibility studies conducted at Virginia Tech demonstrate that the wood products industry can be successful in the region in a variety of formats.^{58 59} The woody biomass production process shares many similar characteristics with other wood products industries that are considered to be feasible candidates for targeting, given a variety of financial and contextual conditions. For example, the wood composites and wood chips industry use the same raw inputs, rely on similar supply and distribution channels, and require roughly the same land and labor dimensions. Each of these industries is found to have a positive net present value and favorable internal rates of return for projects in Southwest Virginia.⁶⁰ The insignificant differences between those industries included in the feasibility studies and the woody biomass industry provide a compelling basis for suggesting that similar value-added wood products facilities could be feasible in the New River Valley.

The RFAAP also provides an interesting opportunity to pursue the principles of industrial ecology, as discussed in the introduction to the industry targeting section of this report. Replacing a portion of the coal necessary to fire the base power plant with woody biomass would reduce carbon emissions from the plant and create a situation of guaranteed reciprocal demand. The base is also the nation's foremost producer of weapons-grade nitrocellulose, which requires a substantial amount of cellulose input. This cellulose is currently sourced by an external supplier via rail, but an opportunity may exist to produce the cellulose input on-base with shared inputs from a wood products processing facility. As highlighted in a study of cellulose quality in the nitrocellulose production at the RFAAP, product inconsistency issues can reduce efficiency and increase costs. Establishing a dedicated cellulose processing facility co-located

⁵⁶ Perkins, B. (2006). A Business Model for a Red Oak Small Diameter Timber Processing Facility in Southwest Virginia. Virginia Polytechnic Institute.

⁵⁷ State of the Forest Report. Virginia Department of Forestry, 2010. Retrieved 3/4/11 from <http://www.dof.virginia.gov/resources/pub-2010-State-Of-Forest.pdf>

⁵⁸ Perkins, 2006

⁵⁹ Walters, J. (1998). Determining the Financial Feasibility of a Wood Products Industrial Park. Virginia Polytechnic Institute.

⁶⁰ Ibid

with a woody biomass facility on the base could provide the operating contractor with a more reliable and higher quality source of raw materials, thus reducing costs and securing a critical input in the Army supply chain.

Establishing a wood production plant at the RFAAP could be initiated by private enterprise, sponsored by the Army due to the co-location benefits mentioned above, or achieved through some combination of the two in a public-private partnership. The primary contractor could also invest in the project and negotiate terms of supply with the Army in the facility operator-use contract. According to ATK, the construction of a new facility would require direct approval from the Army, as the ARMS program at RFAAP is limited to retrofit of existing facilities. While such approval would constitute a new precedent on the base, this should not discourage the pursuit of industry expansion, as renewable energy and manufacturing expansion enjoy considerable support from the Army, NRVEDA, and the State of Virginia. As renewable energy is among the priorities for each of these institutions, cultivating a regional industry cluster around biomass, in addition to solar energy, could attract outside investment and build a foundation for a sustainable local energy industry.

Potential Sources of Funding

Establishing industries in renewable energy and sustainable technology is an expensive prospect. Following are possible sources of funding available through federal and state programs that partners in such a venture on RFAAP property might consider.

Table 6: Renewable Energy Project Funding Sources

Funding Program	Eligible Technology*	Applicable Sectors*	Amount	Terms and Additional Details
FEDERAL				
<p>U.S. Dept. of Energy – Loan Guarantee</p> <p>Date Effective: DOE periodically issues new solicitations</p> <p>The Energy Policy Act of 2005 authorized DOE to offer \$10+ billion in loan guarantees for energy efficiency, renewable energy, and advanced transmission/ distribution projects in three categories: manufacturing, stand-alone, and large-scale integration</p>	<ul style="list-style-type: none"> • Solar thermal electric • Solar thermal process heat • Photovoltaics • Biodiesel 	<ul style="list-style-type: none"> • Commercial • Industrial 	<ul style="list-style-type: none"> • Varies; projects generally have total costs over \$25 million • No maximum incentive specified 	<ul style="list-style-type: none"> • Full repayment required over period up to 30 years or 90% of the projected useful life of the physical asset financed, whichever is shorter • See DOE Loan Programs Office website for more details

Funding Program	Eligible Technology*	Applicable Sectors*	Amount	Terms and Additional Details
<p>USDA – Rural Energy for America Program (REAP) Loan Guarantees</p> <p>Date Effective: USDA periodically issues new solicitations</p> <p>The Food, Conservation, and Energy Act of 2008 combined two existing programs to create the Rural Energy for America Program (REAP) to promote energy efficiency and renewable energy for agricultural producers and rural small businesses.</p>	<ul style="list-style-type: none"> • Solar water heat • Solar space heat • Photovoltaics • Biomass • CHP/Cogeneration • Renewable Fuels • Fuel cells using renewable fuels 	<ul style="list-style-type: none"> • Commercial 	<ul style="list-style-type: none"> • Varies • Maximum incentive: \$25 million per loan guarantee 	<ul style="list-style-type: none"> • Grants and loan guarantees are awarded for investments in renewable energy systems, energy efficiency improvements, and renewable energy feasibility studies • See USDA’s Loan & Grant Programs website for more details
STATE (Virginia)				
Industry Recruitment/Support				
<p>Green Jobs Tax Credit</p> <p>Date Effective 7/1/10</p> <p>Green Jobs: “jobs in the manufacturing and operation of renewable or alternative energy products and technologies used to generate electricity and energy”</p>	<ul style="list-style-type: none"> • Solar water heat • Solar space heat • Biomass • Fuel cells using renewable fuels 	<ul style="list-style-type: none"> • Commercial • Industrial 	<ul style="list-style-type: none"> • \$500 income tax credit for five years for each job created • Maximum incentive of \$175,000 	<ul style="list-style-type: none"> • Must create a new job, with annual salary of at least \$50,000, in the alternative energy/renewable energy fields • See Office of Commerce and Trade website for full list of eligible jobs
<p>Solar Manufacturing Incentive Grant (SMIG) Program</p> <p>Date Effective 1/1/96</p> <p>Jointly administered by VA Dept. of Mines, Minerals and Energy and VA Economic Development Partnership</p>	<ul style="list-style-type: none"> • Photovoltaics 	<ul style="list-style-type: none"> • Commercial • Industrial 	<ul style="list-style-type: none"> • Varies: up to \$.75 per watt for panels sold in the calendar year, with maximum of 6 MW • Maximum incentive of \$45 million per year 	<ul style="list-style-type: none"> • New manufacturers must meet certain production and other criteria to be eligible • See VA Dept. of Mines, Minerals, and Energy website for eligibility criteria

* Relevant to this report’s recommended industry target

HIGHER EDUCATION

Once the next contract for operation of RFAAP is granted, the \$400 million optimization allocation will be available for projects proposed in the winning contract. According to information published in the Single Manager for Conventional Ammunition Industrial Base Strategic Plan: 2015, RFAAP specifically requires updates to nearly all of its production facilities, a more efficient operating footprint, and updates to environmental controls.⁶¹ The details of these projects remain classified due to the on-going competition for the operating contract of the RFAAP. Regardless, it can be assumed that any updates to the RFAAP will require substantial research and development in terms of modernizing equipment, increasing production line efficiency, and environmental impact reduction/prevention. Furthermore, the recommendations concerning marketing and industry targeting may not be feasible without local origins of knowledge, professional, and financial resources. RFAAP is fortunate to be located in very close proximity to several reputable institutions of higher education, including Virginia Tech and New River Community College. As a formal recommendation for the NRVEDA, it is proposed that the NRVEDA fosters collaboration efforts between RFAAP and the local institutions. The following section discusses these opportunities in detail.

Current Involvement

The present state of collaboration efforts between RFAAP and higher education resources in the region is minimal. ATK, the current operator of the RFAAP, has been a sponsor of yearly undergraduate capstone projects within the department of Chemical Engineering at Virginia Tech since 1994. The projects typically focus on aspects of production at the RFAAP and range from topics concerning pollution prevention, process improvement, and product design.⁶² This partnership has proved valuable to both parties by providing students the opportunity to engage in real-world projects, foster networks with industry professionals, and explore potential job opportunities, while providing what basically amounts to a workforce development program specifically tailored for the RFAAP. Several graduates have secured employment at the arsenal post-graduation and some now hold key management positions.⁶³ While RFAAP's present involvement at Virginia Tech is noteworthy, our project group would like to propose expanding outreach efforts between the arsenal and local higher education institutions.

Opportunities at Virginia Tech

Virginia Tech presents a wealth of institutional assets with an extensive network of advanced students and faculty, each representing diverse areas of expertise and skill sets. The university is particularly relevant to our mission because it embodies an innovation powerhouse, is able to leverage multiple sources of funding, and its operations are not restricted to mass production processes.⁶⁴ This stated, Table 7 outlines three specific goals of the RFAAP optimization plan that Virginia Tech is able to directly address through its resources.

“Lean Six Sigma” is a manufacturing efficiency improvement methodology that strategically identifies opportunities for production streamlining. The Grado Department of Industrial and Systems Engineering is the centerpiece for industrial process optimization and participates in several research centers and institutes on Virginia Tech's campus.⁶⁵ The second goal is to increase public/private partnerships, which can be well-served through Tech's Office of the Vice President for Research. This administrative office

⁶¹ Single Manager for Conventional Ammunition (SMCA), (2009, January). Industrial base strategic plan (IBSP): 2015. Retrieved 3/4/11 from

<https://peoammo.army.mil/PMJointServices/Divisions/IndustrialBase/IndustrialBaseStrategicPlan.aspx>

⁶² Liu, Y.A. (2010). Department of Chemical Engineering. Virginia Tech.

⁶³ *ibid*

⁶⁴ Institute for Critical Technology and Applied Science. Outreach. Retrieved 3/4/11 from <http://www.ictas.vt.edu/outreach.shtml>

⁶⁵ Grado Department of Industrial and Systems Engineering. Retrieved from <http://www.ise.vt.edu/main/index.php>

inventories faculty expertise, describes areas of research, and explains procedures and policies for partnerships with the university.⁶⁶ The Director of Energy Initiatives in particular may be a beneficial administrative staff resource as the position is characterized by its ability to collaborate with project sponsors, possess a working inventory of government grant opportunities, and maintain a knowledge base of energy-related research expertise at Virginia Tech.⁶⁷ The last optimization goal aligning with Tech’s assets is that of improving logistics efficiency. Once again, the department of Industrial and Systems Engineering can assist in this task by providing expertise related to streamlining storage and transportation operations at RFAAP. The department manages external projects through the Center for Engineering Logistics Distribution.⁶⁸

Table 7: Comparing Optimization Goals of the RFAAP with Applicable Institutes and Academic Departments at Virginia Tech

Optimization Goals	Applicable Institutes/Academic Departments	Sample Projects
Lean Six Sigma	<u>Institute for Critical Technology and Applied Sciences: Center for Innovation-Based Manufacturing</u> <u>Center for High Performance Manufacturing</u> <u>Industrial and Systems Engineering</u> <u>VPMEP</u>	<u>“Enhanced Lean Mfg and Six-Sigma Integration”</u> <u>“Process Mapping and Cost-Time Profiling in Support of Lean Manufacturing”</u> <u>“Dynamic Value Stream Mapping and Lean Simulation Methodologies”</u>
Public/Private Partnerships	<u>Office of the Vice President for Research</u>	<u>Director of Energy Initiatives</u>
Logistics Efficiency	<u>Center for Engineering Logistics Distribution</u> <u>Industrial and Systems Engineering</u>	<u>“Analysis and Improvement of Stock Inventory Management at Northrop Grumman”</u> <u>“Reducing the Bullwhip Effect Through Appropriate Inventory Systems Design”</u>

Aside from assets at Virginia Tech that could benefit RFAAP’s optimization projects, the university and its professional networks will play a significant role in attracting the recommended targeted industries to the region. Table 8 outlines the applicable institutes and academic departments that are concerned with each of the industries we have identified for co-location at RFAAP. For the purpose of expanding marketing efforts, the Pamplin College of Business is concerned with many types of media presentations designed to help promote businesses. Since the recommendation focuses on web media, the departments of Information Technology and Management could likely provide the most useful services.⁶⁹

⁶⁶ Research at Virginia Tech. Retrieved 3/4/11 from <http://www.research.vt.edu/index.php>

⁶⁷ Research at Virginia Tech. Applications Invited for the Director of Energy Initiatives. Retrieved 3/4/11 from <http://www.research.vt.edu/announcement/applications-invited-for-director-of-energy-initiatives-2010.php>

⁶⁸ Grado Department of Industrial and Systems Engineering. Centers. Retrieved 3/4/11 from http://www.ise.vt.edu/facilities/facility.php?content_id=217&type=center

⁶⁹ Pamplin College of Business. Retrieved 3/4/11 from <http://www.pamplin.vt.edu/>

Furthermore, the AT&T Center for Scientific Visualization of Organizations can aid in website construction by designing innovative display features.⁷⁰

In regards to solar energy and algae biofuel, the Institute for Critical Technology and Applied Science (ICTAS) represents a premier source of alternative energy innovation that could potentially translate into a useful partnership with RFAAP.⁷¹ Furthermore, the previously mentioned Director of Energy Initiatives collaborates closely with ICTAS. Collectively these entities embody a source of funding, research, and best practices for alternative energy projects. ICTAS draws on faculty from many different academic departments, each providing specialized insight on issues concerning alternative energy.

To supplement the industry side of alternative energy programs is the Virginia Cooperative Extension. The Virginia Cooperative Extension is involved with many commercial industry projects oriented around natural resources and green energy.⁷² The cooperative also could play an important role in developing our final target industry recommendation of wood products manufacturing. Virginia Cooperative Extension is engaged in several centers pertaining to forest-related industries and has faculty connections with the Department of Wood Science and Forest Products, which specialize in developing sustainable forestry practices.⁷³

Any one of these entities could possibly act in a consultant or solutions capacity to prospective industries interested in locating in the New River Valley region. Another possible manifestation of collaboration between Virginia Tech and RFAAP could be the locating of field research facilities/sites at the RFAAP. For example, an experimental site for algae biofuel research may be feasible as an ARMS tenant.

Table 8: Comparing Areas of Recommendation with Applicable Institutes and Academic Departments at Virginia Tech.

Recommendation Areas	Applicable Institutes/Academic Departments	Sample Projects
Marketing/Web Media	AT&T Center for Scientific Visualization of Organizations	“Examining the Success of Websites Beyond
	Pamplin College of Business: Information Technology, Management	E-Commerce: An Extension of the IS Success Model”
Algae Biofuel and Woody Biomass	ICTAS Virginia Cooperative Extension Biological Systems Engineering Chemical Engineering Wood Science and Forest Products Forest Industries Center at Virginia Tech	“Biomass Feedstock Modification for Efficient Biofuels Production” “Microalgae as a Feedstock for Biofuel Production” “Determining the Financial Feasibility of a Wood Products Industrial Park”

⁷⁰ AT&T Center for the Scientific Visualization of Industries. (2003). Retrieved 3/4/11 <http://www.attcenter.pamplin.vt.edu/>

⁷¹ Institute for Critical Technology and Applied Science. ICTAS Research. Retrieved 3/4/11 from <http://www.ictas.vt.edu/research.shtml>

⁷² Virginia Cooperative Extension. Retrieved 3/4/11 from <http://www.ext.vt.edu/>

⁷³ Department of Wood Science and Forestry Products. (2010). Retrieved 3/4/11 from <http://www.woodscience.vt.edu/>

Recommendation Areas	Applicable Institutes/Academic Departments	Sample Projects
Solar Energy	<p style="text-align: center;"> <u>ICTAS</u> <u>Physics</u> <u>Chemistry</u> <u>Electrical and Computer Engineering</u> </p>	<p style="text-align: center;"> <u>“Sunlight to Electricity”</u> <u>“Multijunction III-V Photovoltaics and Thermophotovoltaics on Large Area, Low-cost Silicon Substrates for Alternate Energy Solution”</u> </p>

Opportunities at NRCC

Coinciding with the recommendation to cultivate a solar energy industry at RFAAP, it is suggested that the NRVEDA also examine the asset embodied by the New River Community College’s (NRCC’s) Alternative Energy Certificate Program. This one-year course sequence is designed to equip students with the tools necessary for pursuing a professional career in alternative energy systems installation, troubleshooting, repair, and maintenance. Students are instructed by experienced faculty advisors and are able to gain hands on experience by utilizing specialized training equipment.⁷⁴ With such a program in place, the support services required to operate and maintain a larger-scale solar facility should be locally available. The curriculum at NRCC has the potential to develop along side of our industry targeting efforts, as currently there are no major employment opportunities for solar power production in the region.

Future for Higher Education Collaboration

Ultimately, it is the responsibility of the individual entities to explore these possibilities. The analysis from this project indicates that each stands to gain from these types of symbiotic relationships and as these industries prosper, the region as a whole benefits. NRVEDA is indispensable in these efforts in light of the current limitations regarding interaction between RFAAP and higher education institutions. If a smaller, more specialized school such as the NRCC is to maximize its benefit to the community, efforts must be made to reach out and foster opportunities that allow its potential to flourish. In addition, the NRVEDA must work with Virginia Tech to facilitate interaction and access to its large portfolio of assets if they are to truly benefit to the local region and RFAAP. Future relationships between these institutions also depend greatly on efforts made by school administrators to reach out and offer their services to RFAAP. Virginia Tech is moving in such a direction with their new Director of Energy Initiatives position; however, there is no guarantee that the existence of this position alone will ensure the type of collaboration efforts we propose. NRCC might also benefit substantially if their faculty inventoried and maintained contact with local employers and prospective business opportunities for their graduates. One of these could certainly include RFAAP.

⁷⁴ Alternative Energy. Retrieved 3/4/11 from <http://www.nr.edu/energy/>

Conclusion

Of the recommendations provided in this report, some will require more time and resources than the others. An improved marketing strategy and increased collaboration with educational institutions could be pursued in the near-term, while the industry targeting and recruiting process is a much more complex and long-term strategy. Regardless of the different approaches necessary to address these recommendations, the regional economic development community should consider each in the context of impending changes at the RFAAP described by the authors. As the evolution of the RFAAP often occurs in fits and starts depending on the economic and political times, anticipating change and positioning accordingly is a way for the region to maximize the economic opportunities provided by the base.

Appendices

Glossary

ARMS	Armament Retooling Manufacturing Support
ASPI	Arsenal Support Program Initiative
ATK	Alliant Techsystems Inc.
BCR MSA	Blacksburg-Christiansburg-Radford Metropolitan Statistical Area
BRAC	Base Realignment and Closure Process
DoD	Department of Defense
GAO	Government Accountability Office
GOCO	Government-Owned, Contractor-Operated
GOGO	Government-Owned, Government -Operated
HAAP	Holston Army Ammunition Plant
IAAP	Iowa Army Ammunition Plant
ICTAS	Institute for Critical Technology and Applied Sciences
IRP	Installation Restoration Program
JMC	Joint Munitions Command
MLAAP	Milan Army Ammunition Plant
MMA	Main Manufacturing Area
MSAAP	Mississippi Army Ammunition Plant
NAC/SAC	Nitric Acid Concentrator / Sulfuric Acid Concentrator
NDU	National Defense University
NRCC	New River Valley Community College
NRU	New River Unit
NRVEDA	New River Valley Economic Development Alliance
RFAAP	Radford Army Ammunition Plant
RIADG	Rock Island Arsenal Development Group
RPS	Renewable Energy Standard Portfolio
TRI	Toxics Release Inventory
TSEC	The Solar Energy Consortium
VPMEP	Virginia A.L. Philpott Manufacturing Extension Partnership
WAPA	Department of Energy Western Area Power Administration

Sizing a Potential Grid-Connected PV System for Installation at RFAAP

The two equations⁷⁵ below estimate the PV output and array area required to supply the equivalent of 50% of RFAAP's current electricity use. As with other military solar projects, the public-private partners would decide on the distribution of energy between the base and the grid.

Sizing equation 1: PV module energy output required to meet given energy need

$$P_{DC,STC}(kW) = \frac{\text{Energy (kWh/yr)}}{(\text{de-rating}) \times (\text{hrs/day of 1-sun}) \times (365 \text{ days/yr})}$$

where:

- DC,STC is a module's direct current output under standard test conditions
- Energy (kWh/yr) is the energy needed to meet 25% of RFAAP's own electricity requirement (25% is the DoD's renewable energy goal), and this figure is doubled to supply additional electricity to the grid. Twenty-five percent of RFAAP's daily electricity requirement is 290,000 kWh;⁷⁶ doubled, it is 580,000 kWh. Multiplied by 365 days/yr, the total energy required of on-site solar production is 211.7 million kWh/yr.
- hrs/day of 1-sun refers to the annual average solar intensity on a south-facing fixed collector, with tilt angle equal to latitude + 15 degrees; at the nearest location for which data are available, Roanoke, VA, this equals 4.6 kWh/m²-day, or 4.6 hours per day of peak sun⁷⁷
- de-rating factor accounts for various system losses; assume typical de-rating factor of .75

$$P_{DC,STC}(kW) = \frac{211.7 \text{ million kWh/yr}}{(.75) \times (4.6 \text{ hrs/day of 1-sun}) \times (365 \text{ days/yr})} = 168,116 \text{ kW, or } 168.1 \text{ MW}$$

Sizing equation 2: array area requirement

$$A(m^2) = \frac{P_{DC,STC}(kW)}{1 \text{ kW/m}^2 \times \eta}$$

where:

- DC,STC is a module's direct current output under standard test conditions
- η is collector efficiency, which depends on the manufacturer's specifications; assume upper-middle value of 17%

$$A(m^2) = \frac{168,116 \text{ kW}}{1 \text{ kW/m}^2 \times .17} = 988,918 \text{ m}^2, \text{ or about } 244 \text{ acres}$$

⁷⁵ Source of sizing equations: Randolph, J., & Masters, G. M. (2008). Energy for sustainability: Technology, planning, policy. Washington, DC: Island Press.

⁷⁶ Per ATK presentation during site visit, 9/22/10

⁷⁷ National Renewable Energy Laboratory. (1994). Solar radiation data manual for flat-plate and concentrating collectors. Retrieved 3/4/11 from <http://www.nrel.gov/docs/legosti/old/5607.pdf>

Figure 4: Potential Solar Array Sites at RFAAP (over 1 million square meters in total)

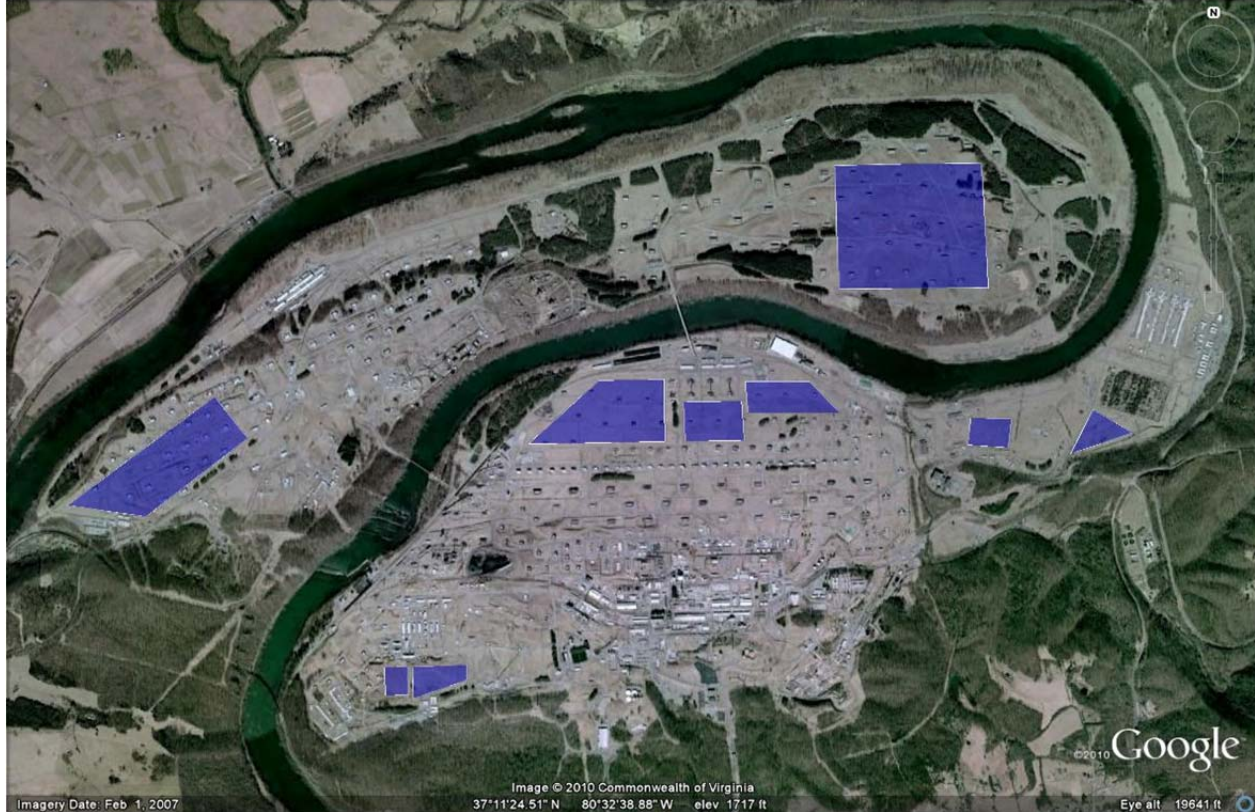


Figure 4 above shows examples of locations at RFAAP that might potentially host solar arrays, based on the estimated array area requirement of nearly one million square meters. As the transparent blue patches indicate, there is very little contiguous open land completely free of structures, and any existing space between storage buildings falls within the no-build blast-arc. However, demolition of buildings that are no longer needed could free up property for a solar energy project.