Solar Decathlon

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As one of the fastest growing cities in the country, Austin is realizing that the effects of growth strain our water and electricity infrastructure. Compounding these issues is an increase in suburban poverty, which amplifies the need for additional affordable housing. NexusHaus, a 784 square foot house designed by students from the University of Texas at Austin and the Technische Universität München (TUM) for the United States Department of Energy Solar Decathlon 2015 competition offers a solution to these issues through the design of a solar-powered home that can be deployed throughout existing Austin neighborhoods as an Accessory Dwelling Unit (ADU). The house will collect most of its own water, provide vegetables and fish for consumption through a closed-loop aquaponics system, and increase density within Austin’s single-family residential neighborhoods.

Austin’s population is undergoing rapid growth; as a result, the demand for housing has increased exponentially. At the same time, Texas is experiencing rising temperatures and prolonged drought, which are straining water supplies and pushing infrastructure to capacity. NexusHaus, will address both sustainable and affordable urban housing in the context of energy and water resource constraints. This net-zero energy, zero water house accomplishes these goals through a combination of photovoltaic electricity generation, integrated thermal/water storage systems, and cutting edge smart home management. The ultimate goal of NexusHaus is to serve as a prototype for a next-generation modular home that could be reproduced en masse in an assembly plant in Austin.

The design of NexusHaus considers a number of environmental control factors unique to central Texas including air circulation and solar heat gain from the intense summer sun. To address these issues, NexusHaus utilizes a
number of design features typical in vernacular Texas architecture. The first of the regional influences, the dog trot, is incorporated through the division of the house into two modules. The central, open space this creates—the nexus—allows for natural air circulation. The second feature employed is the large covered deck on the south side of the house that mimics the typical patios found throughout Texas and shades the house from solar heat gain.

Concerned with the long-term effects of drought, NexusHaus focuses on water conservation and will capture rainwater to supply all of its potable water needs. This will reduce the home’s reliance on city water to which it will only be connected by a small refill line for backup supply during long dry spells. The potable rainwater harvesting system minimizes added stress to the region’s water supplies and minimizes the additional load of more residents on the existing neighborhood water and wastewater infrastructure. Additionally, the on-site treatment system avoids the water losses along the municipal distribution system by approximately 10 percent. The thermal storage tank acts as a secondary storage volume for rainwater, giving the system additional capacity while also providing beneficial load shifting (see Figure 2).

In addition to the water and energy concepts, NexusHaus focuses on involving the residents in the everyday life of the building through the student-designed home management system called NexSmart. The system will not only teach residents how to live sustainably, but make it remarkably simple to make smarter, greener choices. NexSmart will give residents agency and allow them to live more sustainably through the use of integrated educational tools.

NexSmart integrates traditionally separate (or completely unmonitored) home systems, including: electricity consumption and production; water system consumption, collection, and tank level; smart appliance control; indoor environmental monitoring and air conditioning system control; home occupancy; interior and exterior lighting; home entertainment systems; and the aquaponics system. The NexSmart system will monitor the house and interact with residents through a custom in-house touch panel called the SenseBar. The highly intuitive NexSmart app will communicate the quantity of resources used through the SenseBar interactive display. NexSmart will also allow the UT|TUM team to track NexusHaus’s systems over time, providing research opportunities that extend beyond the October 2015 competition.

A major point of focus for NexSmart—the home’s air conditioning system—is an unavoidable fact of life in Texas and serves as the primary component of power demand and energy consumption in Austin. To alleviate afternoon electricity grid congestion—and avoid higher-priced power—NexusHaus will incorporate an Integrated Thermal Energy and Rainwater Storage (ITHERST) system which shifts air conditioning load off-peak to the early morning hours. Thermal storage technology has traditionally only been employed on the large commercial and industrial scale projects; however, NexusHaus will demonstrate the concept on a residential scale.

ITHERST operates the thermal storage tank as an auxiliary rainwater collection and storage volume which increases the effective capacity of the rainwater collection system, and makes use of an otherwise underutilized thermal mass. This integrated thermal/water storage system was developed specifically for the UT|TUM house as a proof-of-concept and aims to provide an advanced design solution uncommon in today’s residential market. Figure 3 contains a schematic representation of the main components in the proposed ITHERST concept using a residential hydronic cooling and heating system with indirect rainwater thermal storage.
Analyses performed to date suggest that the Itherst system could reduce the on-peak cooling-related electricity load by 75 to 80 percent with a corresponding increase in electricity consumption of approximately 5 to 10 percent, when operating in Austin, Texas (compared to a similar system without thermal storage).

This system, coupled with the solar photovoltaic (PV) array, provides electricity to the grid on-peak while simultaneously reducing the house load. The goal is not just to minimize air conditioning load on the grid, but also to supply an abundance of energy to support the surrounding neighborhood during peak power demand.

This approach benefits other grid-connected stakeholders, from customer to utility, and could therefore be a source of savings and revenue generation. The thermal storage system will allow the home occupant to save on their utility bills in areas where there is real-time or time-of-use pricing. Conceivably, the electric utility could offer a rebate for the rainwater collection system as a benefit to residents who implement a thermal storage system.

The dynamic and innovative solution provided by NexusHaus merits description of three distinct beneficiaries—the City of Austin, the property owner (client) and the unit resident (renter). As a cost-efficient solution that responds to Austin’s skyrocketing demand for urban housing, NexusHaus adds density to centrally located neighborhoods without requiring additional infrastructure through the utilization of the City of Austin’s Accessory Dwelling Unit (ADU) code. This code allows for ADUs (granny flats, alley flats, secondary dwellings, etc.) to be placed along existing alleys on more than 42,000 single-family residential lots throughout Central Austin. Many of the available lots are located along existing public transportation routes allowing future residents to utilize public transit. Reducing the number of vehicles added to Austin’s metro area roadways each day (currently 70 per day) will minimize the impact on existing road infrastructure. In addition, increased use of public transportation will alleviate traffic congestion and help better the quality of life for current and future Austinites alike. For the client (property owner), NexusHaus will serve as a unit of economic production, a potential source of rental income used to defray increasing property taxes. Marketability is one of the primary drivers behind NexusHaus’ energy and water concepts, which are attractive to a growing demographic of technologically savvy and ideologically motivated people looking for a low-impact lifestyle. The target resident demographic is less concerned with overall square footage than with the benefits of being located close to recreational areas and downtown amenities, and through implementation as an ADU, NexusHaus can provide access to these amenities at a lower premium that most housing options currently available.

NexusHaus is currently under construction in East Austin. The house and team will travel to Irvine, California, in September to participate in the United States Department of Energy Solar Decathlon competition held in October. After the competition, NexusHaus will return to Texas for a period of monitored study utilized to assess the performance and success of the home over a minimum of two years.
Note: This essay, with minimal edits, revisions, and additions, was originally submitted to the United States Department of Energy Solar Decathlon in April 2015.

Sources:

