ORCAS

Creating an Energy Blueprint for Appalachia

Results of the ARC-ORCAS Energy Workshops

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Summary Report

INTRODUCTION

ENERGY BLUEPRINT BACKGROUND

At the February 2006, Governors' Quorum Meeting of the Appalachian Regional Commission (ARC), the governors of the 13 Appalachian states and the ARC federal co-chair called for the creation of an "Energy Blueprint" for Appalachia, in response to today's changing energy supply, policy, and use environment. The Commission's objective in developing the Blueprint is to provide a strategic framework for the promotion of new energy-related job opportunities through the stimulation of sustainable energy production, efficiency, and conservation efforts throughout the Region.

As envisioned, the Blueprint will include an assessment of the current energy landscape and an examination of both non-renewable and renewable energy opportunities, based on the competitive potential of the Appalachian Region's energy resources; and will identify the Region's energy assets and the potential for developing energy-related job opportunities in the Region based on the competitive potential of these assets and current and emerging energy technologies.

One key aspect of the Blueprint's development will be gathering information from energy experts, the private sector, academia, government and other stakeholders. In order to do this, ARC has commissioned four research briefs and scheduled three energy workshops/roundtables in the Region and one consultation with the Region's local development districts (LDDs).

Based on these inputs, the Energy Blueprint will propose recommendations for investment, research, and advocacy in the development of energy-related job opportunities and in the retention of energy jobs in the Appalachian Region. The Blueprint should be in final form by late autumn 2006.

Research Briefs

ARC has commissioned four research briefs to help inform the Energy Blueprint. These briefs will demonstrate how national energy policy and market dynamics are likely to affect the development potential of energy resources in the Appalachian Region over the next decade. The briefs will draw on existing information and research on domestic energy resources, technology, and trends, with a focus on the Appalachian Region. The brief will cover the following topics:

- **Review of Energy Policies and Market Dynamics:** An analysis of federal and state energy policy initiatives, regulations, and proposals.
- **Non-renewable Energy Innovation:** A review of innovative non-renewable energy resource technologies and an assessment of their application within the Appalachian states.
- **Renewable Energy and Conservation:** A review of all renewable energy sources and an assessment of the current state and resource potential across the

Region for each renewable energy source, as well as identification of any significant concentrations of business activity in each business segment.
- **Supply Chain Analysis:** An analysis of the energy supply chain.

Energy Workshops
The three energy workshops were designed to bring together energy technology, economic development, energy production, environmental, and policy experts to discuss how national energy policy and market dynamics are likely to affect the competitive potential of energy resources and job development opportunities in the Appalachian Region over the next decade. The Oak Ridge Center for Advanced Studies (ORCAS), an independent research organization located in Oak Ridge, TN, was chosen to organize, convene, facilitate, and report back on the workshops for ARC.

The ARC-ORCAS energy workshops were held as follows:

- In Morgantown, WV, on Wednesday, June 21, 2006
- In Oak Ridge, TN, on Tuesday, June 27, 2006
- In Huntsville, AL, on Thursday, July 13, 2006

Each workshop was composed of featured speakers, selected to present a snapshot of a particular issue that would inform the discussions; invited participants, who represented numerous industry, academic, and nongovernmental groups from across the many sectors of energy, economic development, and the environment; and audience members, who represented members of any other interested grassroots, nongovernmental, or academic groups as well as the public.

Each workshop was composed of three focus sessions: energy, economic development, and community focus. While all three workshops had participants knowledgeable in renewable energy, fossil fuels, and conservation issues, each location examined a slightly different energy topic to enable more detailed discussions (i.e., fossil fuels in Morgantown; energy conservation, energy efficiency, and transportation in Oak Ridge; and renewable energy in Huntsville). The economic development focus discussed opportunities for the Region that result from the evolving energy situation and barriers to realizing these opportunities. Finally, the community focus looked for current examples of activities communities are pursuing to lower the cost of energy used in their municipal operations, and to attract new and retain existing energy-related businesses.

WORKSHOP SUMMARY REPORT AND APPENDICES
This report summarizes findings from the workshops, provides overarching recommendations for both the Energy Blueprint itself and for the ARC to help implement the Blueprint, and then provides brief summaries of information presented by workshop participants in each focus area. Information that helped generate the recommendations and findings is addressed in detail here. In addition, three appendices provide supplemental information: Appendix A provides the agendas from the workshops, Appendix B provides contact information for all workshop attendees; and Appendix C includes one-page abstracts about energy-related projects that were submitted by

researchers and institutions across the country. ORCAS gathered these project papers through an open call for submissions on completed research, current projects, and/or visionary programs in energy and/or energy-related economic development. Specifically, ORCAS was seeking innovative projects that could be used in Appalachia to help meet its energy, efficiency, and energy-related job-creation goals.

FINDINGS

It has been almost one year since the devastating effects of Hurricane Katrina. That disaster, in tandem with world events, only increased the United States' concerns about the future of energy prices and the security of our supply. Regardless of the type or source of fuel, however, several overarching facts remain clear: higher energy prices disproportionately affect people with lower incomes than other segments of the population. In fact, energy costs account for over 13% of a low-income family's spending, while it only accounts for 3.5% of a mid-to-upper-level family's expenditure. In addition, rising energy prices harm economic development in rural areas more than in urban areas. As a result, higher energy prices hurt those families and regions least able to cope with the costs.

FOSSIL ENERGY

The Appalachian Region is home to numerous sources of energy, especially fossil energy including natural gas, petroleum, and abundant coal. Exploitation of the Region's fossil energy resources should continue, but with a focus on higher value forms of the resource, such as liquefaction, gasification, and electricity production. The states and Region should continue to foster relationships with industries that are interested in transforming coal into an energy export, not just removing it from the region as a cheap raw material. In addition to the abundant supply in the Region, efforts to continue working with coal have several advantages over other forms of energy. Natural gas and petroleum substitutes are plagued with numerous uncertainties ranging from facility site location for Liquefied Natural Gas (LNG) to the likely commercial competitiveness of tar sands, while coal's contribution is in place and can be expanded in the near-term. As a result, the Energy Information Agency has increased its estimates about the future of coal and its contribution to liquid fuels market.

Coal does face several challenges. Increased coal use bears inherent concerns about air quality, carbon dioxide emissions, and the water required for its processing and use. In addition, coal from the Region is currently at a cost disadvantage compared to that mined in the Western United States, but more stringent air quality standards will work to make the playing field more level. Advanced coal use technologies will also require training and expanding the coal-related workforce. The number of people currently working in the coal arena is declining, and new skills will be needed to work in plants that convert coal to energy via chemical processes. For example, an Integrated Gasification Combined Cycle (IGCC) plant is more similar to a chemical plant that makes electricity than any current coal-fired operation. This workforce will be needed soon, because many of the advanced coal technologies are on the verge of commercial application and could be deployed in the near term. For example, Pennsylvania facilitated the establishment of a coal liquefaction plant by providing a guarantee to purchase some of its product.

ENERGY EFFICIENCY AND TRANSPORTATION

The Appalachian Region currently lags behind the rest of the nation in exploiting energy efficiency measures. However, this creates tremendous opportunities for exploiting energy efficiency tools and techniques and using this resource as an engine of economic growth and development. Much of the Appalachian Region did not follow late 20th century efficiency standards. For example, the Region spends one-fifth the national average, per capita, on energy efficiency programs, ranks near the bottom among regions in the use of ENERGY STAR® appliances, and has completed only one state-level Energy Efficiency Resource Standard (in Pennsylvania). The Region could now leap-frog up to the most recent efficiency techniques and thereby realize even greater savings and/or efficiency improvements. In addition, distributed energy production and integrated resource use planning in economic development projects have great potential. The Region is also set to embrace fuel savings and improvements through its solid progress in developing alternative transportation fuels including hydrogen, biodiesel, and ethanol. Businesses, corporate fleets, and individuals are increasingly utilizing these fuels within Appalachia.

RENEWABLE ENERGY

Findings about renewable energy in Appalachia are similar to those for energy efficiency. For example, the Region has only limited programs for promoting green power and renewable energy, even though these represent significant economic development potential. While the Tennessee Valley Authority has a program to buy and sell green power and to promote more efficient metering and monitoring, demand thus far has not been widespread outside metropolitan areas within its service area. Indeed, most customers who currently embrace the green power and the alternative fuels that are strengths of the Region, pay more for these commodities. With continued investment, this cost differential could be eliminated and jobs created if Appalachia embraces its renewable resources, especially biomass—an energy development field in which the Region could lead the entire nation.

ECONOMIC DEVELOPMENT

In order to reap the rewards from efficiency and the development of renewable energy resources fully, current economic hurdles in the Region must be removed. A significant lack of venture capital funds exists in subsections of Appalachia; in other areas, traditional banks are too risk averse to loan to small entrepreneurs with new technologies. In addition, portions of the Region lack the connectivity and infrastructure to attract and keep new businesses. As a result, even home-grown businesses often are forced to relocate outside Appalachia, thereby denying the Region to benefits of its own innovations.

RECOMMENDATIONS

ENERGY BLUEPRINT

Fossil Energy

As a central economic resource of Appalachia, coal should be used to extend the Region's economic development. The economic benefits of the coal extraction industry can be increased by promoting the location of emerging coal processing facilities such as liquefaction and gasification in the Region. In addition, the Region should work in collaboration with federal partners to focus on the development of technologies to enable this increased utilization of coal. Transmission system improvements to export coal electricity onto the grid, and new carbon sequestration technologies to create affordable zero emissions coal should be priorities in this area.

Energy Efficiency

Appalachia has great potential for taking advantage of opportunities in energy efficiency. Combined with already attractive electricity prices within the Region, efficiency improvements should be viewed as a positive marketing opportunity for prospective energy intensive businesses, and utilized as such. The Energy Blueprint should include a focus on the development of efficiency enabling technologies, in collaboration with federal partners, to further enhance the Region's advantages in this area.

Transportation

The Appalachian Region is enjoying the growth of numerous businesses providing alternative transportation fuels. These successes of these efforts should be transferred to other parts of the Region that have yet to experience these developments. In addition, the Energy Blueprint should include initiation of activity to provide reduced risk for these projects, thereby helping them secure financing. For example, many entrepreneurs cannot secure long-term funding because they cannot obtain purchase guarantees or long-term contracts (without an "early out" clause) for their product. In addition, because energy is inextricably linked with issues of manufacturing and transportation, a strategic approach to development and problem-solving that considers impacts on all three factors is warranted.

Economic Development

Similarly, the keys to economic development rest in the reduction of risk and the provision of venture capital. The Energy Blueprint should advance the exploration and creation of policy options, at both the state and federal levels, to accelerate the deployment of new energy technologies. The Blueprint also should include the creation and planned implementation of a strategy to develop greater venture capital resources with the region. Finding ways to apply all available economic development tools to energy-related economic development should also be envisioned by the Energy Blueprint.

Intellectual Capital
To maintain these regional advancements and innovations, the Energy Blueprint would benefit by recognizing and focusing on a key underutilized asset: the intellectual resources of the Region. Appalachia's universities, colleges, national laboratories, and entrepreneurs should be exploited for their ability to provide technical assistance to local businesses and to provide new technologies and processes around which new business opportunities can be developed. A strategy to offset theses costs to the local businesses and entrepreneurs, perhaps modeled on current programs in several member states, should be included as well.

Renewable Energy/Energy Portfolio
Finally, in order to counter the pressures and uncertainties of the energy supply and to encourage the utilization of the Region's green energy advantages, a balanced supply portfolio including "green" energy is the best path forward. However, due to differences even within the subregions of Appalachia, achieving balance in each state can be difficult. Consequently, the Energy Blueprint should include the initiation of activity to determine the feasibility of a regional, balanced green energy portfolio. The portfolio should include green energy standards and a credit trading program that rewards innovation. Technologies within the green energy portfolio should include clean coal, energy efficiency programs, and renewable energy sources.

ARC IMPLEMENTATION OF THE ENERGY BLUEPRINT
The United States does not lack for energy policies or ideas. However, implementation is often not as prolific. In this era of volatile energy prices and supplies, a strategic perspective that makes the most of integrated and collaborative approaches is needed. As such, the ARC can build upon the Energy Blueprint process—and the support garnered from the Appalachian states' governors—to fulfill several additional, and vital, roles to ensure the Blueprint's successful implementation.

Institutional Leadership
The ARC can serve as the long-term institutional catalyst needed for the implementation of energy/economic development actions envisioned by the Energy Blueprint. By using its convening and educational authorities to coordinate activities of various partners; facilitate their collaboration; disseminate best practices and lesson learned; and provide a forum for research institutions to exchange ideas and identify opportunities for energy and energy-related development, the ARC can continue to act as a catalyst for this long-term regional and national requirement.

LDD Enhancement
The ARC should, in partnership with other agencies (such as the Departments of Agriculture and Energy, or the Small Business Administration), facilitate the expansion of services offered through its Local Development Districts (LDDs) to achieve the objectives of the Energy Blueprint. For example, so that LDDS could provide a unified source of information vital to the establishment of small/rural alternative fuel producers; to help identify local companies with appropriate products and expertise for prospective energy-related companies; and to create resource/product matchmaking programs that

identify businesses with input, waste, or byproduct streams that are resources or requirements for other businesses (similar to the work SEDA-COG has conducted).

Information Dissemination
The ARC should collaborate with other community-based organizations to create a Web-based "best practices" and "lessons learned" database for communities coping with the evolving energy situation. In addition, the ARC should support grassroots efforts that are already in place providing information dissemination, such as the East Tennessee Clean Fuels Coalition. These organizations and the public information service they provide are vital to the future of alternative energy sources, including those with which Appalachia can excel. The importance of information-sharing among areas, businesses, local governments, and small entrepreneurs cannot be underestimated.

WORKSHOP SUMMARY INFORMATION

ENERGY SECTORS
Each ARC-ORCAS workshop considered the same energy sectors (e.g., fossil and renewables) and focus areas (e.g., economic development, community coping, etc.), however, because the composition of the group differed per location, the discussion often elicited different comments. To provide a coherent picture of the workshops' discussions overall, comments from all three events have been centralized under their subject matter not by their location.

Fossil Energy
Of the three workshops, fossil energy discussions were most prevalent in Morgantown, WV. Representatives from state and local governments, the coal sector, and the energy industry discussed the potential for a bright future for coal, so long as several challenges could be met. For example, while the United States coal supply is estimated to last enough 250+ years, much of that production capacity is located in the West. While this coal has lower energy density than Appalachian coal, its easy removal from the ground makes it less expensive than coal from the Eastern United States. As a result, some participants said they felt their Region is in essence competing against other states and that Appalachia needs a new way to compete.

One way by which the Region could compete is by the introduction and encouragement of new coal technologies such as gasification or liquefaction. Participants noted that because coal is a known, and abundant, quantity, it has growing advantages over other energy sources, even natural gas where the increasing prices, declining domestic availability, and uncertainty associated with siting facilities for its import and storage make it less desirable. Companies may not want to subject themselves to the risks of fuel source problems. As a result, IGCC plants, which are essentially chemical plants that turn coal into electricity, are in the planning stages for Appalachia. The fuel source is secure, the price is more stable, and the opportunity to create chemical feedstocks as a byproduct of electricity generation is attractive to some utilities. In addition, electricity suppliers are also looking at improving current coal technologies using pulverized coal and fluid beds. Coal liquefaction is not quite as far along in commercialization, largely for reasons stemming from risk reduction and venture capital, as noted in other sections of this report. Pennsylvania, however, is taking a first step by providing purchase guarantees to a first plant in order to get the process underway.

Overall, participants were optimistic about the potential new uses and development that could come from Appalachia's abundance of coal, provided that clean air/carbon emissions problems did not hinder technology or increase production costs too greatly. Several participants noted that funded demonstration projects, increased venture capital, and dedicated contract terms would also help advance prospects for new coal technologies.

WORKSHOP FOCUS: ENERGY EFFICIENCY

At the Oak Ridge workshop, Marilyn Brown of Oak Ridge National Laboratory spoke about the benefits of energy efficiency, both past achievements and the outlook for the future of energy in the United States. In Huntsville, Skip Laitner of the American Council for an Energy-Efficient Economy provided comments about the economic benefits of efficiency. This is a summary of portions of their presentations.

The Southeastern United States still lags behind much of the nation in recognizing the benefits of energy efficiency, although, as the fastest growing region in the country, its need for energy efficiency is tremendous. For example, the Southeast US spends only one-fifth the national average, per capita, on energy efficiency programs, ranks near the bottom among regions in ENERGY STAR® appliance penetration, and is the last region to establish an energy-efficiency alliance.

Unlike the Southeast, a few states in the West and Northeast have adopted state standards that are more rigorous than federal standards. These state initiatives regulate energy efficiency for DVD players, walk-in refrigerators, residential furnaces, and several other appliances. If these 15 standards were adopted nationally, the natural gas savings would be enough to heat 6.3 million typical U.S. households and electricity savings would reach 52 billion kilowatt-hours per year by 2020, eliminating the need for about 40 average-sized power plants. Greenhouse gas emissions would be reduced by 12 million metric tons of carbon equivalent annually.

At the utility-level, Energy Efficiency Resource Standards (EERS) are operating in 7 U.S. states and are being debated in several additional states, primarily in the West and Northeast and 4 in European countries. An EERS consists of electric and/or gas energy savings targets for utilities, typically with flexibility to achieve the target through a market-based trading system. Targets are achieved through end-user energy-saving improvements and are aided and documented by utilities or other program operators. Key EERS policy design issues include working with utilities, setting appropriate savings targets, and examining the relationship between an EERS and other energy policies.

Despite regional differences in efficiency standards, energy efficiency has already shown dramatic benefits in the national economy and is vital to the nation's energy future. Contrary to some beliefs, increasing energy efficiency is not about slowing the U.S. economy—it is about realizing benefits from existing sources. In fact, due to current technology, energy efficiency has provided about 75% of all new demands for energy services in the United States. Continued development and innovation in energy efficiency can provide more opportunities for energy services, increased energy supply, and a catalyst for economic growth. From the perspective of economic development, energy efficiency, therefore, should be embraced as a way to improve corporate productivity and to enhance state economic benefits.

To illustrate this fact, a simple economic model, drawn from historical data in North Carolina, was shown to demonstrate how a $100 million investment in energy efficiency by the state could lead to the following net impacts: an annual savings of $25 million in energy costs (0.1% of current energy costs) and an annual gain of approximately 300 jobs—roughly the equivalent of one new manufacturing plant. Over time, if cost-effective efficiency gains continued and grew to 10% of the state's current (2006) energy costs, employment could grow as much as 24,000 jobs annually but without the environmental impacts of added traffic. In sum, efficiency costs money, but inefficiency costs even more in dollars and development.

Moreover, if energy efficiency could be increased today and over the next decades, it would continue to place energy efficiency among the primary sources of energy, not just a source of cost-savings or productivity. Just as in the last 30 years, numerous emerging technologies within the building and construction industry could make a significant impact in the future. For example, sealing methods that address unseen air leaks, electrochromic windows, unconventional water heaters, sensors to continuously optimize operations, solid state lighting, and 80-90% efficient integrated energy systems. Additional developments in materials, sensors, and information systems could further advance energy efficiency at the commercial, utility, and residential levels across the United States.

Transportation and Fuels

At each of the workshops, participants noted how much of the nation's energy supply and costs are devoted to transportation fuels. Rural communities especially were very concerned about the ability to keep their school buses running in the face of rising prices. At the Morgantown workshop, coal-to-liquid technologies were discussed as one option to reduce the pressure on transportation fuels. Liquefied coal can be turned into gasoline, jet fuel, diesel, or into ethanol (via methane). However, these technologies currently face the problem of how to get from research into commercialization, due to risk and capital constraints.

At the Oak Ridge workshop, the prospect of turning coal into hydrogen was raised. Like oil, processes to use coal products for fuel would also need to use "clean" methods. (At present, technologies exist to deal with the sulfur in coal, meaning that coal-based diesel fuel is possible in the near-term.) Once achieved, however, the Appalachian Region could become a major force in the hydrogen industry/economy due to its abundance of coal. One way in which the Region could advance into the hydrogen industry is for utilities to get into the fuel business, versus relying on foreign suppliers and the refining supply process. For example, if TVA diverted off-peak power to hydrogen plants, the hydrogen plants could provide fuel all day long. In addition, because hydrogen can be made from so many processes, including wind, solar, and hydro power, other sectors of Appalachia could also establish themselves in the hydrogen-production business.

Hurdles remain for the hydrogen economy. Research is still needed in how to store hydrogen supplies and how to increase the longevity of fuel cells. Pilot projects underway, for example using cars and trucks in Tennessee, are working to address these problems. Even when these problems are solved and consumers can be convinced to switch to a new technology and fuel, the U.S. economy still will not switch to hydrogen overnight. As hydrogen demand and supply go up, oil prices will drop, keeping demand up. As a result, the national economy will remain a mix of oil and hydrogen for some time after hydrogen becomes useable on a broad scale. Consumer education and government policies will also play major roles in any moves away from petroleum-based fuels.

Renewables

Renewable energy sources arose in discussion at all three workshops. Participants noted that consumers need more education about renewables in order to create demand. In much of Appalachia, consumers do not yet provide demand for green power made from renewables, due to both a lack of information and the increased costs currently associated with green power options. Others noted renewables are a good option to protect the United States against shortages due to foreign supply, infrastructure problems as were seen after Hurricane Katrina, and to spur economic development. Again, the importance of becoming a home for energy production, not just the source of raw materials, even renewables, was mentioned. For example, a Spanish wind firm has just relocated to Pennsylvania where they will manufacture wind machine parts as well as capture wind for energy. In addition, a community that is open to wind farms, could become the home to repair and maintenance jobs for those wind machines as well. In Appalachia, TVA is creating a financial incentive as well by buying all excess power created by anyone who is producing green power, even from solar cells on their roof.

Aside from limited demand, renewables face other challenges at present. Green power sources such as wind are not yet cost competitive with traditional energy sources especially low-cost power in the Appalachian Region. In fact, even the burgeoning biomass and biodiesel industries are not yet succeeding on their cost advantages, but on other opportunities they present. Due to its strong history in agriculture, biomass is one area in which Appalachia could thrive. In addition, biomass energy processes can be used to help reduce waste streams from industry. A paper plant or building materials manufacturer creates so much wood waste that removing the waste is in itself a benefit. One biomass project in Tennessee, located within a building materials plant, burns 59 tons of wood waste each year from that plant alone. They not only create their own energy in the process, they also sell excess power to TVA and sell the wood ash to other industries. Notably, this plant was able to become a reality due to the drive of the owner to protect air quality and reduce global warming. Without its private funding, the plant would have faced political and economic hurdles.

Biodiesel is another area of renewable energy that experiences these challenges. With a lack of regulations, standards, or even centralized information, it can be difficult for new producers to enter the market, as participants noted. In addition, consumers are concerned that most cars and engines are not yet covered by warranty to use biodiesel. Whether or not biodiesel engines can be maintained adequately is also a concern due to the lack of facilities that are familiar with biodiesel engines. Producers worry that, due to the absence of standards for biodiesel production, if a customer receives a “bad” batch of fuel, it can ruin the reputation of the fuel—and the producer—forever.

COMMUNITIES COPING WITH ENERGY

Throughout the country, local governments and other groups have identified strategies to reduce energy costs. Discussions of these activities pepper the Web as new stories, press releases, and organizational postings, though details are often scant. A few resources provide collected information that may be useful to local decisionmakers in search of energy solutions. These sources include: the Smart Communities Network (http://www.smartcommunities.ncat.org/); the National League of Cities (http://www.nlc.org/home/); the U.S. Department of Energy, State Energy Program (http://www.eere.energy.gov/state_energy_program/); and The United States Conference of Mayors (http://www.usmayors.org/uscm/best_practices/search.asp). Based on the information that is available on the Web, localities have pursued three general approaches to assuring energy supply and reducing energy cost: waste-to-energy innovations, achieving efficiency gains, and aggregated purchasing.

Waste-to-Energy Innovations

Systems that use methane gas from landfills, steam generated by the combustion of sludge, and gasified poultry litter to create electricity all exemplify local efforts to increase energy production and reduce costs in and around the Appalachian Region.

The Wilkes County Germantown Landfill Gas Utilization Project (Wilkes County, North Carolina), the City of Greensboro (Greensboro, North Carolina), Green Power EMC (Fayette and Taylor Counties), and the Eastern Kentucky Power Cooperative (several sites throughout Kentucky) all use methane gas generated by landfills to produce energy. The City of Huntsville (Huntsville, Alabama) uses steam from the combustion of the city's dried sewage sludge to create electricity. The Green Power Electric Membership Corporation (Franklin County, Georgia) has developed a poultry litter-to-energy operation. Each of these activities is aimed at reducing energy costs and reducing waste.

Achieving Efficiency Gains

Many organizations and groups are identifying ways to improve infrastructure efficiency. Performance contracts provide one approach to financing capital improvements. The Tennessee Board of Regents (TBR) was recently awarded the Middle Tennessee Energy Award 2006 for its Energy Savings Performance Contracting (ESPC) efforts. Five energy-saving performance contracts—one for Middle Tennessee State University, one for Tennessee State University, and three regional system-wide contracts, are in place. Under the contracts, energy service companies work with participating institutions to identify, develop, and construct projects that replace aging equipment, improve the functionality of buildings, and save energy so that the project investment is offset in a few years by the savings from greater energy efficiency. Total TBR system-wide project implementation is projected to cost about $60 million, with corresponding energy savings of $8 million annually.

Aggregated Purchasing

Communities and other groups have aggregated their buying power to save money and buy green. For example, the Northeast Ohio Public Energy Council (NOPEC) is made up of 118 member communities spread across eight Northeast Ohio counties. By banding together into one large energy buying group, the communities gain leverage in the marketplace. As a group, NOPEC participants benefit from bulk buying power and pooled professional expertise. NOPEC has more than 600,000 potential customers and is the largest public aggregation in the United States.

Similar strategies have been employed by several school districts throughout the country, including the Moon Area School District in Pennsylvania, for the purchase of fuel. The Moon Area School District formed a consortium with other districts to buy fuel in bulk, thereby saving money. Also in Pennsylvania, the Allegheny Intermediate Unit created a joint-purchasing program that allowed schools to collectively obtain set fuel prices, saving schools more than $4 million each year.

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WORKSHOP FOCUS: SEDA-COG ENERGY RESOURCE CENTER

At the Morgantown workshop, Stacy Richards of SEDA-COG (Pennsylvania) spoke about regional efforts to increase near-term energy-related savings and long-term economic development. This is a summary of her presentation.

Like other economic development agencies and council of government organizations, SEDA-COG serves a very diverse clientele, which is one of our core strengths. To meet the needs of the local area, SEDA-COG owns railroads; administers the Community Development Block Grant program for many of the counties in the district; operates as a Regional Planning Office under the state Department of Transportation; administers one of the largest small business loan portfolios in the nation; and provides community and regional planning services to our clients, including the management of the Susquehanna Greenways project, which spans the Susquehanna River Basin region in Pennsylvania. Because SEDA-COG leverages public and private sector resources on behalf of their region, the delivery system of information and services can be powerfully efficient and economical.

Two years ago, SEDA-COG began developing an Energy Resource Center when we realized that our rural region is a "fly over" zone in terms of energy efficient and renewable energy activities being voluntarily embraced by our clients. Because Pennsylvania is a leader in green buildings, SEDA-COG realized that our region could, and should, become a center of efficient and renewable energy technology and expertise. However, our clients were spending too much money on energy-related operating costs because we had (and have) very little energy expertise in our region. Several months ago, SEDA-COG launched the Energy Resource Center (ERC) with a $30,000 grant that was leveraged with state and private sector matching funds.

The ERC's goals are to reduce clients' operating costs via energy conservation, develop local technical assistance firms, enhance the regional business base with an alternative energy market focus, and use our own green building as a teaching tool for best practices. Programs to meet these goals will focus on expanding SEDA-COG weatherization services to households spanning all income levels; providing home energy audit workshops to the private sector to encourage the development of regional expertise; providing green building training to the architects, engineers, local zoning officials and construction contractors in the region; and focusing on existing businesses that are, or have the potential to be, part of the alternative energy supply chain. The first two programs are designed to provide immediate energy cost savings for residential and business customers; the last will help develop longer-term economic opportunities in the region.

In order to focus on businesses that could be part of the future of alternative energy, especially as part of the supply chain, SEDA-COG examined the Renewable Energy Policy Project's projections about the future of energy (see repp.org). To date, REPP has studied the wind turbine and solar photovoltaic (PV) markets. The study broke these technologies into their major components and then identified parts or components suppliers, even if they are not currently part of the energy market. For example, one portion of a turbine may be comprised of parts made for many other processes, but the producers are not yet aware of this new application—or market potential. In fact, the REPP study identifies Ohio, Pennsylvania, New York, Tennessee, Alabama, Virginia, and Kentucky as among the leading states with the potential to excel in the wind and/or solar supply chain or production market. With the REPP findings, the ERC utilized their own small business database and identified specific businesses in almost every county of Pennsylvania that could be part of the wind turbine or solar PV supply chain.

With this information, the ERC and SEDA-COG will work to create business-to-business contacts, to build a supplier network, and to continue to assess where the energy market is heading to keep clients informed and positioned to succeed in the energy market. However, SEDA-COG also sees additional methods by which local agencies could help position their clients in the energy market. For example, regions and states could offer grants, provide technical assistance, and draw upon their existing strengths to build public-private partnerships to help small business thrive in the new alternative energy market. With proactive efforts like these now, versus following trends in the future, alternative energy could create long-term advantages for Pennsylvania's economy.

Example: Auditing Alabama's Schools

At the Huntsville workshop, Robert Mitchell's presentation about conducting an energy audit of school buildings highlighted numerous other community issues. Specifically, Mr. Mitchell was part of a team funded by the Alabama Department of Economic and Community Affairs (ADECA) to assess energy use in 44 schools in 14 districts and to make recommendations about improvements. The team, part of the Waste Reduction and Technology Transfer (WRATT) non-profit organization, found that all the buildings could benefit from improvements ranging from better windows, insulation, vestibules at the front door, more efficient lighting, better lighting and thermostat controls/automation, etc. As part of the assessment, WRATT also computed the investment required to make these fixes (including using contractors that are paid over time from the cost savings) and the energy savings that could be realized per building.

Since the report, ADECA has allotted almost $15,000 per school for repairs. However, this will not fund all of the improvements needed. In addition, schools to date have not demonstrated enthusiastic support for the program. Few have returned surveys about whether they have had any of the work completed. In the seriously distressed districts, local companies do not have the capital to undertake the work on a delayed payment plan, such as receiving funds as cost savings accrue. Each of these aspects points to problems at the community level. First, communities are not aware of how much can be gained by efficiency and reduced cost. Little consumer demand exists for energy savings at present due to a lack of public education about conservation and efficiency—or, as TVA noted, green power. Second, energy costs do not significantly change planning for principals. Funds are granted per school for specified expenditures. In addition, the WRATT report, though conducted last year has not been presented to the state association of school superintendents yet. Nor are other state-level departments a part of the energy audit for schools program.

If the cost savings were explained instead in terms of additional teachers hired, new equipment purchased, or direct funding for a school, versus raw dollar figures (perhaps going back to the state), the prospect could garner additional support. In addition, if this worthwhile program was expanded to include collaboration with the state's department of education, or others, perhaps more money or interest-free loans could be granted to schools for the improvements. While this Alabama program is just one example, it is a reflection of the information, education, collaboration, and capital problems that beset small communities wrestling with rising energy costs.

ECONOMIC DEVELOPMENT

Investing in Appalachia

From the opening presentation of the first workshop, economic development—creating new jobs and business deals—arose as a key issue. In each location, participants wanted to know how to turn old resources into new opportunities and how to get new projects off the ground. However, just as the inquiries were the same, the hindrances were also. Overwhelmingly, participants in all three locations pointed to the problem of risk reduction. Numerous governmental and private entities noted that the vicious cycle of reducing risk in order to attract capital, and having the capital in order to reduce risk, was omnipresent. Problems had been encountered trying to convince investors to invest in new technologies, especially those that were not yet cost competitive with existing energy production methods. In cases where long-terms contracts were achieved, and could have been used as proof of financial stability for investors, a key federal department had insisted that all contracts have a 30-day opt out clause. This clause, if activated, would give the company little time to secure new contracts. In addition, this type of contract did not inspire investors to believe in the long-term stability of the company.

Even when the risk reduction issue was not foremost, participants noted the difficulty in raising venture capital simply due to a lack of it. In Oak Ridge, one participant noted that only two venture capital funds exist in the Appalachian area between Cincinnati and Atlanta. Others noted that small, local banks—a mainstay of the Region—are no longer prepared to invest in venture projects, only established firms. Indeed, as a matter of policy, the State of Tennessee, for example, will not invest in venture capital funds, whereas the State of Hawaii provides enormous tax credits for research and development conducted there.

Finally, participants noted that small businesses and communities are often not aware of the approaches they need to take to succeed or the tools and techniques that already exist for them to use. For example, when a new venture does arrive, such as a coal gasification plant, a research project, or a wind farm, the community should look at how it could reorganize itself to take full advantage of the jobs (e.g., repair, accounting, energy/other supplies, manufacturing parts), spinoff opportunities, etc., that are present from this “lynchpin” entity. Similarly, if the community is not prepared to take advantage of or assist new business ventures, they may relocate. East Tennessee, for example, has an unfortunate history of having locally created businesses relocate elsewhere to receive the support, connectivity, and infrastructure needed.

WORKSHOP FOCUS: FUTURE FUELS

At the Huntsville workshop, Brad Taylor of Future Fuels (Alabama) spoke about starting his own biodiesel production firm. This is a summary of his presentation.

Today, Future Fuels is a growing biodiesel business in Haleyville, Alabama. Each week, the two-person operation produces and sells 4500 gallons of 100% biodiesel derived from soybean oil. However, challenges getting to this point were numerous, as are the challenges ahead if Future Fuels is to expand and thrive.

Several years ago, a small trucking company had a problem: the rising cost of fuel for its fleet. In response, Brad Taylor and Marlon Wakefield began to investigate the use of biodiesel for their fleet. Over the course of a year, they researched the production process, became registered with the Internal Revenue Service (IRS), and began perfecting a formula they could use for fuel. First, they experimented with cooking oil from restaurants, but that did not generate enough supply nor did it facilitate consistency between batches. In addition, some restaurants were scared they could get in trouble with the health department for donating their oil for fuel. Taylor and Wakefield contacted enough local agencies to find out this was incorrect, but like all of their research for the process, little information existed in government to help them. Each inquiry took several steps, several levels of government, and multiple people to find an answer. Finally, with little external guidance, a 55-gallon drum, some oil from soybeans purchased almost 200 miles away—and lots of trial and error—Taylor and Wakefield found a process that worked.

While they used the fuel in their own trucks at first, they also kept refining their process. Taylor and Wakefield were keenly aware of the damage to their reputation if they ever sold a fuel that damaged a vehicle. Since there is no standardization or certification process for biodiesel yet, they voluntarily sent their fuel to a government lab to be certified as glycerin-free (and thereby suitable for fuel). With this certification in hand, Future Fuels began to increase its production and look for other purchasers.

Fortunately, other businesses around Haleyville were also looking for fuel alternatives and liked the idea of helping farmers. Today, Future Fuels has several regular customers who would like to buy more than 4500 gallons a week from the operation. While the venture would like to expand its production capability and improve its process with new technologies, capital and risk create hurdles. Although Future Fuels maintains consistent quality standards (and keeps samples from every batch), and its customers are happy, the company is only surviving through IRS incentives. The cost of soybeans and their transport, washing, and preparing, etc., make the biodiesel the same price as gasoline at present. Through rebates from the IRS, Future Fuels is able to make the fuels slightly lower in price than gas in order to be competitive, but it leaves little money for capital investments. Indeed, the IRS rebate for each quarter is not received until 135 days after the quarter began and taxes and bills must be paid in the interim. In addition, soybean costs are volatile and Future Fuel is considering importing palm oil from overseas to maintain price and quality.

As a result, banks are not yet ready to loan to a business with limited funding, and venture capital from private sources is hard to locate. Now Future Fuel will begin research a variety of federal and state government programs that might help the company raise money to expand and become self-sustaining.

Appendix A: Workshop Agendas

1. **Morgantown, WV June 21, 2006**
2. **Oak Ridge, TN June 27, 2006**
3. **Huntsville, AL July 13, 2006**

Making a Blueprint for Energy and Economic Development in Appalachia

Morgantown, WV
June 21, 2006

AGENDA

10 AM	**Welcome and Introduction**	**Anne B. Pope**, Federal Co-Chair Appalachian Regional Commission
10:15	**Roundtable Kickoff**	**Paul Gilman**, Director, Oak Ridge Center for Advanced Studies
10:20	**Energy Sectors** 10:20-11:05 Presentations The Future for Fossil Energy - A National Perspective, James Ekmann, US DOE The Future for Fossil Energy - A Regional Perspective, Richard Bajura, NRCCE The Future for Fossil Energy - An Industry Perspective, Claudia Banner, AEP 11:05-12:00 Discussion	
12:00	*Pick up box lunches*	
12:15	**Communities Coping with Energy Issues** 12:15-12:30 Presentation Energy Efficiency, Stacy Richards, SEDA-Council of Governments 12:30-1:15 Discussion	
1:15	**Economic Development and Energy** 1:15-1:30 Presentation Energy and Jobs in Appalachia, Tim Considine, Penn State University 1:30-2:15 Discussion	
2:15	**Summary and Wrap-Up**	
3 PM	**Conclusion**	

Making a Blueprint for Energy and Economic Development in Appalachia

Oak Ridge, TN
June 27, 2006

AGENDA

10 AM **Welcome and Introduction** — **Anne B. Pope**, Federal Co-Chair Appalachian Regional Commission

10:15 **Roundtable Kickoff** — **Paul Gilman**, Director, Oak Ridge Center for Advanced Studies

10:25 **Energy Sectors**
10:25-11:00 Presentations
The Future for Energy Efficiency – Marilyn Brown, Oak Ridge National Laboratory
The Future for Transportation – Wayne Davis, University of Tennessee
11:00-12:00 Discussion

12:00 *Pick up box lunches*

12:15 **Communities Coping with Energy Issues**
12:15-12:30 Presentation
Heather Dawes, EnergyXchange
12:30-1:00 Discussion

1:00 **Economic Development and Energy**
1:00-1:30 Presentations
Jim Campbell, East Tennessee Economic Council
Joe Rizzi, Bioten
1:30-2:15 Discussion

2:15 **Summary and Wrap-Up**

3 PM **Conclusion**

Making a Blueprint for Energy and Economic Development in Appalachia

Huntsville, AL
July 13, 2006

AGENDA

10 AM	**Welcome and Introduction**	**Richard Peltz**, Alternate Federal Co-Chair, Appalachian Regional Commission
10:25	**Roundtable Kickoff**	**Paul Gilman**, Director, Oak Ridge Center for Advanced Studies

10:30 **Energy Sectors**
10:30-11:00 Presentations
The Future for Renewable Energy - A National Perspective, Jim Powell, US DOE
The Future for Renewable Energy - A Regional Perspective, John Shell, TVA
11:00-12:00 Discussion

12:00 *Pick up box lunches*

12:15 **Communities Coping with Energy Issues**
12:15-12:30 Presentation
Robert Mitchell, Waste Reduction and Technology Transfer Foundation
12:30-1:15 Discussion

1:15 **Economic Development and Energy**
1:15-1:45 Presentations
Brad Taylor, Future Fuels
Skip Laitner, American Council for an Energy-Efficient Economy
1:45-2:30 Discussion

2:30 **Summary and Wrap-Up**

3 PM **Conclusion**

Appendix B: Workshop Attendees by Location

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Appendix C: Energy Project Abstracts

Appendix C includes one-page abstracts about energy-related projects that were submitted by researchers and institutions across the country. ORCAS gathered these project papers through an open call for submissions on completed research, current projects, and/or visionary programs in energy and/or energy-related economic development. Specifically, ORCAS was seeking innovative projects that could be used in Appalachia to help meet its energy, efficiency, and energy-related job-creation goals. The submissions are in no order other than being roughly divided by subject area.

Renewable Energy Production in Appalachia

The Appalachian region has long been associated with this nation's energy supply, in the form of coal mining. The region now has the opportunity to contribute to the nation's energy supply from a new source; namely, from renewable energy supplies. The author, and colleagues from the University of Tennessee's College of Agriculture, has just completed a draft report that details how the Tennessee Valley Authority (TVA) could meet a 10 percent renewable energy requirement by 2020, under the auspices of a federally-mandated Renewable Portfolio Standard (RPS). Over 20 states now have an RPS requirement and the U.S. Senate has advocated a federal RPS in recent years.

Significant amounts of biomass and wind power would have to be generated, much of it in the Appalachian region. The employment impacts associated with meeting the RPS requirement have also been estimated. Particularly promising could be the production of energy crops, namely switchgrass. This crop has the potential for use in both electricity and liquid fuel production.

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Biomass and Bioenergy Research in the Southeast

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The Sun Grant Initiative is a concept to solve America's energy needs and revitalize rural communities with land-grant university research, education, and extension programs on renewable energy and biobased, non-food industries. The University of Tennessee Agricultural Experiment Station is one of five regional centers across the nation and serves as the coordinator of the program to the states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia as well as the territories of Puerto Rico and the U.S. Virgin Islands.

The Sun Grant Initiative enables researchers throughout the southeast to explore the potentials of biomass, bioenergy, bioproducts, and associated fields through a competitive grants program and other research funding mechanisms.

Currently at the University of Tennessee, at least three major Sun Grant related research programs are underway. To facilitate the collection of a comprehensive review of the current state of biomass/bioenergy in the nation, a biomass monograph is being developed. The effort is focusing on two distinct audiences, the academic research community and public stakeholders in general, but specifically those influencing policy decisions. Another project focuses on the use of fluidized beds for chemical modification of lignocellulosic biomass and will demonstrate the use of biomass as a raw material for durable goods through a highly efficient conversion process. A third focused research effort includes focuses on biomass deconstruction and evaluation. The research aim is to develop a database to improve biomass feedstock selection and conversion processes, especially pretreatment processes involving physical deconstruction.

Impacts to the Southern U.S. and the Nation as a Result of Moving Towards a Bio-Energy Future.

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The Bio-based Energy Analysis Group (BEAG) at the University of Tennessee has worked on numerous renewable energy studies during the past several years. Two such studies are summarized. An analysis of co-firing cellulosic material in the South East Reliability Council Region indicated that currently there are power plants that could use wood waste from MSW, forest residues, and/or mill wastes to generate electricity. Applying a value for carbon savings would competitively allow up to a 15% co-fire in many of the region's power plants. In a recent analysis conducted for the 25 X '25 organization, BEAG found that the nation could replace 25% of the btu content of projected 2025 gasoline consumption without impacting food security resulting in increased farm income, reduced federal government commodity payments, increased rural economic development, enhanced environmental benefits, and reduced foreign oil dependency. The national economy would increase nearly ½ a trillion dollars as a result of manufacturing ethanol instead of purchasing it oversees. Average commodity prices for corn would increase about $0.75/bushel over the baseline and farmers would receive a projected $65/ton for their dedicated energy crops.

Soybean Based Transformer Oil

The Tennessee Valley Authority has been conducting research, development, and demonstration of a soybean-based transformer oil. Demonstrations have been conducted at three power distributor locations within the Tennessee Valley Region. The transformer oil is biodegradable, environmentally preferred oil that is less expensive to clean up should there be a spill. The technology was first developed at Waverly Light and Power in Iowa and supported by the American Public Power Association.

Further development and testing within the Appalachian Region provides many benefits. Successful demonstration and testing on a larger scale could have far-reaching benefits to the utility industry across the country by retrofitting larger scale transformer applications. Impacts could include:

Agricultural development - The successful deployment would encourage the growing and sale of soybeans in the Appalachian region.

Economic development - Since the successful deployment could become an industry-altering technology, expansion of manufacturing and jobs in the region is likely to occur.

Involvement of academic institutions - Further research and testing could be accomplished with a few selected community colleges where students would have the opportunity to conduct testing with utilities, develop marketing plans, transportation studies, and environmental assessments.

The proposed plan would be sponsored by the Tennessee Valley Authority, the nation's largest public power provider, in conjunction with regional power distributors.

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ADECA Biomass Energy Program

The Alabama Department of Economic and Community Affairs – Energy, Weatherization, and Technology Division (ADECA-EWT) sponsors the Biomass Energy Program to assist businesses in installing biomass systems. This program is open to any industry participant in Alabama who is utilizing a biomass fuel source as a replacement for traditional fossil fuels, including waste wood, switchgrass, and landfill gas. The target audience includes industrial, commercial and institutional facilities, agricultural property owners, and city, county, and state entities. Program participants can receive up to $75,000 in interest subsidy payments to help defray the interest expense on loans to install approved biomass projects. Technical assistance and feasibility studies may also be provided through the program.

The Biomass Energy Program has installed over 35 projects using wood waste as the primary fuel for generating process heat, process steam, and/or electric power. Over $1.5 million has been invested in installing new equipment or converting existing equipment to burn wood waste. As a result, Alabama businesses are saving over $10 million annually in fuel costs.

The Biomass Energy Program is currently accepting applications from entities that would like to participate in the program. For more information, please contact Clarence Mann at (334) 242-5330 or Clarence.mann@adeca.alabama.gov.

Switchgrass Growing and Conversion Trials in Tennessee: Year Two

Burton C. English, Don Tyler, Roland Roberts, and Larry Steckel

The University of Tennessee currently has 124.5 acres under switchgrass cultivation. The experiments are planted on both Ag. Experiment station lands and farmer owned lands. The experiments are designed to eventually provide guidance to producers and extension personnel by developing recommended best management practices. Currently information on fertilization, varieties, seeding rate, and herbicide use is being developed on four different landscapes typically found in Tennessee. The five producers that are growing switchgrass bid their land into the program and began growing it last year. Seventy-five of the ninety two acres were established is year one with the remainder of the acres not established as a result of a number of problems with the number one problem being weed control, primarily switchgrass competition with other grasses. Herbicide experiments are being conducted to find a herbicide that will kill the grass competition, but not impact the switchgrass stand. It is hoped that the effort conducted on the weed trials will provide information for getting a herbicide labeled for use in the establishment year of switchgrass.

After growing the switchgrass on the 124 plus acres, the switchgrass is transported to Gadsden Alabama where emissions testing are being conducted under a co-fire situation. In addition, switchgrass is being converted to bio-oil at Iowa State University at 3 temperature levels, 3 particle size levels, and 3 moisture levels.

Logistics for Delivery of Biomass to a Plant in Appalachia

Much work has been done to develop potential feedstocks which will meet the national goal for bioenergy production. These results are being collected by the Southeastern Regional Bioenergy Partnership in a database that is continuing to evolve. It is very important that the "Blueprint" be a component of the evolving effort.

An equivalent database for biomass logistics in the Southeast is needed, and initial efforts to develop this database are also underway. (Logistics is defined as harvest, storage, and subsequent delivery to a processing plant. This plant may be a pre-processing plant or a plant producing a bulk commodity product, fuel and/or chemical.) The ultimate deliverable will be comprehensive outline that a business development authority can use to provide a bioenergy company with the following site-specific information.

- List of different feedstocks available
- Quantities of these feedstocks and their geographic distribution
- Average harvesting cost ($/dry ton) for different feedstocks
- Average hauling cost (including loading and unloading cost) for each feedstock
- Suggested design of receiving facility (rail may supplement trucks for some locations, particularly as fuel costs increase)

The utility of this database is its contribution to the business plan for a company being attracted into the community. Production of the biomass(landowner part) is important, and processing of this biomass(company part) is important. Logistics links the *production* and *processing,* thus it is of equal importance in the business plan. By having a strong logistics plan, the Southeast can be the region that leads the nation in bioenergy production.

Appalachia, particularly as a producer of woody biomass, has a very important role to play in the Southeast. This presentation outlines the production/logistical plan for Appalachia to attract an industry that will provide a market for some of the relatively poor quality hardwood currently left on the site after a high-end harvest. This market will encourage better management of thousands of acres of Appalachian woodland and, of equal importance, will provide jobs in the rural community.

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Developing new knowledge and education systems for development of forest bioenergy systems

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ABSTRACT

The current challenges facing outreach and extension professionals in North America include high diversity in clients, rapid advances in knowledge, and changes in markets associated with new products, new buyers and sellers. These factors create an urgent need for a versatile, yet responsive and effective technology transfer system. Meanwhile, advances in information technology have enhanced our ability to meet such a challenge. This paper describes the development of a knowledge base and a delivery system for forest biomass and bioenergy development. Under the framework of the Forest Encyclopedia Network (www.forestryencyclopedia.net), the knowledge base, the Encyclopedia of Southern Bioenergy, is developed in six interrelated modules representing the key components in the forest biomass and bioenergy supply chain. These modules can be further rescaled, integrated, and tailored to meet various educational needs. A variety of tools/means ranging from the Internet to printed materials and to workshops will be employed to disseminate the knowledge to different groups of audiences. Building on the strengths of the Southern Forest Research Partnership and the Southern Regional Extension Forestry, we expect to effectively integrate research and outreach to help meet the educational needs for forest biomass and bioenergy development in the South.

KEY WORDS: Knowledge base, technology transfer, Forest Encyclopedia Network, forest bioenergy, US South.

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Bennett Lumber Company Biomass Fuel Project

With the rise in natural gas prices over the last few years, Bennett Lumber Company in Piedmont, Alabama, found its gas bill rising from $12,000/month to over $50,000/month. The company uses natural gas to run its kiln to dry green lumber, an essential step before shipping the product to market. Owner James Bennett, realizing that his company would not survive under these circumstances, put on his research cap in search of an alternative.

One by-product of a sawmill is sawdust. Bennett had long been selling this by-product as animal bedding. But he also knew that he could convert sawdust to energy, given the right equipment. The equipment was not cheap, but neither were his escalating gas bills.

It can be difficult, if not impossible, to find governmental financial aid for a private for-profit business, but fortunately, Bennett's plans fell within the requirements of the Alabama Department of Economic and Community Development's (ADECA) Biomass Renewable Fuels program. Although Bennett Lumber had to finance his project through a commercial loan, the ADECA program will pay $75,000 of his loan interest for up to 3 years. The Biomass program enabled him to purchase a fuel storage silo, transfer system, and boiler that will use the sawdust as fuel, generating steam which then is pumped through a heat transfer coil in his dry kiln. After all is said and done, this project will save Bennett Lumber upwards of $50,000 each month.

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1.0 EXECUTIVE SUMMARY

Huber Renewable Energy Works (HREW) is a proposed renewable energy project to be located at the Huber Engineered Woods, LLC (Huber) plant in Spring City, TN. The project consists of a biomass power conversion and heat recovery facility which will provide a clean, alternative energy source to the East Tennessee area.

The primary functions of the HREW facility are to produce heat and electric power. This production will be implemented by consuming the wood wastes generated from the normal operations of the Huber plant through the means of the patented Bioten combustion process. Net electrical power generated as a result of this process will be sold to the Tennessee Valley Authority (TVA). The electricity will be connected to the grid at an adjacent 13 kV substation. Heat generated as a by-product of the combustion process will be captured and sold to Huber. The heat will be transferred to the existing Huber thermal fluid heating system and integrated into the plant process which shall serve to increase Huber plant efficiency.

Preliminary engineering has been performed as a part of this study to provide a general facility layout and to identify the equipment required to realize the above HREW functions. Vendors have been included in the preparation of this study to establish costs associated with these equipment requirements. A general contractor has also been included in the preparation of this study by supplying a cost estimate to provide full construction services including material, erection, sitework, and labor costs. Plant startup, engineering, and other ancillary costs have also been included in the cost estimate.

Operating costs have been projected based on historical data for similar power plant projects including a recent Bioten capital project. These costs will vary due to inflation throughout the life of the project, which has been defined as fifteen (15) years. The operating cost in 2006 dollars is projected to be approximately $1.4 million dollars annually.

Since HREW involves the production of renewable energy, financing for this project will be established through zero-interest Clean Renewable Energy Bonds instituted through the Energy Policy Act of 2005. Additional tax incentives and credits have yet to be fully realized in the financial analysis of this study.

Making A Blueprint for Energy and Economic Development in Appalachian Landfills as a Source of Fuel For Community Energy Parks

Purpose – As organic matter in landfills decomposes, methane gas is produced is a serious greenhouse gas, but an excellent fuel. With concerns over national energy security and greenhouse gas emissions, landfill gas utilization makes sense.
The EnergyXchange Renewable Energy Center near Burnsville, NC is now a world-wide model for community-based landfill gas development. Numerous other landfill owners are attempting to follow this model.
The EnergyXchange process recognizes the usefulness of the landfill as a sustainable fuel source, and the wisdom of building community energy parks around available existing energy sources.
Scope – The EnergyXchange model is a 4 acre energy park built by non-profit partners at the tiny Yancey/Mitchell landfill. The investment is $1.3 million – all grants.
Methods – Partners were, Mayland Community College, Blue Ridge Resource Conservation and Development Council, HandMade In America, NC Energy Office, EPA's Landfill Methane Outreach Program, and the NC Cooperative Extension Service.
Results – A business incubator for glass-blowers and potters was created as well as community greenhouses that produce native shrubbery seedling for local nurserymen. In its first 4 years of operation EnergyXchange has saved over $800,000 in energy costs, created 38 temporary jobs, 6 permanent jobs, 10 new businesses, and expanded 27 existing businesses. Replication – Landfills are well distributed and most are still undeveloped for landfill gas. Many have buffer lands that can be used as "Energy Parks". To reach energy self sufficiency, we need to identify all untapped energy resources in our communities and build the infrastructure to utilize that energy near the sites.

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Abstract: There is general need for greater understanding of the feasibility, costs, benefits and risks associated with the use of renewable energy and environmentally beneficial resources to generate electricity. Despite claims that these resources have a variety of benefits, such energy sources make a relatively small contribution to power generation in Virginia and the nation. This study examines the existing barriers to deployment of such resources, and determines the cost of generating electricity from such sources and then compares it with the cost of power generated from traditional sources, for both the case of existing capacity and new capacity additions. This information can be used to estimate the scale of incentives or subsidies needed to encourage investment in renewable resources. In addition the study reviews incentives that have been employed elsewhere for expanded deployment of renewable energy systems and analyzes the effectiveness of such incentives.

Benjamin K. Sovacool. *The Power Production Paradox: Revealing the Socio-technical Impediments to Distributed Generation Technologies* (Blacksburg, VA: Virginian Tech, Doctoral Dissertation, April 17, 2006), accessed July 2006 at http://scholar.lib.vt.edu/theses/available/etd-04202006-172936/.

Abstract: Dramatic improvements in renewable energy and small-scale distributed generation (DG) technologies have been made in the last twenty years. Nevertheless, they remain underutilized in the American electric utility system. Despite the immense environmental, technical, and financial promise of renewable energy systems and DG technologies, such generators still constitute a very small percentage of electricity generation capacity in the United States. This relative neglect occurs despite remarkable gains in their technical performance and reductions in their cost of producing power—the result (in part) of dramatic government support for several decades. Moreover, the technologies often demonstrate great environmental benefits that appeal to policymakers and consumers. At the same time, they offer ways to enhance strained distribution and transmission networks.

This project attempts to answer the paradoxical question: why do new energy technologies that offer such impressive benefits also find the least use? The dissertation emphasizes how the history and culture of the community of electricity producers and users helps explain why the new technologies have seen little use. Going beyond technical explanations of alleged low capacity factors and high capital costs, it focuses on the social nature of decision making among participants in the electric utility system. The approach not only helps us understand the glossing over of renewable energy and distributed generation technologies, but also suggests ways of overcoming the barriers faced by their advocates.

Waste Reduction Partners
– Advancing Energy Efficiency Field Assistance in WNC

Waste Reduction Partners is an award winning, innovative technical assistance program serving 32 counties in Western North Carolina. Waste Reduction Partners (WRP) is a program of the Land-of-Sky Regional Council in Asheville, which utilizes the 'brain power" of NC's growing baby-boomer demographics. The program employs the expertise of 50 retired, volunteer engineers and scientists, working in conjunction with program staff. Since 2000, this nationally recognized WRP program has provided over 74,000 hours of no-cost technical assistance to WNC industries, businesses and public institutions to cut utility costs, reduce energy and water use, improve solid waste management, create new business opportunities, and promote pollution prevention strategies– achieving savings over $12 million.

In partnership with the State Energy Office and the NC Division of Pollution Prevention and Environmental assistance, WRP assessors work on-site, one-on-one with business, industry, and institutional clients on energy efficiency strategies, energy auditing, and implementation guidance. The technical assistance is free and confidential. WRP staff conducts traditional level one and two energy audits, assists organization with energy strategic planning, ISO 14001, performance contracting, and related business development assistance; and provides energy saving outreach in the commercial sector. Staff has also produced energy savings self-assessment tools, fact sheets, awareness posters, etc. WRP engineers are currently developing a Lessons-Learn Performance Contacting Manual for K-12 School and Local Governments.

Performance Measures: Since 2000

Energy Efficiency Audits (business, industry, institutions): > 225
Average Energy Saving (Recommended): 750 MMBtu per Assessment
Client Implementation Rate: 30% - 50%
Simple Payback on Grant Funding investment: less than 2 months
Estimated Client Savings (implemented): $760,000/year

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WASTE REDUCTION PARTNERS
dedicated professionals sharing expertise

WVU's Advanced Power and Electricity Research Center uses a multidisciplinary approach to develop innovations in transmission system-wide control with the goal of ensuring reliability, availability, security, and profitability for large- and small-scale systems.

APERC has extensive experience and a well-established record researching integrated communications and distributed controls for the management of electric power systems in a restructured market. Researchers focus on common power industry issues such as security, self-healing, energy management, distributed resource applications and economics for power systems. As a natural extension of the self-healing grid research, microgrids and intelligrids have been added to the research activities of this group.

APERC researchers are examining distributed resources and microgrid technologies integrated with communications and distributed controls to encourage the assimilation of these technologies into the distribution network. Researchers seek to improve power quality and reliability, increase energy efficiency, reduce peak loads, or improve productivity through the adoption of control and automation technologies for industrial equipment and residential appliances.

APERC economists and engineers also model markets for energy and ancillary services. Research areas include markets and trading; load control through price signals; ancillary service markets, and rates and tariffs for green power. Economic models include a model that explains and assesses the pattern and prices of power plant divestiture by regulated utilities, a model that compares the efficiency of dispatch under market-oriented and traditional vertically-integrated systems and a model that examines the spatial and temporal linkages and patterns in electricity price determination in regional operations like PJM.

Project Title: Sun Grant BioWeb

Description:
The Sun Grant BioWeb is an online resource for bioenergy and bioproducts. Currently under development, the BioWeb is designed to be a comprehensive educational resource for information about biomass feedstocks, biofuels, biopower, bioproducts, and biorefineries. It is essentially an online encyclopedia of everything biomass.

Leading researchers and experts in various aspects of bioenergy and bioproducts—representing academic institutions, federal and state agencies, national labs, private industry, and other stakeholder groups—are contributing information to the BioWeb and reviewing submissions.

All of the information in the BioWeb will be accessible in three levels of detail: (1) an academic version, (2) a general public version, and (3) an abstract version, and users can switch among versions at any time displaying more or less detail. Use of innovative software and content management system applications will make the BioWeb user-friendly and current.

The project is being funded and coordinated by the Sun Grant Initiative, led by the Southeastern Regional Sun Grant Center. Content authors are currently preparing research material for submission to the BioWeb, while a team of programmers is working on development of the content management system databases and web templates. A national Sun Grant conference will be held in Knoxville in February 2007 to review the BioWeb content prior to the system being made publicly available in March 2007. The Sun Grant BioWeb will be fully functioning by March 2007, accessible at www.bioweb.sungrant.org.

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Innovations for Sustainable Residential Development: Partnership to Meet the Challenges of the 21st Century

- ***Accelerate implementation and commercialization of research results for sustainable residential development***.
- ***Place-based adaptation of scientifically sound technologies and practices***.
- ***Highly integrated and coordinated approach designed to overcome:***
  - ***environmental, social, and economic problems*** *of current inefficient and harmful development and building practices*
  - ***administrative, awareness, educational, and market barriers*** *to better, more sustainable solutions*
- ***Initial focus on East Tennessee, one of the fastest growing and most environmentally sensitive areas of the nation***

Our partners from the education, government, and private sectors will cooperate to promote and facilitate development that is far more sustainable than current practice. We use the latest research results and technological advances to assesses full life-cycle impacts of vertically integrated methods and practices that protect our environment and lead to 'net-zero energy' housing, healthier homes, and more livable communities.

The partnership will develop and demonstrate methods for systematic optimization of ecological, social, economic, and technological factors in site selection and site preparation; design; manufacturing, and transportation of building materials and components; construction, operation and maintenance; hazard resistance, repair, remodeling, and decommissioning/reuse of buildings, components, and infrastructure.

The partners will develop comprehensive portfolios of easy-to-use guidelines; manuals; check lists; design and evaluation tools; educational opportunities; workforce training materials and programs; information for community leaders, stakeholders, homeowners, and the general public; model ordinances and public policies; legal and financial services; incentive packets; implementation recommendations; product and service ratings; community assistance; technical support; and consulting services.

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Rapid Manufacturing for Economic Development and Energy Reduction via Metal Casting

A new process for making molds for casting via 3-D printing can produce products more quickly, reduce energy requirements, increase workforce skills, and make a cleaner workplace. The process is viable for prototype products and small batches of parts, which is a major goal of lean manufacturing. The major advantage is that 3-D printing can produce the mold without conventional tooling, which takes approximately 50 percent of the time from concept to product. Other major advantages are less intensive labor requirements; simultaneous production of cores and molds; elimination of storage of conventional patterns and core boxes; lower core and scrap losses; more complex molds and cores are possible; and the ability to run the machine with minimal supervision and thus 24-7 operation is possible with one 40 hour shift operation. It is possible to produce multiple small parts in a single mold, and thus production of a batch of small parts is possible.

A closely related process makes a consumable pattern via the 3-D printing process which is then placed in a chemically set molding material to produce the mold. The advantages of the process are very similar to the 3-D molding process. The time for pattern production may be somewhat shorter, but the mold must still be made and thus the total production times would be similar. It is desired to have a rapid manufacturing casting technology center to promote these technologies in the metal casting industry.

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Development of High Temperature Corrosion Resistant Materials for Next Generation Coal-Fired Ultrasupercritical Energy Systems.

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Abstract

To improve energy efficiency, reduce operating cost, and lower emissions, coal-fired boiler/steam turbines will be operated at higher temperatures than the current available ones. A major challenge in the development of these new energy systems has been in the area of materials technology, such as increasing temperature capability, corrosion resistance of current materials. Currently, WVU is working with other universities, national labs, and industrial partners on developing nano-structured metallic materials for next generation Ultrasupercritical (USC) boiler/steam turbine systems.

The objectives of this research are (1) to improve the temperature capability; (2) to enhance the creep resistance and long-term stability; (3) to maintain enough corrosion resistance of key candidate alloys for USC boiler and turbine systems. Two nano-structured alloys will be investigated in the proposed research, Ni-base Inconel 740 (wrought) alloy for boiler tubes, steamheaders, and steam turbine rotors, and Fe-base CF8C-Plus (casting) alloy for USC turbine casings, centrifugal cast headers, and auxiliary high-temperature steam piping, thus developing new alloys suitable for next generation USC boiler and turbine applications. The goals of this research are increasing temperature capability from 700°C to 750°C for Inconel 740 and from 650°C to 700°C for CF8C-Plus.

This project is a key step toward the succeed of the overall U.S. USCI program, which has significant energy efficiency and environmental improvement. For instance, according to the prediction of Clean Coal Technology Roadmap, comparing with current steam boiler/turbine systems, USC systems will increase plant-wide efficiency from 40% to 50-60%; reduce NOx emission from 0.15 to <0.01 Ib/10^6 Btu.

TITLE: Sequestration of Carbon Dioxide in Appalachian Coal Deposits

ABSTRACT

CO_2 sequestration is one way to reduce the content of carbon dioxide in the atmosphere. In this process CO_2 is captured from the atmosphere, possibly at the source of its production, like fossil fuel power plants, and pumped into underground reservoirs, such as deep saline aquifers or un-mineable coal seams. The latter can provide an additional benefit of residual methane recovery. In order to plan the
CO_2 sequestration operations in each particular area it is important to predict the storage capacity of a reservoir, and the feasibility of long-term containment of CO_2. The purpose of this research is to conduct such feasibility study for Appalachian region using advanced computer simulations. A large

A long term projection of CO_2 transport and possible escape from deep coal seams is an important problem associated with CO_2 sequestration.
Many factors can affect the process of CO_2 transport, such as bounding layers permeabilities, porosities, fracture densities, etc. Within this projects computer simulations are conducted with a purpose of predicting CO_2 transport in a multi-layer environment of typical unmineable coal seams. The San Juan, Appalachian and Powder River basins were considered as examples. TOUGH2 and OpenFOAM simulators were used in the study. In preliminary analysis a four layer sand-shale-coal-shale system was considered with the overlying and underlying medium to be the shales. Fracture zones might present local escape points. Locating faults and fracture zones is one of the objectives of the geophysical characterization and monitoring efforts.
However, a lot of this will be site dependent. Thus, a number of different scenarios was considered: tight (low to zero permeability), seal versus leaky (higher permeability) seal, etc. The results indicate that the diffusion of CO_2 may be affected by the properties of the seal layers. For a tight seal shale scenarios with the reasonable assumptions used there was no considerable CO_2 leakage beyond the shale layers after 50 years or more. The study can provide long term projections for the CO_2 sequestration operations in known coal seams.

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Energy and Energy-Interdependent Critical Infrastructure Resilience and Economic Development Initiatives: Economic Growth and Sustainability for Critical Services and Job Development and Protection

Richard A. Bajura, Timothy McNulty, Kenneth Sochats, and Floyd Russell

Risks to critical infrastructure are not well recognized. Policy development and technology forecasting are as important to understanding infrastructure interdependencies as are the physical linkages and interdependencies for supply chains from production to consumer. The Interim National Infrastructure Protection Plan (NIPP) calls for a variety of security partnerships that cross jurisdictional and sector boundaries and that support national infrastructure protection objectives. The Report of the Homeland Security Advisory Council Critical Infrastructure Task Force emphasizes a focus on infrastructure resilience to ensure the functioning of the economy, the continuity of business operations, and the successful execution of emergency response.

Inattention to the potential impact of natural disasters and low-probability events has a profound effect of the ability of society to prepare for uncertainty and be resilient in withstanding disasters. Collaborations for infrastructure protection and resilience by local and regional government organizations in cooperation with private sector entities are essential to long-term economic sustainability and life safety. Energy infrastructure that is not resilient cannot support essential services. Jobs based on non-resilient infrastructure may not exist after a disaster or a prolonged recovery period.

Carnegie Mellon University, University of Pittsburgh, and West Virginia University, in association with the U. S. Department of Energy's National Energy Technology Laboratory, lead an initiative that brings together selected regional experts to examine public/private sector coordination for energy and energy-interdependent critical infrastructure resilience. The initiative is forming the basis for wider regional public/private sector collaboration and development of research agendas for energy infrastructure resilience.

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SOLUTION OF THE DISCRETE AGGLOMERATION MODEL

WITH A TIME VARYING KERNEL

Agglomeration of particles in a fluid environment (e.g., a chemical reactor) is an integral part of many industrial processes (e.g., Goldberger, 1967) and has been the subject of scientific investigation (e.g., Siegell, 1976). The fundamental mathematical problem is the determination of the number of particles of each **particle-type** as a function of time for a system of particles that may agglutinate during two particle collisions. Little or no work has been done for systems where particle-type requires several variables. Efforts have been focused on a particle-type list with only one variable, size (or mass). This allows use of what is often referred to as the **coagulation equation** which has been well studied in aerosol research (Drake, 1972). Original work on this equation was done by Smoluchowski (1917) and it is also referred to as **Smoluchowski's equation**. The **agglomeration equation** is perhaps more descriptive since the term coagulation implies a process carried out until solidification whereas we focus on the agglomeration process; that is, on the determination of a time-varying **particle-size distribution** even if coagulation is never reached.

In his original work Smoluchowski considered the agglomeration equation in a discrete form. Later it was considered in a continuous form by Müller, (1928). In either case, an **initial particle-size distribution** to specify the initial number of particles for each size is needed to complete the **initial value problem** (IVP) which we refer to as the **agglomeration model**. Since both forms have an infinite number of sizes, the **state (or phase) space** is infinite dimensional. The probability that any two particles will collide and adhere (i.e., agglutinate) is taken into account by the **kernel**. Solution of the model yields an updated particle-size distribution giving **number densities** as time progresses. Existence and uniqueness results have been obtained by Melzak (1957), Marcus (1965), Morganstern (1955), and McLaughlin, Lamb, and McBride (1997) for bounded kernels and by Mcleod (1962), White (1980), and Treat (1990) for special unbounded kernels. For a general coagulation-fragmentation equation which allows a time-varying kernel, Spouge (1984) provides a local existence theorem for the physical case. Formulas for solutions are known for specific examples of kernels and initial particle sizes for both the discrete and continuous models (see Drake,1972, Treat (1990) and Yu, 1990) although the correspondence of results is not always clear. However, for a time-varying kernel, formulas for the solution have not been thoroughly investigated, particularly in the general (not necessarily physical) case.

Let **R** be the real numbers, $Int_o=\{I\subseteq \mathbf{R}$: I is a finite, infinite or semi-infinite open interval$\}$, and for $I\in Int_o$, $A(I,\mathbf{R}) = (f{:}I\to\mathbf{R}{:}f$ is analytic on I$\}$. To develop the discrete model, assume that all particles are a multiple of a particle of smallest size (volume), say Δv. Thus a particle made up of i smallest-sized particles has size $i\Delta v$. Let $n_i(t)$ be a real-valued function that approximates the number of particles of size $i\Delta v$ in the reactor at time t. Assume the initial number density $\vec{n}_0 = \{n_i^0\}_{i=1}^{\infty} \in \mathbf{R}^\infty = \left\{\{a_i\}_{i=1}^{\infty} : a_i \in \mathbf{R}\right\}$ is known. As time passes, particles collide with one another, agglutinations occur, and larger particles result. The net rate of increase in $n_i(t)$ with time, dn_i/dt, is the rate of formation minus the rate of depletion (conservation of mass). Now let $t_0 \in I_0 \in Int_o$, $Int_o(I_0) = \{I \in Int_o : I \subseteq I_0\}$, and $Int_o(t_0, I_0) = \{I \in Int_o : t_0 \in I \subseteq I_0\}$. The kernel, $\mathbf{K(t)} = \{K_{i,j}(t)\}_{i,j=1}^{\infty}$, is a doubly infinite array of real-valued functions of time, all defined on $I_0 = (t_{0-}, t_{0+}) \in Int_o$ containing the arbitrary initial time t_0. We indicate this by the **extended interval notation** $I_0 = (t_{0-}, t_0, t_{0+})$. The resultant mathematical model is an IVP consisting of an infinite system of Ordinary Differential Equations (ODE's) each with an Initial Condition (IC) that may be written in scalar form as:

System of ODE's: $$\frac{dn_i}{dt} = \frac{1}{2}\sum_{j=i}^{i-1} K_{i-j,j}(t)\, n_j n_{i-j} - n_i \sum_{j=1}^{\infty} K_{i,j}(t)\, n_j, \quad t \in I_0 = (t_{0-}, t_0, t_{0+}) \quad (1.1)$$

IVP $\qquad i \in \mathbf{N} = \{1, 2, 3, ...\}$

IC's $$n_i(t_0) = n_i^0, \quad t_0 \in I_0 = (t_{0-}, t_0, t_{0+}). \quad (1.2)$$

where $N = \{1, 2, 3, ...\}$, $\mathbf{K(t)} = \{K_{i,j}(t)\}_{i,j=1}^{\infty} \in A(I_0, \mathbf{R}^{\infty\times\infty}) = \{ \mathbf{K(t)} = \{K_{ij}(t)\}_{ij=1}^{\infty}$:for all $i,j \in N$, $K_{i,j}((t) \in A(I, \mathbf{R})\}$, $\mathbf{R}^{\infty\times\infty} = \left\{ \{a_{i,j}\}_{i,j=1}^{\infty} : a_{i,j} \in \mathbf{R} \right\}$ and for i = 1 the empty sum on the right hand side of (1.1) is assumed to be zero. The first sum in the **discrete agglomeration equation** (1.1) is the (average) rate of formation of particles of size i by agglutinations of particles of size i − j with particles of size j. The second sum is the (average) rate of depletion of particles of size i by agglutinations of particles of size i with particles of all other sizes. Thus we model a **stochastic process** as a **deterministic process**. The physical system is often **stationary** so that each $K_{i,j}$ is constant and the model is **autonomous**.

Smoluchowski solved this problem when $Ki,j(t) = A_0$ is a constant. The solution is:

$$n_i^{A_0}(t) = \left[n_i^0 + \sum_{n=1}^{i-1} \frac{k_i^{(n+1)}}{2^n} \left[\frac{A_0(t-t_0)}{1 + \frac{1}{2} M_{n0} A_0 (t-t_0)} \right]^n \right] \frac{1}{\left(1 + \frac{1}{2} M_{n0} A_0 (t-t_0)\right)^2}, \quad i \in \mathbf{N} \quad (1.3)$$

for t in the interval of validity $I_{IV}^{A}(t_0, \vec{n}_0, A_0) \in Int_o(t_0.I_0)$ where

$$k_i^{(n+1)} = \sum_{i_1 + i_2 + \cdots + i_{n+1} = i} n_{i_1}^{\ 0} n_{i_2}^{\ 0} \cdots n_{i_{n+1}}^{\ 0}, \qquad M(t_0) = M_{n0} = \sum_{i=1}^{\infty} n_i^0. \quad (1.4)$$

In the physical case where $n_i^0 \geq 0$, $M_{n0} > 0$, and $A_0 > 0$, $I_{IV}^{A}(t_0, \vec{n}_0, A_0)$ contains $[t_0, \infty)$. Since the moment of the solution is

$$M(t) = \sum_{i=1}^{\infty} n_i^{A_0}(t) = \frac{M_{n0}}{1 + (1/2) M_{n0} A_0 (t - t_0)}. \quad (1.5)$$

one might expect in this case that $I_{IV}^{A}(t_0,\vec{n}_0,A_0)$ would be $(t_0 - \frac{2}{M_{n0}A_0},\infty)$. Surprisingly, a consequence of our main result is that the infinite series in (1.5) only converges for $t \in I_{IV}^{A}(t_0,\vec{n}_0,A_0) = (t_0 - \frac{1}{M_{n0}A_0},\infty)$.

For a general (not necessarily physical) time-varying kernel, $K_{i,j}(t) = A(t) \in \mathcal{A}(I_0,\mathbf{R})$, this paper provides a new solution procedure by first solving related problems. We obtain uniqueness of all problems as $K_{i,j}(t)$ is analytic. First we solve the moment problem. Next we use the first order linear technique to solve three (simultaneously-solvable) related problems recursively. We then solve one of the problems (and hence all three) explicitly using a generating function. The solution of the agglomeration problem (recursively and explicitly) is then found along with its interval of validity as an often proper subset of the interval of validity of the moment problem. Breaking down the general procedure using several problems should allow additional progress for unbounded kernels.

Reviewing, in this paper we assume for all i and j that $K_{i,j}(t) = A(t) \in \mathcal{A}(I_0,\mathbf{R}) = \{f{:}I_0 \to \mathbf{R}{:}f$ is analytic on $I_0\}$ and look for analytic solutions. This assures uniqueness via Taylor series, but not local or global existence (e.g., information about the radius of convergence for each $n_i(t)$ and the infimum of all such radii). We focus on obtaining a finite process for computing $n_i(t)$ (e.g., a formula) using algebraic and analytical (e.g., integral) operations when $K_{i,j}(t) = A(t)$ (and provides a blueprint for more general kernels). This is fundamentally different from solving via Taylor series or numerical techniques that yield approximations at grid points.

As examples, we are particularly interested in the following **time-varying analytic kernels**:

$A(t) = A_0$	$A_0 \neq 0$	Constant Kernel	(1.3)
$A(t) = A_0 + b_0 t$	$A_0 \neq 0,\ b_0 \neq 0$	Linearly Time Varying Kernel	(1.4)
$A(t) = A_0 + b_0 \cos(\omega_0 t + \phi_0)$	$A_0 \neq 0,\ b_0 > 0,\ \omega_0 > 0$	Oscillating Kernel.	(1.5)