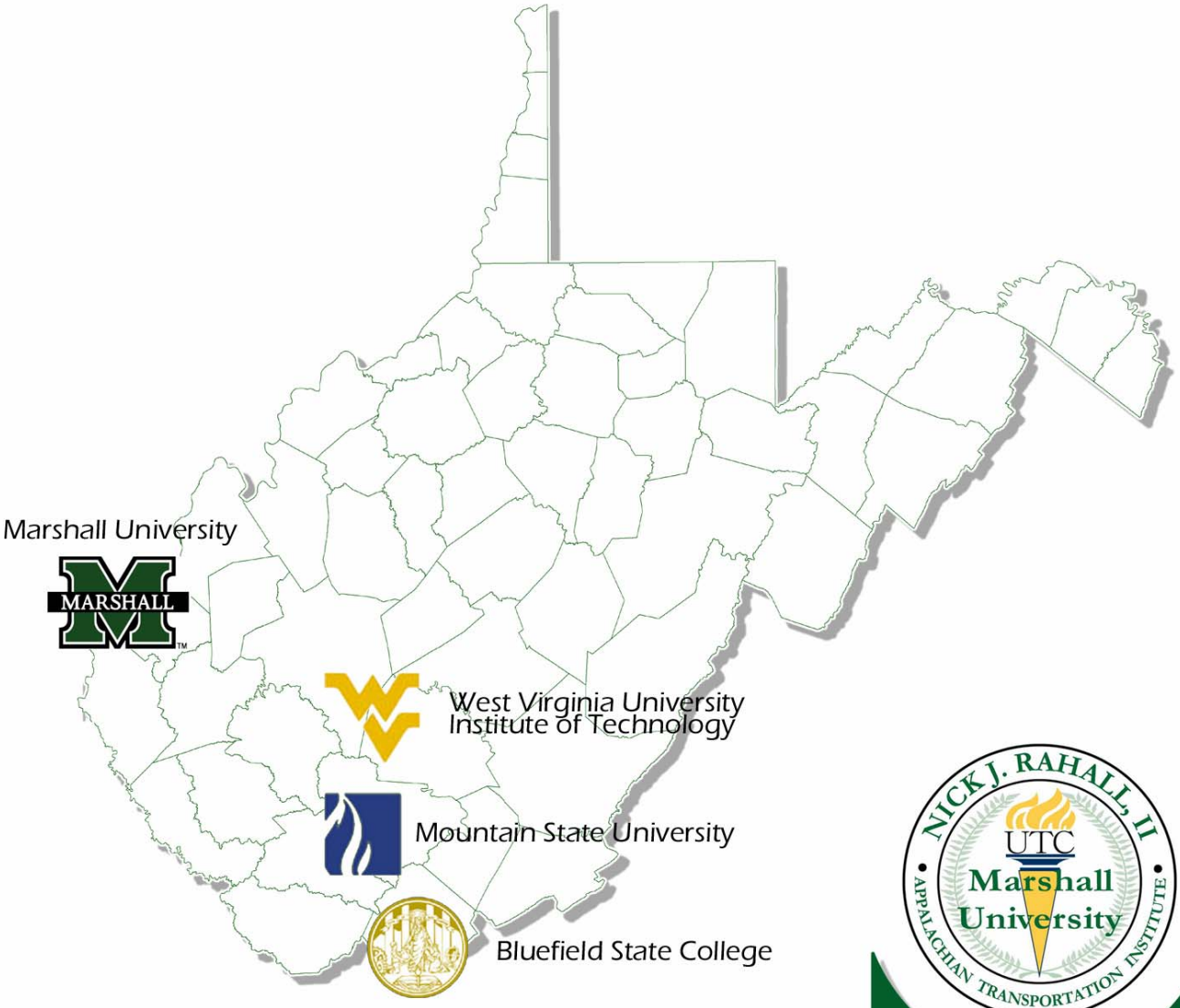
RTI TRP 00-06

Transportation and Market Feasibility Analysis for Innovative Coal Combustion Byproducts to be Manufactured Adjacent to the I-64 High Tech Corridor in Southern WV



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16. Abstract

A consortium of both public and private entities has developed an innovative program designed to eliminate existing coal waste by combining the waste material with coal and burning the mixture in the production of electricity. In order for the overall project to be financially viable, it must be possible to profitably produce, transport, and market an innovative coal combustion product that is produced through the combination of coal ash and saw dust resulting in a brick that has applications in residential and industrial construction. The project will be demonstrating state of the art technology and has the potential to dramatically affect the local economy through the new long term high tech jobs that will result assuming transportation challenges are resolved. A concurrent endeavor to develop and promote a high technology corridor in the region in addition to land use planning underway in the county must be taken into consideration to maximize the potential impact the project can have on the development of the high tech corridor in the shortest amount of time possible.

Preliminary analysis suggests that demand conditions, production costs, and transportation alternatives combine to form very promising opportunities for the profitable manufacture and distribution of the product (Woodbrick). However, this initial analysis lacks the detail necessary to completely convince all involved constituencies that this favorable outcome will, in fact come to fruition. The following study is proposed to address the additional necessary details.

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TRANSPORTATION AND MARKET FEASIBILITY ANALYSIS FOR INNOVATIVE COAL COMBUSTION BYPRODUCTS:

TO BE MANUFACTURED ADJACENT TO THE I-64 HIGH-TECH CORRIDOR IN SOUTHERN WV

TRP 00-06

Rahall Transportation Institute

Prepared for

Western Greenbrier Co-Generation Co-Generation, LLC

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1. INTRODUCTION

This study provides a market analysis for a construction product, WoodBrik™, to be manufactured at a proposed site in Rainelle, West Virginia. The study was commissioned in response to several economic questions posed by the U.S. Department of Energy (DOE) to the Western Greenbrier Co-Generation, LLC as part of a proposal under the DOE's Clean Coal Initiative. It is organized as follows: Section 1 provides a brief project background. Section 2 reviews the structure of the brick and block industry. Section 3 addresses the geographic and product market issues specific to WoodBrik™ production at a Rainelle, West Virginia location and provides some evidence of alternative uses of fly ash products. The study ends with a summary of findings and conclusions about the efficacy and feasibility of producing this product at a West Virginia site.

2. BACKGROUND

In 1999, the Nick J. Rahall, II Appalachian Transportation Institute (RTI) at Marshall University, funded a study entitled "Potential Uses of Fly Ash and other Recoverable Materials in New Transportation Infrastructure Components." Dr. Richard Begley, the principal researcher, found a number of potential uses for fly ash byproducts, ranging from acid mine drainage remediation to construction material suitable for safety and environmental improvements. Key among Dr. Begley's findings was the potential for the use of high quality fly ash for low-cost production of building materials.

Several sites in West Virginia are appropriate for the application of newer coal combustion technologies that generate electricity with material from coal waste impoundments and processed coal. These technologies benefited from several programs under the Department of Energy's Clean Coal Initiative. Importantly also, coal waste burned under such regimes can yield fly ash of varying qualities.

In response to this research, and other stimuli, Western Greenbrier Co-Generation, LLC was formed to facilitate a proposal under the U.S. Department of Energy's Clean Coal Initiative for a fluidized bed combustor located in Western Greenbrier Co-Generation County, West Virginia. The site proposed for the steam powered generator and the WoodBrik™ manufacturing facility is one of the most expensive land and water reclamation sites under state control in West Virginia, so that the proposed program received almost immediate state support.

In early January, 2003, the U.S. Department of Energy announced a $107 million grant for the construction of the generation facility and associated "eco-park" endeavors. However, the current study is confined to the consideration of WoodBrik™ manufacture and distribution at a site co-located with the generation facility in Rainelle, West Virginia.

3. THE MARKET

Economic analyses of markets typically review a number of structure, conduct and performance issues associated with the geographic and product definition of a market. To gain a general understanding of relevant market conditions, the current study examines markets for products with uses similar to those envisioned for WoodBrik™ products – namely concrete pipe, brick and block.

Annually this industry enjoys revenues of $6.9 billion dollars from over 1,480 manufacturing plants. The industry employs over 38,000 workers with a total wage bill of $1.69 billion. The mean wage in this industry is therefore in excess of $44,000 per year or roughly $21 per hour. Not surprisingly given their weight-to-value ratio, net exports of these products account for a trivial proportion of overall sales. Revenue growth in this industry in 2001 was 4.7 percent in inflation-adjusted terms and employment growth during the most recent year was 3.1 percent.

WoodBrik™ is a flexible product that may be molded for a variety of construction applications. Within the current analysis, we define the product market as *wall units* in residential and light commercial construction. Several features of WoodBrik™ suggest the product possesses many qualities that are improvements on block and frame construction materials that currently dominate such markets.

The demand for construction products is generally derived from the demand for new residential and non-residential construction. The use of WoodBrik™ for public infrastructure construction is also a possible source of demand for the product. Blocks for highway and other construction uses present a potential market for WoodBrik™ or a kindred product. However, the market for concrete pipes experiences considerable competition from fiber and glass product substitutes.

The industry suffers few barriers to entry, with the possible exception of high sunk costs. It is highly vertically integrated with distribution controlled heavily by manufacturing firms. Also, R&D costs may be relatively high in an industry where assurance of quality and performance characteristics of new products is critical. The considerable presence of integrated firms implies that successful new entrants must also

be highly integrated. Thus, considerable resources provided by Western Greenbrier Co-Generation, LLC may be required to insure adequate market penetration.

Industry-wide, there are potentially several useful state and federal tax incentives that may be applicable to the clean coal, co-production demonstration project. The project may be eligible for the Business Investment and Jobs Expansion Credit or the Research and Development Projects Credit from the State of West Virginia.[1] Recently, Rep. Boehlert (NY-24) HR-238, introduced a bill to provide federal energy research, development, demonstration, and commercial application activities, and for other purposes.[2] Given the increased interest and need for advanced technologies and alternative uses for waste products, there are likely to be other energy/environmental bills introduced; however, the project's eligibility for certain incentives may be limited if it is scheduled to receive funds through the Clean Coal Power Initiative or other sources.

Regulation of product quality imposes a non-trivial fixed cost. Concrete pipes, brick and block are subject to a variety of quality regulations for strength, durability and corrosion standards. Industry organizations such as the American Concrete Institute and the Precast/Prestressed Concrete Institute set standards for product performance. Additionally, quasi-nongovernmental organizations such as The American Association of State Highway and Transportation Officials (AASHTO) set standards for products used in highway and other infrastructure construction. Many of the costs of compliance must be borne prior to manufacture, making both federal technology transfer funds and state R&D tax credits extremely attractive.

Concentration within these markets is generally low. Indeed, an examination of production within most geographic markets suggests no possibility for market power in regional markets. The median block producing firm in the U.S. employed fewer than 20 workers with only 2.1 percent of the industry's firms employing more than 100 workers.

This industry enjoys many of the most important characteristics of a competitive industry – low concentration, focus on product quality and price and relative ease of new firm entry. Whether or not WoodBrik™ will be a successful entrant into this market is contingent upon several factors including the projected demand for these type products within a

[1] "Analysis and Recommendations for West Virginia Tax Incentives." West Virginia Department of Tax and Revenue and West Virginia Development Office. January 9, 2002.

[2] HR-238 – Energy Research, Development, Demonstration, and Commercial Application Act of 2003 – was introduced January 8, 2003. The bill, as of February 12, 2003, has been referred to the House Subcommittee on Energy and Mineral Resources.

region that can be readily accessed. However, there is no a priori condition that would preclude the venture's success.

4. SPECIFIC GEOGRAPHY AND MARKET ACCESS

Our analysis of the geographic extent of the WoodBrik™ market begins with an analysis of transport costs and is followed by a forecast of housing production in the accessible region through 2010.

4.1 Transportation of Masonry Products

Finished masonry building products are generally transported by truck up to a distance of 100 miles. The raw materials for manufacturing such products are typically moved by rail up to a distance of 400 – 500 miles. With the exception of the Charleston, West Virginia metropolitan area, there are no major construction markets within a 100-mile driving distance of the planned WoodBrik™ production facility at Rainelle, West Virginia.

An analysis of production and potential transportation costs suggests that the unique characteristics of this project will, in fact, make it economically feasible to ship the finished WoodBrik™ by truck up to a distance of roughly 250 miles. This additional market reach will make it possible for the production facility to access eight additional metropolitan areas with an aggregate population of more than six million people (See Table 1). The incremental addition to the West Virginia market should be more than sufficient to assure that the operation can successfully market an output of 10,000 units per day. This is sufficient to assemble five median sized residential structures.

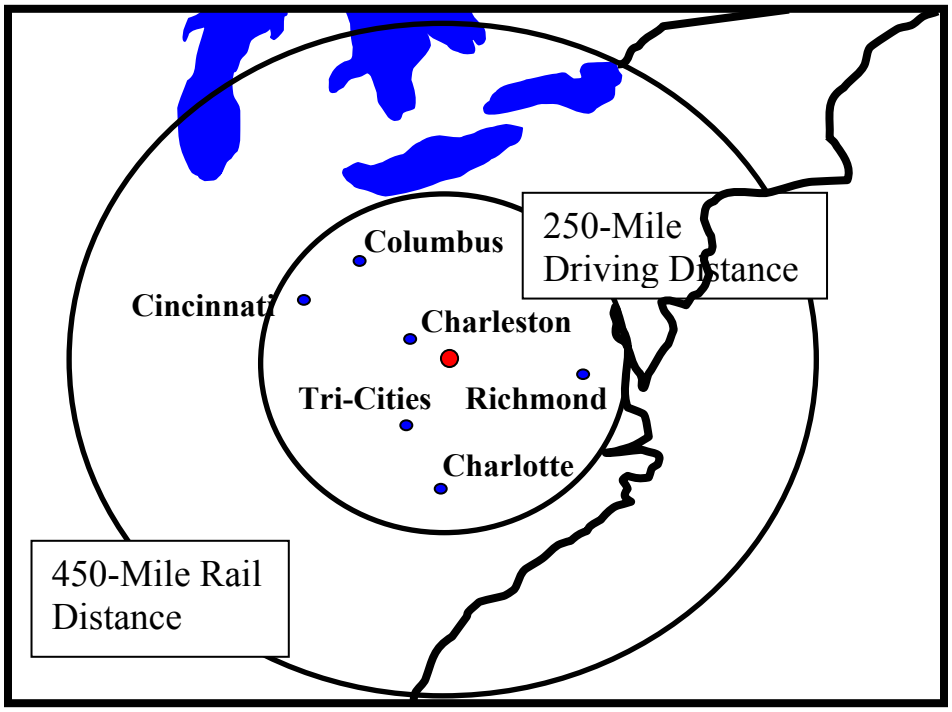
Also, assuming that it is possible to safeguard the dry components against the effects of moisture, it would also be possible to ship a premixed product by rail to locations as much as 500 miles away from the West Virginia production facility for processing by independent manufacturers. We discuss this in more detail in a later section. The market reach under these scenarios is depicted graphically in Figure 1.

4.2 Discussion of Transportation Issues

The ability to adopt these transportation practices is a direct product of the significant difference between anticipated production costs and the estimated retail value of the product. Current estimates suggest an incremental operating cost of $1.30 per finished brick or $42.90 per ton of

output. Assuming that each WoodBrik™ can be retailed for $4.00, the resulting difference between revenue and operating costs of $2.70 per unit must provide an adequate return on capital and pay for all transportation and retailing costs.[3]

Figure 1
Feasible Market Area



Assuming an initial capital investment of $10 million, a six percent *real* interest rate compounded annually, and a 20-year asset life, the total cost of capital would be $17.4 million.[4] Based on an output rate of 10,000 units per day and 300 days of operation each year, per unit capital costs would equal approximately $0.29 for each WoodBrik™. Theoretically, then, the remaining $2.41 per unit is available for transportation and retailing costs.

Absent information on expected retailing costs, the analysis assumes a delivered wholesale price of $3.00 per WoodBrik™. This

[3] Given the difference between the cost of WoodBriks and traditional materials, there is no particular reason to question the estimated retail price of $4.00 per unit. Truthfully, given the performance characteristics of WoodBriks, the retail value may actually be much greater.

[4] The analysis ignores the potential effects of inflation, so that per unit costs and price do not change over the 20-year planning horizon. Accordingly, it is appropriate to use a real rather than nominal price of capital.

would yield a retail margin of 33%, relatively high for a low valued, bulk commodity. This should provide sufficient buffer to absorb retailing costs. Under this assumption, the amount remaining to accommodate transportation and handling costs would be $1.41 per unit. The estimated trucking cost for reaching the target markets is $25 - $30 per ton.[5] Even if the revenue available to offset transportation costs is reduced by one-third and trucking costs are at the top of the foreseeable range, accessing markets within 250 miles of the production facility is still feasible. We believe this is a conservative estimate of the geographic range of distribution of this product.

The eight Metropolitan Statistical Areas (MSA's) within a 250-mile driving distance of the proposed production facility and their 2000 populations are provided in Table 1.

Table 1
Metropolitan Statistical Areas (MSA) within 250 Miles of the Proposed Production Facility

MSA	*Population*
Charlotte	1,508,050
Charlottesville	160,243
Cincinnati	1,649,228
Columbus	1,544,794
Huntington	312,447
Lexington	455,617
Roanoke	235,876
Tri-Cities	480,327
TOTAL	**6,346,582**

4.3 The Demand for New Construction

The existence of over six million urban residents within an achievable transportation range should be sufficient to allay concerns about the potential magnitude of the geographic market. However, to better quantify the potential *future* market for WoodBrik™, the study team

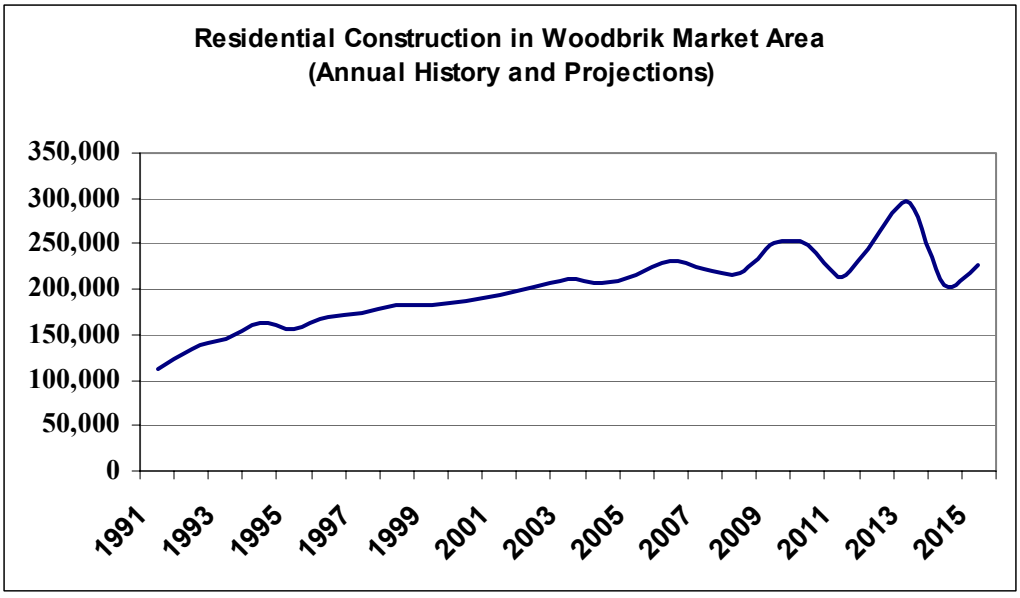
[5] This amount assumes the use of flatbed equipment and no opportunity for a back-haul movement.

constructed a forecast model of new home starts in all counties and MSA's within the 250-mile range.

This forecasting model projected new home starts (residents only) using actual data from the early 1990's through 2001. Accounting for projected regional population and income growth in each state's share of the region as well as expected real home mortgage rates the study team forecasted a daily range of home construction through 2010. Basing home construction rates on a 300-day production year, the forecast points to over 800 new homes constructed daily beginning in 2006 and rising for each year thereafter.[6] See Figure 2.

At this rate of new construction and assuming a 300-day production year, WoodBrik™ market penetration at the proposed production scale would necessarily be only 0.625 percent to break even. If non-residential construction (roughly one-third of total construction nationwide) is included, the necessary market penetration rate drops to less than one-half of one percent. This is less than the median market share for all brick and block producing firms in the United States. It appears reasonable that this market share is a potentially achievable level of penetration.

Figure 2
New Home Construction Forecast



[6] All construction, population, income, and housing values were obtained from the U.S. Census Bureau, Manufacturing and Construction Division (www.census.gov/const/www/index.html).

4.5 Shipping an Intermediate Product

The discussion of transportation to this point, has been focused on distributing the output of one production facility. However, the availability of additional waste materials at other locations suggests that, if the proposed project is successful, it could readily be replicated. If that occurs, it is conceivable that it would be necessary to reach more distant markets. Given the revenues available to offset transportation costs, it may be possible to simply truck additional volumes to markets such as Cleveland, Knoxville, Pittsburgh, or Baltimore. There is, however, another alternative.

If researchers can allay concerns regarding the potential effects of moisture, it may well be possible to ship a dry-mix of component materials by rail in covered hopper cars for subsequent processing at destinations as much as 500 miles from the production facility. This would extend the market reach to practically every metropolitan area east of the Mississippi River basin and north of the Tennessee River basin, including every major urban center in the northeast except Boston.

Railroad charges for the covered hopper car movements would likely be $15 - $20 per ton depending on the total shipment volume. These line haul charges are less than the trucking costs for distributing finished WoodBrik™. However, firms receiving the intermediate dry-mix would likely incur costs in completing the manufacturing process that exceed production costs in West Virginia.[7] Plus, there would be additional transportation costs associated with transporting the finished bricks to area retailers. Nonetheless, the distribution of an intermediate product for final processing could represent a method for disposing of vast volumes of waste products.

5. A HISTORY OF RELEVANT PRODUCTS

Early on, the study faced concerns regarding the scale of market penetration that WoodBrik™ would need to achieve for financial sustainability. As noted, this figure *appears* very low (0.625% of regional construction). However, whether or not this is genuinely a small figure can be discerned by studying the experiences of other producers who have entered similar markets. Accordingly, we examined five other products to determine whether or not this degree of market penetration planned for WoodBrik™ is achievable. Notably, four of the five products have been

[7] As currently proposed, the kiln at the West Virginia facility would be fueled by a mix of coal, coal waste, and wood waste – a combination that is likely cheaper than fuel sources at alternative production locations.

very successful, while a fifth has had some mixed success. Each of these products is either less expensive or enjoys some qualitative advantage over its competitors. WoodBrik™, we believe, enjoys both of these benefits.

5.1 Concrete Roofing Tiles

Although concrete tiles (as an adaptation of clay tiles), were developed in the late 19th century, their introduction in the United States did not occur until the early 1960's. Standard extruded concrete roofing tiles (a mixture of sand and cement), lightweight concrete tiles (using additives such as fly ash to reduce overall weight) and more recently fiber cement panels (combining cement, silica derivatives, aggregates, cellulosic fibers and other additives) have been able to enter the market for three main reasons: non-combustibility, total cost and durability.

Concrete tiles (both standard and lightweight) - as well as most fiber cement panels - are Class A fire rated (noncombustible). This represents a superior alternative to both treated and untreated wood shakes and coated metal panels, which can be rated as low as Class C. (It should be noted however, that some fiber cement panels are rated Class B due to particular cellulosic fiber additives that are combustible).[8]

Although standard weight concrete tiles require reinforced framing to support its weight which could in turn increase cost per square foot, the lightweight concrete tiles and fiber cement panels have costs per square foot that are competitive with other roofing materials. Lightweight concrete tiles cost approximately $350-$375 per square foot installed. Similarly, fiber cement panels range from approximately $300-$380 per square foot installed. While this is significantly higher than that of asphalt/fiberglass shingles ($145-$315), it is comparable to treated wood shakes ($280-$475), coated metal panels ($350-$450) and lightweight clay tiles ($375-$400).[9]

The third and perhaps key reason that lightweight concrete roofing tiles have experienced market success is the expected life of the product. Lightweight concrete roofing tiles are warranted for a 50-year product life. This is twice as long as the warranted life for three tab asphalt/fiberglass shingles (25 years) and more than triple the warranted life of wood shakes (15 years). This durability further reduces the cost per year of lightweight concrete and fiber cement products.[10]

[8] Roof Tile Institute (www.ntrma.org)
[9] Ibid.
[10] Ibid.

In 2001, the National Roofing Contractor's Association, as part of their Annual Market Survey, showed that concrete tile represented 3.3% of new steep-slope (residential) construction and 2.9% of steep slope re-roofing projects. As for low-slope (commercial) construction, concrete tiles garnered 0.9% of new construction and 0.2% of re-roofing.

5.2 James Hardie Company

The James Hardie Company was founded more than 100 years ago by a Scottish immigrant in Australia as James Hardie Industries (JHI), an importer of oils and animal hide tanning products. In 1903, JHI began importing a new French product – "Fibro Cement." When World War I caused an interruption in the supply of Fibro-Cement to Australia, JHI made the decision to manufacture the product in Australia – calling the new product "Fibrolite." JHI produces fiber cement building materials such as siding (most notably – Hardiplank), ceramic tile backerboard, and factory built construction products. JHI began trading on the Australian Stock Exchange in 1951 and on the New York Stock Exchange in 2001.

JHI's sustainable competitive advantages include:

- Unique plant engineering, proprietary process technology and product formulations
- Unique differentiated products, widest range and strongest brand
- Superior capital cost efficiency (plant capital cost ½ that of competitors)
- Largest, lowest cost manufacturer (plant operating cost 20-30% lower than competitors)
- Only national producer in each market
- Superior economies of scale (plants 2-3 times larger than competitors)[11]

JHI began manufacturing in the U.S. at the Fontana, CA plant in 1989. JHI's volume growth has gone from less than 200 mmsf in 1990 to over 1,000 mmsf in 2002 (an increase of 5 times in 12 years). The sales growth has increased from roughly US$150 million in 1997 to US$450 million in 2002 (an increase of 3 times in 5 years). The EBIT growth went from roughly US$30 million in 1997 to US$100 million in 2002 (an increase of 3 times in 5 years). The JHI had an annual production capacity

[11] *James Hardie Unique Technology Driving High Growth* presentation, August 2002.

of 2.1 billion square feet/year in 2001[12]; after upgrades at 2 plants, the production total will be 2.25 bsf/year[13].

Table 3
Total Siding Market Share

Siding Type	*1994*	*2002*
Fiber Cement	***1%***	***13%***
Vinyl	46%	49%
Hardboard	13%	9%
Brick	9%	8%
Stucco	8%	7%
Cedar	7%	5%
OSB	7%	3%
Aluminum	0%	1%
Masonry	3%	2%
Plywood/Other	6%	3%

The total U.S. siding market share for fiber cement products has increased from 1% in 1994 to 13% in 2002. See Table 3. The JHI compared costs with other siding products and found that Hardiplank is more expensive than vinyl, less expensive than brick, equal or less expensive than hardboard siding, and less expensive than synthetic stucco.

Few concerns have been expressed with JHI products. Among those concerns include proper installation procedures must be followed or the warranty may become void, galvanized nails must be used to avoid rust seeping through the siding, the warranty covers "installation within the U.S. and Puerto Rico" – which may exclude Canada, the warranty is transferable but may not be if a third party is involved, and since JHI products contain wood fibers – which can absorb moisture and expand – warps, leaks, and rotting may be possible.[14]

5.3 Insulated Concrete Forms (ICFs)

ICFs are concrete and foam wall systems that are alternatives to wood framing. ICFs are lightweight, interlocking expanded polystyrene forms that have concrete poured over them to create a wall system. The

[12] *James Hardie Annual Report 2002*, page 12.
[13] *James Hardie Unique Technology Driving High Growth* presentation, August 2002.
[14] National Organization of Exterior Finish System Inspectors (NEFSI) bulletin boards.

three main types of ICF walls are flat, waffle, and screen. The forms may also be identified at Expanded Polystyrene (EPS). One of the frontrunners of ICF technology and manufacturing is PolySteel, which began in 1978.

Insulated concrete forms (ICFs) are manufactured by multiple companies and then distributed for resale to contractors, architects, etc. In the U.S., major manufacturers of ICF wall systems (headquarters and founding dates, if available) include: American PolySteel (Albuquerque, NM – 1978), Owens Corning dba Lite-Form Int'l (South Sioux City, NE – 1985), Reward Wall Systems (Omaha, NE – roughly 1988), Reddi-Form (Oakland, NJ – 1990), Quad-Lock (Surrey, British Columbia – 1994), Owens Corning dba Pinkform Xtra (Toledo, OH – 1999), AAB/Arxx Building Products/ Arxx Wall Systems (Cobourg, Ontario). In West Virginia, there are three primary distributors of ICF systems – Adams Trucking and Supply (Barboursville), Mountain State Wholesale, Inc. (Sutton), and Lite-Form of Central WV (Bridgeport). Neighboring states and the number of distributors total: Virginia (8), Maryland (3), Washington D.C. (1), and Pennsylvania (8).

The competitive advantages of ICFs include:[15]

- Solid, lasting construction that resists fire, wind, and time
- Two layers of foam insulation (better than plain concrete)
- Greater energy efficiency (insulation value of R32) and noise reduction
- Provide stability (particularly in areas prone to natural hazards)

The Insulated Concrete Forms Association (founded in 1995) provides data on its members, thus ICFA data is used to provide a picture of the ICF market in the US. The ICFA found that member shipments increased from 4.7 mmsf in 1993 to 28.2 mmsf in 2001 (an increase of 6 times in 8 years) and ICF Shipments are primarily used in residential applications – 80.6% in 2000 and 82.0% in 2001[16]

ICF cost comparisons assert that ICF wall systems are comparable to the cost of an ordinary 2x6 wood-framed house (may be 2-4% higher) and more than the cost of a bare block or poured wall (may be 5-6% higher.).[17]

[15] ICF website (www.forms.org)
[16] *ICFA Shipment Report*, ICFA Board of Directors Agenda, Cincinnati, OH, July 11, 2002.
[17] PolySteel (www.polysteel.com)

One concern expressed about ICF is that carpenter ants and termites may burrow through below-grade foam and into houses. However, many building codes require that below-grade foam be treated to resist pests.[18]

5.4 PVC Vinyl Siding

The plastic used most in building applications is vinyl, or polyvinyl chloride (PVC). Scientists first synthesized vinyl in 1872, but did nothing more than study and record its properties until 1926. At that time, Dr. Waldo Semon, a researcher with the BF Goodrich Company in Akron, OH, began searching for materials that could replace rubber in tires since the supply of natural rubber was dwindling. Dr. Semon produced a waterproof and versatile flexible compound used to coat fabrics, rainwear, shower curtains, and shoes. Some of the first commercial uses include wire and cable insulation and fire safety (vinyl jackets). Germans introduced vinyl windows, which were introduced in the U.S. during the post-war years. In the 1950s, PVC pipe from Europe was introduced to the U.S. In the 1960s, vinyl siding was introduced but it was more expensive than wood and aluminum so it did not immediately capture U.S. market share. Vinyl siding's growth may be attributable to more efficient manufacturing techniques, lower prices, improved quality, and rising costs of aluminum. In the 1970s, vinyl single-ply roofing systems were a clean, quick, safe, and less costly alternative to asphalt built-up roofs. In the 1980s, fencing, decking, railing, and other exterior accessory products were developed. Fencing was the first to gain market acceptance – primarily because horse farm owners did not want to paint miles of wood fencing and horses did not chew on vinyl fencing.[19] By 1980, twenty companies were producing vinyl.[20]

Currently, some of the major PVC Vinyl Siding manufacturers (headquarters and founding date, when available) include: Mastic – acquired by Alcoa Building Products in 1989 (Ingomar, PA – 1932 – InselBrick® first low maintenance asphalt siding) (1969 – Barkwood® first T-lok® vinyl panel); Variform (subsidiary of Nortek, Inc. with a plant in Martinsburg, WV, Kearney, MO – mid-1970s); Alcoa Building Products (Pittsburgh, PA – 1930s – aluminum siding and 1977 – vinyl siding); Alside, Inc. (Akron, OH - 1947 low maintenance residential baked enamel aluminum siding and 1979 – vinyl siding); CertainTeed (Valley

[18] "Insulated Concrete Forms," *The Taunton Press* from the pages of *Fine Homebuilding*, Andy Engel.
[19] "Vinyl By Design: A Proven Material in the Built Environment." *Architectural Record*. McGrawHill Construction.
[20] The Vinyl Institute, "Vinyl – The Material." www.vinylinfo.org.

Forge, PA, roughly 1982); Louisiana-Pacific Corporation; Rollex Corp. (Elk Grove Village, IL – 1980s); Owens Corning (Toledo, OH – 1995); Heartland Building Products (Booneville, MS); and Norandex / Reynolds Building Products (Macedonia, OH); Revere Building Products (Cleveland, OH) bought Gentek Building Products (Cleveland, OH).

The competitive advantages of PVC vinyl siding include value, durability, exterior integrity (never needs painting), and a long warranty. The cost comparison of PVC siding and other siding products revealed that vinyl siding costs less than brick, stucco, wood, stone, and metal when initial costs and maintenance costs are considered.

The Vinyl Siding Institute, a business unit of the Society of the Plastics Industry, Inc., reports the U.S. shipments of vinyl siding and soffit in "number of squares," a unit of measure common in the building and construction industry. One square equals 100 feet of siding, or enough to cover a 10'x10' area. U.S. shipments increased from 12,397,916 squares in 1986 to 38,250,066 squares in 2001 (increase of 3x in 15 years).

In a report published by the George Carter & Affiliates in 1994, the researchers found that vinyl siding accounted for 971.2 mmsf in 1985 (17.3% of total siding market) and 2,047.7 mmsf in 1993 (31.3% of total siding market; increase of 200 percent in 8 years).[21]

5.5 Exterior Insulation and Finishing Systems

Exterior Insulation and Finishing Systems (EIFS) are multi-layered exterior wall systems used in both residential and commercial building applications. Introduced in the United States in the late 1960's (after a successful introduction in post-WWII Europe), EIFS now accounts for nearly 25-30% of the commercial exterior wall market and nearly 2% of the residential wall market.[22] Despite significant legal issues associated with the installation and product life of EIFS, growth in the residential sector is strong with sales increasing at the rate of 12-18% per year.[23] Synthetic Stucco (as EIFS is commonly known) is generally targeted toward higher end residential homes, which accounts for its lower market penetration.

EIFS is composed of three main components. First, an insulation board made of polystyrene or polyisocyanurate foam is secured to the exterior wall surface with a specially formulated adhesive and/or

[21] Available online at www.GCAonline.com/siding.
[22] Exterior Insulation and Finish Systems Industry Members Association (www.eima.com)
[23] Ibid.

mechanical attachment. A water-resistant base coat is then applied on top of the insulation and reinforced with fiberglass mesh for strength. Finally, a finishing coat is applied, typically using acrylic copolymer technology that is both colorfast and crack-resistant.

Traditional "between the studs" insulation leaves "thermal breaks" – gaps where heat and cold pass into the structure – at studs, wall outlets, wall joints, etc. By insulating outside the structure, EIFS reduces air infiltration, stabilizes the interior environment and reduces energy consumption. Note that this insulation effect also captures water that enters through gaps in windows, doors, flashing, and other open areas. When it enters in large amounts (such as during storm conditions) and does not let it escape, this can result in mildew and rot.

Arguably, manufacturers, installers and general contractors all contributed to the problems that thousands of synthetic stucco homeowners are now suffering. Of course, the manufacturers claim that if their instructions had been followed, moisture would not have intruded and destroyed the framing of synthetic stucco homes. The general contractors rebut this argument by claiming that the system simply cannot be constructed to the degree of perfection required in order to prevent moisture intrusion. The synthetic stucco system is not an effective barrier system. It is impossible in the field to build a system that prevents water from reaching a home's sheathing and studs. Newer "water management" synthetic stucco systems (and the latest position espoused by EIMA) recognize this fact. New systems incorporate a moisture barrier on the sheathing to drain the moisture and have a weep capability that sheds the water. EIFS is a multi-component system, which potentially involves many different trades if it is to be installed correctly. According to homeowners and their lawsuits, the manufacturers knew about the system's complexities and failed to adequately train or inform those in the field who were responsible for various aspects of installation. Most importantly, the manufacturers who received thousands of complaints about installation deficiencies, were well aware of widespread misapplication, and took insufficient steps to rectify these problems.

Besides giving incomplete information to those responsible for applying the system, the manufacturers sold EIFS as a low or no maintenance product. EIFS is a complex, unforgiving and extremely high maintenance cladding. In its defense, the manufacturers say that if the system is installed according to specifications, no moisture intrusion, and no damage, will occur. The manufacturers essentially contend that the system can be installed in a manner that prevents moisture intrusion. The fact that many systems have not been properly installed represents the case against the stucco installer and the general contractor. Well over 500

cases against manufacturers, contractors and installers have been resolved to date.

6. SUMMARY & CONCLUSIONS

The overall initiative planned by Western Greenbrier Co-Generation, LLC is both ambitious and exciting. A key component of this program is the production and distribution of WoodBrik™ products for use in residential and light commercial construction. In considering whether the WoodBrik™ portion of the initiative is, in fact, feasible, the study team asked the following five questions:

- Are there general characteristics of the markets in which such products are sold that would inhibit the ability of a new product to be successfully introduced?
- Is it feasible to produce WoodBrik™ products at a West Virginia location and ship them to areas where they might be consumed?
- Will the future demand for building products in the target region be sufficient for the new products to absorbed?
- If the Rainelle site is replicated, is there an avenue for disposing of a much larger volume of WoodBrik™ products?
- Are there other relevant examples of the successful introduction of similar building products from which to learn?

Without qualification, the answers to these questions point to a robust future for WoodBrik™ products. Generally, markets for similar products are not dominated by large manufacturers, but instead feature a larger number of relatively small producers. The remarkably low production costs for WoodBrik™ products makes it possible to transport the finished products further than one would typically ship such products so that a West Virginia production site is feasible. Moreover, the projected growth of the target market is quite strong. If producers are willing to ship an intermediate product by rail, the effective reach would allow them to dispose of an almost unlimited amount of output. Finally, WoodBrik™ products are likely to be only the latest in a nearly continuous stream of residential building products with improved performance characteristics.

In terms of subsequent activities, the study team offers three recommendations. First, most successful producers are highly integrated, so that the project's managers would do well to plan carefully plan distribution paths as early as possible. Second, initial tests suggest that WoodBrik™ products have measurably superior performance

characteristics. This fact is likely to be of paramount importance the architects and builders upon whose favor the products' success will hinge. Therefore, the current analysis recommends continued rigorous testing of product characteristics. Finally, the current analysis has focused on the manufacture of WoodBrik™ products as the lone use of the residual fly ash. However, this same high-quality ash has a more traditional use in the production of ready-mix concrete. For a variety of reasons, this traditional use is less desirable than the production of WoodBrik™ products. It, nonetheless, can serve as an invaluable safety net. Thus, to ensure the overall project's viability, its management should develop a detailed plan under which ready-mix concrete could be substituted for WoodBrik™ products as a profitable use of fly ash.

APPENDIX A: HOUSING FORECAST MODEL

This study includes a forecast of new residential construction. This forecast was designed to predict the number of residential structures within the estimated market range of the product. This market range included all counties and Metropolitan Statistical Areas within a 250-mile radius of Rainelle, West Virginia.

The data was collected from the U.S. Census, Bureau of Labor Statistics, and the Bureau of Economic Analysis. These data include population, residential housing starts, home mortgage rates and price indices. All are publicly available.

We aggregated the county data within the market area (See Figure 1 in text) creating a single series on new residential housing and population. From this we constructed a forecast of population growth using a Vector Autoregression with two lagged endogenous variables. The choice of a VAR in levels was dictated by augmented Dickey-Fuller test results rejecting the presence of a unit root in this series. The results are displayed in Table 4.

Table 4
Results of Population Forecast
(t-statistics in parenthesis)

	POP
POP(-1)	0.483841
	(1.28208)
POP(-2)	0.476391
	(1.29603)
C	1623092
	(3.83008)
R-squared	0.999894
Adj. R-squared	0.999851
Sum sq. resids	3.86E+08
S.E. equation	8786.231
F-statistic	23495.28
Log likelihood	-82.11902
Akaike AIC	21.27976
Schwarz SC	21.30955
Mean dependent	29881961
S.D. dependent	719916.3

From these population forecast we constructed a housing forecast using a similar statistical method where a VAR with two lags of the real mortgage rate and housing starts was regressed on the population forecast. The results appear in Table 5.

Table 5
Results of Residential Construction Forecast

	EX_REALMORT	HOUSE
EX_REALMORT(-1)	-1.446517	1755.490
	(-0.91050)	(3.84407)
EX_REALMORT(-2)	-2.611894	-5450.497
	(-1.36247)	(-9.89110)
HOUSE(-1)	0.000198	-0.533808
	(1.16064)	(-10.8976)
HOUSE(-2)	0.000120	-0.091178
	(1.03194)	(-2.71873)
C	207.6851	-688899.2
	(1.37468)	(-15.8632)
POPF	-7.69E-06	0.032936
	(-1.23992)	(18.4690)
R-squared	0.789944	0.999968
Adj. R-squared	-0.260338	0.999808
Sum sq. resids	0.356253	29436.34
S.E. equation	0.596869	171.5702
F-statistic	0.752126	6248.592
Log likelihood	0.490518	-39.13683
Akaike AIC	1.574138	12.89624
Schwarz SC	1.527775	12.84988
Mean dependent	5.621548	174592.0
S.D. dependent	0.531662	12380.82

This forecasting model provided the forecasts employed in the text. Notably, this forecast contains information only on residential structures. National data suggests that these type structures account for roughly two thirds of total new units annually. The product we are analyzing in this report is potentially appropriate for both residential and light commercial structures as well as a number of infrastructure applications. As we mention in the text a conservative count of light commercial structures would increase the forecasted quantity considerably.