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A Real Home

“Real challenges demand real world solutions.”

Residential energy consumption in the US costs $200 billion each year, spread over 115 million households. It comprises 21% of total US energy use and 10% of all CO₂ emissions worldwide. The Solar Decathlon seeks to address these challenges by promoting the development of innovative solutions for sustainable building design, transfer these solutions to a diverse building industry, and educate the public about the energy solutions available in today’s market. Our team believes that effective solutions require changes by the home-buying public and the production home-building industry.

In response to these challenges, the CU Solar Decathlon team presents CORE – a modular design concept coupled with an energy-efficient building envelope, sustainable interiors, and an integrated energy delivery system. CORE seeks to:
- promote mass production of the building core which can be prefabricated and customized to individual buyers.
- encourage architectural flexibility through diverse envelope systems and materials.
- integrate solar energy production into the roof and energy-efficient system into the interior architecture.
- capitalize on both solar and ambient energy in the outdoor environment to meet household energy and comfort needs.
This design utilizes the shipping container spine to modulate the spatial experience of the home. The dwelling’s "servant" (utility) spaces flow into the "served" areas for living, dining, working, and sleeping. The containers’ central position allows the rooms to be added or subtracted per user needs over the time, as they function as transition zones between the public and private areas of the home.

While competition rules and practical logistics dictate that all homes in the Solar Decathlon are small, light-weight, and mobile, our team has taken the bold approach of designing, and ultimately building, a 2,100 square foot full-size home, and delivering a smaller competition component to Washington, D.C. This component conforms to the programmatic and size constraints of the competition. The full house is more relevant to typical home buyers and home builders, and includes three bedrooms, three bathrooms, a larger living room and an office/media room. All indoor environmental control equipment is sized for the complete house, yet allows modular deployment in the competition entry.
Our CORE concept is based on a prefabricated and customizable central core that includes kitchen, bath and mechanical equipment. In fact, there is no piping, ductwork, plumbing, or other mechanical equipment outside the core. The CORE concept leverages the efficiencies of factory-built, modular construction for those parts of a dwelling that best lend themselves to industrial prefabrication and the economies of scale. Yet, it allows a limitless number of user options in customizing the core components and encourages individual, sustainable home plans and construction techniques outside the core. In addition, the sophisticated mechanical, electrical, and plumbing systems are fully fabricated, installed and calibrated in a factory environment, are protected during transport by the container, and require no additional on-site construction or adjustment.
The Envelope

“Choose your materials and construction method.”

Regionally Specific and Economically Sound

The CORE strategy encourages freedom of aesthetics, construction method, and material selection. In a production home environment, modular construction can be employed without every house looking the same. The system also allows users to create connection and response to local conditions. By combining a prefabricated core and high performance energy technologies with vernacular architecture and local materials and methods, housing can be created with better local economic regeneration, lower materials costs, and less overall embodied energy.
Windows

"Let the right sunlight in at the right time!"

Smart Glass
High performance windows can substantially reduce heat from the sun and greatly increase window insulation.
1. External radiated heat is reflected.
2. Direct heat from the sun is reduced.
3. Internal radiated heat is reflected.
Our design uses Heat Mirror® - low-emissivity, coated films suspended inside an insulating glass unit - to achieve exceptional thermal and optical properties. The airspaces created by the suspended film, filled with a noble gas, further increase the window’s thermal performance. The glazings have a thermal resistance of R-12.5, a solar heat gain coefficient of 0.4, and a visible transmittance of 0.54. High resistance fiberglass frames complete the package.

Passive Solar
With appropriately selected glazing and dimensionally correct shade devices and louvers, passive solar design techniques are applied to both the south and north wings of the full house. In the summer, the awning and shades are designed to block direct exposure to the living room and sunspace. The sunspace is ventilated or opened up to the courtyard. In the winter, full solar gains help heat the mass within the home during the day and reduce heating loads through the night.
Building Integrated Overhangs

Passive design strategies seek to design overhangs or louvers that admit solar energy in the winter and shade the solar energy in the summer. By placing the window pane inboard of the custom jamb-sill assembly, the window header acts as the shade, without the use of an overhang or awning. The optimal depth is dictated by the location latitude.

Architecturally Integrated Louvers

Tall windows require greater depth of overhang to shade the windows in summer months. Site specific angles designed into artful, exterior louver retain visibility from the interior and block the summer sun from the entire vertical height of the wall.
Most current PV systems are installed over the roof, with additional cost for the PV support system and framing. The CORE approach to photovoltaic energy collection eliminates the need for duplicate roofing and support systems - the PV system is the roof. This implementation of a sleek energy-collecting roof offers a low-profile geometry that is aesthetically efficient as well as technologically advanced.
A traditional solar thermal system includes transparent covers and an absorber in an insulated enclosure. Our system consists of an absorber integrated into the roof, between the PV modules and the roof insulation, offering dramatic cost savings. This integrated PV/T system provides hot water for space heating and domestic hot water. The PV/T simultaneously cools the PV, increasing cell efficiency, while producing useful heat. In addition, the large PV/T area serves as a giant “radiator” to the night sky and is used to help meet building cooling needs.
On a cold and dark winter night, heating energy is required to overcome the heat losses through the building envelope. Water from the hot storage tank is circulated through architecturally integrated heat exchangers to meet the heating needs. These contemporary “radiators” actually rely on natural and fan-driven convection as well as radiation to keep the house comfortable.

A traditional solar heating system uses the sun to heat the hot tank directly. However, for much of the winter in Colorado, the sun alone is not enough. Our CORE system uses a water-to-water heat pump to keep the hot tank warm enough. The heat pump literally “pumps” the heat up the thermal gradient, drawing heat from the cold tank (making the cold tank colder) to heat the hot tank. The heat pump actually heat two hot tanks - the heating system tank is typically 35°C (95°F) while the domestic water heater is typically 55°C (131°F).
During the day, the sun shines on the PV array and the solar thermal collection manifolds behind them - our building integrated PV/T solar system. During the spring and fall, the PV/T system may be able to keep the hot tank warm enough to carry through the night-time house heating needs. For most of the winter, though, the heat pump has to boost the hot tank temperature at night, creating a colder cold tank. While there may not be enough solar energy to heat the house alone, there is plenty of solar energy to melt the ice from the night before and warm the cold tank in preparation for the impending heating needs when the sun goes down.

At the height of winter, the heat pump will pump so much heat that the cold tank can freeze. No problem. The fluid in the tanks and pipes is actually antifreeze and the cold tank is filled with plastic balls of water that freeze. Using the latent heat of fusion of water (remember those science classes?), these encapsulated ice cubes keep the cold tank at 0°C (32°F). Since the heat pump is more efficient when the cold tank is warmer - and it’s always much warmer than the outdoor temperature in winter - the CORE system is dramatically more efficient than a traditional air-source heat pump. Who knew you could save energy by heating the house with ice!
On a hot and sunny summer day, cooling energy is required to overcome the house heat gains from internal sources and through the building envelope. Water from the cold storage tank is circulated through architecturally integrated heat exchangers and conventional cooling coils, all located in the core, to keep the house comfortable. With Colorado’s dry climate, the exposed cool surfaces provide radiant cooling with little risk of condensation on interior surfaces. In more humid climates, or in rooms with little wall area adjacent to the core, conventional duct-mounted cooling coils are more appropriate.
The water-to-water heat pump keeps the cold tank cool by “pumping” heat to the hot tank. (A conventional air conditioner keeps a house cool by pumping heat to the outdoors.) The hot tank stores the heat until it is most efficient to reject the heat to the outdoors. The hot tank temperature is typically cooler than the daytime outdoor temperature but warmer than the nighttime outdoor temperature, giving improved efficiency during the day while allowing heat rejection to the outdoors at night.

With the encapsulated ice cubes in the cold tank, it is also possible to make ice at night in the summer, using the stored energy in the cold tank to cool the house during the day without operating the heat pump. Similar ice storage systems are common in commercial buildings where electricity rates during the day can be much higher than at night.

On a typical Colorado summer night, the air is cool and the skies are clear. After the sun goes down, our building integrated PV/T solar system transforms from an energy collector to an energy rejector. Energy pumped from the house during the day and stored in the hot tank is rejected to the outdoors at night. Warm water from the hot tank is circulated behind the PV collectors, which radiate heat to the night sky and are cooled by the night air. The house also has an optional fan-driven outdoor coil to assist the cooling by night radiation. On many nights, outdoor conditions are cool enough to even cool the cold tank, avoiding the need to use the heat pump at all the following day.
The key question asked today is no longer how much capital and labor an economy can amass, but how innovation helps employ those resources more effectively to produce more goods and services. This line of research makes clear that the new technology, by itself, has little economic benefit. As economist Nathan Rosenberg observed, “innovations in their early stages are usually exceedingly ill adapted to the wide range of more specialized uses to which they are eventually put.”

- From The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger by Marc Levinson
Our containers are modified to provide windows, doors, and circulation to adjoining spaces. We also reinforce the openings and retain the removable panels. Once customized as a building core, the removable panels can be re-attached and container shipped to a construction site. With careful design, our containers retain their ISO certification and "ship-ability."
Energy Managing Appliances

“Economically sized and efficiently placed”

The high performance appliances of the CORE are selected based on efficiency, ADA accessibility, and style.

This large capacity, accessible refrigerator features the freezer on the bottom to provide wheelchair access and is shallow enough to fit with in cabinet depth, leaving ample room for a wheelchair to move around it.

The double-drawer dishwasher gives the user the option of running a small single drawer load, or a full size dishwasher sized load with both drawers.

The induction cooktop is efficient, safe, and easy to clean with a sleek, modern aesthetic.

We are a mobile society. Mobility has its costs. Some estimate that a standard car costs the average citizen $10,000 a year in vehicle cost, maintenance, insurance, and fuel. The large PV array on our house will charge an electric car every night while we sleep. The pollution-free, distributed fuel is around us all the time, oblivious to international politics, ready to drive us into the future. Where should we go today?
Breathe!

Breathe!

Sustainable Interiors

“Breathe!”

Marmoleum
With great features such as durability, bacteria resistance, ease of use and large color selection,

Bamboo Plywood Casework
Cabinetry framing uses formaldehyde free wood. Cabinet faces are made from Plyboo Strand which is made of 100% bamboo and is particularly suited for commercial environments.

Recycled Paper Countertops
Richlite, a manufacturer of paper-based counter tops. The unique paper surface is made from environmentally sustainable resources and is a durable, long-lasting material.

3form Plastics
3 Form Material Solutions and are made from ecoresin which is a translucent, co-polyester sheet material. The material contains 40% post-industrial reclaimed material, is non-toxic, durable with 40 times the impact strength of glass, and is chemical resistant.

Tiles
Ecogress mosaic are made from eco-friendly porcelain and highlight durability and versatility among their design features. They are manufactured with raw materials and production processes that comply with conservation methods.

Interior lighting has been engineered to accentuate and enhance architectural elements and meet illumination criteria. Indirect and task lighting feature high efficiency, dimming,
IntelliCORE is the artificial intelligence system that runs the environmental control systems of the CORE, by using a system of user data, weather forecasts, house hold sensors, and a remote server. The system learns to control the house by maximizing both comfort and energy savings while it “self learns” to anticipate ebbs and flows of days, seasons, even years. Through a combination of cutting edge artificial intelligence and sensing technology, the house will actually become more efficient over time as it learns the needs of the occupants, and its own performance abilities and how to best prepare for upcoming weather patterns.
Custom CORE design

This CORE concept uses the shipping container spine to modulate the spatial experience of the home. Our full house design adds a second container, housing two additional bathrooms and a dedicated laundry area. The containers’ central position allows them to function as transition zones between the public and private areas of the home. Countless other variations are possible. The core’s flexible, transportable, and modular nature allows it to be used in diverse applications, from off-grid vacation cabins to high-density in-fill housing. Cores can be stacked in multi-story designs. They can be combined with local materials and methods. Over time, the footprint size can change as the lifestyle of the owner evolves, adding rooms for a larger family or removing rooms as the nest empties.

*Mass Customization - a business technique which allows any customer to buy a product or service that has been pre-designed (customized) to fit a customer’s exact needs.
“Our name reflects our core value — excellence in energy products and services. We are dedicated to providing you the best in service, value and information to enhance your professional and personal life. We are committed to customer satisfaction by continuously improving our operations to be a low-cost, reliable, environmentally sound energy provider. We have been successfully proving this to our customers for more than 130 years and will work hard to continue with this commitment in the future.”
At James Hardie, we create innovative products that increase the beauty, value, safety and durability of the homes you design. Explore increased design options through our wide variety of product colors and textures, and enjoy superior performance that allows your designs to last a lifetime.

www.jameshardie.com