Final Annual Report

Tennessee Tech University

President

Provost

College of Engineering

Energy Systems Research Center

Definition of Unit: Center for Energy Systems Research (CESR)
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Mission/Vision/Goal Statement
Mission: The Center for Energy Systems Research (CESR) was established to advance and apply scientific and engineering knowledge and academic programs associated with energy systems and in particular with electric power while supporting the instructional program of Tennessee Technological University (TTU). Research efforts, both theoretical and experimental, are focused on solving current and anticipated problems associated with energy systems. Special emphasis is given to the needs of the electric power industry.

Vision: The center will be known and be recognized nationally for its research contributions in energy systems and Infrastructure areas.

Goals: The 5 current Goals have been developed on the basis of the mission of the Center. The numerical objectives have been arrived at using historical data with a view on advancement towards reaching the vision.

Goal 1. Increase research activity in the areas of the Center

Define Goal
Increase research activity in the areas of the Center

Intended Outcomes / Objectives
1. Generate external funding that will contribute to the long term growth and sustainability of the Center. As a minimum, the external funding generated per year by the center faculty should match the state funding.
2. The number of Journal publications and conference presentations will be at least 20 each.

Goal 2. Increase Student Research Activity

Define Goal
Increase Student Research Activity

Intended Outcomes / Objectives

1. Increase the number of MS and Ph.D. graduates in the strategic research areas of the Center by 25% during the next three years.
2. Support at least two undergraduate research projects per year in the areas related to energy systems.

Goal 3. Increase Collaborative Research

Define Goal
Increase collaborative research

Intended Outcomes / Objectives
Develop and submit two collaborative proposals with interdisciplinary focus. The number of collaborative proposals submitted per year should be at least two per year.

Goal 4. Add Laboratory Facilities

Define Goal
Add laboratory facilities.

Intended Outcomes / Objectives

1. Add equipment/capabilities to Smart Grid Research Laboratory.

Goal 5. Increase Outreach Activities

Define Goal
Increase Outreach Activities.

Intended Outcomes / Objectives

1. Organize a minimum of two seminars by external speakers per year.

Assessment Tool 1: External grants activated

Goal/ Outcome/ Objective: Goal 1 and Goal 3

Type of Tool: Tracking Spreadsheet

Rationale
External grants activated indicate success in bringing funded research into the university, the result of which will benefit students, the scientific body of knowledge as a whole, and the funding source itself by solving some research problem. It does not address the idea that a bigger project may be better or more smaller projects is better but it does give us a general measure to compare progress. Hopefully some of these projects will also represent collaborative efforts but this tool is not a direct metric of collaboration.

Frequency of Assessment: Annually

Assessment Tool 2: Number of Journal Publications and Conference Publications
Goal/ Outcome/ Objective: Goal 1 and Goal 2 and Goal 3
Type of Tool: Tracking Spreadsheet

Rationale
Papers represent the increase in knowledge from research activities. By concentrating on journal and peer reviewed conference papers the quality of the research is acknowledged by peers in the field of study. By examining the list of authors on these publications we can get a measure of the success in the collaboration goal.

Frequency of Assessment: Annually

Assessment Tool 3: Number of M.S. and Ph.D. graduates during the year
Goal/ Outcome/ Objective: Goal 1 and Goal 2 and Goal 3
Type of Tool: Tracking Spreadsheet

Rationale
If the graduates this year took a long time getting their degrees then this measure might not directly correlate to effectiveness in achieving the goals but on average this assessment tool is expected to historically follow the quantity of research achieved in the center. By examining the graduate committee for each student we can get an indication of the amount of collaborative research.

Frequency of Assessment: Annually

Assessment Tool 4: Number of M.S. and Ph.D. students supported by the center during the year
Goal/ Outcome/ Objective: Goal 1 and Goal 2 and Goal 3
Type of Tool: Tracking Spreadsheet

Rationale
While quantity of students may not directly measure the amount or quality of research being conducted by the center, it is generally perceived that statistically this metric will be relevant to the goals.

Frequency of Assessment: Annually

Assessment Tool 5: Number of undergraduate research projects supported

Goal/ Outcome/ Objective: Goal 1, Goal 2, and Goal 3
Type of Tool: Tracking Spreadsheet

Rationale
Often undergraduate student research results in some of the best innovations since the undergraduate is not burdened knowing what can or can't be done. Including this metric with the others is important to assess the total amount of research being conducted by the center.

Frequency of Assessment: Annually

Assessment Tool 6: Number of collaborative proposals submitted

Goal/ Outcome/ Objective: Goal 3
Type of Tool: Tracking Spreadsheet

Rationale
This metric will directly reflect energy expended toward Goal 3. By comparing proposals to activations an effectiveness can ultimately be determined to guide future proposal writing endeavors.

Frequency of Assessment: Annually

Assessment Tool 7: Laboratory projects completed/initiated

Goal/ Outcome/ Objective: Goal 4
Type of Tool: Tracking Spreadsheet

Rationale
The number of new laboratories created, renovated, expanded, etc. will directly affect the research infrastructure making more meaningful, up-to-date research possible.

Frequency of Assessment: Annually

Assessment Tool 8: Number of seminars by external speakers and feedback from faculty and students regarding the usefulness of the seminars.

Goal/ Outcome/ Objective: Goal 5
Type of Tool: Tracking Spreadsheet

Rationale
Seminars are important to inform researchers what the current state of the art is in various research disciplines and provide new contact opportunities to promote collaborative efforts. This tool directly reflects the efforts expended toward Goal 5. The feedback from the faculty and students will directly reflect effectiveness of this effort and guide future efforts.

Frequency of Assessment: Annually

Assessment Tool 9: Number of outreach activities planned for the upcoming year with a list of persons to be invited for the activities.

Goal/ Outcome/ Objective: Goal 5
Type of Tool: Tracking Spreadsheet

Rationale
This assessment tool forces Center administration to be forward thinking about Goal 5 since many of the activities related to this goal must be planned well in advance.

Frequency of Assessment: Annually

Result for Goal 1. Increase research activity in the areas of the center

Goal/Objective/Outcome Number: 1

Results
Increase research activity in the areas of the center

- Generate external funding that will contribute to the long term growth and sustainability of the Center. As a minimum, the external funding generated per year by the center faculty should match the state funding.
- The number of Journal publications and conference presentations will be at least 20 each.

This goal intersects the University Flight Plan's Multidisciplinary Research Innovation sub goal. The creation of the Smart Grid and Resilient Infrastructure focus areas is to foster multidisciplinary research efforts. Even if considered to be primarily one department; getting power engineers, communication engineers, cyber security researchers, etc. to focus on a common laboratory for collaborative efforts has resulted in several collaborative proposals being prepared.

The new Center Focus Areas also intersect the University Flight Plan focus areas to Create Distinctive Programs and Invigorate Faculty. In addition to hosting meetings for each research area to promote collaboration and proposal writing, the Center has initiated several seminars and introductory trips to kick start collaborative research efforts and energize faculty efforts. Trips to ORNL and attending TREEDC at TTU are examples of these efforts.

Following the example of last year's report, of counting only new activations during the calendar year, the new activations during the calendar year 2015 totaled $483,067, which though lower than the goal is higher than the goal set by TBR for the Center. A full listing of activations can be found in the attachments.

The publications listed in the publications attachment can be summarized for the Center's associated faculty by totalling the 119 conference papers and 74 journal articles which handily surpasses the goal of 20 of each type. Note also 10 technical reports and 3 book chapters were completed.

Attachments

- Goal1Results
  - Calendar Year 2015 Activations
  - Faculty Publications CY2015

Results for Goal 2. Increase Student Research Activity

Goal/Objective/Outcome Number: 2

Results

Increase Student Research activity

- Increase the number of MS and Ph.D. graduates in the strategic research areas of the Center by 25% during the next three years.
- Support at least two undergraduate research projects per year in the areas related to energy systems.

This goal intersects the University Flight Plan's New Graduate Programs sub goal. Since the Center now has the Smart Grid and Resilient Infrastructure focus areas, graduate degrees resulting from this focused Center attention will yield more hire-able graduates in these areas of recognized national importance.

The number of M.S. and Ph.D. graduates for the calendar year 2014 can be seen in Table 1. The listing of the graduating students Masters Thesis and the Ph.D. Dissertation topics can be found in the attachment.

Table 1 Graduate Degrees Awarded

	M.S.	Ph.D.
Number of Students	6	3

Though CESR has traditionally focused on graduate research there are several points that can be made about progress toward the Flight Plan focus area for improving the undergraduate student experience. Encouraging faculty to utilize graduate research labs in their undergraduate teaching is the best way to meet this objective.

Seven undergraduate students from a multidisciplinary array of departments conducted research under the umbrella of CESR (see attachment).

Each term the Center has recently had the benefit of working with a Freshman Honors student. Giving these students real projects has been rewarding to the student and the center facilities.

- In fall of 2015 Ashley Hazlett worked on smart grid laboratory protection. She conducted surveys of available relays, initiated communications with relays and tested appropriateness for general protection. She then conducted a survey of the available smart grid meters and together with Robert Craven developed and implemented a smart grid lab protection plan known as the "Meter Rack".

Increasing student research activity can be partially assessed by the support of students. In an attachment you can see lists of students that have been supported by the Center in a number of ways. This support is summarized in Table 2.

Table 2. Students supported by the Center in many ways.

Number of Students Supported by the CESR

during Calendar Year 2014

	B.S.	**M.S.**	**Ph.D.**
Graduates		**6**	**3**
Financial Support			
Assistantships		**17**	**14**
Hourly Student Payroll	**6**	**15**	**12**
Office/Desk and IT/Technical Support		**15**	**8**

In support of the flight plan undergraduate research sub focus area, it is important to note that the Work Study/ Work Scholarship students listed in the attachment were able to participate in the creation of research laboratory facilities as part of their day to day work.

Attachments

- Goal 2 Results
  - CY2015 Student Participation and Awards
  - Graduate Student Office, Desk, and IT Support Calendar Year 2015 March 10 2016
  - Graduated_MS_and_PhD_Students_2015
  - HOURLY STUDENT Calendar Year 2015
  - Undergraduate Student Research May 10 2016 for Calendar Year 2015
- Undergraduate Student Research for Calendar Year 2015

Results for Goal 3. Increase Collaborative Research

Goal/Objective/Outcome Number: 3

Results

Increase Collaborative research

- Develop and submit two collaborative proposals with interdisciplinary focus. The number of collaborative proposals submitted per year should be at least two per year.

This goal intersects the University Flight Plan's Multidisciplinary Research Innovation sub goal. The recently granted Autonomous drone for transmission line inspection project through the TBR exemplifies this as not only integrating multiple mechanical and electrical engineering researchers from TTU but also reaching out and collaborating with MTSU researchers with drone expertise.

The collaborative proposals listed in the Attachment include 11 proposals with an internal to TTU collaborative aspect, 4 with collaborations with an external to TTU component. There were also 4 project activations with a collaborative component. Four other collaborative efforts are listed consisting of visiting scholars including a Fulbright scholar. This level of collaborative effort readily meets the Center's goal.

Attachments

Goal 3 Results

Calendar Year 2015 Collaboration Efforts CESR

Results for Goal 4. Add Laboratory Facilities

Goal/Objective/Outcome Number: 4

Results

Add Laboratory Facilities

• Smart Grid Research Laboratory - Renovations Complete

• Battery lab facility - Complete

This goal intersects the University Flight Plan's Physical Infrastructure Priorities sub goal and the Technology Service to Students sub goal, and the Technology in Teaching sub goal. Better facilities in areas of national importance like the Smart Grid benefit research, education, and hire-ability of our graduates.

At the end of Calendar year 2015 the Smart Grid Research Laboratory renovation was completed. The Battery lab complete with a side project initiated to meet chemical fume hood requirements of the researchers involved with the laboratory space which was also complete. The center has supported Dr. Indranil Bhattacharya in the establishment of a world class battery research laboratory. PRSC 112 now has the necessary equipment for a 17 step production of modern batteries. Students are vigorously pursuing mastering and advancing this technology.

Renovation of PRSC 227 as a conference room where it can serve as a meeting place for the Smart Grid and Resilient Infrastructure researchers as well as serve the college as a whole. The adjacent room was established as a showcase for 3D printing. This project is complete.

The fume hood project for PRSC 452 is complete.

After facilities finished the renovation of CLEM 103 the real work began and was ongoing at the end of calendar year 2015. Moving the Center's microgrid test bed, Dr. Belkacemi's power grid test bed, the Center's Real Time Digital Simulator (RTDS), and the industrial relay laboratory, all found a new home in the Smart Grid laboratory and work to integrate them into a functional laboratory was began.

Attachments
No items to display.

Results for Goal 5. Increase Outreach Activities

Goal/Objective/Outcome Number: 5

Results
Increase outreach activities

- Organize a minimum of two seminars by external speakers per year.

This goal intersects the University Flight Plan's Co-Curricular Undergraduate Program sub goal and the Multidisciplinary Research Innovation sub goal. By having research area experts from outside the university come teach seminars, workshops or short courses the students will be exposed to a broader base of information and hopefully promote collaborative efforts from TTU researchers with those at other institutions.

The 7 seminars presented in 2015 are listed in the Attachment. Participation with ORNL in an Energy Water Nexus series of workshops has begun in 2015, meetings with EPRI both here and there, Participation in a TREEDC visit to TTU campus.

Attachments

Goal 5 Results

CY2015 Seminars and International Activities

Modifications and Continuous Improvement Goal 1

Goal/Objective/Outcome Number: 1

Program Changes and Actions due to Results
No changes - continue with three year averages of assessments.

Link to Assessment

Link to Flight Plan:

Modifications and Continuous Improvement Goal 2

Goal/Objective/Outcome Number: 2

Program Changes and Actions due to Results
No changes - continue with current assessments.

Link to Assessment

Link to Flight Plan: Improve Undergraduate Student Experience

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Modifications and Continuous Improvement Goal 3

Goal/Objective/Outcome Number: 3

Program Changes and Actions due to Results
No change - continue with current assessments.

Link to Assessment

Link to Flight Plan: Multidisciplinary Research Innovation

Modifications and Continuous Improvement Goal 4

Goal/Objective/Outcome Number: 4

Program Changes and Actions due to Results
Now that the laboratories from last year are complete, we will spend the next year making improvements to the Smart Grid Laboratory. A solar installation outside Clement Hall will be pursued.

Link to Assessment

Link to Flight Plan: Physical Infrastructure Priorities

Modifications and Continuous Improvement Goal 5

Goal/Objective/Outcome Number: 5

Program Changes and Actions due to Results
The outreach of seminars and invited speakers will continue. The workshop/short course will be dropped for now and reconsidered at a future time.

Link to Assessment

Link to Flight Plan: Create Distinctive Programs and Invigorate Faculty