1. RESEARCH PERFORMANCE FINAL REPORT

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a. Federal Agency and Organization Element to Which Report is Submitted
DOE/Office of Energy Efficiency & Renewable Energy

b. Federal Grant or Other Identifying Number Assigned by Agency
DE-EE0006565

c. Project Title
New York City College of Technology Solar Decathlon Proposal: D (diverse), U (urban), R (resilient), A (adaptable)

d. PD/PI Name, Title and Contact Information (e-mail address and phone number)
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f. Submission Date
7/15/2016

g. DUNS Number
064932676

h. Recipient Organization (Name and Address)
RF CUNY on behalf of New York City College of Technology

i. Project/Grant Period (Start Date, End Date)
4/15/2014 - 4/15/2016

j. Reporting Period End Date
1/1/2016 - 3/31/2016

k. Report Term or Frequency (annual, semi-annual, quarterly, other
Final Report

l. Signature of Submitting Official (electronic signatures (i.e., Adobe Acrobat) are acceptable)

NEEDS SIGNATURE HERE

2. ACCOMPLISHMENTS: Mandatory
What was done? What was learned?
The information provided in this section allows the agency to assess whether satisfactory progress has been made during the reporting period. The PI is reminded that the grantee is required to obtain prior written approval from the Contracting Officer whenever there are significant changes in the project or its direction. Requests for prior written approval must be submitted to the Contracting Officer (submission via Fedconnect is acceptable).

New York City College of Technology (City Tech) has participated in the Solar Decathlon 2015 project as DURA. The DURA team consists of students, faculty, volunteers, Service Corps participants, Industry advisers, recent graduates and others. The DURA team researched, designed, and constructed a zero energy prototype house. This process was a stretch for City Tech as a project of such scale has not been completed before with the integration of so many departments and their students.

The team continues to work to function and expand the interdepartmental collaborations, workshops, prototyping labs, and the research and development groups formed through the project. The goal is the development and institutionalization of these opportunities and skill building projects to be available to the students and faculty.

The team continues its collaboration with college administration to find a place to build a permanent home for the prototype. Partnership development initiatives continue to reimburse the College and the instructor's project debt incurred by the project. These challenges have become acute as the state government has drastically decreased its support for the CUNY university system this financial year.

a. What are the major goals of the project?
List the major goals of the project as stated in the approved application or as approved by the agency. If the application lists milestones/target dates for important activities or phases of the project, identify these dates and show actual completion dates or the percentage of completion. Generally, the goals will not change from one reporting period to the next. However, if the awarding agency approved changes to the goals during the reporting period, list the revised goals and objectives. Also explain any significant changes in approach or methods from the agency approved application or plan.

All the major project goals and the majority of all of the project goals were achieved in the (1/1/2016) reporting period.

The two major outstanding challenges issues the final placement of the DURA home and the project's Partnership Development and budget are intertwined as they have a large impact on each other.

The Partnership Development of the project was underfunded by the DOE, leaving the staff and college in debt. The team is continuing through partner development approaches to address these challenges. The team is searching for further partnership, depending upon existing partnership development and expanding support resources within the university system. These challenges have become acute as the state government has drastically decreased its support for the CUNY university system this financial year.

The college administration is actively pursuing the sale of the project to make up the project deficits. Under the circumstances the sale of the DURA prototype project, City Tech will work with the DOE to assure an appropriate portion of any of the return goes towards further research in the areas developed by the DURA for the DOE.

Overall budget and sources breakdown in these approximations relationships:

8%	DOE:
12%	Unallocated support.
33%	IN-KIND support.
45%	**TOTAL Partnership development.**
5%	Dept. / Dean's Office / College.
8%	CUNY match (City Tech).
5%	Other grants with synergies research areas.
18%	**TOTAL CUNY.**
6%	City Tech debt.
23%	Instructor's debt.
29%	**TOTAL Debt.**

The percentages above exclude the costs for additional personnel and most of the student stipends (A small proportion of the DOE contribution went towards student stipends). Additional personal partial expenditures as a percentage above the total project costs are as follows.

11%	College Lab Technicians (CLTs*), summer salary & Instructors Release Time
9%	CUNY Service Corps (student support)
20%	**TOTAL PERSONAL (PARTIAL)**

* CLTs resources supported decathletes, students and instructors

Our alternate placement approach would have the DURA prototype located near the City Tech campus or in the region of the Solar Decathlon 2015 public exhibition. The DURA prototype will, under these placement circumstances, continue its original function as a research prototype and or education facility.

The team deadline for developing solutions for DURA prototype placement is the end of September, 2016. This is the goal as there will be a new cycle of storage costs if the DURA prototype is not relocated by this time.

b. What was accomplished under these goals?
For this reporting period describe: 1) major activities; 2) specific objectives; 3) significant results, including major findings, developments, or conclusions (both positive and negative); and 4) key outcomes or other achievements. Include a discussion of stated goals not met. As the project progresses, the emphasis in reporting in this section should shift from reporting activities to reporting accomplishments.

The DURA [D (diverse), U (urban), R (resilient), A (adaptable)] project was able to accomplish its goals including the Key accomplishments described below:

D, DIVERSE (Completed)
DURAhome represents the diversity of New York City, and City Tech, where a diverse team is working on design solutions to meet our environment's needs. As diverse as the City of New York, the character of DURAhome is developed through elements of international living– interior and exterior areas which reveal open space, accommodate greenery and allow for flexibility and comfort. Thanks to our open floor plan, there are several adaptable spaces which can be used to accommodate a home office, a bedroom, a mechanical room, or a child's play area, depending on the client's needs. The project was developed through a multi-pronged approach: a hybrid of passive and active systems that can adapt to various configurations. Superinsulation, strategic window opening sizes and locations, an exceptionally tight envelope, and a smart mechanical system that harvests waste heat, combine to optimize performance and maximize occupant comfort for net-zero, affordable living in a dense, diverse environment.

U, URBAN (Completed)
Heightened living densities and high consumption rates are often seen as factors inhibiting sustainable practices. DURAhome works with the changing course of urban living as opposed to against it, developing sustainable approaches for the future. As cities grow at exponential rates, DURA represents an urban solution.
Our home is geared to best accommodate young, urban families who are passionate about energy conservation and who believe that one's home is an important factor in the richness and overall quality of one's life. Our home was designed with light in mind. DURAhome has ample natural sunlight, reflective materials, and exterior and interior wood finishes. If one is constantly surrounded by good energy flow and a pleasant environment, they can expect greater work productivity as well as flexibility to entertain friends and loved ones in their amiable home. The multifunctional qualities of a home are intrinsic to a compact modular space allowing the user to quickly and easily interface between private work areas and flexible living spaces. Furthermore, as space in an urban environment is limited, we have engineered a vertical solar array, in which solar panels are mounted on the side of a building, as opposed to on the roof, to allow stacking of up to four units of our home.

R, RESILIENT (Completed)
DURAhome is resilient in responding to environmental disasters, such as Hurricane Sandy. Proximity to the floodplain and the rising sea levels of the Atlantic Ocean increase the need for proactive resilient design in response to the threats of flood water, gale force winds, and seismic activity. The DURAhome is designed for optimal performance and works for the changing climates in fast-growing, populated cities. Where integrated in to the project throughout its development.

A, ADAPTABLE (Completed)
DURAhome is adaptable in its fundamental design. Floor plans are open with design flexibility, so as to appeal to diverse populations and adapt to a wide range of needs. The home is adaptively designed with an open floor plan to allow for a greater range of flexibility for multiple configurations.

The descriptions above are excerpts from the project website. See 3.b below.

Production of our prototype project to further the research has been successful. The team completed its construction's basic prototype components and assembled the prototype for testing. The team worked at displaying their systems at the Irvine exhibition. The items under display included the following:

Prototype Square footage:
Interior Living 897 SF ANSI

Exterior Spaces: 660 SF of Decks, and 380 SF of Ramps

Solar Energy:
Electrical: 19 Sun Power PV array 6.5 kW
Thermal: 4 Sun Drum hydronic solar collector Panels

- Energy Recovery Ventilation (ERV)
- Exterior Cladding/Trim - resistant systems and finishing developed
- Fixtures/Appliances - energy efficient appliances integrated into the project
- Flooring/Finishes/Millwork - prototype refined as an ergonomic space
- Framing - structural system development
- Furring/Drywall/Trim, building systems integrated into building skin
- Greenwall - movable, low, light green wall developed and installed
- Insulation - wall, roof, and floor, assemblies completed
- Interior sheathing/Taping - airtight enclosure developed
- LED lighting
- Mechanical/Plumbing/Electrical - mechanical systems integrated and commissioned
- Mini split heating cooling system interior ceiling recessed & will exterior unit
- Roofing/Sheathing/Taping - development of breathable resistant exterior skin
- South wall - with vertical solar array
    - Steel fabrication - structural and architectural system for solar array
    - Assembly on site - prototype elements moved from shops and assembled on-site
    - Cladding - software cladding integrated into solar system
    - Solar panel install - integrated with micro-inverters
    - Solar thermal install - integrated into solar panels and connected to water system
- Triple Glazed passive house compliant windows and doors
- Water tank, with heat exchange
- Wireless protection system

Specific achievements as they relate to the initial projects goals (tasks and subtasks) are described below

1.0
Task 1.0 Partnership Development
Partnership development has been successful as indicated by the mixture, quality and quantity of participating supporting industry advisers (See table on supporting advisers in section 4 below). The contribution of Partnership Development to the project is indicated by the proportion of their contribution to the whole project. They make up the largest single group of supporters (see budget chart in section 2. a above).

2.0
Task 2.0 Project Management and Reporting
The Projects Team has provided reports in accordance with the project guidelines.

3.0
Task 3.0 Focused Research
All focus topic areas of research, develop technologies and building techniques areas were developed by the DURA team. Most of the research led to strategies and assemblies that were integrated in the DURA house project. Focus areas that were found to be unpractical for integration after research results were studied were rolled into the project educational material on the prototype or published in the project manual.

Subtask 3.1 Solar Panel Mounting Options, Efficiency and Optimization
Computer modelling, scale models and test fabrication pieces were all utilized to find the optimal solution for mounting strategy for a variety of surfaces located on the solar decathlon structure. The research enabled to team to create the south energy wall which was one of the innovative of project. This south energy wall is one of the key ways DURA prototype was differentiated at the competitors from its colleagues.

Subtask 3.2 Mobile Devices
Various mobile devices and apps were tested for their applicability and efficiency in the prototype system. The team is wired the house electric controls such as light switches in such a way that it is mobile device ready. The team also integrated into the project NEST wireless protection prototype.

Subtask 3.3 Cladding and Insulation Assemblies
Industry participation went into the development of the inclusion system. Industry input included both input from industry advisers from passive house experts. Project research and constructed prototype sections and assembly techniques were developed by the team. The resulting assemblies' effectiveness can be gauged by their success at creating a breathable airtight enclosure which achieved the following wall ratings:
Wall insulation R-Value: 44
Floor insulation R-Value: 46
Roof Insulation R-value: 58

Subtask 3.4 Cooling Systems
Interior walls cooling systems were research and explored for the DURA prototype. Some of the early approaches were deemed not to be applicable and cost-effective in the project and were eliminated from the prototype. A cooling green plant wall was integrated into the project.

4.0
Task 4.0 Schematic Design
Schematic Design documents were submitted to the DOE as required.

5.0
Task 5.0 Website Development
Educational and information project specific website was created and is still available for the general public as described herein.

6.0
Task 6.0 Design Development
Design Development documents were submitted to the DOE as required.

Subtask 6.1 Computer Animated Walkthrough
Animated walk-throughs showing major innovative and functional systems and design strategies were created and were made available publicly on the projects' website and the DOE's websites.

Subtask 6.2 Scale Model
Scale models showing the project and its features including stackable units were created and were on display during the public exhibition in Irvine.

Subtask 6.3 Preliminary Building Integration Model
Preliminary Building Integration Model (BIM) cost estimates, energy projections, design comparisons and other simulations was submitted to the DOE as required.

Subtask 6.4 Solar Analysis

Solar analysis on the project including study of the solar radiation levels was developed using computer modelling, physical models, and prototypes this analysis contributed to Subtask 3.1 item above.

Subtask 6.5 Ecology Analysis
Organic systems as grey water and building comfort control were studied and researched by the team. Because of the modular and urban nature of the prototype these systems were found to be to cost effective for the project. Additionally, local codes of the city which would make such a system limited. Some building comfort organic systems were used as described in Subtask 3.4.

Subtask 6.6 Energy Analysis
Energy Analysis and modelling were completed for the project and a detailed account of this Analysis was included in the project manual as well as the project educational material. The Analysis and modelling also helped in craft the project design.

Subtask 6.7 Electric Vehicle
Electrical vehicle types were studied and the selected vehicle was successfully integrated into the project. Its energy allowance was included in the prototype zero energy design.

BUDGET PERIOD 2

7.0
Task 7.0 Construction Documentation
Construction Documentations were submitted to the DOE as required. Wall sections were develop to define the project assembly and from these, details were generating. All disciplines resented within the design team, including structural, landscape, civil, mechanical, electrical and plumbing specialists. They were tightly integrated and coordinated their drawings with the architectural set. BIM was use to ensure that coordination was carried out at all levels. The created documents included Health and Safety Plans, a BIM Model, a Project manual, and PDF CD Drawing sets.

8.0
Task 8.0 Construction
The DURA prototype successfully constructed in the Brooklyn Navy Yard.

Task 9.0 Public Exhibit Materials
Public Exhibit Materials material was design and by the graphics team and utilized before, after, and extensively during the exhibition of the project.

Task 10.0 Testing/Commissioning
Limited testing commissioning was don during the construction phases at the Brooklyn Navy Yard more testing commissioning was accomplished at the Irvine exhibition site.

Task 11.0 Transportation
The house was successfully transported to the exhibition site.

Task 12.0 Assembly
The prototype was reassembled for the public exhibition in Irvine CA.

Task 13.0 Contest and Public Exhibit
The house competed in the contest and was open to the public.

Task 14.0 Disassembly
The project was disassembled from the exhibition site and the site was returned to its previous state. The team used forklifts and cranes to dismantle the dwelling.

Task 15.0 Project Closeout
The house was put into storage while arrangements being made for funding the project and the project final placement. As discussed in 2a above.

c. What opportunities for training and professional development has the project provided?
Describe opportunities for training and professional development provided to anyone who worked on the project or anyone who was involved in the activities supported by the project. "Training" activities are those in which individuals with advanced professional skills and experience assist others in attaining greater proficiency. Training activities may include, for example, courses or one-on-one work with a mentor. "Professional development" activities result in increased knowledge or skill in one's area of expertise and may include workshops, conferences, seminars, study groups, and individual study. Include participation in conferences, workshops, and seminars not listed under major activities.

During the entire course of the project the students, CLT, staff, and Instructors had many training opportunities, included but not limited to:

- Research techniques and approaches
    - Faculty mentored
    - Industry partners and review and mentored.
- Hands-on construction development of prototype systems
    - Typical construction assemblies
    - Energy-efficient enclosure
    - Passive house standard assemblies
    - Solar PV and thermal arrays
    - Modular construction
    - Energy recovery systems
    - Passive air ventilation
    - Decking and ADA accessible routes
    - Water systems and recovery strategies
- Specialized training courses and safety including
    - Scaffolding
    - Construction
    - Electricity
- Organizational and managing workshops and internships
    - Communication skills
    - Collaboration and cloud software
    - Project management software
    - Accounting
    - Partnership development

A continuing set of workshops was developed out of this project, which is now available to the college community.

d. How have the results been disseminated to communities of interest?
Describe how the results have been disseminated to communities of interest. Include any outreach activities that have been undertaken to reach members of communities who are not usually aware of these research activities, for the purpose of enhancing public understanding and increasing interest in learning and careers in science, technology, and the humanities.

The focus the DURA project disseminated has been The U.S. Department of Energy Solar Decathlon 2015 public exhibition in Orange County Great Park in Irvine, California that took place from October 8–18, 2015. The team is continuing to share the technologies and ideas developed during the course of the project.

Other recent events where the project was disseminated include:
On April 13 2016, Professor Paul King presented *The Solar Decathlon: Mentoring an Urban Population* at the International Mentoring Conference in Auburn, Alabama.
City Tech's Ecofest Event took place on April 21, 2016. The Ecofest is part of the institutional, CUNY effort to be more ecological and to promote education about environmental and energy issues.
In the "BKLYN DESIGNS" conference May 6–8, 2016 in the Brooklyn Expo Center, (72 Noble St.) Design, the process of development and technologies were showcased.
On May 16th, 2016 a screening of an award-winning documentary on the Team DURA Solar Decathlon entry was part of a film festival on the Brooklyn waterfront. This documentary was mentored by Department of Entertainment Technology led by Professor Ryoya Terao.

Following is a partial is a list of articles and publications in which the DURA project was covered:

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e. What do you plan to do during the next reporting period to accomplish the goals? Describe briefly what you plan to do during the next reporting period to accomplish the goals and objectives.

This report closes the formal reporting requirements of the DURA project, which has delivered lasting impacts. The DURA team members have and plan to further the research and educational goals the project.

Institutional enrichment from the project include the training of City Tech decathletes to become University CLTs. These decathletes now train other students in the skills they learned while developing and constructing the DURA house prototype. The training takes place in both tutoring environments and as part of the continuing set of workshops developed out of this project which is now available to the college community.

One of the main goals is institutional and continue the project's started research. To that end the team members are developing the following:

- The DURA's team PI is developing collaboration opportunities between New Jersey Institute of Technology's research and development for their Solar Decathlon project in China and City Tech.

- Advancing the creation of research labs and shops on or near campus.

- Extension of the DURA undergraduate student's Service Corps research projects over the next academic year (2016-2017).

- Specific projects to create energy models and façade prototypes are under development for the next academic year. This research will focus around the Energy South Wall, which was specific to the DURA project prototype.

- Collaboration between departments and industry partners will also focus around these areas of development.

- Writing and developing research grants is under way.

3. PRODUCTS: [Optional/Mandatory]

b. Website(s) or other Internet site(s)

List the URL for any Internet site(s) that disseminates the results of the research activities. A short description of each site should be provided. It is not necessary to include the publications already specified above in this section.

The team continued its web and social media based dissemination projects to inform the public about our findings and the various approaches to energy-efficient housing. These sites are being updated regularly by the team. Team DURA social media sites are as follows:

- www.durahome.org
- facebook.com/NYCCTSD2015
- http://instagram.com/teamdura
- TWITTER: TeamDURA@TeamDURA_SD
- www.pinterest.com/teamdura/

Additional websites are under development and will be housed on City Tech OpenLab platform.

c. Technologies or techniques

Identify technologies or techniques that have resulted from the research activities. Describe the technologies or techniques and how they are being shared.

The project is generated research into assembly types, techniques and technologies. This research has not yet produced any patents. Work and research started under this project will continue as noted section "2e" above.

Information on the dissemination of technology can be found in the section "2d" above.

4. COLLABORATING ORGANIZATIONS & INDUSTRY PARTNERS:

Following is a list select list of collaborating organizations & industry partners.

475 high performance building supply
AeonSolar
Architects Newspaper
Arup engineering
Associated Marble Industry, Inc
Association for Energy Affordability
Atelier Ten
Behr
Bentley Systems, Inc.
BLDG 92 [Brooklyn Navy Yard]
Brooklyn Navy Yard
Brooklyn Roasting
Build it Green NYC
CapGemini
Cetraruddy
Coney Island Development Corp
Consolidated Edison
Corcoran
Cosella Dorken

CUNY Service Corps
Daltile
DesignBuilder Software Ltd
Director, Academic Programs,Bentley Systems, Incorporated
DonorsChoose.org
Easy Flex
Eaton
EcoBrooklyn
Ennead Architects Dir of Sustainability
eSpec
FC Modular, LLC
FXFOWLE
Gotham Development
GreenBuilt
Hafele
Hemp Technologies Global
IceStone
Inside Sales Rep , Unirac - Hilti Group Company
James Hardie
Jonathan Flaherty from Tishman Speyer
KES Electric LLC
Klearwall Windows and Doors
Kohler
Kohn Pedersen Fox Associates (KPF)
Marble Couture
Mitsubishi
Mosaico Group Inc.
New York City Planning
NewWorld Capital
PHI
RAB Lighting
Red Beard Bikes
RedHook Re:Building Together
Resource Furniture/Clei
RF CUNY
Robin Reigi / Plyboo flooring
Rockrose Development
ROXUL
S&E Building Materials
Santander
Sciame
SITU Studio / Navy Yard
Skidmore, Owings & Merrill (SOM)
Soprema
Steven WInter Associates
Strohl PR

Student Government Association (SGA)
SunDrum Solar
SunEarth
SunPower
SunSource
Syska Hennessy Group, Inc.
Tishman Speyer
Traditional Weatherproofing & Restoration
Transsolar Climate Engineering
Turner Construction
Unirac
Urban Green
Weyerhaueser
Zehnder