Building America Technical Systems Project Description

1. Project Title: Prototype Analysis using EnergyGauge® USA (EGUSA) & Field Monitoring Support (Information Monitors) for BA Teams

2. Principal Investigators: **EGUSA:** Mr. Robin Vieira, Division Director
Buildings Research Division
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Infomonitors: Mr. Safvat Kalaghchy, Program Director
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3. Other Participating organizations: NREL, IBACOS, BSC, SWA/CARB, Consol/BIRA

4. Project:

1. Schedule:
   a) Initiation Date: EGUSA-1996, Information Monitors- Early 1980's
   b) Phase completion: Ongoing
   c) Original expected completion date: NA
2. Funding Status: Non- competitive. Funded by FSEC and participants with a small amount of funding from DOE.
3. Project/technology maturity: Deployment

5. Statement of the Problem:

Building America teams are required to report the energy performance of prototype homes to DOE in accordance with benchmarking standards developed by NREL. The "benchmark" is a hypothetical home with specified envelope and equipment characteristics, which represents the "standard of performance" against which prototype designs are compared to determine energy savings. The benchmarking process is used for the purposes of goal setting by DOE and for reporting of prototype design performance by Building America teams.

There are at least two problems associated with the benchmarking process. First, prototype designs must be "translated" into benchmark designs using a complex benchmarking "rule set." This rule set defines the characteristics of the benchmark home as a function of both the individual component characteristics of the prototype home and the characteristics of the climate in which the prototype is located. While significant efforts has been made by NREL to construct a benchmarking rule set that addresses all conceivable building design consideration in great detail, there will always be room for differences in interpretation for specific, innovative prototype designs.

Second, the benchmarking process is laborious, requiring extreme attention to detail and offering many opportunities for human error in the configuration of the detailed building simulation inputs required by the process. This is particularly true for the many detailed appliances and temperature schedules required for the benchmark configuration.

Building America teams are also required to measure the in situ performance in at least a portion of the prototype homes that are constructed. This is normally accomplished using remote sensing instrumentation (temperature, moisture, power, etc.) and remote data acquisition equipment that periodically records data. These data need to be collected, archived and analyzed to determine the performance characteristics that are reported. The collected data often reveal unanticipated issues like equipment and control malfunction, improper implementation of design objectives, mismatch between design objectives and building use and other problems. Thus, if data are not collected and analyzed on a regular and fairly short periodic basis, problems are likely to exist for periods of time that result in wasted time and effort on the part of the project teams, reducing the effectiveness of the overall program.

6. Project Objectives:

The objective of this project is to provide high-quality tools that can be used by Building America teams to cost effectively perform benchmarking and field monitoring.

Benchmarking/EGUSA

As previously stated, benchmarking is a complex building simulation procedure requiring significant time, effort and attention to detail on the part of BA teams. This project seeks to reduce the required effort by providing detailed, hourly simulation software (EnergyGauge® USA also called EGUSA in this paper) with an "user-friendly" graphical user interface (GUI). FSEC originally developed EnergyGauge USA as a code compliance and home energy rating system (HERS) software product. The building simulation engine for the software is DOE-2.1E, which makes it very detailed with respect to simulation capability. The EGUSA user interface is designed for use by "less than perfect" users with numerous checks to insure that incorrect and unreasonable inputs do not occur. Additionally, user input options are presented in very straightforward and easy to use formats like pull down menus and pre-constructed building elements and components. In this regard, it is substantially improved over "DOE-2 out of the box."

Presently, four of BA teams (BSC, SWA, IBACOS and Consol) and NREL use EnergyGauge for benchmarking purposes. Development costs for the EnergyGauge software tool have been largely borne by FSEC and BA teams are charged a very modest annual license fee ($99/year at present) for its use.

Field Monitoring/Infomonitors

Over the past 20 years, FSEC has developed a sophisticated, web-based data retrieval, archival and analysis tool for field monitoring of building performance. This tool has been consistently used by FSEC for its remote field monitoring projects all over the nation, some of them very large, involving more than 200 simultaneously monitored homes. This tool, which is presently deployed on a web site called Information Monitors (http://www.infomonitors.com/), contains a number of elements that make it extremely useful and flexible.

First, Information Monitors provides data retrieval capabilities that can be tailored to a large variety of the data acquisition and communication systems. The tool currently communicates with and retrieves and "translates" data from a wide variety of popular data acquisition systems from Campbell Scientific, Fluke, ENETNET K20, and other vendors. The most common communication protocol consists of RS-232 serial communication via telephone lines, however, other options can be readily configured to work with the tool.

Second, the tool provides "command-driven" data manipulation capability to perform a wide range of analysis and statistical functions, including graphing and plotting of results. The fact that the tool is "command-driven" allows for significant flexibility in automating data manipulation such that various research projects can tailor the output of the tool to their individual project needs. Embedded within the tool, is also the capability for researchers to establish "alarm" protocols. These protocols are also quite flexible, allowing researchers to set limits on expected data values (including computed values from multiple streams of data that are used in user-specified equations or even statistical analysis), generating "alarms" when the expected data values are exceeded. The alarms may be communicated to researchers in a variety of ways, including e-mail messaging, phone messaging, electronic activation of on-site visual or audible alarms or other electronic means that may be available.

Information Monitors also have many additional advantages it derives from being web-based. Researches have the ability to create dynamic web based reports. Researchers and clients have "any time, any place" access to the full capabilities of the system; specific data streams can be protected through secure service and password protection; and general data results and information can be quickly shared with large audiences through web-sites that call the capability or through e-mail or other electronic communication that calls attention to specific interesting or important data that has been generated by the system.

Again, the development costs of this capability have been borne by FSEC. However, FSEC provides the Information Monitors tool kit to BA teams for their field

monitoring projects for a modest set-up fee plus a monthly database maintenance fee, both of which are volume dependent.

7. **Project History:**
   The development of EnergyGauge USA began in 1996 and continues as codes and standards, home energy rating systems and benchmarking analysis methodology evolves over time. Information Monitors has been under development in evolving formats since the early 1980s.

8. **Technical Approach:**
   As previously indicated, both EnergyGauge USA and Information Monitors are evolving projects. EnergyGauge evolves as specifications for energy codes and standards and home energy rating systems are modified or improved. Information Monitors evolves as information technologies improve and are expanded and as clients request increasing levels of sophistication in data analysis capabilities.

   For EnergyGauge, the approach is to continue the development of capabilities that ease the burden on BA teams for benchmark analysis and reporting. While EnergyGauge has already simplified many user needs for building simulation and analysis input, it has not yet implemented the needed capabilities that would reduce individual interpretation and use of the benchmark process. This could be done by incorporating benchmark home auto-generation routines, much like those that are presently used for code compliance and energy ratings, into EnergyGauge. The result would be that BA teams would only have to input the characteristics of proposed prototype designs and the software would automatically generate the corresponding benchmark home using the specification of the benchmark rule set. This would largely rule out individual interpretation by analysts, human error in benchmark inputs and inconsistence in benchmark results.

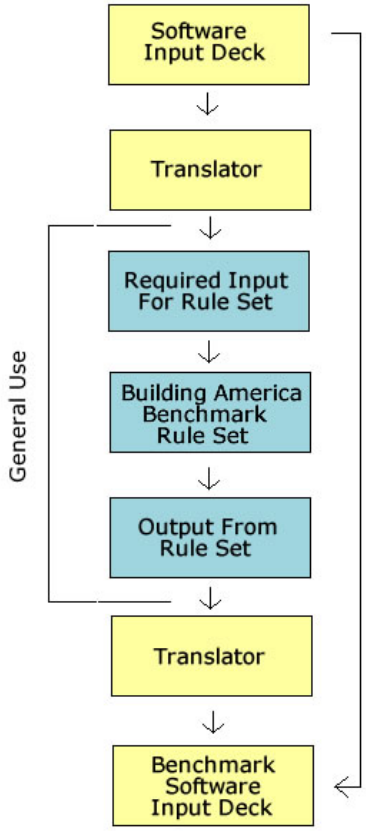
   FSEC is currently working with DOE, NREL and the BA teams to explore means of accomplishing this goal, while at the same time providing the open source code that would allow a generalized computer utility that would allow the capability to be useful to other software developers.

9. **Technical Work Plan for 2005:**
   FSEC is slated to receive $100,000 in FY05 DOE funds to make incorporating the Building America Benchmark more automatic in various simulation software. The task encompasses development of benchmark rules as a utility designed to be robust enough to accept other, future sets of rules (code, etc.) for residential inputs similar to those required by the Building America Benchmark. The Benchmark parameter calculation engine should be verified by working with one or more software products. Any software wishing to invoke the Benchmark should only need a simple translator for inputs and outputs to use the utility.

The following high priority items identified at the Building America Expert meeting in Denver in January 2005 are to be included in the utility or provided as part of separate well documented algorithms which can be implemented by any software developer.

- Breaking out ventilation energy in reports
- Providing more options for forced ventilation control as requested by BSC
- Add simplified capability to estimate energy benefit/liability from hot water recirculation systems for residences
- Add clothes washer and dishwasher schedules in order to obtain credit for Energy Star appliances.

In addition to writing the utility, FSEC is to document the code, test the code against existing Benchmark spreadsheets, and make the utility (as source code) available to everyone wishing to use it. The EnergyPlus team guidelines will be followed for documenting the utility. Thus, the utility will be useful to any organization working on other software platforms that wish to create a Benchmark.



Period of Performance: May 1, 2005 – March 31, 2006

Deliverables:

Progress reported in monthly reports.
Draft utility delivered by October 2005
Final utility, updated for any BA changes received by March 1,2006
Software support to all BA teams through March 31, 2006.

The Information Monitors servers will go through a major overhaul during the next 12 months. The changes will include high-end 64-bit processors, high-speed storage network, and updated operating system and application software.

10. **Technical Barriers:** There are no insurmountable technical barriers in performing either of these tasks.

11. **Status of Project Deliverables: N/A**

12. Commercialization Plans:

EGUSA is publicly available. Please refer to http://www.energygauge.com/ for pricing and other information. Infomonitors is available to all BA teams and others for a fee. Please contact Safvat Kalaghchy (321-638-1510, safvat@fsec.ucf.edu for more information)

13. Efficiency Improvement Metrics: N/A

14. Project Output

Several papers and reports have been written related to EGUSA as listed below.

Lombardi, M., Parker, D., Vieira, R., Fairey, P. (2004), "Geographic Variation in Potential of Rooftop Residential Photovoltaic Electric Power Production in the United States," Proceedings of ACEEE 2004 Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Washington, DC, August 2004. Online at http://www.fsec.ucf.edu/bldg/pubs/geo_variation/index.htm

Fairey, P., D.S. Parker, B. Wilcox and M. Lombardi (2004), "Climate Impacts on Heating Seasonal Performance Factor (HSPF) and Seasonal Energy Efficiency Ratio (SEER) for Air Source Heat Pumps." *ASHRAE Transactions*, American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., Atlanta, GA, June 2004. Online at http://www.fsec.ucf.edu/bldg/pubs/hspf/index.htm

Parker, D. S. and P. W. Fairey (2001). Preliminary Evaluation of Energy-Efficiency Improvements to Modular Classrooms. Report No. FSEC-CR-1272-01. Florida Solar Energy Center, Cocoa, FL 32922. Online at http://www.fsec.ucf.edu/bldg/pubs/cr1272/index.htm

Fairey, P., R. Vieira, and D. Parker (2000), "Validation of EnergyGauge® USA Using the HERS BESTEST." Research Report No. FSEC-RR-55-00, Florida Solar Energy Center, Cocoa, FL, October 17, 2000. Online at http://www.fsec.ucf.edu/bldg/pubs/bestest/index.htm

Fuehrlein, B., S. Chandra, D. Beal, D. Parker, and R. Vieira (2000), "Evaluation of EnergyGauge® USA, A Residential Energy Design Software, Against Monitored Data." Proceedings of ACEEE 2000 Summer Study, pp 2.115 - 2.126, American Council for an Energy Efficient Economy, Washington, DC, August 2000. Online at http://www.fsec.ucf.edu/bldg/pubs/valid/index.htm

15. Budget

The approximate budgets for EGUSA and Infomonitors since 2000 is provided below. Please note that these figures are very approximate as at FSEC accounts are NOT maintained by tasks, only at project levels. All numbers are in K$

	2000	2001	2002	2003	2004	2005	Totals
EGUSA-DOE	20	15	8	0	0	100	143
EGUSA- Costshare	75	75	75	75	75	25	400
Infomon-DOE	15	15	15	15	15	15	90
Infomon-Costshare	32	32	32	32	32	32	192

Notes:

1. EGUSA – DOE 2000 and 2005 funding is from BAIHP. 2001 and 2002 funding is from DOE-SEP projects.
2. Infomon – DOE refers to funds paid by BAIHP and other BA teams.

16. Principal Project Personnel:

The development of EGUSA is co led by Robin Vieira, Philip Fairey and Danny Parker. They spend about 25% of their time on EGUSA. The Infomonitors effort is led by Safvat Kalaghchy. He devotes about 40% of his time to it. Their resumes follow.

17. Other Information Sources:

The websites for EGUSA and Infomonitors are listed below:
http://energygauge.com/
http://www.infomonitors.com/

Mr. Robin K. Vieira
Director, Buildings Research Division

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Education:
Master of Science, Applied Solar Energy,
Trinity University, TX, 1983

Research Focus

Conduct research in green building technologies and green building standards. Helped found the Florida Green Building Coalition, serving as the president for the organizing committee. Served as editor and committee chair for FGBC's Green Development Standard – a first of its kind environmental stewardship designation for land developments meeting objective criteria that far exceeds minimum code. Was one of two co-PIs creating a Green Local Government Designation for Florida City and County governments. Participated in the development of FGBC green guidelines for homes and served on the United States Green Building Council LEED 1.0 committee developing a standard for commercial buildings. Managed research on 384 households, comparing transportation, electricity and water use among ten Central Florida developments.

Directed a million-dollar demand-side management research project including audits and analysis of 400 recently built homes. Key outcomes included changes that were implemented in Florida's energy code and rating system. The analysis demonstrated a detriment to peak load and annual energy use from oversizing of HVAC equipment.

Have helped disseminate information through workshops and publications, authoring one book, *Energy-Efficient Florida Home Building.* Provided builder technical support via EPA Energy Star Homes and Department of Energy building America program. Helped design, write and supervise the development of new energy analysis software for the home energy auditing and construction market (EnergyGauge).

Have developed passive and mechanical cooling methods for off-shore equipment enclosures for the U.S. Navy and researched a new cooling concept using a radiative/desiccant roof system that provides cooling and dehumidification for the U.S. Department of Energy.

Mr. Philip Fairey
Deputy Director, Florida Solar Energy Center

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E-mail: pfairey@fsec.ucf.edu

Education:
M.S., City and Regional Planning, Clemson University, 1974
B.A., Architecture, Clemson University, 1969

Research Focus
Mr. Fairey has more than 25 years experience in building science research. He initiated the building science research program at FSEC in 1980 and, since then, has had primary responsibility for more than 30 major building science research contracts totaling more than $12 million. He has served as Deputy Director of the Center since 1990 and as the Center's Interim Director from 2002 through 2004. Mr. Fairey has extensive expertise in combined heat and moisture transfer in buildings; heating, ventilating and air conditioning systems; building energy efficiency; humidity and moisture control; indoor air quality (IAQ); building forensics; energy codes and standards; computer simulation and modeling; and building energy-efficiency rating systems. He conceived and developed the *Florida Building Energy-Efficiency Rating System* and led the development of *EnergyGauge*®, a user-friendly, windows-based software tool for code compliance, energy ratings and economic analysis. He also initiated and led the development of a sophisticated, finite element, combined heat and moisture transport building simulation software research tool, *FSEC 3.0*, capable of accurately simulating complex building science phenomena in detail.

Mr. Fairey is an active member of the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) where he has served as Research Chairman of TC 4.4 on Thermal and Moisture Retarders and as Chairman of TC 4.9 on Building Envelope Systems and where he currently serves as a voting member SSPC 140, *Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs*. He has also served as a member of ASTM C-16, where he chaired the Task Group that developed ASTM Standard C-1158 on Radiant Barrier Systems. He served as a member of U.S. Department of Energy's National HERS Council Technical Committee and currently serves on the Florida Building Commission Energy Technical Advisory Committee. He is President of the national Residential Energy Services Network (RESNET) and a founding member of the Florida Green Building Coalition (FGBC).

Mr. Fairey is author or co-author of 4 books and more than 80 technical articles and has received two U.S. Patents. He received the U.S. Department of Energy's National Award for Innovation in Research in 1984 and the University of Central Florida's highest award for research in 1987. He has testified before the U.S. Congress and the Florida Legislature and has been qualified by the Courts as a Building Science Expert.

Danny S. Parker
Principal Research Scientist

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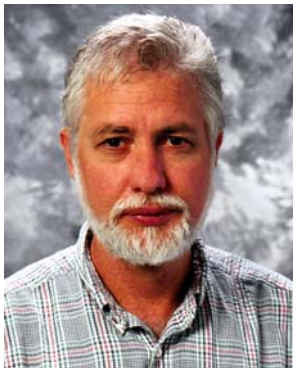

Education:
M.S. Environmental Science
University of Montana, Missoula, Montana 1983

Research Focus
Mr. Parker specializes in collecting and analyzing measured data taken from residential and commercial buildings to determine how results may be applied to reducing energy needs. Over the last 16 years, he has studied technologies to improve energy efficiency in Florida's buildings. He has extensive experience with building energy and field monitoring.

Mr. Parker has spent the last 25 years of his career in the field of energy-efficiency research. He has been involved in a number of field projects in residential and commercial buildings and is expert in building energy measurement and monitoring.

Much of Mr. Parker's research over the last several years has been specifically related to research in highly efficiency buildings and potential impacts when mated with renewable energy resources. He also has extensive experience with large-scale utility monitoring projects and evaluation of load control options. He holds several patents associated with innovative energy efficiency technologies.

Over the last decade, Mr. Parker's residential research includes the following: impact of white roofing on residential cooling energy use, impact of utility load control on appliance demand profiles in large-scale monitoring, impact of attic radiant barrier and attic ventilation performance, evaluation of the impact of programmable thermostats, whole house fan impact on thermal comfort, evaluation of residential AC sizing methods, photovoltaics and solar energy sources as optimized for buildings, potential of energy efficient lighting in residences, impact of reduced evaporator air flow on AC performance, development of a zero energy home where cooling was reduced by 84% and development of a low-energy high performance ceiling fan.

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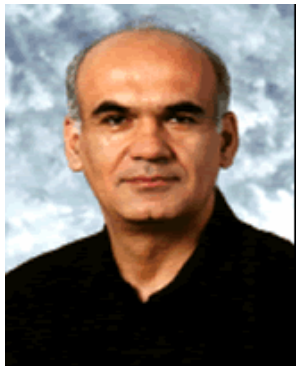

Education:
M.S. in Mechanical Engineering, MBA
Florida Institute of Technology, 1982

Research Focus

Safvat Kalaghchy is the program director for the Computing and Information Technology group at the Florida Solar Energy Center (FSEC). He is responsible for the design, development, and implementation of energy related information technology and scientific computing projects at FSEC. He is the architect for the www.infomonitors.com and the backend engine, the Experimental Management Database System (EDBMS) that enables automated field-monitoring project. He co-developed the first version FlaCom, State of Florida's commercial energy code compliance software, now known as EnergyGauge/FlaCom. He has also developed a number of other complex scientific software to analyze the behavior of thermal systems.