Minutes of the Research, Outreach and Economic Development Committee

The University of Tennessee
Board of Trustees

October 27, 2011
Knoxville, Tennessee

The Research, Outreach and Economic Development Committee of the Board of Trustees of the University of Tennessee met October 27, 2011, in Hollingsworth Auditorium on the UT Institute of Agriculture campus in Knoxville.

I. Call to Order

Mr. George Cates, Chair, called the meeting to order at 1:15 p.m. Mr. Cates asked Dr. David Millhorn, UT Executive Vice President, to call the roll.

II. Roll Call

Dr. Millhorn called the roll and the following voting members were present:

Mr. George Cates, Chair
Mr. Charles Anderson
Dr. Toby Boulet
Mr. Brian Ferguson
Ms. Monice Moore Hagler
Commissioner Julius Johnson
Ms. Carey Smith
Mr. Don Stansberry
Ms. Betty Ann Tanner

The following non-voting members were present:

Dr. Tim Cross
Dr. Joe DiPietro
Ms. Teresa Fowler
Mr. Marty Spears
Dr. Janet Wilbert

Commissioner Kevin Huffman, Dr. David Stern, and Dr. Richard Rhoda were absent from the meeting.

Dr. Millhorn declared a quorum present for the meeting.

III. Approval of Minutes of the Last Meeting

The minutes of the June 22, 2011 meeting in Knoxville were approved as written.

IV. Comments by Committee Chair

Mr. Cates extended a welcome to members, especially to new ROED Committee members Anderson, Cross, Ferguson, Spears, Stansberry (new out of his role as former Chair of the Committee) and Stern. Mr. Cates stated great universities have great research and he believes UT has made great strides in this area over the last several years. He thanked Mr. Don Stansberry and Dr. David Millhorn for their leadership in this endeavor and noted one of the best examples of this progress is the relatively new division of the UT Research Foundation (UTRF) into the UTHSC office in Memphis and the Multi-Disciplinary Office located in Knoxville. UTRF optimization will result in increased dollars and an enhanced reputation for the University, Mr. Cates said. Huge challenges in accomplishing these results, however, include diminished Federal research funding, intense competition and UT's underfunding of UTRF, particularly in regard to staff. UTRF underfunding is not a new issue but one certainly to be repaired, Mr. Cates said. The University has a goal of $425M in research funding by 2020. For its part in achieving this goal, UTRF must acquire one new research associate each year (totaling around $200,000 with salary and associated costs) and an annual additional patent investment of $100,000 should be made. Currently UTRF is understaffed by only one staff member but a UTRF peer-group comparison highlights the staffing gap, likely to increase over time unless addressed. Mr. Cates noted UTRF will be underfunded by at least $1.1M next year. The challenges are great, Mr. Cates said, but addressing the areas noted should be looked at as investments and not as expenses because funds will come back to the University. The investment needs are modest (a few hundred thousand dollars annually) and within a reasonable amount of time this investment should pay itself out and has the potential of bringing in considerable economic resources to the University and helping to achieve the Top 25 research status goal the University has set for itself. Mr. Cates noted members will be hearing more about this important topic in future meetings.

V. News and Highlights

Mr. Cates recognized Dr. David Millhorn, UT Executive Vice President, to give an update on University news and highlights. Dr. Millhorn noted there has been much happening at the University over recent months and he wanted to start the meeting off with a brief overview of this activity.

Dr. Millhorn stated he was pleased to announce the recruitment of the 10th Governor's Chair for the University. Dr. Terry Hazen will be joining the Center for Environmental Biotechnology as early as December 1 of this year. Dr. Hazen was recruited from the

University of California at Berkeley and is a distinguished microbiologist and has done work in environmental bioremediation and bioenergy. Dr. Millhorn noted Dr. Hazen had played a major role in assisting with the BP spill in the Gulf in spring and summer of 2010. Dr. Hazen is joining the UTK College of Engineering, Dr. Millhorn said. UT is fortunate to have Dr. Hazen in his new role here in Tennessee.

Dr. Millhorn extended congratulations to several of the University's research groups. There has been much improvement in UT research programs and the University is continuing to grow and promote its research portfolio. Dr. Millhorn said he is highlighting three such awards in today's program.

UTK won its first-ever Energy Research Center (ERC) award. The Center for Ultra-wide-area Resilient Electrical Energy Transmission Networks (CURENT) will focus on smart-grid technology development. Principal Investigators (PIs) on this award are Kevin Tomsovic, UTK head of Electrical Engineering and Computer Science, and Yilu Liu, UT Governor's Chair. Dr. Millhorn noted the importance of Governor Chair researchers and scientists in competing for and winning large programs. This is an $18.5M five-year program funded jointly by the National Science Foundation (NSF) and the Department of Energy (DOE).

The UT Institute of Agriculture won an award from the U.S. Department of Agriculture to support the development of sustainable regional bioenergy production systems. Within the Southeast partnership for Integrated Biomass Supply Systems (IBSS), Dr. Tim Rials with the Center for Renewable Carbon is the PI for the award. Dr. Millhorn noted 48 different organizations were involved in the proposal and Dr. Rials did a remarkable job in putting the proposal together. The award is $15M over five years.

Another impressive award, Dr. Millhorn stated, is the Memphis Research Consortium in which the UT Health Science Center (UTHSC) is playing a major role. The $10M state commitment is part of Governor Haslam's Innovation program leading to economic development strategy and discovery commercialization. It is designed to promote success through regional collaboration with computational approaches to complex life science problems, integration of genomics and population health science, and regenerative medicine approaches to musculoskeletal challenges. Dr. Millhorn noted Dr. Steve Schwab, Chancellor at UTHSC, played a major role in leading this successful effort.

The three awards highlighted, Dr. Millhorn said, are examples of large awards UT is winning and which are helping to change the University's research portfolio landscape. The researchers noted above and many others are helping accomplish good things for the University and for the state.

Similar good things are happening at the Oak Ridge National Laboratory, Dr. Millhorn said. ORNL was awarded the first energy hub—the Consortium for Advanced Simulation

of Light Water Reactors (CASL)—which looks at making nuclear reactors safer and more efficient in producing electricity and in producing less waste products. This is a $122M over five years' award to ORNL, and the University of Tennessee plays an important role in this grant.

Dr. Millhorn noted the Committee had previously heard him and others speak about UT-ORNL computational capabilities, particularly Jaguar and Kraken. A metamorphosis of Jaguar into a new computer system called Titan has recently transpired. For the last three years, Jaguar has been one of the top three computers in the world and is presently operating at about 2.3 petaflops. As it moves from Jaguar status to Titan status, it will move up to 20 petaflops of high performance computer (HPC) power. This will put ORNL at the top of the world's computing ladder.

Dr. Millhorn showed a power-point slide of the new (July 2011) Chemistry and Materials Science Building at ORNL, a 155,000 square foot facility which offers materials scientists and chemists absolute cutting-edge research resources. Another new development at ORNL (and Dr. Millhorn noted Dr. Martin Keller will likely also discuss this topic in his presentation to the Committee this afternoon) is the Carbon Fiber Technology Center. The Center was created with a $35M grant from stimulus funds to develop a way to produce less expensive carbon fiber for manufacturing. Some related activities are looking at carbon fiber from lignin, one of the products from making biofuels from biomass. These activities and others continue to enhance our partnership capabilities with UT-Battelle at the Lab, Dr. Millhorn stated.

Two new "welcomes" were announced by Dr. Millhorn: Dr. Dick Gourley, former Dean of the School of Pharmacy at UTHSC for 22 years, has accepted nomination as UTRF Interim President. Dr. Gourley has a tremendous amount of understanding and experience in using IP to create commercial opportunities, Dr. Millhorn said, and we are looking forward to his leadership at UTRF. Dr. Millhorn noted the first-ever national recruitment was undertaken for UTRF for the position of Vice President of the UTRF Multi-Disciplinary Office (MDO). There were approximately 50 applications for the position and Mr. Dave Washburn, Assistant Director of Technology Transfer at the University of Illinois, was selected for Vice President of the MDO in Knoxville. Mr. Washburn also brings excellent experience to assist in continuing to grow the important UTRF organization for the University. Mr. Washburn will begin his role at UT on November 2 and we look forward to enlisting his direction in moving UTRF forward, Dr. Millhorn said.

Dr. Millhorn reminded members of the $20M National Science Foundation-sponsored EPSCoR (TN-Score) program which focuses on several important components of UT's mission: research, outreach and economic development. This proposal has two thrust areas based in Knoxville and there is one thrust area in Nashville at Vanderbilt. The program involves over 35 Tennessee institutions, most of which are academic organizations involved in the research segment, in the STEM education program and in

the general outreach program. The three thrust areas focus on the conversion and storage of solar power as a teaching mechanism for our relationship with other universities across the state. At the recent EPSCoR site visit in D.C. (September 2011), good marks were received with the TN-Score programs and the University looks forward in moving this program ahead and enhancing the competitiveness of our research programs across the state, Dr. Millhorn said.

The Tennessee Solar Institute (TSI) was initiated by Governor Bredesen with stimulus funds in 2009, Dr. Millhorn noted, and huge progress has been made in this program. The initiative will conclude Spring 2012. A map of the state of Tennessee was shown depicting the areas impacted by the Solar Installation Grant Program (limited to private businesses and farms, 146 grants awarded, $10.8M in funding, $25.8M additional leveraging in private funding, 6.4 MW electrical-generated capacity, and creation of over 48,640 job work hours)and the Solar Innovation Grant Program (enhanced value within the solar chain, funded 83 projects across the state, had $12.7M in funding, $14.1M additional leveraging in private funding, generated 40,022 job hours). Within the TSI program, workforce development workshops have been held across the state to train solar workers to engage with certain government agencies and become knowledgeable with codes compliance and photovoltaic and fire safety regulations. On the state map green dots were shown depicting completed projects and orange dots depicted programs slated for completion on or before April 30, 2012. The TSI is a huge project that has been successfully undertaken and which will be completed in March or April 2012.

Dr. Millhorn discussed the West Tennessee Solar Farm, and showed a schematic illustration of the Farm, including solar panel locations surrounding a middle plot on a knoll on which a welcome-information-solar energy education center is slated to be constructed. The center was taken out of the budget last year; however, plans are to add this facility back this year through TDOT funding. UT believes the facility is a wonderful opportunity for a West Tennessee presence in solar energy. More than 22,000 solar panels have been installed on the Solar Farm property and electricity is to be generated beginning in February 2012. Electrical hook-up is through Chickasaw Electric. A 20-year power purchase agreement has been negotiated with Tennessee Valley Authority.

The Cherokee Farm project is also continuing to move ahead. Dr. Millhorn showed a slide of the current infrastructure construction, which is approximately 85 percent installed as of this date. Streets are being prepared, most of the utilities are complete, and work is now being done to ensure the proper grade of the building sites. Numerous discussions at prior ROED Committee meetings on Cherokee Farm have taken place, Dr. Millhorn noted, in how the Cherokee Farm property should be developed. A new entity called the Cherokee Farm Development Corporation (CFDC) has now been created. This is a not-for-profit subsidiary company of UTRF. Its sole mission is to develop Cherokee Farm with its overall operations through a master agreement/lease. UTRF has engaged

a real estate attorney to review and counsel on matters relating to the ground lease and negotiations with the State Building Commission to move the lease owned by UT into CFDC. A regional search will be conducted for a development expert to become president of CFDC and to assist with raising funds to staff the corporation. A marketing project plan is in draft form and Dr. Millhorn held up a large notebook containing the drafted plan. Some of the issues incorporated in the plan include capitalizing on regional strengths and existing partnerships, outlining national target opportunities, and developing brand messaging. Dr. Millhorn said work will continue with the marketing firm of Pintoresco Advisors, LLC (located in Los Angeles). Pintoresco understands UT's vision for Cherokee Farm and is providing helpful insight into developing Cherokee Farm into successful reality. Dr. Millhorn said new developments and information will be shared with the group.

Bid announcement went out at the end of August for the Joint Institute for Advanced Materials (JIAM) building on Cherokee Farm, the first building to be constructed at Cherokee Farm, Dr. Millhorn said. There was a six-week bid period. During the course of this period, UT recognized it had to abide not only by State Building Commission guidelines but TDOT and Federal Highway Administration principles as well, as funds for the JIAM building came through the omnibus bill for the Department of Transportation. Constructing a building with the additional highway administration guidelines has compounded regulation compliance efforts with construction management staff. An example of the federal guidelines to be followed is a rule requiring 30 percent of the workforce to be primary employees of the prime contractor. Construction and planning staff are now working through these added complexities to move bids forward. Having said this, Dr. Millhorn noted the JIAM project is still on schedule and bid replies should begin arriving in the next several weeks.

Dr. Millhorn concluded his presentation by saying UT research and economic development programs are moving forward and large gains are being made especially within the large projects he outlined in his presentation. Much of this gain can be attributed to the recruitment of Governor's Chairs and the emphasis placed on our partnership with Oak Ridge National Laboratory.

Mr. Talbott inquired about the timeframe for having a Cherokee Farm developer on board the project? Dr. Millhorn said he certainly would like to have the developer on site by early 2012, at least someone identified by that time who could be moved to the area to begin oversight of the project. Dr. Millhorn said engaging such an individual to work with the marketing firm is now the number one priority as the project is moved forward.

VI. Overview of Bioproducts

Dr. Millhorn introduced Dr. Martin Keller (Associate Laboratory Director, Biological and Environmental Sciences Directorate, Oak Ridge National Laboratory) to give an update

on bioproducts and noted Dr. Keller heads up one of the largest directorates at the Lab, directing programs concerning renewable energy, new energy forms, manufacturing and co-products made from various types of biomass.

Dr. Keller began his presentation with a discussion of the exceptional resources for materials and manufacturing R&D at ORNL—specifically, how to take remarkable science and improve the way manufacturing is done on this science based on new technologies to successfully bring products into the market place. The first consideration in this process is the large number of national user facilities located at the Lab, including: Building Technologies Research and Integration Center, Center for Nanophase Materials Sciences, High Flux Isotope Reactor, High Temperature Materials Laboratory, National Center for Computational Sciences, National Transportation Research Center, and the Spallation Neutron Source. Specialized capabilities include the Carbon Fiber Technology Center, Center for Advanced Thin-film Systems, Materials Processing, Metrology, Robotics and Energetic Systems, Sensors and Signals Research, and the Thin Film Deposition and Analytical Facility. These facilities provide an excellent start for materials and manufacturing development and the promotion of new technologies and industries at ORNL, Dr. Keller stated.

Another important consideration in materials and manufacturing R&D, Dr. Keller noted, is the large number of ORNL partnerships within the U.S. manufacturing community. ORNL has decades of industrial collaboration leading to established relationships with over 1,000 companies. These relationships have a record of accomplishment in technology transfer and commercialization with 164 R&D Top 100 awards. Dr. Keller noted there have been many new initiatives coming out of the new presidential administration. In June 2011 President Obama launched the Advanced Manufacturing Partnership (AMP), a public-private partnership, infusing significant funds ($500M) to revitalize the way domestic manufacturing is conducted and to leverage existing programs. The Chairman, President and CEO of Dow Chemical, Andrew Liveris, and Susan Hockfield, President of the Massachusetts Institute of Technology, are leading the AMP effort to identify the most pressing challenges and transformative opportunities to improve technologies, processes, and products across multiple manufacturing industries. Dr. Keller showed a power-point slide listing the major U.S. manufacturers and top engineering universities enlisted in this initiative and noted there is important administration engagement with the National Economic Council, the Office of Science and Technology Policy, and the President's Council of Advisors of Science and Technology. There is much momentum gaining around this initiative, Dr. Keller said.

There are two major proposals underway, Dr. Keller said, to target funding opportunities linked to the AMP: A DOE $120M Innovative Manufacturing initiative with a focus on manufacturing processes and materials (ORNL is the lead on 60 proposals with industry partners and is a partner on 80 industry proposals) and a DARPA $134M Open Manufacturing Initiative with a focus on roll-to-roll processing, composites, additive manufacturing and manufacturing demonstration facilities(MDFs) (ORNL has $96M in

proposals with the MDF focused on 6 core thrust areas , is the lead on 1 additional proposal and is a partner on 18 industry proposals). Dr. Keller highlighted the six ORNL MDF core technology thrust areas ($10M per year to initiate manufacturing): composites and carbon fiber, magnetic field processing, low-temperature materials synthesis, lightweight metal processing, roll-to-roll processing and additive manufacturing. Developments within additive manufacturing, Dr. Keller said, will revolutionize the way future manufacturing will be done. As an example, Dr. Keller distributed a ball made from titanium oxide in a shape which is impossible to be made with traditional machinery. The new technology used in creating the ball can be taken in many directions, Dr. Keller stated, such as in creating equipment for the military. Dr. Keller emphasized the parts being manufactured with additive manufacturing technology could not be produced with traditional technology and machinery. Additive manufacturing involves high-performance materials and precision and complex geometries with processes such as electron beam melting, ultrasonic additive manufacturing, laser metal deposition and fused deposition modeling. Dr. Keller illustrated a silencer prototype designed on a computer and printed out with new technology which reduces the noise level to half the level of the best silencer currently available. The prototype silencer could not be manufactured by traditional methods.

Another area Dr. Keller highlighted within the MDF core groups was advanced robotics. Dr. Keller showed a prototype of a robotic hand and presented a power-point graph showing factors in delivering a 20kg payload robot such as cost, dexterity, complexity of parts, fabrication challenge, number of parts, leak paths, weight and payload to weight ratio using conventional and mesofluidic manufacturing in comparison to additive manufacturing. Additive technology drastically reduced costs from high ($200K) for conventional, moderate ($80K) for mesofluidic to low ($10K) for additive manufacturing, with remarkable improvement in dexterity and all other factors being measured. In the Army PETMAN program ORNL is teaming with Boston Dynamics to develop a fully anthropomorphic android for testing purposes, again with part complexity that would not be possible with conventional machining.

ORNL is taking its additive manufacturing technology to youngsters in high school, such as the Hardin Valley Academy, and engaging them in new science, Dr. Keller said. ORNL sponsors the Hardin Valley Academy Robotics Team, launched in 2010, and it was the only such team in Tennessee that won an award at the regional level, allowing them to participate in the national competition of the FIRST Robotics Competition (founded by Segway inventor Dean Kamen), whose goal is to inspire youth to be science and technology leaders. The team spoke in front of 5,000 people at the competition, Dr. Keller said. Three Hardin Valley Academy students interning at ORNL have filed an invention disclosure for an omnidirectional track system based on passive roller treads. The students plan to use additive manufacturing to print an entire robot. This is a tremendous program, Dr. Keller said. Many of the team members plan on attending engineering schools. The team is looking for additional sponsors, Dr. Keller noted, and

he'd be delighted to be contacted for additional information (kellerm@ornl.gov) about the program.

Dr. Keller discussed transient field processing, a program which developed from fundamental science. Steel and other ferromagnetic alloys can be strengthened and made more fracture resistant by use of magnetic fields, Dr. Keller stated. This process revolutionizes the way single-metal casting forms are manufactured. These materials can be placed into magnetic fields to create single-crystal metals. This is another example of taking fundamental science, Dr. Keller said, and moving it toward applied science applications, to produce enhanced and improved materials in vastly more cost-efficient processing. A similar process, low-temperature materials synthesis, transforms nanoparticle production and microorganisms and significantly cuts down costs in producing higher-performance materials. An example Dr. Keller gave of the significant potential results in using this process (as opposed to conventional processing) is a reduction in the cost of zinc sulfide from $5,000/kg to $80/kg to deliver a highly-defined final product.

Dr. Keller described an a new process of thin-film creation using nanoparticles and pulse-thermal processing to create green, scalable solar cells on flexible substrate, with results now of 4.1 percent efficiency on processing underway in collaboration with the University of Florida. The next phase of research with this new application, to take place at ORNL, will be the production of solar panels created with layers of the flexible membranes described above but at significantly greater improvement and efficiency. Scientists are predicting this radical new technology will cut solar panel production costs to as much as $0.50/W at 15 percent efficiency.

Dr. Keller also described the use of composites and carbon fiber R&D to create new materials and processes. This is a most exciting field, Dr. Keller said, and UT and ORNL are the lead for this field in this region of the country. Precursor development and evaluation is taking place in the areas of textile PAN, lignin-based, and polyoefin. These areas are coming together to create totally new carbon fiber-base materials (high-strength carbon fiber, plasma stabilization/oxidation, microwave-assisted plasma carbonization, and carbon fiber surface treatment). The vision for this new technology, Dr. Keller said, is to develop and transition to industry technology for significant impacts on U.S. and global energy security, to enable deployment of low-cost technology in high-volume applications (low-cost raw materials, low-cost fiber manufacturing processes, high-rate robust composites manufacturing processes), and to address materials issues "from the cradle to the grave." Carbon fiber is a fantastic material, Dr. Keller said, but it is very expensive. Creating low-cost carbon fiber (for automobile and airplane industries, sports equipment and many other manufacturing applications) will decrease production costs and enhance performance, which in turn helps the consumer in the marketplace.

UT and ORNL will pursue this development within the Carbon Fiber Technology Center at ORNL, a 42,000 sq. ft. facility currently under construction, with occupancy in November 2011 and operations to begin in February 2013. Taking a carbon fiber precursor, such as lignin, Dr. Keller said, which has low cost, has great potential for early market introduction. Such structural carbon fiber has a variety of applications in both defense (heat shields, airplane wings and fuselages, lightweight weaponry) and nondefense (automobile and aviation industries, as noted earlier). No secure domestic source exists at the present time. The Carbon Fiber Technology Center will have a production capacity of 25 tons a year of fiber from multiple precursors in various forms. The Center will also serve to leverage and promote industry partnerships and a site where companies can test their materials. Dr. Keller distributed a sample of bio-carbon fiber from lignin (the glue that holds trees together, he said) used for thermal insulation. There is tremendous application opportunities for lignin-based carbon fiber, Dr. Keller said, especially if costs can be lowered to the cost of steel. ORNL is currently working with a company which produces nonstructural carbon fiber, Dr. Keller stated. A single thermal application requires 600 tons of carbon fiber per year (1800 tons of lignin). The company now receives its fiber from China. The company has told ORNL it can commercialize what is being produced at ORNL within a three-month period. An additional application for lignin-based carbon fiber involves graphite electrodes and this process would require 500 tons of fiber per year. The Center is evaluating technologies at a scale which will allow scale-up to a full-scale carbon fiber plant and there are tremendous opportunities as no secure domestic carbon fiber source currently exists in the U.S. Pulling this science together along with the biofuels initiative has the potential to completely revitalize rural America. Tennessee is absolutely on the forefront of this industry, Dr. Keller stated.

Dr. Keller presented a power-point slide showing the process of creating biofuels from cellulose and hemicellulose. The BioEnergy Science Center (BESC) at ORNL, Dr. Keller noted, is a multi-institutional, DOE-funded center performing basic and applied science dedicated to improving yields of biofuels from cellulosic mass. There are 322 personnel and 19 institutions across the U.S. involved in the BESC organization (including ORNL, UT, Brookhaven National Laboratory, Virginia Tech, the University of Georgia, Georgia Tech, North Carolina State University, and Cornell). A tremendous amount of progress has been made within the Center over the last four years, Dr. Keller said. Breakthroughs at BESC include the generation of a genetically-improved switchgrass that yields 30 percent increased biofuel and requires 3-4-fold less enzyme for processing, the identification of a panel of natural variants of Populus that release 85 percent of sugar with minimal or no pretreatment, the development of genetic tools and new ways to overcome key inhibitors of microbial fermentation efficiency (ethanol or acetate tolerance), and the demonstrated production of isobutanol directly from cellulose. There have been 301 publications, 70 inventions, 22 patent applications, 14 licenses and 1 start-up company (in final negotiations) to date, indicating the significant amount of research and progress going forward within the Center, Dr. Keller said.

As a scientist, Dr. Keller said, he fully believes the technology will soon be available to produce a sustainable biofuels industry here in Tennessee. Field testing is an important aspect of this industry and such testing is taking place with Arbogen in South Carolina, at ORNL in common gardens, with Ceres in Texas, and at UT with its field assessment of genetically improved switchgrass. ORNL researchers are also working on the development of alternative fuels in performing direct catalytic conversion of ethanol to gasoline-like hydrocarbons and significant progress is being made in this process, Dr. Keller noted, in the creation and use of a new, low-cost catalyst by petro-chemical industries. Ethanol coming out of the Vonore plant, for instance, Dr. Keller stated, is now used by UT and ORNL motor pools. Testing on this product is taking place within the National Transportation Research Center (NTRC), which has all the capabilities to perform full-engine testing, and researchers have found that this upgraded ethanol modules product, when overlaid with certain types of gasoline, is a dead match in gasoline quality. The octane numbers of the ethanol were all over 100, which indicate the combustion is exactly the same as the type of gasoline now purchased at gas stations. Dr. Keller said there is much excitement with these developments, particularly with the potential of creating not only gasoline but jet and diesel fuels as well.

Dr. Keller concluded his bioproducts presentation and asked if there were any questions. Mr. Wharton inquired if there was any loss of energy with the rifle suppressor Dr. Keller had discussed at the beginning of his presentation. Dr. Keller said no loss had been observed in testing. The bullets traveled the same distance with the new prototype but noise was reduced by half of the rifle silencer produced with traditional technology and manufacturing.

Mr. Cates thanked Dr. Keller for his excellent presentation and Dr. Keller received a round of applause.

VII. Update on Genera Energy, LLC

Dr. Millhorn recognized Dr. Kelly Tiller, President of Genera Energy, LLC, to provide an update on the biofuels program for Committee members. Dr. Millhorn noted the innovations taking place within UT's biomass program mesh well with programs at ORNL and the BESC program Dr. Martin Keller just described in his presentation.

Dr. Tiller reminded members of the scope of the UT Biofuels Initiative (UTBI) launched in 2007 and said the project remains unique in its comprehensive scope and integrated approach to accomplishing its mission. Four areas of focus and mission were set forth within this project: Energy Crops and Supply Chain (demonstrate the establishment of a dedicated energy crop, switchgrass, with area farmers and demonstrate the logistics system to manage the supply chain) Demonstration-Scale Biorefinery (demonstrate the pre-commercial production of ethanol from switchgrass), World Class R&D Capacity (leveraging resources to establish premier long-term research capacity in bioenergy and bioproducts to serve as a pipeline for future developments), and Build a Commercial

Industry (develop a viable, sustainable, long-term path to commercialization of cellulosic biofuels in Tennessee). Dr. Tiller said the first three areas were targeted at the outset to support the goal of the fourth area: building a commercial industry—putting the pieces in place to lead to commercial-scale development and significant economic impact for Tennessee.

Dr. Tiller also reminded members of the UTBI structure implemented with both the commercial aspect of the project and the partnership collaborations developed with long-term, sustainable success in mind. Through the UT Research Foundation, Genera Energy, LLC, was set up as a separate, private, for-profit, TN limited-liability company to allow assimilation of the pieces needed to develop private partnerships and to move at the speed necessary to work peer-to-peer with businesses within the industry. This framework was instrumental in the 2008 partnership formed with DuPont Danisco Cellulosic Ethanol LLC (DDCE), Dr. Tiller said. Other Genera partnerships range from seed biotechnology companies, equipment manufacturers, and processing companies as well, Dr. Tiller said. A power-point slide listed many of these partnerships, including John Deere, SunGrant Initiative, Vermeer, Ceres, Mendel Bioenergy Seeds, ORNL, BioEnergy Science Center, Center for BioEnergy Sustainability, and the Idaho National Laboratory.

The UTBI program begins with switchgrass. Four years after the initiation of the program, Dr. Tiller said, it is even more evident switchgrass is a great fit for Tennessee and the Southeast. It has been demonstrated to be high-yielding; tolerates poor soils, flooding and drought; is a great fit for farmers as it works with their existing equipment and infrastructure; has additional uses beyond the energy crops, with forage, etc.; has low-input use requiring no irrigation, no pesticides, fungicides and minimal herbicides, and minimal fertilizer; is established within 1-2 years; is noninvasive; improves soil quality; is cost effective; and has a 25-year track record as an energy crop, to name a few of its qualities. The Tennessee switchgrass experience to date, Dr. Tiller said, has involved contracting with more than 60 local farmers within a 50-mile radius of Vonore to grow 5,100 acres of switchgrass. This program, now in its fourth year, has achieved 90+ percent success rate in yield establishment in the initial year. Harvesting yields are meeting (and in some cases exceeding) expectations with an average of about 2 dry tons per acre in year 1, about 5 tons per acre in year 2, and 8 tons per acre in year 3 and thereafter. A map was shown depicting locations of the 61 contracting farms in nine East Tennessee counties, representing a wide cross-section of the agricultural sector in the Sweetwater Valley.

Dr. Tiller showed a slide showing many large, rolled bales of switchgrass in storage and noted this is not the product that goes into the biorefinery. What is produced by the switchgrass farmers on farms is a crop; what needs to go into the biorefinery is a very uniform industrial feedstock. Many things must happen in the biomass supply chain between the time it leaves the farm gate and the time it reaches the biorefinery gate, Dr. Tiller explained. There are many challenges within the supply chain including

storage, handling logistics and transportation. Construction has just been completed on the Biomass Innovation Park (BIP) in Vonore which serves as the link between the farm gate and biorefinery gate. It is a 22-acre world-class R&D campus adjacent to the biorefinery. The BIP integrates the entire biomass supply chain and focuses on material receiving, storage, handling, conveyance, chopping, grinding, milling—all the things which convert a crop into a biomass feedstock. With the completion of the facility, installation is now taking place with the remainder of the equipment and operations will commence in the next few weeks to begin to process the material being harvested this fall, Dr. Tiller said.

The ability to demonstrate the first major component in the UTBI program (energy crops and supply chain) has been demonstrated very well, Dr. Tiller said, with the establishment of the country's largest and most comprehensive program for purpose-grown energy crops, contracting with more than 60 farmers to produce more than 5,000 acres of switchgrass; the evaluation of 1,000 acres of improved switchgrass varieties; the management of over 30 energy crop and logistics research projects, all along the switchgrass supply chain; and the success of not only growing energy crops, but also in supplying value-added feedstock as well.

The second component of the UTBI mission (demonstration-scale biorefinery) began with Genera's partnership with DuPont Danisco Cellulosic Ethanol, LLC (DDCE). The partnership has been a good one, resulting in the construction and now operation for more than a year and a half of the nation's first cellulosic ethanol biorefinery operating on multiple biomass feedstocks—corn cob from the inception and currently on corn stover (stalk, stems, leaves and cob)—located in Vonore. Operations have now begun to process switchgrass at the facility. There are different scales at the facility, ranging from lab-scale to discreet-unit operations in a process development unit (PDU), and then to a full-demonstration scale. The early work is beginning now to move switchgrass into the facility for processing. Dr. Tiller said she is most pleased with the progress of the facility operations. The E-85 fuel produced in the Vonore facility is now being used to supply the UT Motor Pool fleet, which has more than 200 flex-fuel vehicles. Dr. Tiller noted the joint venture of DuPont Danisco has become just DuPont as the company acquired Danisco this past summer for approximately $7B. This acquisition bodes well, Dr. Tiller stated, in indicating the commitment DuPont is making to this sector going forward as the company develops their long-term portfolio. In June 2011 the announcement was made of the first DDCE commercial-scale project to be constructed in Iowa (to be operated on corn stover) and is also another strong testament, Dr. Tiller said, to the success in Vonore and an indication of the next steps going forward. Dr. Tiller showed slides of the 75,000 sq. ft. demonstration-scale biorefinery in Vonore. The processing capacity at the biorefinery is approximately 250,000 gallons per year.

One of the most exciting aspects of the biorefining venture, Dr. Tiller said, is to look at metrics indicating the rapid progress being made in a short amount of time. On a

power-point slide (which Dr. Tiller noted had been updated compared to the slide version provided in advance of the meeting) Dr. Tiller outlined these metrics and progress from 2007 to 2011: technology maturity (2007, proven at lab scale; 2011, proven at pre-commercial demonstration scale); ethanol yield (2007, 60-65 gallons per ton range; 2011, 80-85 gallons per ton); process integration (2007, unproven; 2011, over 18 months of successful integrated operations); feedstocks (2007, proven on cob; 2011, proven on cob, stover, switchgrass); capital cost (2007, about $8 per installed gallon; 2011, about $6 per installed gallon); enzyme usage (compared to the 2007 baseline dosage, 2011 dosage has been reduced by 70-80 percent); and cost of manufacturing (2007, projected $3-4/gallon; 2011, $1.70/gallon today or ~$2/gallon today including the cost of capital). The significant reductions in manufacturing and overhead costs, plus capital costs, puts production of cellulosic ethanol at about $2/gallon using technology ready to go today, which makes this product competitive with crude oil around $90/barrel, without applying any subsidies. In looking at the initial targets for the demonstration-scale biorefinery, Dr. Tiller said, most of the objectives set forth have been achieved. In addition, more than $70M has been secured in private investment for biorefinery construction and commitments for ongoing operations of this facility and plans are moving forward with a commercial-scale biorefinery project.

The third sector of the UTBI program (establishment of a world-class R&D capacity) involves researchers working across the entire supply chain, from switchgrass variety improvements and crop genetics (higher yields, lower lignin, increased seed vigor, herbicide resistance); equipment demonstrations (working with John Deere, Case New Holland, Vermeer, Kuhn, Agco, and Stinger); high-density bale engineering to get 2-3 times the amount of density in the same size package; and crop agronomics, economics and sustainability (seeding rates, weed control, nutrient management, crop insurance, risk management, carbon sequestration, and sustainability indices). A $15M USDA award for the Integrated Biomass Supply Systems (IBSS) program was received, and over the last two years a $5M grant from the Department of Energy was received to demonstrate a new handling system for the switchgrass crop (DOE High Tonnage Logistics (HTL) Project). The HTL project, for example, is examining ways to reduce the costs that occur each time a bale of switchgrass is handled. The UTBI has become adept at moving and handling switchgrass, but efforts are ongoing to gain even better efficiencies by streamlining in-field harvest and collection operations. 500 hp of energy in the processing facility is being substituted for the farmer's field horsepower needed to handle the crop that would have had to be transmitted to the biorefinery for debaling, chopping and refining. Dr. Tiller showed a flow chart of the many aspects involved in this process.

Dr. Tiller showed slides of research activities underway now in Vonore with state-of-the-art capacity in terms of the laboratories and process development units (PDUs). There is a long pipeline of research, improvements and optimizations within the biorefinery operations. These operations tie in very well with the BioEnergy Science Center (BESC) which Dr. Martin Keller described in his presentation, Dr. Tiller said. The fundamental

science link, particularly on the breakdown of the cell structure of the recalcitrant tissue, directly ties into improved economics for the overall system the UTBI is demonstrating and applying in its operations.

Dr. Tiller noted Dr. Millhorn had mentioned the recent award the Center for Renewable Carbon received for the Southeastern Partnership for Integrated Biomass Supply Systems (IBSS). This is a significant award, Dr. Tiller said, for advancing biomass supply structure in the southeast from the research side as well as a demonstrated recognition of the leadership role the University of Tennessee plays in this industry. The IBSS partnership strives to build a sustainable biofuels industry through the effective communication of new knowledge, in demonstrating real-world solutions to barriers limiting deployment of advanced biofuels in the SE region, providing credible and relevant programs to dispense new knowledge for the workforce and stakeholders, and in creating, validating and using new metrics for improved decision-making for regional biorefinery development. Partners include the USDA, Arborgen, Auburn University, Ceres, the University of Georgia, NC State University and UT.

Dr. Tiller showed slides of the October 25 Biomass Field Day on the Farm. Over 350 farmers attended this first-time event and feedback from the farmers was highly enthusiastic, Dr. Tiller said. There were numerous learning opportunities for the farmers with equipment demonstrations and time for the farmers to give their input in the farm process. On October 26 over a 1,000 people were in attendance at the Biomass Innovation Park to see the operations there and to see the biorefinery. There was a wide mix of people for this occasion with industry guests, general public-interest participants and 625 school kids.

In summarizing the R&D capacity of the UTBI to date, Dr. Tiller noted the $23M in federal funds which have been secured for UT for research in biofuels programs; there are unique qualities for the UTBI, including having the only place in the world where equipment manufacturers can field test new equipment designs; the first of its kind Biomass Innovation Park to scale-up and optimize biomass feedstock supply chains and processing operations; the entire switchgrass acreage is a unique, diverse, and comprehensive research canvas for R&D in sustainability, carbon cycling, crop management and decision-making; R&D access to a unique biorefinery and other potential applications in bioproducts and biochemical; and the numerous research partnership opportunities related to key UTBI assets and expertise.

The fourth segment of the UTBI mission (build a commercial industry) involves efforts to develop a viable, sustainable, long-term path to commercialization of cellulosic biofuels in Tennessee. Dr. Tiller described the UTBI timeline via power-point slides, showing progress made from the UTBI launching in 2007 to the present date. In 2007 efforts focused on work with organizations to secure seed, the evaluation of potential conversion tech partners, formation of the Office of Bioenergy Programs in the UTIA and ramping up UTBI R&D programs. In 2008 the first switchgrass crop planting took place

(723 acres on 16 farms), exploration of R&D opportunities began (partnered with DDCE for biorefinery design, construction, operation), DOE committed $135M to ORNL's BESC, and Genera Energy LLC was formed to implement the UTBI. In 2009 UTBI continued to ramp up the switchgrass program with the addition of approximately 2,000 acres of switchgrass, a large-scale feedstock storage and logistics system was designed, construction began on the biorefinery, R&D activities took place with equipment companies, and a crop genetics program was initiated with BESC. By 2010, Dr. Tiller said, operations began in the biorefinery (January 2010), planting of the third year of switchgrass occurred (with acreage totaling 5,000 acres; mature yields averaged 8 tons per acre), planting of 1,000 acres of improved switchgrass varieties took place, the groundbreaking for the Biomass Innovation Park occurred (July 2010), the formation took place of the Center for Renewable Carbon to advance UTIA R&D programs, and the initial commercial project modeling and development was conducted. In 2011 to date, startup of feedstock operations at the Biomass Innovation Park (BIP) began, a $5M DOE demonstration of bulk-handling system grant was received, supply of cellulosic E85 fuel to UT's motor pool fleet began, the first DuPont commercial biorefinery was announced, CRC expanded its lab capability and was awarded a $15M USDA grant for biomass R&D, and the initial commercial-scale project siting began. Significant events are anticipated for 2012 with the launching of commercial biomass and biofuels business operations. 2012 will see wind-down activity of the state-funded, producer-incentive UTBI farmer contract program which is transitioning to market-oriented production programs; new research will be conducted at the BIP; commercial processing of switchgrass will take place to meet market demands; R&D operations of the biorefinery on switchgrass will continue; support of commercial designs and operations will be a key focus; and exploration of multiple partnership and collaboration opportunities and addressing feedstock risk and project financing activity will take place.

One of the reasons for optimism for growth in the biofuels industry, Dr. Tiller stated, is the federal renewable fuels mandate which requires 36B gallons of the country's transportation fuel supply must come from renewable sources by 2022. Further, the mandate also states 16B gallons of the 36B must come from cellulosic sources (advanced biofuels). This creates a tremendous market pool as these technologies are maturing and now ready for commercial-scale development. This fast ramping up makes a ready-made market for the products upon which UTBI is focused. A recently-released study conducted by the USDA (*A USDA Regional Roadmap to Meeting the Biofuels Goals of the Renewable Fuels Standard by 2020,* USDA, June 2010), along with DOE, looks at how the tremendous demand required by the federal renewable fuels mandate will be met. The good news for UT, Dr. Tiller said, is that the Southeast is sitting on the "Saudi Arabia of cellulose" (a power-point slide was shown of the different areas in the U.S. for advanced biofuel production from new capacity). The SE has a real comparative advantage, Dr. Tiller stated, for meeting the demands of the renewable fuels standard (RFS) mandate. According to the USDA study, 50 percent of the entire cellulosic biofuels' supply will come from the SE. In economic terms, the RFS mandate will require (in 10 years) the construction of 263 commercial-scale biorefineries, at a

capital construction cost of $84B and 9-10M acres of land (~11 percent of available cropland). This advantage presents a great opportunity for Genera/UTBI and the study (and others as well) affirms the doability for the projections for the SE.

As Dr. Keller also mentioned, Dr. Tiller said, there are more industry opportunities in this enterprise than fuels alone. In fact, to be sustainable going forward, the enterprise needs to be broader than solely replacement fuels for gasoline; many substances other than gasoline are produced from a barrel of oil. One barrel of crude oil produces 42 gallons, of which 19 gallons is gasoline, at ~$86 cost today. Dr. Tiller showed a graphic depicting the average distribution of products made from a barrel of crude oil (19 products from gasoline, 10 from diesel, 4 from jet fuel, and other oil products such as chemicals precursors to plastics, cosmetics and a multitude of other products we enjoy every day, Dr. Tiller said). The same premise is true for the multitude of products made from a bale of switchgrass (or any cellulosic biomass source), Dr. Tiller stated. There are many values within the cellulosic resource, such as ethanol (40 percent), resins and solvents (5 percent), plastics and polymers (20 percent), boiler fuel (16 percent), carbon fiber (12 percent) and other chemicals (7 percent). One bale of switchgrass equates to 1,500 pounds to produce 24 gallons of ethanol, produced for ~$45. All these uses and products are important to the sustainability of the biomass industry going forward, Dr. Tiller said, and the technologies are rapidly moving toward commercialization.

Dr. Tiller showed a graphic of what the biomass industry potential is for Tennessee. Previous discussion, she said, has focused on the ~10 commercial-scale biorefineries to be supported in Tennessee within a relatively short time. The economic development impact on the state is huge, Dr. Tiller said, potentially translating into 6,000 annual direct jobs and even more indirect jobs, with rural and agricultural job opportunities (where it is often difficult to place workers) and in high-paying manufacturing jobs. This is a state-wide and region-wide opportunity, Dr. Tiller stated, which will attract many complementary industries. It isn't just about fuels, she noted, but the enterprise involves an entire sector of renewable energy; further, it is an entirely sustainable use of land (~800K acres of Tennessee's 1.5M acres of marginal and underutilized ag lands), much of which is underutilized and not in productive agriculture to generate returns. This sustainable economy will attract investment of nearly $6B and generate $775M of annual farm revenues. Annual dividends are estimated to be $2.5B or more. This money is being spent today on fuel consumption, Dr. Tiller said, but much of it is leaving our state and national borders, often going into non-U.S.-friendly hands.

There are challenges to achieving the commercial-scale build-out of this industry, Dr. Tiller said. Chief among them are feedstock supply risk and the investment capital requirements on the commercial side. Work with governmental administrations and other groups is taking place to address these concerns. There are good opportunities to be a first-mover in the industry as it moves forward, Dr. Tiller stated.

Looking ahead to 2013 and beyond, Dr. Tiller said a wrap-up of the state-funded, successful demonstration of the UTBI farmer contract program and expansion of commercial energy crop production will occur, as well as continued expansion of Biomass Innovation Park capabilities and partnerships. Development of commercial-scale projects in Tennessee that return economic benefits to the state and region is targeted, along with enjoyment of the leadership role in the SE biomass energy industry already begun, Dr. Tiller said.

Dr. Tiller concluded her presentation and asked if there were questions. Mr. Wharton noted a recent newspaper article described switchgrass-producer concern for the lack of contract renewals and stated, further, the plan for a commercial biorefinery for Tennessee is now on hold. He asked Dr. Tiller for the status for the commercial plant and to address how producers can be assured of a market for switchgrass without solid contracts for their crops. Dr. Tiller said a chief concern among all farmers is the amount they will be paid for their crop. Genera and UTBI officials are working closely with the farm community and with switchgrass growers to make sure acreage remains in production to continue to grow this enterprise. In regard to any kind of commercial-scale project announcement, Dr. Tiller said, these commercial-scale biorefinery projects cost about $6 in capital for each installed gallon; for a 50-million gallon a year facility, this is a $300M investment. For any company, this is a significant investment. A company making this scale of commitment and investment will drive the timeline on an announcement. The article did not allude to any change in plans or delay, Dr. Tiller noted. DuPont has talked publicly about its continuing support for commercial-scale project development in Tennessee, Dr. Tiller said. Plans are still on track, she said.

Dr. Boulet said he was happy to hear the SE is the "Saudi Arabia of cellulose" and he inquired about Genera/UTBI's competitors within this area and what projects are in the works that will put other competitors in this region. Dr. Tiller said one indication of this competition is the representation at the Biomass Field Day (held October 26) with participants from North Carolina, Kentucky, Georgia, Alabama, Mississippi, and Florida. These states are paying close attention to what is happening in Tennessee, especially in regard to its significant leadership in the biomass enterprise. Other states have made large commitments to commercial-scale project support, chief among them being Mississippi which has announced quite a number of private-commercial-funded projects within the last 12 months, in part supported by a $75M-loan guarantee to one particular company. Mississippi has worked aggressively with the federal delegation to support several projects and the Mississippi Governor, Haley Barbour, has been instrumental in leading much of this activity. Other states are stepping up their efforts with similar activity. Dr. Tiller said she is pleased with the positive discussions with Tennessee state officials and her understanding is they are most supportive to ensure Tennessee is competitive in this enterprise. Dr. Tiller noted the presence of Commissioner of Agriculture Julius Johnson at today's meeting and said work is taking place with his office to ensure attraction for private investment.

Mr. Ferguson remarked he concluded from Dr. Tiller's presentation the economic attractiveness of the biomass initiative and asked how the cost of processing enzymes impacted the enterprise; he also asked about Dr. Tiller's connection with Dr. Martin Keller at ORNL, particularly with regard to his research in developing grass with more cellulose and less lignin, as well as creating bugs that generate enzymes which will reduce the need to purchase these enzymes from other sources. Mr. Ferguson also inquired if Dr. Tiller was locking into technologies or is there flexibility in working with different feedstock or different enzyme sources. Dr. Tiller said the Genera/UTBI enterprise is actually working with both feedstock and enzyme technologies. To add to Mr. Ferguson's comments, Dr. Tiller said, enzymes are an important and costly component of the entire process, but the feedstock itself, prior to even arriving at the processing facility, is over half the cost of production. Anything done on the feedstock side (as well as the enzyme side) significantly impacts the economic bottom-line. The technology investment proposition is ready to go today, Dr. Tiller said, but the new technologies in the pipeline are not ready for commercial rollout. Already proven and demonstrated technologies, ready to go for commercial-scale development today, provide the backbone for the UTBI operations. As soon as the new technologies are demonstrated and ready for commercial rollout, UTBI is eager to incorporate them within the enterprise. Dr. Tiller further indicated that there are strong linkages between the Genera/UTBI programs and the ORNL/BESC programs.

Mr. Horne asked if Genera would receive any economic returns if DuPont pursues commercial application in Tennessee. Dr. Tiller noted there is a private agreement in place with DuPont which provides UT opportunities to benefit, in the long run, in sharing commercial success gained from the state's biofuels investment. Mr. Stansberry noted the principal benefit of this program to the state of Tennessee is the agricultural component, which is enormous.

Mr. Cates thanked Dr. Tiller for her presentation and she received a round of applause.

VIII. Presentation on Center for Interdisciplinary Research and Education (CIRE)

Dr. Millhorn recognized Center for Interdisciplinary Research and Education (CIRE) Director Dr. Lee Riedinger to present an update on the program.

Dr. Riedinger noted members had heard about the program from two CIRE students who spoke today, as well as from the other eight CIRE students who sat among the Board of Trustees members, at the luncheon session. Dr. Riedinger said he was impressed by the students' comments and he is impressed by the CIRE students each time he teaches them in his graduate courses.

Members also heard about the CIRE program approximately a year ago, Dr. Riedinger said, in a previous ROED Committee meeting. THEC approved the program in January and the first graduate class is underway at UT Knoxville now with the new

interdisciplinary Ph.D. program. The CIRE idea began in part with former Tennessee Governor Phil Bredesen, Dr. Riedinger said, to leverage the assets of the University of Tennessee and the Oak Ridge National Laboratory. Within this novel program, Dr. Riedinger said, students can choose to pursue a new interdisciplinary Ph.D. in Energy Science and Engineering (ESE) or a traditional Ph.D. with a concentration in ESE. Within ESE there are six areas of energy-related research: nuclear energy, bioenergy, energy conservation and storage, renewable energy, distributed energy and grid management, and environmental and climate sciences related to energy. Dr. Riedinger reports to the UTK Chancellor, he noted, and CIRE is the academic home at UTK for the Interdisciplinary Ph.D. program.

Dr. Riedinger discussed the process involved in recruiting students for the CIRE program. In part, the unique aspects of the CIRE program are a key attraction for these students, particularly in program structure and curriculum. The CIRE curriculum is much different, Dr. Riedinger stated, from conventional Ph.D. programs in physics, mechanical engineering and other such fields. Dr. Riedinger teaches core ESE courses twice a week (the Introduction to Energy Science and Technology) highlighting energy strategies. CIRE students take two courses to broaden their energy knowledge and expertise as it relates to areas of political, social, legal, ethical and security issues; to entrepreneurship, leadership and management; and to environmental and climate sciences. There is a multitude of curriculum choices for the students, Dr. Riedinger stated. The next level of the program involves in-depth study within a knowledge specialization curriculum of the student's key interests. Seventy-two hours of graduate credit are required for the Ph.D., including at least 36 hours of coursework.

Additional attraction in recruiting students to the CIRE program, Dr. Riedinger said, was the outstanding offers made to the students. The Tennessee state legislature awarded CIRE $6.2M in one-time funds in 2010, enabling generous annual stipends of $28K, with a few $30K stipends for top performers (higher than normal stipends given at UT), as this program competes for the best possible students. CIRE students will work in part or in full on their research at ORNL and this aspect is also highly attractive in recruiting quality students for the program. Three students became a part of the CIRE program in Fall 2010 and 19 students started in Fall 2011 (3 on Distinguished Graduate Fellowships and 16 on ESE Fellowships; 15 students have already decided on their in-depth research course of study). The goal is to recruit 20-30 new Ph.D. students each year, Dr. Riedinger said. National recruitment activity is undertaken, a rare approach for UT due in large part to limited resources, Dr. Riedinger said. ORNL is now combining CIRE Ph.D. student recruitment at the 30 universities where it performs employment-hiring recruitment. Dr. Riedinger noted ORNL Human Resources reps Josh Scull and Channa Palmer and UTK rep Ben Allen, who recruit for CIRE at these 30 universities and at job fairs across the country, talk face to face with the country's most talented students about the unique CIRE Ph.D. program. The ORNL affiliation is a strong component for recruiting, Dr. Riedinger stated, and CIRE is popular at the recruiting events. It is not uncommon for other recruiting institutions to inquire about the CIRE program at these

venues. Approximately 200 resumes are received at each recruiting event, with three-fourths of this number interested in the CIRE Ph.D. program.

Dr. Riedinger discussed the 38 high-quality UT and ORNL faculty members (approximately half from each institution) enlisted in the first round of the CIRE Ph.D. program. Additional faculty members are expected to join in the program. These are not new faculty lines; representatives at both UT and ORNL are applying their expertise in the six core energy-related research areas as they work with the students. Within the environmental and climate sciences core area, ORNL has a world-leading scientific computing facility utilizing two of the best supercomputers in the world, Jaguar and Kraken. Jaguar focuses on large-scale computationally intensive projects with high-scientific impact. UT and ORNL have also a National Science Foundation petascale computer in Kraken. The country's top climate codes run on these computers. Faculty members in this segment of the program are Joshua Fu (Department of Civil and Environmental Engineering, UTK), Jim Hack (National Center for Computational Sciences, ORNL), Rich Norby (Environmental Sciences Division, ORNL), and Jack Parker (Department of Civil and Environmental Engineering, UTK).

Within the area of nuclear energy study, ORNL and UT are well-positioned to support advanced fuel-cycle research. Among the five faculty members for this core area are two Governor's Chair appointees, Brian Wirth and Howard Hall; other members are Ted Bestmann (Materials Science and Technology Division), Witek Nazarewicz (UTK Physics Department), and Mark Williams (ORNL Reactor and Nuclear Systems). Dr. Riedinger noted Drs. Nazarewicz and Williams were unacquainted prior to their work with CIRE Ph.D. student Kemper Talley, who is now the "glue" in bringing the two experts together and strengthening their united research capabilities. Within the nuclear sector CIRE students have access to the DOE Center for Advanced Simulation of Light Water Reactors and the ORNL High Flux Isotope Reactor, among other facilities.

An important part of the energy solution for the future, Dr. Riedinger said, is biofuels. There are six faculty members focused in this sector with CIRE students: Neal Stewart (Department of Plant Sciences, UTIA), Joe Bozell (Department of Forestry, Wildlife and Fisheries, UTIA), Barry Bruce (Department of Biochemistry and Cellular and Molecular Biology, UTK), Jay Chen (Biosciences Division, ORL), Brian Davidson (Biosciences Division, ORNL), and Gary Sayler (Department of Microbiology, UTK). The ORNL $135M DOE BioEnergy Science Center to advance cellulosic ethanol research and the $73M UT Tennessee Biofuels Initiative were discussed in greater depth by Drs. Keller and Tiller, Dr. Riedinger noted, and these entities are great assets for energy biofuels research.

Another solution for future energy needs, Dr. Riedinger stated, is focused on renewable energy. ORNL has a large and growing energy efficiency and renewable energy program, with the largest national lab effort in transportation, industrial technologies and superconductivity. There is significant growth in solar energy, electrical energy storage, biomass, and grid visualization/modeling research, with major research

facilities in the High Temperature Materials Laboratory, the National Transportation Research Center, and other advanced technology centers at the disposal of CIRE students for their research in these areas. Next-generation electric cars, lightweight carbon fiber materials produced from lignin, and "zero-energy" homes are examples of the research taking place in this area which is attracting a new crop of CIRE graduate students. Dr. Riedinger discussed "smart grid" (monitoring and sensing, communication, control and actuation, computation) research to handle renewable energy within the new UT Center for Ultrawide Area Resilient Electric Energy Transmission Networks (CURENT). A $4M/year NSF award for the Center was recently announced, Dr. Riedinger said. CIRE faculty Kevin Tomsovic is Director and Governor's Chair Yilu Liu is the Deputy Director. Electricity generated from wind turbines is the largest growing energy supply in the country, Dr. Riedinger noted. Dr. Riedinger showed a power-point slide of the 14 CIRE faculty members within the renewable energy area of study (including Tom Zawodzinski, another Governor's Chair appointee, an expert in fuel cells).

Dr. Riedinger said the quality of faculty members within the CIRE program of study is a strong attraction for students. Many students through their own review or via undergraduate-professor recommendations recognize working with certain CIRE faculty members will be instrumental in advancing their doctoral course of study and expertise.

Photos of CIRE faculty members in "cross-cutting" areas related to energy were shown by Dr. Riedinger, many of whom have expertise in materials sciences areas. Materials are a basic part of the energy challenges for the future. With the 30-year hence possibility of generating energy from fusion-reactors (not fission-reactors), a process by which stars burn and generate huge amounts of energy, the biggest challenge is not in the physics of this operation but in the materials involved within the process, the likes of which are non-existent at the present time, Dr. Riedinger stated. A host of faculty at UT and ORNL are working on the materials science relating to fuel cells and materials for solar power or needed for the first wall within fusion-reactors.

The CIRE program, Dr. Riedinger concluded, is going well after the first year. It is impressive to have the first set of students in place. After interview visits by the students last May, 28 offers were made for fellowships and 14 offers were accepted, an impressive 50 percent success rate, Dr. Riedinger noted. UTK Chancellor Cheek, Dr. Riedinger said, would be more impressed with a 75 percent acceptance rate. Both the Chancellor and UTK Provost (Dr. Susan Martin) are most supportive of the CIRE program, Dr. Riedinger said. The program is headed in the right direction, but the challenge is in the one-time state funding. There is a matching of funds when a CIRE student commits to either UT or ORNL and assumes the package of the stipend and tuition, and this procedure can be extended for some years. It is hoped, with CIRE-program demonstrated success, the program will qualify for future funding.

Mr. Cates thanked Dr. Riedinger for his presentation and asked if there were any questions regarding the presentation. Mr. Horne inquired if the CIRE program, as a valued student-development enterprise, could be maintained and continued with funds from an annual $6M state grant and he asked President DiPietro if plans were being considered for such an approach. Dr. DiPietro noted funding models for state awards for programs meriting such rewards. The CIRE program is an impressive concept, Dr. DiPietro stated, in bringing the relationship of UTK and ORNL to bear in advancing education and research. In the short time CIRE has been funded, with Dr. Riedinger's leadership and with the support of leaders such as Drs. Cheek and Martin, notable advancements have already been achieved, Dr. DiPietro stated. Seed money has been given to get the program off the ground and beyond this stage both UT and ORNL will strive to grow the program. It is quite an accomplishment for the two divergent cultures to combine in this impressive effort. Successful demonstrated performance, Dr. DiPietro stated, will be a strong argument for continuing funding and support of CIRE.

Mr. Schledwitz complimented the CIRE students who attended the Board of Trustees luncheon and sat among the members. They are impressive individuals and scholars, he noted, and it was a privilege to interact with them.

Mr. Cates thanked Dr. Riedinger for a fine presentation on a most encouraging program.

IX. Other Business

There was no other business to come before the Committee.

X. Adjournment

Mr. Cates thanked members for their participation in the meeting. The meeting adjourned at 2:55 p.m.

Respectfully submitted,

David E. Millhorn, Ph.D.
Executive Vice President