Aligning Occupant Behavior with ZNE Community Goals and Assumptions: Quantifying and Leveraging Behavioral Plasticity

Sarah Outcault, Angela Sanguinetti, Alan Meier, & Nermin Dessouky
Energy & Efficiency Institute, UC Davis

ABSTRACT

In residential communities designed for energy efficiency, do the occupants take an active role in conserving energy, or leave it up to the home itself? We examined cooling practices in a new, low-energy development, located in one of the hottest climates in the world. The Sustainable City (TSC) in Dubai attracts individuals from across the globe, with varying cultures, values, attitudes, and habits. TSC staff promote a culture of sustainability, but there are challenges in achieving zero net energy (ZNE). Data on household energy consumption were collected from residents and household staff through in-person interviews and an online survey. We found evidence of a wide range of occupant values and cooling strategies. Many residents came from cooler regions in the world and were unfamiliar with cooling practices and technologies in their homes. We identified opportunities to leverage behavioral plasticity - i.e., residents' capacity to shift everyday practices - to save energy. This study suggests a framework for aligning occupant behavior with the goals and values embodied in sustainably-built communities. Specifically, designers and managers of sustainable communities need to educate, motivate, and support residents in order to encourage the specific energy-conserving practices required for sustainable buildings to achieve their technical potential.

Introduction

Codes and practices across the United States are rapidly moving buildings towards designs that will achieve near-zero net energy consumption. California's Title 24 and Massachusetts' Building Energy Code are examples of this trend. According to the Net-Zero Energy Coalition's annual inventory of "zero energy" residential buildings, there were 4,077 ZNE buildings in the United States and Canada in 2016 and another 741 projects underway. Ninety-four percent of existing units were part of multi-unit developments. A large part of the expansion of ZNE residences will come from planned communities rather than one-off projects, highlighting the importance of understanding the performance of ZNE homes in the context of communities.

Developments claiming low or zero net energy do not necessarily achieve their goals. A large majority of ZNE-designed buildings have not provided actual performance data to verify ZNE status (New Buildings Institute 2016). Occupant behavior plays an important role in determining the actual energy outcomes (Zhao et al. 2016; Gil, Tierney, Pegg, and Allan 2010; Karlsson, Rohdin, and Persson 2007), which can result in a wide distribution of energy consumption. For example, several studies of ZNE residential communities found that households with high energy consumption have up to several times the usage of households with low energy consumption (Brown et al. 2016; Outcault et al. 2016).

Designing for ZNE requires assumptions about occupant behavior, such as occupancy schedules, temperature preferences, ability to correctly control equipment and other practices, to estimate the requirements for on-site energy production. If assumptions underestimate actual consumption or production, occupant behavior may need to be modified to reach energy goals. This may come as a surprise to ZNE households, and occupants may or may not be willing to adapt to align their behavior with the energy goals of the building or community. For example, Cardwell (2016) found that ZNE home buyers assume that they do not have to change their behavior to save energy, and Berry et. al. (2014) found that near-zero energy households reacted negatively when energy saving strategies required too much effort on their part.

While ZNE is relatively new, the self-selected occupants (i.e., early adopters) may be more inclined than the general population toward values of sustainability and energy conservation. That said, people select homes for many reasons, and even the first wave of ZNE residents may have been drawn by other factors. Barriga et. al. (2013) found evidence of this in West Village, the largest ZNE community in the world, which is largely composed of college student housing at the University of California, Davis. As ZNE construction expands, and adoption broadens beyond early adopters to the population majority (Rogers 2010), occupants will be even less likely to value the energy goals of the building design. Combined with the already low percentage of data-verified ZNE districts, this does not bode well for achieving ZNE in the residential sector on a broad scale.

This paper is concerned with what to do when community-level energy goals are not reached, *not* exclusively as a result of shortcomings of the building systems and technologies, but due to occupant behavior, including energy-consuming practices and user interactions with building systems and technologies. Our main questions are:

1. How do you measure occupants' behavioral plasticity (Dietz et al. 2009), i.e., willingness to change or adopt new behaviors so the community can reach its full technical potential?
2. How can you harness that behavioral plasticity?

We can look to the ZNE and sustainable communities around the world to help us answer these questions. This paper presents a case study of one community, The Sustainable City, which led to the development of: a) a framework for maximally aligning occupant behavior with community energy goals; and b) a methodology for estimating behavioral plasticity for adopting more conservative A/C setpoints.

Introduction to The Sustainable City in Dubai

The Sustainable City (TSC) is a gated community in Dubai, United Arab Emirates (See Figure 1). When complete, TSC will consist of 500 villas, 200 apartments, a commercial center, school, hotel, mosque, and medical center. The development is about 80% complete (as of March 2018). More than 75% of the villas and apartments are occupied, with roughly 2,000 residents.

The developer designed the community to be "sustainable" through the incorporation of numerous features to save energy, water, and to reduce solid waste. Some of these features are readily apparent in Figures 1, 2, and 3. The most distinctive feature is the PV array on the roof of every villa (along with a thermal collector for hot water). The streets are narrow and oriented to maximize shading. This is possible only because automobiles are prohibited from entering the community's core. Automobiles are parked in central parking areas (under large PV arrays) and residents walk or drive electric vehicles from the parking areas to their homes.

A "green spine" bisects TSC (see Figure 3). It contains landscaping, recreational facilities, and nine "biodomes." The biodomes produce some plants and herbs for the community, but most of the output is sold to others. The green spine also contains a water treatment plant; this enables gray water to be used for irrigation of public spaces.

Figure 1. Aerial view of The Sustainable City *Source: Diamond Developers*

Figure 2. The Villas at TSC *Source: Sarah Outcault*

Figure 3. One of the eight biodomes on the green spine, with an electric vehicle being used for personal transport *Source: Alan Meier*

Energy-conserving design features include insulation, high-performance windows and shading, efficient A/C and appliances, passive solar features, and PV arrays on homes and over parking areas. Further details regarding air conditioning (A/C) equipment in TSC homes are relevant to the present research. TSC homes and apartments are outfitted with ductless mini-split systems. Each bedroom and the main common room has a unit that is mounted on the wall and controlled by a dedicated remote control. This is a fairly typical setup in other areas of the world.

The villas in TSC appear to use much less electricity than conventional villas in Dubai. Incomplete data suggest that the average TSC villa uses about 15,000 kWh (compared to the roughly 30,000 kWh/year for villas in other communities). These values may seem high by Western standards, but this is exceptionally low for the United Arab Emirates (UAE). In fact, the UAE defines a "near-zero" home as roughly 90 kWh/m^2 in primary energy (Fayyad and John 2017). TSC homes appear to meet that criterion assuming that all of the electricity is sourced from on-site PV, including residential rooftop arrays and parking lot arrays.

Electricity prices are only about 6 cents/kWh - half of US rates - but electricity bills are still a major concern in most Dubai households because consumption is so high - often three times larger than average US residential use. This is largely because Dubai is hot - very hot. The average temperature between June and September is over 100°F.

The air conditioning season runs from March to November. As a result, about three-quarters of an average home's electricity consumption is for A/C. Air conditioning also contributes substantially to peak energy demand limiting the potential for future efforts to establish grid independence. This paper focuses on understanding behavioral plasticity with respect to raising temperature setpoints by 1°F and behavior change strategies to promote efficient cooling practices, bringing occupant behavior into alignment with TSC's ZNE goal.

Method

The impetus of our study was to inform an effort to develop a model for a micro-grid with integrated energy storage for The Sustainable City. Specifically, we aimed to collect data on residential energy consumption patterns to create an electricity load profile under two scenarios, the base case and another in which we assumed some reduction in A/C use could be achieved through behavioral change. This paper draws on data collected through in-depth household interviews and an online survey. Interview and survey questions related to participants' attitudes and energy-consuming practices (particularly regarding air conditioning).

Table 1. Survey and interview questions used in this study

Survey	
Question	***Response options***
Q24. Please tell us how much you agree or disagree with the following statements. - I feel morally obligated to use energy efficiently - I try to minimize energy use to decrease the household energy bill	Strongly disagree Somewhat disagree Neither agree nor disagree Somewhat agree Strongly agree
Q25. How often do you {Turn off the lights} when leaving a room?	Never; Sometimes; Often; Always
Q26. Do you ever check your energy meter?	Yes/No

Q30. What temperature (in degrees Celsius) is the thermostat typically set to when the air conditioner is running during the following periods?	18-28 °C, Don't know
Q17. How often do you {Run the dishwasher only when full}?	Never; Sometimes; Often; Always; Not applicable
Q50. Please share with us anything else not covered in the survey that you do to save energy or water, or otherwise strive for a sustainable lifestyle.	open-ended
Interviews (open-ended unless otherwise noted)	
Tell me about how the{thermostats} are used throughout the day. When are they on and when are they off?	
How do the ACs get switched on/off? (person, auto, timer – by room)	
What temperature are the ACs set to? Same in every room? Same at night? How did that temperature come to be the one that's used in your home?	
Does the temperature ever get adjusted? When? How? (by room)	
How willing might your household be to turn up the thermostat 1 degree on all ACs in your home from 5-10pm? (Very, somewhat, not)	
If everyone used the AC less, less energy storage would be required, and TSC could rely solely on solar power. What might convince you to use the AC less to help achieve that goal?	

Interviews were conducted in person in residents' homes or in a villa provided by TSC; they lasted between 21 and 80 minutes and were audio recorded. The online survey was programmed in Qualtrics, with slight variations to target householders and domestic staff.

Participants and Recruitment

Interview subjects were recruited through a post on the community portal on TSC's website; no incentive was offered. Diamond staff conducted survey recruitment, inviting participation via TSC's community website and Facebook page. Incentives were offered; specifically, domestic staff who participated received prepaid phone cards (worth AED50 /USD$14) and householders were entered in a drawing for one set of equestrian lessons (worth AED900 /USD$245) and 10 sets of bus passes (worth AED50 /USD$14). Table 2 presents relevant details about the interview and survey participants.

Table 2. Characteristics of study participants

	Interviews	**Surveys**
Number of Participants	22 (from 17 households) (Including: 2 Diamond staff, 1 domestic staff, 5 couples who participated together)	116 (27-31% of all TSC households)[1]

[1] The actual participation rates fall somewhere between 27 and 31 percent, depending on how many survey respondents who did not report their unit number lived in the same household.

Gender Breakdown	Female - 64%	Female - 62%
	Male - 36%	Male - 38%
Age Breakdown	n/a	Minimum - 21
	n/a	Maximum - 61
Nationality of Origin	Europe – 52%	Europe – 58%
	North America – 24%	North America – 5%
	Asia – 10%	Asia – 22%
	Africa – 10%	Africa – 4%
	Australia – 4%	Australia – 6%
	Middle East/North Africa – 0%	Middle East/North Africa – 4%
Length of Residence at TSC	2 weeks to 15 months	Less than 1 month to 18 months
Length of Residence in Dubai	n/a	Less than 1 year to 24 years
Occupancy Type	Own Unit - 14%	Own Unit- 14%
	Rent Unit – 82%	Rent Unit – 70%
	Domestic Staff – 5%	Domestic Staff – 16%
Type of Residence	Villa – 95%	Villa – 88%
	Apartment – 5%	Apartment – 11%
		Commercial Space – 1%
Incentive Offered	No	Yes
Recruitment Method	Post on TSC website	Post on TSC website
	Referral from another study	Post of TSC Facebook page

The interview and survey participants varied in age and nationality. Although the survey garnered a respectable 27% participation rate, the absence of residents from the Middle East was notable. The length of residence in TSC and Dubai varied widely. Interviews revealed that TSC residents chose the community for a variety of reasons, including proximity to work or school, ability to get around without a car, the community feel, and the open green spaces. Many also noted the energy savings promised by the solar panels as an important factor.

Toward a Framework for Behavior Change in ZNE Communities

The data collected from the instruments outlined in Table 1 were analyzed using grounded theory and the results suggest three converging factors contribute to efficient air conditioning practices in TSC: resident motivation to conserve, knowledge about efficient practices, and behavioral contingencies supporting specific practices. Based on these findings, we suggest a framework for maximizing behavioral plasticity to achieve maximum technical potential in ZNE communities. The framework suggests that community developers and managers should educate, motivate, and support residents with respect to specific energy-efficient practices that complement the building energy systems and technologies. Next, we explain how each factor was identified and assessed in the context of our study of air conditioning practices in TSC.

Motivate

TSC residents that were interviewed and surveyed largely resembled the typical early adopter category (Rogers 2010), reporting relatively high levels of moral obligation to conserve energy. However, financial motivation to conserve was even more salient (see Figure 4). Open-ended responses to the survey and interview questions yielded additional insights into residents' motivations for conserving energy, including cultural norms.

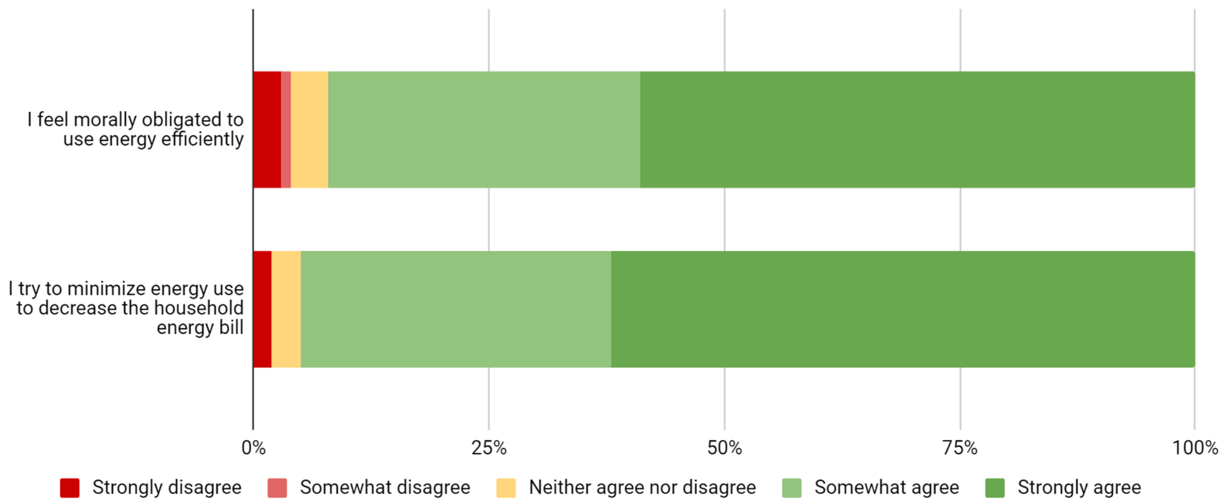

Figure 4. Energy attitudes per household survey

Several European residents noted that their conservation behavior was rooted in the cultural norms of their country of origin. Local norms also have an influence. They explained that the default A/C setting of 18℃ (64F) in buildings and vehicles in Dubai serves as an anchor, influencing their behavior. *That figure [18℃] stays in your head unless you're consciously thinking about it, and you say, oh, I need to raise it up. [Adjusting the setpoint to save energy is] not really there on your radar all the time.* Several residents described how the local norms undermine their motivation to minimize energy use, as this quote illustrates: *If I were in Europe, I would think the [social] environment [would motivate me to conserve energy], but here, I would be the only one to do it in Dubai.* Some residents claimed that TSC office staff and construction workers set thermostats to 18℃ (64°F). This and other inconsistencies between TSC's stated values and workers' behavior (e.g., wasteful irrigation practices, liberal use of plastic bags by community grocery store employees) or inefficient technologies (e.g., inefficient water heaters) seemed to create a disincentive for residents to conserve.

Paradoxically, living in a sustainable or ZNE designed community may undermine the motivation to use energy conservatively. As one interviewee put it: *I think having solar panels [makes me] slightly less conservative about my power use than before.* Another described solar power as "guilt free." It is unclear whether this is evidence of single action bias (Weber 1997; Weber 2006) or moral licensing (Steg et. al. 2015) leading to a rebound effect. In either case, it seems that moving into a ZNE community could have negative spillover effects on other energy-consuming actions.

Interviewees were asked directly what might convince them to turn their thermostats up by 1°C (~1.7°F). Responses included statistics on the impact it would have on health, the environment and the household energy bill; reassurance from studies documenting that occupants would still be comfortable; and a scheme to donate the money saved to a charity providing heating to someone in need in a colder climate.

In summary, it is important for ZNE communities to motivate residents to engage in energy-conserving practices. Our case study shows that even when residents are relatively motivated, there are competing motivations that need to be addressed. Communities must contend with broader cultural and local norms that may run counter to the community culture and norms being promoted. Developers can create and reinforce a sense of community identity by communicating specific sustainability practices as the norm. TSC does a good job of this in some respects (e.g., hosting events, signage, community infrastructure) and its residents are generally oriented toward pro-environmental behavior. Perverse incentives like the single action bias and moral licensing leading to a rebound effect also need to be addressed. Education may help address these issues, if residents come to understand the actual impact of their behaviors and how energy systems in their community work. This relates to the next part of our framework: the need to educate residents.

Educate

There was a wide range among TSC residents in terms of general knowledge regarding energy, sustainability, and A/C. Some had a sophisticated understanding of solar generation and storage as well as household energy consumption, whereas others expressed embarrassment over their ignorance about these topics. Specific to A/C, some residents had been able to program their thermostats with no guidance aside from the manual. However, many lacked such knowledge, as well as more nuanced strategies such as closing doors when cooling a room, which is common practice in places like Japan.

Numerous respondents expressed confusion over how to optimally operate their A/C. To address their lack of experience, a few participants had asked someone (e.g., at work, at the leasing office) for advice on appropriate thermostat settings. Some participants specifically expressed an interest in receiving recommendations from the developer or property management on how to use their thermostats. Topics of interest ranged from how to cool efficiently to the fundamentals of how to achieve comfort. For example, one interviewee expressed interest in being told *the ideal temperature for the human body if it's 40 degrees outside…[We need to be informed on] what's the best practice here, because we don't have that experience.* Others wanted guidance on aspects of A/C control (e.g., programming, temperature setting, fan speed). Several wondered whether it is more sustainable to turn the A/C on and off or maintain a single temperature, either while home or when leaving the house for a period. This is a common question even in more traditional built environments and one that some industry members have found the need to provide guidance on (See MassSave's *Energy Saving Tips*).

TSC staff regularly host events to educate residents on issues related to sustainability - on everything from sorting household refuse to the embedded energy costs of water services. Our study shows that residents are still learning, particularly about efficient A/C use. As ZNE and other sustainable communities become the norm, we can expect their residents will also vary in their knowledge and familiarity with building energy systems. Best practices for educational strategies are needed to support the behavior side of the ZNE equation. Examples could include resident orientation programs, building dashboards (Petersen, Frantz, and Shammin 2014), tip sheets, and online tutorials. These educational strategies can convey to residents that their home's design holds the technical potential to achieve ZNE, but reaching that potential depends on their behavior. It is important to note here that influencing residents' behavior was explicitly not the aim of TSC developers. However, in the U.S. context, where ZNE homes are often built in response to a policy directive, developers may exhibit a greater appetite for nudging residents' to achieve ZNE - particularly if demonstrating ZNE performance becomes a requirement.

Support

Finally, our framework highlights the need for communities to support specific energy management or conservation practices. This relates to the need for education, e.g., on best practices for A/C use in our context, but takes it a step further to specify a need for more direct support, including prompts, training, and reinforcement. For example, some households reported having higher energy use months (e.g., when family members visited), and lower use months (e.g., when they tried to conserve energy), but detecting no difference on their energy bill. The research team validated residents' skepticism when we observed an arithmetic error on an interviewee's energy bill. However, although residents want fair billing, many are resigned to the lack of transparency, as this quote illustrates: *There's so little faith in DEWA [energy utility], that you just think there's no point finding out [what the problem is]*. It is important that residents' efforts to conserve energy are rewarded.

Many respondents reported manually controlling their thermostats rather than programming them. Programming thermostats typically results in greater efficiency (see RLW Analytics, as cited in Peffer et al., 2011). Although most survey respondents (83%) reported routinely turning A/C units off as they leave a room, as Figure 5 illustrates, there is room for improvement. In addition to seeking education on thermostat programming, some residents expressed a desire for TSC staff to program their thermostats for them. Smart thermostats, and similar technologies (e.g., smart plugs, and lights, with occupancy sensors) that provide energy feedback, enhance residents' opportunities to control appliances, and/or automate energy efficiency strategies, could help support specific behaviors to bring energy consumption into alignment with community ZNE goals.

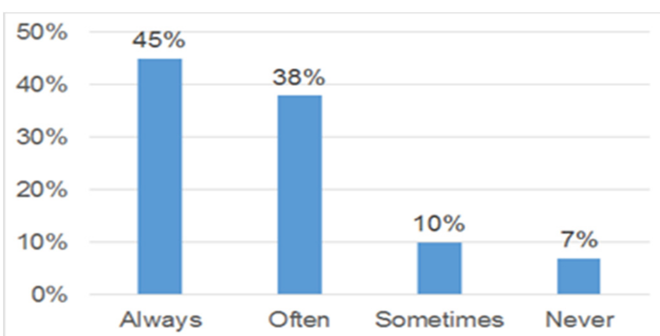

Figure 5. Percent of survey respondents who reporting shutting off A/C when leaving a room

Modeling Behavioral Plasticity to Increase Setpoints

Results from the interviews and survey suggested a potential for saving energy through behavior change among TSC residents, particularly with regard to our focus on A/C usage. To support an effort to model energy storage, we estimated the proportion of households that might be willing to raise their A/C setpoints by 1℃. In the interviews, we asked this directly, and 13 out of 17 households expressed a willingness to turn up the thermostat 1℃. Of the few who were unwilling to increase their setpoint, several already maintained relatively high temperatures (i.e., 26-28℃, roughly equivalent to 79-82°F), and another had health problems that were triggered by high temperatures.

Given that individuals willing to grant an interview on energy use are likely to be among the more energy-conscious in the community, we expected a smaller portion of the community as a whole would agree to adjust their setpoints to save energy. A different method was employed to estimate behavioral plasticity using survey data. A predictive model was developed, leveraging data on reported setpoints and correlated energy conservation behaviors, to estimate the proportion of survey respondents who could be persuaded to raise their typical thermostat setpoint by 1℃ in order to save energy. The model proceeded as follows.

First, survey participants who reported conservative setpoints (i.e., at or above the 75th percentile for each time of day) were excluded. The 75th percentile was 26℃ (79°F) for morning, afternoon, and evening, and 25℃ (77°F) for nighttime. We assume no potential for change in these households, as they are already at the upper end of the setpoint range. Eight of the forty-nine participants who reported at least one setpoint value were excluded based on these criteria. Then, several inclusion criteria were applied to the remaining 41 households; respondents were deemed amenable to raising temperature setpoints by 1℃ if they met any of one of these conditions:

- Reported different setpoints for different times of day, indicating some flexibility or dynamism in preference or tolerance;
- Offered a comment in open-ended responses that implied a lack of efficacy using the thermostat, indicating a potential to save via knowledge gains (i.e., instructions on how to use the system);
- Reported a curtailment behavior that was correlated with higher setpoints (i.e., “Always” turning off lights when leaving a room, “Always” running the dishwasher only when full); or
- Reported checking their energy meter (with any frequency), as this behavior is indicative of interest in energy use and was correlated with higher setpoints.

Applying these criteria resulted in a predicted 49% of TSC households that might be persuaded to increase their temperature setpoint by 1℃. The means and standard deviations of setpoints for this group at various times of day are as follows: Morning: 24℃[2] (2.20); Afternoon: 23.9℃ (1.61); Evening: 23.6℃ (2.09); Night: 23.5℃ (2.50). The energy storage modeling exercise, led by another team, suggested that successfully shifting the behavior of half the residents - to raise setpoints from their usual setting by 1℃ - would significantly reduce the energy storage capacity required in TSC.

---

[2] 24℃ corresponds to 75°F.

Conclusions

Designers of ZNE residential communities and buildings make assumptions about occupant behavior that are prone to error given wide variations in residents' habits, knowledge, and priorities. Gaps between modeled ZNE community design and actual performance were examined for The Sustainable City in Dubai, where air conditioning is the dominant use of energy. We demonstrated an innovative way of measuring behavioral plasticity with respect to temperature setpoints and found potential for nearly half of households surveyed to modify their behavior. Since A/C accounts for the majority of energy consumption in TSC, successfully influencing the behavior of even a portion of those households' behavior could have substantial impacts on energy consumption and peak demand in the community.

The study also presents a three-pronged framework for community developers and managers to bring occupant behavior into alignment with ZNE goals through motivation, education and behavioral support. The findings of this study may be a useful starting point for the developers and policymakers constructing ZNE buildings and communities in the United States in response to policy mandates.

An obvious extension of this work is to test whether households' energy consumption is correlated with self-reported air conditioning practices. TSC is currently taking steps to monitor a small subset of households that would facilitate such an analysis. Subjective assessments themselves are worth exploring further, too, particularly in such a culturally diverse environment; living in a sustainable manner clearly means very different things to different people. To that end, another fruitful line of inquiry would be to explore the correlation between self-reported practices and assessments of "sustainability" or energy consciousness. Developing a framework for understanding how the relationship between behavior and perception may differ across individuals and/or cultural groups would be invaluable for those trying to develop effective messaging for diverse communities among whom "sustainability" may have limited shared meaning.

Residents moving into TSC (and other sustainable communities) undergo an acclimatization process. Further research is needed to understand how residents adapt to new expectations and environments, and the pace, depth and persistence with which they adopt new practices.

Acknowledgments

This work was supported by a grant from the Sustainability Research and Training Program (SRTP) at the University of California, Davis. The authors would also like to acknowledge the assistance of Diamond Developers in Dubai.

References

Barriga, C., A. Meier, N. Biggart, D. Biscotti, B. Finkelor, T. Tanaka, and N. Enomoto. (2013). "Resident Engagement Strategies in Low and Zero Net Energy Communities." In *ECEEE Summer Study Proceedings*, 383–93. Stockholm: ECEEE. Retrieved from: www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2013/2-energy-efficiency-policies-what-delivers/resident-engagement-strategies-in-low-and-zero-net-energy-communities/2013/2-175-13_Barriga.pdf/

Berry, S., D. Whaley, K. Davidson, and W. Saman. (2014). "Near Zero Energy Homes – What Do Users Think?" *Energy Policy* 73 (October): 127–37.

Brown, C., A. LaRue, M. Pigman, J. Roberts, D. Kaneda, D. Connelly, J. Elliott, P. Shanti, P. Abhijeet, E. Dean, and C. Anbarlilar. (2016). "Measured Zero Net Energy Performance: Results, Lessons, and Surprises." In *ACEEE Summer Study on Energy Efficiency in Buildings*. Washington, DC: ACEEE. Retrieved from: aceee.org/files/proceedings/2016/data/papers/10_756.pdf

Cardwell, D. 2016. "A Suburban Experiment Aims for Free Energy." *The New York Times*, June 3, 2016, sec. Energy & Environment. Retrieved from: https://www.nytimes.com/2016/06/04/business/energy-environment/solar-power-energy-efficient-net-zero.html

Dietz, T., Gardner, G. T., Gilligan, J., Stern, P. C., & Vandenbergh, M. P. (2009). Household actions can provide a behavioral wedge to rapidly reduce US carbon emissions. *Proceedings of the National Academy of Sciences*, *106*(44), 18452-18456.

Fayyad, Majd and Jason John. (2017) "Defining Nearly Zero Energy Buildings in the UAE – 2017." Emirates Green Building Council, p. 27. http://emiratesgbc.org/wp-content/uploads/2017/03/Defining-nZEBs-in-the-UAE-2017.pdf

Gill, Z.M., Tierney, M.J., Pegg, I.M. and Allan, N. (2010). Low-energy dwellings: the contribution of behaviours to actual performance. *Building Research & Information*, 38(5), pp. 491-508.

Heiskanen, E., M. Johnson, S. Robinson, E. Vadovics, and M. Saastamoinen. (2010). "Low-Carbon Communities as a Context for Individual Behavioural Change." *Energy Policy* 38 (12): 7586–95.

Hong, T., D.Yan, S. D'Oca, and C. Chen. (2017). "Ten Questions Concerning Occupant Behavior in Buildings: The Big Picture." *Building and Environment* 114 (March): 518–30.

Karlsson, F., Rohdin, P. and Persson, M.L. (2007). Measured and predicted energy demand of a low energy building: important aspects when using building energy simulation. *Building services engineering research and technology*, 28(3), pp. 223-235.

MassSave website. https://www.masssave.com/en/learn/residential/energy-saving-tips/ Accessed online March 31, 2018.

Meier, A., R.Tutwiler, M. Jaskolski, N. Dessouky, C. Estevez, and Y. Moustafa. (2016). *Promoting a Culture of Sustainability at The Sustainable City 1*. Davis, CA: Sustainability Research and Training Program. Retrieved from: sjoseph.ucdavis.edu/sustainability-research-training-program/srtpGrantprogram/copy_of_SRTP.2016.2.1_Meier_Tutwiler Report1CharacteristicsofSustainableCommunities.pdf.

New Buildings Institute. (2016). "List of Zero Net Energy Buildings." Retrieved from: https://newbuildings.org/wp-content/uploads/2016/10/GTZ_2016_List.pdf

Outcault, S. Pritoni, M., Heinemeier, K., and A. Mikami. (2016). "Can you take the heat? A cross-national comparison of thermal comfort strategies and energy-saving field experiments." ACEEE Summer Study Conference Proceeding Paper.

Peffer, T., M. Pritoni, A. Meier, C. Aragon, D. Perry. 2011. "How people use thermostats in homes: A review." *Building and Environment.*

Petersen, J. E., C. Frantz, and R. Shammin, 2014. Using socio technical feedback to engage, educate, motivate and empower environmental thought and action. *Solutions*, 5, 79-87.

Rogers, E. M. (2010). *Diffusion of innovations*. Simon and Schuster.

Zhao, D., A. McCoy, J. Du, P. Agee, and Y. Lu. (2016). "Interaction Effects of Building Technology and Resident Behavior on Energy Consumption in Residential Buildings." *Energy and Buildings* 134: 223–33.