Architectural Engineering and Design Management

ISSN: 1745-2007 (Print) 1752-7589 (Online) Journal homepage: https://www.tandfonline.com/loi/taem20

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To cite this article: Wendi Goldsmith & Thomas Flanagan (2017) Value methodology – case studies within climate resilience and sustainability policy application, Architectural Engineering and Design Management, 13:1, 3-21, DOI: 10.1080/17452007.2016.1257420

To link to this article: https://doi.org/10.1080/17452007.2016.1257420

Published online: 30 Nov 2016.

ARCHITECTURAL ENGINEERING AND DESIGN MANAGEMENT, 2017
VOL. 13, NO. 1, 3–21
http://dx.doi.org/10.1080/17452007.2016.1257420

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Value methodology – case studies within climate resilience and sustainability policy application

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ABSTRACT
Design solutions addressing climate resilience and sustainable development are desired for policy application, yet often encounter friction within the design team as well as between designers and external community members. Factors include unfamiliarity with issues and strategies, resistance to innovation, and constraints of time and budget, among others. Here, we aimed to understand how design may be supported through adapting the established practice of Value Methodology to better address policy goals. Action research methods adapted the standard Value Methodology process by collecting community inputs and addressing second law considerations. Challenges related to stakeholder concerns, practitioner preferences, and uncertainty under future conditions, especially climate change, were addressed by applying Multi-Criteria Decision Analysis to elicit community value expressions. Absent detailed forecast or scenario analysis, entropy-based qualitative assessment was applied in proxy for resilient approaches. The adapted Value Methodology approach was applied for collaborative innovative design across green buildings, net-zero military installations, regional climate resilient infrastructure systems, and multi-state renewable energy developments. Examination of how and when parties shared inputs indicated general patterns revealing user acceptance. Through cumulative action research across multiple cases, our study revealed that entropy assessment aided systems-level problem-solving during community and designer workshops to guide problem definition, generate designs, and evaluate alternatives. Additionally, outcomes were improved when stakeholder input was obtained early and repeated iteratively. The main findings are drawn from practitioner and stakeholder responses which may provide input to shape further research and practical use in the field as design teams seek practical ways forward for complex assignments.

ARTICLE HISTORY
Received 4 December 2015
Accepted 31 October 2016

KEYWORDS
Sustainable development; climate resilience; value methodology; case study; policy implementation

Introduction

Background

Given the complex and evolving nature of sustainability and resilience policy themes, varied practitioners have expressed that they welcome strategies to support addressing their social and technical considerations. Having no supplemental staff or funding to apply, many project owners seek to address compliance with sustainability and resilience mandates through application of project investments previously justified for other purposes. However, realities of existing project budgets, work

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scopes, and practice conventions demand following certain expected procedures which, without adequate adjustment, may hinder desired outcomes. Value Methodology (VM) is a commonly used process to support effective design, yet its origins predate current policies and it does not inherently address their intentions. However, in many situations VM is expected or at least familiar. Multi-Criteria Decision Analysis (MCDA) represents a set of tools and practices to promote transparent and accountable consideration at various stages in the decision process. Rating systems for building and infrastructure sustainability exist such as those proffered by the US Green Building Council or Institute for Sustainable Infrastructure, among others. However, these systems are intended to evaluate designs, not support, steer, or enhance designers' processes. Additionally, it is uncommon for practitioners to systematically incorporate community inputs to the design process in a manner (unlike Charrettes) which expresses functional values. The authors have experience with multiple combinations of multiple tools, leading to an idea to incorporate entropy assessment during community and designer workshops to link the two, while also introducing systems-level thinking to define and solve problems. A proposed methodological innovation combining MCDA and VM in related contexts, both informed by entropy assessment, has previously been reported (Goldsmith & Flanagan, 2016). A detailed examination of theoretical derivation and practical suitability of the approach was provided. Examining case study applications could be useful to guide policy implementation through funded and constructed projects, and in further research, especially understanding how to navigate issues that arise in practice. Of particular relevance are questions related to how and why adaptations to the methodology appear to operate, especially when resulting in superior uptake by practitioners and/or project performance.

One issue of interest during our action research was consideration of when to draw inputs from community stakeholders and design practitioners to define problems, state and address value preferences, and evaluate solutions. Insight into factors affecting success, resistance, or failure in adopting methods or VM recommendations could be highly useful to inform possible future application. Using qualitative methods (Baškarada, 2014) seven case studies were assessed which span site-scale projects for private clients to site-scale and regional-scale projects and programs for large US defense agency clients. These project types represent significant financial investments (cumulatively over $15 billion to date) and potentially high environmental impacts, with infrastructure and other large programs shaping land uses with effects often lasting on the order of a century or more due to influence on further development patterns. The main aim of the research was to further develop the adapted VM approach. Exploration, description, and explanation were used to examine case studies in relation to key research questions relevant to contemporary design processes situated in real-world conditions:

- How can established methodologies align with effective systems-level design decisions?
- How can value expressions which account for community context be incorporated?
- How can entropy assessment serve as a cross-cutting factor to guide sustainable and resilient projects?
- How (including sequentially when during the process) can stakeholders including community and practitioners be called upon to express values to guide design?

Definitions and literature review

VM is an established best management practice required under law by the US government and used in multiple international industry sectors to improve the design of projects, products, and programs which is well documented (e.g. Bolton et al., 2008). It is considered a best practice for major design projects such as buildings and infrastructure. In professional circles, VM is at times regarded as a crude cost-slashing exercise, though this reputation appears to stem from its clumsy practice, not its intended purposes. Documentation of its use for sustainability and resilience-oriented policy implementation is scant (Al-Saleh & Taleb, 2010). However, the demonstrated benefits of VM for project improvement pose interest as a tool for the purpose of improved sustainability, and substantial performance increases have been shown applying standard methods for new geographies and topics (e.g. Rachwan, Abotaleb, & Elgazouli, 2016). MCDA is geared to accounting for complex trade-offs and unique preferences or constraints faced in project planning and design. It is often used to aid in capturing and/or translating value-based judgments by stakeholders into criteria for use by practitioners involved in design. MCDA has been applied to devising and selecting solutions, especially for complex environmental engineering problems, and little variation has been noted among results using different tools (Huang, Keisler, & Linkov, 2011). Combining the two methods has not been identified in academic literature.

Among practitioners, semantic distinctions are commonly blurred, and the problem is compounded where changing understanding and terminology usage exist, which is common as policy and technology evolve. For this paper, sustainability is defined to address natural resource-limited growth as examined by Meadows, Meadows, Randers, and Behrens (1972; Meadows, Randers, & Meadows, 2004). Given the human focus of the design sphere, social and economic factors must be addressed along with natural resources and ecological processes. Sala, Farioli, and Zamagni (2013) note the absence of a singular sustainable science-based mode to solve societally relevant problems, instead observing the need for incorporating values, perspectives, and interests of legitimate stakeholders. Likewise for this paper, resilience is defined through grounding in the ecological concept of systems maintaining their capacity to perform certain functions in the face of perturbance (Holling, 1996). Resilience in the context of sustainable development and disaster management also draws upon ecological principles (Brand, 2009; Walker et al., 2002). An intrinsic attribute of resilient systems is their ability to resist or absorb damage and recover after disturbance without altering the essential pattern of the functional regime. In the US, the National Academy of Sciences defines resilience in terms of functional capacity related to natural disasters and other threats: planning and preparation, absorption, recovery, and adaptation. Folke et al. (2010) examine socioeconomic and biophysical systems and pose the seemingly counterintuitive idea that the ability of systems to change and adapt is requisite to their ability to persist. However, the complex theoretical basis underlying these conceptualizations limits their application in real-word practices, as noted by Bene, Godfrey Wood, Newsham, and Davies (2012). Ongoing US federal research has posed a seamless view of resilience in which natural ecosystem and built infrastructure elements operate jointly to utilize physical and biological elements to address social priorities (Bridges et al., 2015).

The second law of thermodynamics currently plays important roles in analysis of complex systems from economies, to watersheds, to energy infrastructures, and more. Increasingly, mathematical modeling tools incorporating entropy-based functions allow treatment of self-organizing systems (such as biological and ecological systems) with implications for future applications (e.g. Cattani, Chen, & Aldashev, 2012). Since Georgescu-Roegen (1971) first posed the linkage between entropy and economics, debate has continued on how, and under what conditions, the second law applies. Second law assessments have been applied to energy systems in the built environment to address efficiency and sustainability criteria (e.g. Cleveland et al., 1984; Hall, 2011). Gutowski, Sekulic, and Bakshi (2009) observe that millennia of evolution have equipped natural systems with an ability to sustain their key functions on a resilient basis, and suggest that society emulate its second law characteristics. Current interpretations (e.g. Ayers, 2002; Ho & Ulanowicz, 2005) suggest the importance of storage and cycling to reduce systems' entropy production. In the fields of energy efficiency, operational self-sufficiency, and disaster resilience, assessments aimed toward recovering and conserving energy and materials already exist (e.g. Kryziak, 2006). While detailed quantitative analysis remains beyond the reach of practitioners in the context of project design, qualitative entropy assessment poses interest.

Social dynamics within design teams and between teams and their clients and affected communities often propel an expedient or over-simplified decision process which impedes innovation. Hatano and Inagaki (1986) describe how practitioners favor efficiency over adaptive expertise, and self-interest motivates them to choose routine and automatic solutions perceived as comfortable and low-risk. The design process itself has been described as benefiting from 'rule-breaking' jolts to generate outside-the-box thinking, ideally within an efficient facilitated framework (e.g. Hatchuel, Le Masson, & Weil, 2009). VM has been applied in situations where innovations to support sustainability are sought, and technical breakthroughs are pursued (e.g. Elmquist & Segrestin, 2009). However, references on VM applications toward creative breakthroughs encompassing social and ecological values have not been identified.

Methods

The authors drew from engagement on clients' projects through action research to study the process with particular interest in practitioners' perspectives which may be shifted through adjustment of established methods used in the planning, design, and continuous improvement processes for environmental engineering and large infrastructure projects. Identifying details of parties are confidentially maintained as per action research convention (McNiff and Whitehead 2011). The research revolved around testing the validity of using the proposed methodology for integrating MCDA and VM framing sustainability and resilience as community values. Namely, the objective was improving understanding of how and when stakeholders could be engaged to define value preferences related to multiple criteria, and how the VM process could then be adapted to foster design solutions aligned with sustainability and resilience, rather than defaulting to customary financial considerations alone. Assessment of entropy in terms which are subjective and/or qualitative is similar to assessment of financial metrics during project planning or VM workshops: detailed studies with rigorously derived information are typically unavailable so professional judgment is the prevalent influence. Illustrative examples of qualitative entropy assessment are:

Lower Entropy	Higher Entropy
Renewable energy sources	Fossil fuel combustion
Locally produced solar power	Centrally generated solar power
River corridor with complex form and riparian vegetation	Concrete lined straight flow channel
Re-use of process water on site	Disposal of water after one use
Harvesting rainfall for irrigation	Curb/gutter off-site conveyance

Qualitative entropy assessment was performed for initial project conditions, policy goals, stakeholder values expressed, and feasible technical solutions. Qualitative and relative assessments of entropy state (S) for existing conditions and possible alternatives were identified using expert opinions supplemented by industry data. Entropy assessment was introduced in lay terms to guide community workshop inputs, and was applied in a manner deemed suitable by the participants of the designers' workshops (which in all cases was more sophisticated than during community workshops). In a manner of speaking, use of entropy assessments was applied in proxy for more detailed information such as scenario analysis, simulations, life-cycle assessments, and other tools useful for evaluating project sustainability and resilience. Doing so allowed rapid evaluation and design guidance toward creating or revising design solutions, when other information was unavailable, or appeared infeasible to apply.

MCDA and especially VM are inherently structured to match questions probing *how* cases and workshop participant responses vary. Per Yin (2013), such *how* questions are well served by answers which trace operational links over time, as opposed to statistical analysis of incidence or frequency, when units of analysis are clearly defined. Our study defined the unit of analysis as the design process linking MCDA (for stakeholder value inputs) with VM (for design functional optimization) and guided through systems-level thinking through qualitative entropy assessment (the adapted methodology). Selected case studies are revelatory of evolving methodology within an action research framework. To a practical, though not ideal, extent they serve to identify and shed insight on longitudinal trends over time, as sought by the US General Accounting Office (1990), the agency responsible for fiscal responsibility in public spending. Cases were selected based on several factors shaped by their action research context, namely:

- Convenience – allowing expedient access for data collection and process observation
- Special Interest Purpose – based on Sustainability and/or resilience attributes of projects
- Criticality – Strategic importance to the general problem

MCDA and VM are both semi-structured processes for engaging multiple parties for information exchange and evaluation. As such, they include opportunity for unexpected responses such as revealing surprising evidence (Daymon & Holloway, 2002). Huang et al. (2011) note that practitioners are inclined to share case studies with successful applications which tends to produce censored data in the literature. The intent here was to offer a range of cases to provide richness and relevance for within-case analysis as a trade-off for formal between-cases analysis.

Case study information, featuring type of project and client, geographical location, functional highlights, and outcomes (reflecting constructed features, observed performance, third-party recognition, or unmeasured program-level impact), is presented in Table 1. Methods of engaging stakeholders in a whole systems approach supported by useful decision procedures and tools followed a variety of established methods (e.g. Christakis & Bausch, 2006; Flanagan & Christakis, 2010; Tylock, Seager, Snell, Bennett, & Sweet, 2012). Although VM was formally applied in all cases in the form of one or more designer workshops, additional decision support methods were also addressed

Table 1. Case study presentation.

Project	Location	Functional highlights	Sustainability/resilience outcomes
A-Campus Quadrangle Stormwater Harvesting System (private academic client)	Cambridge, Massachusetts	Beneficial water re-use using small increment of added infrastructure; biofiltration swale for water quality treatment; locally generated power (from solar panels) operates pumps	Project recognized by US EPA for sustainability; water use reduction valued as local water shortages occurred
B- Regional Water Purification Facility (public utility client)	New Haven, Connecticut	Water gravity-flows through treatment system; ground source geothermal heat/cooling; and landscape elements function to process stormwater and backflush water	Power outages from ice storms and Hurricane Sandy did not affect operations, other facilities suffered
C-Hurricane and Storm Damage Risk Reduction System (national defense client)	Greater New Orleans, Louisiana	Risk-based decisions addressed change/uncertainty; dredged sediment re-used for wetlands; flood measures engineered for system synergy; photosynthesis assessed as key system input	Decision frameworks used post-Katrina (2005) enabled resilience for Gustav (2008) and risk reduction for Isaac (2012)
D-US Air Force Capability Based Planning (national defense client)	Multiple States, USA and Int'l	Mission support linked to facility asset management; sustainable sites and Green Infrastructure promote personnel retention and health via walkability, livability, and family preferences	No Data; however, threat reduction, sustainability, and operational efficiency are stated program goals
E-Regional Renewable Energy Plan (national defense client)	Multiple states, USA	Prioritized collaboration with other agencies for resource sharing; identified co-location opportunities for renewable generation and energy-secure consumption for mission support	No Data; however various Public Laws and Executive Orders require energy security and sustainability
F-Ultra-Low Energy Military Installation Study (national defense client)	Forts Irwin, Belvoir, and Carson	Assessed natural gas co-generation and tri-generation alternatives; identified options for linking water and energy infrastructure for resource harvesting; developed 2nd Law-based decision support tool	No Data; however various Public Laws and Executive Orders require energy security and sustainability
G-Energy Independence and Security Act Compliance Study (national defense client)	Fort Campbell, Kentucky	Stormwater managed through Green Infrastructure; building energy efficiency reduced peak demand; identified landfill site for solar panel ground array	No Data; however various Public Laws and Executive Orders require energy security and sustainability

on a contingent basis within a framework (Howard, 1988) suiting individual project needs, client customs, and stakeholder concerns. Concurrent notes and/or recordings documented practitioners and stakeholders' responses, in addition to project-specific reports and technical articles produced, some of which are available to the public where referenced. Pattern matching per Trochim (1985) was applied to analyze and interpret across cases, considering patterns developed through observations.

Participants

Community workshops spanned either multiple professionals from various organizations, or additionally included general community members. Experience levels and training types (if any) varied widely, though community members often had levels of expertise equivalent to practitioners. Smaller-scale and shorter-term projects had 4–6 parties with direct interests and detailed knowledge of a project, and also subject matter expertise and/or demonstrated creative problem-solving skills. For larger projects where the number of interested parties and applicable forms of expertise was vast, stakeholder groups were large – ranging from 125 to 250 people – and extremely strong facilitation and management skills were demanded. One very large, pressing, and controversial project initially relied upon a smaller group of 30 representatives to determine a clearly framed starting point for inclusive consideration, and subsequently venues were provided for all interested parties to contribute to the construction of the inclusive view of expressed values integrated within the situation under consideration. Community workshops included ground rules which were clarified regarding confidentiality terms, as well as group dynamics such as acceptance of vigorous challenge, and non-tolerance of negative attacks, which would otherwise lead to exclusion from the process. Once workshops were convened and ground rules understood, sustainability and resilience topics were introduced in a manner accessible to community members. The intent of this step was to open new channels for framing project values, surfacing impacts and/or benefits for stakeholders, and suggesting improved solutions highlighting systems-level advantages. Qualitative entropy was typically not discussed overtly during community workshops, but facilitators considered entropy assessment during formulation of triggering questions and discussions.

Next, during VM workshops which largely included professional practitioners, qualitative entropy assessment was introduced into the process, initially to shape designs and later to select among alternatives. Case projects generally followed VM protocols suited to their scale and type, as per Project Management Institute standards. The adapted methodology addressed topics and issues that standard planning and design procedures had previously failed to accommodate (during the project history, or for prior similar projects). Each case involved the application of qualitative analysis of entropy toward optimizing sustainability within the built environment and natural systems and processes, mainly through resource recovery and co-functioning within systems. Workshops included tightly facilitated group meetings, driving team members toward focused analysis of functional benefits, with access to detailed supporting project-specific information and industry best practices. Workshops started by ensuring all participants understood not only the construction program details, including current status and identified issues, but also key mandates, such as ensuring the entire military installation or civilian community was fulfilling all requirements related to performance and policy, including reduced threat from natural disaster or military action. VM workshops varied, lasting up to a full week assessing an entire military installation, multiple installations and Project E which was unique in using a series of four intensive workshops. In five case studies, briefings provided education on unfamiliar measures (such as green infrastructure for stormwater management) to increase awareness, comfort level, and motivation. In practice, many decision-makers individually and collectively possessed only some critically important information needed to make environmentally and economically sound decisions that fully reflect community interests. Hence, procedures to fully engage people and information consistently were considered useful.

Practitioners included Certified Value Specialists with credentials for facilitating VM workshops in all cases. Additional practitioners included engineers, architects, landscape architects, earth scientists, biological scientists, dedicated research scientists, energy managers, budget managers, facility managers, public safety officials, end users, and representatives of local communities and special interest groups. Although the constellation of practitioners varied between projects and their phases, a similar degree of diversity was generally present. In all cases, parties beyond professional designers were involved as well, necessitating the use of methods accessible through levels of shared knowledge, rather than specialized expertise.

Unit of analysis

Project case details and participant responses were assessed through pattern matching for recognition of patterns, examination of linkages, and interpretation of practices concerning systems-level basis for design decision-making. According to action research conventions, the queries involved departing from routine interactions by introducing new elements, in this case community value statements related to sustainability, and resilience linked with entropy assessment complementing standard VM financial assessment. Analysis emphasized the identification of the technical and procedural points which participants indicated were important for improved understanding, novel solutions, and generalizable future practice. The process of linking MCDA and VM methods varied across project cases as the Unit of Analysis (|Yin, 2013). Insights related to differences in the thematic content or sequential timing of the process were noted and are tabulated in Table 2. Potential analytical results indicative of methodological failure were identified, ranging from the newly introduced elements being rejected by participants as a valid course of inquiry, to not supporting the development of novel preferred solutions (as viewed by participants), and also not corresponding to performance (as documented through formal monitoring or anecdotal reporting). Performance of case study projects was identified as potentially existing at various levels, namely, attainment of shared decisions related to completed or intended actions, to operational functionality demonstrating sustainable and/or resilient characteristics, as well as uptake or other influence to a wider community. Success or failure was understood to be potentially revealed at various points in time, including during the workshops through direct subjective feedback (namely verbal and body language conveying mood/tone, and similar immediate responses to workshop content and group dynamics), upon devising/refining project plans and specifications through clashing (subjective or objective) technical issues, or during facility operation and use or similar channels of objective review.

Results and discussion

Sustainability and resilience as special interest purpose

In action research, the focus on social dynamics and group process tends to produce findings that are subjective in nature, guided by researcher interpretation within the real-world context. This study faced further challenges due to the confidential, and in some cases security-sensitive, nature of the projects and teams involved. The authors have sought to balance useful findings with the need to avoid revealing identifying detail. In order to validate the projects that fulfilled special interest purposes related to sustainability or resilience, project performance outcomes were considered. The nature of the targeted and/or achieved outcomes related to sustainability and/or resilience varied among projects as outlined in Table 1. Evidence for the outcomes was derived from project owner reporting, with additional third-party reporting confirming results for Project A (namely an EPA review during an award submittal, though increasing use of USGBC LEED certification may provide similar evidence with the benefit of the certifying body applying its standards). However, to address the research questions per the defined Unit of Analysis, the authors considered objective

Table 2. Workshop attributes and insights.

Project	MCDA Program Community participation	VM Program Designer participation	Timing and approach insights
A	Wkshp 1: 6 people, 2 hrs Preceded VM, highly productive	Wkshp 1: 10 people, 3 hrs Wkshp 2: 6 people, 2 hrs Wkshp 3 6 people, 2 hrs Initially contentious, but resolved by Wkshp 3	Early community inputs were effective at overcoming initial designer antagonisms. Success of process led to wide future adoption
B	Wkshp 1: 4 people, 2.5 hrs Wkshp 2: 6 people 3 hrs First wkshp preceded VM, second occurred after VM wkshp 2	Wkshp 1: 12 people, 4 hrs Wkshp 2: 12 people, 16 hrs Wkshp 3: 10 people, 8 hours Smooth integration of community preferences into VM	Community and design team workshops were interspersed. Initial aesthetic focus gave way to efficiency and resilience focus
C	Wkshp 1: 152 people, 6 hrs Wkshp 2: 30 people, 6 hrs Wkshp 3: 243 people, 2 hrs Wkshp 4: 126 people, 2 hrs Wkshps 1 and 2 preceded VM, then alternated through 1-year design period	Wkshp 1: 18 people, 16 hrs Wkshp 2: 14 people, 16 hrs Wkshp 3: 12 people, 16 hrs Well integrated throughout	Initial community wkshp was instrumental to overcome mistrust and elicit clear value preferences for use by designers. Iterative wkshp cycles supported refinement
D	Wkshp 1: 25 people, 6 hrs Intended as agenda-setting exercise to provide input to guide future projects which are mandated by federal rules to include VM process during design phase	N/A as design phase had not been initiated at the time researcher involvement ended as per contract scope	Up-front workshop included significant preparation and coordination to ensure relevant parties participated. Client found the process enlightening to restructure future programs, including for defining requirements
E	Wkshp 1: 24 people, 6 hrs Wkshp 2: 22 people, 6 hrs Wkshp 3: 62 people, 2 hrs Wkshps 1 and 2 triggered interest from wider group of self-identified stakeholders and provided clear inputs for later VM	Wkshp 1: 22 people, 6 hrs Wkshp 2: 28 people, 6 hrs Wkshp 3: 8 people, 6 hrs Subsequent to community workshops and intended to formulate program strategy, not project-specific design	Early community engagement allowed problem re-definition, clarification of relevant policy and law, and prioritization of design criteria and program strategy
F	Wkshp 1: 8 people, 6 hrs Preceded VM wkshp	Wkshp 1: 11 people, 12 hrs Included additional R&D participants to examine emerging technology during VM process	Early community workshop informed prioritization of self-sufficiency and efficiency as design goals
G	Wkshp 1: 6 people, 2 hrs Called for during multi-day VM process to troubleshoot compliance issues	Wkshp 1: 18 people, 24 hrs	Adding community wkshp to supplement VM wkshp provided clarification of nearby compliance shortfalls, thus expanding design criteria

(numbers of workshops and participants and their timing and sequencing) along with subjective interpretation (including self-reported observations quoted from participants). Consistency of patterns was observed relating to how systems-level thinking supported improvement and alignment of understanding (by stakeholders) and design problem-solving (by practitioners). This understanding and alignment aided the development of solutions, as well as decision-making related to valuing their direct and external costs and benefits. When the perceived driver was regulatory compliance (originally viewed as low value) rather than addressing community or project owner interests (viewed as high value), workshops featured reluctant or dismissive participation. Yet attitudes changed abruptly when participants considered systems-level issues that revealed alignment between regulatory and policy drivers and stakeholder interests. In this manner, implementation of sustainability and resilience policy became perceived and ranked quite differently, and often generated wider interest in the design process and subsequent practice or program approaches. In short, designers and community members rallied around project solutions and achieved design revisions and improvements when they understood that solutions addressed problems they were concerned with (safety, mission operability, life-cycle cost savings, etc.) rather than abstract policy issues (sustainability and community support were often seen as trade-offs that distracted resources away from core priorities, until they were shown to align with them).

Analysis across varied cases

Table 3 identifies the key themes that emerged through application of the adapted methodology. Given that the variations in the processes used among cases are numerous and irregular, it is nonetheless possible to distill themes broken out by unit of analysis.

The stakeholder engagement assessment summarizes the obstacle, conundrum, query, or driver that instigated the use of the methodology, by case. Though the issues varied, the common pattern was a perceived need to improve communication, advance coordination, and resolve conflicts. The origin of the need or intention to apply VM with community and entropy features to the process was universal, though the pathway and timing to begin the process varied.

Table 3. Case study analysis.

Project	Stakeholder engagement assessment	Multi-functionality assessment	Qualitative entropy assessment
A	Academic building boom viewed as conflict with Combined Sewer Overflows (CSO); City posed requirement for on-site detention of 100-year storm; building investments co-opted to solve problem, resolve conflict	Measures function for stormwater detention, water harvesting, treatment, and aesthetic focus of quadrangle; campus uses site for teaching students and professionals	Energy inputs from photosynthesis/ solar power = lower S than grid; water re-use creates low-S on-site cycle; lower energy supply risk = lower S
B	Abutter opposition and stringent multi-layer regulatory constraints conflicted with infrastructure siting; Green Infrastructure approach appealed to all, converting opponents to supporters and changing agency culture	Wetland restoration and mitigation coordinated to function for on-site natural water treatment, aesthetic and recreation resource, and public demonstration/ education; surface water infiltrations promotes geothermal efficiency	Energy inputs from geothermal, gravity flow, and photosynthesis = lower S than grid; water management creates low-S on-site cycle
C	Environmental and navigation interest groups initially concerned opponents of rapid project, became advocates once input was sought and used; strong proactive formalized program and project stakeholder processes adopted	New structures and management regimes functioned beyond flood control for improved ecosystem services and navigation; infrastructure supported estuary health, and wetlands buffered structures	Photosynthesis and sediment re-use (wetland surge buffers) as inputs create low-S on-site cycles; system synergy/redundancy reduces risk = lower S
D	Fiscal pressures demanded long-term budget reductions, which conflicted with current facility plans and morale; mediation with senior officers to engineering experts to enlisted personnel shaped win-win strategy	New policy compliance (energy and sustainability priorities) also functioned for healthy living, attractive grounds, and ecosystem services; Green Infrastructure doubled as anti-terrorism force protection (ATFP) measures	Energy inputs as photosynthesis (shade trees and bioswales) and humans (walking) = lower S than grid/cars; health/retention reduce inefficiency
E	Formal and informal coordination among senior leaders spontaneously generated recognition that a coordinated plan could offer many benefits related to savings, military readiness, local economic stimulus, and environment	Proposed measures functioned for re-use and co-use of existing facilities; efficient retrofits of dams (and transmission), coordination of generation and critical infrastructure energy demand, and fulfilling multi-agency needs	Hydro/wind/solar/biomass/etc. generation = lower S than grid; co-location of generation and use creates low-S on-site cycles; low energy risk – low S
F	Competition for investment and operations resources created conflict and lowered the bar for infrastructure upgrades. Identifying ways to combine water/energy and efficiency/security stimulated buy-in and creativity	Evaluated alternatives to combine/link energy/water/materials infrastructures for efficiency and cyclic operation; considered loss prevention via resilience and risk reduction as priority rather than first-cost savings	Beneficial re-use of wastewater and rejected heat (from gas generator/ sewer) creates low-S on-site cycles; reduced energy supply risk = lower S
G	Planners, designers, users, and external subject matter experts to evaluate if project suite could address base-wide EISA requirements individual scopes failed to incorporate.	Clarified cumulative EISA requirements; examined individual projects for solution opportunities for same or other sites; identified ways to combine/share facilities for cost savings	Energy inputs from photosynthesis/ solar power = lower S than grid; water re-use creates low-S on-site cycle; lower energy supply risk = lower S

The multi-functionality assessment identifies the design measures or operational practices that arose as desirable solutions. The design feature configurations, and the degree to which projects improved their value and acceptance through increasing multi-functionality, ranged widely. However common themes included use of natural systems, reliance on locally available resources, and varied functions at different times. Participants welcomed broadened and overlapping scopes of solutions, though often commented the process prompted a different way to think about problem-solving.

The qualitative entropy assessment summarizes how the entropy state of one solution (be it current conditions or an alternative design) compared to another. Again, the content and format of second law considerations varied, but the effect of linking it with design produced consistent effects. Introducing the concept forced community member and designer participants to consider new facets of how to approach projects. Generally, fresh critiques of current designs ensued and a round of creative new ideas were generated. These creative rounds often went through multiple iterations, including cycling between community and design team exchanges. Notably, resistance (observed through facial expression, body language, tense dialog, etc.) was lower than commonly encountered during typical design critiques, despite profound shifts in the course of the design approach. Rather than defensive or turf-shielding attitudes, participants indicated through word and deed their grasp of shared purpose and collective value.

Workshops: presumed intent vs. functional outcomes

Every case study project included a recognized obstacle (time, funding, regulatory constraints, perceived conflicts, knowledge gaps, etc.) that had invoked some type of special handling to support and enhance the ongoing design process related to sustainability and resilience themes. However, even when these issues were known, and some type of facilitation and coordination was sought with the scope and purpose of constructive problem-solving, the ability to formulate a proactive strategy was rather poorly characterized in most cases; hence, stakeholder elicitation included (re-)framing the defined problem as well as examining preferences. Guidance and involvement were provided ranging from highly ad hoc and sporadic, to well-structured and intentional formats. The initial step of convening suitable stakeholders around an identified project or problem is itself subject to judgment, and each case study differed accordingly. Stakeholder engagement was interpreted through assessment of utility obtained through expressed preferences, though methods varied between projects due to unique constraints. Some examples are:

- Written feedback collected through formal public environmental review which was extensive but poorly structured for use
- Detailed ranking performed interactively by workshop participants, both revealing and strengthening stated preferences in a manner that flowed smoothly into design decision process
- Application of software tool to correlate stated preferences with calculated values, though the approach generated curiosity about the algorithms more than useful insight from outputs

Utility elicitation varied widely as methods and concepts were explored and developed, and according to project demands. Stakeholder inputs regarding value preferences used methods ranging from informal rankings, to formalized decision analytical tools tailored to the domain of resolving social conflict, to production of detailed multi-variate utility models. However, in all cases, participants engaged in what they consistently described as a new type of understanding of the situation at hand, including desired attributes of possible design solutions. These inputs were integrated within MCDA tools which varied in format and level of sophistication. As noted by Huang et al. (2011), results as indicated by stakeholder acceptance do not vary significantly between MCDA tools used for environmental projects, and those applied in the seven case studies varied in terms of method, timing, and participants. Although it was not possible to structure projects to create closely replicated procedures, the variations in timing and sequencing of workshops allowed rich observation and interpretation. In particular, responses of participants revealed thoughts affecting their decision-making. Workshop attributes for community inputs (via MCDA) and design team process (using VM), including insights, are presented in Table 2.

Regarding timing of stakeholder value inputs, MCDA, VM, and related assessments applied during projects and their relative merit for outcomes, evaluation is by nature highly subjective. In general, the observed patterns suggest that early and often works best for linking community preferences and design decisions. Four projects benefited from early planning phases which served to structure agreement and support for deciding how to balance utility and trade-offs. In the other three cases, some disturbance to decision process and value agreements occurred, and it was useful to have prior expressions regarding utility preferences and design linkage in order to regain the proper course to achieve desired outcomes. Lastly, two projects identified utility related to potential design solutions or compliance strategies simply too late in the process to effectively adopt them, though insight was absorbed for future occasions (as formal program strategy going forward, or as practitioner learning to apply later). For example, in Project A, collaboration was established early among design professionals, yet special city-required conditions were seen as the driver, not innate value in pursuing a sustainable approach. Appealing measures using engineered wetlands and solar powered pumps to handle and cleanse urban stormwater were developed, with community and practitioner curiosity and eagerness vocally expressed. However, when the city's rules were relaxed and the overall multi-building project budget became too high, the proposed measures were cancelled (for a period of two years) due to low perceived value. A new issue arose related to failed regulatory compliance, and it created a new driver to 'do something sustainable' so the proposed measures were re-adopted. This illustrates a partial failure to consistently develop and maintain valuation, though eventually the prior VM-guided design solutions became justified again.

As an example of different dynamics, in Project C, collaboration was well structured, highly formalized and inclusive, and captured many resource recovery functions developed through entropy assessment discussed in workshops (Goldsmith, DeSoto-Duncan, & Durham-Aguilera, 2012). One design idea which was posed early, yet not adopted at the time, was incorporating wind power generation for on-site resilient energy supply co-located with flood control structures (Goldsmith & Temple, 2013). Due to schedule constraints, the alternative was not used directly, but consideration of financial/technical feasibility, risk reduction potential, and other utility factors proved attractive and became embraced as a new standard to incorporate in future projects. One non-federal infrastructure owner near the project site stated

> I was gobsmacked to realize the floodwall footings could also serve to support large wind turbines. Building infrastructure that generates revenues, at least to partially offset ongoing costs, is a great idea we are now using nearby – how did we all miss thinking that way for so long?

This illustrates the benefit of value elicitation for shaping creative designs and for linking them with benefits of utility to community stakeholders and risk managers. In this sense the VM approach was successful, just not in terms of near-term outcomes for the one energy proposal not yet adopted. For all projects, workshops resulted in better defining project benefits in terms of utility to key decision-makers, including through avenues found to be surprising or novel to participants, rather than driven by regulatory policy and related requirements.

Linking second law considerations with utility values

Issues facing progress toward outcomes are discussed with emphasis on generalizable findings rather than case-specific details. Table 3 identifies the key features supporting project outcomes, highlighting stakeholder, multi-functionality, and entropy-related assessments within the VM process. In all cases stakeholder context contributed to defining (generally at the starting phase) and integrating (facing conflicts or opportunities for improvement) value using a utility approach. High-value solutions featured multi-functional elements identified through VM functional assessment with consideration of utility improvements through combined purposes. General project performance and development outcomes were framed on a case-by-case basis in terms of conflict resolution, problem redefinition, shared solution identification, scalar adjustment, cross-disciplinary linkage, cost savings, time savings, qualitative entropy, sustainability, risk, and resilience. Practitioner responses varied among projects, and included problematic points, as well as surprising insight-building points. In several cases, consideration of systems-level value appeared to generate unexpectedly high interest among stakeholders, resulting in technical solutions and community buy-in that greatly exceeded early expectations, as discussed below. Overall, the seven case studies did not encounter overt failure during the MCDA and VM process, or during operation and use (where applicable). However, the process for reaching satisfying or exceptional outcomes is not without challenges as seen through case-specific observations of antagonism, mistrust, and competing interests.

Several possible ways to integrate MCDA and VM were applied, all including entropy assessment to guide the decision process. For dealing with regional issues such as climate change adaptation for urban areas with sensitive and low-lying landforms, the methodology allowed utility to be expressed in relation to changing risk profiles. The process identified measures to effectively address risks, but also generated solutions that were financially viable and contributed to resilience of coastal landforms and local socioeconomic systems. For example, in Project B, stakeholder elicitation yielded utility related to use of portions of one land parcel for multiple complementary purposes, thereby avoiding tens of millions of American dollars of cost previously assumed as necessary. The cost-saving, multi-use plan required modified design, but was preferred by community members, one of whom stated 'Community meetings usually attract people venting displeasure. I was surprised to be asked to help steer the design, and more so as our inputs were actually put to use. When I came to this meeting, my attitude was "not in my backyard!" but now it is "please yes in my backyard!"' The initial multi-purpose infrastructure-as-park concept in turn inspired designers to identify further multi-functional opportunities for deeper cost reductions which counterintuitively had even higher utility to stakeholders. Ultimately, a radical approach to maximize on-site water- and energy-handling technology, and employ passive systems including gravity-fed flow replacing originally designed pumps, produced a highly sustainable facility (which also proved disaster resilient, as discussed below). However, these unusual project elements would likely not have arisen if community meetings were only held as a pro-forma step toward the end of project design, as is typical.

A different example in Project G began by presuming that additional funding would be needed but ended with recognition that many costs could be avoided with money diverted to invest in a PV array providing renewable backup power supply. Focusing on unattended requirements for resilience and sustainability with high utility for end users allowed the VM process to structure design solutions and allocate costs, with life-cycle savings. Key project phases have not yet been implemented, though they are designed, and in fact required by regulation. Incremental increases in coordinated stakeholder and practitioner engagement appeared consistently fruitful for identifying and modifying (through improvements) utility of design related to multi-functionality and low entropy resource management patterns. Often this increase in utility corresponded with cost avoidance, though at times additional costs or other resources (for land, equipment, etc.) were needed.

Capacity building for organizations and communities was an intended goal or accidental outcome for some projects. For example, Project F was structured as a research study to identify novel methods and solutions related to efficient water and energy use within military and civilian communities. Investigation of entropy-based assessment in the context of MCDA was targeted for research within the original study design (Bawden, Prado, Seager, Mechtenberg, & Bennett, 2011). VM was used to engage practitioners and end users to refine design alternatives to address utility as preferred by end users. Stakeholder engagement occurred with an emphasis on building a decision support tool, and was not warmly received by end users who were unfamiliar with the approach or its potential benefit. The study produced published results and practitioner's interest, but did not gain reception within the potential client community, representing a failure to build capacity at that point in time. However, practitioner insight from the project informed further efforts elsewhere, with one engineer noting,

> Entropy assessment forced me to interact with other team members and consider aspects of design beyond what has occurred in other workshops structured in similar ways – and I have been doing this work for over 20 years, so that is noteworthy to me.

A differing example in Project D sought to generate and institutionalize understanding related to military facility planning addressing multiple criteria including sustainability (efficiency and leading by example), user appeal (soldiers and families find military bases livable and prefer continued military service), and improved health (reducing lifetime medical costs and improving physical performance). Utility models were developed, and VM was employed to structure generalizable design solutions (Weigand, Flanagan, Dye, & Jones, 2014). A solution enshrined in the new standards was green infrastructure, as measures were found to handle stormwater sustainably, create attractive streetscapes lined with trees, and provide shade making walking possible, thereby increasing physical exercise. Broad agency-wide standards were developed, with stakeholder utility forming the basis for value. While the standards do not represent observable outcomes in a concrete sense, they do represent a substantial capacity-building result.

One case study, which can be properly described as a program rather than a project, stands out as an example for how a utility-oriented approach to elicit value preferences of a relatively small group could spontaneously gain interest of a large group addressing multiple utility models. In Project E, managerial and technical practitioners entered a formalized VM process to systematically evaluate a new program at its start, related to renewable energy generation in a four-state region (Strategic Value Services, Inc., 2010). As depicted in Figure 1, the project was initially conceived for the purpose of ensuring compliance with new regulatory mandates to increase renewable energy

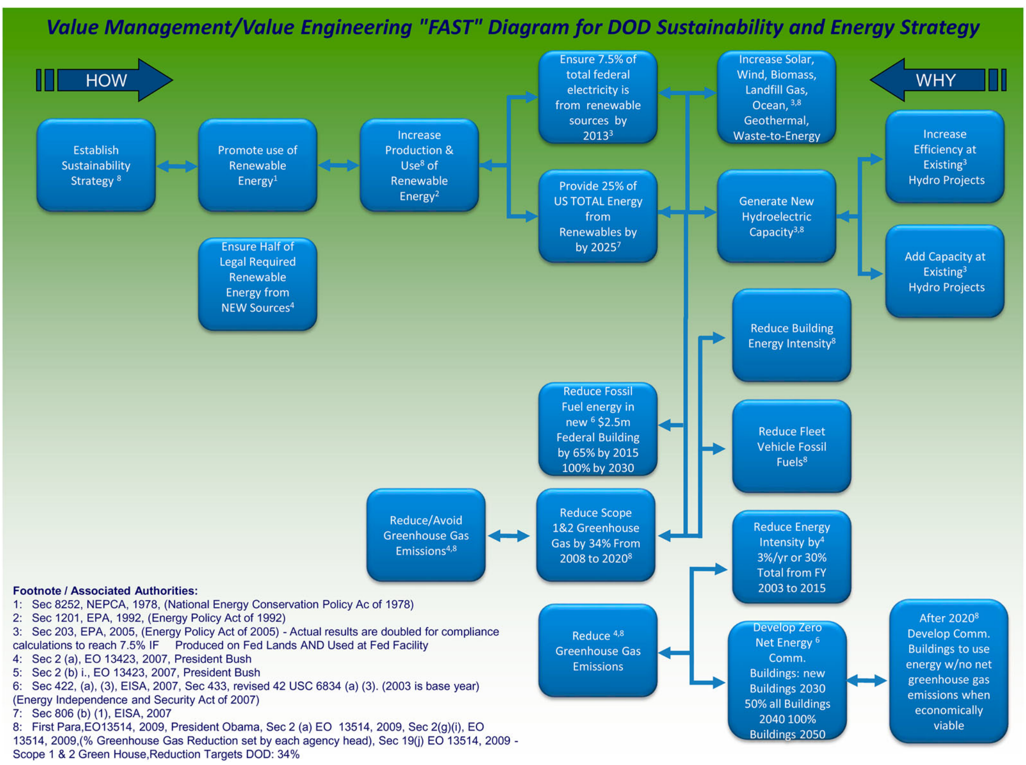

Figure 1. Functional assessment systems technique.

generation, but the functional assessment systems technique revealed four 'boxes' supporting 'establish sustainability strategy' which could be evaluated using a utility approach to identify value as well as justify resources. For instance, energy security was noted as a preference in terms of reducing dependence on distant generation sources, making hydroelectric power produced in the region more highly valued than solar power produced cheaply in the sunny southwest states. Consequently, the decision process aligned around solutions with preferred benefits, rather than lower costs. Energy security, which was understood to imply resilience from power transmission failures as well as foreign supply, was also viewed as an acceptable justification for additional costs. Potential energy producers and users learned of the workshops and sought inclusion. The resulting utility approach to project preferences identified synergistic matchmaking. Essentially workshop participants were able to identify ways to share resources to solve reciprocal problems and developed utility models that obviated the need for redundant expenditures.

As one participant noted

> Normally when creating a FAST diagram, we seek to define clear linear relationships governing how vs. why to take certain related actions, and facilitators frown on too much back-and-forth that keeps people spiraling in non-linear thoughts. But here, the assessment of multi-functional solutions with fewer inputs and outputs actually helped us develop improved options. It was as if we had a new sub-routine for iteratively considering efficiency and sustainability at each linear step.

This comment is not unlike those in other case studies, in which similar practitioner responses noted appreciation and acceptance of loop-like functions inserted into normally linear design procedures, with assessment of entropy prompting iterative improvements to resource utilization and non-monetary values. Figure 1 shows in the four upper right 'boxes' a series of proposed actions related to generating energy, with new hydroelectric capacity further broken down into two 'boxes' for increasing efficiency of existing hydro projects, and adding capacity at existing hydro projects. The government managers responsible for existing hydro projects in the region had ample data related to current operation, projected energy demand, and costs for improvements, thus informing detailed utility models which addressed project alternatives in terms of the previously mentioned four 'boxes' of security, prosperity, taxpayers, and environment. By embedding a utility approach into the VM process, team members engaged in problem-solving at the level of the program system, not the single project. The program did not result in construction to date, but did result in establishing a new paradigm for multi-functional, multi-agency cooperation that continued after project close-out.

Interpreting factors affecting adoption and outcomes

Consideration of second law assessments improved the design process dramatically with regard to resource consumption levels and vulnerability to disruptions such as disasters. Design practitioners voiced acceptance of the process, and either shared remarks or demonstrated behaviors indicative of how the novel adapted methodology allowed the work process to better harmonize multiple professional disciplines as well as scales of impact not typically integrated into design procedures. Decision-making rarely operated in isolation: rather, external systems (e.g. power and food supplies) that connect across time and space posed dependencies which were at times removed from awareness. Decision-making initiated before an appropriate shared understanding of sustainable outcomes is constructed could produce maladaptive or even destructive results. When resilience in the face of threats was considered, supply chains for power, water, and other resources were recognized as high-value features of potential design solutions. When a decision-making body was prepared to better integrate external factors, assessment of entropy appeared to aid identification and valuation of systems-level benefits between alternatives.

Creativity in the design process improved noticeably due to clearly presented community values framed by entropy assessment. Community inputs stated as preferences for resource reductions and resilience improvements propelled design brainstorming to develop new solutions and select among alternatives. It is important to highlight the conceptual nature of this exercise: detailed data and analysis are not generated during workshops, but rather existing data and new conceptual information are considered to stimulate creative design as well as critical design assessment. Quality of ideas has been related to number, quality, and variety of ideas generated, as well as group ability to discern quality (Girotra, Terwiessh, & Ulrich, 2010) and workshop patterns matched this wider research. However, a decision process with a focus on generating values versus alternatives may have advantages, notably addressing to a higher degree future consequences (Selart & Johansen, 2011). In the workshops, disagreements erupted over choices of actions, but were reduced when the context of the broader systems view was consensually discovered. Antagonistic individuals and groups found common ground for collective action with their 'opponents' when they saw options for action that connected to a systems view, especially concerning risk in the face of disaster (flood, wildfire, and earthquake) or shortages (water, power, medical services, and military readiness). Parties with staunch opinions about short-term preferences typically ceded to new options that improved long-term community risk reduction related to emerging conditions in the future. Often the collective thought process of a diverse group led to identifying deeper layers of challenges even as they converged on solutions for action. An emerging shared grasp that the situation was more complex than each party initially realized brought different perspectives together in a common purpose. Some seasoned practitioners commented that they had found the novel methodology transformative during what was commonly routine work; six individuals have reported they independently continued practicing it.

Uptake of adapted methodology influenced by perceived success

Community members and design professionals alike revealed tendencies to avoid uncomfortable or unfamiliar ideas and processes, yet remained open to accept them upon perceiving their value. As many participants' quoted statements reveal, individuals can detect 'success' through personal experience and reflection. Indeed, community members and practitioners alike reported their (often surprising) experience of success during the adapted VM approach. To allow non-participants (such as program management parties, up to and including the GAO) to perceive success, measures must ideally be concrete rather than subjective and experiential. While saving time, money, and goodwill during planning and design is part of success, so is project/program performance. Along with practitioner responses during the VM process, case study performance may also be evaluated in terms of project outcomes. Two case studies were tested by events related to natural disasters which highlighted resilience benefits which appear linked to attributes resulting from the VM process. In the example of Project C, the entire project was intended to function to change future risk and resilience profiles, so it was not a surprising outcome when Hurricane Isaac was shown through internal agency computational modeling to have caused damages estimated over 30 billion dollars, had the solution not been built. In that project, the utility approach helped guide the formulation of flood measures, but notably also supported integration of non-flood functions for the measures related to navigation and habitat improvements. In this sense the value was derived from multiple sources, though the return on investment could be justified through disaster loss avoidance alone (estimated ROI of 200% within first year of construction alone). Conversely, Project B featured formulation of facility designs intended to fulfill community preferences and reduce operating costs. However, when Hurricane Sandy impacted the region, the majority of water utilities experienced operational failures, in large part due to widespread power outages as well as flooding, yet Project B continued uninterrupted. Because the supply chain and energy demands were reduced through on-site handling of critical resources, emergency back-up generators were adequate to fulfill remaining demands. In this sense, the resilience was a surprise co-benefit, which has gained substantial interest for future intentional consideration. Clearly these reported results do not represent comprehensive or readily comparable data concerning performance;

however they are consistent with anecdotally reported or intended (as per basis of design documentation) performance of the other design case studies. However, the impact on uptake and future study or refinement of approach doubtless hinges on perceived success.

Conclusion

Summary

Within the complex, rapidly evolving, and often unfamiliar sphere of policies driving planners, designers, and managers toward identifying and adopting sustainable methods, effective approaches appear within reach. The adapted VM approach was shown to be useful for addressing design challenges, through delivering solutions compatible with resilient and sustainable development that addresses diverse and long-term stakeholder interests. In this sense, the approach goes beyond other variants of VM reported in the literature (e.g. Byggeth, Ny, Wall, Broman, & Robèrt, 2007). The adapted methodology supported leveraging stakeholder value inputs and entropy assessment to address systems-level design, posing a solution more amenable to uptake by practitioners than Ferguson, Brown, and Deletic (2013) have proposed. The patterns extracted through observation and self-reporting of community and designer experience suggest the proposed methodology is acceptable to users and useful in supporting improved design decision-making in terms of sustainability and resilience. Similarly, it appears useful in terms of case study outcomes where results have been reported concerning project performance and, where relevant, further programmatic influence and/or uptake. Intentionally improving the timing, participation, facilitation, and integration of community workshops appears promising to improve participant experience and project outcomes. Multiple facilitated community and VM workshops that customarily occur for large-scale public projects can be adjusted using the novel methodology to better align with current policy objectives, while adding no additional cost or time to the process. Among all case studies, applying systems views of current or future situations exposed unexpected interdependencies and supported dialog about resource recovery and avoided losses. Use of MCDA methods supported transparent engagement of diverse parties to frame and evaluate criteria relevant to design solution development and selection among alternatives. Methods of inquiry focused on resource use efficiency and system resilience consistently generated interest and improved understanding among laypeople and experts alike, whether framed as triggering questions in stakeholder groups or entropy assessments during VM. Project teams reported discovering novel solutions and readily incorporating unfamiliar aspects of facilitation processes and systems-level assessments. The study offers generalized guidance useful to practitioners and researchers seeking to adopt and further improve methods.

Further recommendations

Noting that illustration of the approach in documented professional practice is a precursor to its wider acceptance, further research is warranted to develop increased detail related to process and metrics. Applying a qualitative or quantitative assessment of entropy state to develop improved project solutions through VM is in its infancy, and much further research is needed related to improvement of planning and design phase assessment methods, quantitative verification of actual performance results, and tools to support or automate decision-making. One area that practitioners remarked could be useful for further investigation is the role of the adapted methodology in supporting commercialization of new technologies with improved thermodynamic characteristics (such as rooftop air conditioning units using solar panels for power and thermal resources to run heat pumps). The decision process informed by entropy considerations may offer an alternative to current approaches with underlying reluctance to accepting emergent technology. By highlighting low entropy solutions, designers may be able to steer the uptake of prototypes technologies (even at higher cost and perceived risk) to spur development of improved technologies in the future, rather than merely using low-cost systems that are available today. In this way improved decision-making has potential to create new markets aligned with sustainable development priorities that may seem beyond current reach financially and technically, thus steering sustainable innovation (Iacovidou & Wehrmeyer, 2014). Further attention to utility models that factor in desirable future conditions is an area that could be fruitful in the context of climate change and disaster resilience especially. For instance, the resilience of Project B was not factored initially, but was revealed as a co-benefit when disaster strikes; a utility approach that specifically addresses future conditions could help guide improved decision-making. Improved automation, including possible design measures in multiple combinations, could support discourse on preferences or generation of detailed utility models. Tools to aid visualization of decision process, as well as design solutions, were specifically requested by participants; laypeople sought gaming-style video display and menu bars, and professionals sought 3-dimensional, computer-aided design software linked to information modeling. Research into better application of existing tools, and development of tailored and expanded tools, is advised. The potential for application of the adapted methodology could be as broad as for conventional VM which has become a mainstay of business and government best practices, indicating a need for close examination of gaps related to contexts of interest to practitioners and policy-makers.

Limitations

This study reflects limitations related to action research methods; hence caveats include context-specific factors, partial inconsistency of process, and extensive variation due to participant behaviors. As with all practitioner-involved methods, the study poses inherent limitations with regard to investigator bias and the nature of the topic, and the epistemological difficulties in accessing knowledge. For projects that were implemented and tested by real-world events in some relevant way, performance results could be related objectively to the VM approach; however, where implementation is abstract (e.g. in the form of new program guidelines, or a plan for future action) performance is essentially speculative and based on future assumptions. The study is intended to serve as guidance on further investigations and for use by interested practitioners for whom the methods and findings could be helpful in their work.

Disclosure statement

No potential conflict of interest was reported by the author.

Funding

This work was supported by Norden Top-Level Research Initiative sub-program 'Effect Studies and Adaptation to Climate Change'.

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