

West Virginia University

“A Strategic Plan for the Advanced Energy Initiative”

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Executive Summary

The economic prosperity of the country is dependent upon reliable and affordable sources of energy. However, the forces of globalization and shrinking reserves of fossil energy have combined to make energy expensive with a concomitant effect on the economy. The state and federal government have responded to this challenge by funding a wide range of energy research activities.

To address energy research at WVU, a committee was appointed with the responsibility of devising a *Strategic Energy Plan*. Input from a variety of sources, including university faculty and the U.S. Department of Energy was obtained. The *Advanced Energy Initiative* (AEI) is the output of this activity.

The AEI strategic plan was developed through a review of the research skills and resources available to the university. The goals of the state and federal governments were taken into account. The adopted research plan consists of three major focus areas:

- Fossil Energy
- Sustainable Energy
- Energy Policy

The document outlining the AEI consists of two sections. Section I describes the mission, vision and overall goals for this initiative while Section II contains implementation plans for each goal.

Table of Contents

| | |
|--|--------------|
| Executive Summary | 2 |
| Introduction | 4 |
| I. The Strategic Plan | 5 |
| Mission, Vision and Overall Goals of the Advanced Energy Initiative | 5 |
| The WVU Advanced Energy Initiative | 6 |
| • Fossil Energy | 7 |
| • Sustainable Energy | 8 |
| • Energy Policy and Regulatory Affairs | 9 |
| Organization and Integration | 10 |
| WVU Energy Funding | 12 |
| II. Implementation Plans | 13 |
| • Organizational Goals 1-6 | 14-19 |
| • Integration Goals 1-7 | 20-26 |
| • Fossil Energy Goals 1-6 | 27-32 |
| • Sustainable Energy Goals 1-6 | 33-38 |
| • Energy Policy and Regulatory Affairs Goals 1-3 | 39-41 |
| Concluding Remarks | 42 |
| Appendix A: Global Energy Challenges | 43 |
| Appendix B: Key Issues from the WV Plan | 50 |

Introduction

Reliable and affordable sources of energy such as oil, natural gas, coal and nuclear are major contributors to the economic prosperity of the United States. However, over the last decade numerous forces have emerged that are affecting energy utilization and consumption.

The major energy issues facing the nation include declining domestic production of oil and natural gas and increasing competition for global supplies driven by the growing needs of emerging industrial countries. Much of the fossil fuel imported into the country comes from politically unstable regions of the world. These issues introduce a risk into the energy supply that has major implications for our nation's physical and economic security. One way to reduce this risk is to reduce the nation's dependence on imported fossil fuels. Concurrently, the environmental challenges caused by burning these fuels, such as global warming and carbon management, must be addressed and economically viable solutions identified. A more extensive discussion about the global and domestic energy challenges can be found in Appendix A.

As a result of these challenges to the United States energy supply, the federal government has embarked on a major research and development initiative. The goals of this program are: (1) advance the clean use of domestic fossil fuels (2) seek innovations in alternative and sustainable energy sources and (3) use energy policy and regulatory management to ensure stability and reliability of the nation's energy supply. The State of West Virginia has also issued an energy plan and this is described briefly in Appendix B. Given the importance of these initiatives, it was concluded that West Virginia University (WVU) will take a leading role in energy research and development to advance the national energy research agenda and serve the state and nation.

To address energy research at WVU, a committee was appointed with the responsibility of devising a strategic energy plan. Input from a variety of sources, including university faculty and the Department of Energy was obtained. The *Advanced Energy Initiative* (AEI) is the output of this activity.

The document outlining the AEI consists of two sections. Section I describes the mission, vision and overall goals for this initiative while section II contains implementation plans for each goal. This plan is designed to be evergreen and will be revised and updated regularly.

I. The Strategic Plan

Mission, Vision, and Overall Goals of the Advanced Energy Initiative

The strategic planning process for the Advanced Energy Initiative (AEI) sought input from WVU faculty, members of federal agencies and national laboratories and leaders of private sector organizations. This led to development of a vision and high-level goals statement. These provide the roadmap for achieving the strategic plan through such means as organizational change for an energy mission, assignment of resources, development of new and/or enhancement of existing programs and relationships, the addition of new energy faculty, and alignment with the needs of the many stakeholders that the university serves.

The following **Vision Statement** was adopted following university wide consultation and input:

“West Virginia University will become internationally recognized as a leading academic institution driving innovative research in the socially and environmentally responsible production, management and utilization of energy”.

The **Overall Goals** of the Advanced Energy Initiative were defined and are shown below.

- Develop a strong R&D portfolio that targets key issues, and places West Virginia University among the ranks of the most eminent public research universities engaged in energy and environmental research.
- Strengthen interdisciplinary cooperation to bring the full capabilities and resources of the University together to compete for R&D funding.
- Develop superlative research and development facilities, laboratories, and infrastructure that provide unique capabilities and that attract the best and brightest undergraduate and graduate students and faculty to the University.
- Offer an exciting educational experience for students providing broad interdisciplinary skills that prepare them to be productive members of society for careers as leaders in energy and the environment.
- Partner with private industry, government agencies and laboratories, and other research universities to enhance our capability to compete for research support to address important energy/environmental challenges.
- Apply relevant knowledge and capabilities to provide input on important national and state policy issues to policy-makers.

Based upon these overall goals, a detailed strategic research plan with specific goals was developed. Implementation plans to support these goals were then developed. The details of the plan are outlined below.

The WVU Advanced Energy Initiative (AEI)

The AEI strategic plan was developed through a review of the research skills and resources available to the university and an understanding of the goals of the state and federal governments. The central thrust of the research plan that was adopted consists of three major focus areas:

- **Fossil Energy:** *Fossil Energy Resources, Conversion, Utilization, and Environmental Management*
- **Sustainable Energy:** *Energy Efficiency, Conservation, and Renewable Energy*
- **Energy Policy:** *Analysis of Energy Policy, Carbon Management, Environmental, and Infrastructure Issues*

Each of these focus areas consists of four components, namely: research, partnerships, outreach and education. However, to be successful, we must first focus our resources on research. Success in the research activities will then allow us to develop the partnerships, outreach and educational components of the AEI.

The specific goals for each research initiative are shown in Figure 1. They are discussed in more detail below. The goals are referred to as SMART Goals, since they are Specific, Measurable, Attainable, Realistic and Timely.

| Strategic Plan for the West Virginia University Advanced Energy Initiative | | | | |
|--|---|--|---|---|
| Vision | | | | |
| West Virginia University will become internationally recognized as a leading academic institution driving innovative research in the socially and environmentally responsible production, management and utilization of energy. | | | | |
| Organization (VP R&ED) | Integration (Director) | Fossil Energy (Associate Director) | Sustainable Energy (Associate Director) | Energy Policy (Associate Director) |
| <ol style="list-style-type: none"> 1. Appoint interim management structure during 3Q08 2. Appoint director by 2Q09 and associate directors by 3Q09 3. Establish internal advisory board by 1Q09 and external board by 3Q09 4. Establish an internal competitive funding program for grant writing by 3Q08 5. Develop incentives, resources, and recruitment strategies to focus energy research by 3Q09 6. Fill gaps with new resources (faculty, facilities, funds) by 4Q10 | <ol style="list-style-type: none"> 1. Create at least three cross-initiative research teams to address competitive funding opportunities by 1Q09 2. Develop a 3-year funding plan by 2Q09 with target of at least \$100M/Yr in competitive submissions 2010 through 2012 3. Use senior faculty successful in securing funding to mentor junior faculty by 2Q09 4. Determine important gaps in research expertise by 2Q09 5. Conduct an annual internal funding program for grant writing in key focus areas beginning 1Q09 6. Protect, and license/commercialize intellectual property disclosures for the fossil and sustainable AEI focus areas 7. Secure at least two (2) Centers of Excellence grants with a total of \$10M in funding by 4Q12 | <p>Establish at least one major research program in each of the following areas by 4Q09, with new external project funding in these areas at the rate of 2 by 4Q10, 2 by 4Q11, and 2 by 4Q12:</p> <ol style="list-style-type: none"> 1. Carbon capture and geologic storage with \$10 M in funding by 4Q12 2. High-efficiency engine and vehicle technology with \$8M in funding by 4Q12 3. Fuels production with \$4M in funding by 4Q12 4. Clean power generation and distribution with \$5M in funding by 4Q12 5. Extraction technology with \$3M in funding by 4Q12 6. Coal to clean fuels and chemicals, with \$2M in funding by 4Q12 | <p>Establish at least one major interdisciplinary program in each area below by 4Q09 with newly funded projects in each:</p> <ol style="list-style-type: none"> 1. Biomass conversion and utilization with \$3M in funding by 4Q12 2. Biomass /coal conversion with sequestration with \$3M in funding by 4Q12 3. Energy-related water resource management with \$4M in new funding by 4Q12 4. Sustainable design and development with \$1M in funding by 4Q12 5. Solar conversion with \$2M in funding by 4Q12 6. Efficient and sustainable use of energy and natural resources with \$4M in funding by 4Q12 | <ol style="list-style-type: none"> 1. Create a broad interdisciplinary energy policy team to identify critical issues in energy policy and regulatory affairs by 2Q09 2. Develop at least 2 major programs addressing critical issues in energy policy by 4Q09 with \$2M in funding in each program by 4Q12 3. Coordinate and enhance economic and policy analysis program for energy systems by 4Q09 with \$1M in funding by 4Q12 |
| <p>Notes:</p> <ol style="list-style-type: none"> 1. All dates based on Calendar Year 2. Funding projections are cumulative new awards through 4Q12 | | | | |

Revised 8/11/08

Figure 1

To achieve these SMART Goals, broad Implementation Plans have been developed and these are documented in section II of the strategic plan.

Fossil Energy: The goal of this focus area is to address global and national needs and concerns regarding the environmentally responsible use of fossil energy through a university-wide research program focusing on the use of West Virginia's energy resources. The fossil energy resources within West Virginia are extremely large and can provide a stable, domestic energy supply for the foreseeable future. However, the environmental challenges presented by the continued use of fossil energy, especially with respect to greenhouse gas emissions, must be adequately addressed. This area is heavily focused on development of advanced, affordable technology that will enable the state and the nation to meet these environmental challenges and reduce its energy imports.

West Virginia University is well positioned to establish a program of excellence in the environmentally responsible production and utilization of fossil energy resources given our research heritage in this focus area and our partnerships with other organizations such as the U.S. Department of Energy's National Energy Technology laboratory (NETL).

The fossil fuel focus will directly support the State of West Virginia Energy Plan which is to displace imported oil and to be energy independent by 2030. It will ensure integration with the national energy goals of the US Department of Energy and the Energy Policy Act of 2005.

The SMART goals for the fossil energy area shown in Figure 1 are:

1. Establish at least one major research program in carbon capture and geologic storage with \$10M in funding by 4Q12
2. Establish at least one major research program in high-efficiency engine and vehicle technology with \$8M in funding by 4Q12
3. Establish at least one major research program in fuels production with \$4M in funding by 4Q12
4. Establish at least one major research program in clean power generation and distribution with \$5M in funding by 4Q12
5. Establish at least one major research program in extraction technology with \$5M in funding by 4Q12
6. Establish at least one major research program in coal to clean fuels and chemicals with \$2M in funding by 4Q12

The individual goals defined above are designed to capture a wide variety of research activities. WVU already has ongoing activities in most of these areas and fully expects to expand its funded activities by the amounts shown by 2012. An Implementation Plan for each of these goals is detailed in section II of this strategic plan.

WVU, Carnegie-Mellon and the University of Pittsburgh have formed a consortium, known as **CWP Inc.**, to undertake research projects that use fossil fuels. The consortium will consist of approximately 75 university faculty, post-doctoral fellows and graduate

students who will work with about 150 research personnel from NETL to address key areas of fossil fuel research. The initial contract will cover the following program areas: materials for energy technologies, process and dynamic systems modeling, catalyst and reactor development, carbon management, sensor systems and diagnostics, energy conversion devices, gas hydrates and ultra deep and unconventional oil and gas production technology. Many of these research areas fit extremely well with the WVU Energy Initiatives.

Sustainable Energy: This focus area concentrates on renewable energy as well as energy efficiency and conservation. Renewable energy includes biomass power, biofuels, solar, wind, hydro, and geothermal energy. Energy efficiency and conservation include residential, commercial and industrial opportunities to produce more useful output per unit of raw energy consumed and design for zero or low energy buildings. It also includes energy efficient lighting, heating, and air conditioning, land use and urban designs to reduce transportation and energy needs and improved insulation and energy management. Other important areas to explore include technologies for sustainable energy solutions such as hydrogen fuel cells and energy storage and the use of waste products and residues from agricultural, industrial, commercial and residential sources.

Significant opportunities exist to incorporate renewable along with traditional fossil-based energy as a way to transition to energy sustainability, provided we can develop cost-effective, reliable technology for co-processing (e.g., Coal-Biomass-to-Liquids) and technology integration approaches to combine fossil and renewable energy (e.g., wind + coal gasification). Ultimately, as global energy demand grows, energy sustainability will require large-system solutions such as fusion technology to be developed.

Water availability is a growing global concern that can directly impact sustainable energy use, and agriculture and energy are the two largest water consumers. This Initiative will examine ways to reduce consumption of water for energy purposes and help move towards sustainability in water use.

The goals for the sustainable energy area in Figure 1 are:

1. Establish at least one major interdisciplinary program in biomass conversion and utilization with \$3M in funding by 4Q12
2. Establish at least one major interdisciplinary program in biomass/coal conversion with sequestration with \$3M in funding by 4Q12
3. Establish at least one major interdisciplinary program in energy-related water resource management with \$4M in funding by 4Q12
4. Establish at least one major interdisciplinary program in sustainable design and development with \$1M in funding by 4Q12
5. Establish at least one major interdisciplinary program in solar conversion with \$2M in funding by 4Q12
6. Establish at least one major interdisciplinary program in the efficient and sustainable use of energy and natural resources with \$4M in funding by 4Q12

It is expected that a wide variety of research projects can be defined under these goals. Most of the goals associated with this initiative are new, with little ongoing activity in this area across the WVU campus. Consequently, the funding goals to 2012 are less aggressive than those for fossil energy and a significant effort will be required to organize these new research areas. Implementation Plans for each of these goals are described in section II of this strategic plan.

Energy Policy: The plan calls for creating an interdisciplinary group at WVU for the analysis and modeling of energy and environmental policy issues, analysis and development of strategies for the management of carbon, and analysis of energy infrastructure systems (i.e. an “energy think-tank.”)

Energy policy issues span a broad array of disciplines, from the legal issues associated with long-term storage of carbon dioxide, to the macro- and micro-economics of various proposed strategies, to life-cycle analysis of environmental impacts, and to important social issues associated with the fact that energy resources are often concentrated in areas that may not coincide with energy consumption patterns. WVU possesses a strong background in fossil-energy-related issues and also possesses many of the required capabilities for conducting policy analysis in the College of Law, the College of Business and Economics, and in the science and engineering disciplines to become a major contributor to policy analysis and development. Those capabilities, if coordinated, strengthened and focused on analyzing current important issues, can contribute to policy and regulatory development both within the state and nation.

The energy infrastructure is a complex system that delivers energy from its original raw state source to the end user or consumer. It comprises many components – the electrical transmission grid and distribution system, natural gas transmission and distribution pipelines, oil and LNG tankers, liquid fuel and chemical pipelines, rail, ships, barges and trucks that deliver fuels. It also includes the facilities that transform raw natural resources into more useful products (e.g., refineries). America’s energy infrastructure is aging and has not kept pace with national needs. It will require major upgrades to replace aging components, to meet growing demand, and to accommodate major changes that will be required as we adopt carbon management and other energy policy changes. The safety and security of our energy infrastructure has become a major concern, heightened by recent major electrical blackouts and natural gas pipeline ruptures. Understanding these coupled, interdependent energy delivery systems requires a multidisciplinary approach along with development of complex models to assess the impacts of changes and potential disruptions.

This focus area will unite the multi-disciplinary analytical capabilities of the university to examine and model energy-related systems and will foster a broad-based policy approach to solving some of the key energy-related issues facing society.

The goals for the energy policy and regulatory affairs area shown in Figure 1 are:

1. Create a broad interdisciplinary energy policy team to identify critical issues in energy policy and regulatory affairs by 2Q09
2. Develop at least 2 major programs addressing critical issues in energy policy by 4Q09 with \$1M in funding in each program by 4Q12
3. Coordinate and enhance economic and policy analysis program for energy systems by 4Q09 with \$1M in funding by 4Q12

WVU already has some important ongoing activities in these areas. The goal is to expand these activities, and funding, by 2012. Implementation Plans for each of these goals are detailed in section II of this strategic plan.

It should be noted that some important energy related topics such as nuclear, fusion and wind power are not presently represented in this plan. This omission is deliberate since resources are limited and choices had to be made that are a good fit with our current and near-term capabilities. This does not mean that these topics could not be considered at a later date, since we intend to update this document on a regular basis.

Organization and Integration

To implement this initiative and achieve the WVU vision, the following organizational steps will need to be taken:

- Establish a faculty leadership position for the AEI. A Director will be appointed to ensure responsibility, accountability and coordination of activities. Associate Directors will be appointed to oversee the three research focus areas.
- Create a high-level national advisory board of policy makers, private sector, and other stakeholders to provide guidance and direction to the Energy Initiative and to ensure balance between energy and environmental goals.
- Establish an internal executive board or steering committee comprised of university stakeholders to whom the Director reports on a regular basis. This board provides oversight and guides direction and policy for the AEI.
- Guide and encourage faculty through incentives, resources, and recruitment to focus energy research in the three focus areas. Identify opportunities to transition ongoing research efforts with low probability of funding into more promising research areas.
- Enhance the capabilities of the three focus areas and fill important gaps in expertise by selectively channeling new resource additions (faculty, facilities, and funds) to these areas.
- Establish a central administrative location for the AEI and its staff and provide a location where meetings can be held.
- Establish a position for a grants administrator to support funding opportunities and to encourage and assist in preparation of grant applications.

The immediate **Organizational Goals** that need to be implemented to support the vision for the AEI are shown below:

1. Appoint interim management structure during 3Q08
2. Appoint director by 2Q09 and associate directors by 3Q09
3. Establish internal advisory board by 1Q09 and an external board by 3Q09
4. Establish an internal competitive funding program for grant writing by 3Q08
5. Develop incentives, resources, and recruitment strategies to focus energy research by 3Q09
6. Fill gaps with new resources (faculty, facilities, funds) by 4Q10

It is anticipated that most (but not all) of the research projects will be carried out by multidisciplinary teams. In order to foster such cooperation and create the climate necessary for such teams to flourish, numerous activities need to be implemented and these are described in the **Integration Goals** below:

1. Create at least three cross-initiative research teams to address competitive funding opportunities by 1Q09
2. Develop a 3-year funding plan by 2Q09 with target of at least \$100M/year in competitive submissions 2010 through 2012
3. Use senior faculty successful in securing funding to mentor junior faculty by 2Q09
4. Determine important gaps in research expertise by 2Q09
5. Conduct an annual internal funding program for grant writing in key focus areas beginning 1Q09
6. Protect and license/commercialize intellectual property disclosures for the fossil and sustainable AEI focus areas
7. Secure at least two (2) Centers of Excellence grants with a total of \$10M in funding by 4Q12

The Organization and Implementation Goals support the Vision for the WVU Advanced Energy Initiative. The Implementation Plans for these goals are given in Section II of this plan.

WVU Energy Funding

An analysis of WVU funded projects shows that the energy area is already quite strong. The amount of funding from 2005 through 2008 is shown in Figure 2.

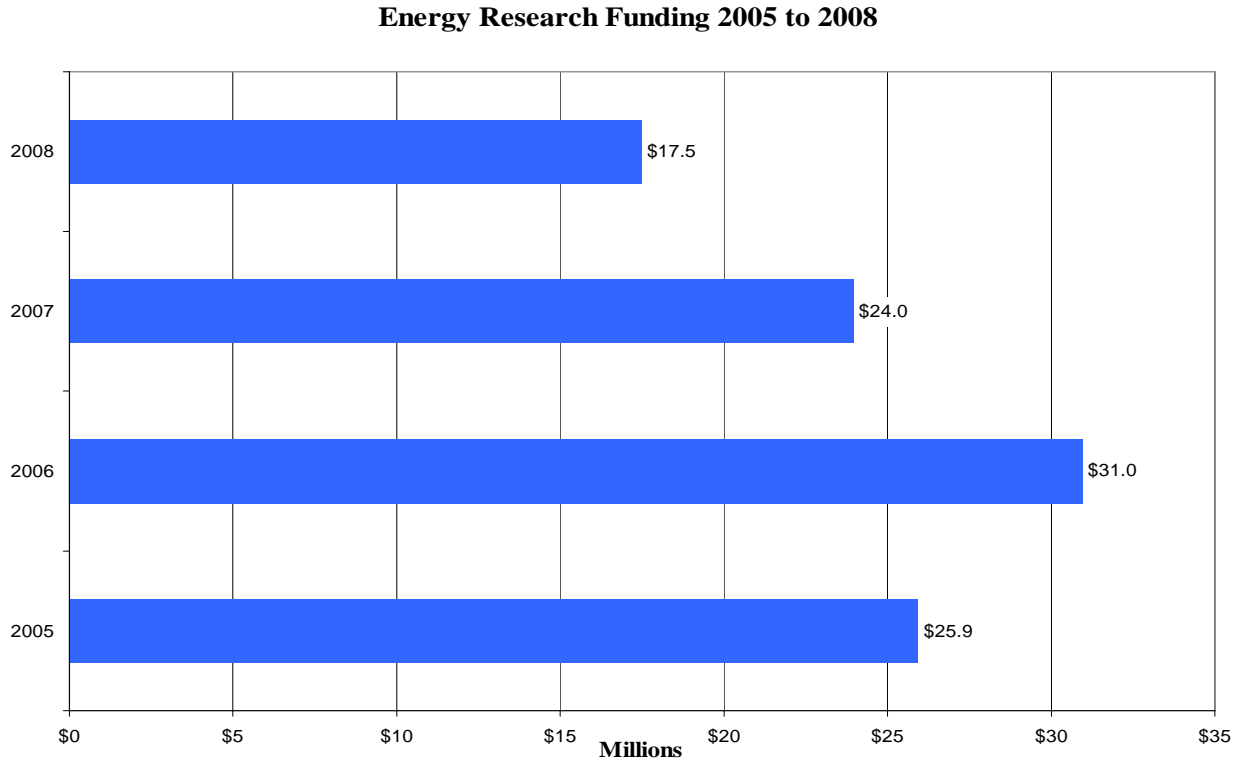


Figure 2

The figure shows that over the last four years WVU has brought in \$98.4M for energy studies. The main areas that have been recipients of this funding are:

- Environment
- Extraction and Natural Resource Management
- Renewable Energy, Conservation and Clean Fuels
- Fossil Energy
- Carbon Management

All of these areas are represented in the AEI. Approximately 65% of the funding indicated in Figure 2 comes from the Federal Government. The remainder comes from the State Government and from industrial companies. These are impressive funding numbers, indicating that WVU already has a major activity in this area. However, this research presently exists in individual colleges and is not coordinated at the university level. The AEI Strategic Plan encourages and promotes interdisciplinary research programs that cross college boundaries.

II. Implementation Plans

An implementation plan for each SMART Goal in the strategic plan has been outlined. Each implementation plan consists of a one-page narrative containing the following elements:

- Key Objective
- Accountability
- Rationale or Brief Background
- Measurement
- Implementation Steps and Timeline

As with the Strategic Plan, the Implementation Plans will be updated on a regular basis.

Each of these plans presently state measurable goals by 2012. However, the committee realizes that all these goals cannot be started immediately, but will be initiated as resources permit. Consequently, the implementation plans will be tracked and updated on a regular basis.

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

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|-----------------------|--|
| KEY OBJECTIVE | Organization |
| SMART GOAL 1 | Appoint Interim Management Structure by 3Q08 |
| ACCOUNTABILITY | VP Research and Economic Development |

RATIONALE OR BRIEF BACKGROUND

It is anticipated that the hiring and appointment of a Director for the AEI will take a minimum of six months once approvals for the position have been received. However, organization of the initiative needs to start immediately as shown by the tasks documented in the Integration Implementation Plan. In order for these activities to start this year, it will be necessary to appoint an Interim Director and Interim Associate Directors to start these tasks.

MEASUREMENT

Interim Director and Interim Associate Director Appointments for the WVU Advanced Energy Initiatives will be confirmed during 4Q08

IMPLEMENTATION PLANS

- (1) A call for the names and CV's of potential internal candidates for the Interim Director and Associate Director Positions will be made during 2Q08
- (2) A selection committee will be appointed during 3Q08
- (2) The selection committee will compile a shortlist of candidates during 3Q08
- (3) All candidates on the short list will be interviewed by the selection committee during 4Q08
- (4) The selection committee will meet to make recommendations to the Vice President for Research and Economic Development for the appointments during 4Q08
- (5) Appointments will be announced by the VP of Research during 4Q08

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

| | |
|-----------------------|--|
| KEY OBJECTIVE | Organization |
| SMART GOAL 2 | Appoint Director by 2Q09 and Associate Directors by 3Q09 |
| ACCOUNTABILITY | VP Research and Economic Development |

RATIONALE OR BRIEF BACKGROUND

The Advanced Energy Initiative at WVU is a cross-cutting research program that will draw scientific, engineering, and policy personnel from colleges of the University. The AEI, as a major research initiative, requires individuals with exceptional organizational skills, who will have a thorough understanding of the complexity of energy research, and who have the capability to make major contributions to energy research at West Virginia University. It is anticipated that leadership of the AEI will be recruited from outside the University to bring deep experience in energy research across the spectrum of the initiative.

MEASUREMENT

Director and Associate Director Appointments for the WVU Advanced Energy Initiatives will be announced during 2Q09 and 3Q09 respectively.

IMPLEMENTATION PLANS

- (1) Submit documentation to hire a Director during 3Q08 (VP Research)
- (2) Select hiring committee and advertise the position during 3Q08. A list of candidates should be received by 4Q08 (AVP Research)
- (3) Decide on short list of candidates during 4Q08 and complete telephone interviews by the end of 4Q08 (AVP Research)
- (4) Conduct campus interviews of selected candidate's and recommend final candidates to the VP Research during 1Q09 (AVP Research)
- (5) Announce Director's appointment by end of 2Q09 (VP Research)
- (6) Initiate hiring of Associate Directors from within the university during 2Q09 (Director)
- (7) Associate Directors are announced by end of 3Q09 (VP Research/Director)

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

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| KEY OBJECTIVE | Organization |
| SMART GOAL 3 | Establish Internal Advisory Board by 1Q09 and External Board by 3Q09 |
| ACCOUNTABILITY | VP Research and Economic Development |

RATIONALE OR BRIEF BACKGROUND

The WVU AEI is a multidisciplinary research effort that demonstrates West Virginia University's leadership in energy research, development, production, and use. To have access to expert advice from across the energy industry and from government agencies, an AEI External Advisory Board will be established. Concomitantly, to promote cross-campus cooperation and discussion, an Internal Advisory Board will also be established. Both of these boards will have well-defined functions and mandates that are complementary for advising the AEI and providing general oversight advice about the AEI to the Vice President for Research and Economic Development.

MEASUREMENT

Announcement of the members of both Advisory Boards made by 1Q09

IMPLEMENTATION PLANS

- (1) Define the function, mandate, responsibilities, and the number of members of both Advisory Boards by 3Q08 (VP Research)
- (2) Develop a list of candidates for both boards by 4Q08 (VP/AVP Research)
- (3) Identify and solicit candidates for the Internal Board positions by 4Q08 (VP/AVP Research)
- (4) Finalize and announce membership of the Internal Advisory Board by 1Q09 (VP/AVP Research)
- (5) Identify and solicit candidates for the External Board positions by 2Q09 (VP/AVP Research)
- (6) Finalize and announce membership of the External Advisory Board by 3Q09 (VP/AVP Research)

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

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| KEY OBJECTIVE | Organization |
| SMART GOAL 4 | Establish an Internal Competitive Funding Program for Grant Writing during 3Q08 |
| ACCOUNTABILITY | Director, WVU Advanced Energy Initiative |

RATIONALE OR BRIEF BACKGROUND

A Program to Stimulate Energy Research will be initiated that will fund faculty to spend their time writing a competitive grant proposal to a federal agency. It will allow faculty members to buy their way out of their teaching obligations. The proposals submitted will be reviewed by the AEI Internal Advisory Board on the basis of merit and the significance of the proposed work within the AEI. This competition will be held semi-annually.

MEASUREMENT

An internal fund for energy grant writing will be announced by 3Q08

IMPLEMENTATION PLANS

- (1) Develop recommendations and plans for funding, administering and sustaining the funding program by 3Q08 (Associate VP)
- (2) Garner approval for the internal funding program from the Vice President for Research and Economic Development by 3Q08 (Associate VP)
- (3) Announce an internal funding program during 3Q08 (VP Research)
- (4) Accept the first proposals for internal funding during 3Q08 (Associate VP)

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

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| KEY OBJECTIVE | Organization |
| SMART GOAL 5 | Develop Incentives, Resources and Recruitment Strategies to Focus Energy Research by 3Q09 |
| ACCOUNTABILITY | VP Research and Economic Development |

RATIONALE OR BRIEF BACKGROUND

The West Virginia University Energy Initiative includes a wide range of multidisciplinary research programs. The initiative's success will require a significant investment by the university to recruit new research personnel, acquire the necessary research tools, and develop the infrastructure for the initiative. This will require the development of both short-term and longer term funding strategies.

MEASUREMENT

Development of a five-year budget, referenced to federal agency plans and budgets.

Determine the number of new hires and the associated investment required through 2012 by 1Q09.

IMPLEMENTATION PLANS

- (1) Define near term research programs and deliverables during 1Q09 (Director/Associate Directors)
- (2) Develop detailed plans and strategies for the resources necessary to develop and perform each of the individual research programs outlined in the Strategic Plan during 2Q09 (Director/Associate Directors)
- (3) Detail the overall financial investment necessary to undertake AEI projects through 2012 during 2Q09 (Director/Associate Directors)
- (4) Define hiring and incentive strategies for AEI by 3Q09 (Director/Associate Director)

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

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|-----------------------|--|
| KEY OBJECTIVE | Organization |
| SMART GOAL 6 | Fill Gaps with New Resources (Faculty, Facilities and Funds) by 4Q10 |
| ACCOUNTABILITY | Director, WVU Advanced Energy Initiative |

RATIONALE OR BRIEF BACKGROUND

The WVU AEI plan calls for research programs in three areas (1) fossil energy (2) sustainable energy and in (3) energy policy. Projects in each of these areas will require the recruitment of new hires to fill critical gaps (identified in Integration 4) and start-up funds to assist these new hires in initiating their research programs, and potential renovation of facilities for new research programs. These gaps in our research skills will need to be filled in order to be successful.

MEASUREMENT

Conclude hiring of new faculty members to fill critical gaps by 4Q10

IMPLEMENTATION PLANS

- (1) Define the investment required to obtain the required skills, equipment and infrastructure necessary to complete ongoing and planned projects by 1Q09 (Integration Goal 4)
- (2) Develop plan to hire the skills necessary to carry out ongoing and planned projects including hiring priorities by 1Q09.
- (3) Advertise positions to be filled by 2Q09 and fill positions by 4Q10.

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

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|-----------------------|--|
| KEY OBJECTIVE | Integration |
| SMART GOAL 1 | Create at least three Cross-initiative Research Teams to address competitive funding opportunities by 1Q09 |
| ACCOUNTABILITY | Director, WVU Advanced Energy Initiative |

RATIONALE OR BRIEF BACKGROUND

The WVU AEI plan emphasizes research programs in three multidisciplinary areas: (1) fossil energy (2) sustainable energy and (3) energy policy. Each area will be defined by development of programs with projects that are performed by cross-cutting research teams. To help facilitate collaboration among the three areas, cross-cutting teams will be formed. Multi-disciplinary, cross-cutting projects require researchers who are open-minded and flexible in approaching problems. Consequently, choosing the research team is as important as defining the research project. Both of these issues are important to program and project performance.

MEASUREMENT

At least three cross-cutting research teams will be created and operating by 3Q09.

IMPLEMENTATION PLANS

- (1) The AEI Director will call for initial cross-cutting preliminary research proposals in the three areas outlined in the strategic plan by 2Q09
- (2) The Director/Associate Director will select at least three preliminary proposals for development into full proposals by 2Q09 on the basis of AEI plan conformance, research skills, required resources for performance, and potential for funding.
- (3) Create cross-cutting research teams for each proposal selected in (2), selecting only research personnel with the ability to work in a team by 4Q08 (Director)
- (4) Cross-cutting teams develop competitive proposals for submission to federal agencies by 1Q09 (Director)

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

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| KEY OBJECTIVE | Integration |
| SMART GOAL 2 | Develop a 3-Year funding plan by 2Q09 with a target of at least \$100M/year in competitive submissions 2010 through 2012 |
| ACCOUNTABILITY | Director, WVU Advanced Energy Initiative |

RATIONALE OR BRIEF BACKGROUND

To achieve our vision of WVU becoming internationally recognized for its energy research program, the amount of funding from federal agencies must be significantly increased. To accelerate the amount of funding received; we will develop a 3-year plan with defined financial goals significantly above current energy related funding levels at WVU.

MEASUREMENT

Three year funding plan with at least \$100M in submissions in place by 4Q09

IMPLEMENTATION PLANS

- (1) Determine the 2009 baseline funding for energy research at WVU and establish the incremental funding level required to meet the assigned goal. Complete by 4Q08 (Director)
- (2) Establish the levels of new funding required from cross-cutting research projects in each focus area to meet AEI funding goals by 1Q09 (Associate Director's)
- (3) Define new projects necessary to achieve the desired funding level for 2010 by 2Q09 (Director/Associate Director's)
- (4) To enable the funding plan, develop a 5-year AEI Logic Model and Business Plan that is based on federal funding cycles and a rolling 3-year funding income forecast by 2Q09 (Director)

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

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| KEY OBJECTIVE | Integration |
| SMART GOAL 3 | Use senior faculty successful in securing funding to mentor junior faculty by 2Q09 |
| ACCOUNTABILITY | Director, WVU Advanced Energy Initiative |

RATIONALE OR BRIEF BACKGROUND

To achieve the vision of becoming internationally recognized for energy research, the AEI will increase funding from federal agencies. This will require both larger grants and more research personnel. To increase the success rate senior faculty with excellent funding histories will be assigned to mentor junior faculty members to increase the competitiveness of their submitted proposals.

MEASUREMENT

Mentored junior faculty increase competitive grant awards by an average of 25%

IMPLEMENTATION PLANS

- (1) Identify successful senior faculty members who can be assigned to mentor junior faculty members by 3Q08
- (2) Identify junior faculty members who can be mentored by senior faculty by 4Q08
- (3) Establish senior-junior faculty pairs who can interact successfully together to develop fundable energy research projects by 2Q09

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

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| KEY OBJECTIVE | Integration |
| SMART GOAL 4 | Determine important gaps in research expertise by 2Q09 |
| ACCOUNTABILITY | Director, WVU Advanced Energy Initiative |

RATIONALE OR BRIEF BACKGROUND

The WVU AEI plan emphasizes research programs in three areas: (1) fossil energy (2) sustainable energy and (3) energy policy. While the university already has much of the required expertise to successfully complete the initiative, there are key areas that must be strengthened. Overall needs and current key skills must first be inventoried so that gaps can then be identified. When determining gaps to fill, consideration will be given to the skills necessary to start new research projects in AEI focus areas.

MEASUREMENT

A report detailing the overall skill needs, current skills, and identified gaps (categorized as must have, should have and desirable) and the resulting additional headcount and investment required to satisfactorily carry out the ongoing projects should be issued by 2Q09

IMPLEMENTATION PLANS

- (1) Define near term research programs and deliverables by 3Q08 (Director)
- (2) Identify in detail the resources necessary to initiate and undertake key objectives by 4Q08 (Associate Director's)
- (3) Identify the gaps between the present skill base and the skills necessary to initiate and perform new research programs at a high level of excellence by 1Q09 (Associate Director's)
- (4) Define the investment required to obtain the skills required to initiate and undertake key objectives by 2Q09 (Director)

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

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| KEY OBJECTIVE | Integration |
| SMART GOAL 5 | Conduct an annual internal funding program for grant writing in key areas beginning 1Q09 |
| ACCOUNTABILITY | Director, WVU Advanced Energy Initiative |

RATIONALE OR BRIEF BACKGROUND

To provide faculty with the time to write major grants for energy research , the AEI will establish an internal grant competition to fund research that enables competitive proposals to be submitted to federal agencies in the AEI focus areas.

MEASUREMENT

Funding for new internal awards released by 1Q09

Plan for funding and conducting subsequent internal grant competitions announced by 3Q09

IMPLEMENTATION PLANS

- (1) Circulate guidelines and a call for proposals by 3Q08 (Director)
- (2) Complete first cycle proposal review by 4Q08 (Director)
- (3) First awards announced and funded by 4Q08 (VP Research/Director)
- (4) Sustainable grant competition plan developed for subsequent years by 3Q09 (VP Research/Director)

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

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| KEY OBJECTIVE | Integration |
| SMART GOAL 6 | Protect and license/commercialize intellectual property (IP) disclosures each year for the fossil and sustainable AEI focus areas |
| ACCOUNTABILITY | Director, WVU Advanced Energy Initiative |

RATIONALE OR BRIEF BACKGROUND

Technology-based economic development is critical to overall economic growth in West Virginia. Many of the needed innovations will come from the State's major research universities. The WVU energy R&D personnel need to be aware of the potential commercial value of the intellectual property that they generate, and they should protect it in accordance with University Policy. The Office of Technology Transfer within the WVU Research Corporation is charged with licensing any patents generated from IP developed through research activities at West Virginia University.

IP can be defined as research disclosures, patents, licenses or commercialization activities.

MEASUREMENT

At least 2 projects per AEI focus area will result in IP starting in 2009.

IMPLEMENTATION PLANS

- (1) Issue guidelines and communicate the importance of protecting the results of the AEI research effort by 4Q08 (VP Research/Director)
- (2) Set and communicate targets for the number of patent disclosures and licensing agreements that should be generated in 2009 by 4Q08 (Director)
- (3) Develop a plan to assist researchers in obtaining patents and licensing technology, and otherwise developing IP by 4Q08 (Director/Director IP)
- (4) Each quarter, the AEI Director will issue a report in collaboration with the Office of Technology Transfer, showing the number of disclosures and licensing agreements signed against the set target (Director/Director IP)

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

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| KEY OBJECTIVE | Integration |
| SMART GOAL 7 | Secure at least two Centers of Excellence (COE) grants with a total of \$10m in funding by 4Q12 |
| ACCOUNTABILITY | Vice-President Research and Director, AEI |

RATIONALE OR BRIEF BACKGROUND

West Virginia University (WVU) has built an excellent reputation for its ongoing activities in many areas of energy research, and this strategic plan will increase both those activities and WVU's reputation. However, the university needs to develop well-financed, self-sustaining units as Centers of Excellence. Becoming a COE acknowledges that the research carried out is nationally recognized. The funding that comes with being named a COE will allow for a formal structure to be established which will enhance the ability of the center to grow and offer a wider range of activities.

MEASUREMENT

Announce 2 Centers of Excellence by 4Q11

Announce \$10M in funded projects for the COE by 4Q12

IMPLEMENTATION PLANS

- (1) Establish a team to decide what areas could sustain a COE and decide upon suitable funding agencies by 4Q10 (Director)
- (2) Write at least 3 proposals for a COE by 3Q11 (Associate Director)
- (3) Obtain at least \$10M in funding for two COE by 4Q12 (Associate Director)
- (4) Develop funding and other plans for additional COE's by 2Q12 (Director)

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

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| KEY OBJECTIVE | Fossil |
| SMART GOAL 1 | Establish at least one major research program in Carbon Capture and Geologic Storage by 4Q09 with \$10M in funding by 4Q12 |
| ACCCOUNTABILITY | Associate Director for Fossil Energy |

RATIONALE OR BRIEF BACKGROUND

Management of the greenhouse gases, specifically carbon dioxide, is vital for future fossil energy use and commercialization. Capturing carbon dioxide emissions from power generation and sequestering it in geologic formations is technically feasible and promising. However, current technology would increase electricity costs by 30% for new systems and over 80% for retrofits. Advanced technology that enables lower costs and energy requirements is clearly needed for future fossil fuel usage.

MEASUREMENT

Establishment of at least one major program in Carbon Capture and Geologic Storage by 4Q09 with \$10M in funded projects by 4Q12

IMPLEMENTATION PLANS

- (1) Determine program areas in Carbon Capture and Geologic Storage in which West Virginia University can be competitive, using an interdisciplinary team of university research faculty, external consultants and partnership relationships as necessary, by 2Q09
- (2) Establish at least one major program in Carbon Capture and Geologic Storage with qualified program leads by 3Q09
- (3) Identify projects for competitive submission and the interdisciplinary teams to develop and submit proposals in identified program areas by 4Q09
- (4) Submit at least six (6) interdisciplinary competitive research proposals in the Carbon Capture and Geologic Storage program areas at the rate of two per year, for a total dollar value of \$10M in awards

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

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| KEY OBJECTIVE | Fossil |
| SMART GOAL 2 | Establish at least one major research program in High-Efficiency Engine and Vehicle Technology by 4Q09 with \$8M in funding by 4Q12 |
| ACCOUNTABILITY | Associate Director for Fossil Energy |

RATIONALE OR BRIEF BACKGROUND

Advanced, high efficiency engine technology using clean fuels that will emit significantly lower greenhouse gases could play a major role in the nation's energy usage in areas such as mass transportation. West Virginia University should capitalize on nationally recognized research units currently at WVU such as the Center for Alternative Energy, Emissions and Engine Technology (CAFEE), the National Research Center for Coal and Energy (NRCCE) and the National Institute of Fuel Cell Technology (NIFT), to increase recognition and leverage R&D support for high-efficiency propulsion programs.

MEASUREMENT

Establishment of at least one major program in High-Efficiency Engine and Vehicle Technology by 4Q09 with \$8M in funding by 4Q12

IMPLEMENTATION PLANS

- (1) Determine program areas for High-Efficiency Engine and Vehicle Technology in which West Virginia University can be competitive, using an interdisciplinary team of university research faculty, external consultants and partnership relationships, as necessary, by 2Q09
- (2) Establish at least one major program in High-Efficiency Engine and Vehicle Technology with qualified program leads by 4Q09
- (3) Identify projects for competitive submission in High-Efficiency Engine and Vehicle Technology and the interdisciplinary teams to develop and submit proposals for funded projects in identified program areas by 4Q09
- (4) Submit at least six interdisciplinary research proposals in High-Efficiency Engine and Vehicle Technology program areas with a total dollar value of \$8M awarded by 2012.

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

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| KEY OBJECTIVE | Fossil |
| SMART GOAL 3 | Establish at least one major research program in Fuels Production by 4Q09 with \$4M in funding by 4Q12 |
| ACCOUNTABILITY | Associate Director for Fossil Energy |

RATIONALE OR BRIEF BACKGROUND

Reliable and affordable sources of energy are needed for the economic future of the United States. The world's capacity and capability to produce oil will one day be insufficient to meet the global oil demand. The consequence of demand exceeding supply will cause rapid price increases with national and regional shortages. New fuels, from fossil energy such as coal to high efficiency production systems such as fuel cells, are required to ensure a secure energy supply while reducing environmental damage.

MEASUREMENT

Establishment of at least one major program in Fuels Production by 1Q10 with \$8M in funding by 4Q12

IMPLEMENTATION PLANS

- (1) Determine program areas for Fuels Production in which West Virginia University can be competitive, using an interdisciplinary team of university research faculty, external consultants and partnership relationships as necessary by 1Q10
- (2) Establish at least one major program in Fuels Production with qualified program leads by 2Q10
- (3) Identify projects for competitive submission in Fuels Production and the interdisciplinary teams to develop and submit proposals in identified program areas by 3Q10
- (4) Submit at least four new interdisciplinary competitive research proposals in Fuels Production program with a total dollar value of \$4m in awards by 4Q12.

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

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| KEY OBJECTIVE | Fossil |
| SMART GOAL 4 | Establish at least one major research program in Clean Power Generation and Distribution by 4Q09 with \$5M in funding by 4Q12 |
| ACCCOUNTABILITY | Associate Director for Fossil Energy |

RATIONALE OR BRIEF BACKGROUND

Energy infrastructure is a complex system that includes the electrical transmission grid and distribution system, natural gas transmission and distribution pipelines, oil and LNG tankers, liquid fuel and chemical pipelines, rail, ships, barges and trucks that deliver fuels. It also includes the facilities that transform raw natural resources into more useful products (e.g., refineries). America's energy production and distribution infrastructure is aging and will require major upgrades to meet growing energy demand and to accommodate major industry changes that will be required as we adopt carbon management and clean power generation technologies. The resiliency of the energy infrastructure is also an important consideration and this area is receiving increasing attention by government and by the energy distribution industry.

MEASUREMENT

Establishment of at least one major program in Clean Power Generation and Distribution by 1Q10 with \$5M in funding by 4Q12

IMPLEMENTATION PLANS

- (1) Determine program areas for Clean Power Generation and Distribution in which West Virginia University can be competitive, using faculty, external consultants and partnership relationships, by 4Q09
- (2) Establish at least one major program in Clean Power Generation and Distribution with qualified program leads by 2Q10
- (3) Identify projects for competitive submission in Clean Power Generation and Distribution and the interdisciplinary teams to develop and submit proposals in identified program areas by 3Q10
- (4) Submit at least six new interdisciplinary competitive research proposals in Clean Power Generation and Distribution with a total dollar value of \$5M awarded by 4Q12

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

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| KEY OBJECTIVE | Fossil |
| SMART GOAL 5 | Establish at least one major research program in Extraction Technology by 4Q09 with \$3M in funding by 2012 |
| ACCOUNTABILITY | Associate Director for Fossil Energy |

RATIONALE OR BRIEF BACKGROUND

Advanced technologies for coal mining and natural gas extraction can make additional energy resources economically recoverable and reduce the environmental impacts of extraction. West Virginia University is well positioned to establish programs of excellence in the environmentally responsible production and utilization of fossil energy resources given the extensive coal and natural gas extraction industries in the State and the surrounding region. The safety and community impacts of mining are also important subjects which demand attention.

MEASUREMENT

Establishment of at least one major program in Extraction technology by 4Q09 with \$3M in funding by 4Q12

IMPLEMENTATION PLANS

- (1) Determine program areas in Extraction Technology in which West Virginia University can be competitive, using an interdisciplinary team of faculty research personnel, external consultants and partnership relationships as necessary, by 4Q09
- (2) Establish at least one major program in Extraction Technology with qualified program leads by 1Q10
- (3) Identify projects for competitive submission in Extraction Technology and the interdisciplinary teams to develop and submit proposals in identified program areas by 3Q10
- (4) Submit at least six new interdisciplinary competitive research proposals in Extraction Technology with a total dollar value of \$3m awarded by 4Q12

WVU ADVANCED ENERGY INITIATIVES IMPLEMENTATION PLAN

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| KEY OBJECTIVE | Fossil |
| SMART GOAL 6 | Establish at least one major programs in Coal to clean fuels and chemicals by 4Q09 with funding of \$2M by 2012 |
| ACCCOUNTABILITY | Associate Director Fossil Energy |

RATIONALE OR BRIEF BACKGROUND

As the price of oil increases, chemical companies are looking for less expensive feedstock to make clean fuels and chemicals. Coal has been seen as a source of these materials for more than forty years. However, since oil has been inexpensive and easier to transport, convert, and handle than coal, it has been, along with natural gas, one of the starting materials of choice for chemical companies. Since coal is now significantly less expensive than oil and is found in abundance in the US, it is again attracting attention from fuel and chemical manufacturers. West Virginia is a major coal producing state with a strong chemical industry, consequently, the coal industry is very interested in having coal used in value-added applications and clean fuels and chemicals are such applications.

MEASUREMENT

Establishment of at least one major program in coal to clean fuel and/or chemicals by 4Q09 with \$2M in funding by 4Q12

IMPLEMENTATION PLANS

- (1) Determine program areas in coal to fuel or chemicals in which West Virginia University can be competitive, using an interdisciplinary team from the university research faculty, external consultants and partnership relationships as necessary, by 1Q09
- (2) Establish at least 2 major programs in coal to clean fuel or chemicals with qualified program leads by 2Q09
- (3) Identify projects for submission of competitive research proposals in coal to clean fuel or chemicals and the interdisciplinary teams necessary to develop these proposals by 3Q09
- (4) Submit at least four new interdisciplinary competitive research proposals in the coal to fuel or chemicals program area by 1Q10 with \$2M in funding being awarded by 2012

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

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| KEY OBJECTIVE | Sustainable Energy |
| SMART GOAL 1 | Establish at least one major Interdisciplinary Program in Biomass Conversion and Utilization by 4Q09 with \$3M in Funding by 4Q12 |
| ACCOUNTABILITY | Associate Director Sustainable Energy |

RATIONALE OR BRIEF BACKGROUND

Biomass is obtained from aquaculture and agricultural products. It includes materials such as wood, grasses and algae. It is an attractive starting material for the production of biofuels and chemicals because it is a renewable resource which is also considered to be carbon neutral. The conversion of biomass into energy products can be accomplished using either thermal or biological techniques. However, the economics and technology of converting biomass into useful energy are formidable. Solving these problems is extremely important if the U.S. is to reduce its reliance on fossil energy and solve the concurrent environmental problems.

MEASUREMENT

Establishment of at least one major program in Biomass conversion and Utilization by 4Q09 with \$3M in funding by 4Q12

IMPLEMENTATION PLANS

- (1) Form a multidisciplinary team from across the WVU campus to study the opportunities in biomass conversion and potential funding sources by 3Q08
- (2) Determine and prioritize opportunities and funding sources and decide on appropriate research projects by 2Q09.
- (3) Have at least two biomass proposals submitted for competitive review by 4Q10 with \$3M in funding by 4Q12

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

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| KEY OBJECTIVE | Sustainable Energy |
| SMART GOAL 2 | Establish at least one major interdisciplinary program in Biomass/Coal Conversion with Sequestration by 4Q09 with \$3M in funding by 4Q12 |
| ACCOUNTABILITY | Associate Director Sustainable Energy |

RATIONALE OR BRIEF BACKGROUND

Biomass/coal co-combustion represents a near-term sustainable energy option that promises reductions in carbon dioxide and other greenhouse gas emissions. It is also seen as a relatively low risk option. However, numerous technical issues associated with co-firing exist, including the nature of the fuel supply, handling and storage challenges, potential increases in corrosion, decreases in overall efficiency, ash deposition, greenhouse gas emission, and sequestration and process economics. Numerous biomass/coal co-combustion trials have demonstrated the feasibility of this approach. However, further details regarding the composition of the biomass/coal mixture and a better understanding of potential commercial processes needs to be developed.

MEASUREMENT

Establishment of at least one major program in Biomass/Coal Conversion and Sequestration by 4Q09 with \$3M in funding by 4Q12

IMPLEMENTATION PLANS

- (1) Form one or more multidisciplinary study teams to determine and prioritize the opportunities and funding options for biomass/coal conversion research by 3Q08
- (2) Select appropriate research projects incorporating biomass and coal by 2Q09.
- (3) Submit at least two proposals for competitive review by 4Q09 with funding of \$3M by 2012

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

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| KEY OBJECTIVE | Sustainable Energy |
| SMART GOAL 3 | Establish at least one major interdisciplinary program in Energy-related Water Resource Management by 4Q09 with \$4M in Funding by 4Q12 |
| ACCCOUNTABILITY | Associate Director Sustainable Energy |

RATIONALE OR BRIEF BACKGROUND

Electric power generation is a major consumer of water. As the global demand for electric power increases the pressures on global water resources will surely increase. Water is also required in the mining, processing and transportation of coal, all of which can have direct impacts on water quality. Programs will be initiated to reduce water consumption for energy generation and help move towards sustainability in water use.

MEASUREMENT

Establishment of at least one major program in Energy-related Water Resource Management by 4Q09 with \$4M in funding by 4Q12

IMPLEMENTATION PLANS

- (1) Form a multidisciplinary energy/water study team by 4Q08. This team should understand the WVU research skills in this area before deciding upon potential research opportunities
- (2) The study team will determine and prioritize viable areas for research by 2Q09 and help pair suitable investigators together to write research proposals
- (3) The team(s) will submit at least two proposals for energy/water funding by 4Q09 and each year thereafter obtaining \$4M in funding by 4Q12

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

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| KEY OBJECTIVE | Sustainable Energy |
| SMART GOAL 4 | Establish at least one major interdisciplinary program in Sustainable Design and Development by 4Q09 with \$1M in Funding by 4Q12 |
| ACCCOUNTABILITY | Associate Director Sustainable Energy |

RATIONALE OR BRIEF BACKGROUND

Sustainable Design and Development (SSD) refers to the design and development of physical structures, such as buildings, villages or cities that comply with the principles of economic, social and ecological sustainability. It encompasses many fields and is of growing importance in urban planning, architecture, engineering and industrial ecology.

The central tenet of SSD is to produce places, products and services that minimize the use of non-renewable resources and that have minimal environmental impact. WVU, through its many colleges, has many of the skills necessary to participate in these activities.

MEASUREMENT

Establishment of at least one major program in Sustainable Design and Development by 4Q09 with \$1M in funding by 2012

IMPLEMENTATION PLANS

- (1) By 3Q09 assemble a multidisciplinary sustainable design and development study team to determine, prioritize, and recommend suitable areas for research together with potential funding agencies
- (2) Establishment of at least one major program in Sustainable Design and Development by 2Q10
- (3) The teams submit at least two proposals for sustainable design and development funding by 4Q10 and each year thereafter achieving \$1M in funding by 4Q12

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

KEY OBJECTIVE Sustainable Energy

SMART GOAL 5 Establish at least one major interdisciplinary program in Solar Conversion by 4Q09 with \$2M in Funding by 4Q12

ACCCOUNTABILITY Associate Director Sustainable Energy

RATIONALE OR BRIEF BACKGROUND

It is anticipated that the amount of energy needed globally will double between now and 2050. New energy resources will need to be carbon neutral and derived from sustainable resources. The conversion of sunlight into electricity using a photovoltaic device has been actively investigated for more than thirty years. While conversion efficiency of these devices has constantly improved, the energy produced is still expensive. Consequently, devices with higher efficiencies which are less expensive to produce are now under investigation. The combination of device physics and nanotechnology is thought to be one route to achieve this goal. WVU has the skills required to play a key role in this important research area.

MEASUREMENT

Establishment of at least one major program in Solar Conversion by 4Q09 with \$2M in funding by 4Q12

IMPLEMENTATION PLANS

- (1) Determine faculty members with the skills required to undertake projects in this area by 4Q08. This activity should be undertaken by a multidisciplinary team with representation from across the WVU campus
- (2) Form at least two multidisciplinary photovoltaic energy conversion groups, including at least one nanotechnology group by 2Q09
- (3) Establishment of at least one major program in Solar Conversion by 4Q09
- (4) Submit at least two proposals, one involving nanotechnology, by 2Q10 and 2 each year through 2012 achieving \$2M in funding by 2012

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

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| KEY OBJECTIVE | Sustainable Energy |
| SMART GOAL 6 | Establish at least one major interdisciplinary program in the Efficient and Sustainable Use of Energy and Natural Resources by 4Q09 with \$4M in Funding by 4Q12 |
| ACCCOUNTABILITY | Associate Director Sustainable Energy |

RATIONALE OR BRIEF BACKGROUND

The smart, efficient and sustainable use of energy and natural resources is a largely untapped solution to addressing energy security, global warming and the depletion of fossil fuel. It has been estimated by the Rocky Mountain Institute that “up to 75% of the electricity used in the US could be saved with efficiency measures that cost less than the cost of electricity.” The 2007 UN Report on climate change stated that “energy efficiency can achieve real emissions reductions at low cost.” The WVU-based Industries of the Future – West Virginia (IOF-WV) program has been at the forefront of advancing energy efficiency in the industrial sector since 1997. The IOF-WV program will take the lead at WVU in advancing the research effort in energy efficiency by developing partnership projects with academic researchers, national laboratories, foundations, government agencies, and the private sector.

MEASUREMENT

Establishment of at least one major program in the Sustainable use of Energy and Natural Resources by 4Q09 with \$4M in funding by 4Q12

IMPLEMENTATION PLANS

- (1) By 3Q08 assemble a multidisciplinary sustainable energy and study team to determine, prioritize, and recommend suitable areas for research together with potential funding agencies
- (2) The study team determines viable multidisciplinary research areas by 2Q09
- (3) Establishment of at least one major program in the Sustainable Use of Energy and Natural Resources by 4Q09
- (4) The teams submit at least two projects on energy efficiency for funding by 2Q10 and each year thereafter achieving \$4M in funding by 2012

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

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| KEY OBJECTIVE | Policy |
| SMART GOAL 1 | Create an Interdisciplinary Energy Policy Team to Identify Critical Issues in Energy Policy and Regulatory Affairs by 2Q09 |
| ACCCOUNTABILITY | Director |

RATIONALE OR BRIEF BACKGROUND

Demonstrated expertise in energy policy and regulatory affairs is essential to the success of the AEI because these issues are important in setting the national energy research agenda and in getting new technology and research into commercial use. At present, energy policy issues are studied in several colleges across the WVU campus. Establishing an interdisciplinary Energy Policy and Regulatory Affairs team that develops research programs in energy policy and regulatory affairs, and advises the AEI management team, will strengthen the initiative and contribute to its recognition as a leading energy program that contributes to solving significant energy challenges. Such studies also need to be integrated within the fossil and sustainable energy research teams to enable research proposals to be more competitive and help guide the research effort.

MEASUREMENT

Announce (1) an interdisciplinary team to develop energy policy research at WVU by 1Q09 and (2) develop and implement plans for a specific energy policy and/or regulatory affairs program with specific funding proposals by 1Q10

IMPLEMENTATION PLANS

- (1) Determine what energy policy areas are being actively studied at WVU and their relationship to the AEI goals by 1Q09
- (2) Hold an internal conference to develop a common understanding of the needs of the AEI in the energy policy and regulatory affairs area and explore funding opportunities by 3Q09
- (3) Integrate the findings from the WVU capability assessment in policy and regulatory affairs with the results from the internal conference into the 5-Year logic model and business plan for the AEI by 4Q09.

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

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| KEY OBJECTIVE | Policy |
| SMART GOAL 2 | Develop at least two programs addressing critical issues in Energy Policy by 4Q09 with \$2M in funding in each program by 4Q12 |
| ACCCOUNTABILITY | Associate Director Policy |

RATIONALE OR BRIEF BACKGROUND

The WVU Energy Policy conference (see Goal 1) will provide a baseline understanding of the breadth of the Energy Policy and Regulatory Affairs studies that are ongoing at WVU that can be compared with the goals of the AEI. The AEI Director and the Associate Director for Policy, with the advice of the interdisciplinary policy and regulatory affairs team, will select program areas in which to develop competitively funded research projects. At least one of these program areas should be funded in an area associated with:

- sustainable land-use and transportation policy and its effects
- energy efficiency policy (including green construction) and its effects
- carbon mitigation policy and its measurement, regulation & management

MEASUREMENT

Development of at least two major fundable program areas in Energy Policy by 4Q09 with funded projects in each area by 4Q12

IMPLEMENTATION PLANS

- (1) Determine what policy areas are being actively studied at WVU and their relationship to the AEI goals by 2Q09 (see Energy Policy Goal 1).
- (2) Selects major areas for Energy Policy and Regulatory Affairs research by 4Q09. (AEI Director and Associate Director, Policy)
- (3) Development of at least two major fundable program areas in Energy Policy and Regulatory Affairs by 2Q10
- (4) Submit at least three interdisciplinary competitive research proposals per program area (six total) at the rate of two in 2010, two in 2011, and two in 2012 with a funding value of \$2M/program by 4Q12

WVU ADVANCED ENERGY INITIATIVE IMPLEMENTATION PLAN

| | |
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| KEY OBJECTIVE | Policy |
| SMART GOAL 3 | Coordinate and Enhance Economic and Policy Analysis Program for Energy Systems by 4Q09 with \$1M in Funding by 4Q12 |
| ACCCOUNTABILITY | Associate Director Policy |

RATIONALE OR BRIEF BACKGROUND

The coupling of economic models with energy systems models has allowed policy makers to quantify the economic impacts associated with changing energy and environmental policies, technologies and world market conditions. The debate on the costs of climate change mitigation is also informed by the results of these models. A strong capability in modeling macroeconomic energy systems at national and regional scales will demonstrate West Virginia University's leadership in energy research and improve the Advanced Energy Initiatives capability for securing competitive research funding.

MEASUREMENT

Development of an Economic and Policy Analysis Program for Energy Systems by 4Q09 with \$1M in funded projects by 4Q12

IMPLEMENTATION PLANS

- (1) Determine what economic modeling studies are being carried out at WVU and their relationship to the AEI goals by 2Q09
- (2) Select focus areas for economic analysis and policy programs within the AEI by 3Q09.
- (3) Development of an Economic and Policy Analysis Program for Energy Systems by 2Q10
- (4) Submit at least six interdisciplinary competitive research proposals in energy system economic policy analysis by 4Q12 with two submissions in 2010, two in 2011, and two in 2012, obtaining \$1M in funding by 2012

Concluding Remarks

Energy sustainability and security is a critical issue for this country that will endure well into the 21st century. In an effort to overcome these problems the federal government has embarked on a program to develop technologies that advance the clean use of domestic fossil fuels and encourage innovation in alternative and sustainable energy sources.

WVU has an impressive record in energy research. The SMART Goals described in this Advanced Energy Initiative, together with the supporting Implementation Plans, are intended to enhance our research effort, while advancing the national energy agenda.

Since this initiative will be campus-wide, it will require leadership that will set priorities and coordinate these activities. A Director will be appointed to lead this activity. The research goals are segmented into three broad initiatives, fossil energy, sustainable energy and energy policy and Associate Directors will oversee each of these activities.

This is an important initiative for WVU that builds upon its solid foundation in fossil energy research opens new research areas in sustainable energy and strengthens its involvement in the energy policy and regulatory affairs area.

Appendix A

Global Energy Challenges

Global Situation

World energy consumption is continuing to grow at an unprecedented rate, with a heavy dependence on fossil energy that is expected to persist well into the current century. Under current policies, relatively unfettered economic growth around the world can be expected to will result in an increase in energy demand of 55% by 2030 from today. This increase is driven largely by the growing population and economies of the developing countries that account for about 75% of the increase, with 45% of the total increase coming from China and India alone. But there are complexities.

Concerns about global climate change dominate international debate on energy. Climate change is predicted to have major impacts on agriculture, forests, water resources, ecosystems, oceans, and human health. Stabilization of climate will require fundamental changes to the current global energy system, including a shift from fossil fuels to non-carbon fuels, increased priority on conservation and efficiency and to large-scale carbon management strategies. But there is more.

Steadily increasing demand for globally limited energy resources, especially oil, will pose near-term and long-range security risks. Competition for the available energy resources, being produced by a relatively small number of nations, will result in high energy prices as well as periods of uncertain availability. The challenge for all countries is to put in place a more secure and lower carbon energy system without undermining their economic futures. The linkage between economic growth and prosperity and the need for affordable and reliable electric power, is undeniable. The rising economic development and prosperity of developing nations such as China and India will create substantial global market opportunities for advanced low-carbon energy technologies. With abundant indigenous fossil energy resources being available in many of the developing nations, pressures will remain to continue their use which leads back to the issue that carbon management challenges must be addressed.

Carbon Emissions/Climate Change: Any policy to meaningfully curb greenhouse gas emissions is likely to be fostered at a global level. However, the planning, regulation and implementation are very likely to be done at the National level. A peaceful and prosperous future world is dependent on the behavior of nations and that is predicated on how well changes in the energy sector are conceived and managed. Opportunity awaits the prepared.

The momentum on climate change discussions was nothing short of breathtaking in 2007, culminating in the adoption of the Bali Road Map at the climate convention meetings in Indonesia. Climate change and its implications for endangered ecosystems, geopolitical stability, and economic prosperity have ceased to be the preoccupation of scientists and

negotiators -- it is now a universal public issue. From 1990 to 1999 the global growth rate of CO₂ emissions averaged around 1.1% per year. From 2000-2005 the growth rate climbed to more than 3.3% per year. Constant or slightly increasing rates of carbon intensity characterize energy use in both developed and developing countries: no region is decarbonizing energy supply as both population and per capita GDP increase. The growth rate in emissions is strongest in rapidly industrializing developing countries, particularly China. While developing countries -- 80% of the world's human population - - accounted for 73% of the increase in emissions during 2004, they accounted for 41% of the total emissions during 2004 and only 23% of the accumulated global emissions since industrialization began.

Biofuels have been widely promoted as a low-carbon alternative to fossil fuels. These fuels are mostly used to replace fossil fuels in the transportation sector and are derived from maize, oil palm, sugar, canola, jatropha, miscanthus, sorghum, wheat, and other plants. Many countries have introduced mandatory proportions of biofuels particularly ethanol, in their fuel mix (typically 10%). However, a global controversy stirs over the impacts associated with this soaring demand, ranging from sharp rises in food prices, to increased land use, to pressures on water resources, to extensive deforestation in south-east Asia.

Historically, economic productivity has been closely related to growth in energy consumption – and that energy was derived largely from fossil fuels. Since 1750, economic development has been fuelled by leveling forests and burning wood, then coal, oil, and more recently with increasing amounts of natural gas. However, it may be possible to decouple growth and carbon use. Between 1990 and 2005, some industrialized regions appeared to achieve this decoupling of carbon consumption and national productivity to reduce carbon intensities, but the possible ‘trend’ is not entrenched and is currently not growing. Innovations in photovoltaic technologies, geothermal systems, micro-hydro, wind turbines, and other renewable energies developed over the last few decades; show clearly that pollution is not an unavoidable side effect of development.

The issue is broader than looking at CO₂ alone. Methane is a significant greenhouse gas (it accounts for about one sixth of total GHG emissions) and the energy sector is a significant source of methane (energy produces over one third of global methane emissions – the rest coming mainly from agriculture and waste). Energy-related methane emissions occur from coal and hydrocarbon production and natural gas transportation.

A broad conclusion that can be drawn that the carbon management/climate change issue is multi-factorial – there is no single driver of emissions and no single area for policy to focus on. There is a broad correlation between increasing economic prosperity and increasing energy consumption, but the implications for CO₂ emissions depend on a number of other factors: geography, industrial structure, indigenous resources, climate, and policy stance. There is no absolute link between economic development and emissions, so it is in principle, possible to grow in a more sustainable manner. Nonetheless, the same opportunities are not necessarily available to all countries. While

some of the factors are susceptible to policy intervention, others – like geography and resources – are not. Critical and objective life cycle analysis of different mitigation options can help identify how and where the most effective reductions can be achieved. Effective policy needs to be based on full information.

Oil Peaking: Concerns about the reliability of global oil production forecasts and estimates of recoverable oil resources are the basis of warnings about future oil supplies and the deliverability of oil. The concerns are compounded by the challenges some companies face in adding new reserves to replace those already produced. The warnings are strongly expressed in a set of forecasts known collectively as “peak oil”. Peak oil is not the notion that the world will run out of oil, but rather that the world’s capacity and capability to produce it will be insufficient to meet the global oil demand over an extended period of time. The consequence of demand exceeding supply would cause rapid price increases, national, and regional shortages, and geo-political instabilities – it is a security issue.

Because oil is a depleting, finite natural resource, world conventional oil production will, at some point, reach a maximum, called “the peak,” after which production will decline. The notion of a global peak in oil production follows observations of what has happened in specific fields (small and large) and in oil-producing regions of the world (e.g. North America). New technologies to expand and extend oil production have been successfully developed and deployed (e.g. CO₂ injection for enhanced oil recovery and ever-deeper exploration and production systems). Using differing methodologies and information of widely varying quality, experts and organizations have attempted to forecast the likely year of conventional oil production peaking with wide-ranging results. Peak oil presents the world with a risk management problem of tremendous complexity and enormity. Prudence requires the implementation of mitigation measures roughly 20 years before peaking to avoid a very damaging world liquid fuels shortfall. Global solutions will likely take a variety of forms ranging from increased conservation, improved efficiency, and alternative energy sources, such as biomass and coal to liquids, and electrification; all represent viable mitigation strategies. The questions remain as to how much and when such solutions will be needed. The delivery timeline for the significant infrastructure changes that will be needed to meaningfully deploy these options is not short, and will likely take decades to accomplish.

Water Resources: With the projected expansion in global energy demand and the importance that electric power generation -- a major water consumer -- has in driving demand, the pressures on global water resources will only increase over the foreseeable future.

The U.S. serves as a useful study in understanding the challenges and opportunities that exist in developing solutions to the demand for energy supply while addressing the limited nature of water resources. While providing the United States with almost 60% of its annual energy needs, fossil fuels also place a high demand on the Nation’s water resources in terms of both use and quality impacts. Thermoelectric generation is water intensive. Water is also required in the mining, processing, and transportation of coal, all

of which can have direct impacts on water quality. Surface and underground coal mining can result in acidic, metal-laden water that must be treated before it can be discharged to nearby rivers and streams. Although not directly related to water quality, about 10% of total U.S. coal shipments were delivered by barge in 2003. Consequently, low river flows can create shortfalls in coal inventories at power plants. Natural gas and oil production can displace significant quantities of ground water. Water management issues can and do materially impact domestic natural gas and oil development projects – at a time when commodity prices are extremely high and additional supplies are sorely needed.

As population increases and economic development continues, the demand for fossil energy will grow, putting additional stress on the Nation's water resources. At the same time, fossil energy's demands for water will increasingly compete with demands from other sectors of the economy such as public supply, agriculture, domestic, livestock, industrial, and in-stream use – particularly in regions of the country with limited freshwater supplies. In response to this challenge, the Department of Energy's Office of Fossil Energy (DOE/FE) is carrying out an integrated energy-water research, development, and demonstration (RD&D) effort that cuts across its coal, oil, and natural gas programs. The DOE has recently begun sponsoring research to focus on these issues, particularly in the areas of (1) fossil-fuel-based thermoelectric power generation, (2) coal mining, and (3) oil and natural gas production.

Domestic Energy Challenges

Reliable and affordable energy is central to our economic and national security. Energy helps drive the U.S. and global economy and has a significant impact on our quality of life and the health of our people. Diversifying America's energy supply, improving our energy efficiency, addressing environmental and climate change issues, and modernizing our energy infrastructure, are the key challenges of the road ahead.

The U.S. Department of Energy has organized its research priorities to address the National needs along strategic themes. Within each theme, broad goals and strategies are articulated. It is principally in the themes of "Energy Security" and "Scientific Discovery and Innovation", that the civilian (i.e. non-military) aspects of the future energy scene are supported. The national challenges and priorities presented below provide meaningful opportunities for the academic community, both in terms of conducting innovative and breakthrough research and in strengthening the capacity of our workforce.

Environment/CO₂. Climate change is emerging as the central environmental challenge for the U.S. to address in the coming years. Both technical (increased understanding and improved technology and systems) and non-technical approaches (policy, financial and risk management strategies) will be required. Climate change has been forecast have significant potential impact on the United States: a rise in average temperatures in most regions, changes in precipitation amounts and seasonal patterns in many regions, changes in the intensity and pattern of extreme weather events, and sea level rise. Some of these impacts have clear implications for energy production and use. For instance, average

warming can be expected to increase energy requirements for cooling and reduce energy requirements for warming. Changes in precipitation could affect prospects for hydropower, positively or negatively. Increases in storm intensity could threaten further disruptions as experienced in 2005 with Hurricane Katrina. Concerns about climate change impacts could change perceptions and valuations of energy technology alternatives. Any or all of these effects could have very real meaning for energy policies, decisions, and institutions in the United States, affecting courses of action and appropriate strategies for risk management.

The Energy Information Administration estimates that carbon dioxide emissions from energy use in the U.S. are expected to increase from 5,890 million metric tons in 2006 to 6,859 million metric tons in 2030, an average annual increase of 0.6 percent. Increases in carbon dioxide emissions primarily result from a continued reliance on coal for electricity generation and on petroleum fuels in the transportation sector.

Three key questions arise with respect to the climate change issue are emerging as follows:

- How might climate change affect energy consumption in the United States?
- How might climate change affect energy production and supply in the United States?
- How might climate change have other effects that indirectly shape energy production and consumption in the United States?

Clearly, these topics will define an important research agenda in the coming years. Because of the lack of research to date, prospects for adaptation to climate change impacts by energy providers, energy users, and society at large are speculative, although the potentials are considerable. The current knowledge base is limited; this suggests that expanding understanding is important to energy users and providers in the United States. Contributions, by a wide range of participants, to expand the level of knowledge by conducting a variety of research is called for in federal and state governments, industry, non-governmental institutions, and academia.

Mitigating the carbon dioxide emissions from existing and new fossil-fired power plants in the U.S. and the world is a major technological and economic challenge and is an ongoing research priority. Capturing the carbon dioxide emissions from power generation and sequestering it in geologic formations is technically feasible and promising, however the cost when using currently available technology is quite high (raising electricity costs by 30% for new systems and over 80% for retrofits). The total cost to meet both projected demand growth and to retrofit the existing fleet of coal-fired power plants, including replacement of lost power, will be well over \$100 billion. Development of advanced technology that can capture carbon dioxide at a lower cost and with lower parasitic energy requirements is clearly a major opportunity.

Energy Security/Imports: For more than half a century, the United States has been the leader in global economic integration and a strong advocate for the free flow of goods,

services, and capital to benefit both the American and the global economies. Throughout this period, the United States has been a net importer of oil. Domestic oil production peaked in 1970. In 2030, oil and natural gas is projected to continue to dominate primary energy demand. The notion that the United States, as the world's largest energy consumer, can truly be rid of reliance on imported oil and natural gas is politically appealing, but fanciful. "Energy independence," if it were to be pursued vigorously without taking into account economic consequences, could work at cross purposes to America's other international objectives and obligations in this increasingly interdependent world. Managing "energy interdependence" is a world-wide geopolitical challenge, one in which the United States must play a constructive leadership role. As the price of energy rises, its political importance to both producing and consuming countries increases. Producers and consumers regard energy security from different perspectives. Energy security involves various perspectives and requires many potential solutions making managing global energy flows extremely complex. The interconnected nature of the global oil and natural gas markets means that decisions made by producer or consumer countries will affect the energy security of others.

The Nation's reliance on oil and gas presents a complex challenge that encompasses; economic competitiveness by having access and benefit from what has historically been a generally affordable and available global supply; the growing recognition of the value of a more diverse and hence more secure energy future, and; the increasing awareness of the issues surrounding climate change and managing our carbon emission profile. Finding ways to use alternative energy resources that are consistent with resolving these challenges represent ripe areas for new understandings and technologies.

Infrastructure: The nation's existing energy infrastructure is vast, complex, and vital to virtually every facet of modern life and to the functioning of the U.S. economy. At more than 20 million barrels per day, the nation's demand for oil -- chiefly to fuel the 220 million cars and trucks now on U.S. roadways -- requires 17 million barrels per day of refining capacity and 200,000 miles of oil pipeline. The nation's infrastructure for extracting and transporting natural gas encompasses some 1,300 drilling rigs and over 300,000 miles of pipeline. In addition, thousands of power plants linked by some 200,000 miles of interconnected transmission lines and countless transformer substations must operate synchronously to deliver power for lights, computers, household appliances, and essential equipment to millions of homes and businesses. The total capital investment embodied in the nation's existing energy infrastructure is enormous, as are the financial and institutional resources that will be required to continue maintaining and expanding this infrastructure. Recent events, most notably, the widespread havoc wrought on the Gulf Coast in 2005 by a series of hurricanes -- have highlighted vulnerabilities in parts of the existing energy infrastructure, while underscoring the importance of robust and resilient energy delivery systems. It is recognized that it will not be possible to meet the nation's energy and economic needs, achieve desired reductions in greenhouse gas emissions, or diversify its transportation fuels without enhancing, expanding, and diversifying America's energy infrastructure.

Siting and permitting processes are often at the hub of challenges of planning and installing new infrastructure. Recognizing that important infrastructure issues exist in all major energy sectors, five areas where challenges will most directly affect the evolution of future energy systems;

- Intra- and inter-state electricity transmission;
- Renewable energy systems, notably wind and biofuels;
- New nuclear power plants and spent fuel storage;
- Natural gas facilities, including pipelines, storage, gathering systems, and processing facilities, as well as LNG re-gasification and storage facilities; and,
- New coal-based integrated gasification combined cycle power plants with technology to capture and sequester carbon.

The Department of Energy, through its Office of Electricity Delivery and Energy Reliability (OE) is addressing challenges to America's energy security by supporting a portfolio of research and development of advanced electricity technologies that will modernize our nation's electric delivery system focused in the following areas; Climate Change, Control Systems Security, Distributed Energy, Energy Storage, High, Temperature Superconductivity, Renewable Energy Integration, Small Business Innovation Research (SBIR), Smart Grid, Technology Transfer, Transmission Reliability. Resulting technological advances will help the U.S. make more effective use of the existing energy infrastructure and enable deployment of new generation of more efficient and environmentally friendly energy delivery systems.

Energy Productivity: Energy productivity is a measure of the useful output of goods and services generated for a given unit of raw energy input. It takes into account energy conservation as well as, energy efficiency. Since 1992, the energy intensity of the U.S. economy has declined on average by 1.9 percent per year, in large part because the share of industrial shipments accounted for by the energy-intensive industries has fallen in recent years and is projected to continue declining.

Improvements in energy productivity can result from both efficiency improvements at the consumer or end-use level (e.g., more efficient appliances, more fuel efficient automobiles) or at the energy transformation level (e.g., more efficient power plants). Advances in technology are expected to play a major role in improving future energy productivity resulting in significant economic and environmental benefits, including reduction in carbon emissions.

Appendix B

Key Issues from the State of West Virginia Energy Plan

The State Energy plan was drawn up by the WV Division of Energy and the WV Development Office and was published in 2007 under the title *West Virginia Energy Opportunities: A Blueprint for the Future*. The objective of the plan is to “Develop an Energy Policy and Plan for the State that seeks to achieve energy independence by 2030. The policy will include all forms of feasible energy technologies, from clean coal, to coal liquefaction, natural gas, biomass, hydrogen, hydro, wind and solar power”.

The Energy Plan considers that the long-term solution to WV’s energy needs involves taking action on three fronts:

- Enhanced production of fossil energy sources including advanced coal technologies
- Renewable energy development
- Energy efficiency

West Virginia accounts for approximately 10% of US coal production and its recoverable coal reserves are the second largest in the nation. Consequently, coal plays a pivotal role for achieving energy independence in the state. The WV plan is to replace 1.3 billion gallons of oil by 2030. It is anticipated that coal-to-liquid (CTL) plants could produce synthetic oil and oil products that could replace the oil that is presently imported. Calculations indicate that five 20K barrels per day CTL plants could supply WV’s liquid fuel needs as well as providing chemical feedstock.

The State is a major generator of electricity and interstate sales are an important component of its economy. This electricity is produced by coal fired coal plants which also yield greenhouse gases. Using integrated gasification combined cycle (IGCC) technology; coal can be converted into synthetic gas (syn gas) which can then be burned to produce electricity. The pollutants produced during processing are selectively removed to produce clean power generation.

Other techniques discussed in the State Energy Plan include the recovery of coalbed methane before coal mining begins. This would enhance the safety aspects of mining and reduce atmospheric emissions. Similarly, coal waste from West Virginia’s 360 abandoned coal mines could also be reclaimed. It is presently an environmental hazard but could be a valuable energy source. Similarly, landfill gas can also be harnessed for energy purposes.

The West Virginia plan also wants to take advantage of the wood residues and agricultural resources to produce chemicals and biofuels such as cellulosic ethanol. One of the immediate goals is to establish a biomass-to-chemicals Center of Excellence at WVU. A longer term goal is to secure financial support for a demonstration project incorporating this technology.