The Reenergize Undergraduate Research Program in Its Second Year

Dr. Dan G. Dimitriu, San Antonio College

Dan G. Dimitriu has been practicing engineering since 1970 and taught engineering courses concurrently for more than 20 years at various institutions. In 2001, he joined San Antonio College full-time as the Coordinator of its Engineering program. He has been involved with several engineering societies and became a member of the Two-year College Division of ASEE in 2002. His research interests are in engineering graphics, design, alternative fuels, plastics, and engineering education.

Mr. Klaus Bartels, San Antonio College

Klaus Bartels is an Adjunct Faculty member at San Antonio College (SAC) in both the Mathematics Department and the Physics/Engineering/Architecture Dept. He was born near Buenos Aires, Argentina and immigrated to the U.S. in 1956. He grew up and went to college in the Boston, MA area. He has a B.S.E.E. from Tufts University (1972) and an M.S.E.E. from M.I.T. (1975). He served as a Communications-Electronics Engineer/Officer in the USAF from 1975 to 1999, retiring as a colonel. He worked part time as a Flight Director at the Challenger Learning Center of San Antonio from 2000 to 2009, and has been teaching remedial math and engineering classes at SAC since 2000. He has been involved in various engineering summer programs at SAC, including instructor for Robotics Camps for 3rd to 5th graders (2012 - 2014), and instructor/coordinator for the Early Development of General Engineering program for high school students (2007 - 2015). Since 2011 he has also served as faculty adviser for numerous undergraduate research projects involving solar and hydrogen fuel cell technologies at SAC.

Mr. Steven F Lewis, San Antonio College/Alamo Colleges

Steven Lewis served as a training manager for Lockheed and Raytheon corporations around the world and spent a total of 27 years primarily in Colombia, Iran, Saudi Arabia and Mexico. He assumed the leadership role at the Service, Trade, and Industry Center of Alamo Colleges/San Antonio College in 2006 and quickly expanded the scope of the center by launching the Alamo College Green Training Initiative. In order to strengthen the initiative, Mr. Lewis collaborated with the college grant office to submit a successful proposal to the United States Department of Urban Development in 2010 for construction of the William R. Sinkin Eco Centro. He since served as director of Eco Centro while collaborating with Texas State University on the Re-Energize grant and EverGreeen grants in overseeing undergraduate research projects

The Re-Energize Undergraduate Research Program in Its Second Year

Abstract

The initiation of the Re-Energize Undergraduate Research Program was presented in a previous ASEE paper at the 2016 Annual Conference in New Orleans. It started as a network of renewable energy education and research labs fully contained and established at each of the four participating member institutions. The main goal of this collaborative effort is to share effective new green technology content and impart skills to faculty members of this network in order to strengthen their capacities and arm them with additional resources to support their efforts in recruiting and retaining students, and in particular, minorities, in STEM programs offered at their institutions.

Our two-year college, San Antonio College (SAC), as part of this network is working on developing and implementing new undergraduate research projects related to green technologies for the entire duration of this partnership. Our college made a commitment to

1) encourage our STEM faculty to attend Re-Energize professional development opportunities to learn and include green energy educational modules into our STEM curriculum;
2) seek space to establish a "start-up green lab" on our campus with Minority Science and Engineering Improvement Program pass through funding from the four-year institution so that faculty can conduct classroom demonstrations and our students can perform undergraduate research. This initiative is meant to diversify and continue our undergraduate research program as we include our William R. Sinkin Eco Centro facility into this program.
3) promote additional related outreach and educational Re-Energize efforts to support our students and encourage them to seek successful careers in STEM and green energy-related fields and to
4) participate in on-going evaluation and research efforts related to this program.

Numerous reports demonstrate that undergraduate research programs at four-year institutions have been responsible for increasing retention and graduation of their students. Our previous results indicate that two-year institutions can also initiate successful programs with similar

results. This paper presents in detail the results of the second-year partnership between the participating institutions to continue developing new directions for summer undergraduate research programs at our community college, offers recommendations, and outlines future plans.

Career Growth Projections for Engineers

Bureau of Labor Statistics (BLS) indicates that demand for engineers will continue to show a steady growth during the 2014-2024 period and expects greater-than-average growth from several individual engineering fields with rates ranging from 23.1% for biomedical engineers to 5.3 % for mechanical engineers [1]. The increasing employment of engineers in service industries, research and development, and consulting is expected to generate most of the employment growth.

The National Science Foundation in a 2015 Survey of Graduate Students and Post-doctorates in science and engineering [2] found that from 2008 to 2013 STEM graduate students in the U.S. who were U.S. citizens or permanent residents rose 3.1%. Of these, 25.8% were Hispanic and 7.8% were African-American.

San Antonio College, being a minority serving institution, has a stated mission to attract and engage minorities on a path toward higher education. A high level of achievement in Science, Technology, Engineering, and Mathematics (STEM) education is essential if the U.S. is to maintain a leading role in space science, aeronautics, cybersecurity, and technology in general. As shown in previous papers, for the last fifteen years San Antonio College has been on a continuously ascending path to attract and retain more students, in particular minorities, into the STEM fields as well as striving to align its engineering program with the engineering programs offered by the surrounding area four-year institutions [3], [4]. At the same time, this college's engineering faculty made every effort to provide the highest quality education for our students [5].

A previous ASEE paper [6] described a new partnership, called "Re-Energize," that is expected to help several two-year colleges develop their own research capabilities in renewable energy in collaboration with Texas State University.

The Re-Energize program plans to establish a creative research and development (R&D) and professional development (PD) ecosystem. This ecosystem will empower institutions of higher education who prepare students in engineering and engineering technology in Central Texas to

continue to do so with enhanced and focused knowledge, facilities, and student programs. Re-Energize addresses the learning needs of faculty and students via a systems approach and aims to serve as a replicable and scalable national model.

The previous paper presented the results of the first year of the program. This paper presents the results of the second year of the program.

Re-Energize Project: Results of the Second Year (1 Oct 15 to 30 Sep 16)

Objective 2: Provide awareness, training, and financial support to attract and motivate students from the minority institutions to consider education and career opportunities in STEM.

> **Activity 2.3:** Texas State will facilitate a day-long tour for the participating students to Texas State labs and facility with STEM-oriented educational and entertainment programs.

In Year 2, one SAC faculty member and seven students visited Texas State University in February 2016 for a day-long tour of renewable energy demonstration/research laboratories and engineering manufacturing facilities. Texas State faculty and graduate students also provided an update on the Re-Energize program, including research and scholarship opportunities. Comparison of student surveys done before and after the TxState tour showed a significant increase in students' desire to learn more about sustainability and environmental issues, as well as a significant increase in their knowledge of solar and wind energy technologies.

Objective 3: Design and develop a replicable renewable energy laboratory to carry out the training and hands-on activities proposed in the Re-Energize program. A replica of the lab will be established at Eco Centro to operate independently once the training is completed.

> **Activity 3.2**: San Antonio College will nominate selected members of STEM faculty and encourage as well as support them to attend the designated Re-Energize professional development activities to learn and adopt green energy educational modules.

In Year 2, one faculty member (physics/astronomy) attended the one-week Re-Energize training seminar at Texas State University in May 2016. During the week, Texas State faculty and industry representatives provided a detailed overview of the Re-Energize program including partner institution responsibilities, as well as instruction on sustainable/renewable energy systems and demonstrations of solar, wind, and rainwater catchment systems. Texas State also

provided a tour of their engineering/manufacturing lab facilities. Three STEM faculty (two engineering and one environmental) attended the training in Year 1.

In Year 2, SAC faculty continued the use of educational modules/activities that were developed during Year 1 for use in engineering and math classes. These modules/activities improved student awareness and learning in sustainability and renewable energy systems. These modules included renewable energy application problems for use in exams as well as a sustainability team design project. The sustainability project is the most complex and ambitious in regards to student learning outcomes. This team project requires students in our Introduction to Engineering classes to modify a builder's existing new home design to improve its sustainability by reducing its resource consumption and/or improving energy efficiency. Student teams developed written design proposals and gave oral presentations on their more sustainable new home designs. These designs, two of which were done in collaboration with Habitat for Humanity, included two or three sustainability features such as improved insulation, xeriscape landscaping, solar photovoltaic (PV) electric systems, higher efficiency HVAC systems, geothermal systems, sustainable building materials, and rain harvesting systems. This project is most aligned with the following course student learning outcome: *As part of a team, design a simple engineering device, write a design report, and present the design*. Based on students' project grades, 91% of students met this student learning outcome by completing this sustainability project. The detailed requirements/guidelines for this team project are provided as Appendices 1 and 2.

> **Activity 3.3**: San Antonio College will utilize the funding provided by Texas State and designated for the establishment of a start-up green lab incorporating technical collaboration with Texas State.

As year one was drawing to a close, it became apparent that there was a need for a dedicated room other than the shipping container in which experimentation related to hydroponics food production could take place. A laboratory was set up to house the rack prototype, instrumentation, and equipment assembly kits. Design strategy meetings and development of additional prototypes take place in the lab.

During the first year of the Re-Energize grant, six students and a college staff member developed a prototype hydroponics grow rack using PVC pipes and a simple wooden structure. The

objective was to come up with a design that could be replicated at low cost in developing countries (Fig. 1). The prototype is housed in the lab and has served as a structural starting point for modification and refining during years two and three of the Re-Energize hydroponics project.

Fig. 1 - Hydroponics Grow Rack Prototype

Fig. 2 - Instrumentation and Equipment Aligned with the Hydroponics Project

Even though Year 1 Re-Energize project activity focused heavily on structural aspects of the grow rack, students took into account the need to control many operational factors that directly affect the health of plants in protected environment agriculture. Instrumentation including a pH, CO_2 and turbidity sensors were factored into the design (Fig. 2). The scope of sensor use expanded in year two with the planned buildout of the grow racks in the dedicated shipping container.

Given the multi-faceted nature of lab work, students engaged in lab projects divided into teams. Team specialties include lighting, programmable monitoring devices, seed propagation and structural design. Assigned team leaders keep records of their project and coordinate with team members to schedule work sessions on a weekly basis. One important advantage offered by the lab as opposed to the containerized hydroponic project is that it can be used for public demonstrations, accommodating groups of visitors from the community and area schools.

Fig. 3 – Propagation Station with Grow Lights

Fig. 4 – Conductivity Meter Test of the Nutrient Level of Hydroponic Liquid

The lab offers a wide enough variety of student activities to engage students from most STEM departments. Students involved to date represent the college departments of biology, chemistry, engineering, and environmental science. Specialized grow lights allow students to conduct experiment comparing growth of plants when exposed to specific light spectrum mixes and intensities (Fig. 3). It is well equipped with instrumentation including this liquid conductivity probe and a PAR sensor for light measurement (Fig. 4).

Activity 3.4: San Antonio College agreed to participate in on-going evaluation and research efforts related to this program.

The following paragraphs describe the projects that fall under this activity:

Hydroponics Projects

During Year 2 of the hydroponics project, the focus of activity expanded from rack prototype development to design of all support systems for the shipping container that houses the project. Design concepts evolved thanks to input from affiliated institutions of higher education including Texas State University, University of Texas San Antonio and Wageningen University in the

Netherlands. The turnkey approach used by those institutions had to be pared back in order to accommodate the team's goal of creating a low-cost containerized hydroponics system that can be assembled using materials readily available in developing nations.

In April of 2016 students, staff and faculty involved in hydroponics projects at San Antonio College and Texas State University engaged in a collaborative planning session when they gathered for the combined EcoExchangeEdu and Re-Energize grant event held at the William R. Sinkin Eco Centro facility of San Antonio College. The scope of higher education collaboration on the hydroponic and other environmentally-related projects expanded with the participation of Coastal Bend College, Palo Alto College and Southwest Texas Junior College. Based in part on concepts exchanged at the event, the San Antonio College team moved forward with the design, construction and placement of support arches and crossbeams for the interior of the hydroponics container that reinforce side walls while providing stability for the grow racks to be placed against the two side walls of the container (Fig.5). In addition, Texas State University came away with design concepts for vertical agriculture experimentation at their agricultural facility.

Fig. 5 -Hydroponics Structural Team Installing Support Arches

As the support structure went into place, the students engaged in support infrastructure design were able to flesh out details related to the electrical system, the nutrient transmission system, and climate control. The scope of higher education collaboration expanded at that point to include students with relevant majors from the University of Texas in Austin and University of Texas in San Antonio. The team and support staff met with Alamo Colleges' electricians to

define specifications needed to contract with a local electrical contractor for the installation of a 200-amp meter loop. The loop was installed and a bid went out to run conduit from the meter to the container. This time-consuming process of designing the electrical system, sending out to bid, and them monitoring installation proved to be a valuable learning experience for the hydroponics team.

As the second year drew to a close, the opportunity arose for students to develop a remote-controlled cart to be used in moving environmental monitoring sensors throughout the grow chamber of the hydroponics shipping container (Fig. 6). The sensor data and control of the vehicle will be monitored from a workstation separated from the plants by a barrier. This layout facilitates data gathering while minimizing exposure to harmful plant diseases or pests that would be introduced if humans had to repeatedly enter the grow area. Two prototype carts were successfully designed and developed during the summer. These designs will be refined to produce a final operational hydroponics remote monitoring vehicle as the project progresses through Re-Energize Year 3.

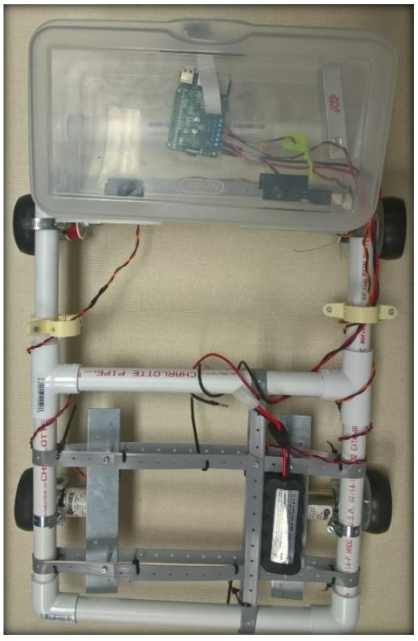

Fig. 6 – Prototype Remote-Controlled Hydroponics Monitoring Vehicle

Late in year two, one of the hydroponics team members combined forces with several others to create a vertical hydroponics unit on one of the exterior walls of the hydroponics container (Fig. 7). The need to create an exterior demonstration unit stems from the restrictions on human access to the interior of the hydroponics container. The exterior unit allows team members and

staff of the William R. Sinkin Eco Centro facility to demonstrate vertical agriculture to the numerous tour groups who visit the facility. The system components incorporated into the interior grow chamber are demonstrated in reduced form using the exterior unit.

Fig. 7 - Exterior Hydroponics Unit

Fig. 8 - TxState and SAC Students Sharing Ideas during TxState Campus Tour

The achievements of the hydroponics team during years one and two came to fruition in mid-2016 with the announcement that Texas State University's USDA EverGreen grant proposal was funded, thus paving the way for several more years of collaboration between the two institutions. The EverGreen grant is a joint project of the Ingram School of Engineering and Department of Agriculture at TxState as well as San Antonio College and Palo Alto College. It strengthens the collaboration between the three institutions involved and creates a pipeline for talented STEM students at Alamo Colleges to pursue further scholarship-funded studies at Texas State University. EverGreen's goal is to find innovative solutions for the global food-water-energy nexus while simultaneously increasing the number of Hispanic students with advanced technical degrees at the food-water-energy intersection. As year 3 of Re-Energize was about to begin, students from San Antonio College traveled to the Texas State campus to meet with counterparts and discuss implementation strategies (Fig. 8). Ongoing collaboration between the two institutions exposes undergraduate students at the college to graduate research projects at Texas State, thus establishing a cross-pollination of ideas that strengthens the hydroponics teams at both institutions.

Solar Electric Vehicle Project

During Year 1, eight engineering and chemistry students and two faculty advisors converted an old, worn-out gas utility cart into a solar-electric vehicle. This project was primarily funded through a National Science Louis Stokes Alliances for Minority Participation CIMA Alliance grant along with donations from Alamo Colleges. The solar-electric cart has four 12-volt batteries, two 230-watt roof-mounted photovoltaic (solar) panels (one on a slide mount), and a four horsepower, 48-volt DC electric motor (Fig. 9).

Fig. 9 - Solar-Electric Cart (2015)

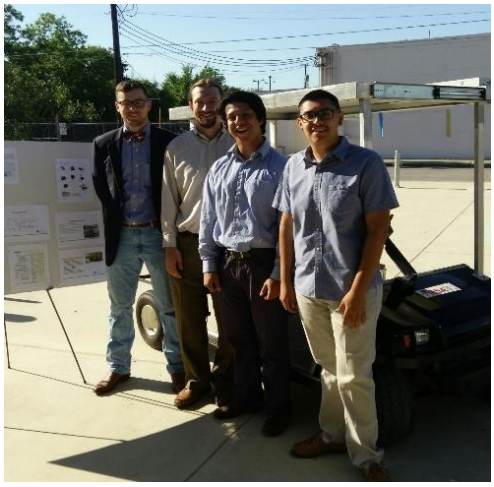

Fig. 10 - Solar-Electric Cart Project Team (2016)

This difficult and complex project produced a functional solar-electric vehicle. However, due to time constraints, vehicle performance was not tested, and certain desired capabilities were not incorporated. During 2016 spring semester a team of 4 engineering students finished this project including research, troubleshooting, design, fabrication, installation, testing, and documentation of various vehicle modifications, and upgrades (Fig. 10). The team installed a stronger electric motor mount that is adjustable (Fig. 11) and a DC-to-DC converter for accessories.

Fig. 11 - Solar-Electric Cart – Electric Motor Mount (2016)

In addition, they repaired the parking brake, installed a protective plexiglas panel over the electrical components, and added storage compartments on both sides of the vehicle for holding flyers and educational materials (Fig. 12).

Fig. 12 - Solar-Electric Cart – Plexiglas Protective Cover and Side Storage Compartments (2016)

Performance testing of the vehicle determined solar panel output, battery charge time in sunny conditions, and the cart's top speed and range with fully charged batteries. The SAC Mathematics Engineering and Science Achievement (MESA) Center [7] is using the vehicle to promote STEM programs at various events at SAC to increase students' interest in STEM careers. It has been a showcase project for the SAC undergraduate research program[8] while also promoting sustainability, renewable energy technology, and the Re-Energize program (Fig. 13).

Fig. 13 - Solar-Electric Cart – Promoting Renewable Energy and STEM on Campus (2016)

Hydrogen Fuel Cell Vehicle Project

During Year 1 of the Re-Energize program, a team of more than 20 energetic engineering students (mostly Hispanic) from San Antonio College established the SAC Motorsport Team (Fig. 14). Their goal is to design and build a prototype hydrogen fuel cell vehicle (HFCV) to compete in the prestigious Shell Eco-Marathon Americas tournament (shell.com/ecomarathon) in Detroit in April 2017 (Fig. 15). Shell Eco-Marathon challenges student teams from around the world to design, build, test and drive ultra-energy-efficient vehicles. This project has generated more interest and participation by SAC STEM students than any previous undergraduate research project.

Fig. 14 – SAC Motorsport Team

Fig. 15 – Shell Eco-Marathon Competition

In Year 2 the SAC Motorsport Team with assistance from SAC faculty, industry contacts, and the Texas State University students and faculty worked hundreds of hours researching, designing, and selecting equipment/materials for the HFCV; i.e., wheels & tires, steering and suspension, frame and body (Fig. 16), motor and motor controller, and the fuel cell. The team also worked hard getting equipment/parts donations and raising funds for this extremely complex and expensive project.

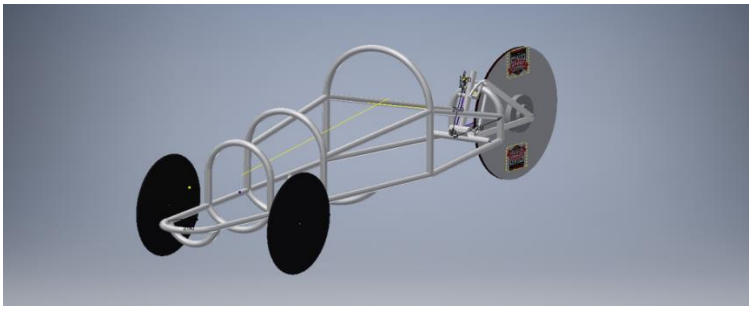

Fig. 16 – Preliminary Design for Hydrogen Fuel Cell Vehicle

During Year 2 the team also procured most of the equipment/parts needed to build the vehicle, including the expensive Hydrogen Fuel Cell Stack (HFCS) that will provide electrical power for the vehicle. To compete effectively in Shell Eco Marathon there was a need to better understand how the H-1000XP Hydrogen Fuel Cell Stack (HFCS) performs under different circumstances to find its most efficient operational configuration. To do this, four SAC Motorsport team members tested the HFCS in a summer, 2016 undergraduate research project (Fig. 17).

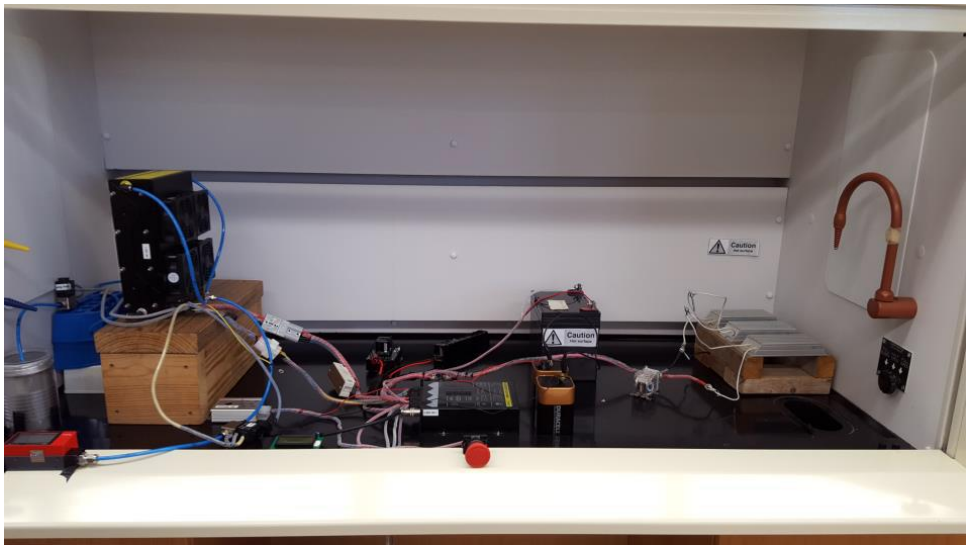

Fig. 17 – Hydrogen Fuel Cell Stack Performance Test Setup

HFCS performance was tested with two different variables being controlled; i.e., the hydrogen gas supply pressure and HFCS output load. During testing, the supply pressure varied from 7.25 psi to 9.25 psi and output loads varied from 87 Watts to 867 Watts. At the same time, fuel (hydrogen) consumption in liters/min was measured. With this data, charts were produced showing the fuel efficiency in Watts/liter/min for different input gas pressures and output power levels. Test results showed that HFCS fuel efficiency at output power loads of 87, 125, and 164 watts was highest at lower input gas pressures (7.25 to 8.5 psi), and dropped substantially at higher gas pressures. At the four highest output loads (214, 401, 553, and 867 watts), the fuel efficiency was fairly constant at input gas pressures of 7.75 psi and above (Fig. 18).

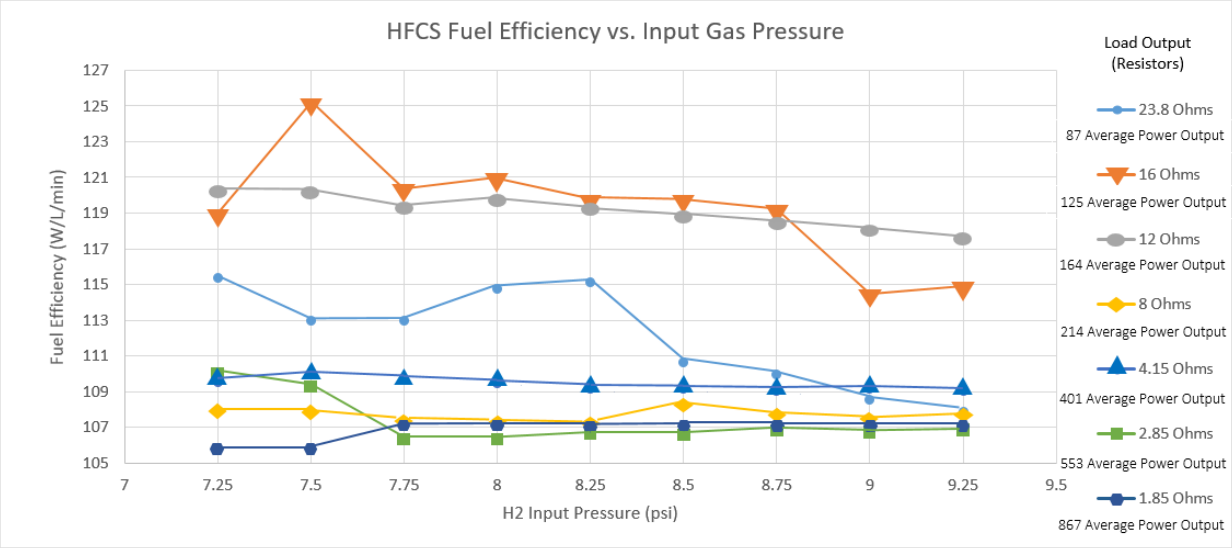

Fig. 18 – HFCS Performance Test Results

The objectives of this research project were met; i.e., a better understanding of HFCS performance and determining its most efficient operational configuration. This information will be used to improve the fuel efficiency of the Hydrogen Fuel Cell Vehicle. During Year 3, the hydrogen fuel cell vehicle will be constructed, including the frame, body, wheels, steering, and electrical system; and, after local testing, will then compete in the Shell Eco-Marathon in Detroit in April 2017. This marquee Re-Energize and SAC undergraduate research project promotes sustainability and energy efficiency. In addition, this project will continue to be used to recruit students into STEM fields/programs and help train the engineers of tomorrow.

Research Project Surveys

Surveys of students involved in the preceding Re-Energize research projects were taken to assess the students' opinions regarding their project experience. The survey results of a representative sample of the students involved in these projects is shown in Table 1. As seen, there was universal agreement that the research projects were very interesting and were also enjoyable. In addition, the results indicate the students felt competent in the research work they did and were satisfied with their performance.

Statement	Number of Responses					Average Response
	5 (Very True)	4	3 (Somewhat True)	2	1 (Not at All True)	
1. I found the task very interesting.	9	1	0	0	0	4.9
2. I would describe the task as very enjoyable.	7	2	1	0	0	4.6
3. After working at this task for awhile, I felt pretty competent.	4	6	0	0	0	4.4
4. I am satisfied with my performance at this task.	3	6	1	0	0	4.2

Table 1 – ReEnergize Research Projects Student Survey Results Summary

Conclusions

In Year 1 of this collaborative effort, San Antonio College ramped up quickly with equipment acquisitions, faculty training, student recruitment, and research team formation and project execution. In Year 2, our student participation in Re-Energize activities increased by 76% (from 21 to 37 students), and we added a fourth "green-energy-trained" faculty member to the program. In addition, Year 2 saw more students involved in Re-Energize-supported undergraduate research projects. These students completed the solar electric cart project and made major progress in the hydroponics and hydrogen fuel cell vehicle projects. As indicated from student surveys, students involved in Re-Energize undergraduate research projects rated their experiences in these projects extremely high. In Year 2, SAC also continued the successful use of educational modules/activities that were developed during Year 1 for use in engineering and math classes. Finally, Year 2 brought increased collaboration between SAC and TxState which will continue for several years with the awarding of USDA's EverGreen grant in 2016 that will provide scholarships for studies in sustainable technologies for underrepresented minorities. San Antonio College was successful in meeting both the Year 1 and Year 2 objectives of the Re-Energize program and is well-positioned for executing Year 3 SAC and the other Re-Energize institutions are united in strengthening their capacities to use renewable energy technologies and activities to support efforts to increase recruitment and retention of students, especially minorities and females, in STEM programs offered at their institutions.

References

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8. Initiation of an Undergraduate Research Program, by Dan G. Dimitriu and Jerry O'Connor, ASEE Conference, San Antonio, TX, June 2012

Appendix 1

ENGR 1201 – Team Project #1 — Guidelines
Sustainable New Home Design

- Goal: Prepare a proposal for modifying an existing new home design to improve its sustainability by reducing its resource consumption and improving energy efficiency
- General Project Requirements:
  - Obtain an existing San Antonio builder's design, including floor plans and specifications, for a typical, middle income 3 or 4-bedroom new home
  - Select **two (min) or three (max) ways** to change the home's design to increase its sustainability and/or reduce resource consumption, yet still be affordable for middle income families
  - Examples of sustainability measures that can be incorporated into the design include:
    - more sustainable building materials
    - more efficient HVAC or water heating systems
    - more efficient appliances
    - alternative energy systems (solar, wind, biofuel, or geothermal)
    - xeriscape landscaping
    - rainwater harvesting
  - Prepare a written report and oral PowerPoint presentation detailing your proposed design
- Written and Oral Report Requirements: (Note - much more detail must be provided in the written report. The oral presentation will include the most important aspects of the written report/proposal.)
  - Description of the existing new home design to include:
    - Name of builder, floor plan, dimensions, lot size, primary building materials, total cost
    - Energy efficiency specs. for house (e.g., HVAC, water heater, insulation, appliances)
    - Estimated average annual utilities usage and cost for family of four for electricity, water, and gas (if used in the home)
    - Limitations of current design as regards to sustainability and efficiency
  - Description of each change/improvement you propose for the home to include:
    - Description of the improvement and list of equipment and materials required
    - Description of how the improvement would be implemented and how it would operate
    - Drawings and/or diagrams of the improvement as incorporated into the home design
    - Benefits and limitations of each design change/improvement
    - Additional initial implementation cost and additional annual maintenance cost (if any)
    - Cost analysis including **dollar savings per yr.** on utilities and **payback period in yrs.**
- Administrative Requirements:
  - Oral presentation:
    - 6 - 12 mins (each person does equal portion; grade reduced if time limit busted)
    - Must use a minimum of 6 PowerPoint ® slides during the presentation
      - Include Title, Overview, and Conclusion slides
  - Written report:
    - 8 to 12 pages typed (double spaced) including title page, references, and diagrams
    - Include a title page with your team name, team logo, title, report date, and typed name of each team member – also, each member **must sign** by his typed name
    - Include a table of contents page as well as introduction and conclusion paragraphs
    - Use chapter designators/topic titles (Ex: Intro., Existing Design, Improvements, etc.)
    - **Add name of person responsible for each paragraph at beginning of each para.**
    - Gantt chart for research/design/documenting/acquiring materials/building/selling home
    - Number pages and include a list of references (**including title, author, and date**)
      - **Use the guidelines sheet as a check sheet (√) and staple it at the end**

Last revision: 23 Jan 16 **Due Date:** _____

Appendix 2

Team Project #1 – Sustainable New Home Design

Grade Sheet

Name:_____ Team: _____ Date: _____

Written Report Grade Sheet:

Item Description	Max. Points	Points Earned
Title page with title, team name/logo, date, course #, and teammate names and signatures	2	
Table of Contents with topic titles and page numbers for each topic	2	
Report length of 8 to 12 pages typed (double spaced) including title page & references page	2	
Pages properly numbered and topic titles (chapter designators) used	2	
Annotated name of the specific person responsible for each paragraph in the report	2	
List of reputable references (minimum 3) including title, author, and date for each reference	2	
Guidelines sheet stapled at the end of the report and used as a check sheet (√)	2	
Included separate introduction and conclusion paragraphs that have appropriate information	2	
Correct spelling, grammar, punctuation, and sentence structure	4	
Existing new home design description – builder, floor plan, dimensions, lot size, materials, cost	5	
Existing new home design – energy efficiency specs for HVAC, water heater, insulation, appliances	5	
Existing new home design – estimated average annual utilities usage (electricity, gas, water)	5	
Existing new home design – estimated average annual utilities cost (electricity, gas, water)	5	
Existing new home design - limitations with regards to sustainability and efficiency	5	
Description of improvements – list of equipment and materials required	5	
Description of improvements – describe how it will be implemented and how it would operate	5	
Description of improvements–drawings/diagrams of improvement incorporated into home design	10	
Description of improvements – benefits and limitations	10	
Description of improvements–additional costs for implementation & annual maintenance (if any)	5	
Description of improvements – cost analysis: $/yr savings on utilities and payback period in years	10	
Step-by-step project timeline (Gantt chart) for researching, designing, documenting, acquiring equipment/materials, building, and selling your sustainable home (not a team project Gantt chart)	10	
Certification from SAC Writing Center of assistance obtained on written or oral report	5 (optional)	
Total:	105	

Oral Report Grade Sheet:

Item Description	Max. Points	Points Earned
Duration between 6 and 12 minutes (each individual between 1.5 and 3 minutes)	10	
Oral delivery (eye contact, voice clarity/strength, enthusiasm, hand gestures, pace)	45	
Content (understandable, slides readable and not too busy, covered required material)	45	
Total:	100	

Overall Project Grade: $\frac{Written\ Report\ Grade + Oral\ Report\ Grade}{2}$