Measuring the Performance of Sustainable Communities

Marcella Whitfield, CEM, LEED AP

ABSTRACT

Designing a community aligned with a sustainable development framework should theoretically lead to sustainable performance measurable by key performance indicators. These indicators can be qualitative or quantitative and are used to evaluate and measure of progress.

However, perception is reality for stakeholders, as they readily accept that green designs will perform sustainably when constructed and occupied. A 2008 study by the New Buildings Institute (NBI) revealed that only 11% of Leadership in Energy and Environmental Design for New Construction (LEED-NC) rated buildings were performing to their modeled energy use intensity (annual energy consumption per ft^2) [1]. This study led many to question the effectiveness of the LEED certification process in creating high performance buildings.

The realization that design intent, modeling and certification did not guarantee sustainable performance, spurred interest in monitoring key performance indicators in buildings. The best building designs can deliver unsustainable performance after occupancy for a number of reasons. Despite this disconnect, few developments are actually measuring and verifying performance to substantiate these claims. As seen with individual sustainable buildings, the development industry claims sustainable neighborhoods perform as designed and consumers do request proof.

This article analyzes current sustainable urban developments in the occupancy stage to determine if monitoring is occurring. The research presented will reveal what is monitored, how it is monitored, and seek underlying motivations for monitoring sustainable performance indicators. Barriers to monitoring development community performance are examined, presenting a set of methodologies to effectively overcome those barriers and motivate stakeholders towards post occupancy monitoring and reporting in sustainable developments.

SCOPE AND LIMITATIONS OF RESEARCH

Sustainable developments (SDs) encompass a large variety of development types. The research presented in this article considers new or retrofitted urban developments of the district to neighborhood scale in urban settings that are characterized as sustainable. As such, city-scale efforts where municipal governments are assessing their sustainability holistically are not relevant to this research. Most of the SD sites researched consist of both residential and commercial/industrial building types, along with the components that comprise a functioning neighborhood (infrastructure, utilities, transportation, etc.). Due to the low number of SD developments that presently meet these criteria, developments that are not yet completed are also included if monitoring is proposed or required for their future occupancy.

This research concentrates on the long-term monitoring efforts of SD communities exclusively in their occupancy stage and does not analyze any efforts to characterize the sustainability of the SD community construction process. The intent of the research is to identify and analyze current monitoring efforts present in occupied SD communities. The research focuses on:

- Is the community monitoring their sustainable performance post occupancy?
- What is the community monitoring post occupancy?
- How is the community monitoring their performance post occupancy?
- Why is the community monitoring their performance post occupancy?

The research does not evaluate *which* SD communities surveyed are the most sustainable since the definition of a "sustainable development" has various meanings and relevance for different audiences. This analysis does not assess the actual performance of any one community, only whether the communities are using monitoring. The analysis also does not assess whether the communities that are monitoring performance are meeting their own goals. It does not evaluate individual key performance indicators (KPIs) to ascertain which indicators are appropriate or effective in measuring the sustainability of a neighborhood development. The attempt to determine which KPIs can define and assess

SD with a universal framework is the focus of other current research efforts. Sustainable development frameworks combine targets or goals with indicators that measure and track their progress using methodologies that provide paths toward urban sustainability. Frameworks offer a standardized approach to implementing and measuring sustainability in community developments.

EVOLUTION OF SUSTAINABILITY IN THE BUILT ENVIRONMENT

As the world's people begin to fully realize the finite nature of the planet's resources and boundaries, alongside the explosion in population and resource consumption, there is an impressive surge of interest surrounding resource efficiency and low impact systems and processes. Concerned designs and developments re-imagine the built environment by utilizing resources more efficiently throughout the development lifecycle to lower negative impacts on the planet.

"Green Building" emerged as a philosophy of designing and constructing the built environment and services towards the ultimate goal of zero net negative impacts on environmental systems. Common goals of green building designs include water, energy and resource efficiency and lower negative impacts on and off site when compared to traditional building designs. This is movement in the direction of *sustainable design* which ultimately aims for no net negative impact on environmental, economic and social health.

Among the paramount concerns regarding sustainability is measuring the impact of green building systems. Measurement allows the design community to understand the extent and effectiveness of a design's success deploying sustainable strategies. It offers the design community the opportunity to improve and refine current sustainable strategies to become more effective.

Individual buildings were the focus of the early green building movement. Green building proponents have broadened their goals beyond singular buildings to encompass components and infrastructure that create communities and sustainable neighborhood developments. A sustainable neighborhood development aims to reduce the net negative impacts a community has on social, environmental and economic health. A sustainable neighborhood, however, is more complex than just

assembling a collection of green buildings to form a neighborhood. For example, a remote community consisting entirely of green buildings on large lots which necessitate long daily commutes for residents using inefficient automobiles fails as a sustainable neighborhood. Sustainable communities consider not only infrastructure and community services but also the lifestyle, quality of life and actions of their residents.

By assessing relevant qualities, criteria and target objectives (indicators), organizations around the world are refining their definition of sustainable community. These initiatives include *Eco2 Cities* (World Bank), *International Ecocity Framework*, BioRegional's *One Planet Communities,* and the U.S. Green Building Council's (USGBC) *Leadership in Energy and Environmental Design for Neighborhood Development* (LEED-ND) rating system. Currently, most frameworks model performance to predict how a neighborhood will perform post-occupancy. Modeling should be verified by evaluating the actual performance of these communities after occupancy to assess how realistic the models were. Without accurate measurement of critical indicators, it is uncertain whether the frameworks being used are effective in achieving the goal of creating sustainable communities.

THE ROLE OF MEASUREMENT AND MONITORING

The world's designers are working to determine the best ways of designing and constructing sustainable developments and communities. New frameworks and rating systems have fueled a powerful momentum towards sustainability. Yet, design professionals, developers and municipalities are struggling since many sustainable development frameworks are being implemented with little feedback as to their effectiveness. Do those frameworks really achieve sustainable developments? Without a means of performance measurement, the success of the initial frameworks and completed pilot projects remains untested. While developers often claim that their developments are "sustainable," many are unable to validate such claims and offer proof that their developments are performing more sustainably than conventional developments. How can the design community measure progress when frameworks for assessment are lacking?

There is a great need to evaluate the performance of various sustainable development frameworks to discover which are the most ef-

fective and successful, and make the strategic changes necessary to improve future developments. Coleman suggests, "The globally accepted standard for gauging sustainable development progress is the indicator system" [2]. Indicators measure the progress of specific criteria against a targeted benchmark. Indicators can be used to evaluate a sustainable development before and after construction. This entails collecting and reporting data using common indicators (metrics) that allow for comparisons against benchmarks and provide a means to evaluate progress. Measuring performance allows the development community and stakeholders to discover:

- Which strategies are effective for meeting specific targets?
- Are there improvements?
- Which goals need more attention?
- How does this development or framework compare to others, and is it more effective?
- How can we adjust and refine future frameworks to improve performance?
- How can we use this feedback to improve (behavior or technical) our community?

The initial intent of this research was to compare the performance of various indicators across developments and communities touted as sustainable to identify best practices, methodologies and frameworks to highlight the most effective and successful. Early research revealed that very little performance data from sustainable communities was available to enable this type of comparison. Instead, most developments cited attributes based on *design intent* rather than actual *performance*. It became apparent that such comparisons were impossible unless more developers used monitoring systems and reported post occupancy performance.

The Importance of Measurement

Perception seems to be the reality in the development industry. It is much easier to claim a community (or building) is sustainable than to prove or demonstrate it. In addition, there has been minimal demand to validate claims of sustainability in community development.

The USGBC touts LEED as "the most widely recognized and widely used green building program across the globe… transforming

buildings and communities in 50 states and 135 countries… guiding design, construction and maintenance of nearly 50,000 projects worldwide (9.3 billion ft^2 or .864 billion m^2)." LEED's reputation suffered in 2008 after the New Buildings Institute (NBI) published its study of the post occupancy energy performance of 121 LEED certified buildings. This study revealed that while 48% of the LEED-NC buildings included in the study exceeded their predicted energy targets another 42% failed to meet their modeled energy targets [3]. This research highlighted the fact that LEED certification (like many other rating systems) is based on both good intentions and best predictions. LEED-NC was criticized for rating buildings based on design intent and modeled (predicted) performance, versus actual performance after construction. Building model accuracy can miss targets due to occupant behavior and building operation. To address this disconnect and mend its reputation, the USGBC began requiring post occupancy energy and water consumption for a specified time period as a precondition for LEED Building Design and Construction (BD&C) and New Construction (NC) building certifications.

In the press conference announcing the change to monitor performance for all future LEED BD&C-NC certified buildings, Scot Horst, senior vice president of USGBC, indicated that "ongoing monitoring and reporting of data is the single best way to drive higher building performance because it will bring to light external issues, such as occupant behavior or unanticipated building usage patterns, all key factors that influence performance." USGBC's vice president of LEED technical development also touted that "Building performance will guide LEED's evolution. This data will show us what strategies work—and which don't—so we can evolve the credits and prerequisites informed by lessons learned" [4].

Regardless, LEED BD&C-NC buildings can perform worse than they were designed to perform and maintain their rating, as long as they are reporting that poor performance. This rating system falls short since it lacks definition for actual high performance (lower resource consumption), only achieving high performance design standards and reporting the resulting performance. The rating system is only for building design and construction phases and does not require sustainable performance post occupancy. LEED BD&C-NC is not alone with this type of design rating system. The Comprehensive Assessment System for Built Environment Efficiency (CASBEE) and Green Globes both lack high

performance operational requirements. Future versions of LEED rating systems for newly designed buildings may address this shortcoming and increase the credibility of the certification by requiring annual or recurring verification of high performance, as found in Energy Star and LEED for Existing Buildings, Operations and Maintenance (EBOM). Both of these rating systems are for existing buildings and require annual recertification based on performance. Building Research Establishment Environmental Assessment Methodology (BREEAM) bridges the gap between two distinct rating systems by requiring BREEAM certified buildings to apply for a separate rating system for existing buildings to maintain their level of certification.

Evaluating Sustainable Development Strategy with Monitoring

Beddington Zero Energy Development (BedZED) in the London Borough of Sutton is an example of a mixed use, large scale sustainable community that has made monitoring performance integral to its vision of creating a carbon-neutral development. BedZED was developed through a partnership with the BioRegional Development Group, Bill Dunster Architects and the Peabody Trust Housing Organization. This development sought to minimize its ecological impact by setting these targets:

- Reduce potable water consumption by 33% compared to the U.K. average.
- Reduce hot water consumption by 33% compared to the U.K. average.
- Reduce electricity consumption by 33% compared to the U.K. average.
- Reduce space heating needs by 90% compared to the U.K. average.
- Reduce private fossil fuel car mileage by 50% compared to U.K. average.
- Generate enough electricity and hot water on site for entire development.

With these targets in place, the developers felt that "Monitoring progress towards achieving targets is vital in order to assess the effectiveness of the development, identify areas for further improvement and highlight lessons learned that can be applied to future developments" [5]. BedZED was completed in 2002 and monitored multiple areas for

performance in 2003, 2004, 2005 and 2007. Resident surveys were used to collect data on quality of life, food, travel and transport, shelter and thermal comfort, goods and services, waste and community amenities. Data loggers, metering devices, census and waste audits were used to monitor performance. The results of the monitoring are accessible to the general public and posted reports are available online. The indicators measured included energy, water, transportation, food, waste, quality of life, construction materials and methods, and ecological footprint.

BedZED's encouraging results revealed what was possible and what could be improved. The lessons learned are shared openly with the public so that they can be applied to future developments. Monitoring data revealed that BedZED did not realize all of its goals. Despite this, BedZED benefitted by learning from their results, analyzing their operations and continuing improvement. The transparency of the data and lessons learned from monitoring "helped drive U.K. government's legislation for all new homes to be built to zero carbon standards by 2016." Though there is no present monitoring of BedZED, there remains a focus on continuous improvement towards the original goals.

BedZED also became the prototype for One Planet Living (OPL) sustainable community development framework. The data and lessons learned from BedZED guided the development of the OPL framework for replication worldwide. OPL has expanded upon the initial targets of BedZED to create the Ten OPL Principles including: zero carbon, zero waste, sustainable transport, sustainable materials, local/sustainable food, sustainable water, land use and wildlife, culture and heritage, equity and local economy plus health and happiness. The name One Planet Living stems from the desire to reduce ecological footprints to the point where we would only need one planet to support earth's population.

The transformative premise behind the OPL framework is that ongoing monitoring encourages continuous improvement towards the optimal targets. Communities change impacting their structures. Long-term monitoring fuels future improvements, refines operations and behaviors, and captures the inherently dynamic nature of communities. This is a crucial departure from current development frameworks. OPL endorsements have demanding requirements. They require sustainable design and planning according to OPL's ten principles, plus monitoring, evaluation, reporting and *progress* towards sustainable targets in each of the ten principles. Communities must

create a One Planet Action Plan and BioRegional must approve this plan. The action plan details each community's strategy to reach stringent One Planet Community 2020 targets based on the ten principles. Communities must also commit to independent monitoring of performance until 2020, which entails developer involvement past completion of construction. The monitoring of performance through indicators and benchmarks informs OPL's required annual review for each community. This technical guidance evaluates the success of plan implementation and publicly reports progress towards targets, lessons learned and areas for improvement. OPL endorsed communities must also show progress towards the 2020 targets to maintain endorsement. Repeated failure to show progress towards targets and dismissal of attempts to get the community on track leads to loss of endorsement. Endorsed OPL communities include Grow Community (U.S.), One Brighton (U.K.), Mata de Sesimbra (Portugal), Sonoma Mountain Village (U.S.), North West Bicester Eco Town Phase 1 (U.K.), Hollerich Village (Luxembourg), Westwyck Ecovillage (Australia). BedZED and the OPL communities provide an excellent case study on the benefits of sustainable community monitoring post occupancy.

RESEARCH METHODOLGY AND RESULTS

The intent of this research was to compare the performance of various performance indicators across sustainable community developments. Apart from BedZED, preliminary research revealed a lack of performance data from sustainable communities. This prompted a redirection of the research into the monitoring and reporting trends in the sustainable community development industry. Internet searches, trade journals, case studies and academic research papers revealed a number of sustainable communities that could be examined for their monitoring and reporting practices, or lack thereof. Initially, emails and phone calls were made to developers, community managers and the local municipal planning departments of 27 sustainable community developments. These emails inquired about a possible point of contact or location where "data on key performance indicators for sustainable development" might be found. The emails included a ten question survey to validate the intent of the research and standardize the responses. The survey questions were:

1) Does your community monitor (or plan to monitor in the future) the performance of any sustainable performance indicator annually?
2) How far from completion is your community development? (% complete)
3) Who is responsible (or will be responsible) for monitoring performance in your community? (administrative, funding and reporting duties)
4) What is the motivation to monitor sustainable performance? Is it required or voluntary? What drives your monitoring?
5) Is (or will) energy performance monitored? How do you compile this information?
6) What issues were encountered trying to monitor sustainable performance or accessing data?
7) Can you share the methods used to collect data?
8) How is performance reported? Is it publicly available?
9) How much does it cost to operate the monitoring program and publish the annual report?
10) Are there any lessons learned in monitoring sustainable performance that you would like to share with others?

Contacts also revealed a variable level of understanding regarding sustainability and monitoring key performance indicators. Some municipalities confused post occupancy monitoring with project status reports for projects in progress. As seen in the Dockside Green Community Development, the municipality stated monitoring efforts were provided in the annual report published by the developer VanCity. Dockside Green is still in progress but it has completed some of the housing units and has occupants in residence. The Dockside Green annual report is primarily a status report of completion and compliance. It is a checklist of accomplishments, rather than data revealing the measurement of the performance of the community. As an example, Goal #13 Install Vertical Green Wall is listed as complete in spring 2009. Installed in 2009 the green wall was removed due to lack of plant growth. This indicator not only failed to inform of the performance of the green wall

but it also misinformed readers. The report fails to share information about the performance of sustainability indicators in the community post occupancy, rather it is focuses on ensuring items in the developer's agreement are accomplished. It neither informs the municipality of the development's sustainable performance, nor allows for the community to "set the benchmark as the future of sustainable harbor front communities for years to come," as the developer's website suggests.

It became evident that the awareness of monitoring efforts was uneven among representatives of the developer, the municipality and community management. Surveys were often redirected to many points of contact for responses. This may be an aspect of the cross-functional nature of sustainability, involving many departments of a single municipality, as well as external organizations. Due to this, it was important to contact several individuals in an organization, rather than to rely on the response of one informant. Communities that were not yet constructed to their monitoring thresholds were included so that information could be collected on their future monitoring plans. Surveys were forwarded to the list of communities in Table 1. A total of 16 responded to the survey. Communities that responded and were either completed or in construction were included in the data and research conclusions.

Survey Responses

The data were primarily taken from the survey responses. It was assumed that the community, developer or Homeowners Association of America (HOA) provided accurate information. Sometimes the data from different sources conflicted. In these instances, all information provided is reported. In some cases, the person responding for the municipality, developer or HOA was unaware of monitoring that had been conducted in the community. One example included the community Village Homes, where the HOA representative responded: "I am not aware of any interest or motivation to monitor our community's sustainability." A case study of Village Homes, utilized for the community profile, revealed contradictory information. The author stated that there were numerous studies and post occupancy monitoring to evaluate more than one sustainability indicator [6]. In this case, both the response of the HOA and the relevant contradictory information are provided. Tables 2 and 3 provide information identifying which communities monitor sustainable performance.

Table 1. List of communities contacted for survey responses.

Name	Nation	City
Linz Solar City	Austria	Linz
Dockside Green	Canada	Victoria, British Columbia
Eco-Viikki in Helsinki	Finland	Helsinki
Vauban	Germany	Freiberg
Rieselfeld	Germany	Freiburg
Braamwisch Ecological Settlement	Germany	Hamburg-Bramfeld
Kronsberg	Germany	Hannover
Sudstadt	Germany	Munich
Eco City Tubingen (Tuebingen)	Germany	Tubingen-Derendinden
Eva Lanxmeer	Netherlands	Culumborg
Bo01 in Malmo Western Harbour	Sweden	Malmo
Ekostaden Augustenbourg	Sweden	Malmo
Hammarby Sjostad	Sweden	Stockholm
One Brighton	UK	Brighton, East Sussex
BedZED	UK	Wallington, Sutton
Grow Community	USA	Bainbridge, WA
Village Homes	USA	Davis, CA
Babcock Ranch	USA	Fort Myers, FL
Prairie Crossing	USA	Grayslake, IL
Fields of St Croix	USA	Lake Elmo, MN
The Brewery	USA	Milwaukee, MN
Sonoma Mountain Village	USA	Rohnert Park, CA
Civita	USA	San Diego, CA
Excelsior & Grand	USA	St Louis, MN
Renaissance Place at Grand HOPE VI	USA	St Louis, MN

Of the 16 communities that responded to the survey, six remain under construction and four of these plan to monitor more than one sustainable indicator post occupancy. The communities aiming for OPL endorsement are required to monitor more than one sustainable indicator post occupancy and all plan to monitor post occupancy. Of the three communities seeking LEED-ND certification solely, two are not planning to monitor any sustainable indicator post occupancy.

Of the 16 communities that responded to the survey, ten communities are completed and in a post occupancy phase. When reviewing post occupancy monitoring, six of those communities reported moni-

Table 2. Monitoring practices and frameworks for sustainable communities under construction.

Sustainable Development (SD) Community Name	Construction Complete?	Monitor post occupancy?	Monitor >1 SD indicator post occupancy	Framework
Grow Community (NA)	No	Plan to	Plan to	OPL
Sonoma Mountain Village (NA)	No	Plan to	Plan to	OPL and LEED-ND
Kronsberg (EU)	No	Yes	Yes	Local Agenda 21
The Brewery (NA)	No	Plan to	Plan to	LEED-ND
Civita (NA)	No	Plan to	No plan	LEED-ND
Dockside Green (NA)	No	No plan	No plan	LEED-ND

Table 3. Monitoring practices and frameworks of sustainable communities (construction completed).

Sustainable Development (SD) Community Name	Construction Complete?	Monitor post occupancy?	Monitor >1 SD indicator post occupancy	Framework
Eco-Viikki (EU)	Yes	Yes	Yes	PIMWAG
BedZED (EU)	Yes	Yes	Yes	OPL Prototype
Village Homes (NA)	Yes	Yes	Yes	NA
Braamwisch Eco Settlement (EU)	Yes	Yes	Yes	Local Agenda 21
Linz Solar City (EU)	Yes	Yes	Yes	LeS!
Prairie Crossing (NA)	Yes	Yes	Yes	LEED-ND (Station Village portion)

toring more than one sustainable indicator post occupancy. The OPL prototype (BedZED) monitored extensively, while the two communities using the LEED-ND framework only monitored one or two sustainable development indicators post occupancy (stormwater quality and biodiversity). While these communities are motivated to design to LEED-ND sustainability guidelines they are not assessing their sustainable performance using the various criteria that LEED-ND requires. Interestingly, some of the communities surveyed touted as being the "greenest" or most sustainable do not have the monitoring efforts in place to validate their claims. Tables 4 and 5 document the community locations, monitoring status, the responsible parties and the key motivators.

Among the communities responding to the survey, European communities tend to monitor to demonstrate effectiveness of sustainable technology and to advance sustainable development. In these, the municipality or involved academia were mainly responsible for monitoring to demonstrate the effectiveness of new strategies and technology. Most of these communities were a part of an exposition to showcase sustainable development for future developers and to "learn what works and what does not." The funding for monitoring, and in some cases the actual development itself, was supported by partnerships with outside organizations, such as the United Nations, their federal governments, academic institutions or nonprofit research organizations.

The North American communities that responded to the survey were generally motivated by compliance and economic drivers. In the North American instances of compliance, developers were typically responsible for complying with monitoring requirements of either master development agreements with the municipalities or special zoning requirements. Other North American communities explained that the driver to monitor was economic in nature. Sonoma Mountain Village is one community where monitoring was driven by economics. In their survey response they stated, "We want this to be replicable and part of that is financial viability. OPL status allows us a competitive edge in this market. We are required to monitor to maintain OPL status. So ultimately, we monitor to attract sales, to promote our development and to share a model of sustainable development." Grow Community, another community whose main driver was economic in nature, stated that though monitoring was required to maintain OPL endorsement, there was nothing that required them to maintain the endorsement. They plan to maintain the monitoring and OPL endorse-

Table 4. Motivation and responsible parties for monitoring post occupancy in SD communities (under construction).

Name	Monitor post occupancy?	Monitor >1 indicator post occupancy	Responsible Party	Driver	Continent
The Brewery	Plan to	Plan to	Municipality/ Owner	Compliance	North America
Kronsberg	Plan to	Plan to	Municipality	Demonstration	Europe
Sonoma Mountain Village	Plan to	Plan to	Developer/HOA	Economic	North America
Grow Community	Plan to	Plan to	Developer	Economic	North America
Civita	Plan to	No Plan	Developer	Economic/ Compliance	North America
Dockside Green	No Plan	No Plan	Developer	Not applicable	North America

Table 5. Motivation and responsible party for monitoring post occupancy in SD communities (construction completed).

Name	Monitor post occupancy?	Monitor >1 indicator post occupancy	Responsible Party	Driver	Continent
Village Homes	Yes	Yes	Outside Orgs	No interest	North America
Prairie Crossing	Yes	Yes	Municipality/HOA	Compliance	North America
Eco-Viikki	Yes	Yes	Municipality	Demonstration	Europe
Linz Solar City	Yes	Yes	Municipality	Demonstration	Europe
Bedzed	Yes	Yes	Developer	Demonstration	Europe
Braamwisch Eco Settlement	Yes	Yes	Academia	Demonstration	Europe
Bo01	Yes	Unknown	Developer	Compliance	Europe
Vauban	Yes	No	Academia	Demonstration	Europe
Fields of St. Croix	No	No	Not applicable	No interest	North America
Excelsior & Grand	No	No	Not applicable	No return on investment	North America

ment because it "differentiates our project in a competitive market, this is the direction that the industry is headed and we want to be in front of it (competitiveness)."

If the industry is going to develop sustainably, sustainable communities will need to be economically viable to be effective and replicable. Designers, developers, municipalities, residents and owners need to look holistically at the communities (economics, environment, social) to ensure their success. Developing sustainably needs to be environmentally, socially and economically effective to succeed. Interestingly, some communities declared transparency was another driver for monitoring, though no community cited transparency as the sole driver to monitor. This suggests that communities are not investing in monitoring for the sake of transparency alone.

The communities that did not perform post occupancy monitoring were also questioned as to the reasons monitoring was not accomplished. In these responses, developers and communities either had no interest in monitoring, or there was no incentive to monitor as it was too expensive or they did not have the resources available to monitor. Tables 6 and 7 detail the indicators communities chose to monitor.

Table 6. Indicators of sustainability that communities plan to monitor post occupancy (under construction).

Incomplete Communities	What are you planning to monitor post occupancy?
Sonoma Mountain Village (NA)	OPL Targets: carbon emissions, waste reduction, transportation, sustainable materials, sustainable food, sustainable water, land use and wildlife, culture and community, equity and local economy, health and happiness.
Grow Community (NA)	OPL Targets: carbon emissions, waste reduction, transportation, sustainable materials, sustainable food, sustainable water, land use and wildlife, culture and community, equity and local economy, health and happiness.
The Brewery (NA)	Energy and water consumption for 12 months. Lighting performance for a year in the LEED parking garage.
Kronsberg (EU)	Energy consumption and carbon emissions, heat energy and renewable energy.
Civita (NA)	Traffic .
Dockside Green (NA)	No monitoring plans for post occupancy.

Table 7. Indicators of sustainability monitored post occupancy by communities (construction completed).

Completed Communities	What is monitored post occupancy?
Bedzed (EU)	Energy, water, transportation, food, waste, quality of life, ecological footprint/CO_2 emissions.
Linz Solar City (EU)	Energy and environmental performance, related economic factors and mobility issues.
Braamwisch Ecological Settlement (EU)	Heating energy, energy consumption, effectiveness of water purification system, wastewater generation, potable water consumption, alternative transportation, annual utility costs, carbon emissions.
Eco-Viikki in Helsinki (EU)	Energy, water, waste, biodiversity, water infiltration, satisfaction and opinion of residents.
Bo01 (EU)	Energy.
Vauban (EU)	Indicators for traffic concept, energy consumption.
Prairie Crossing (NA)	HOA: Water quality of the created water bodies, the health of wetlands and prairies, biodiversity. City: storm water quality and flow.
Village Homes (NA)	HOA reported no monitoring.
Excelsior & Grand (NA)	No monitoring post occupancy.
Fields of St. Croix (NA)	No monitoring post occupancy.

A variety of indicators are discovered upon examining the responses regarding monitoring that is conducted or planned. Four of the ten completed communities (BedZED, Braamwisch Ecological Settlement, Linz Solar City, Eco-Viikki) monitor a wide variety of sustainable indicators within the community, though none of these communities monitors recurrently. Most of the monitoring in these communities was completed for a limited time following occupancy to verify community performance. Post occupancy performance is dependent on variable occupant behaviors and management strategies. Similarly, performance varies from that reported in the years immediately after project completion. A community may have monitored and revealed sustainable performance in the earlier years; however, there may be a tendency for less sustainable behavior and performance when occupants and management realize monitoring has ceased. In such instances, the opportunity for continuous improvement gained from recurring monitoring is lost.

The limited (or lack of) monitoring that occurs in the other communities (Bo01, Vauban, Excelsior and Grand, and Fields of Saint Croix) fails to provide a holistic picture of the community's entire sustainable performance. Many of these communities are touted as sustainable or environmentally friendly. As seen from this compilation of their responses, most have little proof to substantiate these claims.

Of the six responding communities that are under construction, only two (Sonoma Mountain Village and Grow Community) reported plans to monitor economic, social and environmental sustainability indicators to allow a holistic assessment of the community performance. This extensive annual monitoring is a requirement of all OPL communities, highlighting interest in assessing ongoing performance and continuous improvement. The other communities are mainly concerned with monitoring just one or two of the categories of water, energy and traffic.

For many communities under construction, monitoring plans have yet to be drafted and implemented and these plans can change. A Dockside Green Monitoring Program prepared for the city of Victoria, British Columbia, by Sheltair Group in March 2007 lists 49 sustainable indicators and methodologies for extensive and holistic monitoring post occupancy. The survey from the city of Victoria revealed that there is no requirement for monitoring post occupancy nor does the city have future plans to monitor environmental performance post occupancy. The community is years away from completion so this may change in the future, as could the monitoring plans for the other communities under construction.

Table 8 identifies how communities monitor sustainable performance. Occupant surveys and interviews, automatic remote metering devices for utility data, audits and public census or registration information are used to gather data on sustainable performance in the communities that responded to the survey. Data collection methodologies not used by these communities include voluntary self-monitoring and data from site retailers and service providers. Several communities teamed with academic institutions interested in evaluating indicator performance to conduct monitoring and evaluation. Other methods included hiring an outside consultant to monitor performance and utilizing the eco-concierge position within the community to facilitate the monitoring and feedback processes. What are the issues realized with monitoring practices and methods? A sample of the issues with monitoring practices and methods reported by survey respondents are provided in Table 9.

Table 8. Methodologies used to monitor sustainable performance (post occupancy).

Name	How do you Monitor Sustainable Performance?
Civita	Surveys.
Dockside Green	Not applicable.
Grow Community	The Grow Community still needs to develop their monitoring plan. The monitoring will utilize an eco-concierge to facilitate the monitoring and provide feedbacks to residents of Grow. Methods that may be utilized include metering, self-monitoring, intranet, retailer provided customer data, occupant surveys and interviews.
Sonoma Mountain Village	"As you noticed from reviewing our Sustainability Action Plan, we will have a myriad of metrics to measure and we will rely on our BioRegional and One Planet Communities Partners for best practices. I imagine that academia plays a big role as well. Academic research is vital to understanding and moving sustainable design and lifestyles forward."
Kronsberg	Surveys, audits, metering devices were all mentioned in the literature.
The Brewery	Metering devices and utility bills.
Eco-Viikki	The city of Helsinki with the Ministry of the Environment used a consultant to collect consumption data from 2002-3. The data were obtained from the property manager's utility (heating, electric and water) bills for each residential block and from Helsinki Energy. Ecology, water runoff reports and resident surveys were also used in the monitoring process. Property developer VVO also contributed data. Some of the buildings participated in Project HOPE which conducted a survey on health aspects of living on a block of flats. There is also social research carried out by University of Helsinki Department of Social Policy (Sanna Ahonen).
Fields of Saint Croix	Not applicable.
Excelsior & Grand	Not applicable.
Braamwisch Eco Settlement	Surveys were the only confirmed method used for monitoring. Data from TU Braunschweig has not confirmed their methodology.
Prairie Crossing	No response.
Vauban	Surveys and vehicle registration information.
Bo01	No response.
Village Homes	No response.
BedZED	Meter readings, surveys, waste audits.
Linz Solar City	Surveys.

Table 9. Issues reported while monitoring sustainable communities (post occupancy).

Issues with audit results being skewed as a result of occupants aware of monitoring (behavior varies when observed).
Energy calculations were not well developed or standardized so results and accuracy varies.
As urban planners and designers, monitoring is not a standard practice for us so we are unsure how we will monitor.
Figures were only available for a few blocks on hot water demand, so that others had to be estimated from actual summer energy demand, making them less precise.
As a private development we are not now able to reliably monitor metrics such as water use or energy consumption of individual households. Several years ago we sponsored a contest among homeowners to self-report their energy use. The people who responded were obviously those who were already interested, not a reliably "typical" population.
There is a vital need for consistent and transparent monitoring systems, ranging from understanding the high level development economics to raising public awareness and support.
We have neared the goal to consume less energy and would appreciate some measuring but the most important things are immeasurable.
The monitoring process revealed that collecting information about construction and building use was time-consuming. It also revealed there were no measurements yet available for the eco-criteria that were "simple enough or dependable enough" (http://www.hel.fi/static/ksv/julkaisut/eco-viikki_en.pdf). Some of the monitoring methods, such as household waste monitoring were unreliable, as the garbage truck driver estimates and resident surveys did not reveal similar results.
It is important to establish a base of reference to compare the information. It is also important for the appropriate entities to provide monitoring.

The issues associated with monitoring a sustainable community reported by the respondents considered topics that included:

- Inaccurate and un-standardized monitoring methods.
- Difficulty in quantifying data that is qualitative or indicative of success.
- Unfamiliarity with monitoring practices.
- Inaccurate, unavailable, or unreliable data.

- Complicated and time-consuming measurement methods.

There seems to be a great need for well-developed best practices in monitoring and measuring performance in sustainable communities, or consultants that can guide developers and municipalities in accurate and reliable monitoring.

BedZED, among other communities, struggled to pinpoint effective indicators for health and happiness, culture and heritage, etc., making it difficult to monitor and report performance in those areas. Some of the more important aspects of a community and its success are difficult to accurately and effectively measure or quantify. Often communities use survey responses and local statistics but feel their data and resulting conclusions are inaccurate.

Survey findings can be remarkably variable from year to year for reasons that include the level of participation, varying interpretation of questions and sensitivity of questions (e.g., when surveyed, some people may feel uncomfortable reporting that they do not recycle). Another important aspect of monitoring is that the monitoring itself often influences behavior (some suggest that what gets monitored, improves). Audit results can be less accurate if the residents surveyed want to show better performance when being monitored than when not being monitored. Residents of sustainable communities often make greater efforts to recycle (or change other behaviors) if they know the results of their efforts are being documented. There can be pressure to perform well during an audit or monitoring process, rendering the data less accurate or atypical of common practices. Table 10 provides a sampling of lessons learned from monitoring.

The lessons shared by the survey respondents were diverse. Some communities cited issues with data collection, calculations and monitoring practices. Kronsberg shared the need for multiple years of data to uncover data anomalies and to "ascertain the true performance of the development resulting from occupant behavior or lifestyles," and to improve performance by examining data for operating inefficiencies. Dockside Green shared the unanticipated effects of a recession on their community monitoring.

Lessons learned in monitoring practices at BedZED were shared in public reports allowing others to benefit from the knowledge gained. While monitoring at BedZED, developers realized that privacy must be respected throughout the process to avoid resident perceptions that

Table 10. Lessons learned reported by communities monitoring sustainable performance (post occupancy).

Name	Lessons Learned from Monitoring
Bedzed	Detailed action plans are necessary to avoid monitoring fatigue.
Bo01	Some developers did not calculate wind conditions in their energy calculations.
Dockside Green	Little activity has occurred in relation to Dockside Green since the economic downturn in 2009 and the MDA, which sets out monitoring requirements, is currently under review. Some of the monitoring has not taken place in recent years.
Grow Community	Monitoring is expensive and budgets are slim so we are looking for opportunities to partner with organizations to lower our monitoring costs while simultaneously providing third party verification of data accuracy.
Kronsberg	Monitoring post occupancy must be accomplished to ascertain the true performance resulting from occupant behaviors and lifestyles. Some issues that were found in the emissions study included the initial high consumption seen in 1999. In following years the consumption leveled out and it was determined that construction crews left radiators on to ensure that areas dried out. After residences were occupied the heating use was lowered. This emphasized the need for multiple years of data to obtain accurate results. 2,890 households were included in the study area in 2001, where energy consumption of the household was measured to be 1/5 of the intended energy savings per household. This audit discovered that appliances were a major contributor to this figure. 2001 studies on thermal losses in the district heating system allowed them to lower system losses. It was suggested that the cause for these losses could be further investigated with specific metering and optimization of buildings. "The proof of sustainability on Kronsberg over the next decades will be derived from a combination of the given conditions and the evolving behavior of the residents."
Vauban	You asked what we learn from monitoring. We have hardly any monitoring at all, but we know what improvements we could accomplish. We do not focus on the "lab rat" part of our reality so much. We know what we achieved, very often in terms of real, massive savings. Anyone is invited to copy and improve. We hope to continue learning, but all the houses are built now.

they may later be singled out for unsustainable behavior. Grow Community's action plan suggests detailed and thorough plans that consider the monitoring frequency and transparent use of data to avoid the "monitoring fatigue" that plagued BedZed's residents. Their plan also

calls for a "balance between full monitoring and privacy issues" and assurances that all residents are aware of the monitoring and its purposes. They stress to residents the ethical treatment and anonymous quality of the data and offer the residents the option to opt out if they feel uncomfortable.

Further monitoring could inform the other OPL communities on monitoring best practices and lessons learned. Throughout the interviews with OPL endorsed community developers, there was a repeated need for assistance with methods and solutions to monitor more cost effectively. Partnerships and research are needed to improve the practice and quality of resulting data from sustainable community monitoring.

BARRIERS TO MEASURING AND MONITORING PERFORMANCE

While the 2008 NBI LEED study reported that 42% of LEED-NC certified buildings failed to perform as designed in energy performance, it also noted that few building managers or owners measured their performance. Measurement over time culminates in a monitoring process which gauges performance and progress towards goals. Since communities are investing considerable effort and capital to design and develop sustainably, it would be reasonable to assume they would want to understand if their communities are actually performing sustainably. There are many barriers that were revealed from the survey and other field research. The barriers that prevent measuring and monitoring performance in sustainable buildings include:

- Cost to monitor and lack of resources
- Developers and municipalities cite "monitoring is expensive"
- No return on investment for developer
- Municipality does not have the staff to monitor
- Accountability
- Who is to blame if it is not performing as designed?
- Design cannot control and predict the behavior of occupants and operators
- No demand from consumers
- Developer's effective green marketing
- Perception is reality with consumers

- No interest in validating success (or failure)
- It's complicated
- Cross-functional monitoring and data
- Who is responsible for monitoring?
- Accurate monitoring practices

Cost to Monitor and Lack of Resources

There are several reasons municipalities, developers, building owners and facility managers may not want to measure and monitor their individual performance. Foremost, there is an added expense to install measurement devices, verify building performance, and report performance. In the survey results, developers and municipalities stated that monitoring is expensive and a primary reason for not monitoring or continuing to monitor after occupancy. Some municipalities report that they lacked staffing to monitor their developments. Monitoring and reporting results is a recurring operating expense for the facility management budget. Many owners are unaware or overlook the fact that added initial expenses can be offset if the monitoring systems indicate:

- Incorrect installation or operation of building/infrastructure systems
- Unsustainable occupant behavior
- Need for system adjustments or calibration to maintain optimal efficiency and operation
- Unknown equipment malfunctions
- Maintenance, operation or control strategies that could be improved to save resources

As indicated above, it makes sense to install monitoring systems if you are also paying the operational budget and utility bills. However, developers, municipalities, and other entities that do not pay the operational bills lack incentive to voluntarily invest in monitoring post occupancy. This will not change until real estate values include the lifecycle costs and impacts of building and infrastructure operations.

Accountability

Building and infrastructure operation, technical malfunctions, and occupant behavior affects the sustainability of a building or a community development. The ways people live and work in their buildings impacts the sustainability of a community.

The strategies and innovations that comprise green buildings and sustainable developments are different than those using conventional designs. One might assume design professionals would be interested in evaluating the accuracy of their models and the effectiveness of their designs' in meeting the sustainable design objectives and targets. However, design professionals typically will not guarantee building performance after occupancy due to uncontrollable variables that affect overall performance. These include how facility managers and occupants use the buildings. As a result, owners are often unable to hold design professionals accountable for sub-par building performance. Aside from good public relations (PR), there is rarely incentive for design professionals to monitor performance in the buildings they design. This may change with the growing interest in energy savings performance contracting (ESPC) agreements between owners, design professionals and contractors that guarantee the energy savings performance of designed buildings. In such agreements, owners offer incentivizes to design professionals and contractors who design and construct high performance buildings. In these, measurement and verification (M&V) of performance is necessary to determine if targets were met. M&V services are often provided by an independent third party to ensure unbiased and accurate results. Design professionals who participate in ESPC agreements are becoming more competitive in the marketplace and increasing the use of this form of project delivery in both individual buildings and neighborhood developments.

Lack of Consumer Demand

For the owners, investors and developers seeking green certification to increase real estate values and garner positive PR, measurement and monitoring that reveal unsustainable performance could be counterproductive to their objectives. This reduces interest in both monitoring and reporting building performance. Few designers and owners like to publicize the fact that their buildings are not performing as well as intended. Choosing not to monitor the performance is a way to avoid both the proof and the responsibility to report a failure to perform. It is easier to manage public perceptions that green building design and certification equates to green building performance when there is no evidence suggesting otherwise. From a developer's perspective, when green certification programs lack validation of performance, there is little motivation to monitor performance to ensure post occupancy

sustainability.

Developers often market designer's claims rather than proven results. Some of the community development websites in this study included statements intended to appeal to the typical consumers while revealing little information about performance. Consumers perceive that developments designed as sustainable are performing sustainably, since they are not provided information to the contrary. Without monitoring, it is impossible to clarify the gap between that perception and actual performance.

It Is Complicated

Barriers and issues concerning measurement or progress in green buildings are common in the study of sustainable communities. Monitoring performance in sustainable community developments is complex and involves many objectives and indicators. Monitoring sustainability in a community involves cross-functional coordination and collaboration with internal departments and external organizations. The surveys in this study were often forwarded to many departments within the municipalities, as the intended recipients were unaware of all monitoring practices in their developments. Additionally, there were several surveys that revealed that the developers and municipalities had different views as to the monitoring underway in their developments. Some communities centralize their information in their sustainability office; however, the office representatives were often not fully aware of specific monitoring operations being performed. This added collaboration and integration of data increases costs and requires extra time to report performance.

It may be difficult to determine who bears the responsibility of measuring and reporting performance in a sustainable community development. Developers and municipalities have limited resources and lack funds for monitoring initiatives. Developers might be more inclined to invest capital in physical improvements that would increase property value, yield better performance or increase visible aesthetics, rather than spend that same capital on performance evaluation. Some developments require the developer to measure and report performance until a majority of the development is completed, at which time responsibility is transferred to another stakeholder. The survey responses suggest that this responsibility varies depending on the situation and the task could be a larger undertaking than the responsible stakeholder is capable of

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managing. Some OPL communities propose that an eco-concierge from the home owners association (trained in monitoring practices) facilitate the monitoring. This might be more effective since monitoring efforts originate from the group representing the owners and occupants whose lifestyles and behaviors largely impact the community's sustainable performance. Furthermore, the results of the monitoring could be used by this group to support beneficial community improvements.

To further complicate the monitoring of developments, there are many stakeholders and outside factors that affect their performance. Investors, municipalities, businesses, future occupants and tenants all rely on the success of the development. Failure to perform sustainably in one area (e.g., energy use) affects the performance of other areas (e.g., operating costs) due to the interdependent connections in a sustainable community. Such failures create greater interest in assuming that the community is performing sustainably. A report of poor performance could damage the economic viability of the sustainable development and the competitive advantage that sustainability affords over conventional developments. This might include loss of potential commercial and industrial tenants, home buyers and future expansion opportunities. Stakeholders want to see their developments succeed because they believe they are moving the market in a sustainable direction. Successful developments that are economically viable can be replicated in other locations, increasing awareness and adoption of these frameworks and evolving conventional development practices and minimum standards. Stifling that progress with reports of poor performance could slow the adoption of sustainable development and hinder momentum. Failing to perform measurement robs the development of an early opportunity to identify areas needing improvement. Such improvements would strengthen the subsequent performance of other developments adopting similar frameworks.

Accurate Monitoring Practices

The field of monitoring sustainable performance is developing best practices and standards to improve the reliability and accuracy of data use. In the surveys, municipalities cited problems such as questionable sample sizes, lack of data, inconsistent data, data access, lack of third party verification of results, inaccurate monitoring methods, and the lack of calibration and standardization.

Research in sustainable monitoring reveals problems that involve

sustainable indicator weight, evaluation priority, lack of baseline comparisons, and data aggregation issues when developing averages. When reliability, accuracy and precision are questioned, it is difficult to report conclusions based on compromised data. Furthermore, when devising new monitoring and measurement methods and protocols, third party verification is needed to confirm that the results are reliable and accurate.

Encouraging Trends in Voluntary Monitoring and Reporting

Most real estate developers purchase land and guide the planning, design and construction of the community. They then market and sell the real estate and repeat the process elsewhere, hoping for a minimum 20% profit. Development budgets are slim and developers often believe that post occupancy monitoring is an unjustifiable expense. Developers cite lack of adequate returns on such investments and their need to move on to their next development. Committing to monitor sustainability post occupancy is a departure from typical development schemes and entails voluntary reporting beyond industry norms. In an interview with Asani, the developer for Grow Community in Bainbridge, WA, their choice to develop sustainably was driven in part to obtain a competitive advantage and distinguish themselves from other developers. Since they are interested in creating more sustainable developments in the future, they chose performance monitoring. As a business model, "It is our goal to create sustainable projects that are affordable, profitable and replicable." Despite the costs of monitoring, it allowed Asani to quickly gauge successful strategies and eliminate those that fail to contribute to community sustainability targets. Additionally, monitoring allows them to refine their processes for future communities and offers verification that their community is performing sustainably. This builds their reputation, offering proof that they have developed sustainable communities.

There is encouraging research from CarbonBuzz that suggests voluntary reporting post occupancy may be gaining interest. CarbonBuzz is a collaborative platform that invites energy tracking for projects from design to operation, allowing modeled performance to be compared to the actual performance. This information is voluntarily provided and all data remains anonymous unless owners wish to publish their information. Users benefit by measuring the performance gaps between design expectations and actual performance in their properties. Users can also

compare their performance with benchmarks of similar buildings and develop an understanding of how occupant behavior and operations affect energy use. The industry benefits from the collective data of post occupancy energy performance that is audited for quality assurance. The data compiled indicates trends in post occupancy performance, raises awareness of the performance gap between modeled and actual operational performance, and highlights effective strategies that are proven to be successful in high performance buildings and communities. Their published case studies "demonstrate an organization's engagement with research into achieving low carbon performance in operation" [7]. CarbonBuzz conducted a survey in 2013 (58 replies) to understand more about the use of CarbonBuzz, including possible motivations to use CarbonBuzz. The encouraging results, provided in Table 11, indicate that owners are increasingly aware of the benefits that both monitoring and reporting offers.

CONCLUSION

Peter Drucker's popular phrase, "If you can't measure it, you can't manage it," applies equally to businesses as to sustainable communities. Unless we measure and assess the impacts from community developments, we are unable to effectively manage them. Post occupancy monitoring is extremely important in evaluating the success of sustainable community developments. There are many developers building sustainable community developments with intentions of having fewer negative environmental impacts than experienced with conventional community developments. While developers are advancing the field of sustainable development, the surveys from several sustainable community developments indicate there is very little research occurring. Monitoring is crucial to understanding whether or not their strategies are actually effective at reducing environmental impacts.

Historically North American sustainable community developments focused on monitoring during construction only. Only recently have they monitored sustainable indicators after occupancy. When monitoring occurs after occupancy, communities tend to monitor for either compliance or economic reasons. This monitoring responsibility is often born by the developer as a requirement of the development agreement or zoning requirement.

Table 11. Carbon buzz survey on relevance of reporting carbon emissions.

Rank in order of importance how CarbonBuzz would be relevant to your organization? (10 = most important 1= least important)	
Find out how a building performs against others.	8.0
Compare design estimates against operational energy use.	8.0
Study the end use composition of other case studies.	7.8
Track the design and actual CO_2 emissions of a portfolio of buildings.	7.2

Table 12. Carbon buzz survey on motivation to report carbon emissions.

What would encourage you to use CarbonBuzz?	**% Responding**
Provision of research data and benchmarking information to download.	84%
Analyze trends in building energy performance on the CarbonBuzz website.	64%
Ability to estimate operational performance from design data.	64%
Ability to identify best practice examples and advice for relevant sectors and projects.	60%
Ability to report energy consumption of buildings via a user-friendly template.	59%
Short webinars on key issues and topics with relevant and respected presenters.	47%
Share building energy use data with other organizations.	41%

Quite contrary, European communities have a history of monitoring post occupancy to research and demonstrate sustainable strategies and the effectiveness of technologies deployed. Partnerships among municipalities and outside organizations are often responsible for monitoring with the intent to test and research the effectiveness of sustainable community prototypes and develop guidance for future communities.

Of the small number of sustainable community developments that are monitoring post occupancy, roughly a third of these communities are assessing performance holistically by looking at several environmental indicators. The communities that are monitoring performance holistically were either OPL endorsed communities or communities that were otherwise motivated to demonstrate the performance of their sustainable community development. The remaining communities are either not monitoring or monitoring only a few indicators of interest. This results in insufficient proof to substantiate claims that they are actually performing sustainably. The public often perceives claims of intended performance as actual performance and generally does not challenge such claims or demand proof of performance.

The science of developing sustainable communities is in its infancy. The industry lacks a unifying voice that demands the evaluation of current sustainable community development frameworks and strategies to determine if they are performing as effectively as intended. Many sustainable community development frameworks and strategies are not contingent on a holistic final condition or defined end state; rather they focus on performing "better" than conventional developments. The piecemealed strategies make it difficult evaluate whether they are effective in advancing sustainability within the development. OPL is a unique sustainable community development framework that requires annual progress reporting on comprehensive end goals and final conditions in order to maintain endorsement. The combination of both comprehensive end states and monitoring and reporting of the progress shows movement in the right direction.

There remain many barriers to monitoring and measuring performance in sustainable community developments. These barriers impede important research of early sustainable community developments in revealing actual performance and lessons learned. Among the chief barriers, cost was frequently cited as a reason why communities do not monitor their performance in the surveys. Interestingly, economic

reasons were given as a primary driver for other communities to implement monitoring. There should be more research into the positive benefits and impacts monitoring can have on communities and what can be changed in the industry to motivate more communities to monitor performance voluntarily, as witnessed in the Responsible Care Program. Alternatively, the industry could move towards regulation and compliance of monitoring holistically, as this was indicated as an effective motivator when municipalities required developers to monitor as a stipulation of their community development agreement. It's difficult to ascertain which method would be more effective in garnering performance monitoring in more sustainable communities without additional research.

Another barrier to monitoring performance in communities stems from clinging to traditional development mentality and practices. Municipalities, developers and other involved stakeholders have mindsets that are entrenched in conventional development methods. Just as sustainable development has evolved the built environment and infrastructure strategies and methodologies; stakeholders need to consider alternative and innovative public and private partnerships that pair private investments with community needs in ways that benefit both organizations (such as Fund Rise and The Jacobs Center for Neighborhood Innovation). Municipalities, developers and community associations need to adapt to the new roles and responsibilities that accompany sustainable community developments. Sustainable community development must continue after construction is complete.

Creating sustainable developments involves more than just changes in the built environment; some involved entity will need to develop accompanying post occupancy programs and activities to encourage sustainable behavior and lifestyles. Consumers should start demanding more information that will substantiate sustainable claims and report progress, just as we do in other projects and industries where significant capital and time are invested. Owners, occupants, community associations and facility managers should expect monitoring well beyond the construction phase to accompany their involvement with a sustainable development, as well as accept their new roles as participants of the monitoring and research process.

Today, developers are creating more communities that perform sustainably. The developer may have intentions of progressing on a path towards sustainable performance; however, there may be no over-

sight to ensure communities are performing as intended. How will they perform if there are no penalties for failing to perform as intended? Good design intentions are irrelevant if they fail to create the intended performance in sustainable communities.

The survey respondent from Kronsberg municipality stated succinctly that the proof of sustainability in their community depends on post occupancy monitoring. Without measuring and monitoring performance in sustainable developments post occupancy, how will the industry know if current strategies are effective? It's time to close the gap between perception and reality in sustainable communities. To paraphrase Alan During of the Sightline Institute, "What gets measured gets fixed." Monitoring not only indicates what is working, it indicates what's not working. Monitoring data can pinpoint inefficiencies and issues that impair sustainable performance, leading to improvement and progress towards the goals of each community and refining sustainable community development frameworks.

As the demand for monitoring sustainable performance increases, the monitoring practices will become more reliable and accurate as a whole. Standard protocol and best practices should emerge along with common benchmarks, relevant sustainable indicators and units of measurement. Best practices will include automation methods of data collection and data presentation that increases understanding for all stakeholders. Ultimately, the goal is to develop communities that perform sustainably. Without post occupancy monitoring, the development industry cannot know if communities are reaching this goal. The solution is to refute that perception is reality in this case and increase post occupancy monitoring in sustainable community developments.

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ABOUT THE AUTHOR

Marcella Whitfield is a portfolio energy manager with Jones Lang Lasalle in their Energy and Sustainability Services Group. She has 14 years of consulting experience involving institutional sustainability, C&I energy management, life-cycle analysis and resource/energy efficiency. She also serves as an engineering officer in the Air Force Office of Energy Assurance, United States Air Force Reserves, focusing on resilient energy projects throughout the Air Force. She has a B.S. in Civil Engineering from Tulane University and a M.S. in sustainable design from Boston Architectural College. She is a Certified Energy Manager, Association of Energy Engineers (AEE), and a Leadership in Energy and Environmental Design Accredited Professional (LEED AP). Her email address is mrwhitsie@gmail.com.