UNIVERSITY OF MARYLAND

U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON 2017

reACT
TEAM MARYLAND

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Project Summary
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Summary
re*ACT* (Resilient Adaptive Climate Technology), is Team Maryland's entry for the Solar Decathlon 2017. re*ACT* will change how sustainable houses are viewed, constructed, and used. Featuring 993 sq ft of living space and 214 sq ft of glazed outdoor space, re*ACT* is distinguished by a mechanical core at the heart of an interior oriented about a central heat-collecting courtyard. Managing the flow of water, air, and energy, the home's core controls the high-performance, interactive, and environmentally sensitive systems while the courtyard regulates light, temperature and humidity. Together they operate in sync to advance self-sustainability.

Design philosophy and house design, indicating goals, architectural style, target market
Designed around a glazed courtyard, re*ACT* allows for seasonal expansion of indoor living space and connection to the natural world resulting in a combination of innovative technology, modern design, comfort and affordability. Comprised of six modules, a dining/living room wing, bedroom/office wing, glazed courtyard, and attic are plugged into a central core composed of both a bathroom and kitchen module. Catering to occupants needs as household requirements change, living systems have been fully disentangled from structure to accommodate alterations. The mechanical core allows for modules to be easily added providing opportunity for expansion. The modularized space can be reconfigured rapidly and inexpensively. Designed within a modern framework with influences from the St. Croix Chippewa Indians of Wisconsin, re*ACT* has been developed for a household of 2 married young adults with a baby on the way.

Goals and aspirations include:

- Positioning re*ACT* as an industry model, embracing principles of the Living Building Challenge, Responsible Industry and Net Zero Waste by exemplifying non-toxic, ecologically restorative, transparent, and socially equitable architecture
- Proving re*ACT*'s adaptability to a diverse range of climates, communities, construction technologies and ecological environments, as well as to other cultural and logistical variables such as building material supply chains
- Conserving resources via both active and passive heating/cooling, green mold-resistant wall prototypes, rainwater-catchment and greywater filtration systems
- Enabling efficient manufacture, transport and assembly alongside flexible configuration, building sizes and forms via disentangled systems design
- Offering families building expansion/contraction options with easily upgradeable advanced technical infrastructure and features into their evolving homes (e.g. by adding multiple modules, PV arrays, smartHome control systems, composting toilets, dual-barrel composting, grey-water irrigation, and rain-catchment systems)
- Predicting re*ACT*'s performance via detailed, physically based model based on open source weather forecast feeds developed by student engineers
- Developing an open source computer model that includes first-principles description of solar irradiance, house PV array power output, nominal house energy-related loads, and thermal modeling of re*ACT* and its HVAC system
- Transferring intellectual property to a like-minded housing industry partner, ready to bring to market re*ACT*'s prototypical DNA and flexible configurations

Unique house features. What makes the house unlike any other?

Analyzing the modern home as a series of inputs and outputs, re*ACT* harnesses waste in the form of energy to drive efficiency. The home's centralized glazed courtyard acts as a solar heat collector. re*ACT*'s unique solar attic utilizes the heat stack effect in the winter by skimming heat from the top of the courtyard, increasing efficiency of HVAC and water systems by pre-heating air & water. In the summer, heat is rejected and expelled by operable baffles.

As a series of independent modules arrayed about a central core, re*ACT* is imagined as an organism, each module emulating crucial bodily functions. The central core acts as the heart, the courtyard is the lungs, and solar power is the life blood providing crucial functions. Imagined as a circulatory system, living systems are separated (disentangled) from structure allowing for ease of adaptability through the home's life cycle. A shared wall in the center of the core modules acts as a spine, allowing for ease of integration and maintenance while efficiently distributing living systems throughout the home. The HVAC and smart systems work together as the house's endocrine system regulating efficiency and temperature. The water filtration system acts as a liver, removing toxins to enable water reuse. The living systems (gardens and composting) provide the vital functions of digestion, converting food into human energy and through composting processing waste into basic nutrients for the gardens.

Core module links all mechanical functions in a single, fully accessible chassis wall, while integrating the home's mechanical, electrical, waste and water systems for beneficial exchanges between them.

Courtyard with operable roof and doors allowing additional dynamic space for dining, leisure, and entertainment, as well as enabling 'season extension' in Fall and Spring. Supports plants and vegetation for beauty, growing food, converting CO2 into oxygen. Regulates temperatures and humidity by circulating clean, thermally comfortable air throughout the house

Living Systems contributes to the sense of place, food security, and the understanding of responsibility towards sustainable produce. Various water are used for different applications, e.g., hydroponic garden uses a closed loop water and demonstrates one method of water conservation. A movable Green Wall can travel between the greenhouse (courtyard) to protect from frost and the southern facing elevation in clement conditions. Both vertical applications demonstrate principles of urban farming. re*ACT*'s landscaping utilizes plants that are native to our target market (Great Lakes), many of which are edible or have additional uses. Wherever, possible xeriscape options have been chosen.

Intelligent data system (SmartHouse):

- Features sensors and predictive data (weather forecasts and user profiles influence the system's interaction with power, HVAC, waste, and water)
- Offers resident feedback through an intuitive user interface
- Provides automatic/human schedule optimization options
- Displays data on power, water, and other resources
- Independently upgradable as new technologies become available

Technological innovations incorporated into your house

POWER

re*ACT* uses the innovative and cutting-edge DC coupled storage solution by SolarEdge. This produces net zero power waste that is associated with the more traditional additional conversions from AC to DC and back to AC. It automatically provides homeowners with seamless backup power in case of grid interruption. Unused power is stored then used during power outages or when production is insufficient. In this event, a combination of PV and battery is used to power, day or night, important loads such as the refrigerator, TV, lights and AC outlets. The user can easily monitor the battery status, PV production, and self-consumption data at anytime from the convenience of their phones or computers.

LIVING SYSTEMS

Many communities are disconnected from their food sources both in knowledge and in distance. re*ACT*'s living systems are designed to aid the homeowner in understanding of food producing plants and its production especially in relation to water types and waste. The systems designed include an interior hydroponic wall, an exterior vegetable garden, and an exterior green wall. The systems plan demonstrates the integration and innovations possible for sustainably producing food. Moreover, these systems in and around the home utilize different water types produced from the home.

WASTE

Composting is re*ACT*'s method to decrease the unusable portion of the waste stream. Although this system won't be active during the competition, it demonstrates various home-scale technologies emerging from historically practiced methods in aid of a more sustainable lifestyle. The barrel composter can be used for the composting of food scraps, yard waste, and non-biologic organic materials. The self-contained composting toilet is a non-water-contaminating approach to human waste.

WATER

Potable water is a precious but limited resource. This year's competition features a juried component where water conservation and re-use methods will be judged. re*ACT* emphasizes remedies to potable water scarcity through careful design considerations and research of existing water filtration components. The house uses greywater filtration technology to actualize potable re-use. re*ACT* features technology that separates grades of water based on its quality after primary use then channeling it to appropriate filtration that will process it for re-use. The methods in developing a filtration system required the identification of several things; different types of water coming from a residential household, necessary filters to take out different sized particles, components inside the water, and the typical residential household water budget. The goal of the design is to filter light grey water coming from the house and filtering that to potable standards. The purpose of this design is to incorporate it into a community structure where the costs will be paid back in the future.

AUTOMATION

A key innovation is the accessibility of data from multiple sensors for personal use and manipulation. While there exists technology that integrates communication with control systems, it is locked behind proprietary and costly software. re*ACT*, has developed and will demonstrate an open-source system that will be made freely available. Also, Team Maryland has begun a meteorological data collection for accurate predictive forecasting of house performance as opposed to traditionally used year averaged data such as TMY3. This is key for homeowners as predictive information for the upcoming day allows homeowners to quickly consider and redefine their schedules as needed.

SYSTEMS ENGINEERING

re*ACT*'s systems engineering integrates HVAC, power, and water subsystems to ensure the house meets all its requirements. Team Maryland has developed modeling using MATLAB and Python predicting re*ACT*'s performance. Monte Carlo simulations are being used to predict performance to a certain statistical significance. Simulations use random variables with specified distributions to research how the house's systems are affected by different inputs. Using these random values, uncertainties inessential metrics for the water, power, and HVAC systems will be determined helping to identify probability that the house will not meet its requirements.

<u>Define the target client for the team house & how the design responds to this market's needs</u>

The target client for re*ACT* is a married couple in their late 20's living on Turtle Lake Wisconsin. Our couple recently found out that they are expecting their first child. The wife works as a nurse and the husband is a student at the Lac Courte Oreilles Ojibwa Community College. They are members of the St. Croix Chippewa Indians of Wisconsin, a band of indigenous people called Ojibwe, itself a part of a larger ethnic group called the Anishinaabe, or *good humans*. Life is lived in a manner that harmony with all created things is achieved through principles of love, respect, honesty, bravery, humility, truth, and wisdom. They are a woodland culture who rely on the forest for their needs. Materials of significance include birch, maple, copper, and wild rice. Attention to furnishings with these materials will be attended to. re*ACT*'s sustainable and regenerative design principles aligns with the Ojibwe way of life, promoting quality of life while respecting Native American cultures. Tribal leaders are increasingly seeking sustainable housing and renewable energy technologies to provide their communities with cultural renewal, self-sufficiency, economic opportunity, and sustainable returns on investment that compliment tribal culture. Despite its humble size, re*ACT* enables families to incrementally build larger and more technologically advanced infrastructure creating a home that evolves with its occupants. re*ACT*'s living systems and attention to limiting waste will help this couple to live in harmony with the land as a gift from the Great Spirit.

<u>Teams organization, number of members, full list of members attached</u>

Our 2017 Solar Decathlon Team is currently comprised of nearly 400 University of Maryland community members. More specifically, 300 undergraduates, 50 Master level students, 20 PhD students, and 35 faculty, staff and industry mentors. The A. James Clark School of Engineering enrolls 56% of students, with the School of Architecture, Planning & Preservation enrolling 12%, the College of Agriculture & Natural Resources accounting for 12%, the College of Computer,

Mathematical & Natural Science registering 5% and the remaining 15% from the other nine colleges and schools. Forty-five percent of Engineering students specialize either in Civil or Mechanical Engineering, with Electrical Engineering holding second place at 18% and Chemical Engineering at 15%. Engineering is predominantly represented by undergraduates (87%). The Architecture students have slightly higher number of Masters seeking students (58%) than those seeking a Bachelor's degree (42%). The students from the College of Agriculture & Natural Resources are mostly undergraduates (86%). Our team is inclusive. By gender, we are 41% female, 57% male and 2% declined or self-defined as other. By ethnicity, we are half Caucasian and one quarter Asian. Eight percent of us are African American or Black with another 8% being Hispanic or Latino, 3% are from the Middle East, with 1% Native American and 5% self-identifying as other or declined.

Competition Officers	Research & Development Systems Teams
Project Manager Lead: Srijesh Sudarsanan Debuty: A. Paige Andros	*Automation,* Lead: Alan Uy
Construction Managers Architecture: Alla Elmahadi, Greg Goldstein, Christiane Machado Engineering: Michelle Stanley, Sean Richardson	*HVAC,* Lead: Charles White
Health and Safety Officer Architecture: Sophie Habib, Anil Moore Engineering: Eyuel Gorfu	*Living Systems,* Lead: Matt Lagomarsino
Architecture Project Managers, Sandra Oh Boun, Malik Johnson-Williams	*Power,* Lead: Srijesh Sudarsanan
Project Engineer, James Shen	*Water,* Lead: Emily Goo
Electrical Engineer, Srijesh Sudarsanan	*Systems Engineering,* Lead: Andrew Poissant
Sponsorship Officer, JT Stanley	
Public Relations Contact, Emma Schrantz	Communications
Faculty Advisors, Ray Adomaitis, Garth Rockcastle, Mike Binder, Patti Cossard	*Outreach:* Michael Molyneaux-Frances
	Visual Identity: Emma Shrantz
	Information Technology: Yehuda Katz

Future plans for the house. Where will it go after the competition?

reACT will be disassembled and shipped back to campus after the competition. It will join LEAFHouse, Team Maryland's 2007 second place winner, to create a sustainability park which will house research and development labs, research fellows, and hold colloquiums and symposia.