A multi-dimensional energy-based analysis of neighbourhood sustainability assessment tools: are institutional indicators really missing?

Dawodu, A., Cheshmehzangi, A., Sharifi, A.

University of Nottingham
UK | CHINA | MALAYSIA

University of Nottingham Ningbo China, 199 Taikang East Road, Ningbo, 315100, China

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A Multi-dimensional Energy-based Analysis of Neighbourhood Sustainability Assessment Tools: Are Institutional Indicators Really Missing?

Abstract

Neighbourhood Sustainability Assessment Tools (NSATs) have become the modern day template for urban planners to achieve sustainable development in their communities, districts and cities. The popularity of the pioneering NSATs led to the creation of other tools in different regions. Also, with the popularity and replication of these tools came the replication of their limitations. The most notable limitation and motivation for this study is the inadequate recognition of the complexities of institutional dimensions (i.e. policies, laws and regulation) that contribute to mainstreaming and operationalising sustainable neighbourhood development. Studies that have investigated NSATs generally argue lack of coverage of the institutional dimension. However, there has been little consistent and explicit mention of the precise indicators and criteria sought out to make this claim. Also, there is a clear confusion as to what institutional indicators actually are, what characteristics they possess and how best they can be identified. This study, via the lens of energy-based indicators, expands on the role of the institutional indicator and its associated dimensions. This study also utilises a multi-dimensional approach to indicator analysis and draws out current trend or characteristics of institutional indicators in 15 currently existing NSATs. The results show a limited view on the classification of institutional indicators. The study also demonstrates that there are more institutional indicators than previously reported in prior studies. Additionally, this study confirms that an institutional indicator cannot be a single entity or identity but rather it must operate under the linkage of the other dimensions (environment, social and economic). Finally, this study, based on the analysis of 15 NSATs provides a definition of what can be considered an institutional indicator. In conclusion, it is recommended that future development of NSATs should ensure a constant institutional link to indicators, as this could provide an enhanced alternative to the development of NSATs, particularly for regions that are looking into developing their own assessment tools.

Keywords: Energy; Institution; Indicators; Neighborhood sustainability assessment tools

1. Introduction: Emergence of NSATs and pillars of sustainability

Since the introduction of sustainable development in the Brundtland Report (1987), various efforts across different sectors and scales have been made to operationalise the concept and to monitor its progress (Sharifi and Murayama, 2013). At the local scale, the main focus was initially on tools that evaluate sustainability performance at the building scale. After several years of practice, it was realised that only focusing on buildings is not sufficient as it does not allow taking account of complex interactions between different forces that shape cities. This led to the recognition of the significance of the neighbourhood scale as the minimum scale to deal with such complex interactions. Neighbourhood is also considered as suitable scale for experimenting with innovative sustainability solutions and for mobilising different stakeholders to accelerate local transition to sustainable development. Accordingly, the first generation of voluntary Neighbourhood Sustainability Assessment Tools (NSATs) were introduced in the mid-2000s in Europe and North America before being imbibed worldwide. NSATs utilise sustainability indicators (SI) and scoring systems as innovative means of providing prescriptive solutions to sustainable development in the urban realm (Berardi, 2015; Dawodu et al., 2019). These indicators, and more specifically headline sustainability indicators (HSIs), give procedural, operational and feature-based instructions to developers, planners and engineers. Notably, for NSATs, an SI is essentially the assessment criterion, while a series of related SIs can be placed together under a given HSI (Cappuyns, 2016). Broadly speaking, if the HSI is considered to be a finite set, then the SIs are elements of this set.

The three pioneering NSATs that have been widely used are Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) for Urban Development in Japan, Building Research Establishment Environmental Assessment Method (BREEAM) Communities in the UK, and Leadership in Energy and Environment Design (LEED-ND) Neighbourhood Development in the US. However, a major gap in terms of sustainable development that has been mentioned in the literature is that these tools are mainly focused on environmental challenges and do not consider institutional directives or indicators, thereby having a reductionist approach and failing to gain success in operationalizing sustainable neighbourhood development (Sharifi and Murayama, 2013). The reason for this failure is partly attributed to the way sustainable development is conceptualized in the Brundtland report, as a "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (World Commission on Environment and Development, 1987). From a Sustainable Urban Development (SUD) perspective, this conceptualisation was translated into approaches to planning and design of the built environment that are based on compartmentalised economic, environmental and social dimensions, widely known as the triple dimensions/pillars of sustainability (Berardi, 2015; Komeily and Srinivasan, 2015). This compartmentalized Triple Bottom Line (TBL) approach led to the omission of the institutional dimension and associated institutional sustainability indicators (Ameen et al., 2015). This omission undermines efforts toward comprehensively addressing sustainable development challenges because institutions facilitate dealing with inter-relationships between the other three dimensions and can also mobilise resources to optimise efforts aimed at their operationalisation (Valentin and Spangenberg, 2000). For example, slum development is known to deny residents' access to basic services and amenities, such as energy and water; this is mainly due to the illegality status of the residents. This increases the marginalisation of people and erodes the legal basis that allows them to obtain their basic needs. Therefore, informal settlers need to be re-integrated into the society with their full property rights; and this can only be achieved with the help of policy and institutions (Charoenkit and Kumar, 2014; UN-HABITAT, 2014). This presents a good example of the importance of institutions and policies and how they can aid in legalising informal setting, thereby providing basic amenities and incentivising sustainability practices through establishment of formal organisations (UN-HABITAT, 2014). In view of the importance of the institutional dimension, Komeily and Srinivasan (2015) and Sharifi and Murayama (2013, 2015) mention the growing desire to include "institution" as the fourth dimension of sustainability. This classification was first introduced at the Johannesburg conference and was firstly put into practice by Valentin and Spangenberg (2000) in the development of urban based indicators. In fact, this sentiment is now shared by several researchers in the field of sustainability indicators and NSATs (Ameen et al., 2015; Berardi, 2015; Dawodu et al., 2017; Komeily and Srinivasan, 2015; Sharifi and Murayama, 2013; Turcu, 2013).

Yet, challenges still exist as regards to dimensions of sustainability, institutional dimension and NSATs. Several studies that have investigated NSATs, generally argue a lack of coverage of the institutional dimension (Boyle et al., 2018; Sharifi and Murayama, 2013; Villanueva and Horan, 2018). However, there has not been an explicit mention of the kinds of specific indicators and criteria sought out to make this claim, rather vague terminologies are used: (1) In the study of five assessment tools, Komeily and Srinivasan (2015, p. 35) states that "Institutional category is the least emphasised category."; (2) In their study of seven NSATs, Sharifi and Murayama (2013, p. 78) conclude that "the NSATs have failed to address institutional sustainability", their study further states that "there is no mechanism for assessment of the performance of governmental and non-governmental institutions in the neighbourhood" and criteria such as governance, decentralisation, legal frameworks and instruments, information systems, and research and education to institutionalise sustainable development are also overlooked"; (3) Another study by Sharifi and Murayama (2015) highlights outreach and involvement, transparency, local institutions, monitoring and innovation as institutional-HSIs; and (4) Turcu (2013) places local authorities services, community activities and local partnership under institutional sustainability. The latter also states that "community activity" can be placed both under "institutional sustainability" and "social sustainability." Overall, two major issues can be drawn from these studies of NSATs: first, they generally argue for a lack of coverage of the institutional dimension, without consistently and explicitly mentioning the precise indicators and criteria that have been explored to make this claim. Secondly, it would seem that a specific institutional HSI can also bear other dimensional traits, as was the case with "community activity". Finally, it is evident that an institutional dimension is largely considered as a basic part of government and non-government organisations i.e. formal or informal organisations that set rules and sometimes enforce those rules as regards complying with sustainability initiatives.

Against this background, by focusing on 'energy' as a theme, this study aims to shed more light on the role of the institutional dimension to achieve the following aims:

- Redefine how the institutional dimension is viewed and by doing so redefine what is an institutional indicator.
- Expand on the role of the institutional dimension by utilising three institutional classifications, which are organisations, regimes and informal rules.

- Due to vague parameters that determine what is and is not an institutional indicator, this study also aims to determine consistent parameters that can be used to determine if indicators bear institutional characteristics with respect to NSATs.
- Utilise a multi-dimensional approach to indicator analysis to investigate the possibility of multi-dimensional institutional indicators and if such possibilities exist, to elaborate on their trends and characteristics.

To execute this, 15 NSATs are investigated and this are strictly limited to energy-related indicators for brevity. This is because these indicators are dominant (or major components) in most NSATs, and are highly entangled with institutional factors (Ameen et al., 2015; Reith and Orova, 2015; Xia et al., 2015).

2. Literature Review:

2.1. Motivation for Institutional study: Origins Benefits and Shortcomings of NSATs

NSATs are the latest generation of assessment tools developed for attaining sustainability within the built environment. They are the third generation of environmental impact assessment methods and are derivatives from building sustainability assessment systems. This is in part due to the need and success of the green building movement in the late 90's but also due to the shortcomings of simply assessing or developing green buildings (Boyle et al., 2018). Sharifi (2013) acknowledges this by highlighting the lack of understanding of the impact of buildings on their surrounding structures as well as their immediate environment and vice versa. Sharifi (2013) further quotes Choguill (2008) and argues that,"no single city can contribute to the overall sustainability if its own component parts are found not to be sustainable". Thus emerged NSATs, third part verification systems to determine the sustainability of neighbourhoods, as building blocks of cities.

NSATs are unique because they utilise sustainability indicators or headline sustainability indicators (HSI). Each headline indicator is given a specific point or weight, where the weight signifies the importance of the specific issue to the locale. Furthermore, each HSI has several sustainability indicators called criterion that must be achieved in order for the point to be given. After points are accumulated, rankings such as platinum, gold, or silver are awarded to represent or indicate the sustainability performance quantitatively, therefore allowing sustainability comparison with other developments and buildings (Haider et al., 2018).

NSATs are third party verification assessment tools that allow for third-party evaluation against a number of pre-defined sustainability criteria (Tam et al., 2018). This provides credibility for planning projects and nudges the planning organization to define and use sustainability targets early in the process, thereby highlighting environmental and other sustainability issues that would otherwise risk being overlooked (Wangel et al., 2016). Additionally, developers and government authorities can use the certificate for marketing and evidence of sustainability compliance. The certification systems also provide common language for communication and collaboration between stakeholder groups and promote joint understanding of projects and their intended outcomes. Also, the operating mechanism of NSATs hinges on sustainability indicators, leading to better decisions and more effective actions by simplifying, clarifying, and making aggregated information available to various stakeholders (Moroke et al., 2019; Wangel et al., 2016). These indicators also help in implementing physical and social science knowledge into the decision-making process, as well as in setting targets, and measuring and calibrating progress toward such targets (Kaur and Garg, 2019)

As influential as these tools have been, they have not been without their pitfalls and shortcomings. In terms of their shortcomings they have been described as too prescriptive and static, essentially meaning that no single strategy for sustainability can apply equally in all parts of the world, thus some level of flexibility and context specificity in their development is generally required in order to be applicable in other region that do not possess NSATs, this is especially true in developing nations, where sustainability is seen more as a social and economic endeavour and less ecological (Dawodu et al., 2019; Balouktsi et al. 2017),. These static variables affect factors such as weighting of the indicators, selection of the indicator and the criterions used. Furthermore, the NSATs have consistently been criticized to be overly environmentally focused with little consideration for other dimensions of sustainability Wangel et al., 2016;).

These dimensions include the social, economic and more recently institutional. In some other cases NSATs are argued to be too data oriented, reducing sustainability to codes and numbers which is more of scientific endeavour thus neglecting the more experiential, contextual and qualitative aspects of sustainability (Ali-Toudert et al., 2019). The aforementioned point has been linked to the expert-led nature of the development of NSATs, with not enough input from the citizens of the region the tools are to be applied. However, recent frameworks have emerged that provide transparent integrated model for developing newer tools, particularly in developing regions such as Africa (Dawodu et al., 2019).

The final key gap and precursor to this study is the fact that there has been argument from several authors on not just the lack of balance of traditional three dimensions of sustainability but the need to acknowledge and include the fourth dimension (institution) in order to optimize the operational performance of NSATs (Boyle et al., 2018; Dawodu et al., 2018; Sharifi and Murayama, 2013; Valentin and Spangenberg, 2000). On a fundamental basis, the institutional dimension is a key aspect of the Agenda 21 towards achieving sustainability, bearing in mind that Agenda 21 is the core principle that NSATs were built upon (Berardi, 2013; Cheshmehzangi and Dawodu, 2018) These same authors have claimed that the institutional dimension is generally lacking in NSATs (see section 1). However, there seems to be a lack of consistency of what exactly the institutional dimension is or consists of, making it difficult to define institutional indicators. Secondly, authors such as Villanueva and Horan (2018), Komeily and Srinivasan (2015), Sharifi and Murayama (2014), and Turcu (2013) do not explicitly mention the precise criteria that have been explored to conclude on the missing institutional indicators. Furthermore, it would seem that a specific HSI can also bear multiple dimensional traits as suggested in Turcu (2013) and Dawodu et al.,(2017) suggesting that an institutional indicator could be an indicator that possesses not only the institutional dimension but other dimensions simultaneously. Additionally, Boyle et al (2018) argue that in achieving sustainability, certain levels of balancing trade-offs between the four dimensions of sustainability are required. However, the execution of these processes requires trade-offs from different stakeholder groups and institutions due to their conflicting interest and priorities. Thus, poor mechanisms to maintain these trade-offs has reduced the implementation of successful sustainability projects and thus it was argued by Boyle et al. 2018 that this in itself represents the lacking institutional dimension.

Consequently, while this study does subscribe to the notion of a fourth institutional dimension, it is not necessarily convinced that the institutional considerations are indeed lacking in NSATs as proposed in numerous studies. No specific study has investigated the role and presence of the institutional dimension in NSATs holistically. This is more so confusing due to the fact that the various aforementioned authors view the institutional dimension and associated indicators vary, even though their observations remain relatively the same. Essentially, there is congruence in the observation of the lack of institutional indicators but there seems to be different notions of what institutional indicators are or what constitutes indicators with institutional parameters. The upcoming sections and investigation aim to address this and provide further clarity on what institutional indicators are or should consist of, in addition to if they are indeed a missing component in the theoretical development of NSATs.

2.2 Understanding the true nature of institution

Valentin and Spangenberg (2000) elaborate on the need for four dimensions of sustainability with institutional dimension being pivotal. Their study adds an additional layer to sustainability principles by emphasising linkages between all dimensions. It also argues for addressing dimensional intersections, such as 'socio-economic' termed equitable, 'enviro-institutional' termed care, and etc. The essential point to be considered is that sustainability indicators are more effective in promoting sustainability when they address multiple dimensional issues. In fact, although isolated approaches may address one dimension of sustainability, they are most likely not as effective as multi-dimensional approaches that consider inter-relationships between different dimensions. This is because sustainability is the ability to attain parity between all three dimensions of sustainability simultaneously or in the case of this study, four dimensions (Reith and Orova, 2015; Sharifi and Murayama, 2013). This conceptualisation was further improved by Dawodu et al. (2017) who proposed 14 combinations between dimensions of sustainability such as Econo-socio-institutional, Enviro-socio-institutional, and etc. Their combination model was applied to NSATs for the first time. These interrelationships were further categorised as point aspect (one dimension) linear (two dimensions), planar (three dimensions) and super planar (sustainable dimension). Yet, the parameters used to classify institution were not fully explained. Relating this to NSATs and HSI, Sharifi and Murayama (2013) and Komeily and Srinivasan (2015) argue towards the relevance of the institutional dimension. In their studies, they emphasise that institution is not just the interactions among and between government and non-government organisations, but is also set of norms and laws governing such interactions. They clearly highlighted the absence and limited consideration of the institutional dimensions. However, they did not specify various types of institutions developed through interlinkages with other dimensions. They majorly illustrated the lack of a mechanism to assess the performance of government and non-government organisations. Additionally, a limitation to their analysis is the fact that they categorise institution as a singular dimension. But by consideration of Maclaren's integration ideology on sustainability assessment (1996), it is stated that indicators should cover multiple issues and cover linkages among them. For the very fact that institutions operationalises other dimensions of sustainability (Spangenberg et al., 2002), it is intuitive that the institutional dimension would not be able standalone as a single dimension. This means that the institutional dimension should be linked with others, e.g., socio-institutional, econo-socio-institutional, econo-institutional, and etc. Hence, it is evident that the institutional dimension plays a significant role in sustainability indicators, and should be viewed as a multi-dimensional entity that assists the other dimensional functions of an indicator. However, confusion still exists in its definition; i.e., what constitutes an institutional dimension?

Generally, the definition or description of institutional HSI with relation to NSATs is largely catalogued under a broad banner. For instance, HSIs such as information systems, research and education, and governance were indicated to be relevant and missing the institutional HSI in seven NSATs under investigation by Sharifi and Murayama (2013). In another study, HSIs such as outreach and involvement, transparency, local institutions, monitoring, and innovation were indicated to be relevant in three NSATs under investigation by Sharifi and Murayama (2015). The issue stems from why and how these are institutional HSIs, and further still, the compartmentalisation of the scope of an institution. Compartmentalisation in this context is a major gap, as it would seem as though the categorisation of institutional HSIs are solely based on the broad understanding of an organisational institution (such as, legal institutions that determines and enforces policies) as opposed to an invisible entity that guides and supports the implementation frameworks; i.e. regulations, standards, codes, norms, policies, guidelines. The institutional dimension is broader than what has been implied in the literature on NSATs. The pioneering documents released following the Agenda 21 meeting, as well the manual on institutional indicators published in the Brundtland report (1987) do not define institution specifically (World Commission on Environment and Development, 1987). Hence, Pfahl (2005) contends, through the study of Agenda 21, that institutions are implicitly understood as political or social organisations that are involved in policy making or implementation. Thus, making an organisation a legal entity that enforces the rules and implements the goals. However, as stated earlier, institution simply transcends organisational boundaries; and this becomes evident when the context of specific institutions is investigated. From a sociologist perspective, it is used as a tool to help individuals facilitate decision making. Gehlen (1964) states that it is only through institution that societal activities become effective, normative, permanent, and predictable. Parsons (1978) adds that institution do not only guide people's behavior but also lead the society and political community. These studies also argue that the success of an institution depends on the need for that institution and the role that it can play by providing the knowledge and support needed to overcome challenges that people face at that point in time. An additional definition and facet of institution is that it is synonymous to being an agent of change. That is to say, since institutions are linked to people, when the values or identities of people change the institution should also change. Otherwise, they can no longer be an intermediary element. In mainstream of international relation theory, this is defined as a "*persistent and connected set of rules and practices that prescribe behavioural roles, constrain activity and shape expectations. They may take the form of bureaucratic organizations, regimes (rule-structures that do not necessarily have organizations attached), or conventions (informal practices)*" (Haas et al., 1993, p. 5). These definitions and contextual understanding of institution led to organisational hierarchy categorised by Pfahl (2005). This was divided into three categories according to the degree of institutionalisation: (1) organisation (Legal personality); (2) Regimes, systems of rules (connected set of rules and agreements in specific issue area), and mechanisms; and (3) Social norms and traditions (informal rules, property rights, values, normative orientations). Similarly, Valentin and Spangenberg (2000) describe institutions as not only interactions between the governmental and non-governmental organisations involved in the decision making, but also a set of norms, laws, and regulations governing these interactions. Applying this to modern SUD, as an example, it provides the impetus to categorise establishments that provide eco-labels to sustainable or green building products, as valid institutions. The popular e-certification has been developed in several countries such as American Green Seal, Euro Ecolabel, German Blue Angel, and Japanese Eco Mark. These labels identify or indicate sustainable products without the ability of the user to necessarily measure its greenness. Energy labels are also very popular in United States with the organisation called Energy Star gaining popularity and being sponsored by organisations such as Environmental Protection Agency (EPA), and Department of Energy (DOE). The argument here is that these eco labelling schemes, particularly those related to energy, are not in themselves institutions that provide regional and global metrics for energy efficient products (Berardi, 2015).

Also, from the authors perspective, the experts or developers of these tools utilise standards, laws and codes from different institutes and organisations as means to objectively represent the impacts. This brings forward the argument that the institutional dimension is very much present in HSIs of NSATs. This is because, as mentioned earlier, without these institutions, guidelines and codes that validate the level of impact of a specific entity; the indicator cannot be measured or used effectively. More astutely, Lancker and Nijkamp (2000, p. 114) states that, "*a given indicator does not say anything about sustainability, unless a reference value such as thresholds is given to it*". The thresholds in the case of NSATs are the benchmarks given by these HSIs and the benchmarks are supported by international or local standards or codes, and guided by organisations such as the Department of Housing and Urban Development (HUD), U.S. Environmental Protection Agency (EPA), and the Department of Energy (DOE).To summarise, the debate of three versus four pillars indicates that there is a clear gap in definition, which ultimately influences how the foundation of NSATs will be developed. Also, results of several studies on NSATs highlight the dominance of the environmental dimension. There is also a narrow view of what is considered to be an institutional dimension leading to possible incomplete or incoherent results of the impacts of the institutional dimension (Ameen et al., 2015; Berardi, 2015; Komeily and Srinivasan, 2015; Reith and Orova, 2015; Sharifi and Murayama, 2013; Turcu, 2013; Villanueva and Horan, 2018). The next section aims to establish consistent parameters that can be used to determine if indicators bear institutional characteristic and also utilise a multi-dimensional approach to investigate the possibility of multi-dimensional institutional indicators.

3. Methodology

3.1 Overview and Selection of NSATs

This study analyses 15 NSATs (see table 1) with a specific emphasis on energy-based HSIs (E-HSIs). 15 NSATs were chosen as this represents the highest number third party assessment tools that could be obtained for analysis. It should be remembered that these tools are largely commercial, and the guiding manuals and operations handbooks are not always available. Nonetheless, 75% of the available third party verification tools were investigated in this paper (Tam et al., 2018). Secondly, this study chose to focus on energy based indictors, as these tend to be the most dominant indictors in terms of weighting in most NSATs (Charoenkit and Kumar, 2014). They also have strong relationship with institutional parameters under investigation in these NSATs (Dawodu et al., 2017):. In line with the aforementioned statement, three key aspects are considered to determine characteristics of these tools as relates to the institutional dimension: (3.2) classification of institution by Pfahl (2005) analogy of organisations, regimes and informal rules (3.3) utilising theme-, index- or HSI-based comparison (Dawodu et al., 2017; Sharifi and Murayama, 2013; Wangel et al., 2016); and (3.4 & 3.5) utilising the multi-dimension based comparison developed by Dawodu et al., (2017). These are summarized Fig. 1 and elaborated in the subsections below:

Table 1. Neighbourhood Sustainability Assessment Tools and Region of Development

Fig. 1. Summary of Methodological Approach

3.2 Classification of Institutions

The first aspect of the methodology is the classification of the policies, organizations, codes and standards used. This is done by utilizing the definition and classifications of institution developed by Pfahl (2005); Organizations and policies, Regimes, Informal rules. Furthermore, Pfahl's approach to institution provides a complete, well-grounded concept derived from international relations theory that transcends an institution being merely a political and social organization but also includes behavioral roles, rules and practices and instruments to facilitate decision making. This is generally conducted through the consideration of numerous variables that constitute an institution. Furthermore, Pfahl (2005) approach was pioneering template developed that brought most aspects that constitute an institution into an organisational hierarchy. This has made his approach an ideal technique to evaluate the performance of NSATs as relates to its consideration of the institutional dimension of sustainability (see section 2.2 for Pfahl's explanation of institution). Table 2 breaks down the classification further.

Table 2. Classifications of institutions

3.3 Theme-based comparison

Wangel et al. (2016) describes theme-based classification as the rearrangement of the issues, indicators or, in this case, HSIs into a common framework. This redistribution of HSIs also means the redistribution of the associated credits or weights. Hence, in this study of 15 NSATs, similar E-HSIs are collated together under one terminology, where an overall E-HSI categorisation is established (appendix A and table 3). Appendix B also shows the total frequency of occurrence of similar E-HSI across the 15 NSATs being investigated. For instance, the urban heat Island effect is covered 11 times out of possible 15. By doing this, all indicators and their associated weights become standardized, thereby making comparisons accurate.

3.4 Dimensional Analysis

A content analysis via the qualitative review of each E-HSI is done to identify which dimension of sustainability is possessed by the E-HSI under investigation. Fig. 2 gives an example of how this is done by illustrating via the BERDE E-HSI called "Energy Efficiency Improvement". The next paragrapgh illustrates how the dimensions of sustainability were obtained for the energy-based indicators. Further examples can be seen in studies by both Dawodu et al., (2017) and Villanueva and Horan (2018). Invariably, each E-HSI is placed under a specific identified dimension of sustainability. This was done via a review of all HSIs and the associated guidelines, aims, and assessment criteria. Note these aims and assessment criteria can be either qualitative, quantitative or both. The strategies used to identify the dimensions of each HSI followed two instructions termed primary and secondary derivatives (Dawodu et al., 2017): (1) The primary derivative implies the identification of an explicitly stated or obvious dimension (s) of sustainability that is directly shown within the text of the HSI. It should be noted that primary derivatives could include 2 or 3 interrelationships (i.e., Environmental-Social-Economic (E-S-EC), Environmental-Institutional (E-I), or Environmental-Social (E-S), etc.), (2) the secondary derivatives is an extraneous sustainability metric for the development of the SI, by being only indirectly linked to the motivation of the HSI under analysis. The following are all the possible dimensions and their combinations given based on the four pillars of sustainability and their relationship: 'E, S, I, EC' relationship are known as point aspects, those with 2 interrelationships such as 'E-EC, E-S, E-I, EC-S, EC-I, S-I' are known as linear aspects, and those with 3 inter-relationships 'E-S-EC, E-S-I, EC-S-I, E-EC-I' are defined as planar aspects.

Example: In Fig. 2, two dimensions are explicitly mentioned; one of which uses primary derivative (E-I) and the other uses secondary derivative (E-C). The first primary derivative is under "Criteria" and describes a number of environmentally friendly procedures that can be used to improve energy efficiency. For example, the use of "passive methods including energy efficient building envelope design" and "Use of carbon dioxide sensors". This addresses the (E) aspect of the E-HSI. Using the second derivative and analyzing the statement under "intent" involves the use of energy efficient technologies to reduce baseline consumption of educational buildings by 200 kWh/m^2 or 400 kWh/m^2; this not only considers the environmental (E) dimension, but also the economic (EC) because saving energy is indirectly linked to saving operational cost. Finally, the second primary derivative is institution. As can be seen in Fig. 2, various codes, standards and guidelines (the DOE Guidelines on Energy Conserving Design of Buildings, ASHRAE Std. 90.1 – 2004 and Occupational Safety and Health Standards) need to be adhered to in order for this E-HSI to be successfully implemented. This is explicitly stated under the "criteria" section. Hence, the dimension would be (E-EC-I). By utilizing this method, it becomes possible to draw out the dimensions of different E-HSIs and determine if they can be considered institutional indictors or not

Fig. 2. Example of E-HSI for BERDE NC- Residential Development NSAT

3.5 The procedure for exploring the state of coverage of the institutional dimension

To examine how the institutional dimension is addressed, we developed a matrix with "Classification of Institutions" on the columns and E-HSIs on the rows. One or more criteria are listed under each E-HSI, for which the dimensional characteristics are also identified. As mentioned in section 3.3 and shown in Appendix B under the 15 NSATs, similar E-HSI were grouped together based on the qualitative review of their similarities or dissimilarities. Observing Table

3, on the left hand column, the true title of the E-HSI and the type of institutional dimensions they possess are given. For example, under the group title of passive energy design you have their actual title given in their manuals as Natural ventilation (E-I) – BERDE and Passive Design (E-I) – BEAM. A breakdown was needed to understand why they possessed institutional dimensions; hence they were further placed into any of the five categorisations of institutions based on how the institutional dimension was used in the E-HSI. Take, for instance, minimum building energy performance (categorised under energy strategy), the E-HSI references Commercial Energy Services Network (COMNET), which is a quality assurance program involved in energy performance in commercial buildings. COMNET also provides accreditation to energy software. The direct quote from the manual is "*Alternatively, use the COMNET modeling guidelines and procedures to document measures that reduce unregulated loads*" (U.S. Green Building Council, 2014, p. 56). Also, from a standards and codes perspective, achieving the points for this E-HSI requires compliance with a specific ASHRAE code (ASH_1) (American Society of Heating, Refrigerating and Air-Conditioning Engineers). ASHRAE is classed as an international organisation due to its international recognition and use in majority of non-American countries. ASHRAE has several energy guidelines and codes (Ciulla et al., 2010; Melo et al., 2014). Alternatively, American National Standards Institute (ANSI_1) and Illuminating Engineering Society of North America (IESNA_1) are classed under local bodies due to their local and context specific use (Fan et al., 2015; Lo et al., 2012). The direct quote from the manual is "*Demonstrate an average improvement of 5% for new buildings, 3% for major building renovations, or 2% for core and shell buildings over ANSI/ASHRAE/IESNA Standard 90.1–2010*" (U.S. Green Building Council, 2014, p. 56). This demonstrates how these organisations and codes were classified for all E-HSI. In terms of informal rule or informal organisations, assessment tools and journals were placed under that banner as it was discovered that newly developed tools make reference to these journals and assessment tools as points of reference. Bear in mind that Berardi (2005, P.520) in his description and selection of NSATs for analysis states that "*The considered systems were selected for their established worldwide diffusion and resonance with the help of institutions and organizations actively involved in promoting their use*". Hence, it can be understood that these tools have been and can be classed as informal institutes or developing institutes. In the same vein, peer-reviewed journals are classed under various academic and research institutes that govern quality and distribution of academic research.

4 Results

4.1 Classification of Institutional Dimension of Sustainability

Table 3 shows the result of the classification of 93 E-HSIs and Appendix A provides the nomenclature for each organisation and code in Table 3. Out of those 93 E-HSIs, 49 were considered institutional indicators under informal considerations (considers informal institutions such as 3rd party assessment tools and peer-reviewed journals). However, the total number of E-HSIs becomes 37 under business as usual (does not consider informal institutions - 3rd party assessment tools and peer-reviewed journals) (see Fig. 3).

This leads to the categorisation of indicators under a particular dimension of sustainability, with the use of the multi-dimensional method also termed sustainable pathway (SP). Table 3 shows all the associated dimensions to each of the E-HSIs. Fig. 3 draws the SP and illustrates the dimensional characteristics of each E-HSI that have institutional dimensions. It shows that E-I has the highest interlinkage. E-I here means how the guidelines that determine human interactions influence the environment, and also the response or modifications to these guidelines to create a particular effect on the environment. Also, results from Fig. 3 show weakness on the other two- and three- dimensional interlinkages. It is worth noting also that the US-based tools have higher reliance on international standards and local codes than tools that were developed in other regions. Investigating this further (as shown in Fig. 5) explains, by regional origin, the amount of indicators that have institutional dimensions. Also, overall observations showed that five E-HSIs under Energy Efficient Lighting required organisations, codes or guidelines. This was the highest out of any E-HSI category, followed by district heating and cooling, which also had informal organisation of LEED-ND and Green Mark District (GMD) as institutional references. Overall, the results have elaborated on the methods and logic behind the characterisation of the E-HSIs. In addition, results show that the institutional dimension can be presented more explicitly and providing details on the related institutional mechanisms/roles contributes to this. The next section briefly discusses the implications of the results.

Table 3. Results of the Classifications of institutionally oriented Headline Sustainability Indicators

Fig. 3. Sustainable pathway of All 15 NSATs

Fig. 4. Business as usual indicators versus non institutional indicators

Fig. 5. Regional percentage distribution of institutional dimension (Including Informal consideration)

5 Discussions

5.1 Trend and characteristics of Energy-oriented sustainability indicators in currently existing NSATs

Why was the four-dimensional approach needed and utilised in this study? Mainly because by taking this approach and establishing the inter-relationships between the dimensions, it is easier to describe the behaviour characteristics of a specific HSI. To that end, the results in Table 3 provide an overall snapshot of the SP. The SP indicates the current status and frequency of all 93 indicators of the 15 NSATs. Currently, certified green buildings, passive energy design, renewable Energy: onsite, and the Urban Heat Island (UHI) effect are the highest occurring E-HSIs (see appendix B). This illustrates to a strong extent, what all tools prioritise in terms of achieving sustainability from an energy perspective. Fig.3 shows two cases, which are business-as-usual and informal consideration – in the methodological analysis of each E-HSI. These were placed into dimensions depending on their sustainability focus. Business-as-usual shows that E-HSIs are more environmentally-driven, which would seem understandable; though there is a secondary emphasis on E-I as opposed to other dimensions of sustainability. The significance illustrates that in terms of the prior criticism of being environmentally focused, E-HSIs show the same environmental focus; though this should not be surprising due to the strong links between energy and the environmental dimension of sustainability. In contrast, from the "informal consideration" perspective, Fig. 3 and 4 also demonstrate that E-I dimension is actually considered more than the E dimensions of the business as usual case.

The second observation is on the implications of the charactertisation of E-HSI. For instance, the E-HSI of "Photovoltaic/Solar Hot Water Ready", which is guided by EPA Renewable Energy Ready Homes (RERH) and regulated by National Renewable Energy Laboratory - Solar Ready Buildings Planning Guideline, is classified as E-I. The result of the charactertisation of E-HSI improves upon Sharifi and Murayama (2013). In their analysis, it was made clear that sustainability includes institutional aspects as its fourth dimension, and this was missing in NSATs. In addition, there was no explicit mentioning of the kinds of specific indicators and criteria sought to make this claim. Hence, this method not only identifies the institutional-based HSIs but also supports the previously-mentioned statement by Dawodu et al. (2017) that institutional indicators cannot be standalone. Instead, they have to be interpreted and tied to other specific dimensions (E-I, E-S-I, E-EC-I). This also gives a better explanation to why Turcu (2013) argues that the HSI of "community activity" was classified under both social and institutional dimensions, as based on the SP method, it would be classified as a socio-institutional HSI. The classification of dimensions also showed the limitations of currently developed E-HSIs to consider other dimensions (e.g. E-S-I, E-EC, E-EC-I). This has significant impacts if applied in developing regions, where the economic dimension may play a stronger role in the implementation of an indicator. In such cases, the specific E-HSI (e.g. ENERGY STAR Appliances) may not be implementable because it is not affordable.

Also, while Sharifi and Murayama (2013) addressed a maximum of seven NSATs, this study looks into 15 NSATs. Even though limited to energy-based HSIs, the results still indicate a higher consideration of institutionally-based indicators. As argued in the literature review section, this study delves deeper into the meaning of institution. This brings out the next point of interest with respect to NSATs studies that have made claims of institutional limitations (Komeily and Srinivasan, 2015; Reith and Orova, 2015; Sharifi and Murayama, 2013, 2015; Turcu, 2013). The scope of previous studies focused on the organisations and presence of an institute to represent the given HSI, e.g. education institute. However, as Pfahl (205) asserts, institutions are not just organisations but laws, policies, regulations and guidelines. In this study, these regulations and organisations came in the form of building codes and international standards as well as organisations. This provided a broader scope to the definition of institution. This further led to categorisation of formal and informal institutions. Under these categorisation and interpretations, it became evident that a lot of E-HSIs require these codes in order to promote best practices and have reliable reference of what works, thereby ensuring duplication of successful results in other regions. It also showed that policies go a long way in determining the success of a HSI. The best example is the UAE-based Pearl Community Rating, in which the development of many indicators is linked to master plans and policies that are bounded by the country's urban laws (Abu Dhabi urban planning council). The Abu Dhabi Urban Planning Council developed the following policies and plans: Capital 2030 Master Plan, Al Ain 2030 Master Plan, Al Gharbia 2030 Master Plan, UPC Community Facility Requirements, Abu Dhabi Urban Street Design Manual, Coastal Development Guidelines, and Abu Dhabi Development Code (Abu Dhabi Urban Planning Council, 2010). These plans and regulations were all linked to various HSIs (energy-based HSI included). For BREEAM Communities, this is slightly different due to the embedded nature of its institutional links in a number of their environmental initiatives; hence, institutional support is generally not explicitly mentioned but implicitly intended. Their policies act like silent partners in actuating energy strategies selected. Hence, in BREEAM Communities, the institutional support or dimensions are not specifically highlighted, thus making it harder to identify and categorise them. For instance, the E-HSI "energy strategy" under BREEAM Communities cannot been seen to possess E-I but rather E. However, the literature shows that energy policies are in place to support their energy-based indicators (Charoenkit and Kumar, 2014; Reith and Orova, 2015; Wangel et al., 2016). LEED-ND, on the other hand, focuses on guidelines and building codes, also most of the other US-based tools are governed by building and energy codes. As mentioned earlier, these codes and standards provide a threshold or best-practice reference value that a given HSI operates under. For example, under the LEED-ND HSI of "Energy efficient improvement in performance of buildings", codes utilised to establish best practices are IESNA Standard 90.1–2010, Appendices B and D, and ANSI Standard 90.1–2010. This demonstrates how the institutional dimension guides effective implementation of the HSI, when it is utilised in a project. Finally, key E-HSIs showed particular affinity to institutional dimension such as the "efficient lighting", this is because lighting organisations have a long and strong lighting research background, which allows them to provide reputable threshold values that can be adhered to under various contexts and used for best practice procedures. This is evident in the lumens and lux values that are often used guidelines for best practices in outdoor lighting, security lighting, avoidance of glare etc. The results further illustrate a need for assessment tools to continuously work with these organisations to not only ensure best practice procedures, but also to serve as examples to more skeptical audiences i.e. developing or emerging economies, thus creating stronger opportunities for such organisation to partner with other regions that would otherwise not deem these code as necessary or lack the capacity to develop them. This subsequently makes market penetration for tools such BREEAM Communities into other regions easier and more context relevant. The same argument can be made for E-HSI indicators generally as Table 3, Fig. 3 and Fig.4 show; it is evident that they are heavily reliant on codes, standards and organisations in order for the indicator to be effective.

Taking another example, it is perhaps worth mentioning that these NSATs are generally voluntary tools though some legislation such as that in Bristol have mandated that new construction projects should be certified. Nonetheless, these are often seen as voluntary tools and they are marketed to go above and beyond the typical industry standard practices. However they are also known to work in tandem with legislated standards especially when those standards are observed to be quite high. Take the Philippine tool BERDE NC: under energy efficient lighting, it is quite common for developing countries not to possess codes and standard for certain building services and in some cases these countries adopt codes with international recognition. Nevertheless, the Philippines does have local codes for lighting, though possessing the code is one aspect and enforcing the correct implementation in urban projects is another. Under the BERDE schemes, in order to obtain the points under the lighting E-HSI, the developers would have to 'install light fittings, fixtures, and luminaires with a minimum luminous efficacy of 80 lumens per watt in all common areas within the development.' Furthermore, it states that these light fixtures and fittings must be *'compliant to the pertinent Philippine National Standards (PNS) on Lighting Products, and lighting power indices or densities must meet the minimum standards stated in the Guidelines for Energy Conserving Design of Buildings'*. Hence, we have two situations that occur, first it is evident that NSATs can work hand in hand with building codes that exist in a region, especially when those standards are already best practice procedures. Secondly, by utilizing NSATs, and possibly making them mandatory and seeking points under needed E-HSI you are obligated to adhere to the standard, otherwise your project cannot be declared green or sustainable. In some cases, such procedures raise awareness of developers who may have simply bypassed the system. Essentially, the point being raised here further buttresses the fact that we need to make clear what institutional indicators are or what constitutes an institutional indicator. This allows to maximize the implantation of NSATs and know indicators being governed by best practices versus those that lack such guidance.

5.2 Regional Institutional coverage of NSATs

Fig. 5 illustrates the percentage distribution of institutional indicators based on tool developers and also based on the region in which they were developed for. The top three tools that possess the highest institutional dimension within their indicators are EGC (US), ECC (US) and the Pearl Community (UAE). From the results shown, it is quite evident that US-based tools place heavy emphasis on codes and standards as a form of quality assurance to ensure that the best design and implementation practices are upheld. This could be the reason why the use of NSATs within regions of the US is quite popular as they tend to incorporate international and local codes in most aspects of their design and implementation practices, thus improving their adoption by planner, designers, and developers. In a sense, they become more convincing to state governments through the adoption of nationally accepted codes and guides, thereby increasing the propensity of these state authorities the adopt these tools locally and in some cases making them mandatory or prerequisite frameworks for new buildings and community development. This is most likely why LEED ND is still widely considered the most popular assessment tool. Even though LEED ND is observed to be only 6% of institutional indicators identified among the 15 tools (see fig. 5), it should be understood that LEED ND is a pioneering tool which had several gaps, which subsequent tools learned from; one of such lessons is the incorporation of more institutional based dimensions in their frameworks. As the timeline suggests LEED ND was the 3rd Assessment tool that emerged globally (Tam et al., 2018). Subsequent tools especially within the Asian region (BERDE, HK BEAM, Pearl communities) have emulated this method involving codes, standards and guidelines to ensure high quality standards and comparable results among best-practice solutions. However, other factors have also contributed to LEED ND's success such as aggressive marketing and also the fact that the US has the third largest land mass (9,629,091km^2), thereby creating more opportunities for the use of the NSAT frameworks. Additionally, the tool is focused on repairing sprawl that has been a major concern in the countries since several decades ago. BREEAM communities is also popular. However, as mentioned before, due the embedded nature of the institutional dimension in the UK, the tool does not explicitly state codes, guidelines and standards as compared to LEED ND. This may cause confusions and inconsistencies. For example developer A could use a set of unverified or debatable methods to achieve the point(s) under a E-HSI (e.g. the debate of 1st and 2nd generation biofuels), while Developer B could follow practices based on a different context (i.e. utilizing codes and standards from another region that have limitation in the region of implementation). This makes it difficult to ascertain the best practice strategies for indicator implementation and it also makes it difficult to compare and reproduce results after implementation of a particular E-HSI. These could be key factors explaining why BREEAM Communities, despite being recognized internationally trails behind LEED ND in terms of implementation. The aforementioned argument can be made for CASBEE UD with only 2% of its E-HSIs possessing the institutional dimension relative to other NSATs. However, one likely reason for relatively limited uptake of CASBEE-UD could be that it is highly focused on the Japanese context and, unlike LEED ND and BREEAM communities, the tool developers have not attempted to export the assessment frameworks to other regions of the world. In sum, it is quite clear that the emerging tools have chosen to emulate the US-based tools in terms of ensuring that their indicators possess a higher number institutional dimensions. The argument also further illustrates why less vague and more specific understanding of institutional indicators is required, in order to better understand their role in the development of indicators and thus ensure that this higher understanding can lead to more effective indicators that can lead to improvements in new version of NSATs.

6 Conclusions

This study improved our understanding of the institutional dimension of sustainability by elaborating on the institutional bases for development and implementation of indicators for NSATs. Indeed, by taking a multi-dimensional perspective that expands the spectrum of understanding of what can be called institutional indicators, the study indicates that there are actually more institutionally-linked indicators that what was previously claimed in the literature (Sharifi and Murayama, 2013; Komeily and Srinivasan, 2015). The study argues for the inclusion and recognition of informal institutions, which include previously-developed assessment tools and peer-reviewed journals. Under the two scenarios ('Business as usual' and 'Informal consideration'), the results demonstrated that there are more institutionally-based indicators than previously reported. Also, when informal institutions are considered, there are actually more institutionally-based indicators than non-institutionally based ones. The study also shows how the institutional dimension via linkages and relationships can be used to operationalise and incentivise the other three dimensions. In fact, the institutional dimension is so essential that certain indicators lose their functionality and effectiveness without the dimension being present. For instance, the lighting indicator, which is heavily dependent on lighting codes or the Energy Star appliance indicator, is heavily dependent on the functionality of the international organizations such as IESNA. The absence of the institutional dimension is, therefore, likely to lead to a lack of trustworthy data and lack of pre-established best practice procedures and performance values.

This study also shows that the institutional dimension cannot be a single entity or identity, and operates in tight connection with other dimensions (E-I, E-S-I, E-EC-I). With this in mind, this study, albeit via energy-based indicators corroborates the dominance of environmental perspectives in NSATs, though this is to be expected of energy-based indicators due to their strong environmental linkages. However, a significant recommendation should be the inclusion of other types of dimensions to make such indicators more implementable. For instance, the economic dimension linked with both institutional and environmental dimensions would improve the success of implementing indicators in developing regions of the world. The study also showed that the institutional dimension can be explicitly stated or implicitly intended. 'Explicitly stated' refers to NSATs such as LEED-ND and Pearl Community Rating that explicitly mention the institutional bodies and their roles in influencing a given indicator in their manuals. 'Implicitly intended' refers to tools such as BREEAM communities that have strong local and state policies, hence such tools do not explicitly state which codes or standards will be adhered to, but rather it is assumed that whatever method is used would conform to existing governance frameworks. It is also often implied that BREEAM Communities in some form or way will utilize these institutions without explicitly stating or identifying them. This could lead to difficulties in ascertaining, comparing and reproducing best practice strategies for indicator implementation. For NSATs, a suggestion would be that the institutional dimension needs to be visibly and explicitly mentioned as a parameter of the indicators, not only for clarity but also to account for different factors that contribute to successes, failures and trends of the given indicator. Future studies and development of NSATs should look into the explicit application of the institutional dimension in indictor development. Also, future studies, could investigate the wider implication of institutional indicators on other NSAT themes (waste management, transport, water, security, connectivity etc.). This is because in this study, a key limitation was that the investigation focused solely on the Energy theme

Hence, to ensure increased presence of these institutional dimensions this study has sought to unravel the many vague terminologies, factors and criteria that have been used to described an institutional indicator. Throughout this study, terminologies such as institutionally-linked indicator, institutionally-based indicators, institutional indicators and indicators that possess institutional dimensions have been used interchangeably. That is because the purpose of this study is to show that they can all be categorized or classed as institutional indicators. Thus, this study proposes a new clear definition of an institutional indicator within the context of NSATs:

An institutional indicator is one that explicitly bears the institutional dimension (i.e. policy, regulations, incentives, organizations, codes and standards) within the instructions of how to implement the given HSI. The institutional dimension is rarely a single entity or identity and must operate under the linkage of the other dimensions of sustainability.

By making this definition clear and transparent, it becomes possible to optimize the use of indicators in the development and application of NSATs to different urban regions, thereby enhancing clarity and consistency on the metrics that support the other three dimensions of sustainability. Ensuring a constant institutional link to indicators could contribute to the development of more effective NSATs, particularly for regions that are looking into developing their own assessment tools. Hence, the definition and clarification of what makes an institutional indicator not only optimizes the potential to further improve the existing tools, but it also informs those regions/stakeholders interested in developing new ones of the issues that need to be considered to develop more locally-relevant and effective NSATs that can facilitate transition towards sustainability.

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Appendix

Appendix A: Keys to the classification of energy-based institutions

Appendix B: Energy based –Headline Sustainability Indicator and frequency

Table 1. Neighbourhood Sustainability Assessment Tools and Region of Development

Tool	Acronym	Country	Developer	Reference
Comprehensive Assessment System for Building Environmental Efficiency for Urban Development	CASBEE-UD	Japan	JSBC (Japan Sustainable Building Consortium), Institute for Building Environment and Energy Conservation (IBEC)	http://www.ibec.or.jp/CASBEE/english/overviewE.htm
Building Research Establishment Environmental Assessment Method - Communities	BREEAM Communities	UK	BRE Global Ltd	http://www.BREEAM.com/
Leadership in Energy and Environmental Design - Neighbourhood Development	LEED-ND	US	United States Green Building Council	http://www.usgbc.org/LEED
Indian Green building Council - Township	IGBC Green Township	India	Indian Green Building Council	https://igbc.in/igbc/
Green Building Index Township	GBI Township	Malaysia	Green building index Sdn Bhd	https://new.greenbuildingindex.org/
Global Sustainability Assessment System	GSAS District	Qatar	Gulf Organization for Research and Development	http://www.gord.qa/gord-trust
Green Star Communities	Green Star	Australia	Green Building Council of Australia	https://new.gbca.org.au/green-star/rating-system/communities/
The Pearl Community		United Arab Emirates	Abu Dhabi Urban Planning Council Beacon pathway	https://www.upc.gov.ae/en/-/media/files/upc/media/prdm/prrs_v1.ashx
Green Mark for Districts	GM	Singapore	Building and Construction Authority	https://www.bca.gov.sg/green_mark/
Building Environmental Assessment Method Plus Neighborhood	BEAM Plus Neighborhood	Hong Kong	Hong Kong Green Building Councils	https://www.beamsociety.org.hk/en_beam_plus_neighbourhood_assessment.php
Building for Ecologically Responsive Design Excellence – Clustered Residential Development	BERDE NC – Residential Development	Philippines	Philippine Green Building Council (PHILGBC)	https://www.berdeonline.org/
Enviro-Development Master planned community	Enviro-Development	Australia	Urban development institute of Australia	http://envirodevelopment.com.au/

Enterprise green communities	EGC	US	Enterprise Community Partners, Inc.	https://www.enterprisecommunity.org/solutions-and-innovation/green-communities
Earth community craft	ECC	US	Earth Craft, Greater Atlanta Home Builders Association, Southface	https://earthcraft.org/earthcraft-professionals/programs/earthcraft-communities/
Sustainability Tool for Assessing and Rating communities	Star Community Rating System	US	Star Communities nonprofit organization	http://www.starcommunities.org/

Table 2. Classifications of institutions

Organisations (legal personality)	Regimes: systems of rules (connected set of rules and agreements in a specific issue area), mechanisms		Informal rules and organisations	
Policies and organisations that govern policies	International standards and codes	Local governing bodies, codes, guidelines	Peer-reviewed journals	3rd party assessment tools

Table 3. Results of the Classifications of institutionally oriented Headline Sustainability Indicators

	Organizations (legal personality)	Regimes: systems of rules (connected set of rules and agreements in specific issue area), mechanisms		Social norms, traditions (informal rules, property rights, values, normative orientations	
	Policies and organizations that govern policies	International standards and codes	Local governing bodies, codes, guidelines	Peer reviews journals	3rd party assessment tools
Energy Strategy Minimum building energy performance (E-I) - LEED	CNT (LEED)	ASH_1 (LEED)	(1) COMG (2) ANSI_1 (3) IESNA_1 (LEED)		
Energy Infrastructure Energy Efficiency for Infrastructure and Public Amenities (E-I) - GM		ASH_2 (GM)	(1) SS_530 (2) SS_553 (3) CP_13 (4) AHRI (GM)		
Certified Green buildings					LEED, EGC, ECC, SCRS, BEAM, NHK, BERDE, GBIT, GMD, CASBEE, IGBC, TPC, GSASG, EDM, GSC, BREEAM
Renewable Energy: Offsite (E-I)	GCO (Pearl)				
Passive energy design Additional Reductions in Energy Use (E-I) – Enterprise Natural ventilation (E-I) – BERDE Passive Design (E-I) - BEAM	(1) DET (Enterprise) (2) HKP (BEAM)	CIBSE (BERDE)	HKC_1 (BEAM)		
Renewable Energy: Onsite Renewable Energy (E-I) –BEAM Renewable Energy(E-I) –Enterprise	(1) HKE (BEAM) (2) USDE (Enterprise) (3) ASES (Enterprise) (4) FSEC (Enterprise) (5) NREL (Enterprise)				

Urban Heat Island Effect (UHIE) Reduced UHIE and paving (E-I) - Enterprise Urban Heat Reduction (E-I) – Pearl Intra Urban Temperature and Urban heat island effect (E-I) -BEAM	(1) USEPA (2) CRRC (non-binding)(Enterprise) (3) ENERGY STAR (partnered with EPA) (Enterprise) (4) LBNL (Partnered with EPA) (Enterprise)	(1) ASTM_1 (2) ASTM_2 (3) ASTM_3 (4) ASTM_4 (5) ASTM_5 (6) ASTM_6 (PEARL)	[1] CNC (BEAM)	J1, J2, J3, J4, J5 (BERDE)	
Energy Efficient Lighting Efficient Street and Park Lighting (E-S-I) - GBI Efficient Infrastructure: Lighting (E- I) - PEARL Energy efficient lighting (E-I) - BERDE Lighting (E-EC-I) - Enterprise Efficient Site Lighting (E-S-I) – ECC	(1) ENERGY STAR (partnered with EPA) (Enterprise) (2) IDA (Enterprises)		(1) PNS (BERDE) (2) IESNA_2 (PEARL) (3) IESNA_3 (PEARL) (4) MS_825_1 (GBI) (5) MS_825_2 (GBI) (6) IESNA_4 (ECC) (7) IESNA_5 (Enterprise)		
District Heating / Cooling Energy Efficient Infrastructure (E- I) - BEAM Energy efficient equipment (E-I) - BERDE Sizing of Heating and Cooling Equipment (E-I) - Enterprise District heating or cooling (E-I)– LEED	(1) ENERGY STAR: Duct sealing (partnered with EPA)(Enterprise)	ASH_3 (LEED)	(1) USAC_1 (Entire) (2) USAC_2 (Entire) (3) ASH_5(chapter not specified) (Entire) (4) DOE_1 (BERDE) (5) ANSI_2 (LEED) (6) IESNA_6 (LEED)		(3)LEED-ND (BEAM) (4) GMD (BEAM)
Energy efficient improvement in performance of buildings Optimize Building Energy Performance (E-I) – LEED Energy efficiency improvement (E-EC-I) - BERDE		ASH_4 (LEED)	(1) IESNA_7 (LEED) (2) ANSI_2 (LEED) (3) DOE_2 (BERDE)		
Energy efficient building envelope Energy efficient building envelope (E-I) – BERDE Neighborhood daylight access (E-S-I) - BERDE			(1) DOE_3 (BERDE) (2) HKC_2 (BEAM)		
Reduction in greenhouse gas emissions	ABC (Enviro)				
Nearing net zero (E-I) – Enterprise	(1) USDOE (2) PHIUS (supported by US DOE) (3) LBC (Alliance with USGBC)				
ENERGY STAR Appliances (E-I) – Enterprise	ENERGY STAR products (Partnered with EPA)				
Photovoltaic/Solar Hot Water Ready (E-I) – Enterprise	(1) RERH (2) DSIRE		NREL		
Resilient Energy Systems: Island-able Power (E-I) – Enterprise		USGBC	USGBC		
Earth Craft Builder Training (E-I) – ECC	SEI (Partnered with ECC, Atlanta, Georgia etc.)				
Renovation of Existing Commercial (E-I) – ECC			ASH_6		
Clean Emissions Protocol for Heavy Equipment (E-I) – ECC	EPA: National Clean Diesel Campaign and verification		EPA		
Industrial Sector Resource Efficiency (E-S-EC-I) - STAR					

Appendix

Appendix A: Keys to the classification of energy-based institutions

	Organizations and policies	INTL Standards and codes	
CNT	COMNET (LEED)	ASH_1	ASHRAE Standard 90.1–2010, Appendix G (LEED)
GCO	Green E certification organization (Pearl)	ASH_2	ASHRAE guide 22: Instrumentation For Monitoring Central Chilled-Water Plant Efficiency (GM)
DET	Department of Energy buildings Technology office (Enterprise)	CIBSE	Chartered Institute of Building Services Engineers (CIBSE) Applications Manual 10: Natural Ventilation in Non-Domestic Buildings.
HKP	The government of Hong Kong China, the planning Department: Wind Availability Data for Air Ventilation Assessment In Hong Kong	ASTM_1	ASTM E1980 - 01 Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces
HKE	Electrical and Mechanical Services Department (EMSD): the Government of Hong Kong special administrative region - Energy Utilization Indexes and Benchmarks for Residential, Commercial and Transport Sectors (BEAM)	ASTM_2	ASTM E1918-06, Standard Test Method for Measuring Solar Reflectance of Horizontal and Low-Sloped Surfaces in the Field
USDE	U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy Enterprise (Enterprise)	ASTM_3	ASTM C1549-09, Standard Test Method for Determination of Solar Reflectance Near
ASES	American Solar Energy Society (ASES) (Enterprise)	ASTM_4	Ambient Temperature Using a Portable Solar Reflectometer
FSEC	Florida Solar Energy Center (FSEC) (Enterprise)	ASTM_5	ASTM E 408-71(2008), Standard Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques
NREL	National Renewable Energy Laboratory (NREL) (Enterprise)	ASTM_6	ASTM C1371-04a, Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissions meters (PEARL)
USEPA	U.S. Environmental Protection Agency, Heat Island Effect	ASH_3	ASHRAE Standard 90.1–2010 (LEED)
CRRC	Cool Roof Rating Council (CRRC) (non-binding)(Enterprise),	ASH_4	ASHRAE Standard 90.1–2010, Appendixes B and D (LEED)
LBNL	Lawrence Berkeley National Laboratory, Heat Island Group (Partnered with EPA) (Enterprise)		
ES_1	ENERGY STAR (partnered with EPA) (Enterprise)		
IDA	International Dark-Sky Association (IDA) (Enterprise		
ES_2	Energy Star: Duct sealing (partnered with EPA)(Entire)		
ABC	Australian Building Codes Board (Enviro)		
USDOE	US DOE Zero Energy Ready Home (Enterprise)		
PHIUS	Passive House Institute US (PHIUS)(supported by US DOE)		
LBC	Living Building Challenge Net Zero Energy Building Certification (Alliance with USGBC)		
RERH	ENERGY STAR products (Partnered with EPA)		
DSIRE	Database of State Incentives for Renewables & Efficiency (DSIRE): developed by DOE and the North Carolina Clean Energy Technology Center		
SEI	South face Energy Institute (Partnered with ECC, Atlanta , Georgia etc)		
NCDC	EPA: National Clean Diesel Campaign and verification		
	Guides Local governing bodies, codes, guidelines		**Third party assessment tools**
COMG	COMNET modeling guidelines	LEED	LEED ND (US)
ANSI_1	ANSI Standard 90.1–2010, Appendix G,	EGC	Enterprise green communities (US)
IESNA_1	Standard 90.1–2010, Appendix G, (LEED)	ECC	Earth community craft (US)
SS_530	SS 530: Code of practice for energy efficiency standard for building services and equipment	SCRS	Star Community Rating System (US)
SS_553	SS 553 Code of practice for air-conditioning and mechanical ventilation in buildings	BEAM	BEAM Plus Neighbourhood (Hong Kong)
CP_13	CP 13: code of practice for mechanical ventilation and air-conditioning in building - Legionella	BERDE	BERDE Clustered Development (Philippines)
AHRI	AHRI:Performance Rating of Water-chilling and Heat Pump Water-heating Packages Using the Vapor Compression Cycle (GM)	GBIT	Green Building Index Township (Malaysia)

HKC_1	Hong Kong Buildings Department: Sustainable Building Design Guidelines APP-152 (BEAM)	GMD	Green Mark for Districts (Singapore)
CNC	Ministry of Housing and urban-rural development 2013, Design Standard for thermal environment of urban residential areas (JGJ 286-2013), MOH, People's Republic of China.	CASBEE	CASBEE UD (Japan)
PNS	Phillipenes National standard (PNS) for Lighting products (partnered with International Electrotechnical Commission IEC)(BERDE)	IGBC	IGBC Green Township (India)
IESNA_2	IESNA RP 33 99 Lighting for Exterior Environments (PEARL)	TPC	The Pearl Community (UAE)
IESNA_3	IESNA RP 8 Roadway Lighting (PEARL)	GSASD	GSAS Dsitrict (Qatar)
MS_825_1	Malaysian Standards: MS 825 : Part 1 Code of Practice for the Design of Road Lighting; Part 1 Lighting of Roads and Public Amenity Areas (GBI)	EDM	EnviroDevelopment Master planned community (Australia)
MS_825_2	MS 825 : Part 2 Code of Practice for the Design of Road Lighting; Part 2 Lighting of Tunnels(GBI)	GSC	Green Star Communities (Australia)
IESNA_4	standards for Lighting Zone 2 as detailed in the IESNA publication RP-33-1999, Lighting for Exterior Environments (ECC)	BREEAM	BREEAM Communities (UK)
IESNA_5	IESNA Manual: Lighting for Exterior Environments includes lighting design guidelines.(Lighting for Exterior Environments, IESNA publication, RP-33-1999) (Enterprise)		
USAC_1	Air Conditioning Contractors of America, Manuals J: Residential Load Calculation and Manual S: Residential Equipment Selection (Entire)		
USAC_2	Air Conditioning Contractors of America, "HVAC Quality Installation Specification: Residential and Commercial Heating, Ventilating, and Air Conditioning Applications" (Entire)		**Peer review journals**
ASH_5	ASHRAE handbooks(cahpter not specified) (Entire)	J1	Santamouris M. 2001, 'On the impact of urban climate on the energy consumption of buildings', Solar Energy, vol. 70, pp. 201-216.
DOE_1	DOE Guidelines on Energy Conserving Design of Buildings: the Minimum Performance Rating of Various Air Conditioning System (BERDE)	J2	Oke TR. 1988, 'The urban energy balance', Progress in Physical Geography, vol.12, pp. 471-508.
ANSI_2	ANSI Standard 90.1–2010	J3	Shashua-Bar, L. Hoffman, M. E. 2002, 'The Green CTTC model for predicting the air temperature in small urban wooded sites', Building and Environment, vol. 37, pp. 1279 –1288
IESNA_6	IESNA Standard 90.1–2010	J4	Elnahas, M. M., Willimanson, T. J. 1997, 'An improvement of the CTTC model for predicting urban air temperatures', Energy and Building, vol. 25, pp. 41–49.
IESNA_7	IESNA Standard 90.1–2010, Appendixes B and D (LEED)	J5	Unger, J. 2004, 'Intra-urban relationship between surface geometry and urban heat island : Review and new approach', Climate Research, vol. 27, No, 3, pp. 253-264 (HKBEAM
DOE_2	DOE Guidelines on Energy Conserving Design of Buildings: minimum efficiency requirement of the air-conditioning system (BERDE)		
DOE_3	DOE Guidelines on Energy Conserving Design of Buildings: thermal wall transfer(BERDE)		
HKC_2	Hong Kong Buildings Department: Sustainable Building Design Guidelines APP-152 (BEAM)		
NREL	National Renewable Energy Laboratory, "Solar Ready Buildings Planning Guide," NREL Technical		
	Report (NREL/TP-7A2-46078): A paper published by NREL in December 2009 that details design		
	guidelines and checklists for designing solar-ready buildings.		
USGBC	Urban Green Council (New York affiliate of the U.S. Green Building Council (USGBC)): Building Resiliency Task Force Full Report, Backup Power Chapter;		
ASH_6	ASHRAE energy audit: Procedures For Commercial Building Energy Audits manual		
EPA	PA emissions standards of Tier 2		

Appendix B: Energy based –Headline Sustainability Indicator and frequency

Energy based –Headline Sustainability Indicator (E-HSI)	Frequency	E-HSI	Frequency
Energy Strategy	7	Energy efficient building envelope	2
Energy Infrastructure	5	Reduction in greenhouse gas emissions	1
Certified Green buildings	12	Nearing net zero	1
Renewable Energy: Offsite	3	Energy star appliances	1
Passive energy design	8	Electricity Meter	1
Building Energy Guidelines	1	Photovoltaic/Solar Hot Water Ready	1
Renewable Energy: Onsite	9	Resilient Energy Systems: Flood proofing	1
Peak Electricity Demand	6	Resilient Energy Systems: Islandable Power E-S-I	1
Urban Heat Island Effect	11	Earth Craft Builder Training	1
Energy Efficient Lighting	5	Renovation of Existing Commercial	1
Energy Monitoring and Management	2	Alternative Thermal Production E	1
District Heating / Cooling	6	Clean Emissions Protocol for Heavy Equipment	1
Energy efficient improvement in performance of buildings	4	Industrial Sector Resource Efficiency	1
		Total E-HSI	93