ENERGY INITIATIVE

Current Energy Capabilities Survey & Analysis and Proposed Energy Educational Initiatives

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Internal Energy Research Assessment: Executive Summary

Summary of Charge:

At the direction of the Vice President of Research & Economic Development this assessment was begun to determine LSU’s current energy research capabilities and opportunities.

The Vice President established a committee that includes representatives from LSU colleges/schools as well as the library and is chaired by David Dismukes, Executive Director of the Center for Energy Studies. The charge to the committee was to review the scope and extent of energy-related research at LSU, develop a comprehensive review of the various energy-related assets at LSU (infrastructural and educational), develop a prioritized list of areas of strength at LSU, identify areas where LSU has special strengths that can catapult us into leadership positions, identify approaches in the strength areas that LSU can build on further, and develop an inventory of various opportunities (federal, state, and private) where LSU can be competitive.

In late 2014, the group identified LSU’s current energy-related research activities and funding levels after surveying major units and colleges and reviewing research project funding undertaken by the Office of Sponsored Programs. Results show that LSU’s energy-related research is impressive and spans a wide range of topics, including upstream oil and natural gas drilling and production topics (including hydraulic fracturing), geology, solar, wind, biomass, geothermal, materials, efficiency, electrical conductivity, nuclear, environmental impacts, and socioeconomic impacts. Annual LSU energy-related research funding is estimated to have averaged from between $1.2 million to $14 million per year over the past seven years. Total energy-related funding for the past seven years is estimated to total $97.9 million over 153 separately identified projects.

Findings:

a. Infrastructure and Opportunities:
   - 75 percent of LSU’s energy research funding comes from federal sources. Industry sources rank as the second-largest energy research funding source with 11 percent of the funding. There is an opportunity to diversify across potential funding sources.
   - Most of LSU’s energy research funding is in renewables and environmental issues (62 percent), not fossil fuels, which comprises 15 percent of the funding. There is an opportunity to increase our fossil fuel research funding levels.
   - The College of Agriculture and the LSU AgCenter (collectively Agriculture) and College of Engineering (Engineering) are the largest recipients of funding for energy research. The Center for Energy Studies as well as the School of the Coast & Environment are also funded with energy research dollars. There is an opportunity to increase funding levels in the E. J. Ourso College of Business and the College of Science.
   - Cumulative energy research funding over the past seven years has been concentrated in three large projects ($41.4 million, 45 percent). LSU needs to diversify and build up smaller/moderate-sized projects to avoid “cyclical” problems.
   - There is an opportunity to push more interdisciplinary energy research projects to improve scope and award sizes and to improve research funding and topical diversity.

b. Educational:
   - Development of a comprehensive and cohesive energy educational focus
   - The core components of a uniform energy educational program should supplement traditional degree programs in law, business, engineering, environmental sciences, geology and geophysics, and social sciences; should be an interdisciplinary field of study; have limited prerequisites; the educational component should be new courses and not a “repackaging” of existing courses; courses will be timely, practical, and applied
   - The educational initiative will span a number of different areas (undergraduate, graduate, and professional) across a wide range of activities through opportunities such as graduate education, professional education, teaching, mentoring, and network/professional development.
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LSU’s Energy Initiative

Volume 1: Current Energy Capabilities Survey & Analysis

March 25, 2015
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1. Assessment of LSU’s Externally Funded Energy-Related Research

LSU’s current energy-related research activities and funding levels were compiled from an informal survey of each major unit and college. The solicited information has been utilized on an “as given” basis from each of the colleges/units. No attempt was made to review the degree to which the identified projects were, in fact, “energy-related.” The information was, however, compared against a review of research project funding undertaken by the Office of Sponsored Programs (OSP) to ensure funding level accuracy, dates, and other relevant information.

1.1 Overview: LSU Energy Research Areas and Funding Levels

LSU’s energy-related research is impressive and spans a wide range of topics including upstream oil and natural gas drilling and production topics (including hydraulic fracturing), geology, solar, wind, biomass, geothermal, materials, efficiency, electrical conductivity, nuclear, environmental impacts, and socioeconomic impacts. Annual LSU energy-related research funding is estimated to have averaged from $1.2 million to $14 million per year over the past seven years. Total energy-related funding for the past seven years is estimated to total $97.9 million over 153 separately identified projects. Table 1 summarizes LSU’s energy-related funding amounts over the past seven-year period.

### Table 1: Summary of LSU Energy-Related Research by Source

<table>
<thead>
<tr>
<th>Agency/Source</th>
<th>Funding</th>
<th>Percent of Total</th>
<th>Number of Projects</th>
<th>Average Award per Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal</td>
<td>$73,258,813</td>
<td>75%</td>
<td>86</td>
<td>$851,847</td>
</tr>
<tr>
<td>Foundation</td>
<td>$50,000</td>
<td>&lt;1%</td>
<td>1</td>
<td>$50,000</td>
</tr>
<tr>
<td>Higher Education</td>
<td>$786,331</td>
<td>1%</td>
<td>1</td>
<td>$786,331</td>
</tr>
<tr>
<td>Industry</td>
<td>$11,252,717</td>
<td>11%</td>
<td>20</td>
<td>$562,636</td>
</tr>
<tr>
<td>State</td>
<td>$5,711,790</td>
<td>6%</td>
<td>30</td>
<td>$190,393</td>
</tr>
<tr>
<td>Utilities</td>
<td>$320,000</td>
<td>&lt;1%</td>
<td>3</td>
<td>$106,667</td>
</tr>
<tr>
<td>Not identified</td>
<td>$6,548,544</td>
<td>7%</td>
<td>12</td>
<td>$545,712</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$97,928,195</strong></td>
<td><strong>100%</strong></td>
<td><strong>153</strong></td>
<td><strong>$640,054</strong></td>
</tr>
</tbody>
</table>

LSU’s energy-related research dollars come from a variety of sources. The majority of funding is provided by the federal government and entities supported by the federal government, such as the National Science Foundation (NSF). Over the past seven years, federal funds have supported at least 86 (or more than half) of the energy research projects at LSU for a total of $73.3 million in external funding. The implied average award amount is $851,847 per project over this seven-year period. Federal funds account for over 75 percent of LSU’s current external energy research funding and over 56 percent of the 153 identified projects.

Industry-funded projects served as the second-largest component of LSU’s energy research agenda over the past seven years, accounting for 11 percent of total energy-related external funding and about 13 percent of all externally funded energy-related projects. Industry sources provided $11.3 million in financial support for 20 projects. The average award amount for industry-funded projects was $562,636, ranking third in average award per project among all external energy research funding sources. The average award amount for industry-supported energy research was about $200,000 less than the energy research projects supported through higher education, which ranked second in awards per project.
State funding represents the third-largest total source of external funding for energy research at LSU, accounting for $5.7 million over the past seven years. This amount, however, is a relatively small share of LSU’s recent energy research, accounting for only 6 percent of total energy-related external funding. Further, this is a funding source that, like higher education, will continue to be pressured given the current state funding challenges. The average award level for state-funded projects has also been historically very low at about $190,393 per award. This amount is significantly lower than the federal, industry, and higher education average award amounts, which are all in excess of $500,000 per project.

All of the remaining external funding sources (foundations, higher education, and utilities) are relatively small in total dollars terms, estimated at totaling only $1.2 million, collectively, over the past seven years. Interestingly, the average award level for higher education funding is the second highest of any external funding source at $786,331 per project. This is likely an anomaly since only one energy-related project is estimated to have been supported from higher education funding sources during the past seven years.

### 1.2 Analysis of LSU’s Externally Funded Energy Research by Typical Project Size

The total award for an LSU energy-related research project can (subjectively) be defined as “small” (less than $50,000 per award), “medium” ($51,000 to $1 million per award), and “large” (those over $1 million per award). Table 2 summarizes the distribution of LSU energy research projects over these three different funding size categories.

<table>
<thead>
<tr>
<th>Total Project Award</th>
<th>Number of Projects</th>
<th>Percent of Funding</th>
<th>Percent of Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small (&lt;$50K)</td>
<td>$ 659,426</td>
<td>25</td>
<td>1%</td>
</tr>
<tr>
<td>Medium ($50K-$1M)</td>
<td>$ 31,542,760</td>
<td>110</td>
<td>32%</td>
</tr>
<tr>
<td>Large (&gt;1M)</td>
<td>$ 65,726,009</td>
<td>18</td>
<td>67%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$ 97,928,195</strong></td>
<td>153</td>
<td>100%</td>
</tr>
</tbody>
</table>

Small energy research projects (those less than $50,000 per award) account for only one percent of LSU’s recent energy research funding over the past seven years. These small projects, however, account for close to 16 percent of LSU’s recent energy-related research on a total project basis (i.e., 16 percent of all LSU energy research projects are funded at the “small” level). This implies that the average award level for a “small” energy research project is somewhere around $26,377 per project.

The remainder of LSU’s energy research is distributed between medium and large projects. Energy research projects funded at “medium” levels of financial support (between $51,000 and $1 million) account for 32 percent of LSU’s energy research funding over the past seven years. Medium-sized projects, however, account for 72 percent of all projects over the past seven years.

Large energy research projects accounted for well over half (67 percent) of all LSU energy research funding, but only 12 percent of all energy research projects. LSU is estimated to have been awarded more than $65.7 million for 18 large-sized energy research projects over the past seven years. The average award level for these 18 projects, collectively, is around $3.6 million per award.
1.3 Analysis of LSU Externally Funded Research by Topical Area

Louisiana is a major fossil fuel producer and consumer, and LSU’s academic programs that support fossil fuel industries are well-recognized. However, the majority of LSU’s externally funded energy research is not associated with fossil fuels but renewables. Table 3 breaks down LSU’s $97.9 million in energy research funding by topical research area.

Table 3: Summary of LSU Energy-Related Research by Topical Area

<table>
<thead>
<tr>
<th>Topical Area</th>
<th>Funding</th>
<th>Percent of Total</th>
<th>Number of Projects</th>
<th>Average Award per Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>$17,297,166</td>
<td>18%</td>
<td>43</td>
<td>$402,260</td>
</tr>
<tr>
<td>Fossil Fuels</td>
<td>$14,506,904</td>
<td>15%</td>
<td>43</td>
<td>$337,370</td>
</tr>
<tr>
<td>Materials</td>
<td>$18,815,701</td>
<td>19%</td>
<td>25</td>
<td>$752,628</td>
</tr>
<tr>
<td>Renewable</td>
<td>$43,019,831</td>
<td>44%</td>
<td>29</td>
<td>$1,483,442</td>
</tr>
<tr>
<td>Other</td>
<td>$4,288,593</td>
<td>4%</td>
<td>13</td>
<td>$329,892</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$97,928,195</strong></td>
<td><strong>100%</strong></td>
<td><strong>153</strong></td>
<td><strong>$640,054</strong></td>
</tr>
</tbody>
</table>

Note: “Other” includes aerospace, electricity, nuclear and socioeconomic.

LSU’s renewable energy research, estimated at close to $43 million over the past seven years, accounted for almost half (44 percent) of all energy-related research. This funding supported more than 29 different renewable energy research projects with an average award level of $1.5 million per project.

Materials science–based energy research accounted for close to $19 million, or 19 percent, of LSU’s total energy research funding over the past seven years. LSU secured over 25 materials science–based energy research projects with an estimated average award level of $752,628 per project.

Research associated with energy and the environment is estimated to be the third-largest research topic, accounting for close to $17 million in externally funded energy projects over the past seven years. Interestingly, there have been the same number (43) of externally funded environment-related energy research projects over the past seven years as there have been projects associated with fossil fuels.

The average award level for energy research projects focused on energy and the environment is $402,260 per award: an amount considerably lower than renewable energy ($1.5 million per project) and materials science ($752,628), but one comparable to fossil fuel–oriented research. Thus, in what may come as a surprise to some, LSU’s three largest areas of energy-related research are in renewable energy (in total funding levels), energy and the environment, and fossil fuels (in terms of total number of projects funded).

LSU has been awarded more than $14.5 million in fossil fuel–oriented energy research over the past seven years. While this amount may seem low relative to other topical areas, the same number of fossil fuel–oriented research projects have been externally funded as energy and the environment projects (43 projects). The average award level for a fossil fuel–oriented research project is $337,370 per project: a level comparable to projects funded on topics related to energy and the environment.

1.4 Analysis of LSU’s Externally Funded Energy Research by Major Funding Source

Table 1 indicated that federal funding is the largest source of external financial support for LSU’s energy research over the past seven years. This funding, analyzed in Table 4, comes from a variety of different federal agencies and other federal sources.
Table 4: Summary of LSU Energy-Related Research Supported by Federal Sources

<table>
<thead>
<tr>
<th>Federal Agency</th>
<th>Funding</th>
<th>Percent of Total</th>
<th>Number of Projects</th>
<th>Average Award per Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOE</td>
<td>$21,861,561</td>
<td>30%</td>
<td>8</td>
<td>$2,732,695</td>
</tr>
<tr>
<td>DOI</td>
<td>$3,367,852</td>
<td>4%</td>
<td>16</td>
<td>$210,491</td>
</tr>
<tr>
<td>DOL</td>
<td>$1,253,000</td>
<td>2%</td>
<td>1</td>
<td>$1,253,000</td>
</tr>
<tr>
<td>DOT</td>
<td>$2,162,000</td>
<td>3%</td>
<td>2</td>
<td>$1,081,000</td>
</tr>
<tr>
<td>EPA</td>
<td>$2,067,505</td>
<td>3%</td>
<td>3</td>
<td>$689,168</td>
</tr>
<tr>
<td>GSA, NRC, USGS</td>
<td>$1,977,113</td>
<td>3%</td>
<td>13</td>
<td>$152,086</td>
</tr>
<tr>
<td>NASA</td>
<td>$2,132,129</td>
<td>3%</td>
<td>3</td>
<td>$710,710</td>
</tr>
<tr>
<td>NOAA</td>
<td>$1,803,615</td>
<td>2%</td>
<td>3</td>
<td>$601,205</td>
</tr>
<tr>
<td>NSF</td>
<td>$9,453,723</td>
<td>13%</td>
<td>29</td>
<td>$325,990</td>
</tr>
<tr>
<td>USAF</td>
<td>$1,060,931</td>
<td>1%</td>
<td>2</td>
<td>$530,466</td>
</tr>
<tr>
<td>USDA</td>
<td>$26,119,384</td>
<td>36%</td>
<td>6</td>
<td>$4,353,231</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$73,258,813</td>
<td>100%</td>
<td>86</td>
<td>$851,847</td>
</tr>
</tbody>
</table>

The U.S. Department of Agriculture (USDA) is the largest single source of federal financial support for LSU’s energy research. Over the past seven years, the USDA has funded more than $26 million in energy research, mostly in the area of renewable fuels research being conducted by the LSU College of Agriculture and the LSU Agricultural Center (AgCenter). This funding represents 36 percent of all federal research support for LSU’s energy research efforts. The USDA has funded six major renewable energy-related research projects, for an estimated average award of $4.3 million per project. USDA support has clearly been LSU’s largest and most profitable source of external funding for energy-related research.

The U.S. Department of Energy (DOE) and the National Science Foundation (NSF) are the second- and third-largest sources of federal financial support for LSU’s energy research. Over the past seven years, LSU has received almost $22 million from DOE and more than $9 million from NSF for energy research. The DOE has funded eight different projects for an average award amount of $2.7 million per project. NSF has funded 29 different projects for an average funding level of around $325,990 per project. More importantly, NSF supports the largest number of energy-related research projects (29 projects) relative to all external funding sources (federal, state, industry, etc.).

As noted earlier in the discussion of Table 1, industry ranks as the second-largest source of external funding for LSU’s energy research. Table 5 breaks down the major industries that have supported LSU’s energy research on a project-specific basis over the past seven years. This industry support, as noted earlier, is estimated to have totaled close to $11.3 million and supported 20 projects over the past seven years. Table 5 clearly shows that industry funding for energy research projects at LSU has come primarily from large integrated energy companies and industry groups comprised, at least in part, by large energy producers.
Table 5: Summary of LSU Energy-Related Research Supported by Industry

<table>
<thead>
<tr>
<th>Industry</th>
<th>Funding</th>
<th>Percent of Total</th>
<th>Number of Projects</th>
<th>Average Award per Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Energy Consortium</td>
<td>$1,890,462</td>
<td>17%</td>
<td>1</td>
<td>$1,890,462</td>
</tr>
<tr>
<td>BP</td>
<td>$1,456,203</td>
<td>13%</td>
<td>4</td>
<td>$364,051</td>
</tr>
<tr>
<td>Chevron</td>
<td>$2,759,583</td>
<td>25%</td>
<td>3</td>
<td>$919,861</td>
</tr>
<tr>
<td>Shell</td>
<td>$2,172,708</td>
<td>19%</td>
<td>2</td>
<td>$1,086,354</td>
</tr>
<tr>
<td>Other</td>
<td>$2,973,761</td>
<td>26%</td>
<td>10</td>
<td>$297,376</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$11,252,717</strong></td>
<td><strong>100%</strong></td>
<td><strong>20</strong></td>
<td><strong>$562,636</strong></td>
</tr>
</tbody>
</table>

Note: "Other" includes ANGA, Cameron Int'l, Enervana Technologies, EXCO Resources, Gold Leaf Energy, InnoVida, LA Tank Inc., Lanza Tech, Mariner Energy, Inc. and RPSEA.

Total funding levels from industry sponsors span a range from $1.5 million to slightly over $2.7 million. While the industry-provided award levels are similar in total, this funding varies, on a per project basis, given the diversity in number of projects supported by industry funds. Chevron, for instance, has provided the largest level of financial support for energy research (at $2.8 million), but that funding has been provided to cover three separate projects for an average award level of less than $1 million per project. Shell has provided over $2 million in financial support for two different research projects at about $1 million each. The Advanced Energy Consortium, however, has provided $1.9 million in funding to support one large energy research project.

State funding is the third-highest source of directly-attributable external support for LSU’s recent energy-related research. This funding comes primarily from state executive agencies, such as the Board of Regents, and accounts for around $5.7 million in research funding. State funding has supported 30 energy-related research projects over the past seven years, and the average award was $190,393. The per-award level for state research projects is the lowest of any major identified source of financial support in the energy research survey.

1.5 Analysis of LSU’s Externally Funded Energy Research by College/Unit

Table 6: Summary of LSU Energy-Related Research by College/Research Unit

<table>
<thead>
<tr>
<th>College/Research Unit</th>
<th>Funding</th>
<th>Percent of Total</th>
<th>Number of Projects</th>
<th>Average Award per Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>$38,642,116</td>
<td>39%</td>
<td>19</td>
<td>$2,033,796</td>
</tr>
<tr>
<td>Art &amp; Design</td>
<td>$2,460,000</td>
<td>3%</td>
<td>1</td>
<td>$2,460,000</td>
</tr>
<tr>
<td>Business</td>
<td>$1,257,973</td>
<td>1%</td>
<td>3</td>
<td>$419,324</td>
</tr>
<tr>
<td>Center for Energy Studies</td>
<td>$4,492,286</td>
<td>5%</td>
<td>33</td>
<td>$136,130</td>
</tr>
<tr>
<td>Coast &amp; Environment</td>
<td>$12,033,649</td>
<td>12%</td>
<td>23</td>
<td>$523,202</td>
</tr>
<tr>
<td>College of Science</td>
<td>$6,328,234</td>
<td>7%</td>
<td>22</td>
<td>$287,647</td>
</tr>
<tr>
<td>Engineering</td>
<td>$32,713,937</td>
<td>33%</td>
<td>52</td>
<td>$629,114</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$97,928,195</strong></td>
<td><strong>100%</strong></td>
<td><strong>153</strong></td>
<td><strong>$640,054</strong></td>
</tr>
</tbody>
</table>

Most of LSU’s energy-related research is conducted by the departments and units within the College of Agriculture and the LSU AgCenter (collectively “Agriculture”) and the College of Engineering (Engineering). Table 6 summarizes total energy-related funding by major college and unit-level research institute over the previous seven years.

Agriculture brought in 39 percent of energy-related research funds ($38.6 million), over 19 projects, for an average award amount of $2 million per project. A large portion of this external support ($25.2 million) was awarded to the Audubon Sugar Institute for renewable fuels and energy crop research.
Engineering has generated the second-largest level of externally funded energy research with over $32.7 million in projects for an average award level of $629,114 per project. A large share of this funding ($12.6 million or 39 percent) is associated with the Energy Frontier Research Center.

The School of the Coast & Environment generated the third-largest level of externally funded energy research at $12 million over the past seven years. This funding has supported 23 projects for an average award level of $523,202 per project. Energy and environmental research includes $8.6 million in the study of oil spill impacts and clean-up (including dispersants and oil characteristics), as well as $2 million for the study of ecosystems near offshore oil rigs. This suggests that over 80 percent of the School of the Coast & Environment–related energy research over the past seven years has been related to a one-time event (i.e., the Deepwater Horizon accident).

Various other units have generated between $1 and $6 million in external funding. The College of Science is estimated to have generated over $6.3 million for 22 different energy-related research projects. The Center for Energy Studies (CES), and its component units (including the Louisiana Geological Survey or LGS), has been awarded approximately $4.5 million in externally funded research for 33 projects, which is more research projects than the School of the Coast & Environment. The School of Art & Design has one major energy research project that includes $2.46 million for the Coastal Sustainability Studio. Lastly, the E. J. Ourso College of Business reported three energy-related research projects totaling $1.2 million over the past seven years.

Table 7 has been provided to put some perspective on the level of energy research funding relative to the size of the college or unit under consideration. The results provide a different light on the comparative magnitude of each college’s/unit’s energy research efforts. For instance, the CES has generated approximately $4.5 million over the past seven years, which accounts for only 5 percent of LSU’s total externally funded energy research. However, this level of effort is 230 percent of that unit’s FY2014-2015 budget.

<table>
<thead>
<tr>
<th>College/Research Unit</th>
<th>Budget (FY 2014/15)</th>
<th>Research Funding (2007-2014)</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>$7,488,438</td>
<td>$38,642,116</td>
<td>516%</td>
</tr>
<tr>
<td>Art &amp; Design</td>
<td>$6,945,356</td>
<td>$2,460,000</td>
<td>35%</td>
</tr>
<tr>
<td>Business*</td>
<td>$16,999,443</td>
<td>$1,257,973</td>
<td>7%</td>
</tr>
<tr>
<td>Center for Energy Studies</td>
<td>$1,953,889</td>
<td>$4,492,286</td>
<td>230%</td>
</tr>
<tr>
<td>Coast &amp; Environment</td>
<td>$6,201,707</td>
<td>$12,033,849</td>
<td>194%</td>
</tr>
<tr>
<td>College of Science</td>
<td>$37,172,392</td>
<td>$6,328,234</td>
<td>17%</td>
</tr>
<tr>
<td>Engineering</td>
<td>$23,035,977</td>
<td>$32,713,937</td>
<td>142%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$99,797,202</strong></td>
<td><strong>$97,928,195</strong></td>
<td><strong>98%</strong></td>
</tr>
</tbody>
</table>

*State operating budget FY2013/14

The AgCenter and College of Agriculture had the largest amount of energy research funding over the last seven years compared to its current state fiscal budget (516 percent), followed by CES (230 percent), School of the Coast & Environment (194 percent), and College of Engineering (142 percent).

2. Major Energy Research Initiatives

2.1 Introduction

LSU’s energy-related research efforts involve several disciplines that cover a wide range of topics. While the university and the state have historically been closely associated with the oil and gas industry, a large number of research projects and initiatives currently address renewable and alternative sources of energy in an effort to utilize our region’s vast renewable natural resources.
Leading the renewables effort are scientists with the LSU Agricultural Center (AgCenter) and the College of Agriculture who study the conversion of sugarcane and sweet sorghum into biochemicals and examine the economic viability of converting biomass to biofuels and bioenergy.

The interrelationship between energy and the environment dominates the energy-related research by faculty in the School of the Coast & Environment. The 2010 Deepwater Horizon incident prompted urgent and relevant inquiries into the sustainability of coastal communities and the environment along the Gulf Coast. Researchers have investigated the fate and distribution of hydrocarbons after an oil spill and their impacts on animal and plant life in and along the Gulf.

The energy-related research focus of both the College of Engineering and the Center for Energy Studies tend toward issues involving conventional oil and gas, power, materials, efficiency, and nuclear energy. Other disciplines not commonly associated with energy research, such as the College of Art & Design and the Paul M. Hebert Law Center, have addressed the challenges of coastal restoration, flood protection, and energy law.

This section provides an overview of the major energy research initiatives at LSU that have been in progress for at least the past five years.

2.2 Recent Major Energy Research Initiatives

2.2.1 Sustainable Bioproducts Initiative (LSU AgCenter): In 2011, the LSU AgCenter was awarded a five-year, $17.2 million grant from the U.S. Department of Agriculture to develop a faster, economically viable process for creating biofuels from sugar cane and sweet sorghum. The goal is to create a year-round rotation of crops that not only generates fuel but that does so at a cost comparable to traditional gasoline. The Sustainable Bioproducts Initiative (SUBI) involves a team of university and industry partners, led by the LSU AgCenter, studying the regular production of biomass for economically viable conversion to biofuels and bioenergy using existing refinery infrastructure. Through new and existing industrial partnerships, the project will use energy cane and sweet sorghum to help reinvigorate the Louisiana sugar and chemical industries. Project objectives include determining dollars per acre to be sustainably earned by a farmer for each feedstock and studying dollars per gallon of fuel (or per pound of chemical) paid by the consumer.

The project will expand the southern regional agricultural sector by utilizing sweet sorghum and energy cane to produce butanol, gasoline, isoprene, and byproduct chemicals. If successful, the project will contribute significantly to improving rural prosperity and job creation in the region.

2.2.2 Louisiana Institute for Biofuels and Bioprocessing (LSU AgCenter): The Louisiana Institute for Biofuels and Bioprocessing (LIBBi) is a Board of Regents research, education, and outreach initiative designed to serve as a source for reliable science-based information to support planning and decision making by emerging biofuels and bioprocessing industries in the state. Many of Louisiana’s agricultural products, including crops, livestock enterprises, and forest species, have the potential to be used as raw material in fuel and chemical enterprises. The institute links Louisiana’s agricultural base with emerging bioenergy initiatives, thereby expanding and strengthening local, state, and regional economies.
LIBBi faculty represent the Audubon Sugar Institute; Biological and Agricultural Engineering; Plant, Environmental and Soil Sciences; Renewable Natural Resources; Agricultural Economics and Agribusiness; and the Sugar Research Station. LIBBi’s objectives are to:

- Develop economically and ecologically viable technologies to produce biofuels, polymers, and specialty chemicals from agricultural crops and forest species in Louisiana
- Prioritize directions for biofuel and bioprocessing efforts to ensure sustainability and compatibility with Louisiana agricultural industries
- Facilitate information exchange and foster collaboration among stakeholders at all levels
- Deliver technical expertise and science-based information to industry clientele, policymakers, and the public
- Provide training and educational opportunities for professionals in emerging biofuels and bioprocessing industries

2.2.3 Energy Frontier Research Center (Chemical Engineering): In 2009, the U.S. Department of Energy’s Office of Basic Energy Sciences established a $12.5 million Energy Frontier Research Center (EFRC) at LSU’s Gordon A. and Mary Cain Department of Chemical Engineering. LSU’s EFRC, the Center for Atomic-Level Catalyst Design (CALCD), is one of 46 such centers located at universities, national laboratories, and nonprofit organizations across the U.S. Under the direction of James J. Spivey, professor of chemical engineering, the LSU CALCD studies methods for modeling catalytic reactions using advanced computational tools, including those at LSU’s synchrotron radiation facility, the Center for Advanced Microstructures and Devices (CAMD), to synthesize and characterize new nanostructured catalysts.

The center’s research efforts combine the expertise of computational theorists, surface scientists, and experimental experts to simulate, synthesize, and characterize atomically precise catalysts with the goal of advancing the emerging field of computational catalysis with experimental and spectroscopic methods to develop new materials that can help provide clean energy.

The LSU team of researchers includes faculty from Chemical Engineering, Chemistry, Physics, Astronomy, and CAMD, as well as scientists and engineers from other institutions, including Clemson University, Texas A&M, the University of Florida, Louisiana Tech University, Grambling State University, Tulane University, Georgia Tech, Pennsylvania State University, the Oak Ridge National Laboratory, the Institute of Applied Physics in Austria, and Utrecht University in the Netherlands. The Center for Atomic-Level Catalyst Design also includes approximately 50 graduate students and postdocs.

DOE funding spanned 2009 through 2014, and the Louisiana Board of Regents provided $940,000 in additional support.

CALCD is working in three main areas (synthesis, characterization, and computation). Projects include the following:

- Synthesis of atomically precise metal cluster catalysts
- Characterization of metal nanostructures and complex catalysts
- In situ study of CO\textsubscript{2} reduction
- Use of ordered porous support materials to study 3D-supported catalysts
- Density derived electrostatic and chemical (DDEC) method
- DFT+U method applied to transition-metal-doped CeO\textsubscript{2} catalysts
- Development of COMB potentials for hydrocarbon-Cu/ZnO interactions.
Recent developments include chip-based reactors for the synthesis of ultra-small copper nano-clusters, nanostructured mixed rare earth oxides (for removal of sulfur and tar from coal or biomass-generated synfuel), the first use of single-crystal electrodes for in situ FTIR (Fourier Transform Infrared Spectroscopy) analysis of CO$_2$ reduction, and using density functional theory to handle the complexities of catalytic materials/systems.


Future directions for CALCD research include 1) developing ways to retain atomic precision of catalysts on conventional oxides; 2) understanding, designing, and synthesizing novel efficient catalysts; and 3) isolating individual modeling features to analyze impact on catalytic mechanisms and optimal catalyst performance.

2.2.4 Gulf of Mexico Research Initiative Oil Spill Grants (School of the Coast & Environment and others): In late 2014, the Gulf of Mexico Research Initiative (GoMRI) announced its second round of BP-funded consortium research grants to study the effects of the Deepwater Horizon oil spill. One of the projects is the first GoMRI-funded study of the oil spill’s impact on human health and coastal communities. Matthew Lee, LSU sociology professor and senior associate vice president for research, is the lead co-principal investigator for the project. Since 2010, LSU researchers have collected data on the mental and physical health impacts of the oil spill on residents in coastal Louisiana. LSU will receive $1.2 million from GoMRI to continue this research as part of the **Consortium for Resilient Gulf Communities** project. This consortium, which consists of experts from RAND Corporation, Tulane University, Louisiana Public Health Institute, the University of South Alabama, and LSU, received $8 million to extend the research to the Gulf Coast communities that were impacted most directly by the oil spill. Researchers will survey a large but targeted geographical region in order to collect an array of information on demographically diverse coastal communities and a variety of coastal industries.

The **Coastal Waters Consortium**, composed of researchers from LSU and 13 other institutions under the leadership of the Louisiana Universities Marine Consortium (LUMCON), received $16.1 million to expand its research on the impacts of petroleum pollution on the marine and coastal ecosystems. The multi-agency consortium’s research, which includes the work of more than 20 researchers, has evolved to examine how larger scale impacts such as sea-level rise, salinity changes from proposed freshwater diversions, warming temperatures, and changes in animal and plant life will interact with future oiling events. Additionally, the project will continue its public outreach and education components, which include the training of students from high school through graduate levels. New to this round of research are efforts to reach out to the oil spill response industry. Gene Turner, LSU Boyd professor in the Department of Oceanography and Coastal Sciences, is a Coastal Waters Consortium executive committee member and co-principal investigator on this project.

2.2.5 Center for Energy Studies: The Center for Energy Studies (CES) is an applied research, policy analysis, and public education organization concerned with energy and environmental
problems and issues that are important for Louisiana. CES’s capabilities and experience related to the offshore oil and gas industry and its relationships with Louisiana’s petrochemical industries, pipelines, and other energy producing and consuming facilities are considerable. Since the mid-1990s, the center has produced studies on the history, performance, and socioeconomic impacts of the offshore oil and gas industry for the U.S. Department of the Interior’s Bureau of Ocean Energy Management (BOEM), formerly the Minerals Management Service (MMS). The majority of the center’s projects have been funded through the Coastal Marine Institute (CMI), a funding program created in 1992 by a cooperative agreement between LSU and BOEM. CMI/BOEM investments have been lucrative: From 32 original projects, the center has produced more than 175 related publications and presentations, providing important knowledge and tools for the energy industry, policy makers, and citizens of the state.

Since 2002, CES has produced a significant amount of work on critical energy infrastructure along the Gulf of Mexico (GOM), most notably an outer-continental-shelf-related infrastructure fact book and post-hurricane impact assessment for BOEM. The work, as well as subsequent volumes of related research performed by CES, is regularly used by offshore oil and gas regulators for environmental impact statement purposes prior to any lease sale or major federal offshore regulatory action. This infrastructure research includes an extensive GIS-enabled database that includes information on all types of critical energy infrastructure, such as oil and gas wells, natural gas processing facilities, petrochemical plants, refineries, ports and offshore service bases, platform fabrication yards, heliports, and more. CES possesses geographic information and descriptive statistics on these assets.

Recent notable research includes David Dismukes’s oft-cited study, “Unconventional Resources and Louisiana’s Manufacturing Development Renaissance,” sponsored by America’s Natural Gas Alliance and the Louisiana Oil & Gas Association, which provides an economic overview of the Louisiana manufacturing sector, examines the importance of natural gas to this sector, and shows how the emergence of unconventional resources resulted in a virtual manufacturing investment renaissance in Louisiana. Its findings show that approximately $62.3 billion in new capital investments have been announced in Louisiana and are likely to be developed within the next six years.

Mark Kaiser’s ongoing work on Louisiana’s Haynesville Shale provides economic analyses, production forecasts, and profitability assessments of the unconventional natural gas resource. The internally funded Haynesville research has been featured in a series of articles for the Oil & Gas Journal, a leading petroleum industry weekly publication with worldwide coverage.

CES houses the award-winning Louisiana Geological Survey (LGS), the premier geological research institution in the state of Louisiana. LGS conducts investigations of the surface geology of Louisiana and performs research on the nature and occurrence of oil, gas, and coal in Louisiana and around the world. LGS’s Cartographic Section prepares maps and geographic information systems for its own publication series, other LSU research departments, and several state and federal government agencies through sponsored research. The Cartographic Section has won seven map design awards, including the 2013 award for “Best Reference Map” in the 40th Annual Cartography and Geographic Information Society (CaGIS) Map Design Competition.

The Minerals Processing Research Institute (MPRI) housed within CES facilitates research and public service programs in process research and technology transfer, sustainable development, energy management, energy sustainability, and inherently safer design. Ralph Pike, Paul M. Horton Professor of Chemical Engineering, is the MPRI director. The division’s current research is focused on the development of new processes that utilize biomass resources and of bioprocess-
es that consume carbon dioxide. Cooperative research agreements are in place with Monsanto, Motiva Enterprises (formerly Texaco), and Mosaic (formerly IMC Agrico). This research and technology transfer involves collaboration with process and plant engineers at these and other companies. A parallel effort focuses on efficient use of available energy resources in an industrial setting.

2.2.6 PERTT Lab (Petroleum Engineering): The Petroleum Engineering Research & Technology Transfer Laboratory (PERTT Lab), part of the Craft & Hawkins Department of Petroleum Engineering, represents a $2 million dollar investment by industrial and governmental interests to provide an industrial-scale facility with full-scale equipment and instrumentation for conducting research related to borehole technology. Originally assembled for blowout prevention research and training activities, the PERTT Lab has set the standard for outstanding undergraduate education, with a reputation for practical, hands-on training that prepares innovative future engineers for the workforce. Undergraduate students are exposed to a traditional core curriculum that includes five hands-on laboratory courses and training in advanced computer simulation, along with electives on relevant topics such as natural gas engineering, geothermal energy, and deepwater production.

Faculty in the Craft & Hawkins Department of Petroleum Engineering specialize in geomechanics, fracture modeling, reservoir engineering, reservoir characterization, carbon storage, cement chemistry and durability, enhanced oil recovery, foam and surfactant processes, wettability and interfacial processes, reservoir geology, geostatistics, drilling, well control and blowout prevention, wellbore stability, borehole mechanics, well design, wellbore computational fluid dynamics, environmental technologies, pore-scale flow modeling, and computational methods. Research funding comes mainly from industry and federal grants.

2.2.7 John P. Laborde Energy Law Center (Law Center): In August 2012, the LSU Law Center, with the approval of the LSU Board of Supervisors and the Louisiana Board of Regents, created an academic center for comprehensive instruction and research in energy law. The LSU John P. Laborde Energy Law Center, the first such center in Louisiana and one of a handful in law schools nationwide, will prepare lawyers to address the full range of twenty-first century issues in the complex energy sector and to assume leadership roles in industry, government, nonprofits, and academics.

The Laborde Energy Law Center offers a graduate certificate in energy law and policy, which prepares graduates for complex projects involving teams of interdisciplinary professionals in the energy industry. Coursework includes foundational energy law courses, applied learning experiences, and service with the Laborde Energy Law Center.

2.2.8 Enabling Process Innovation through Computation (College of Engineering): Enabling Process Innovation through Computation (EPIC) is a consortium of internationally renowned experts in the field of multiphase flow science whose research focuses on process innovation in the chemical, materials, energy, environmental, petroleum, and mineral industries. Through its graduate research and course offerings, EPIC provides invaluable career training for engineering professionals.

2.2.9 Nuclear Power Workforce Development Program (College of Engineering, College of Science): In 2009, LSU, in partnership with Entergy Corporation and the Shaw Group, initiated the Nuclear Power Workforce Development Program. A cohesive interdepartmental and intercollegiate effort, the program was created to leverage both industrial and academic support to develop a comprehensive program in Nuclear Engineering, offered by the Department of Mechanical Engineering, and in Health Physics, offered by the Department of Physics and Astronomy.

The funds have supported new faculty member Shahab Mehraeen, assistant professor in the School of Electrical Engineering & Computer Science (ECE), as well as his lab equipment, one
Ph.D. student and two master’s students.

Entergy also donated four power simulators for the ECE’s Power Systems Protection Laboratory for use in the Power Systems Protection class that is currently being taught as a special topics course.

2.2.10 Coastal Sustainability Studio (College of Art & Design, College of Engineering, School of the Coast & Environment): The Coastal Sustainability Studio (CSS) is a transdisciplinary program of the College of Art & Design, College of Engineering, and the School of the Coast & Environment that addresses the challenge of sustaining the ecological, settlement, and economic framework of the Gulf Coast. Under the direction of Jeff Carney, associate professor of architecture, and working in conjunction with the goals of the Louisiana Coastal Master Plan, the CSS approach centers on supporting resilient human communities in the dynamic Gulf of Mexico environment. CSS works to envision and design sustainable systems that reduce vulnerability to increased storm strength, coastal hazards, habitat degradation, and global environmental change.

Graduate and undergraduate students in architecture and landscape architecture frequently participate in CSS supported projects, and several studios and courses have been funded by CSS. Located in a large open space in the Design Building, the studio incorporates training, learning, and demonstration to help educate and train students, staff, and faculty on the principles and practice of coastal sustainability.

3. Energy Research Infrastructure

3.1 Introduction

LSU’s energy-related research infrastructure includes more than 30 laboratories and resource centers that address six sectors: oil and gas, petrochemical and industrial, power, energy efficiency, alternative and renewable, and environmental. The range of resource types includes full-scale industrial equipment, computer visualization software, biochemical laboratories, nanotechnology resources, reference libraries, and repositories.

Table 8 shows the areas of energy research addressed by several research centers. Library collections, centers, departments, and consortiums serve as rich sources of research-based information. Table 9 describes these resource offerings. Table 10 summarizes the campus laboratories energy research specializations.

3.2 Research Centers

Table 8: LSU Energy Research Infrastructure: Research Centers

<table>
<thead>
<tr>
<th>Infrastructure Category</th>
<th>LSU Unit</th>
<th>Oil &amp; Gas</th>
<th>Petrochem./Industrial</th>
<th>Elec. Power</th>
<th>Efficiency</th>
<th>Alternative / Renewable</th>
<th>Environ.</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research &amp; Resource Centers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Center for Rotating Machinery</td>
<td>ME</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Center for Turbine Innovation and Energy Research</td>
<td>ME</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy Frontier Research Center / Center for Atomic-Level Catalyst Design</td>
<td>ChemE</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LGS Resource Center</td>
<td>LGS</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pilot Biomass Processing Plant</td>
<td>AgCtr</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LSU Units/Departments: ChemE: Chemical Engineering; ME: Mechanical Engineering; AgCtr.: AgCenter; LGS: Louisiana Geological Survey
3.2.1 Energy Frontier Research Center (Chemical Engineering): LSU is home to one of 46 multi-million-dollar Energy Frontier Research Centers (EFRCs) that pursue advanced scientific research on energy. Five EFRCs, including LSU’s, focus on research into catalysts for energy applications. LSU’s EFRC, the Center for Atomic-Level Catalyst Design (CALCD), is headed by James J. Spivey, J. M. Shivers and C.M. Eidt, Jr. Professor of Chemical Engineering. The center is housed in the Cain Department of Chemical Engineering and relies heavily on LSU’s own synchrotron radiation facility, the Center for Advanced Microstructures and Devices (CAMD), for synthesis and characterization of novel nanostructured catalysts. LSU’s EFRC examines new ways to use advanced computational tools to accurately model catalytic reactions, and thereby provide the basis for the new design of catalysts.

3.2.2 Center for Turbine Innovation and Energy Research (Mechanical Engineering): The Center for Turbine Innovation and Energy Research (TIER), is an interdisciplinary group of researchers from several universities focused on gas turbine technology. TIER’s goal is to improve the performance and reliability of gas turbines for aeroengines and power generation. Faculty include researchers from LSU’s departments of electrical, mechanical, and chemical engineering as well as computer science. Facilities include laboratories for research involving gas turbine combustion, blade cascade for external cooling, rotating heat transfer for internal cooling, microsystems engineering, flow dynamics and control, microfluidics, computational fluid dynamics, fuel cells, and plasma-spray (thermal barrier coatings).

3.2.3 Center for Rotating Machinery (Mechanical & Industrial Engineering): Established in 2000, the LSU Center for Rotating Machinery (CeRoM) is dedicated to state-of-the-art research and development associated with rotating machinery. CeRoM serves the needs of the large industrial based within Louisiana and across the U.S. The center’s R&D activities include the following areas: tribology addressing lubrication, friction, and wear; fatigue and damage analysis; dynamics and vibration analysis of machinery; materials selection; measurement, testing, and sensing; modeling and simulation. These activities directly support improvements in design, manufacturing, diagnostics, reliability, performance, durability, and environmental compliance of vital mechanical systems and components, including but not limited to bearings, seals, gears, turbines, compressors, and generators. Professor Michael Khonsari, Dow Chemical Endowed Chair and Professor of Mechanical Engineering, is the founding director of CeRoM.

3.2.4 Sustainable Bioproducts Initiative (SUBI) (LSU AgCenter): The LSU AgCenter’s Sustainable Bioproducts Initiative (SUBI), launched in 2011, explores production of biomass for cost-effective conversion to bioproducts using the Louisiana chemical and sugar industries’ existing refinery infrastructure. SUBI is funded by a five-year $17.2 million grant from the U.S. Department of Agriculture’s National Institute of Food and Agriculture. The grant is part of a larger USDA effort that funds five multi-faceted research projects with hopes of jumpstarting industries that use regional feedstock to produce alternative fuels. The goal of the AgCenter initiative is to expand the agricultural sector by incorporating energy cane and sweet sorghum, which can be used to make biofuels and biochemicals.

A cornerstone of the grant project is a pilot plant that processes feedstock grown at the AgCenter Sugar Research Station in St. Gabriel and coverts them into syrup that is shipped to industry partners for testing with their processes. The leftover plant material, called lignocellulose, can be chemically treated and placed in water with enzymes to make a solution that can be used as
feedstock juice and boiled into syrup. The lignocellulose can also be burned for steam to power the plant. To help make growing feedstock economically feasible, researchers with the initiative are studying how to produce the crops with low inputs of fertilizers. They are also developing new varieties of energy cane that are suitable for bioproduction, which is a 12-to-15-year process.

3.3 Libraries and Resource Centers

Table 9: LSU Energy Research Infrastructure: Libraries and Resource Centers

<table>
<thead>
<tr>
<th>Infrastructure Category</th>
<th>LSU Unit</th>
<th>Oil &amp; Gas</th>
<th>Petrochem. / Industrial</th>
<th>Elec. Power</th>
<th>Efficiency</th>
<th>Alternative / Renewable</th>
<th>Environ.</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Libraries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy Information and Data Division</td>
<td>CES</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Center for Energy Studies Library</td>
<td>CES</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>LaHouse Resource Center (AgCenter Extension)</td>
<td>AgCtr</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>LSU AgCenter's publications catalog</td>
<td>AgCtr</td>
<td></td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>LSU Libraries</td>
<td>LSU</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Petroleum Geomechanics Research and Application Consortium</td>
<td>PE</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LSU Units/Departments: CES: Center for Energy Studies; AgCtr: AgCenter; PE: Petroleum Engineering.

3.3.1 LSU Libraries: LSU Libraries’ provide grant research, education, and supporting infrastructure. Subject librarians serve all energy-related disciplines at LSU and maintain collections in the fields of chemistry, agriculture, engineering, coast and environment, business, and geology.

LSU Libraries’ infrastructure capabilities include more than 20 energy-related electronic database subscriptions. Its Federal Regional Depository Library is charged with receiving and retaining government publications, including those covering energy. Energy-related purchases in 2013 included 10 print monographs totaling $592.07, and 22 serial subscriptions totaling $16,435.75. The library was awarded a grant to support the digitization of 100 years (1888–1989) of LSU research experiment station publications, which includes energy-related research that took place during that time. The $3,400 grant was funded by the Project Ceres program through the United States Agricultural Information Network.

3.3.2 The Center for Energy Studies Library: The Center for Energy Studies Library provides access to energy information to university researchers and the public sector through reference services and a specialized book collection. The library also houses supporting documents for the center’s statistical databases.

3.3.3 The Center for Energy Studies Energy Information and Data Division: The Center for Energy Studies Energy Information and Data Division provides reference services related to energy research and policy to the academic community, government agencies, non-profit organizations,
business and industry, and the general public. Librarians obtain research studies and legislation related to energy policy at the state and federal levels in response to CES, legislative, and executive branch requests. They monitor and assess print and non-print information resources for their pertinence to energy issues and their applicability to the CES Library collection, which supports the reference services. The division maintains a database of statistics on oil and gas reserves; drilling and production; refining and refined products; electricity generation, cost, and consumption; and energy employment, wages, prices, taxes, and revenue.

Much of the collected energy data can be accessed via the CES website’s Louisiana Energy Data page, which also provides links to other important energy sites, including the U.S. Department of Energy’s Energy Information Administration, the Louisiana Workforce Commission’s Labor Market Information, and the Louisiana Department of Natural Resources’ Strategic Online Natural Resources Information System (SONRIS).

3.3.4 The LSU AgCenter’s Publications Catalog (AgCenter): The LSU AgCenter Online Publications Catalog provides research-based objective information published by AgCenter researchers and extension faculty on topics including energy and the environment, engineering, economics, and water quality.

3.3.5 Petroleum Geomechanics Research and Application Consortium (Petroleum Engineering): The Petroleum Geomechanics Research and Application Consortium (PGRAC) investigates mechanical processes and their interactions that affect hydrocarbon production from the subsurface. Ongoing research includes hydraulic fracturing modelling, hydraulic fracturing in naturally fractured reservoirs, an integrated analysis of hydraulic fracturing treatments, and damage mechanics for rock. PGRAC researchers include faculty and staff from the Craft & Hawkins Department of Petroleum Engineering, the Department of Mechanical and Industrial Engineering and Mathematics. The consortium combines industry input with their ongoing research plans annually to develop key engineering research topics.

3.3.6 LaHouse—Home and Landscape Resource Center (AgCenter): The LaHouse—Home and Landscape Resource Center is a permanent sustainable educational exhibit and outreach program of the LSU AgCenter. LaHouse provides a one-stop source for research-based information on and solutions for the challenges of the Gulf Region climate, natural hazards, and environment. The exhibit house includes four green, high-performance building and foundation systems, three high-efficiency space conditioning systems, and a wide variety of materials, products, and technologies with green, healthy, and low-maintenance characteristics. LaHouse demonstrates Building America, ENERGY STAR, Healthy Home, Green Building, as well as Fortified for Safer Living program guidelines.

3.3.7 Louisiana Geological Survey Resource Center (CES): Founded in 1934 by Act 131 of the Louisiana legislature, the Louisiana Geological Survey (LGS) provides unbiased geological/environmental information to state agencies and other decision-making bodies. Under the direction of State Geologist Chacko John, LGS develops, interprets, and provides information describing the characteristics and distribution of Louisiana’s energy, mineral, water, and environmental resources, with special efforts applied to research into the habitat of hydrocarbons and their
environmentally safe extraction for commercial purposes.

The LGS Resource Center consists of a core repository and log library. Located behind the old Graphic Services building on River Road, the core and log collections are included as part of the LSU Museum of Natural History as defined by the Louisiana Legislature, and the center is the only one of its kind in Louisiana. The core facility has more than 30,000 feet of core from wells mostly in Louisiana. The well log library contains more than 50,000 well logs from various parishes in the state. The LGS Resource Center is available for use by industry, academia, and government agencies, as well as others who may be interested.

3.4 Laboratories and Equipment

Table 10: LSU Energy Research Infrastructure: Labs and Equipment

<table>
<thead>
<tr>
<th>Infrastructure Category</th>
<th>LSU Unit</th>
<th>Oil &amp; Gas</th>
<th>Petrochem. / Industrial</th>
<th>Elec. Power</th>
<th>Efficiency</th>
<th>Alternative / Renewable</th>
<th>Environ.</th>
<th>Other</th>
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3.4.1 Hydraulic Fracturing Lab (Geology & Geophysics and Petroleum Engineering): In 2013, Juan Lorenzo, associate professor of geology & geophysics, and Arash Dahi Taleghani, assistant professor of petroleum engineering, received funding from the Research Partnership to Secure Energy for America (RPSEA) to establish the Hydraulic Fracturing Lab. In the lab fracturing treatments are simulated with the goal of developing advanced methods and techniques for the design and execution of environmentally safe and economically efficient hydraulic fracturing. In the absence of surrounding noise and geological uncertainties, simulated hydraulic fracturing tests will lead to an understanding of the physics of hydraulic fracturing interactions with natural fractures and how these interactions may affect seismic waves recorded by geophones used to convert ground movement into voltage. The lab supplies two major components: small high-frequency sensors that are about 100 times more sensitive than the human ear for precise seismic monitoring and a super computer capable of collecting the large amounts of data that the sensors produce. The lab is designed for conducting research but with more resources could be developed into a teaching lab and incorporated into the senior elective course Unconventional Reservoirs.
3.4.2 Petroleum Engineering Research & Technology Transfer Laboratory (PERTT Lab): Originally assembled for blowout prevention research and training, the LSU Petroleum Engineering Research & Technology Transfer Laboratory (PERTT Lab) is an industrial-scale facility with full-scale equipment and instrumentation for conducting research related to borehole technology and multiphase flow experiments on field-scale tubulars at high pressures. Developed in the early 1980s, the PERTT Lab, also known as the “Well Facility,” represents a $2 million dollar investment by industry and government. The lab houses six wells and associated surface facilities. LSU is the only university in North America that provides students with hands-on training in well control at a full-scale research and training facility. The Donald W. and Gayle A. Keller Well Facility Classroom, opened in 2012, is a 4,300 square foot state-of-the-art facility that features a 60-student classroom and a separate computer lab. Currently, petroleum engineering courses in oil and gas well blowout prevention and field operations are taught in these facilities.

3.4.3 Chevron Reservoir Characterization Lab (Petroleum Engineering): The Chevron Reservoir Characterization Lab in Patrick F. Taylor Hall contains state-of-the-art computers and visualization software for oil and gas reservoir modeling. The lab allows for visualization that is essential for engineers and scientists to study subsurface structures that contain oil, gas, or geothermal energy, or that can be used for CO2 storage. The facility, developed for use in interdisciplinary research and teaching, was funded by Chevron Corporation through the LSU Foundation. The donation is part of Chevron’s University Partnership Program.

3.4.4 Enhanced Oil Recovery Lab (Petroleum Engineering): The Enhanced Oil Recovery (EOR) Laboratory in the Craft & Hawkins Department of Petroleum Engineering has been the center of the department’s experimental research activities in the areas of flow through porous media, fluids phase behavior, and gas injection EOR. The EOR lab includes high-pressure 6-foot horizontal and 6-foot inclined coreflood systems that flow a fluid (gas or liquid) through a core sample at a controlled pressure and temperature, and measure or monitor flow parameters. These systems are used to develop, evaluate, or prove concepts in the laboratory that will improve oil recovery and production in the field.

3.4.5 Geological CO₂ Sequestration Lab (Civil Engineering): The Geological CO₂ Sequestration (GCS) Laboratory facility is designed to help researchers understand the process of injecting carbon dioxide (CO₂), captured from an industrial or energy-related source, into deep subsurface rock formations for long-term storage. The lab includes high-pressure pumps (~5,000 psi), a high-pressure transparent chamber system, high-pressure microfluidic models, temperature controller, high pressure / temperature interfacial tension measurement, contact-angle measurement, and a high resolution microscope.

3.4.6 Wind Tunnel Laboratory (Civil Engineering): The Wind Tunnel Laboratory, part of the Center for Turbine Innovation and Energy Research, includes two low-speed wind tunnels. One is
capable of aerodynamic studies, while the other is modular for either aerodynamic or boundary-layer (wind-engineering) studies. The facility can be used for wind energy harvesting tests and wind turbine related tests.

3.4.7 Electric Machines Laboratory (Electrical & Computer Engineering): The Electric Machines Laboratory, part of the Electric Machine Design course (EE 4422), is equipped with the four major types of electric machines: DC machines, induction machines, synchronous machines, and transformers, as well as dynamometers. The lab provides variable and constant AC and DC supply and meters to measure voltages, currents, power, and speed. Students can perform several experiments to determine the DC and AC machine electromechanical characteristics, analyze the machine’s performance under variable supply, and load in steady-state conditions. Students learn how to wire the measurement stand, perform the experiment applying variable supply voltage and variable load, and study the performance of electric machines in steady-state conditions.

3.4.8 Smart Grid and Renewable Power Laboratory (Electrical & Computer Engineering): The Smart Grid and Renewable Power Laboratory: Control and Protection, under development in the fall of 2014, will provide a real power system for educational and research purposes. The power system is a lab version of the IEEE 14-bus five-generator power system, equipped with power system essential components such as controllable synchronous generators, transmission lines, and loads. The lab will feature renewable energy sources, including solar cells and smart grid components with communication and storage capacity. The equipment will allow for the analysis of current power system designs as well as emerging technologies, such as micro grids, intermittent renewable energy sources, and smart grids that will be fully implemented by utilities in the near future. The lab will support coursework at the undergraduate and graduate levels, and students working on research and course projects.

3.4.9 Built Environment Informatics Studio (Construction Management): The Built Environment Informatics Studio (BEIS) is equipped to support live interactions, such as video conferencing at building, industrial, or highway construction sites using remote video and sensing technologies. Housed in the Bert S. Turner Department of Construction Management, the lab provides a state-of-the-art analytic and visualization environment, enabling energy and environmental impact research on building energy simulation and performance analysis, human behavior and energy consumption, and high performance buildings.

3.4.10 Biogasifier/Green Energy Lab (Biological and Agricultural Engineering): In 2007-2008, the former auto mechanic shop/motor pool building was converted to the Green Energy Lab by Biological & Agricultural Engineering professor Chandra Theegala and several College of Engineering undergraduate students. Energy saving features of the lab include a super-high-efficiency geothermal-assisted heat pump, 22 SEER inverter-based heat pump, solar water heater, LED lighting, solar light tubes, and a photovoltaic/battery system. The lab also features a patented gasifier capable of producing heat and electricity from wood pellets, a patent-pending dairy-manure/sand separator, a convection solar dryer, a hammermill/pellet mill that converts waste biomass (including office paper and agricultural wastes) to fuel/ fertilizer pellets, a novel multi-stage algal harvesting system, a computer-automated light-optimization setup that may serve as a basis for producing algal lipids at two to three times DOE’s 2018 target, a senior-design built wind turbine for low wind speed areas, and a mini-version of the patent-pending oil-water separator that was covered by CNN Live in 2010.
3.4.11 **Audubon Sugar Institute (AgCenter):** The Audubon Sugar Institute conducts laboratory and pilot-scale research on potential alternative fuels. Institute researchers are producing ethanol from sugars and biomass at raw-sugar mills and using starch-based products to produce butanol to investigating the technical feasibility of the supplemental production of ethanol from algae. The technology closest to commercialization after biodiesel is the production of ethanol from sweet sorghum and sugarcane bagasse. The facility includes a pilot biomass processing plant, traditional sugarcane processing equipment for biomass handling and processing, and laboratory and field equipment to support and expand its research and educational programs.

3.4.12 **Cartographic Section of the Louisiana Geological Survey (CES):** The Cartographic Section of the Louisiana Geological Survey (LGS) specializes in the compilation, design, and production of maps, technical and desktop publications, and geographic information systems products utilizing the latest electronic publishing and pre-press software. LGS-produced maps include Oil & Gas Map of Louisiana, Louisiana Shoreline Change 1937–2000, and the State Map of Louisiana.

3.4.13 **Environmental Sciences Labs (School of the Coast & Environment):** The Department of Environmental Sciences in the School of the Coast & Environment occupies approximately 22,000 square feet in the Energy, Coast & Environment Building. All laboratories are equipped with state-of-the-art equipment for environmental research.

The Aquatic/Industrial Toxicology Lab is a state-of-the-art laboratory addressing state and industry soil, water, groundwater, and air pollution problems. The focus of the laboratory is international, namely addressing problems associated with industrial effluents, contaminated groundwater, and hazardous wastes in riverine environments.

The Environmental Law and Regulation Lab supports research and graduate education involving environmental law, international environmental law, oil spill natural resource damage assessment, and ocean/coastal law research (including legal research on a Louisiana ocean policy, coastal restoration efforts, and local coastal management programs). The lab hosts three computer workstations for graduate students and informal space for graduate meetings, and maintains a set of documents related to environmental law and regulation and legal research, including journals, state and federal government reports, texts, treatises and other legal materials. Since 2003, the Environmental Law Lab has supported more than $501,000 in external research funding.

The Environmental Policy Lab supports research and graduate education involving environmental policy analysis, program evaluation, and quantitative assessment of social-ecological resilience of coastal communities. The lab houses two computer work stations for graduate students and...
a group meeting space, and serves as a repository of journals, state and federal government reports, and other technical documents related to current research projects. Since 2003, the facility has supported more than $592,000 in extramural research funding.

The Instrument Development Lab, Industrial Toxicology Lab, and NOAA-HAZMAT Lab are three laboratories grouped under Environmental Analytical Chemistry that support research and graduate education in the fate and effects of petroleum hydrocarbons and other organic compounds from spill incidents, and fieldable analytical instrumentation development. The labs have a strong partnership with federal agencies such as the National Oceanic and Atmospheric Administration (NOAA), U.S. Environmental Protection Agency (EPA), and the Bureau of Ocean Energy Management (BOEM). The labs have full sample analysis capabilities as well as an electronics laboratory equipped to design and develop new instrumentation. In addition, the labs have been active in technology transfer of patented technology to the commercial sector.

The Remote Sensing and Geographic Information Science (GIS) Lab supports advanced research and education in environmental remote sensing, GIS, spatial analysis and modeling, and environmental health. The lab currently houses three SUN Ultra 40 work stations, each equipped with dual screens and designed for intensive computing, image processing, simulation, and visualization. In addition, the lab has two Dell file servers, five Dell workstations (one with dual screens), two color laser printers, one large-scale color plotter, a scanner, one laptop, one LCD projector, two GPS systems, and a number of portable storage drives. A variety of statistics, mathematics, computer languages, and neural network and data mining software is also available.

3.4.14 Department of Oceanography & Coastal Sciences Labs (School of the Coast & Environment): The Department of Oceanography and Coastal Sciences (DOCS) is nationally recognized as a center for research on deltaic wetland ecology, sedimentary geology, stratigraphy, sediment transport, and coastal ecology. The Coastal Ecology Group labs allow researchers to find solutions to environmental problems affecting coastal and marine environments, and Wetland Biogeochemistry Group labs support research on the chemical and biological behavior of plant nutrients and toxic substances in wetlands and the environmental impacts of plant nutrients, pesticides, toxic heavy metals, and hydrocarbons in wetlands.

4. Energy Courses and Educational Initiatives

4.1 Overview

LSU offers a number of degrees and minors/concentrations that are relevant to energy issues. Relevant degrees include those in engineering (petroleum, electrical, chemical, agricultural and biological, and mechanical), law, geology, basic sciences, environmental science, and oceanography/coastal sciences. This section highlights some of the specific energy-focused classes and programs.

4.2 Academic Courses

Energy-relevant undergraduate and graduate courses are taught in the areas of fossil fuels, renewable sources, electricity, nuclear energy, and law. While most of these courses relate to oil and natural gas, a number of classes teach the science and economics of renewable resources and electric power grids. Classes also cover the important topic of nuclear radiation safety. The Law Center has numerous energy-related courses. The discussion below groups courses in five general categories: fossil fuels, renewables, electricity, nuclear, and law.

4.2.1 Fossil Fuels: The LSU catalog includes the following courses taught in Engineering, Geology & Geophysics, and other departments.

- Petroleum Engineering
• Prevention of Oil and Gas Well Blowouts (PETE 4060)
• Heat and Mass Transfer in Wellbores (PETE 4084)
• Natural Gas Engineering (PETE 4089)
• Unconventional Reservoirs (PETE 4090)
• Surface Handling of Produced Fluids (PETE 4085)
• Nonthermal Methods of Enhanced Oil Recovery (PETE 7231)
• Thermal Methods of Enhanced Oil Recovery (PETE 7232)
• Chemical Engineering
• Process Economics and Optimization (CHE 3171)
• Chemical Reaction Engineering (CHE 4190)
• Chemical Processing of Nanomaterials (CHE 4272)
• Chemical Reactor Design Methods (CHE 7140)
• Geology & Geophysics
• Geology and the Environment (GEOL 2020)
• Petroleum Geology (GEOL 4044)
• Reflection Seismology (GEOL 4068)
• Sequence Stratigraphy (GEOL 7061)
• Seismic Stratigraphy (GEOL 7062)
• Advanced Basin Analysis (GEOL 7900)
• Petroleum Seismology (GEOL 7900)
• Imperial Barrel Award Seminar (GEOL 7972)
• Thesis research related to industry needs (GEOL 8000)

Other Departments

• Energy and the Environment (ENVS 4261)
• Mathematical Modeling in Energy and Environmental Management (ENVS 7010)
• Petroleum Accounting (ACCT 4501)

4.2.2 Renewables: Courses on renewables are taught in Agricultural Economics, Civil Engineering, Chemical Engineering, Economics, Environmental Sciences, Petroleum Engineering, and the School of Renewable Natural Resources.

• Natural Resource Economics (AGEC 3503)
• Dynamics in Natural Resource Economics (AGEC 7513)
• Special Topics in Civil Engineering (Wind Engineering) (CE 7701)
• Biochemical Engineering (CHE 4260)
• Environmental Economics (ECON 4320)
• Applied Resource Economics (ECON 4325)
• Geothermal Engineering (PETE – not in 2014/15 catalog)
• Forest Resource Economics (RNR 4038)
4.2.3 **Electricity:** Electricity-related courses are offered in Chemical, Mechanical, and Electrical engineering.

- Processing of Advanced Materials (CHE 4270)
- Sensors and Actuators (ME 4683)
- Electric Machine Design (EE 4422)
- Power System Analysis (EE 4430)
- Power System Operation and Control (EE 4445)
- Distribution System Design (EE 4450)
- Semiconductor Devices I: Bipolar (EE 7220)
- Semiconductor Devices II: Field Effects (EE 7222)

4.2.4 **Nuclear:** The Department of Mechanical & Industrial Engineering and the Nuclear Science Minor in the College of Science offer the following courses covering nuclear power and safety:

- Renewable and Nuclear Power Plant Engineering (ME 4663)
- Nuclear Reactor Engineering Design (ME 4953)
- Nuclear Reactor Systems Engineering (ME 4963)
- Fundamentals of Nuclear Radiation Science (NS 4411)
- Environmental Radiological Evaluation and Remediation (NS 4352)
- Nuclear Facility Safety (NS 4570)

4.2.5 **Law:** Courses on energy law are taught at both Environmental Science and the Law Center.

- Natural Resources Law Seminar (LAW 5895)
- Energy Law and Regulation (ENVS 7043, LAW 5220)
- International Environmental Law (ENVS 7046, LAW 5413)
- Mineral Rights (LAW 5205)
- International Petroleum Transactions (LAW 5206)
- Advanced Mineral Law (LAW 5207)
- Selected Issues in Gulf Oil & Gas Development (LAW 5242)
- Climate Change Law (LAW 5414)
- Energy Law Seminar (LAW 5805)
- Oil and Gas Seminar (LAW 5840)

As shown above, a range of energy-related courses are taught at LSU.

4.3 **Educational Initiatives**

Energy-related initiatives include workforce development, worker safety, continuing education, and specializations.

4.3.1 **Workforce Development:** The Petroleum Engineering Research and Technology Transfer (PERTT) Laboratory conducts training at an industrial-scale facility for future oil industry employees. The Donald and Gayle Keller Building provides a classroom and computer lab for professional training. In 2009, in partnership with Entergy Corporation, LSU initiated a Nuclear Power Workforce Development Program. The program includes developing a new curriculum and recruiting students. Support was requested for two nuclear engineering faculty positions in the
Mechanical Engineering. An external advisory committee was formed and will aid in new faculty hire selection, curriculum and internship program oversight, and monitoring students’ progress, job placement, and success in the nuclear energy industry.

4.3.2 Worker Safety: The Nuclear Power Workforce Development Program works in conjunction with the Medical Physics and Health Physics program, which offers classes in radiation protection, exposure evaluation, and nuclear facility safety. LSU’s Continuing Education office offers a Certified Occupational Safety Specialist program for which participants receive a 10-hour Occupational Safety and Health Administration (OSHA) completion card.

4.3.3 Continuing Education: The Mineral Law Institute’s annual symposiums offer continuing education credits for lawyers and other professionals, such as certified engineers and city planners. A large number of sessions at conferences held by the Center for Energy Studies are also registered for continuing legal education. The Department of Petroleum Engineering works with the Society of Petroleum Engineers to offer short courses and continuing education credits, including Professional Ethics for Petroleum Engineers and Mechanical Tubing Forces: Temperature, Ballooning, Piston, and Buckling Effects. The Department of Chemical Engineering offers an online course Essentials of Chemical Engineering for Non-Chemical Engineers.

4.3.4 Specializations and Certificated: The College of Business is launching an Energizing Business initiative in 2016 whereby any interested business student can complete a specialization in energy studies, taking courses such as Energy Economics Policy, Petroleum Accounting, and Product Lifecycle Management (PLM), plus courses offered in the College of Engineering, College of Science, and School of the Coast & Environment. The Graduate Certificate in Energy Law and Policy (the “Energy Certificate”) allows the Paul M. Hebert Law Center to officially recognize students who have demonstrated substantial competence in the study of energy law and related subject matter. It helps prepare participating students for careers in energy law and related fields by ensuring that they take appropriate coursework and providing exposure to relevant applied learning experiences.

5. Energy Outreach and Service Activities

5.1 Introduction
Throughout the year, several centers and departments across campus offer seminars, institutes, and courses, and engage with various communities on topics as varied as sustainable development in the chemical industry, energy efficiency in the home, and the use of supercomputers in advancing process design. Highlighted in this section are some of the university’s most notable outreach efforts related to energy research.

5.2 Outreach and Service

5.2.1 LSU Agricultural Center: The LSU AgCenter carries out the land-grant mission of the LSU
System through research and extension programs. Educational and outreach units that focus on energy include the following:

The Louisiana Institute for Biofuels and Bioprocessing (LIBBi) facilitates information exchange and fosters collaboration among stakeholders; delivers technical expertise and science-based information to industry clientele, policymakers and the public; and provides training and educational opportunities for professionals in emerging biofuels and bioprocessing industries.

The Audubon Sugar Institute, with LSU Chemical Engineering, LSU Biological & Agricultural Engineering, and Southern University Division of Agricultural Sciences, is developing educational opportunities in the areas of sustainable, renewable energy production. These include:

- Undergraduate concentrations in “renewable bioenergy” that will provide cross training to biological and chemical engineering students and give them practical training through summer internships and operational experience at the pilot plant.
- Horticulture summer courses that will build bridges across plant biology and process operations.
- Development of online educational and safety resources in the area of bioenergy conversion technologies.

The concentration streams have been developed by carefully designing and working within existing curriculum structure and making use of the technical electives so that the program can be sustained beyond the time frame of the supporting grant. The program’s effectiveness will be monitored throughout using such metrics as student demand, internship placement, and relevant job placement upon graduation.

LaHouse—Home and Landscape Resource Center is a permanent, sustainable housing exhibit and outreach program that provides research-based solutions for creating an energy efficient, safe, and environmentally sustainable home. The center includes a showcase house with a garage that doubles as a teaching center as well as a mobile display unit and landscaping exhibits. Consumers as well as consultants, inspectors, and builders visit LaHouse during regular business hours for self-guided tours or during seasonal Saturday open houses with set themes and experts on hand. The house exhibits “universal design”—strategically designed to be safe for all ages and levels of mobility—and it demonstrates Building America, ENERGY STAR, Healthy Home, Green Building, as well as Fortified for Safer Living program guidelines.

The AgCenter worked with Southern University’s Division of Agricultural Sciences in Fall 2012 to host a Bioenergy Symposium, which addressed the advances made in the application of technologies for energy recovery from biomass and waste and to encourage discussion on relevant aspects such as the reliability of processes and technologies, full-scale applicability of new processes, technical and economical optimization, and improvement of energy balance. The program included oral sessions, poster sessions, and a small exhibition by companies working in the field.

In 2013 the Ag Center partnered with Southern University’s Center for Energy and Environmental Studies (CEES) to design biofuel and bioen-
ergy activities for CEES’s annual Math, Science and Reading Summer Enrichment Camp. Activities included the following:

- **Bio Fuels (4th–8th grade):** tour of sugar cane processing pilot facility, concentration on use of corn for alternative fuel, and presentation and demonstration of E-Fuel Machines
- **Water/Wind (K–3rd grade and 6th–8th grade):** presentations on the power of water and wind energy (coordinated with Louisiana Universities Marine Consortium)
- **Building Things that Use Energy (4th–8th grade):** presentations by the Port of Greater Baton Rouge, and discussions on sustainability and solar energy (K–3rd grade).

5.2.2 Center for Energy Studies: The Center for Energy Studies frequently organizes and conducts conferences, seminars, workshops, and other public events that provide energy information and analysis to the academic community, public agencies, business and civic groups, and the general public. CES faculty are regularly invited to present research to industry groups and members of state and federal agencies. Local, state and national media frequently seek expert commentary on energy issues from CES researchers.

The Center hosts an annual fall energy conference, Energy Summit™, which addresses current topics in conventional oil and gas. The Fall 2015 Energy Summit™, which attracted a record crowd, was titled “The Future of Louisiana Energy” and featured experts on industrial energy usage and development, regional wholesale power markets, the Haynesville and Tuscaloosa Marine Shale plays, offshore Gulf of Mexico, and energy and the environment.

In 2011, CES hosted an Energy Summit™ entitled “Unconventional Louisiana: Shales, Sands, and Other Opportunities.” The event addressed issues related to unconventional methods in oil and gas exploration and development, including an oil and gas shale overview, industry structure, environmental issues, storage, exporting, and power industry impacts.

Following the BP oil spill, the 2010 Energy Summit™, “Deep Exploration and the Future of the Gulf of Mexico,” examined the importance of deep-water drilling to supply and energy security, as well as market perceptions of changes to deep-water drilling regulation, and public perceptions of spills and offshore activity.

In February 2006, in the aftermath of the 2005 tropical season, CES hosted a workshop titled “Rebuilding Utility Infrastructure: Challenges and Opportunities,” which brought together electric power industry stakeholders to discuss key issues related to infrastructure rebuilding. The workshop emphasized industry’s infrastructure needs, the option of infrastructure hardening, and other states’ experiences in the wake of disasters.

Since 2010, CES has conducted six workshops for the Louisiana Public Service Commission, funded through the American Recovery and Reinvestment Act, on topics including combined heat and power, smart grid technologies, net metering, and renewable technologies.

Other regular CES outreach and education includes a legislative update in the form of a twice-weekly email report to subscribers that tracks energy-related bills proceeding through the legislature. Throughout the year, CES staff respond to public inquiries on local, state, and regional energy topics ranging from home energy efficiency information to oil and gas prices.

5.2.3 LSU Law Center: For two days each spring, the LSU Law Center hosts the Mineral Law Institute, the second oldest annual mineral law symposium in the U.S. The program draws hundreds of oil and gas lawyers, landmen, and energy executives each year to hear presentations made by some of the country’s most prominent mineral law practitioners and scholars. Typically, each speaker prepares a paper that is distributed to attendees and later published in the Proceedings...
of the Annual Mineral Law Institute. In 2014, more than 350 lawyers and landmen attended.

In addition to holding its annual two-day symposium, the Mineral Law Institute publishes a newsletter that summarizes recent Louisiana court decisions relating to mineral law. Twice yearly, the Law Center publishes the Journal of Energy Law and Resources, a law review-style publication that includes articles on a variety of energy law topics, as well as environmental law topics that have a nexus to energy law.

The Law Center has one of the most extensive energy law course offerings in the country.

5.2.4 College of Engineering: The Enabling Process Innovation through Computation (EPIC) Seminar Series, launched in 2013, invites chemical, mechanical, and petroleum engineering students, as well industry employees, to engage with leading researchers from academia and industry on multiphase, multi-scale, and multi-physics processes. EPIC, led by Krishnaswamy “Kumar” Nandakumar, Cain Endowed Chair and professor in the Cain Department of Chemical Engineering, addresses process innovation, energy efficiency, workforce development, and economic development for the energy, chemical, and bioprocess industries.

6. Current Assessment

6.1 Research Assessment

LSU’s energy research performance (as estimated by total research funding only) over the past seven years has been impressive, with total energy-related research funding of around $91.5 million. Equally impressive is that this funding is punctuated by a number of very large, high profile research projects such as the DOE-funded Energy Frontiers Research Center (EFRC), the various DOE/USDA funded biofuels research projects in the AgCenter and College of Agriculture, and, collectively, a number of oil-spill related projects in the School of the Coast & Environment. Despite these significant achievements, there are some areas of concern.

First, LSU’s energy-related research performance comes from one of its earlier-referenced successes: a large concentration (45 percent or $41.4 million) comes from three projects and initiatives: the Audubon Sugar Institute’s biofuels and energy crop research ($25.2 million), Engineering’s Energy Frontiers Research Center ($12.6 million), and the oil spill research by the School of the Coast & Environment ($8.6 million). Clearly, these are significant projects with impressive research. But, these projects are concentrated in a handful of areas and address non-recurring issues or are funded by a one-time set of funds (like the oil spill). This means that maintaining LSU’s high level of energy-based research (as measured in funding levels only) will be very dependent on either maintaining these projects or replacing them with other projects at comparable funding levels.

Inversely, projects that could be thought of as representing recurring/ongoing research activities (those funded at less than $1 million per award and in the one-to-three-year time horizon) represent a smaller share of total research, something that should be examined in evaluating total research funding diversity (see Table 3). Currently, these smaller-scale projects amount to about 30 percent of total funding ($27 million), but 70 percent of the total number of projects (around 100 projects). A large number of these projects are supported by such units as the College of Engineering and CES. Thus, one potential area of emphasis is encouraging and growing the university’s efforts in more “periodic” energy research projects. Such an emphasis could help: 1) diversify total energy funding streams; 2) potentially diversify energy research funding sources (particularly if the sources are non-federal); and 3) position LSU to strike more easily on big-ticket research funding opportunities when they arise.

Second, LSU’s energy research funding is heavily dependent upon the federal government. As noted earlier in this report, around 75 percent of LSU’s total energy-related research funding
comes from federal sources, and even that funding is concentrated in a few projects, like the DOE- and USDA-funded efforts here on campus. If either agency were to discontinue funding, due to a lack of funds or political backlash against biofuels/renewable research, LSU would see a precipitous drop in energy-related research funding.

Third, state-funding for energy-related research is very small relative to other sources, such as industry and the federal government. This problem is likely more a function of state willingness to fund energy research than it is LSU’s ability to develop and propose timely and important energy research topics and proposals. This is paradoxical given that Louisiana is one of the largest energy producing and consuming states in the U.S. Compounding this paradox is the fact that the state often, even in the midst of budgetary challenges, contracts with a number of out-of-state and non-university related entities for projects that could be done at LSU. Policy makers cannot expect LSU and LSU research to serve as the engines of economic growth if they are not committed to providing some fuel from time to time. LSU’s opportunities for expanding its energy research footprint could certainly be enhanced if state commitments, even in the form of some degree of guaranteed (cash) matching on other externally funded projects, were forthcoming.

Fourth, Table 1 indicates that industry was the second-largest funding source over the past several years. This funding is project specific and not gift related. Industry-related research is also estimated to be one of the more profitable external sources of funding as measured on a dollars per award basis. LSU should consider exploring and growing opportunities for partnering with industry on its energy-related research needs, particularly given the vagaries of federal and state funding in difficult budgetary times.

Fifth, a paradox of LSU’s energy research funding over the past several years has been its topical concentration in non–fossil fuel related projects. Renewable energy and energy/environmental research account for around 64 percent of all energy-related funding. Fossil fuel research alone, as a topical area, accounts for only $11 million (of the $91.5 million total) and, even when combined with materials-based research, only accounts for 32 percent of all energy-related research. This is an area where LSU can take advantage of a research strength to diversify its research portfolio and increase funding.

Sixth, there is considerable diversity in energy-related research funding performance (as measured strictly by external funding) across colleges and units across campus. Clearly, the AgCenter and College of Agriculture are the most significant contributors to LSU’s total energy research funding totals. The College of Engineering, however, is not far behind. Other smaller units, like the School of the Coast & Environment and CES, make smaller, yet not trivial financial contributions on a total funding basis, and particularly on a relative basis where past cumulative external energy research funding has been around, or in excess of, two times each of these units’ state-run budgets.

Two units, however, stand out as potential growth areas for future energy research: the College of Science and the College of Business. Both units appear to secure small levels of funding for energy research, not only in the absolute, but also given their relative sizes. There could also be roles for the College of Humanities & Social Sciences and the Law Center. Neither unit reports any significant levels of energy-related research despite the considerable opportunities for
policy research in energy. Currently, most policy-related energy research on campus is conducted almost exclusively by CES.

Finally, one last observation about LSU’s energy-related research that goes beyond the numbers is that there has been very little consistent cross-pollination of effort or interdisciplinary projects. Granted there are some exceptions, but generally, the university could do better in developing interdisciplinary approaches to energy research, particularly with an emphasis on industry-funded energy research or the development of an energy center of excellence on campus. Further, focusing on interdisciplinary opportunities may be a first step in increasing the energy research footprint of such units as the College of Science, Humanities & Social Sciences, E.J. Ourso College of Business and the Law Center.

6.2 Educational and Outreach Assessment

LSU offers a number of energy-related courses; however, currently the course offerings tend to be discipline specific, require a number of technical prerequisites, and are not organized with a specific energy-concentration in mind. LSU’s approach differs from the trend currently underway at other major research universities in energy producing states that are developing interdisciplinary programs for traditional undergraduate and graduate students, as well as many nontraditional professional students.

There are several units, however, on campus that have expressed an interest in moving in this direction and that are already taking active steps in developing an energy concentration. For instance, the Law Center and Business School are actively in the process of developing energy specialization programs. The School of the Coast & Environment has also been in discussions with the Law Center about participating in their energy concentration program. So there is very strong interest across campus for moving in this direction. The College of Engineering and the College of Science, however, will need to be important parts of this process.

In terms of outreach, most of the current outreach on campus is focused within three units: the AgCenter; the Law Center; and CES. All three have very active and well-recognized initiatives; however, consistent energy outreach efforts tend to be restricted to these three units, and there has been little coordination across these units or among other units on campus. LSU should explore opportunities for expanding its energy outreach initiatives, particularly in a collaborative fashion across various colleges and units.
March 25, 2015
Energy Initiative Task Force

David Dismukes, Chair
Center for Energy Studies

James A. Richardson, Co-Chair
E. J. Ourso College of Business

Committee members:

Troy C. Blanchard
College of Humanities & Social Sciences

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Emily Frank
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Amy L. Reynolds
Manship School of Mass Communication

John S. Russin
LSU AgCenter

Karsten Thompson
College of Engineering

Angela Webb
College of Human Sciences & Education

Carol Wicks
College of Science
1. Overview

The LSU Energy Initiative Volume 1: Current Energy Capabilities report notes that while the university has energy-related courses, they are relatively few in nature, uncoordinated, and more importantly, do not lead to any meaningful formal energy-based certification or degree specialization outcome. One of the first and best opportunities LSU has to move its broader energy initiative forward is through the development of a comprehensive and cohesive energy educational focus. The benefits of this energy educational focus to the university are multifaceted:

**Local/State Need:** Energy extraction and production, as well as energy-based manufacturing, have been recent growth industries in Louisiana and across the U.S., since the financial crisis of 2008–2009. Over $100 billion in new energy-related infrastructure projects have been announced for Louisiana alone over the next eight to ten years. There is a near-term and ongoing opportunity to educate the workforce who will be designing, constructing, and operating these assets. Recent cyclical changes in energy prices, while impacting the speed and scope of future energy infrastructure development, will not dampen the need for energy professionals with specialized skill sets that are constantly being “sharpened” given the quick and changing nature of the business.

**Development of LSU’s internal intellectual infrastructure:** Building up faculty expertise in energy-related subject areas takes time and is highly dependent upon external funding vagaries. The development of a strong interdisciplinary educational initiative will give existing and new faculty the opportunity to develop their expertise in the energy area independently of external funding. It should also give new and existing faculty the opportunity to network with other LSU faculty through cross-teaching/team-teaching opportunities. Further, continuing education, certification programs, and other LSU-based professional development activities—all component parts of a comprehensive energy educational initiative—will give many LSU faculty members access and opportunities for interaction with industry leaders, policy makers, and government agencies, access that many faculty often find to be elusive.

**High success/low risk/speed:** The development of an energy educational initiative could be completed relatively quickly and would be relatively successful if done in a comprehensive fashion that defines key goals and expectations. The key is coordination across colleges and units, and ultimately, faculty participation.

**High profile/marketability relative to cost:** Louisiana is an energy producing and consuming state. There is a high demand for the types of energy-based educational offerings that LSU could offer. These programs, which could be advertised and promoted via the Internet, social media, traditional media, and other informational outlets, would be easy to “sell” and would likely garner considerable interest. On-line offerings could expand the scope of the university’s footprint in this energy educational space to areas outside the state, tapping into LSU’s extensive energy-affiliated alumni.

The following sections of this report examine a number of topics related to the development of energy related education and outreach programs. The second section examines energy concentration programs at other major universities with a particular emphasis on those universities located in major energy producing states. The third section of this report examines the potential framework for a multi-faceted energy education concentration within
the current LSU curriculum while the fourth section identifies a scope for this potential educational concentration. The fifth section of this report discusses continuing education and ongoing professional development opportunities. The sixth section of the report discusses networking and outreach. The last section provides a summary and conclusions.

2. Survey of Other University-Based Energy Concentration Programs

Concentrations in energy studies are a diverse set of academic programs that range from nine-credit certificate programs to full, 120-credit undergraduate majors. Energy certificates are commonly offered as part of MBAs and graduate or undergraduate engineering degrees, but are also occasionally part of environmental studies or public policy programs. Table 1 summarizes the results of a survey of over 40 major university energy concentration programs. These universities offer what are variously called minors, certificates, and concentrations in energy studies (hereafter referred to as “energy concentrations” regardless of the program official title at its respective university). Typically, minors require more credits than concentrations or certificates, but definitions vary. Table 1 distinguishes between executive style professional certifications and concentrations that are part of existing degree programs. See Table 1

2.1 General Structure

In general, energy concentrations require students to take two to three specialized core courses and a variable number of electives. The core courses are typically designed specifically for the program while the electives may be drawn from existing courses. For example, Columbia’s School of International and Public Affairs offers a concentration in Global Energy Management and Policy that requires three 600-level core courses: the Economics of Energy (3 credits), Energy Systems Fundamentals (3 credits), and Global Energy Policy (3 credits), and two electives. The electives are wide ranging, can be selected to tailor the requirements of the program to the interests of the student and may be energy related but not energy specific (e.g., Global Maritime Policy, Environmental Policy).

Of course, there is a great deal of variation in requirements and every concentration is unique. There are several concentrations that require only nine credits (Rice MBA, University of Houston MBA) while others with similar goals require 24 credits (University of Wyoming’s MBA). Some programs do not require core courses, and in these cases energy concentrations can sometimes be earned without taking any energy-specific courses. For example, the University of Houston’s Energy Finance MBA Concentration can be earned by taking advanced finance courses, none of which are specifically energy related; alternatively, the same degree can be earned with a heavy emphasis on energy specific coursework. Thus, in designing curricula there is a balance between flexibility for the student and ensuring that the coursework fulfills the mission of the concentration.

2.2 Executive-style Certifications

A number of universities offer certifications and degrees that are explicitly designed for working professionals. These certifications are similar in intent to executive MBA programs in that they offer flexible class schedules and often offer online learning options. Executive-style certifications may or may not be designed for degree seeking students and vary significantly in requirements. The programs at Stanford and Tulane represent the two extremes of the executive-style certification programs, and the University of Texas represents a middle ground example.

2.2.1 Stanford: Stanford’s Center for Professional Development offers a certification program that proceeds entirely online and results in a professional certificate for non-degree seeking students. Each course takes approximately three to four hours to complete, and four courses are required to complete the certificate; thus, the certificate requires approximately 12 to 16 hours
Table 1: Survey of University Energy Concentration Programs

<table>
<thead>
<tr>
<th>University</th>
<th>College/Department</th>
<th>Student Type</th>
<th>Name of Concentration Program</th>
<th>Required Credits</th>
<th>Curriculum Essentials</th>
<th>Program Emphasis (By Major)</th>
<th>General Program Structure</th>
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<tr>
<td>Colorado</td>
<td>Renewable and Sustainable Energy Institute</td>
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<td>Renewable energy Certificate Program</td>
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<td>6 core electives</td>
</tr>
</tbody>
</table>

LSU’s Energy Initiative: Internal Energy Research Assessment

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of online instruction to complete. The cost of the program is approximately $1,000. To our knowledge, this represents the least demanding professional certification program.

2.2.2 The University of Texas: The University of Texas’ McCombs School of Business offers an Energy Certificate in which students select six one-day courses. All courses are offered in Houston on Saturdays and represent eight hours of instructional time. The entire program of study requires 48 hours of course time. Courses offered include Business Valuation; Decision and Risk Analysis in Hydrocarbon Exploration and Production; Economics & Technology of Crude Oil; Natural Gas & Liquefied Natural Gas Value Chains; Economics & Technology of the Electric Power Value Chain; Energy Finance; Energy, Technology, and Policy; Global Oil and Gas Accounting and Contracting Procedures; and Managing External Stakeholder Relationships. Tuition for six days of courses is approximately $7,300. The Texas program represents a middle ground in executive-style certifications between Stanford’s and Tulane’s programs.

2.2.3 Tulane: Tulane’s Masters of Finance with a Concentration in Energy is an accelerated degree program in which students take classes on alternate weekends over 14 months. In the Tulane program, students take 16 “modules,” four of which are energy specific, and unlike the Stanford and Texas programs, the Tulane program results in a degree rather than a certificate. Tulane’s program provides an example of a hybrid program that is more rigorous than most other professional certificate programs, but still offers nontraditional course times and is designed for working professionals. Tulane’s program is offered in both New Orleans and Houston.

2.3 Traditional Degree Programs

While the executive style certification discussed above is increasingly popular, energy certificates and concentrations are more commonly offered as an optional component of a traditional degree program, often an MBA, MPA, or other graduate or undergraduate degree. These programs typically supplement the requirements of the degree and offer students a way to structure electives so that they receive a specialized concentration or certification on their degree without necessarily taking extra credits beyond the requirements of the degree. In general, these programs are more academically demanding than executive-style certifications.

2.3.1 University of Texas: In addition to the executive-style certificate program discussed above, the McCombs School of Business at the University of Texas offers an Energy Finance concentration as part of their MBA program. In total, 19 credits are required to complete the concentration requirements; however, many of these credits are in advanced finance courses rather than energy specific courses. Students take two modified versions of core courses (Financial Strategies [Energy] and Financial Risk Management [Energy]) and up to three energy specific electives (Energy Law, Energy Finance Practicum, and Oil and Gas Taxation). The program is not designed to require additional studies beyond the degree requirements of the MBA or to reduce the academic rigor of the MBA degree, but rather is a way for students to select electives centered on a specific theme and to gain an acknowledgment on their transcript.
2.3.2 Pennsylvania State University: Penn State offers graduate degrees (MS and PhDs) in Energy and Minerals Engineering through their college of Earth and Mineral Sciences. These degrees are roughly equivalent to the degrees in Petroleum Engineering or Geology offered by LSU; however, Penn State also offers an option in Energy Management and Policy, which focuses on the economic issues associated with energy engineering and energy systems. Thus, within a primarily engineering degree, Penn State offers a supplemental course of study that links engineering and technical issues with more policy-relevant economic instruction. The specific courses vary depending on the degree program (MS or PhD) and previous preparation of the student, but generally include basic courses in policy analysis and economics followed by energy economics coursework.

2.3.3 Texas A&M: The Bush School of Government and Public Service at Texas A&M offers a concentration in Energy, Environment and Technology Policy and Management as part of their Master’s degree in Public Service and Administration. The concentration is one of six concentrations students may choose from and requires two core courses and one elective. As suggested by the name of the concentration, the program is relatively broad and can be tailored to meet the requirements of the student, and electives can be chosen from departments across the university.

Texas A&M also offers a certificate in Energy Engineering for undergraduates. Both engineering majors and other science majors are eligible to participate in the program. The program requires one core course, Energy: Resources, Utilization and Importance to Society, and three generally technical electives. While many energy certificates are designed to provide a broadening of the student’s focus (e.g., Penn State’s Energy Management and Policy), Texas A&M’s Energy Engineering certificate is primarily designed to provide science and engineering majors with a very specialized, technical skill set.

2.3.4 Colorado School of Mines: The Colorado School of Mines offers an undergraduate minor in Energy which requires 18 credit hours of course work. There are three curricular tracks: Fossil Energy, Renewable Energy, and General. All Energy Minors take Introduction to Energy, Energy Economics, and Global Energy Policy, and three electives determined by their track. Electives may be drawn from courses across the university. The program is designed to supplement and expand upon the student’s major by exposing them to new ideas and coursework they would otherwise not take. Minors may come from any major in the university.


As noted in the prior section, a casual survey of the energy-based educational initiatives at other universities in larger energy producing states (such as Colorado School of Mines, Stanford, University of Texas, Texas A&M, and Penn State) finds that the nature of the courses offered in these programs is relatively broad and inclusive: They are not designed to be replacements for, but supplements to, traditional discipline-focused degree programs. The “supplemental” nature
of these universities’ energy educational initiatives is in keeping with the needs of the primary “consumer” of the benefits associated with these educational programs, which is ultimately an “employer.” Most energy employers would likely find attractive potential employees (current graduates) educated in various disciplines who have a working knowledge of the world of “energy” from both a technical and more general perspective. This is not to suggest that technical course work in petroleum engineering or geology is not important for a student seeking employment in the upstream part of the oil and gas industry, but rather that a petroleum engineering or geology student who supplemented the core curriculum in areas like energy commodity markets or energy law and/or regulation would likely be more attractive.

**Supplementary:** LSU’s energy educational program should be developed in a fashion that supplements traditional degree programs in the College of Engineering, Paul M. Hebert Law Center, the E. J. Ourso College of Business, the College of Science, the School of the Coast & Environment, and the College of Humanities & Social Sciences. Courses should be created and offered on an almost independent, stand-alone, or “survey” basis, accessible to any junior- or senior-level undergraduate. The goal of the program is not to replace, change, or “water down” any current degree program or requirement, but should be thought of as a university-wide recognized specialization that certifies a student’s competence in energy-related study, regardless of his or her primary discipline/degree program.

**Interdisciplinary:** Energy is an interdisciplinary field of study, and almost all work in the energy business is often conducted through interdisciplinary teams. LSU’s energy educational offerings need to be interdisciplinary in nature as well as accessible to students from different disciplines. For instance, a mechanical engineering major interested in a career in power generation needs a basic understanding of economics to comprehend the economic dispatch of generation units by regional transmission authorities. A student focusing on environmental law for nuclear utilities will need to understand the basics of nuclear engineering and the differences between reactor vessels, the containment system, and other nuclear plant components. Courses offered in this program would benefit from the use of an interdisciplinary faculty advisory group reviewing individual course offerings and adding suggestions on areas of emphasis and resources available to facilitate this interdisciplinary diversity.

**Limited prerequisites:** Courses included as part of the energy educational initiative need to minimize discipline specific pre-requisites for a variety of reasons. First, minimizing these pre-requisites will likely reduce the barriers to entry for some students interested in crossing disciplinary boundaries. Second, as noted earlier, these courses are intended to supplement current discipline-specific degree requirements. Attaining a “concentration” or attaining “certification” on a specific energy-related study program is not the same thing as attaining a major, and should not have the same requirements and prerequisites.

**New, incremental, and separate:** Courses included as part of this program cannot simply be a “repackaging” of (most) existing undergraduate- and graduate-level courses. For instance, a student interested in an Energy and Earth Sciences Concentration should not be simply directed to take a first-year geology course, but a course developed for non-majors that is directly tied to energy and includes specific examples, class projects, and special guest lectures, and that tackles current problems and issues, such as hydraulic fracturing.

**Practical/applied/timely:** All courses should include the appropriate balance of timely subjects that are relevant to applied and everyday challenges in the energy industry. Students attaining a specialization in energy should understand the issues and technologies they will face in an energy-based career.
4. Energy Course Work: Potential Course-Based Concentrations

LSU’s energy educational initiative should focus on the development of a number of different energy concentration areas that certify a student’s understanding and competency in various aspects of energy. Under this proposal, no one college or unit would be “in charge” of the energy concentration program. Instead, the program would be governed by an Energy Program Advisory Council (the “Council”) that reports directly to the Office of Academic Affairs. Each college/unit participating in the program would have a representative on the Council who would, collectively, pick a chairperson for a one-year term. The Council’s purpose would be to maintain the concentration areas of the program, ensuring their academic integrity, marketability, and consistency with the university’s broader energy goals. The Council would review the active slate of energy concentration areas and make suggestions on the continuation, modification, or termination of any individual topical area. The Council would also be responsible for assessing whether any new topical areas should be added.

The course work aspect of the energy concentration program would be open to all types of students: undergraduate, graduate and professional. The concentration program would work like an academic degree program minor for traditional undergraduate and graduate students. The program would work similarly to a professional certification program for nontraditional/professional students seeking to return to the university to sharpen their skills or to earn a credential in a particular subject area. This would require development of undergraduate courses as well as graduate courses, as undergraduates cannot enroll in graduate courses, and graduate students can enroll in 4000-level courses for graduate credit only if the faculty member is approved to of-

Table 2: Summary of Potential Energy-Based Concentrations/Certifications

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<th>Engineering/Science-Directed Concentrations</th>
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<tr>
<td>• Energy Technology Concentration</td>
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<td>• Energy Manager Concentration</td>
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<td>• Energy &amp; Earth Sciences Concentration</td>
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<tr>
<th>Environmental-Directed Concentrations</th>
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<tr>
<td>• Energy &amp; Environment Concentration</td>
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<tr>
<td>• Energy &amp; Environmental Regulation &amp; Permitting Concentration</td>
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<td>• Alternative Energy Concentration</td>
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<tr>
<th>Business-Directed Concentrations</th>
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<tr>
<td>• Energy Economics &amp; Finance Concentration</td>
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<tr>
<td>• Energy Accounting &amp; Auditing Concentration</td>
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<td>• Energy Business Development Concentration</td>
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<td>• Energy Project Management Concentration</td>
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<th>Law-Directed Concentrations</th>
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<td>• Energy &amp; Mineral Law Concentration</td>
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<td>• Energy &amp; Environmental Law Concentration</td>
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<th>Public Policy-Directed Concentrations</th>
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<td>• Energy Policy</td>
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<td>• Public Administration and Regulation of Energy</td>
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<td>• Media, Communications and Public Relations of Energy</td>
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<td>• International Energy Issues</td>
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fer graduate-level courses and if the course has additional requirements for graduate students.

Energy is a large field of study, and not all students (or a critical mass of students) are interested in each and every nuance of the field. Energy concentration programs at most other universities are specialized around various topical study areas. LSU’s program should be developed in a similar manner. A lead college should be designated for each topical area. For instance, study areas that have more of a business orientation should be directed by the College of Business (with ongoing input from the other colleges via the Council). Likewise, study areas that have more of a science or engineering basis, should be directed by either the College of Engineering or the College of Science, or administered jointly.

A suggested slate of energy concentration areas of study is summarized in Table 2 below, and discussed in further detail in the following section of this report. The list is merely a recommendation, based upon similar offerings at other universities, concentration ideas unique to Louisiana, or concentrations that may enhance the uniqueness of the LSU program. This list is only offered to stimulate thinking and discussion about an LSU-specific energy concentration program. Ultimately, the specific number, composition, and lead college should be decided by the provost and the Council governing the program (assuming this type of framework is selected).

5. Discussion of Potential Energy Concentration Field Areas of Study

5.1 Engineering and Science Directed Concentrations

5.1.1 Energy Technology Concentration: This concentration would likely be attractive to undergraduates seeking employment in energy industries, particularly those in nontechnical fields such as business. Most major universities with energy concentrations have this type of focus area. This concentration would focus course work on the analysis of energy production, transportation, distribution and processing technologies. The area could be general across all fossil fuel-based industries or just one aspect such as upstream oil, gas, and power generation (which are likely the two most popular). Topics associated with a curriculum focusing on oil and gas technologies alone would address the intricacies of various types of oil and gas drilling and production techniques, seismology, basics on petroleum geology, oil and gas industry structure, offshore technologies, natural gas processing and fractionation, among other things. An oil and gas centric concentration would likely rely heavily on the Craft & Hawkins Department of Petroleum Engineering, whereas electric power would rely on The Department of Mechanical & Industrial Engineering and the School of Electrical Engineering & Computer Science.

5.1.2 Energy Manager Concentration: This concentration would be very attractive for existing professionals working in petrochemical and industrial plants. This may also be a concentration of interest to engineering undergraduate students for credentialing purposes. Consider that all of the major plants along the river corridor employ professionals who examine on-site energy use, off-site energy sales, and the procurement of energy for plant use (energy and feedstock). Many plants run their own on-site power generation facilities. This concentration would introduce students to aspects of industrial energy use and management and how on-site energy use at industrial facilities is optimized. This concentration would also require some understanding of gas and power markets and sales and procurement for industrial plants. Considerable input from the Gordon A. and Mary Cain Department of Chemical Engineering and Mechanical Engineering, with some input from the College of Business, would be needed.
5.1.3 Energy & Earth Sciences Concentration: A concentration in energy and earth sciences would likely be attractive for undergraduates seeking careers in the upstream oil and gas business from nontechnical backgrounds (like business and policy). Course offerings in this concentration would have a heavy geology focus, particularly petroleum geology, but could get into other meteorological issues impacting renewable energy generation (wind, solar) as well as examining the relationship between procuring financial hedges for weather-related risks impacting energy production and use. Additional courses within this concentration could focus on the relationship between the use of natural resources in energy production, including air emissions, water use, and waste treatment/disposal issues. This curriculum would draw heavily from geology but also environmental sciences. The Department of Geology and Geophysics currently offers an Environmental Geology Concentration that could be transformed into an Energy and Environment Concentration.

5.2 Environmental-Directed Concentrations

5.2.1 Energy & the Environment Concentration: This concentration would likely generate broad interest from both an undergraduate and professional perspective. Course offerings would explore the various aspects and interactions of energy production and use and the environment. The Department of Environmental Sciences already has one successful course offering in this area. The relationships between energy use and production would be included. Other courses could explore, in greater detail, energy sustainability and resilience and alternative energy (renewable) development. This course would rely heavily on resources in the School of the Coast & Environment and the College of Science.

5.2.2 Energy, Environmental Regulation & Permitting Concentration: This concentration area would primarily target existing energy professionals and comprise course offerings that are focused and applied, preparing students for energy industry careers in environmental permitting, monitoring, and compliance. Courses would include some from the general Energy & Environment Concentration, but would also include a number of applied permitting classes that already exist at LSU. A successful concentration of this nature should explore securing the expertise of practitioners as professionals-in-residence.

5.2.3 Alternative Energy Concentration: A concentration in alternative energy would likely have broad interest from both undergraduates and professionals. Courses would cover a wide range of topics within the alternative energy space but focus heavily on renewables. Courses would include an overview of technologies, the economics and policy of alternative energy, and alternative energy business development and finance. Energy policy would also be included in the core courses for this concentration.
5.3 Business-Directed Concentrations

5.3.1 Energy Economics & Finance Concentration: This concentration would be of interest to a wide range of undergraduate majors as well as professionals seeking educational diversity and credentialing opportunities. Course offerings and topics would focus on various factors, including energy supply and demand and how prices are determined in energy markets. Considerable emphasis would be placed on understanding extraction and production costs for energy resources and technologies. Energy demand and the economics of energy efficiency, as well the economics of energy policy—particularly subsidies, incentives, and tax policy—would be explored. Energy commodity markets and the use of financial instruments in energy markets would also be covered.

5.3.2 Energy Accounting & Auditing Concentration: Large integrated energy companies typically have expansive operations that can span broad geographic areas (regional, national, international). These companies also own or control subsidiaries or business units that cross a variety of regulatory structures (regulated, unregulated). Energy companies of this nature are required to keep very detailed and often separate accounting records, and are typically subjected to a variety of different audits. Courses in this concentration would prepare accounting and other business students for work in this particular field. Courses would focus on applied financial accounting and internal audit, a strength that already exists in the College of Business.

5.3.3 Energy Project Development Concentration: Energy professionals, across a wide range of disciplines, will likely, over the course of their careers, be involved in the development of a new energy project, capital investment, or service offering. Courses in this concentration will build on existing energy economics and finance classes, with additional specialized classes in the area of project finance. Support from the Law Center in this area would be necessary for contracting and other legal issues associated with project development. This concentration would be attractive for engineering students as well as business students.

5.3.4 Energy Project Management Concentration: This concentration would likely be attractive to engineering students as well as entry level engineering professionals. Large energy project management is a complicated interdisciplinary skill. Successful project managers are often required to have an understanding of capital budgeting, expenditure authorization processes, accounting project finance, and management, even though they may have a technical background. Courses in this concentration would cover a wide range of business and project management topics. This is another concentration area that could benefit from the use of practitioners in a professional-in-residence capacity.

5.4 Law-Directed Concentrations

5.4.1 Energy & Mineral Law Concentrations: A concentration in energy and mineral law would likely be of interest to undergraduates seeking careers in oil and gas exploration, production, and transportation. It would also be attractive from a professional development perspective. This concentration would focus on aspects of oil and gas-related legal issues. Courses could explore such topics as oil and gas contracting, titles, property ownership and unitization, royalties and royalty regimes, oil and gas permitting, state and federal lands use regulation, and offshore and maritime issues impacting oil and gas operations.

5.4.2 Energy & Environmental Law Concentrations: This concentration would be attractive for students interested in environmental law issues focused on the energy industry as well as professionals (legal and non-legal) already working in the energy business. The program of study would build on the already existing energy and environmental law courses in the Law Center but would be “tweaked” for an energy-industry focus.

5.4.3 Energy Regulation Concentration: Most concentrations in this area focus on regulatory
issues associated with electric and natural gas utilities. The program would be of interest to technical professional’s working in this area (mechanical/electrical engineering) as well as some law students. This would also likely be a very attractive course for professionals just starting out in these particular industries, or are seeking credentialing opportunities. Courses within this concentration would focus on general regulatory principles and policies, the mechanics of rate and tariff development process, cost of service analysis, resource planning and fuel procurement, open access and retail choice, wholesale energy and commodity market regulations.

5.5 Public Policy-Directed Concentrations

5.5.1 Energy Policy Concentration: This concentration would likely be of interest to students already majoring in social science or policy fields, but may also be of interest to students in more technical disciplines seeking to “round-out” their education (such as engineering). Energy policy is a concentration that could be developed in conjunction with other concentrations (energy technology, energy economics, as well as energy and the environment). Additional specialized courses in federal and state policy would be included that cover fossil fuel and alternative energy sectors. Courses would also include the analysis of current and timely topics such as energy supply and availability, energy exports, the role of energy and economic growth, sustainability and climate change, and the regulation/oversight of certain types of energy extraction and production techniques/technologies.

5.5.2 Public Administration & Regulation of Energy Concentration: The public sector (local, state, federal) plays a large and important role in energy industry development and operations. This concentration would likely be of interest to students in public administration and current professionals working in state and local executive and regulatory agencies. Courses in this concentration would be developed to prepare students interested in future (or ongoing) public sector careers in energy (such as permitting, regulation, etc.)

5.5.3 Media, Communications, & Public Relations of Energy Concentration: Targeted to journalism/communications undergraduates and entry-level professionals (or others) working in the energy industry, this concentration would include courses in energy and the media, public perceptions of energy, energy and politics, energy and environment, energy crisis/disaster management, energy industry/local community interaction, internal corporate communications, and digital and social media marketing.

5.5.4 International Energy Issues: Courses in this concentration would be directed toward students already seeking an international career, including those in international business programs, public policy, finance, and potentially engineering. The focus would be on such topics as global energy supply and demand topics, energy security, energy trade issues, the relationship between energy commodities and the foreign exchange, state/national owed energy company structures and operations, and global climate change and sustainability issues.

6. Continuing Education/Professional Development

As noted earlier, a large number of universities in energy producing states (as well as some states that do not have a long history in energy) offer professional energy educational programs. These courses, or programs, usually span a fixed period of time that can be as short as one day or as long as one full week. Professional energy courses and programs often come with their own form of “certification.” While these courses and programs are similar in nature to continuing educa-
ation course, they do differ in a number of ways:

First, an important aspect of these professional energy educational programs is their ability to offer a non-degree form of credentialing in a specialized energy area. This differs from continuing education, which can tend to focus more heavily on assisting existing professionals in maintaining their current professional licenses and certifications (lawyers, certified public accountants, professional engineers). The use of the word “certificate” in these professional programs at other universities differs from the discussion in the prior section of this report, which is more curriculum-based and part of an overall degree program.

Second, professional energy education programs and certifications also differ from traditional continuing educational programs since they often attempt to bridge the differences between topical timeliness and skills development. These professional energy certification programs tend to take an approach similar to that of a college level course more than simply a seminar, workshop, or lecture. These professional energy certification programs are interactive and often require the completion of tests or projects in order to receive a certificate of completion.

Lastly, these professional energy certification courses are often priced at levels much higher than traditional continuing education courses. Certification courses can run several thousand dollars, and in some instances close to $10,000 per program. The higher price tag likely arises because they are typically not paid by individuals but by employers looking to minimize their own in-house training and educational costs. This often makes professional energy certification programs look more like an executive education program than continuing education.

LSU should consider developing a professional educational certification program comparable to those offered at other major universities. The Department of Geology & Geophysics has been offering its Applied Depositional Geosystems program for several years and is now seeking formal approval from the Graduate Council to formalize that program as a Graduate Certificate. There could be a number of synergies in the development of these programs if done concurrently with the curriculum-based approach discussed earlier. The benefits of a professional energy certification program could be meaningful and include:

- A new revenue source for LSU
- Increased community/industry engagement
- Consistency with Louisiana’s current workforce development strategies
- Potentially serving as basis of stimulating interest in traditional educational programs such as an MBA, law degree, or Professional Master’s degree
- Providing an in-state resource for those that now likely go to other states for such certification.

A professional energy educational program could be set up by the Council by addressing the following potential issues:

- Defining the goals of a professional energy certification program
- Reconciling or defining the difference between a professional “certification” and a curriculum-based certification program
- Assessing the marketability/need for a program
- Developing a means by which to attract and incent faculty participation as well as other potential “professionals-in-residence”
- Developing a business and marketing plan
- Seeking and attaining university administration approval.
7. Networking and Outreach

LSU could also expand its networking and outreaching efforts on campus with current and prospective energy professionals. Expanded networking could include developing tight working relationships with local chapters of professional energy associations, and perhaps, in some instances, sponsoring meetings for associations with a particular emphasis on professional orientation such as the Energy Bar Association, the Association of Energy Engineers, Young Professionals in Energy, the American Association of Petroleum Geologists, the U.S. Association for Energy Economics, and the Gulf Coast Power Association, to name a few. Another networking opportunity would be to develop student chapters for these associations on campus to complement the energy certification curriculum initiatives.

Energy related outreach represents another on-going opportunity of communicating LSU’s commitment to energy research and education. The current initiative being developed and implemented by University Relations will likely go a long way in communicating this message in the near term. LSU should consider the development of continued, sustainable interactions with the community through workshops, conferences and seminars. Coordination of LSU energy-related events would be helpful in order to “cross-pollinate” opportunities.

8. Conclusions

Table 3 provides a comprehensive look at the initiatives discussed earlier. The table attempts to show that there is a coordinated and comprehensive opportunity for developing a broad and inter-related energy education and outreach initiative.

Table 3: Big Picture View of a Potential LSU Education and Outreach Initiative

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<tr>
<th>Educational/Instructional Type</th>
<th>Undergraduate</th>
<th>Graduate</th>
<th>Professional</th>
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<tbody>
<tr>
<td>Educational/Institutional Type</td>
<td>Educational/Instructional Type</td>
<td>Undergraduate</td>
<td>Graduate</td>
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<tr>
<td>Course-Based Offerings</td>
<td>Engineering/Science-Directed Concentrations</td>
<td>Energy Technology Concentration, Energy Manager Concentration, Energy &amp; Earth Sciences Concentration</td>
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<td></td>
<td>Environmental-Directed Concentrations</td>
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<td>Law-Directed Concentrations</td>
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<td>Student-Based Research</td>
<td>Directed study program</td>
<td>Thesis/Dissertation</td>
<td>Professional-in-Residence Research Program</td>
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<tr>
<td>Offerings</td>
<td>Industry/University Research, Undergraduate/Graduate Research Supervision, Initiative</td>
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<td>(Limited) Certification Options, Continuing Education Options</td>
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<tr>
<td>Networking</td>
<td>Energy Student Clubs, Young Professionals in Energy, Academic Assc.-Local Chapters</td>
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<tr>
<td></td>
<td>Quarterly “Energy Breakfast”, Quarterly Distinguished Speaker Series, Undergraduate/Graduate Mentoring</td>
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