



FLORIDA SOLAR ENERGY CENTER®

Creating Energy Independence

**Self-Study Review
Florida Solar Energy Center (FSEC)
University of Central Florida (UCF)**

FSEC-RR-564-15

Final Report

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A Research Institute of the University of Central Florida

Introduction

This document has been prepared for the use of the Florida Solar Energy Center's (FSEC's) External Review Team. The document follows an outline provided by the University of Central Florida. With added sections addressing FSEC's strengths, weaknesses and opportunities

Section I. Self-Study Information provided to External Review Committee

1. Evaluate the effectiveness of the center in meeting its stated mission, goals, and objectives. Indicate whether the center has outgrown or altered its original purpose.

The Florida Solar Energy Center's motto, "Creating Energy Independence," is as timely now as when FSEC was created by the Florida Legislature in 1974. FSEC's mission is to research and develop energy technologies that enhance Florida's and the Nation's economy and environment, and to educate students, practitioners and the public on the results of the research. The Center has gained national and international recognition for its wide range of basic and applied research, and for its education, training and certification programs.

As a Type I university research institute assigned to the University of Central Florida (UCF), FSEC also functions as Florida's statewide energy research institute. The Center has a 40 year history of basic and applied research excellence, which has grown in scope to include all aspects of renewable energy, alternative fuels, fuel cells, energy storage, electric vehicles, and energy efficiency technologies.

FSEC R&D activities and programs include:

- Hydrogen energy
- Fuel cell technology
- Flow Batteries
- Electric vehicle technologies
- Photovoltaic (PV) systems
- PV cell/module manufacturing
- Solar thermal systems
- High-performance buildings
- Energy-efficiency technologies
- Energy codes and standards
- Simulation model development
- Indoor air quality
- Windows and daylighting
- Photo-electrochemical processes
- Alternative-fueled vehicles
- Product testing and certification
- Education, training and certification
- Energy policy analysis
- Public Outreach

The Center serves or has served as the program lead and research program integrator in many comprehensive and multi-organization research efforts in the areas mentioned above. FSEC also continues to conduct its long standing PV and building systems research programs for DOE and its solar testing and training programs for Florida and the nation's solar industry. The Center's 99-member staff includes 52 professionals with

expertise in energy research, building science, energy policy analysis, and education and training. The remainder of the staff is comprised of technical and administrative support personnel and university student assistants. FSEC’s research and its results are well known nationally and internationally. Over its 40-year history, FSEC has attracted over \$200 million in external contract funding to conduct research for many federal, state and industry clients.

With regard to FSEC’s original mission, energy still remains one of the most challenging and rewarding fields of research and discovery globally and it will remain so for the future. Renewable energy and energy efficiency offer the most promising alternatives to fossil and nuclear fuels making FSEC’s mission as viable today as it was when it was established.

2. Evaluate the center’s funding and the sustainability of funds. Indicate how the center will manage its activities if funding shifts have occurred.

The primary obstacle hindering growth and advancement for any organization is the lack of adequate financial resources. FSEC is no different in this regard. Figure 1 presents FSEC’s financial position.

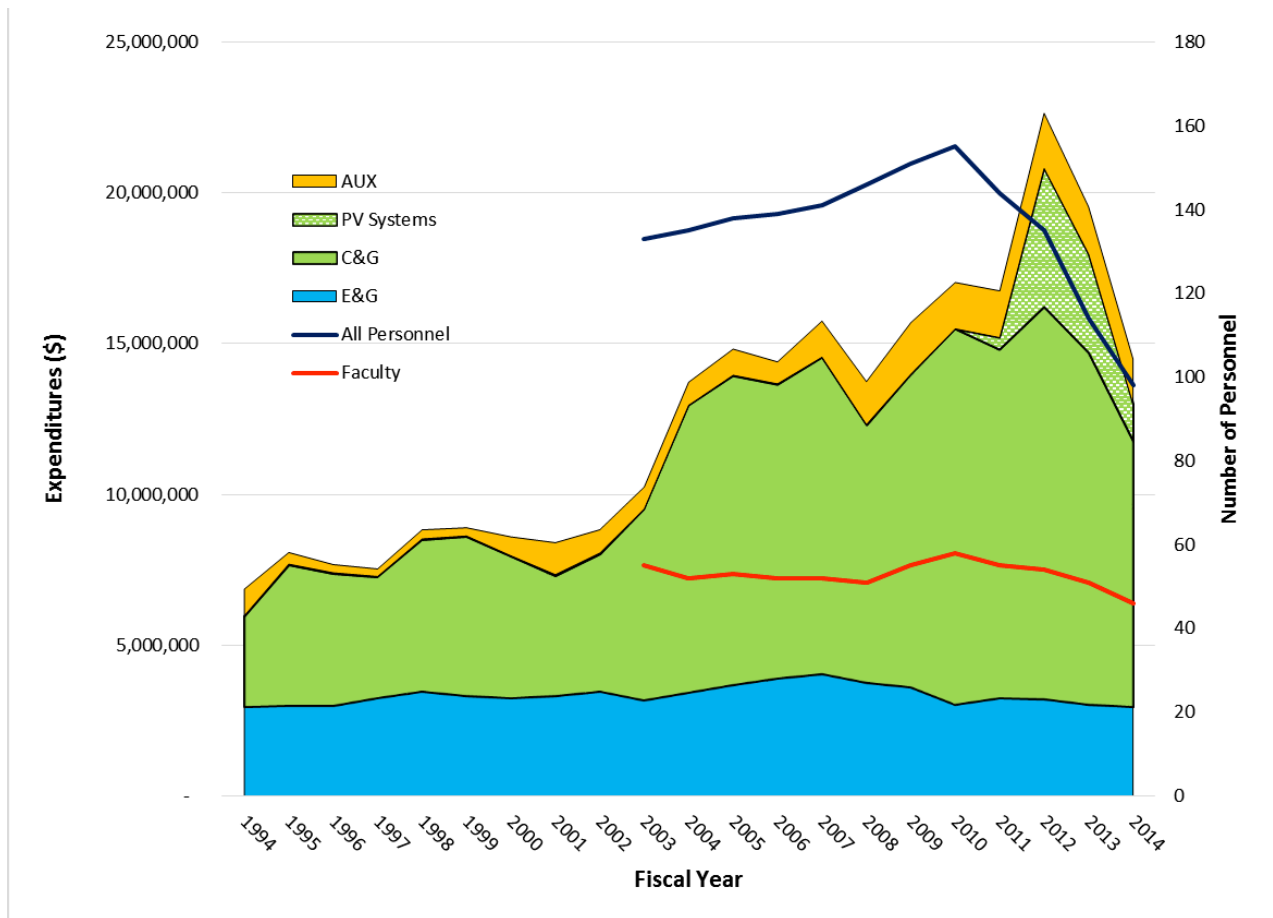


Figure 1. Annual Expenditures and Number of Personnel

Figure 1 shows that the annual state budget (E&G) since 1994 has remained relatively flat (~\$3M), if E&G followed the Consumer Price Index, a 60% increase over the same period, the budget would be \$4.8M. The center uses state funds primarily for salaries and benefits for staff and for infrastructure expenditures. With increased payroll costs, expanded program activities and increasing federal related compliance requirements, an increase to the budget allocation to FSEC is a real need.

The actual expenditures for the single fiscal year of July 1, 2013 to June 30, 2014 were:

State (E&G)	\$ 2,986,818
Contracts & Grants (C&G)	\$10,006,248
Fees (AUX)	\$ 1,500,870
Private	\$ 4,614
TOTAL	\$14,498,550

In the last several years the Center received contracts and grants funds primarily from the U. S. Departments of Transportation, Energy, Defense, Utility Companies and State of Florida Office of Energy. Much of the funding increase from 2011 on has been for PV systems (equipment and not salary) installed under the SunSmart E-Shelters Program, shown as light green in Figure 1. The darker green shading reflects Contracts and Grant funds after subtracting out the PV system equipment.

A functional analysis of the activities of all staff provides the following results.

Primary Functions	(2008)		(2014)	
	# Employees	Percentage	# Employees	Percentage
Research & Development	92	63.0%	61	62.2%
Education & Training	12	8.2%	8	8.2%
Testing & Certification	9	6.2%	5	5.1%
Professional Service	2	1.4%	2	2.0%
General Support Services	31	21.2%	22	22.5%
Totals:	146	100.00%	98	100.00%

Budget comments: The past three years have seen a downward shift in the availability of funds from the U. S. DOE. This has resulted in staff reductions, leaving the current staff at about 67 percent compared to 2008 through 2012. Reducing staff has been the only option available to FSEC to handle funding shortfalls. Finding new funding sources while broadening our areas of research is the number one priority of FSEC. Recent success in this regard is the one-year-old U.S. Department of Transportation “Electric Vehicle Transportation Center” (EVTC); it is an example of funding in a new area of research as well as from a new source.

3. Evaluate how well the center advances the overall goals of the university and the State University System (SUS) of Florida (UCF and SUS Strategic Planning) Overview: (<http://afia.ucf.edu/files/StrategicPlanningInfo.pdf>).

FSEC's goals and programs are strongly aligned with those of UCF and of the State University System and are set to advance both. FSEC's program activities clearly support the goals of international prominence and focus, inclusiveness and diversity, and partnerships. Offering the best undergraduate and graduate education available in Florida is accomplished through FSEC's partnership with the UCF College of Engineering and Computer Science. Joint research and teaching programs include the US DOT funded "Electric Vehicle Transportation Center" (EVTC; <http://evtc.fsec.ucf.edu/>) and the US DOE funded "Foundations for Engineering Education for Distributed Energy Resources" (FEEDER; <http://feeder-center.org/>) program. The Departments of Electrical Engineering and Computer Science (ECE) and Civil, Environmental, and Construction Engineering (CECS) have partnered with FSEC on the EVTC with a focus on graduate student research and curriculum development. Electrical Engineering has partnered with FSEC in the smart grid graduate student and electric utility workforce education and training program (FEEDER). In addition FSEC has partnered with UCF's College of Education and Human Performance to provide resources and learning opportunities for teacher candidates in the areas of STEM and energy education.

In an effort to prepare students for these post-secondary and graduate education opportunities, FSEC's staff has developed and implemented K-12 science curricula for public schools, professional development opportunities for teachers, and STEM programs for students, including the long-standing EnergyWhiz Olympics (EWO; http://www.fsec.ucf.edu/en/education/k-12/energywhiz_olympics/index.htm). Through the SunSmart Schools Emergency Shelter (E-Shelter) program, 115 ten-kilowatt photovoltaic solar electric systems with battery back-up in 46 Florida school districts (<http://www.fsec.ucf.edu/en/education/sunsmart/index.html>).

FSEC's continuing education programs have encompassed solar thermal systems, photovoltaics, alternative fuels, electric vehicles, energy-efficient building design, energy rating, and energy education for teachers, students and industry. Auxiliary (AUX) operations (see Figure 1) include all "fees for services" activities, excluding all sponsored (contract and grant) projects. Auxiliary programs conducted for the benefit of external customers include: testing and certification of solar thermal collectors/system and PV modules/systems; continuing education workshops and training programs (courses not for university credit); and EnergyGauge software development and support. Internal auxiliary programs include recharge centers such as computer services and managing a small fleet of FSEC vehicles. The expenditures reported here are covered by fees charged to the users of these services. Since FY2007, the expenditures for all Auxiliary operations have averaged about \$1.5M per year.

FSEC is a leader in developing long-standing partnerships with industry and government through the development of standards, testing and certification programs. These programs have evolved from Florida based efforts to national and international

recognition. For example, the International Code Council has adopted the Solar Rating and Certification Corporation as its official standards and their party certification agent. This effort began at FSEC in 1979 as a result of FSEC's support of the Florida and national solar energy industries associations' move towards a system of quality control for its products and services.

4. Evaluate the collaborative activities of the center with a focus on the center's multi-disciplinary and multi-university activities.

FSEC's collaborative activities use existing infrastructure coupled with science and engineering faculty members, industry and utilities to create meaningful and productive partnerships.

- a) Building America Partnership for Improved Residential Construction (BA-PIRC), - Formerly known as the Building America Industrialized Housing Partnership (BAIHP), this program is a university-based Building America team competitively selected for funding by the U.S. Department of Energy, Office of Energy Efficiency. BA-PIRC works with developer, builder, supplier, research and utility research partners <http://www.baihp.org/partners/index.htm> throughout the United States to foster adoption of systems engineering principles leading to enhanced energy efficiency in new and existing housing. FSEC has been awarded DOE funds of \$13.98 M and \$1.3 M in Cost Share since April 2006 to date. <http://www.ba-pirc.org/>
- b) Electric Vehicle Transportation Center (EVTC) – The EVTC is a U.S. Department of Transportation funded center focused on developing a transportation system to accommodate the influx of electric vehicles and their power demands and made up of transportation and energy experts from the University of Central Florida, University of Hawaii, and Tuskegee University in Alabama. The EVTC program also employs a collaborative working group of industry professionals, utility representatives, manufacturers and national labs and agencies to assist in program development for the purpose of accelerating EV acceptance and adoption. FSEC was awarded \$5.6M over 4 years, which began in September 30, 2013. <http://evtc.fsec.ucf.edu/>
- c) Foundations for Engineering Education for Distributed Energy Resources Consortium (FEEDER). Led by UCF's Electrical and Computer Engineering Department (ECE) and FSEC, FEEDER is made up of eight universities, two national laboratories, eight utilities and eleven industrial companies. Its primary mission is to significantly advance power systems engineering capability in the United States. The overall goal is to accelerate the deployment of distributed power systems technologies through innovative research, cross-institutional highly-collaborative education of the current and future workforce, partnering with public and private entities in energy systems and smart grid, and leveraging well-designed and complementary research, development, test, analysis, and evaluation. UCF was awarded \$3.2 million to lead one of four national DOE consortia that started September 30, 2013. <http://www.feeder-center.org/>

- d) U.S. Photovoltaic Manufacturing Consortium (PVMC) – The PVMC is an industry-led consortium for cooperative R&D among industry, university, and government partners to accelerate the development, commercialization, manufacturing, field testing and deployment of next-generation solar photovoltaic (PV) systems. UCF manages the \$10M dedicated to the c-Si PVMC programs and activities within the PVMC, currently with 14 collaborative projects being carried out in collaboration across the c-Si PVMC member base. There are currently 39 members in the PVMC, 12 specifically signed up for the c-Si activities, with more than 50 additional collaborative and non-member participants. Members and participants span the entire supply chain (e.g., cell/module manufacturers, equipment manufacturers, materials suppliers), with c-Si PVMC members currently offering greater than \$500K per year of cash and in-kind support to collaborative consortium projects. It is potentially a critical element of a new UCF manufacturing center initiative in Osceola County. FSEC was awarded \$10 M in DOE, UCF and Industry funds, to run c-Si PVMC for five years starting September 1, 2011.
http://www.uspvmc.org/technology_csi_PVMC.html
- e) Photovoltaic (PV) Regional Test Center (RTC) – The DOE has commissioned five RTCs to provide the long-term technical data and the model validation for the performance and reliability of new PV technologies required to help U.S. PV industry expand; reduce overall costs; and reduce risks to the integrators, owners, and finance groups. The RTCs provide the framework to demonstrate large-scale manufacturing and bankability of new technology pathways. PV systems perform differently at different sites for many reasons (solar resource, environmental conditions, etc.). Thus, one of the objectives of the validation work is to measure and document these differences—to improve industry’s ability to predict the output of new technologies regardless of where they are deployed. The southeast RTC is operated and managed by FSEC with its testing sites located in Cocoa and Orlando, FL. FSEC has been awarded \$1.07 M in DOE funds since August 1, 2011.
<https://rtc.sandia.gov/test-centers/orlando-florida/>
- f) Southeast Provider of Solar Instructor Training -- The Southeast Solar Training Network is a U.S. DOE funded five-year effort that creates a network offering solar energy training programs across the southeastern region of the U.S. The training network provides train-the-trainer instruction in photovoltaics and solar water heating to faculty from institutions designated by the Energy Offices in the nine partner states and territories. The trained instructors then conduct training in PV and SWH at their educational institutions. FSEC leads the Southeast U.S. network. FSEC has been awarded \$1.08 M in DOE funds since October 1, 2011, with a program end date of June 30, 2015.
http://www.fsec.ucf.edu/en/education/southeast_training_network/index.html
- g) SunSmart E-Shelters Program -- The SunSmart E-Shelter Program, coordinated by FSEC, has installed more than 115, ten-kW photovoltaic systems on emergency shelter schools throughout Florida. The Program has added more than one MW of

combined photovoltaic generating capacity to Florida using American-made components. This program, initially funded by the American Recovery and Reinvestment Act of 2009 (ARRA), through the Florida Department of Agriculture and Consumer Services, has been expanded to include additional funding from investor owned and public utilities. In addition, through the program's education and outreach efforts, more than 350 Florida teachers have received professional development in the science and use of photovoltaics. FSEC received DOE ARRA funds of \$9.6 M from Feb 10, 2010 through June 30, 2013. Duke Energy (formerly Progress) provided \$2.25 M (June 2012 – July 2013) and \$1.7 M (October 2013 – March 2015). TECO provided \$0.53 M (June 2013 – February 2015). The Florida Energy Office provided \$0.43 M (June 2013 – Feb 2015).

<http://www.fsec.ucf.edu/en/education/sunsmart/index.html>

- h) Florida Energy Systems Consortium – UCF received funding as part of a Florida multi-university program to enhance & expand the use of solar energy and other renewable energy and energy efficiency technologies in the State of Florida. The UCF project was a multi-task R&D effort which supported both FSEC and UCF Electrical Engineering. The program covered a five year period with tasks in biomass, PV, solar thermal and building efficiency. State Funding for FSEC of \$4.1M July 2008 – December 2012. <http://www.floridaenergy.ufl.edu/energy-research/>
- i) High Temp Membrane for PEM Fuel Cells – FSEC prepared and evaluated new polymeric electrolyte phosphotungstic acid composite membranes. FSEC led eleven other university/industry teams in meeting DOE targets for membrane resistivity at 120 °C and managed the U.S. DOE's High Temperature Membrane Working Group (HTMWG) (<http://energy.gov/eere/fuelcells/high-temperature-membrane-working-group>). Standardized experimental methodologies to 1) measure conductivity 2) characterize mechanical, mass transport and surface properties of the membranes and 3) predict durability of the membranes and their membrane electrode assemblies was developed. DOE funding of \$2.65 M with \$0.6 M cost share, April 1, 2006 – May 31, 2012.
- j) Central Florida Clean Cities Coalition: FSEC has served as the Coordinator of the U.S. DOE funded Central Florida Clean Cities Coalition since 1997. This project has resulted in slightly over \$1.2 million in contract funding and includes stakeholders from all Florida utility companies, Nissan, GM and local transportation planning organizations. Coalition activities include facilitating the adoption of alternative fuel vehicles (AFVs); assisting in the development of AFV infrastructure; conducting public education and outreach programs; organizing and hosting stakeholder meetings and events; and, providing technical assistance and special training to early adopters of AFVs. FSEC has been awarded) US DOE funds of \$0.5M (Jan 2013 to February 2015). Applied for renewal, asked US DOE for \$0.69 M for April 2015 – April 2017. <http://centralfloridacleancities.com/>

- k) Go Solar Florida: Part of the US DOE SunShot initiative, Go Solar Florida serves to reduce the soft costs associated with photovoltaic installations. FSEC is spearheading the effort to streamline and automate PV system design, certification and permitting. FSEC is also providing training and educational opportunities for building officials, solar practitioners, community associations and the general public. As part of this initiative, FSEC has convened a solar energy industry advisory council to assure their participation and acceptance of the system. Initial funds of \$75,000 have been received from Broward County for July 2014- March 2016. Additional funds of \$170,000 are expected for an expanded scope of work. <http://www.broward.org/GoGreen/GoSOLAR/GoSOLARFlorida/Pages/Mission%20Objectives.aspx>
- l) SEMATECH (from Semiconductor Manufacturing Technology) is a not-for-profit consortium that performs research and development to advance chip manufacturing. SEMATECH applied for \$100 million from the US DOE to form the *U.S. Photovoltaic Manufacturing Consortium (PVMC)* with support from the Department of Energy's Photovoltaic Manufacturing Initiative in 2010. This consortium has the potential to boost the U.S. photovoltaic manufacturing industry, speed up commercialization of next generation photovoltaic technologies and products, and considerably increase the U.S. share of this critical market. The SEMATECH consortium, in a joint venture with the College of Nanoscale Science and Engineering (CNSE) at the University of Albany-SUNY and the University of Central Florida (UCF), has secured commitments from over 80 companies, universities and government laboratories nationwide to join this alliance. The consortium had financial commitments totaling \$400 million from state and corporate entities. While this project was not funded as intended, UCF did receive funding for the PVMC-cSi listed as 4) above. The SEMATECH alliance with UCF was based on an interaction between FSEC and Dan Holladay of SEMATECH.

5. Evaluate the productivity of the center, including an assessment of overall impact and external funding received. Comment on challenges and opportunities, and provide suggestions for improvement, if appropriate.

Productivity of a research based organization can be measured by calculating return on investment which is defined as contracts and grants (C&G) funds divided by state (E&G) funds. Figure 2 presents a time plot of C&G to E&G funds for the past 30 years with the results showing a 3 to 1 ROI.

The major challenge facing FSEC is the shrinking of opportunities for funding from the U. S. Department of Energy. DOE has been the primary agency providing FSEC's federal funding for the past 30 years. DOE's long-term program strategy has led to a significant drop for university level R&D programs. This problem is a national concern and ranks very high at UCF/FSEC. The DOE programs have shifted to support of industry and national labs. It is noted that the new U.S. DOT electric vehicle program is from a federal agency that makes direct support to university research.

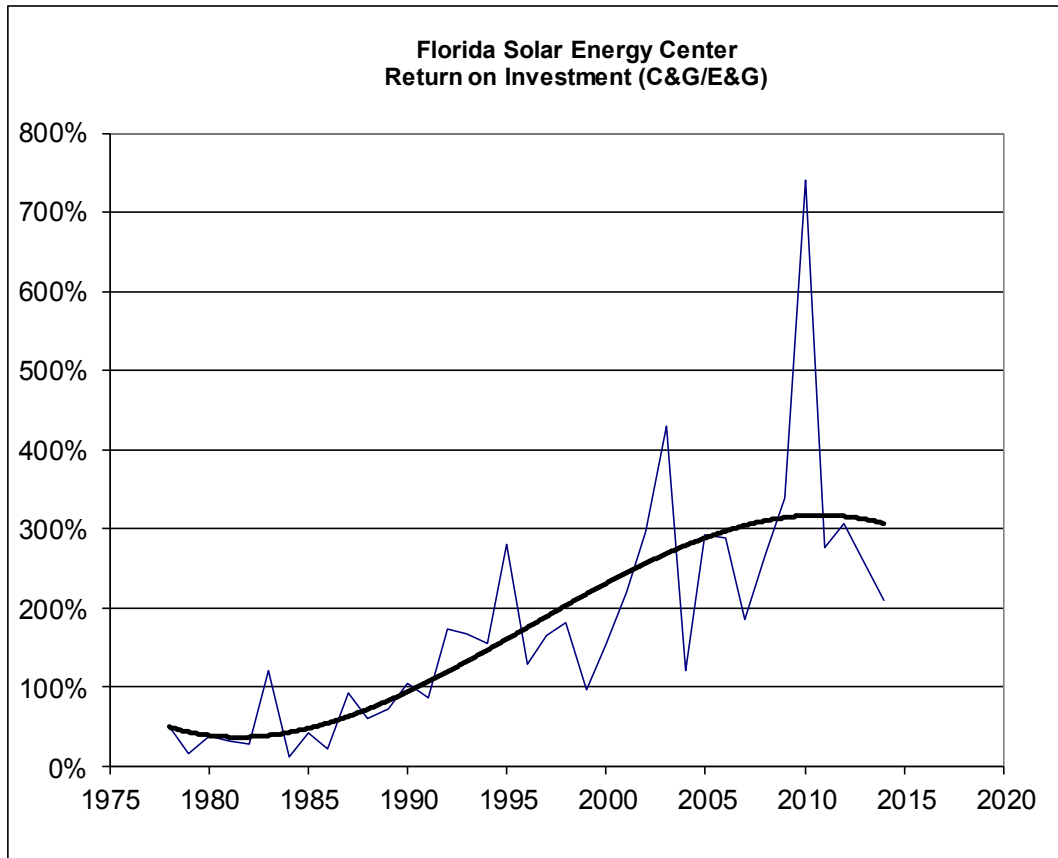
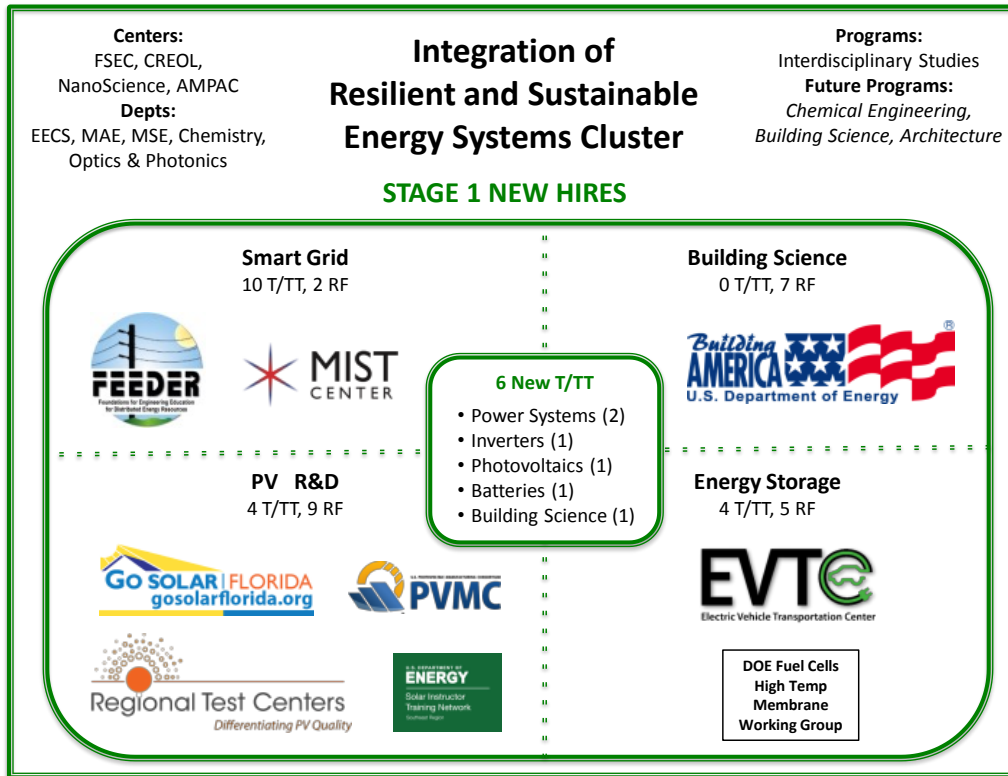


Figure 2.

The second challenge is also funding related and is directed at state funding. As Figure 1 has shown, state funding has remained relatively constant for the past 20 years. Both of these funding reductions cause ripple effects presenting challenges in keeping outstanding faculty, hiring new staff in emerging areas of technology and overall staff morale. They also cause problems for development of new laboratory and other capital improvements. On the positive side, it goes without saying that FSEC's challenges have prompted its faculty to use their capabilities and reputation to develop new programs with federal agencies, private utility companies, and state agencies.

UCF has recently created a Faculty Cluster Initiative designed to leverage UCF's existing strengths and foster the development of strong, interdisciplinary diverse teams focused on solving today's most challenging scientific and societal problems. One hundred new tenure track faculty will join UCF in AY 2015-2016, and an additional one hundred new faculty will be hired in AY 2016-17. 30 to 50 of these will be cluster hires. FSEC is working with other Centers, Departments and Programs to create an Integration of Resilient and Sustainable Energy Systems Cluster (six new tenure-track hires) as shown below.



6. List center or institute strengths.

FSEC's strengths may be listed in many ways, but for this review, three areas are used – existing capabilities, program development and education.

A. Existing Capabilities

- Strong reputation
- Technical expertise of faculty
- Support staff and laboratory facilities
- UCF support in both R&D and education
- The adaptability to new opportunities
- Successful cooperative programs

B. Program Development

- Reputation with DOE is strong
- Very strong proposal writing skills
- Recognized for high quality R & D
- FSEC brand

C. Education Programs

- Continuing Education and K-12
- Public education
- Train-the-trainer programs

7. List center or institute weaknesses as well as perceived barriers, threats, and vulnerabilities.

As already mentioned in 5 above, the continuation of funding is the critical problem in maintaining the Center's programs and faculty. In a SWOT analysis done by FSEC staff and the FSEC Advisory Board December, 2014, a number of weaknesses, barriers and threats were identified. Again the critical ones were funding related; however, other areas were:

- Need to increase outreach to other universities
- Focus not always understood by outside entities
- Need to develop Smart Grid Research and Development Focus
- Lack of marketing arm
- Must improve interaction with state energy office and private utilities
- Need to define solar commercialization strategies for Florida
- EV and smart grid development in FL
- Provide national certification in renewable energy and energy efficiency
- Expand Latin American presence
- Provide energy efficiency products testing
- Consult to other state agencies
- Aggressive licensing of IP
- Spin-off businesses
- Need to work with Utilities to increase Utility solar usage

8. Identify potential opportunities to improve center or institute quality, competitiveness, productivity, or efficiencies not already identified above.

One other critical area is for FSEC to become a more integral part of the UCF teaching and research programs. To accomplish this goal, FSEC has studied the creation of both an architectural and chemical engineering program at Brevard and has made offers to new tenure and tenure earning faculty members. These activities are critical to FSEC's ability to participate in UCF budget allocation procedures. The second critical area is the need for laboratory equipment. To attract and to provide resources for a new tenure-track faculty, new laboratories are a must. A third element to increasing FSEC's resources and viability is to plan an effort for greatly increased state and/or utility company support. FSEC also has new opportunities in partnering with both the Air Force and Navy in solar energy generation, energy efficiency, electric vehicles and micro-grids. With the new UCF downtown campus there is the opportunity to make the campus a model of sustainability, renewable energy and energy efficiency.