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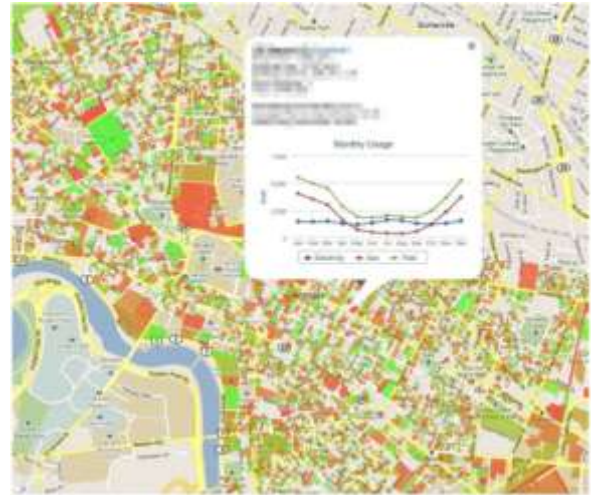
MIT Energy Efficiency Strategy Project

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In spite of the evident reasons to utilize energy efficiency measures, absorption rates remain low and success stories are varied. One theory of application supports investing efficiency measures at the community-level rather than solely targeting customers at an individual level. In order to amplify energy efficiency services to a community scale, energy service providers will more heavily rely upon information technology and web-based tools. This paper promotes the implementation of a community-level energy mapping tool as the information platform to amplify energy service scales, increase the degree of transparency, and improve the level of coordination amongst service providers. The goal of the mapping tool is to provide publically accessible and highly legible information to all viewers and to enable the success of self-identified community group efforts to manage energy efficiency measures and behavior. Such a tool, that enables public and transparent discourse between all users, would be mutually beneficial to energy consumers and energy providers. To develop this energy mapping concept, the authors conducted a literature review on previous research findings, performed a case study assessment of existing energy maps, and surveyed eight industry professionals about their experiences with energy data. This paper attempts to respond to the following research question: what could be done with this information and how should that information be visually presented? This paper concluded that energy mapping is a largely untapped resource for the energy efficiency industry, however many professionals have begun experimenting with it in the confines of research and academia. It also postulates that an impactful energy map requires three components: a data information display, corresponding program & Incentive features, and a two-way feedback input option.¹

¹ This research was carried out as part of the Energy Efficiency Strategy Project (EESP), based at the MIT Department of Urban Studies and Planning and led by Harvey Michaels (hgm@mit.edu). We are grateful for the support for this work provided by The U.S. Department of Energy and its National Renewable Energy Lab, Duke Energy, CISCO Systems, Edison Foundation Institute for Electric Efficiency, and NSTAR Electric and Gas.

I. Introduction

In the ever-pressing challenge to power the world with energy while preventing further climate change, specialists are investing increasingly more faith into energy efficiency measures. Now touted as the “first fuel” by Duke Energy CEO Jim Rogers, energy efficiency is being increasingly seen as a serious means of meeting the energy demands of the 21st century, along with coal, natural gas, nuclear, and renewable energy (Duke Energy Corporation). As the movement towards a universal cultural adoption of energy efficiency is still in its infancy, the pathway forward is riddled with challenges and complexities.

Energy efficiency is most prevalently addressed through individual-based programs. Actions are promoted through tools that empower the individual customer. Automated in-home displays are largely installed in homes and buildings to convey complex energy consumption information to the energy-uneducated public. What has been less investigated is a display tool for communities to depict and receive aggregate energy use. The Energy Efficiency Strategy Project (EESP) at MIT has posited that innovation in community-level energy data presentation and analysis can substantially improve aspects of efficiency implementation because it can motivate whole movements of collective change through knowledge sharing and social pressures (Michaels H. G., et al., 2011). Collective organized actions, supported by programmed services, information tools, and financial resources, from community groups and municipalities may be the key to deploying deep energy efficiency across the built environment. EESP found that both sides, the utility companies and energy suppliers, and the communities and municipalities, can mutually benefit, meeting each other’s energy efficiency needs, in a community-based approach. This community energy efficiency model is gaining momentum amongst policy makers and regulators, but to be successful, communities will need new tools and innovative support systems (Michaels H. , 2009).

In this paper, we propose components and aesthetics for a community-based energy mapping tool that can better communicate, inform, and interpret energy data and energy efficiency potential for energy users and energy providers. Energy use is largely invisible to the average energy customer, who cannot see it, touch it, or know how to use less of it. The map is a way to visualize energy data in conjunction with other geographic, demographic, and real-time data to inform and enable actions towards energy efficiency goals (Donnelly & Sklarsky, 2010). In the energy efficiency industry, there is a need for a basic language of concepts; at the present, multiple definitions of energy efficiency are in use, sustainability inconsistently measures different resources in each situation, and a broad gap of comprehension in discussions between the energy-educated and the energy-uneducated people occludes the progress of sustainable actions. Graphic illustrations can serve as a universal language and a tool that documents and graphically displays communal energy consumption is meant to be that basic language of concepts. Here, we generate images to show what the visualizations may look like if they were tailored to community-scale rather than individual home or building level energy efficiency.

In the following sections, we give context to this research by presenting the previous findings which support the effort to develop a community-level energy mapping tool and then describe how the contents in this paper extend these findings. We then explain the method of our research design and

execution, and explain the data that was collected through case studies and surveys. Finally, we propose a set of components and graphic illustrations that demonstrate what a community-level energy mapping tool could look like.

Methodology

The energy efficiency sector advances very quickly in terms of best management practices, policy changes, and pilots of new applications. In order to give a snapshot of where the energy industry stood at the time of this research, we canvassed the field to find the most relevant visualization mapping tools to the community-level one described in this paper. We also surveyed several thought-leaders in the energy efficiency world on their experience-informed opinions of the best uses of energy data.

We investigated energy efficiency visualization case studies from well-known applications and literature reviews. In order to understand what information is most desired by the supply and support side, we interviewed eight professionals from six different sectors of the energy field— two utility representatives, one local government energy specialist, one federal agency, two energy data consulting groups, one community engagement organization, and one research firm. We then generated graphic visualizations from GIS, representational utility data, and any other accessible data from complimentary topics. The final product is a set of design criteria for the energy mapping tool.

This research holds two assumptions: (1) Energy data is available for every meter, and (2) some version of asset-based scoring system is in use that standardizes the efficiency rating of buildings. Based on these assumptions, the research question is simply to ask: what could be done with the provided information and what would that information then look like?

II. Background

This paper builds upon the research conducted at the MIT Energy Efficiency Strategy Project (EESP), and incorporates findings from other MIT energy-related studies and experiences from energy sector players. EESP has been examining the programmatic and political paths necessary for consumers to reduce their energy demands sustainably, and currently postulates that a community-level approach, enabled by information technology, is key to unlocking the efficiency movement.

Community Scale

EESP has been supporting the notion of a community-based approach as an effective means of achieving greater energy efficiency absorption, as it has the potential to produce community-scale social movements. (Donnelly & Sklarsky, 2010). This community orientation is reflected in practice where traditional energy efficiency programs run by utility companies become increasingly complemented by community-managed programs that target whole communities – not individual customers and building owners. Community-managed programs have the capacity to build upon existing social networks and leverage unique social characters which are shown to increase participation rates, drive greater investment into efficiency products and services, and to help communities achieve community-wide goals beyond energy efficiency (Mekler & Michaels, 2011). Utility outreach programs have found that

approaching self-identified communities to address their self-identified problems draws significantly greater public participation (Biddulth, 2012). Programs will often rely on community groups and their members to conduct outreach efforts through neighborhood canvassing and local events. Leveraging community connections can create a word-of-mouth “buzz” that is indicative of their sense of ownership and is seen to yield higher absorption rates for efficiency mechanisms (Michaels H. G., et al., 2011).

Tools and Technology

Data driven tools that utilize building-energy-usage data are an effective way to amplify program efforts to usher communities towards energy efficient measures in a less human-resource intensive way (Mekler & Michaels, 2011). Researchers at MIT have shown that deeper building and community efficiency levels are achievable with the application of more time and resources from the program administrators (Michaels, Song, Mackres, & Metzner, 2010). To achieve the levels of energy reduction needed to comply with state policies and national goals, energy efficiency programs will become increasingly expensive. Information technology can mechanize and distribute information more affordably, help identify energy saving potentials, inform target and outreach strategies, and standardize measurement and verification.

As advanced metering infrastructure (AMI) and smart meters become more prevalent, the available energy data is becoming universally real-time. Currently, energy data is primarily issued on a monthly utility bill from the utility companies to the individual consumer. The longer the lag in time between using and being informed of the energy use, the less likely a consumer is to take action in response (Donnelly & Sklarsky, 2010). It is evident that showing small timescales of data in an energy visualization image is important to achieve deeper efficiency levels.

Energy Efficiency Transparency

The democratization of energy efficiency entails giving customers the ability to take charge of their electricity production and energy use as opposed to the system currently in place where a few large energy producers and operators control these processes (Wood, 2011). Transparency of energy data is crucial to energy democratization (Michaels H. , 2011). Opening up the energy market and giving the public access to transparent energy data is reliant on the emergence and popularization of new technologies and the internet. If a democracy is going to be put into place, where the masses take charge of their energy management, some rules will need to be set in place in order to organize the chaos. The internet is an excellent example of a functional democracy – it involves a near infinite amount of information, no single ownership, but with a few rules, it works. Technology, specifically applications that can work in conjunction with smart meters, dynamic pricing, virtual net metering, solar gardens, home energy displays, internet enabled appliances, etc., is one vehicle to give structure to and enable an open opportunity for customers to manage their own unique energy situation.

Democratization: Reducing Barriers to Entry in the Energy Efficiency Market

The economics of the energy efficiency market pose barriers to entry for both energy users and energy product suppliers, and ultimately discourages its deep and pervasive adoption. Consumers are often discouraged from putting capital investments into energy-efficient goods and adopting more sustainable consumption habits because of conflicting economic market conditions, social norms, and personal preferences. Suppliers of energy efficient goods and services are deterred because products are in nascent form and are expensive, and efficiency programs are costly to develop and require broad expertise in building technology, program management, and marketing. The efficiency market will not mature until the barriers to entry are reduced, encouraging the perpetuation of competition, investments, and innovation. Until costs fall, knowledge of energy efficiency spreads, and green lifestyles become more socially accepted, this market will struggle to gain momentum. In other words, the energy efficiency market would greatly benefit from democratizing, or allowing any person interested to contribute or manage energy to enter the market. The research conducted by EESP suggests that a community-based energy feedback and mapping tool designed to influence social norms and energy consumption habits may be the key to unleashing the energy efficiency market and democratizing the responsibility to manage energy consumption (Donnelly & Sklarsky, 2010; Michaels H. G., et al., 2011). Such a data tool can hurdle the communication and knowledge barricades by creating a space for public discourse and sharing, and enable the social pressures and competitive natures of community groups to propel the collective momentum towards a cultural efficiency value.

Mapping

Today's energy infrastructure lacks mechanisms to help consumers understand the broader impacts of their consumption habits (Michaels H. G., et al., 2011). Several companies have developed energy-usage visualizations using utility data to some measure of success. However, combining energy data with spatial data to generate a map of energy-use over community layouts and buildings is less prevalent. A community-based mapping tool creates a greater transparency for consumers to see their impact by using energy data to create benchmarks, expose patterns, and display building performance. However, interactive energy maps that use multiple sources of data to show disaggregated or mildly-aggregated energy use primarily exist in academia. Mapping data requires that an individual's information be viewable to display community level trends, but the privacy measures upheld by utility companies deter the implementation of an interactive energy map.

Mapping energy data would be instrumental in propelling community-based program approaches for a number of reasons. Primarily, mapping energy will allow more players, energy and non-energy industry players alike, to enter the efficiency quandary game. Program outreach often includes a place-based community component that requires geographic targeting. Similar to satellite mapping of subterranean fossil fuel deposits, mapping energy consumption data will surface "energy gushers", illuminating where potential substantial energy savings exist in the landscape. Gushers may emerge geographically, as in neighborhood locations, or programmatically, as in specific building sectors or among demographic groups of people. Unearthing these community-level energy trends is essentially providing the energy efficiency industry with equivalent amounts of consumer marketing information as exists in other industries. With better information, community-based programs can more accurately target consumer needs. Past case research performed by EESP suggests that community-based approaches may yield

greater efficiency results, with higher participation rates, and perhaps even deeper efficiency per participant, than individual-based strategies because it can address many barriers common to community members (Michaels H. G., et al., 2011). Mapping community energy data may be collective enough to gather broad support and attention towards a cultural efficiency movement by motivating mass participation.

Figure 1.1 Mapping Community-Level Energy Data is Mutually Beneficial²

| Energy User Benefits | Energy & Service Provider Benefits |
|--|---|
| <ul style="list-style-type: none"> • More accurate community context information and benchmark comparisons. | <ul style="list-style-type: none"> • Identify aggregate energy efficiency potential |
| <ul style="list-style-type: none"> • Enable greater autonomy in managing their own energy use & identifying their own trends | <ul style="list-style-type: none"> • Engage community-wide, sustainable social behavior change |
| <ul style="list-style-type: none"> • Amplify learning tools to encourage universal energy understanding & collective intelligence (strength in numbers) | <ul style="list-style-type: none"> • Segment the market by understanding consumer habits |
| <ul style="list-style-type: none"> • Better suited actionable items that are custom tailored to community culture | <ul style="list-style-type: none"> • Measure and verify the energy savings |
| <ul style="list-style-type: none"> • Social Networking & Community Building | <ul style="list-style-type: none"> • Evaluate and optimize demand response, energy efficiency, and pricing programs |
| | <ul style="list-style-type: none"> • Track energy projects and community progress • Discover new ways to use the data |

If coupled with behavior-changing strategies that attempt to influence social norms and individual habits, community-based mapping applications have the potential to reduce wasteful energy use, accelerate investment in energy efficient products, and build the potential capital to enact government energy policies (Michaels, Song, Mackres, & Metzner, 2010). Being able to analyze energy data in its geographic location will likely generate a clearer determination of energy resource needs and inspire the onset of new innovations in efficiency management. Researchers at MIT have experimented with components of mapping energy and are aware of the potential they hold to mobilize a movement of change (Donnelly & Sklarsky, 2010). This paper takes the next step and postulates what that energy mapping could actually look like.

Current Research

To date, EESP research suggests that an energy information platform based on customer energy usage and building records, combined with other available data sources, in a spatially accurate layout is the keystone tool needed to make progress in enabling community-level energy efficiency. This paper suggests that a community-based approach is a promising strategy to enabling and sustaining energy

²Draw upon research by (Donnelly & Sklarsky, 2010) and then added to by Lindsay Reul.

efficient measures, and by democratizing the management of our energy consumption, community groups will naturally emerge in a bottom up fashion to tailor a management style for their community, if given the right tools. Mapping energy data may be essential for community-based energy efficiency efforts to gain traction and make significant energy-reducing impacts. This paper presents the energy information platform in the form of an energy map to equip communities with the information and incentives needed to organize themselves into functional groups that optimize their ability to usher and sustain energy efficiency.

III. Visualization Case Studies

Mapping energy efficiency is a relatively new concept and few material applications exist. Before proposing a new visual style to enable community-level energy efficiency, we looked at what applications of energy mapping visualizations already exist in order to understand what approaches have already been tested and what graphic elements work best. We assessed ten existing energy specific mapping visual tools and reviewed four non-energy specific mapping visual tools that have relevant lessons for this paper's intentions. The individual case study assessments can be viewed in the appendix of this paper.

Of the ten energy-specific maps, nine mapped energy efficiency, but these nine maps used at least seven different methods of efficiency assessment. Many of the publically displayed maps used Google Maps as a basemap whereas most of the energy maps prepared for individual clients or those which never left the realms of academic research are constructed with GIS. While most energy maps did not display energy data in isolation, those that did show energy in combination with additional information only showed one or two types of other data sets. A comprehensive energy mapping tool which includes multiple options to correlate data sets perceivably does not exist such that the possibility of observing patterns of latent opportunities and new causal relationships can be drawn.

Mapping energy is clearly a very new style of managing energy data. Most applications are no more than three years old, and many energy specific mapping applications have not yet left the academic research environment. The question of who and what audience the mapping visualizations intend to target surfaced as a salient quandary. Naturally tradeoffs occur between clear and simple map applications, and having more versatility and control with the displayed data. Ratepayers, community groups, and the politically vested individuals need the former while the program administrators and planning consultants require the latter. Several additional observations were concluded from this exercise.

Case Studies

Mapping case studies were identified from sources via literature review and personal interviews. For each case study, a standard template of comparable information was applied:

1. Who developed the map? What party wanted this map to be developed?
2. Who did they develop the map for and why?
3. What are the pros and cons for each mapping system?

4. What is the key lesson to extract from this example? Why was this example showcased?
5. Where can users access this application or further information to this application?

The fourteen assessed case studies are:

Energy Specific Mapping Visuals

- **Mobile Infrared System**, Sanjay Sarma and the MIT Field Intelligence Lab
- **Energy View**, Zico Kolter and the MIT Computer Science and Artificial Intelligence Lab (CSAIL)
- **Gainsville Green**, Energy IT
- **Energy Points**, Energy Points
- **Housing + Transportation Affordability Index**, Center for Neighborhood Technology (CNT)
- **The Municipal Energy Profile Project for Kane County**, CNT Energy
- **Enernet**, MIT Senseable City Lab
- **Urban Ecomap**, Cisco Systems
- **Cincinnati Region Market Study**, ACEEE
- **New York City Building Energy Map**, Columbia School of Engineering

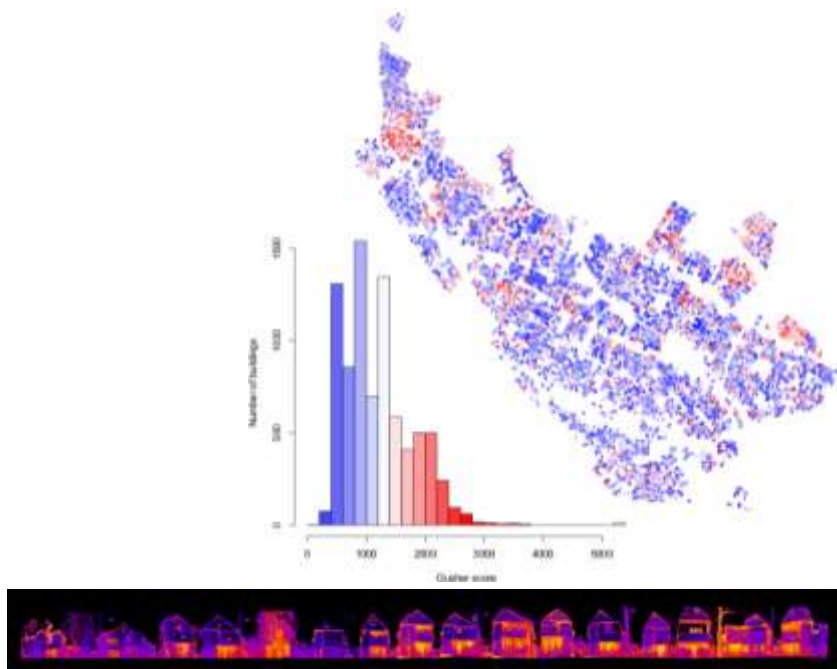
Non-Energy Specific Mapping Visuals

- **Mapping America**, New York Times
- **Weave**, MAPC and Boston Indicators Project
- **DataCommon**, MAPC
- **Walkability Map**, Walk Score

Each case study is presented using the same template that gives cursory information to each of the five questions listed before. For a deeper assessment of the mapping visualization, a link to the application source or further material is given.

Energy Specific Mapping Visuals

Sanjay Sarma, MIT Field Intelligence Lab | Mobile Infrared System ³



Images: MIT Field Intelligence Lab, 2012

Intended User: Efficiency Consultants, Energy Service Providers, Corporate Users

Intended Use: This tool captures their own IR images with the mobile infrared system, which are then translated into energy efficiency metrics, such as cost and return of investment and targeted areas with high savings potentials, and clustered into large groups and communities to show Negawatt (or wasted energy) reservoirs.

Pros: Mapping heat leaks as a proxy to locate efficiency gushers is a more concrete approach to identifying energy efficiency potentials because the IR thermal scans make these leaks a palpable quantifiable object. By pinpointing and quantifying heat leaks, the building asset and performance data are highly granular and accurate. This process creates instant picture images that are marketable to individual homeowners and can be instrumental for organizations who campaign to policy makers. Thermal readings take the guesswork out of knowing which buildings are most in need of retrofitting. The authors of this technology are also able to quantify a cost amount in savings based on the IR readings.

Cons: Pinpointing leaks seems to be only one portion of the energy equation. As of March 2011, the inventors of this technology were developing software that would translate the images into estimates of energy efficiency potential, but the inputs of that calculation are undisclosed and unavailable to assessments.

Key Take-Away: Visuals are very compelling – both for the individual homeowner and for the aggregate community – to rally action behind efficiency. Quantifying how much energy consumption is due to heat leaks, and precisely where those leaks are emitting from, is extremely useful data.

Source: http://fieldintelligence.drupalgardens.com/research_projects/negawatt-mining

³ (MIT Field Intelligence Laboratory)

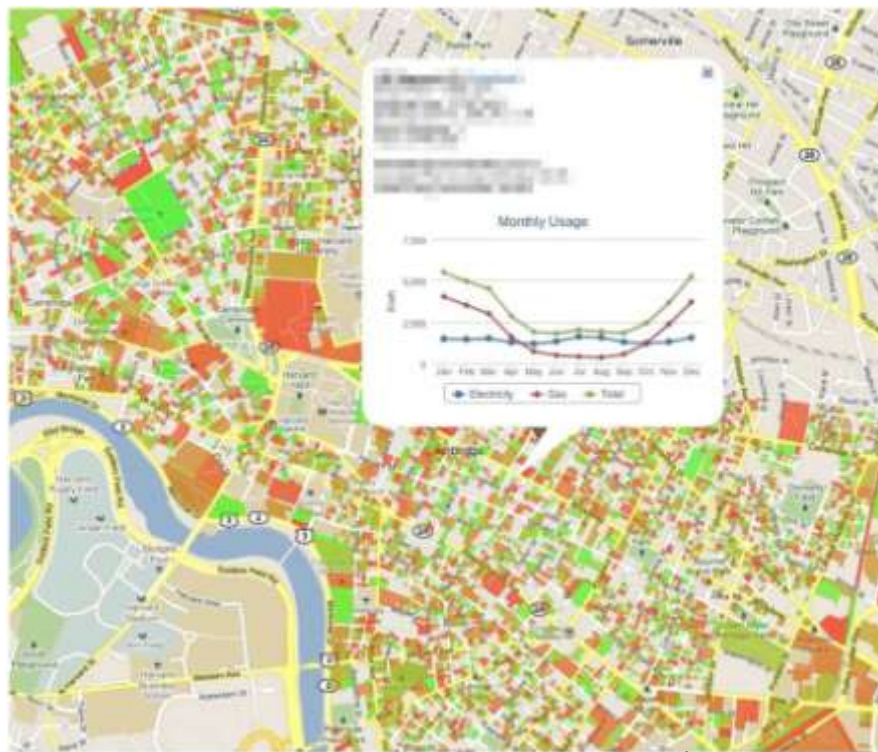


Image: Kolter, 2012

Intended User: (1) Utility Companies or Authorized Institutions, or (2) Ratepayers

Intended Use: (1) City-wide Scale: For a quick identity of building outliers which inform authorized institutions how to structure program targets and tiered pricing schemes. (2) Single-Building Scale: To provide ratepayers with a contextualized view of their consumption habits as it compares to the benchmark.

Pros: The program functions with two interfaces: one for the authorized institutions so that they may see community-level trends, and another for the individual ratepayer so they may see where his/her usages falls when compared to their community and benchmarked category. Mapping energy efficiency, or showing where high levels of efficiency and efficiency gushers lie within the community, at this scale of granularity, per tax property, works well at the city level since it can foster neighborhood and smaller level engagement.

Cons: The spatially represented energy data is only available in the authorized user interface. The ratepayer interface only displays an individual's contextualized data in graphs. Google maps should not be used as the base for the efficiency ratings because the background is too garish and competes too heavily with the information layers.

Key Take-Away: The model uses utility data both to generate the mapped visuals and to predict benchmark comparisons. The benchmarks are very statistically significant, suggesting they base predictions on nearly all significant asset inputs, leaving only the behavioral influences out of the predictions.

Source: <http://people.csail.mit.edu/kolter/energyview/>

⁴ (Kolter Z. J., Energy View Example)

⁵ (Kolter Z. J., A Large-scale Study on Predicting and Contextualizing Building Energy Usage, 2011)



Image: EnergyIT, 2012

Intended User: Rate Paying Property Owners, Renters, Program Planners, and Building Contractors

Intended Use: Publicly displaying energy consumption data in order to influence home owner purchase or renter lease decisions. Puts public social pressure on Gainesville property owners to make infrastructure and behavioral investments towards efficiency.

Pros: Gainesville is served by a publicly owned utility and due to the Freedom of Information Act, energy utility data is freely accessible and able to be publicly displayed without aggregation. EnergyIT used an opt-out approach, rather than an opt-in, such that a large majority of the residential units are represented in the energy map. The tool also estimates greenhouse gas emissions (carbon footprint). Historic energy use trends date back to 2000 for most houses and can be viewed publicly as well. The tool publicly tracks energy consumption such that program planners and building contractors can see how effective their programs and retrofits have been.

Cons: EnergyIT claims to mix utility consumption data with appraised building data using formulas, presumably to gauge efficiency levels, but then displays data that appears disaggregated and evaluated purely by utility costs. The graphics of the map are cumbersome, with the efficiency icons appearing and disappearing with every move or zoom of the map.

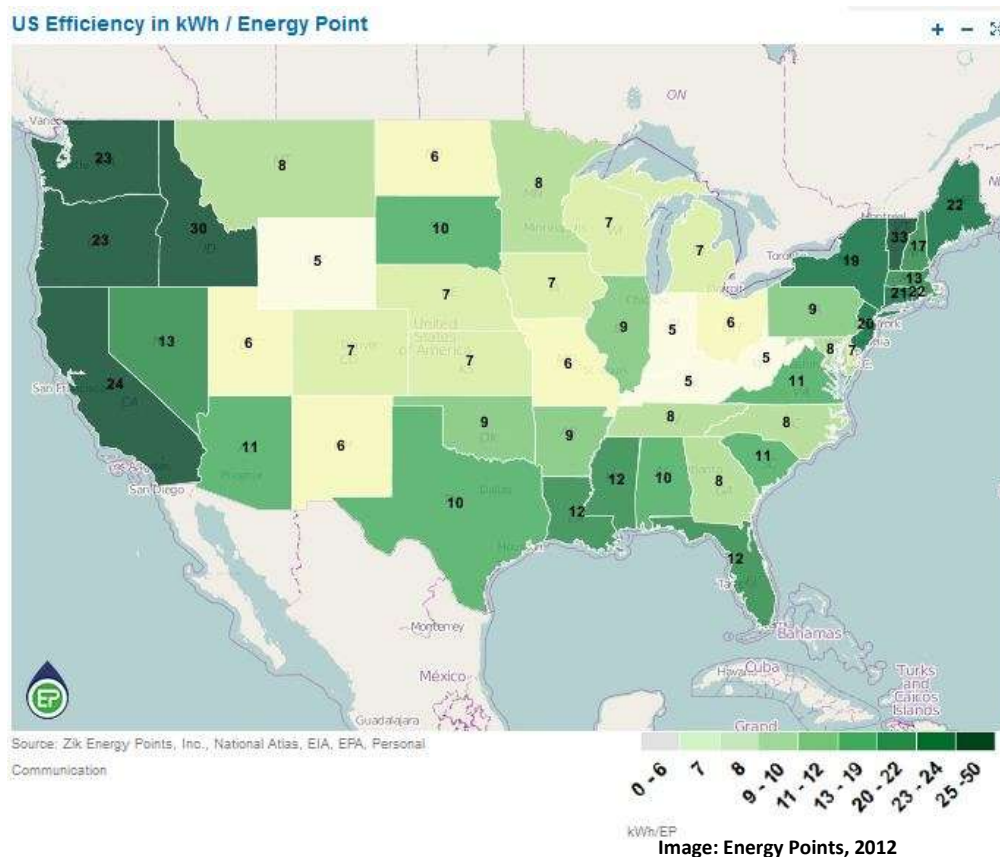
Key Take-Away: Energy data is publicly available and publicly displayed directly to the ratepayers. The tool allows users to self-select their communities (or peer groups), enabling competitions amongst family members, friends, or co-workers to emerge.

Source: <http://gainesville-green.com/>

⁶ (Energy IT, 2011)

⁷ (Energy IT, 2012)

Energy Points | Energy Points ⁸



Intended User: Firms & Corporations looking to develop their Sustainability Plans

Intended Use: Energy Points invests in making maps because they seek to portray sustainability in the simplest way possible to their corporate clients. The Energy Point rating and the maps create a common language for energy industry people and non-energy-educated people to understand consumption and sustainability alike.

Pros: The “energy point” score normalizes the consumption of energy, water, waste, and other resources into one standard unit that roughly equates to one gallon of gasoline. This puts energy consumption into a form that the average person understands and can realistically weigh a value on. The energy point considers the time and location of consumption, accounting for different resource pricing.

Cons: The maps are not intuitive enough to express meaning on their own. They are really mapping energy points, not levels of energy use, and therefore incorporate a lot of information that is not explained or expressed fully. Instead, the maps appear overly simplified and lose the power of persuasion.

Key Take-Away: To be useful to a broader audience, these maps would need more explanation, a more granular breakdown, or higher interactive capability. Normalizing energy & consumer resources to an “energy point” is a powerful approach, but allowing users to disaggregate the point can be beneficial.

Source: <http://www.energypoints.com/technology/maps/>

⁸ (Energy Points)

Center for Neighborhood Technology (CNT) | Housing + Transportation Affordability Index ⁹

Housing Costs - % Income

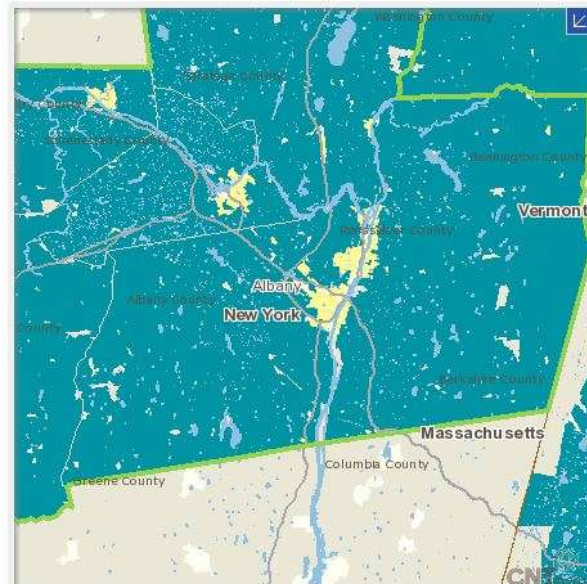
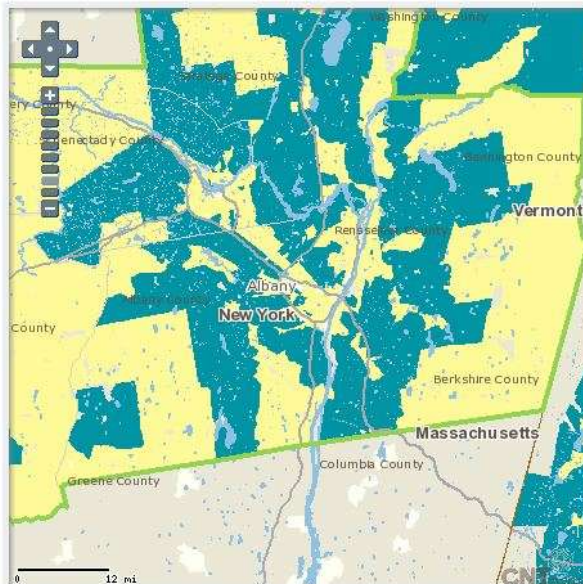
- Data Not Available
- Less than 30%
- 30% and Greater

Housing Costs factored as a percent of income has widely been utilized as a measure of affordability. Traditionally, a home is considered affordable when the costs consume no more than 30% of household income.

Housing and Transportation Costs - % Income

- Data Not Available
- Less than 45%
- 45% and Greater

H+T has been developed as a more complete measure of affordability beyond the standard method of assessing only Housing Costs. By taking into account both the cost of housing as well as the cost of transportation associated with the location of the home, H+T provides a more complete understanding of affordability. Dividing these costs by Representative Regional Incomes illustrates the



Intended User: The Public

Image: CNT H+T Index, 2012

Intended Use: These maps surface the hidden costs of transportation and re-assess the true costs of urban living. This Housing and Transportation (H+T) Affordability Index is part of an effort to raise political awareness about underlying urban causes of economic hardship for many Americans.

Pros: The model allows users to have a lot of freedom and select a large amount of variables in how they view the map, all the while making the interface manageable and easy. A menu of census data is available to view in the map display, so users can easily change which region they zoom into, and the accompanying statistics can be substituted for line graphs or legends. The map zooms in and out to very appropriate scales, increasing and decreasing in granularity to maintain legibility.

Cons: The H+T Affordability Index is more of a teaching tool than it is an enabler of change. Again, this map is more so designed to impact urban policy than it is to equip energy programmers or community groups with the tools necessary to organize a strategy for sustainability implementation.

Key Take-Away: Mapping alternative outcomes, or even displaying the same data with alternative ratings weighted, has a value, and posing two comparative scenarios adjacent to one another can have a huge variation in spatial outcomes. Using twin screens that automatically mimic one another in scale and location is a good way to understand simultaneous comparisons.

Source: <http://htaindex.cnt.org/map/>

⁹ (Center for Neighborhood Technology, 2003-12)

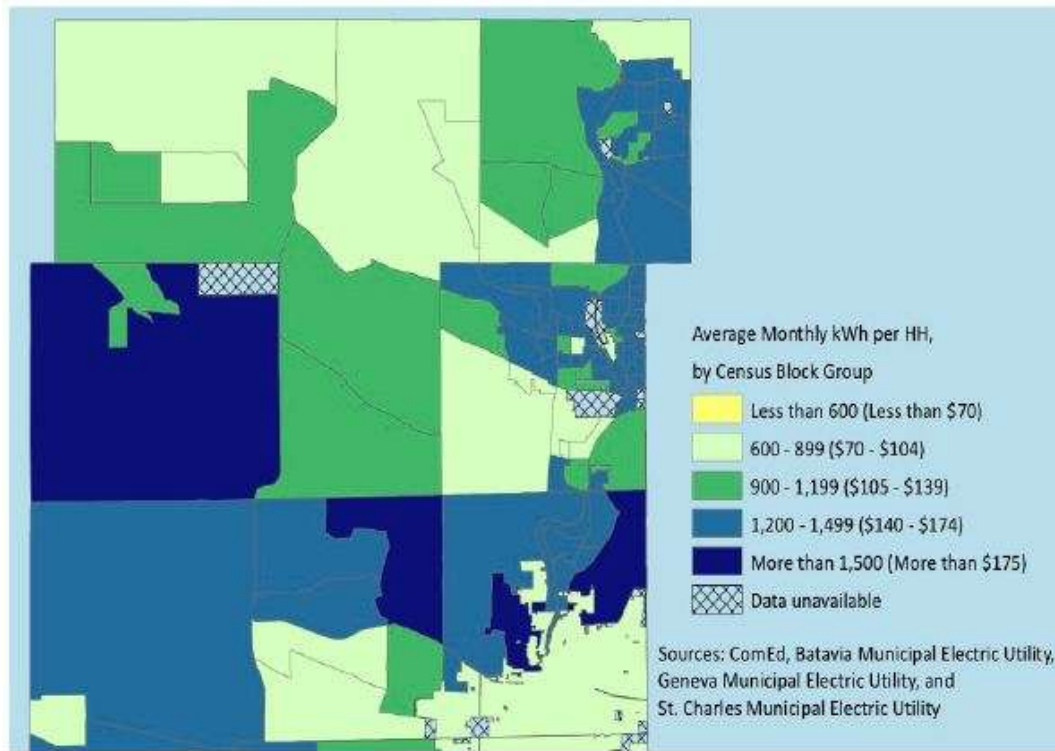


Image: CNT Energy, 2011

Intended User: Municipal Governments

Intended Use: To promote regional energy planning by better informing municipalities about the distribution of their energy usage patterns.

Pros: Regional scale energy mapping is a seemingly important scale at which to view energy patterns. Existing census data and GIS information is abundant at this level and can easily be overlaid with energy data. The mapping tools displayed here are consistent with traditional planning tools and therefore CNT Energy's energy mapping fit into regional comprehensive planning plans well.

Cons: Since these maps were generated for a report and not for a tool application, they appear in a series of separated static images. Displaying energy consumption in isolation and in such aggregation seems less effective at this scale than if it were to be paired with other relevant data.

Key Take-Away: At the municipal level, displaying information uniformly in census blocks may not be the most productive unit when municipalities have a lot of rural areas and no major urban center. Viewing census blocks in context of the entire metropolitan region, using more granular units at the municipal level (quartersections), or overlaying census block energy data with geographic or social data may provide a better portrayal of trends.

Source: <http://www.cntenergy.org/publications/>

¹⁰ (CNT Energy)

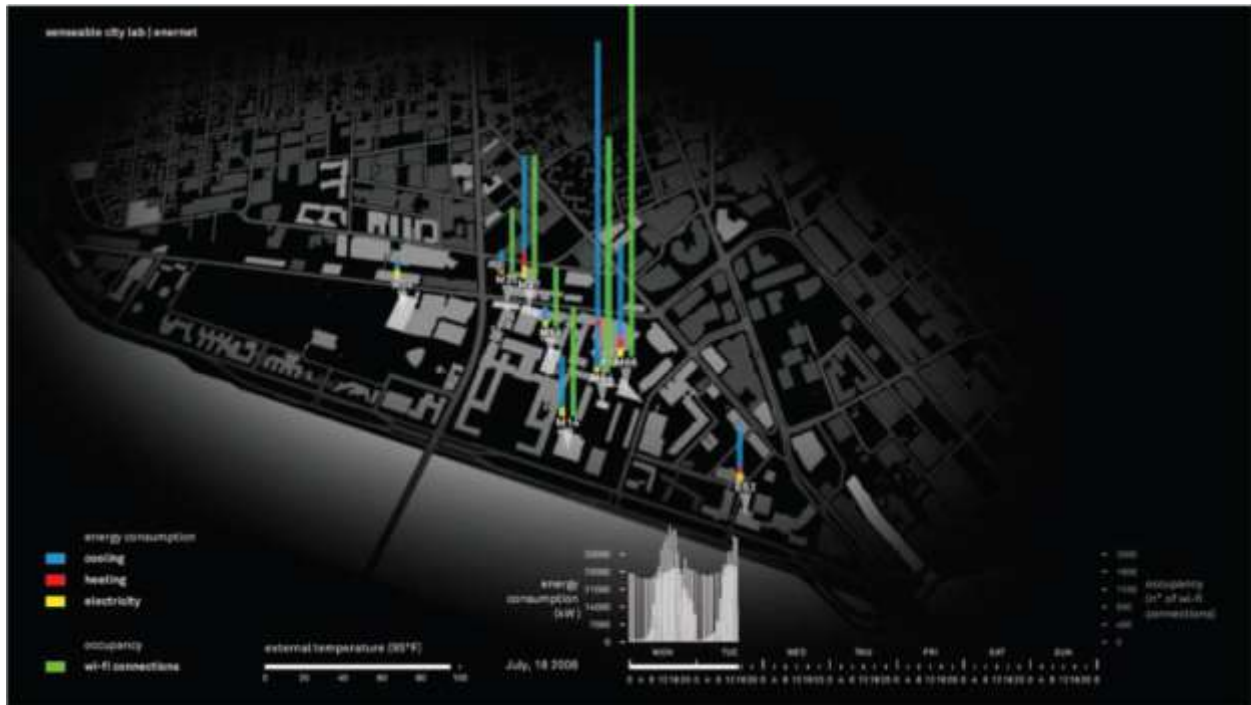


Image: Senseable City Lab, 2012

Intended User: Science Researchers and Academics

Intended Use: These visualizations were produced in a research project that questioned what the underlying drivers of energy consumption were. It used WiFi connections as a proxy for human occupancy in testing the correlation between the operation of HVAC systems and the occupancy of the heated or cooled space over time.

Pros: The project uses WiFi as a proxy for the presence or absence of people in places around the MIT campus. This is a very appropriate proxy to gauge the level of activity in a university setting and raises the point that there may be other proxies to account for the occupancy and frequency of people in other settings or building sectors. This data and its visualization functions at different levels of granularity: at the scale of a room, building, campus, or even an entire community.

Cons: The obvious disadvantage to this visual is that it proves human occupancy to not be a significant factor in determining the level of HVAC operation, but rather other components, such as external temperatures, better regulate the automated energy systems. Also, while the bar charts imbedded into the map seem effective at this scale, this graphic will not happily amplify when the scale of the community expands beyond a campus.

Key Take-Away: Pairing dynamic human interaction with energy levels in a time lapse is an excellent approach to explaining the issues surrounding peak demand and price indexes on a user face display. The bar charts are effective in displaying the largely invisible amounts of energy consumption, like WiFi and heat.

Source: <http://senseable.mit.edu>

¹¹ (MIT Senseable City Lab)

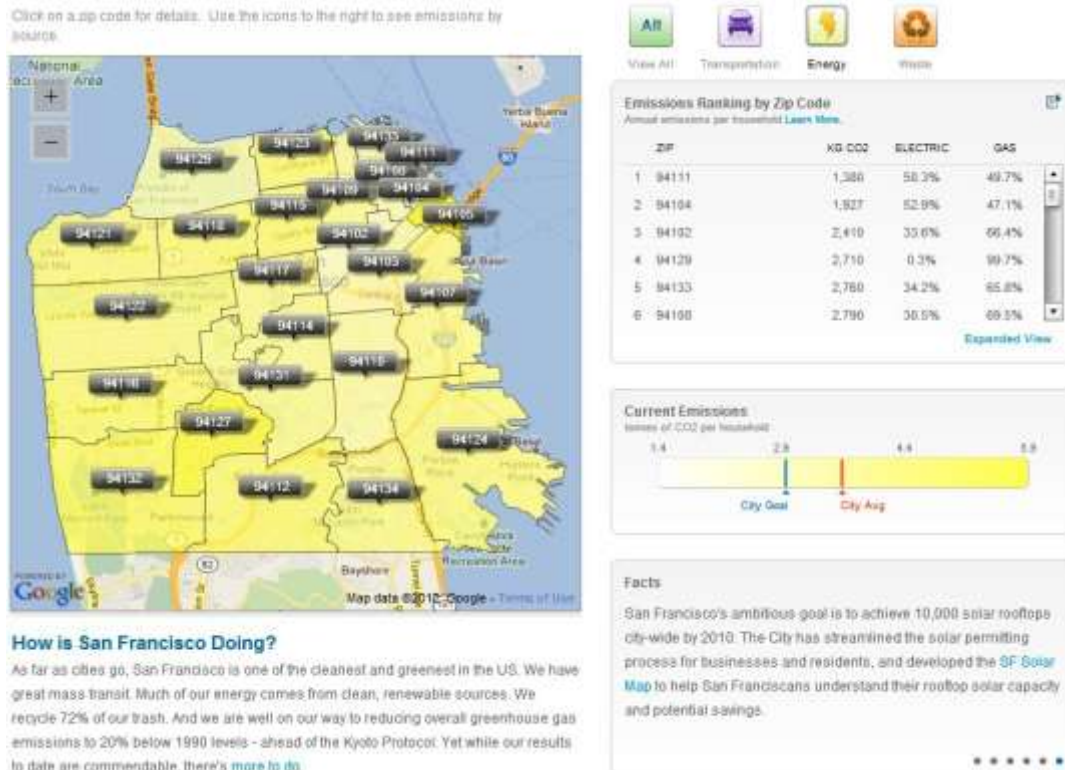


Image: Urban Ecomap, 2012

Intended User: Urban citizens via their City Governments

Intended Use: The Ecomap give cities the ability to pass free and accessible climate change information on to every citizen in their jurisdiction at a neighborhood level regarding their collective impact on carbon emissions and to promote smarter sustainable behavior.

Pros: This program is very simple, clear, and very user friendly. It shows a contained amount of information and suggests strong correlating actions one can take in response to the data.

Cons: This visualization style is less conducive to observing and displaying trends or urban patterns and more adept to contextualizing consumption data for individual benefit. Since the Ecomap is a public open source, the data must be aggregated, but it is clearly designed to educate citizens into action. The Ecomap serves more as a political or marketing motivator than a measurement or verification problem solver. The cartoonish icons and map markings are distracting.

Key Take-Away: This program is very clear and easy to understand. It is particularly good at connecting the data with actionable items to address what one has just learned. Its approach is linear: explore, act, resources. Explore the map & information graphics. Act according to a list of actionable items per your preference. Resources are then provided to guide you in your achieving your action goals.

Source: <http://urbanecomap.org/>

¹² (Urban EcoMap, 2009)

¹³ (Mitchell, Stewart-Weeks, Villa, & Bulchandani, November 2011)

Figure 37. Residential Combined Potential Index

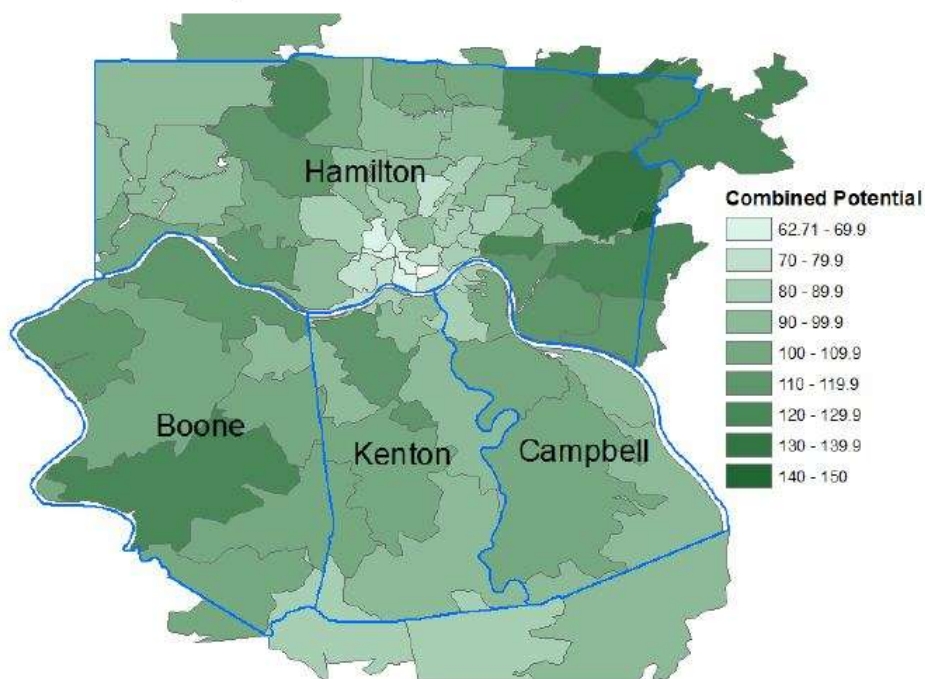


Image: ACEEE, 2012

Intended User: Greater Cincinnati Energy Alliance (local NGO)

Intended Use: These visualizations were generated using GIS and other data sources for the purposes of a market study. They are not a part of a functional tool, but were rather prepared for the NGO to show a snapshot assessment of the energy efficiency potential, as measured by a developed efficiency unit, in their program territory.

Pros: The mapping project constructed a participation potential index that was based off of specific demographic variables commonly associated with higher rates of program participation. This behavioral element was weighted with building asset efficiency ratings to give a combined potential index. Not only did communities need to have energy retrofit potentials in their building stock, but they also needed to suggest high likelihood to participate in energy efficiency measures in order to be deemed an area of high energy savings potential. This is a compelling definition of efficiency.

Cons: An on-the-ground neighborhood canvas effort found this metric to be less accurate than expected, showing higher and lower levels of interest for engaging with energy efficiency measures than the participation potential index estimated. However, as the index continued to be used and retroactively checked, the inputs would become increasingly more informed and more accurate.

Key Take-Away: The scale (aggregated by zip codes) seems more useful for holistic assessments and long range planning as it show regional trends very clearly at the metro level. Also, displaying the four counties in the metro area together shows stronger trends.

Source: <http://www.aceee.org/blog/2011/12/neighborhood-outreach-energy-efficien>

¹⁴ (Mackres, Neighborhood Outreach for Energy Efficiency: Finding Homes that Need It and People Who Want It, 2011)

¹⁵ (Mackres, Neubauer, Laitner, Lowenberger, Talbot, & Bell, 2011)



Data Source: [Spatial distribution of urban building energy consumption by end use](#)
B. Howard, L. Parshall, J. Thompson, S. Hammer, J. Dickinson, V. Modi

Image: Columbia University School of Engineering, 2012

Intended User: Open to the public; Useful for urban planners, policy makers, and engineers

Intended Use: To display Energy Use Intensity (EUI) estimates across the city that informs building owners and energy service providers with potential locations for energy infrastructure coordination.

Pros: The map is very intuitive to use and displays a lot of information in a very digestible format that works at multiple levels in seamless navigation. The resulting visuals display persuasive images that can be constructive during political advocacy. The map handles granularity well when zooming in and out.

Cons: This model does not actually calculate energy efficiency, but rather evaluates the built environment according to the intensity of energy use. Building assets are not considered in this rating. Only the building use (whether it is residential, educational, or office space) is weighted and assigned a ratio. While these use-typologies have associated building characteristics, an EUI rating does not identify why a building consumes a lot of energy – not crediting behavioral tendencies, the scale of the building, or building asset qualities – just that it consumes intense loads of energy.

Key Take-Away: The visualization is useful for advocating for better energy policy, but displaying EUI as a rating metric makes this map less productive in terms of designing efficiency programs and strategies. The map characteristics, however, are excellent – they deliver a high degree of granularity while still aggregating the data to protect citizen privacy. However, this scale may uniquely work for the dense fabric of New York City.

Source: <http://modi.mech.columbia.edu/nycenergy/>

¹⁶ (Modi Research Group, 2012)

¹⁷ (Howard, Parshall, Thompson, Hammer, Dickinson, & Modi, 2012)

Non-Energy Specific Mapping Visuals

New York Times | Mapping America¹⁸

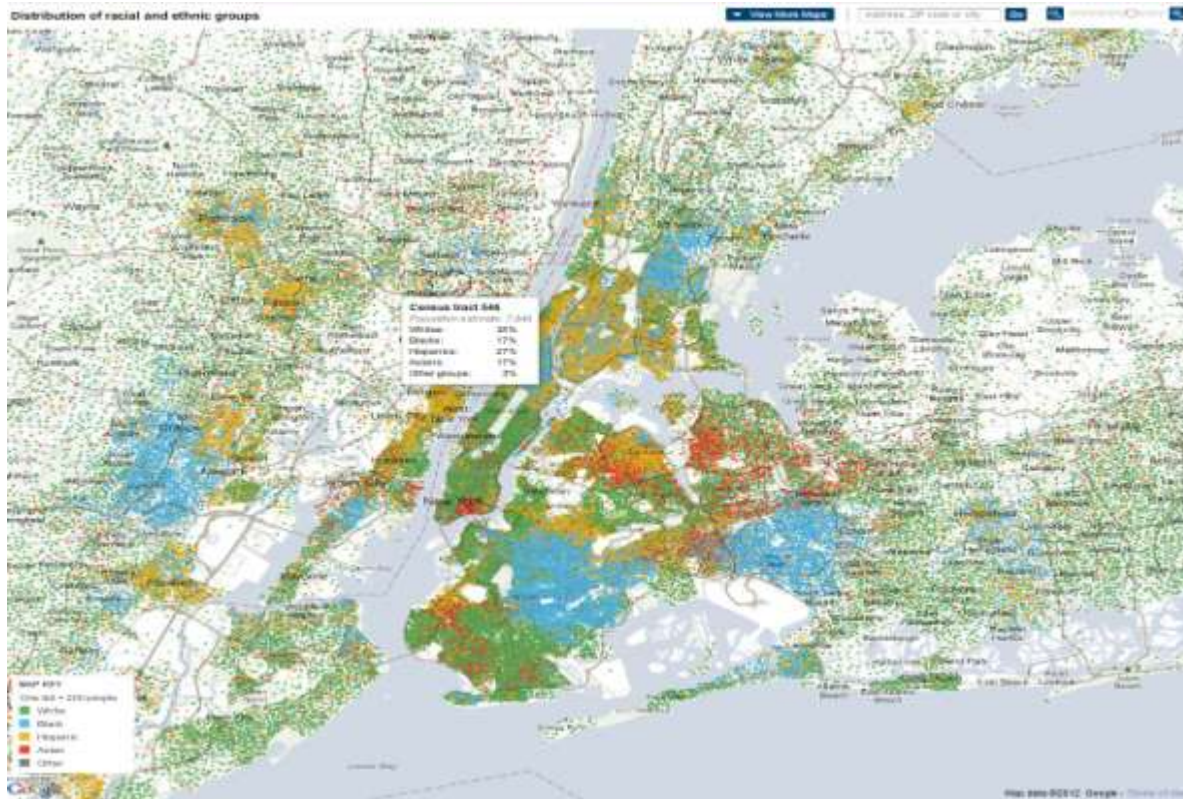


Image: New York Times, 2012

Intended User: The Public

Intended Use: These interactive maps are meant to shed commentary on the demographic state of the nation and what trends are emerging in terms of education, immigration, and income.

Pros: This interactive map is one of the best existing examples of data visualization in terms of high legibility, seamless navigation, easy functional understanding, and even fun to engage with. The census track highlights as the mouse moves over the map & updates the dynamic scrolling data per location. The edges of the “community” in review are defined by the edges of the screen since the map does not apply edges to the map until the national level.

Cons: The viewer can only look at one set of data at a time. The map does not allow two layers to overlap one another simultaneously such that one can view their correlation. The information becomes sparse in the rural areas of the map, making assessments difficult if at too small of a scale.

Key Take-Away: As commendable as this mapping style seems, it functions best in urban centers and at larger scales (county, state, or national) and may not be an ideal model for an energy map that needs to function on a neighborhood or lower level.

Source: <http://projects.nytimes.com/census/2010/explorer>

¹⁸ (The New York Times, 2012)

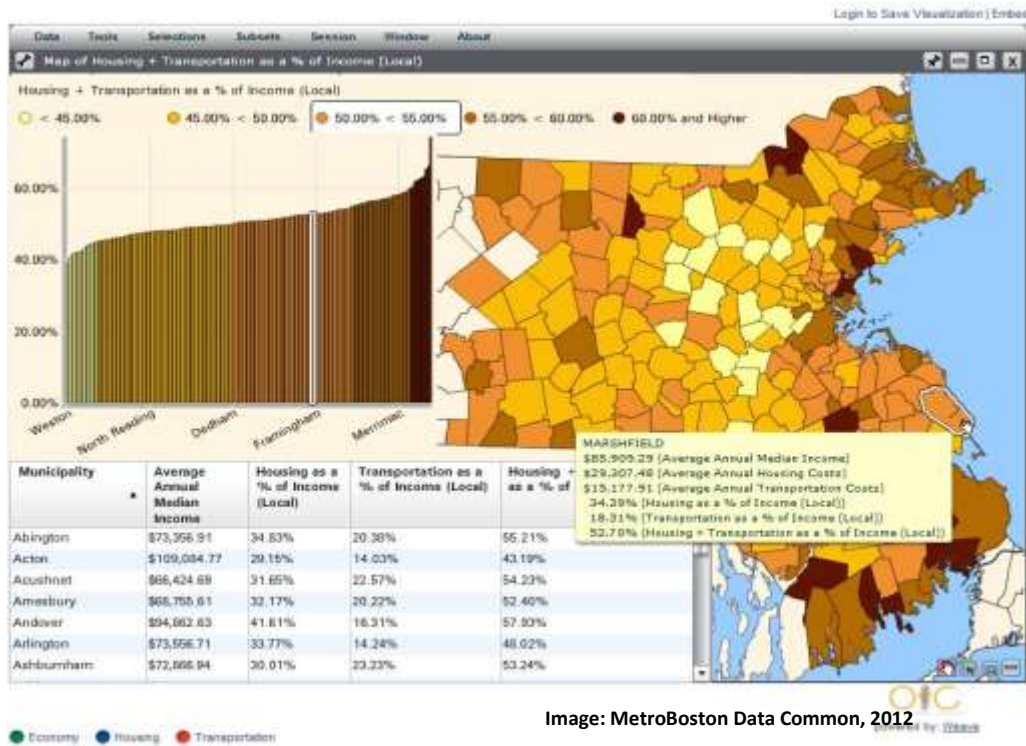


Image: MetroBoston Data Common, 2012

Intended User: Open Source Data for the Public

Intended Use: This program is meant to provide the public with a central and organized repository for GIS, US Census, and other open source data for their personal use.

Pros: This program gives the users all of the building blocks to develop their own images as they prefer. Once built out, all of the visualizations - the maps, graphs, and charts - are completely interactive with each other. This grants users a lot of freedom to receive the exact data they are in search of and useful visualization tools to help them assess it. This interface might be best used on the program side.

Cons: This model is accessible on a public website, however prior knowledge or interest in data management is needed to engage productively with these visualizations. The program also seems a bit choked up with delays and lags while mousing over or clicking interactively. This is not so much of a problem if this interface is primarily going to be used by a select interested group of people and not the public masses. The map works in concert with some predesigned snapshot visualizations that are available under different pages on the website. While this is helpful to get started, the format is unexpected and difficult to navigate through.

Key Take-Away: This program requires too much prior knowledge to release it as a productive tool for utility customer facing programs, but also doesn't necessary amplify a program facing tool capacity to assess the energy landscape beyond what a typical GIS might offer.

Source: <http://metrobostondatacommon.org/visualizations/new>

¹⁹ (Metropolitan Area Planning Council & the Boston Indicators Project at the Boston Foundation, 2012)

Walk Score | Walkability Map²¹



Image: Walk Score, 2012

Intended User: the Public

Intended Use: These visualizations display how pedestrian friendly urban areas are according to the metrics developed by Walk Score. They stitch together the spatial layout of several transportation options and advertise real estate vacancies in relation to the walkability of the area.

Pros: This map uses relatively simple graphics to convey a somewhat untraditional concept in a very clear manner. The map is very logical. It works at the city level and at the neighborhood level effectively. Shadowing out the ¼ mile radius around each transit line is very effective. Coupling the walk score with available rental and ownership properties fits the walk score into property hunting as a seamless assessed element in the property valuation. The green to red gradient is easily understood. Clustering areas by neighborhoods is helpful when connecting the map to the real estate market.

Cons: The map is focused on urban centers and metropolitan areas and cuts off immediately at the edges of the city. The walk score maps are also somewhat compromised by the overbearing real estate listings and advertisements crowding up the screen. The map has unexplained gaps that do not display the walk score layer even within some of the metropolitan areas.

Key Take-Away: This is a very handy visualization, however, laden with icons, Google Maps text, real estate listings, and cartoonish transportation routes, this visual suffers from too many distracting elements.

Source: <http://www.walkscore.com/>

²¹ (Walk Score, 2012)

After evaluating the fourteen case studies cross-comparatively to one another, we created a matrix to display each visualization's comparative answers to the following questions:

Isolated Energy: Does the map only show energy?

Does the map only visualize energy data or is energy data displayed in concert with other genres of information? How many maps display energy as a component of other information? The energy efficiency industry has often been criticized for not cross-collaborating with other industries. This question attempts to reveal how energy data is presented to the public – by itself or embedded with other information?

Energy Data: Shows consumer utility data?

Does this energy visualization display use utility energy data of consumers' energy use to display community energy patterns? Or, has the creator of the energy map circumvented using utility data visualizes energy consumption either through interpolation or through alternative measurements?

Data: Disclosed additional data sources used?

What sources of data does the visualization draw from? What data sets, other than energy utility data if available, were used in the mapping application?

Zoom In: Smallest unit of displayed data?

Whether the map is interactive or not, this question seeks to know what the smallest unit of displayed data is – how granular or agglomerated is the most precise, zoomed in level of data?

Zoom Out: Largest scale displayed?

Again, whether the map is interactive or not, this question strives to compare what the largest extents of the map are. What is the largest unit of agglomerated data available for display? How far out can the map zoom?

Interactive: How dynamic is the map?

Is the map an inanimate image or does it have dynamic features that allow for a smart user interface where the audience can change, control, adjust, and toggle different features within the application?

Efficiency Score: How is the data normalized?

This question essentially asks if energy efficiency is calculated as opposed to simply displaying energy. If energy efficiency is visualized, how was efficiency calculated? If disclosed, how did the author of the visualization score efficiency, or what rating system was used to assess efficient properties versus inefficient properties?

Visuals: Paired with other forms of data visualization?

Is the data only showed in the form of a map or have other graphic visualizations, such as charts, bar graphs, tables, or images, also been used to display the data? Is the same data represented both as a map and another visual? Is other data displayed in non-mapping forms in conjunction with the mapped data?

Audience: Who is the intended audience of the map?

This question aims to extract who the author of the map intended to reach with the application. What groups of people were meant to interact with the map? Was this application open and accessible to the public or is the intended user meant to have more specific qualifications?

Creator: Who solicited the creation of the map?

The creator of the map is distinct from the party that actually built the map. The creator of the map is the entity that willed the map into fabrication. This party wanted the map to exist for specific reason, and either constructed the map themselves or commissioned a professional to design and build the map.

Legibility: How easy is it to understand? (5=clearest)

The factor assesses how easy the map is to comprehend and how usable the map is. The maps were gauged on their own merit and did not consider explanatory text that may exist in a written report accompanying the map. If the maps were embedded in a report, and did not convey clear and legible information by themselves, they were deducted legibility points.

Action Items: Paired with recommended actions?

This question reveals whether or not the mapped data is displayed in conjunction with programmatic actions. The actionable items lend suggestions to the viewer to inform them on what they may do as a result of the information displayed to them in the mapped data.

Resources: Paired with resources to direct next steps?

Not to be confused with action items, resources are links or locations for additional resources. The question asks if the mapping tool connects users with live links to actual sources of services, information, or registry.

Year of Development: When was the map created?

This is a straightforward question that simply aims to discover what year these maps were first generated.

Visual Lessons

This paper can derive several lessons from these case studies. The most legible maps used traditional cartographic aesthetics; a layer of colored shape files, as opposed to icons, such as circles or pushpin decals. Additionally, those maps which display an appropriate degree of granularity per the perimeters of the elected community exhibited the most compelling trends and patterns. For example, zip codes seemed effective when displaying cities and metropolitan areas. Using neighborhoods as the smallest unit of aggregate data seems effective for urban centers. Applying data per quartersection units in rural areas was effective while still adhering to some privacy standards. Quartersections can have the same effect as a gradient, which incidentally is a very good approach to displaying community level trends.

The maps that were displayed in isolation or that were overly simple tended to be less explanatory and harder to understand. Using a mixture of graphs, text, and mapping graphics gave the fastest and most understandable portrayal of the data on display. However, the maps that displayed many cartoonish qualities, icons, and pop-ups were less effective than the simpler graphics and muted backgrounds.

Programmatic Lessons

Among these fourteen case studies alone, efficiency is either not accounted for or, when it is considered, it is measured using half a dozen different metrics: megawatts; scaled energy data with select building features; energy points; whole costs calculations; retrofit savings and participation potential; and energy use intensity. The mission of energy efficiency is more universally accepted – to reduce demand side energy consumption. The best method of achieving this goal is under dispute by many parties in the energy industry, and therefore the best means of representing efficiency is equally arguable. Perhaps standardizing efficiency is not the silver bullet solution, but rather a more successful approach to understanding the root causes of efficiency hesitation is by portraying it in a number of metrics.

Few programs made the connection between mapping information and suggesting programmatic actions. Mapping data seems to be comfortably stuck in the information technology world and not strongly embraced by the program action and strategy planning efforts. The program implementation

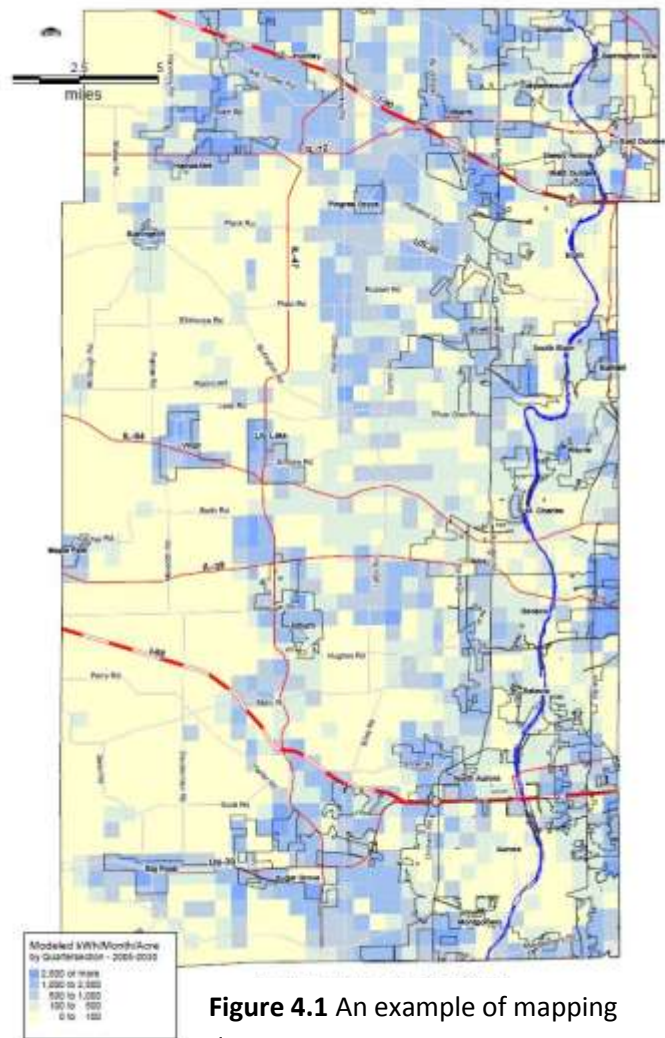


Figure 4.1 An example of mapping data in quartersections, CNT Energy.

and activation parties should harness the power of mapped data by taking custody of this practice. Currently mapping techniques are largely hosted by non-energy affiliated industry; this separation is missing the potential opportunity to influence undiscovered or hard-to-reach groups. None of the mapping programs offered feedback loops, and, when action items that were offered, they were separated from the data mapping.

Where do we go next?

This research proposes the development of a mapping tool that displays energy efficiency in the context of other environmental, demographic, climactic, etc. information at a scale that equips any self-identifying community group to take charge of their own energy consumption. The proposed model will function as a two-way feedback tool that is mutually beneficial to the energy suppliers, who want to know how to better serve their customers, and the energy consumers, who want to do the right thing and need to learn about their impact on energy consumption. The next iteration of tools needed to advance the impact of energy efficiency in our built environment will need to bridge the gap between the data and information technology, and program items that direct users to take concrete actions.

IV. Industry Outlooks

Practitioners in the energy sector were asked directly to share their opinions on energy data and inspiring a mass movement toward greater energy efficiency. Energy professionals were selected from all parts of the energy industry to see if the perspectives changed depending on where they sat. All who responded were positioned at the forefront of efficiency and sustainability within their section of the energy sector. The same three questions were asked to all practitioners:

(1) What data would you want that you do not already have?

(2) What would you want to do with that data?

(3) What do you wish you could do with your existing data that you are currently not doing?

These questions were written in plain language and strategically worded to harvest the most telling information that might shed light on what content of



data to include and how to best display it in a user-friendly visualization.

When asked what data they would like to have, practitioners overwhelmingly responded that they wish they knew what motivates people to take action. Representatives from energy utility companies and community consultancies alike both wanted to know “how do you mobilize people to make changes towards greater efficiency?” Utility companies want to know why one community adopted the energy stretch codes but its neighboring community did not. Discovering the vast array of individual and community mobilizers presents a data collection challenge since this feedback is not likely to come in standard or quantifiable units. Developing a survey mechanism to harvest this data from ratepayers is beyond the scope of this paper, nor could any of the interviewed energy professionals could posit a solution (O'Neill & Donnelly, 2012; Zenni, 2012; Passe, 2012).

Secondary to discovering mobilizers of action, practitioners, especially those situated in the data management and display positions, were most interested to obtain universal highly granular data. Specific requests were made for highly frequent (as high as hourly) meter data, energy data by house level, building data, and information on how spaces are being used. However, most practitioners understood the tradeoffs between obtaining copious amounts of highly granular data and the laws of diminishing return. At some point, having more data does garner greater value, and the realistically the computers used to process and manage all of that data will become overwhelmed and slow. Reaching the tipping point in data frequency is only a cautionary tale since currently no one was faced with too much data (Sklarsky, 2011; Mackres & Foster, ACEEE, 2012; Edwards, 2012; O'Neill & Donnelly, 2012; Hausfather, 2012).

The final most prevalent data request largely came from practitioners who worked in community outreach positions. They want to view energy data in correlation to other types of data – most specifically building data and socio-economic data (Mackres & Foster, ACEEE, 2012; Biddulth, 2012; O'Neill & Donnelly, 2012; Edwards, 2012). This section of the energy sector works most closely on the ground and understands how communities do not regard energy as an isolated mission, but rather as one piece in the sustainability puzzle. The energy industry is more prone to working in a silo and does not largely benefit from cross-over knowledge that adjacent industries may possess. Practitioners were curious what methods other markets and industries were applying to their community efforts. Having energy professionals assess energy in terms of socio-economic, demographic, environmental, etc. data may unlock deeper efficiency penetration potential.

V. Finding and Conclusions

Taking into consideration the current state of the energy industry in regards to energy data displays, and spring-boarding from the research previously conducted on community-level mapping tools, we propose a set of criteria that such a dynamic tool might include. The components were selected with the mission of equipping community-level efforts with tools and knowledge they need to mobilize towards greater energy efficiency. The tool has three main components:

- (1) **Data Information Display**, which will pair energy data with accessible data from other sources and then be overlaid onto GIS layers, thereby creating a geographically accurate map of the energy usage in the community;
- (2) **Program & Incentive Features**, which were found to be mobilizing components in the prior research conducted by EESP and industry professionals. These components inspire action through competition, goals, etc., and work in concert with actionable steps that begin mobilizing users;
- (3) **Feedback Input Option**, which allows energy suppliers to receive indirect data (information collected after the energy has been consumed as opposed to while it is being consumed) and information that cannot be found in data sets, such as the age of appliances in the household and the community's requirements to incent mobilization towards energy efficiency (Donnelly & Sklarsky, 2010).

Target Audience

The energy map is meant to be a tool that can be used by virtually anybody looking to start a green movement in their community. Without knowing what form or configuration that action may take, tomorrow or in 20 years, the tool intends to be functional for an undefined variety of users. A movement may be initiated by an energy consumer looking to organize their campus, neighborhood, village, or state towards a self-identified goal. While the community-based mapping tool is primarily meant to propel the democratization of energy efficiency by equipping consumers with the tools and information necessary to manage their own energy, this mapping tool may prove to be mutually beneficial to the energy service suppliers. Utility companies and ESCOs could use the information to more readily identify energy efficiency “gushers” where savings opportunities are high, and tap into the expansive benchmark repository that shows common characteristics across building types, demographics, and locations to more accurately target their services (Michaels H. G., et al., 2011).

A data mapping tool such as the one proposed in this research will perform best with two interfaces – one for the ratepayers who are not necessarily energy-educated individuals, and one for the program directors who consult advice and shepherd programs of people through energy efficiency strategies. The program-facing end of the tool does not need to be user friendly and can manage greater quantities and more disaggregated data, while the customer facing end will need to have heightened legibility and ease of use. With this understanding, the target audience refers to the customer-facing audience.

How this Data Might Be Used

(1) Value Engineering EE Programs From an energy supplier and energy service provider perspective, this energy information platform needs to provide the data necessary to run consumer market surveys and assess what program components are financially feasible (O'Neill & Donnelly, 2012; Mekler & Michaels, 2011). These organizations need to administer services in the most cost effective manner and are therefore restricted to identifying the community that will deliver the “biggest bang for their buck”. The break-even point, where investment in saved energy and returns equals the investment in capital and time input, will develop efficiency benchmarks to inform financial feasibility (Donnelly & Sklarsky,

2010). The visualization tool can help the utilities and service providers analyze the energy landscape and prioritize these high energy saving potentials.

(2) Innovation in EE Since community-based mapping visualizations give a new perspective on energy data, users of the tool will likely discover new ways to use the data. Innovative approaches may surface to drive collective action and public motivation. The proposed methods of displaying data and feedback could together motivate grassroots efficiency movements, increase participation in demand response programs, and improve utility-customer relations (Donnelly & Sklarsky, 2010). Additionally, energy researchers continue to look for additional sources of data, such as home audit data, image data, or other sources not yet identified, that could be incorporated into a mapping tool such as this (Kolter & Ferreira, 2011). By including these data in systemic and accountable forms, MIT researchers anticipate that the enriched energy knowledge will unleash latent opportunities and innovation.

Flexible But Franchiseable Tool

The energy mapping tool will only be as effective as it is accurate. Communities have broad ranges of characteristics, having highly diverse to highly homogenous compositions or strong to weak levels of organization and engagement. While the tool needs to maintain a system of standards that streamline the transaction costs of collecting, analyzing, and displaying data, it must also be flexible enough to fit each unique kaleidoscopic environment. To satisfy both needs, embodying both extreme flexibility and efficient standardization, the most granular and high frequency data should be inputted into the mapping tool which can then be bundled and aggregated into the most suitable packages of information per each community. Those energy-educated 3rd party organizations and service providers who manage data and design programs thus have sufficient access to copious amounts of accessible data, institutional knowledge, and local culture receptivity to aggregate bundles of data and package them with program incentives that accurately fit the target community. In effect, the energy mapping tool is a

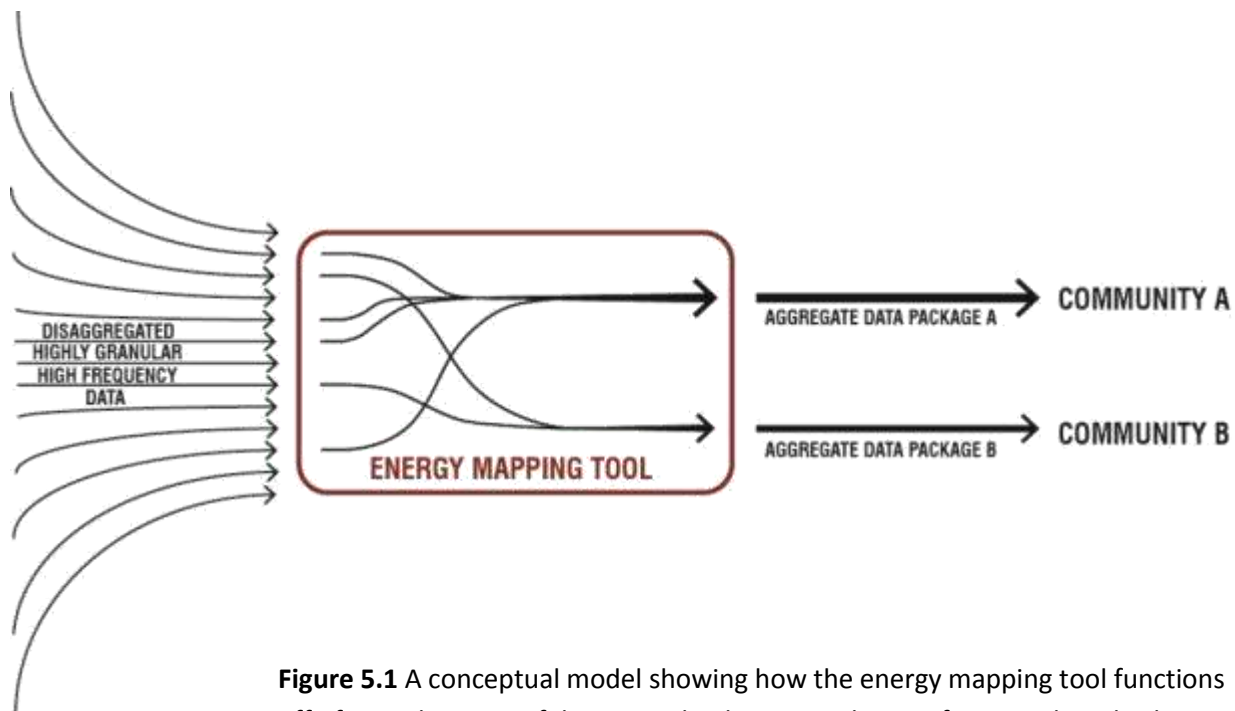


Figure 5.1 A conceptual model showing how the energy mapping tool functions off of granular units of data to make diverse packages of energy data displays.

franchiseable element, or a replicable tool, that reigns in the randomness of community diversity while it harnesses the power of community innovation and collective knowledge (Michaels, Song, Mackres, & Metzner, 2010).

Concluding Thoughts

It is evident that deploying deep and effective energy efficiency measures is a complex challenge. Pockets of knowledge and isolated surges of expertise exist in energy firms, institutions, and individuals dispersed in all sectors around the industry. In order to amplify the campaign for energy efficiency, we advocate that two paradigm shifts must take place: energy programming players need to extend their services solely from an individual target to also addressing whole communities and incorporate the psychology needs of group mobilizing, and disparate parties must operate with a greater degree of transparency and cooperation. In order to increase the scale of service, transparency of information, and level of coordination between thousands of stakeholders to collectively push the efficiency agenda forward, the efficiency industry will need a publically accessible energy information platform to exchange data and knowledge, and conduct strategic discourses. Advancing the formation of a community-level energy mapping tool will support these paradigm shifts and provide a structure for the anticipated logistics needs of the energy field.

The energy efficiency culture is relatively new to the mapping visualization technique. At the time of the writing of this paper, privacy concerns and customer protection continue to sensor data visualization and display. Several pilot examples of energy mapping have nevertheless materialized as early examples of what can be done. Given that energy efficiency mapping is in its infancy, several components need to be further researched.

Defining the community and defining the limits of the community is an important issue to resolve. Communities can be self-identified or politically assigned (Mekler & Michaels, 2011). They may be pre-existing or they may form to rally behind a common energy mission (Michaels, Song, Mackres, & Metzner, 2010). How each community is recognized by the mapping tool is a topic to further research.

Degree of granularity can alter how impactful energy visualizations may potentially be. What scale of data granularity is most effective to work with? This may largely be answered by the scale of the self-identified communities.

Privacy concerns continue to dominate the discussions of energy data. Even with the assumption in place, that energy data is available and accessible for every meter, customers' privacy should be regarded with caution to ensure that their right to security and the ability to live and provide for themselves is not violated.

Aligning community goals with state and federal efficiency targets may evolve as a significant consideration as efficiency policy becomes more stringent and efficiency ratings are redefined by higher standards. How does one get many independent community groups to coordinate with state and national policies and standards? This point is assuming that state and national energy policies should still be upheld and that disparate community groups will not independently know what degree of efficiency is necessary to create a sustainable energy plan.

Program Face vs. Customer Face emerged as a practical concern of application. Many industry parties believed that customers should not be able to see the full contents of the mapping data but instead only be ushered a display that is cushioned in programmatic elements which have been packaged by a 3rd party efficiency or outreach service provider. What data should be shared with customers in a customer-facing application and what data should stay on the program-facing side?

Algorithmic interpolation is currently used to fill in the gaps of information that are either inaccessible or are not able to be collected. With complete disclosure of energy data, would there still be a need to have an analytics engine estimate certain energy or behavior components? (Laskey & Kavazovic, 2010)

Municipal Light and Power Authorities are energy service providers that operate by drastically different standards than utility companies. What does community mapping and data visualization imply for service providers that are more transparent and service smaller and more local communities?

Tapping into social media is an exciting topic that many energy professionals are experimenting with. Several companies have wigitized energy data such that it can be posted on Facebook and other social-networking websites (Donnelly & Sklarsky, 2010). There is an evolving discovery that distributed leadership leads to enhanced innovation (Michaels, Song, Mackres, & Metzner, 2010). Plugging energy data into crowdsourcing networks may be a significant breakthrough in the cultural adoption of efficiency by being absorbed into our greater society's values.

Developing the community-based mapping tool as a public energy platform for energy service providers and energy users to use collectively is principle to forwarding the efficiency initiative. However, the design of the tool may be equally significant to the success of the deployed tool. This research most strongly supports using a split interface – one for the program administrators and service providers and the other for the customers' or communities' view – for any data visualization tool. Energy data non-mapping visualizations are treated in this fashion currently, where the program administrators package and deliver data to their clients once a relationship has been established between them. For the proposed mapping tool to be effective in equipping community energy initiatives that spring up organically, the customer-facing data will need to be accessible without an established customer-client relationship. While it is important that customer-facing data is appropriately packaged and delivered with nominal messaging, a certain base level of interactive data needs to be publically available to serve all of the unanticipated and self-organizing efforts. Rigidly adhering to a service provider initiated process, where the provider either approaches the customers first or data is delivered to customers only after a relationship has been established, will case bottlenecks and occlude the democratization of energy efficiency. Data display designs should incorporate all three components: data visualization, program incentives, and feedback loops. Additionally, displays should visualize the data in a number of ways since people understand information in different styles. Mapped data should be accompanied by graphs, charts, and text, even if only to explain the same data three different ways.

The feedbacks loops, either from the customers to the providers or vice versa, are a valuable element of such an information platform. The inputted data that circulates through the feedbacks will act both to further complete the scope of data needed to perform efficiency services, and to track and store data for M&V or benchmarking purposes. Access to exhaustive and historically deep data is a weakness if not

a full gap in the energy efficiency field. Professionals from nearly every sector in the industry wish to know more about how to connect with communities and what inspires them to act. Having a consistent platform to input data, especially qualitative data, can elicit new potentials to assessing and understanding these arcane motives.

Open-sourced information publicized on the internet is suggesting to have a profound effect on the way people make decisions. Energy efficiency relies on its universal acceptance into public society to be considered a viable substitution to fossil fuel energy. Before greater society can be expected to embrace efficiency as a principle value, it must first be exposed to efficiency as an attainable trait. Portraying communities in terms of their energy and resource consumption will becoming increasingly more intuitive for the public to understand as mapping precipitates in common public applications and data displays. This will become a common language of information sharing for people of all skill levels to understand and will display energy in material forms that collectively tell a powerful and compelling story to motivate action towards a more sustainable future.

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APPENDIX A :: Transcription of Stakeholder Interviews

ACEEE

Eric Mackres & Ben Foster

January 24, 2012

1. What data would you want?

These would be the high level 3 categories:

Energy Side: I would want data on energy consumption, but the other question is what frequency of data would be good to have? Annual, Monthly, Weekly Data would be nice. Daily data would be nice to have (understanding that there is a level of diminishing return at some point), but if the goal is to allow people to understand their energy use in their community. To give people data frequently is enough. We don't want to inundate people with too much information because it has the opposite effects - but hourly data will be important to have (even if you don't show everyone). Hourly data is important for some stakeholders.

Building Side: There many building assessor records that will have a lot of data. But it will be incomplete and unavailable.

Social & Economic Data: Who is living and working in those buildings, income, race, class, etc. would be another valuable layer.

The Question of Time/Frequency for Data: New York Times, mapping of the recent US census data - they are interactive and you can overlay different sets of data. Time: You could do something down to 2-6 hours & take a snap show.

Infrastructure Location: Look at transmission and infrastructure location. Overlay where the infrastructure is in the landscape. Utilities would have this. (Marshfield) Talk to NStar to see how they identify these issues... ACEEE Efficiency as a Resource. NYC Metro area on this quesiton. Plannig for efficiency, forecasting, Chris Gazze. Fortnightly.com (someone from Vermont)

2. If you overlaid energy data on to the political and societal information? Richard Florida's Agglomerations? Would different cities have different personalities? To take a look at a lot of these insights. A movement towards heterogeneity towards EE, if you just looked at what factors work? Low income populations are being underserved... Politically, how can you mobilize politics to do something?

3. It would be nice to know from existing data why people do what they do. We have from anthropological studies that people don't care about energy per say but they do care about the services they get from their energy. If you give people normative comparisons to their neighbors, it saves on average 2%. Competitions encourage behavior change with information about each other.

How are these changes occurring? Maybe not why, but how?

OTHER | Definition of Community

For the purposes of community-inspired actions, the street was found to be the scale at which community ties were strongest to make successful organized efforts.

OTHER | Privacy

Privacy: As long as data is aggregated in some way, I don't think there is a privacy concern at all. Like the census, is designed to collect aggregated data and has for centuries. I don't think that there would be that much pushback from consumers.

Recommended References:

- Energy Start Billing: The DOE did a study back in the 1990s that suggests that communities are most strongly defined by the street. Especially providing normative comparison between communities or households, they did some research to ask what level of neighborhood, town, or zip code level to use. But they found that the street was one of the most recognized communities.
- ACEEE Report on Cincinnati: The energy efficiency potential by zip code
- CNT: Characterize and understand transportation energy use at a local scale via a lot of local data sets down to the census tract level. **Housing & Neighborhood Index (HNP)** It could be interesting on how to translate into EE methodology. Find out who is working on the transportation side.
- E Know Bill: On the topic of letting utility customers to opt in or opt out of having their data be available to 3rd party organizations.
- CNT: Chicago metro region, a lot of success with ComEd to share data for planning purposes.
- Green Button Program: XXX Science and Technology. 3 California utilities allow customers to press one button and download their utility information.

Berkshire Gas
Laura Biddulth
12January2012

If you can figure out if your area is free of roadblocks like high water table.

Your work has to be - when you pick an area and you want to work in that area to increase their awareness of energy efficiency - talking about energy efficiency seems to get you nowhere. It's not on their radar screen. No one will show up -

In order to generate a willing audience, you have to present that you have a solution to a problem that they already found.

Two things I have found have been ice dams and windows. Everybody thinks their windows suck and they need to buy new ones. I've been giving ice dam workshops and lots of people come out for it. And I give workshops on windows and lots of people show show up.

It's the same topic and the same information. I'm just couching it differently.

It's profound.

Earth Markets
Kerry O'Neill & Kat Donnelly
26January2012

(1.) What data would you want?

I would work from the premise of "how do you mobilize?" Who has an issue? How do you mobilize? Just energy consumption data is one of the leading indicators that locations which are using more energy are probably places that have problems that need to be addressed.

I would want to see, for targeting markets for contractors or programs, energy data that are geo-concentrated. I would want to see energy data by house level, by neighborhood, and I would want to code it (high, medium, low). This is because I would be looking for neighborhoods that probably speak to housing developments – you know the same housing development was built by the same developer and they're all crap. I'm assuming that you could take this one type of usage data (meter level) and normalize and you can smash it against your asset-based scoring system for each home and see what you have in your combination. So for me, it would be interesting to take these two bits of information – meter readings and asset-backed scoring systems – and pair it with other data, such as parcel data, median income, etc.

For me I would want it to help targets. Personally, I'm not a big believer to putting it into the home in front of users immediately (but this may be because I'm from CT and the utilities here suck so badly) It's not about the data to be available; it's about how it's executed in the market. It's about program execution. My bias is going to be market segmentation, targeted marketing for programmers and contractors – as opposed to putting it into the home to drive change by putting it into the home.

What you're doing is **consumer facing** versus what you might do when you're more **program facing**. How you might roll a program like this into a community. I have a bias for community-based programmatic based implementation and/or a contractor targeted marketing implementation because I have a bias around "you need more than just information" to get homeowners to do something. You need those additional supports around to get homeowners to do something, and just putting the information out there in their home will not be enough.

(2.) What do you want to do with this data?

To me it's very much tied to wanting to help drive targeted marketing and outreach strategies, whether their contractor driven or community driven, sector or channel driven, to really drive at what the most cost effective marketing and outreach strategies will be. I want to know where the gold is and I want to mine the gold.

I'm looking at this from a customer acquisition side. If I'm going to run a contractor oriented program and I want them to do val-pack inserts, and I want to set them up for success, I need to be able to give them the data that tells them which census tracts to start with. Or to give them a list to tell them where to mail to. Or I want to give this list to the municipality to mail out, and for political reasons, they may need to mail something out to the entire community but I will give them a specific message to target a specific community. But I'm only willing to do a canvas in very targeted areas.

I know what my thresholds I have to hit, I know what my assignments have to be, what my bid rate, what my upgrade rates have to be to be cost effective. I'm going to use this data to decide where the good hunting grounds are. It's what consumer marketers do every day, all day long. We just don't seem to do this in energy efficiency. I can imagine then that once you have this information, and part of a program, putting this information out there so that consumers can see it, on a dashboard or on a facebook page so that they can start boasting about how well they're doing, and you can put it in the context of a competition with goals, etc. But you see it's in a program – there is a program element to this – it would be in the context of some kind of social support.

Putting this data against other demographic or psychographic data would be very helpful because I'd like to target, not only who has the greatest energy opportunity, but what's their financial wherewithal to actually deal with it, and who I have to make a really aggressive and compelling financial offer to do it. (Because their middle income and they're going to be stretched they're going to need zero percent financing, and some money down, and I know their creditworthiness is an issue, and they won't have discretionary income etc. They'll need onbill repayment, and underwrite these 5 year utility payments not based on their credit score, etc.) It will be good to know where they are to the AMI (Average Median Income). You can get all of this data at the census tract level – you won't believe what kind of

data is available. If you put this data against the data that all consumer marketers have available to them, you could get a lot. Some communities even have their own tax assessor records on line, etc.

(3.) What do you wish you could do with your existing data?

The problem with what we have access to today – we get usage data every month delayed by a week & a half every month from the utilities. It's unreliable as to when and what kind of data we get. This is ridiculous. Our data seems to be off somewhere by a factor of 10 (the aggregate data). The individual use data is accurate. **We want regular and consistent data.**

The tools that are out there to give us complete data are insufficient for doing this.

The individual use data is interesting because you can target offers and do messaging etc. We don't have usage data that is normalized, we don't have that usage data has good comparisons to others. We're in CT, electricity is not the only factor, we have oil and propane, etc. It's just incomplete and it's not timely. We don't have saturation data for each home, and we don't know what kind of upgrades they've done. It's just that there is a lot of missing data (Saturation = what kind of appliances and devices that they have in their home, what kind of heating system, how many TV, etc.)

We have a program that does allow this kind of data to be offered called Snugghome. SNUGGHOME = they provide for us a tool that provides a personal energy dashboard. We also have a DO IT YOURSELF Energy Audit (more like an assessment)= where people go in and they fill out information about their house (what kind of insulation, how much are they paying for their energy/electricity, how do they heat their home). We try to get an estimate back from them so that we can do some kind of number crunching and make recommendations about what kind of upgrades they can make to their home.

Ann Livingston, Snugghome

RDRR - Sanjay Sarma, Infrared Drive-By: It's combining this infrared drive-by with that whole database of all the existing parcel data and all of the existing census data. We would use this if we could get him to give it to us. We'd use it as a marketing tool after we target the right area. But we'd use this tool with targeting.

Recommendations

You need to talk to more people in the community-based sectors of energy efficiency. Even Efficiency2.0 and clients like that, they are all working for the utilities so they will all have a similar mindset. Talk to Amy Stitely and talk to some of her contacts in the community based programs. Utilities are not thinking 10 to 15 years ahead, they're not thinking with the customer in mind.

Zico Koulter would be very interesting to speak to. He was working with **Tom Piper** who was really the brains behind this system – where they are able to get it down to the appliance.

Try benchmarking with other industries. There are very functional things occurring in other industries and we should learn what is working for them and pull them into energy efficiency.

Easton, Massachusetts
Adrienne Edwards

(1) What data would you want?

Since I began collecting energy data for the Town of Easton I have thought how interesting and useful it would be to learn how much energy the community as a whole consumed. If this data were available it would be particularly useful to break it down by Zone (commercial, industrial, residential, etc.) and even by neighborhood. This would allow energy consumers to obtain a "snapshot" of how much energy their Town uses, what sectors consume the most (likely to be industrial) and allow one to generate averages by sector (such as average Easton residential energy use, average business use, etc.). Much of this data processing of course would need to also include and incorporate other attributes, especially building square footage, age of structure, type of business, and so on.

(2) What would you do with this data?

Through my work as the Chair of Easton's Green Communities Committee I am actively involved in educating the community on energy issues, particularly home energy use. If the data noted above were available I believe it could serve as an effective learning tool that would help community members to familiarize themselves not only with how much energy they use but how this information compares with others in the community who have similar houses and business facilities. If there were a way to break the data down by village or neighborhood (maybe utilizing GIS technologies?) this could possibly inspire those within subdivisions, condo and business complexes, and the like, to develop energy efficiency efforts at a kind of micro-local level!

(3) What do you wish you could do with your existing data?

As I mentioned in my answer to question #1 I have desired data to be available at the community level for some time. Although I currently report on the energy usage data from the municipal government sector, and realize this is of interest to many residents as well as town officials, particularly in this age of concerns with energy and cost efficiency, I feel obtaining data at the community level would speak more directly to those residing in town who have an interest in energy efficiency beyond what is reflected on energy bills.

Recently I viewed a US DOE webinar "Introduction to Using Community-Wide Behavior Change Programs to Increase Energy Efficiency". This webinar described, among other findings, how energy consumers were more likely to save energy and continue this efficiency if they knew where they stood in comparison to their neighbors. This conclusion seemed convincing but it would be necessary to have access to community, zone, and even neighborhood scale data in order to implement this approach in communities like Easton.

Efficiency 2.0
Zeke Hausfather
January 20, 2012

1)

I would want both billing data (ideally hourly interval data in real time), but practically even day-after hourly data or monthly data would still be desirable. I would also want property records (from county tax assessment offices) for all homes in an area.

2)

a - Assuming that real-time interval data was available, I would create a real-time comparison for each individual user showing how their energy use compares to that of similar homes. This would be coupled with gameification aspects: showing folks their rank, awarding points for using less energy than similar homes, etc. The real-time data would allow immediate feedback between a user's actions and their displayed energy use relative to their neighbors.

b - Usage data could also be turned into energy use heatmaps that visually display patterns of energy use in an area. This could be done in such a way that obscures the energy use of any single house while preserving broad patterns. You could also overlay a colored dot representing the relative energy use of a given user on top of the neighborhood pattern.

3)

The community level energy use visualization mentioned in 2-b is probably doable with our existing data, but client privacy concerns have prevented us from implementing it in any of our active projects to date. I'm attaching a version of this sort of heat map that we did (using synthetic data) awhile back.

EPA, Energy Star
John Passe
21 February, 2012

Data Delivery: With certain information, paired with their zip code, we're able to serve residents with fairly customized recommendations for any typical area. So we know how many people use the tool, but we cannot say how many people actually take action on those recommendations.

Data Tracking: We also have a whole house of retrofit programs called Performance with Energy Star. This is a program available through the Mass Save Program – with NStar and National Grid, so basically what we do there is you have a professional home energy auditor to come to your house to give you an assessment of the house and give the homeowner a very customized set of recommendations. And then that auditor then links the homeowner with various contractors that can get that work done. Then the contractors come back at the end, re-inspect the home, and test the home to make sure that measures were all done correctly. Then that order is reported to the local utility who often incentivizes for the consumer some of the cost. So in that case, there is some tracking information insofar as how many homes are upgraded. The other big program in that area is run out of New York through

NYCERTA. They would be great to reach out to. So at the national level we often initiate policy and mechanisms through the local entities in each location. Well, we certainly try to look more broadly at the level of effectiveness of our programs by looking at information across different regions that tell us information about different data.

Feedback: We do have some ideas in the works for creating a portal for homeowners to keep track of their home efficiency improvements. That's something that we're looking into to do over the next year. Use these tools and create something of a to-do list. Keep track of the things that they have done – and obviously we would have the ability to track their decisions through that.

21 February, 2012

One of the things that came up in our conversation this morning is that we really don't know what people actually do (we give all of this guidance, tips, and suggestions). So to me the first big thing that came up was of course we would like to know of people who came to our site, and for those people who viewed something of Energy Star, and then took action? What percentage did do something, what did they do, and ideally what the effects were? We do have good data on energy savings potentials, but we don't necessarily always have good data on actual things.

I look at data number of ways. One is (1) data going out – you have that interaction of data, you have a message and you are broadcasting it, and asking if people are doing something with it, or (2) the background data on evaluating that you receive (it tells if what you are actually doing has an impact). It's always nice to have one informs the other. But I think it's always been problematic for us in some ways, not in that we don't know what data we want, we don't know how to ask for it in certain ways. Some data is very easy to ask for: What's your zip code, etc.? It's not so much the homeowner data we've had trouble with, it's really been the contractor data is what we are having trouble with. It's using language that the contractors will respond to and give the data that we are looking for. So when it comes to numbers, that data is actually really easy to get – something that you can measure. When you are asking for data that is a bit more subjective like, "what really happened?", it's very hard to ask and recruit. We need a deeper level of data than we would normally get and it's hard to ask. This other kind of data, this is the data that we would like, but it's hard to figure out how to ask for it.

With this kind of feedback data, you're going to get to a point where you don't want to show the homeowner everything. There are these very complex systems at home, how do you simplify it so it has any meaning to the homeowners? Having these two faces. There is this notion that providing homeowners real time information on the energy use on a moment to moment basis – it will influence their behavior. I'm not sure that there is great research out there that suggests that that's actually the case. I think this is really a lot for utilities to deal with, and they need to figure out how to manage, because the person needs something actionable at the moment: "If you do this, this will get you to where you need to be." As opposed to "Oh, you're peaking." – they're going to go, what the heck am I supposed to do?

Home energy monitoring and real time is becoming more and more ubiquitous. There is a lot of talk about this in terms of the true believer. You're speaking to different people, different publics. This

information could be very influential for the “true believer”. If you do put one of these monitoring devices – with the real time energy use – for the true believer this could be a very effective application. But the true believe is far and few between. There is this notion that displaying real time data to the homeowner will impact their behavior, but I’m not sure this is entirely true. You have to be a willing subject to make the visualization meaningful.

I would say by extentions, many of those types of “program side” organizations are very much involved in marketing in the long run the value of energy efficiency to those end users. So you pick a utility who would probably be a type of organization that will put the data monitoring device in the end users hands – so what’s in it for the utility than to ultimately change behavior. Some of those organizations could use that data to do different things. Some of them could use that data simply to set policy. Some of them could use that data to set marketing campaigns to influence their users. Organizations (program side) could use this data to (1) set policy, (2) develop a efficiency program.

The irony is, these days, in talking about the “Yardstick” and the commercial “Portfolio Manager” which are much more sophisticated, the trend right now in how the homeowner would visualize the data or how their home or building is performing is by the “miles per gallon” type metric. Personally, this is not my favorite way – because what you’re doing is taking a complicated system and rolling it all up, and through some sort of “math magic”, and then providing just another complicated way for people to understand. People need to understand how that score was generated in order for them to get any benefit out of it. So they’re essentially taking one complex system and replacing it with another complex system. In my mind, you need a combination of things, not just roll things up into a metric. You’re not going to get one number that will help a homeowner understand everything. It has to be a series of metrics. It has to be a combination of information. It doesn’t have to be super complex or anything; like a list of things with a number, or a visualization with a number. I’m very weary of rolling all of these things up to a number.

Recommendation: Look at OPower. They are a great example where you have real field research about truly visualizing with a power bill and the consumer getting some feedback on a normative basis.

Church groups are really interesting groups that are surfacing in terms of community groups. Church groups are popping out to try and help their petitioners save energy. It’s a group that we’ve been trying to engage but haven’t really had the right tools. We have the right tools to help the church themselves, but not the right information to help the church help their petitioners.

Recommendation: Products Group: Energy Star Pledge. This is a social action effort. The EPA is directly asking individuals to take certain steps to improve the efficiency of their home through either asset upgrade products, insulation changes, or simple behavior changes. Also, we have something called our Pledge Driver Campaign to drive community groups (whoever they may be: they could be a company, a neighborhood, a municipal government, it could be anyone) to bring the message of the energy star pledge to their community and we are able to credit them (in loose terms) for driving those pledges. You can see on our website the types of organizations that are pledging. It’s the “Change the World, Start with Energy Star Campaign”. **Brittney Gordon, Lead Person for the Pledge Campaign 202.343.9122**

(1) What data would you want?

We want to know which energy conservation measures were implemented, what the impacts of that (saved kwh/therms/btu) and would obviously want to translate that into carbon. We'd be interested in carbon but we would formulate that.

We'd want to know the statistics of how the consumer interact with the information and what actually made them do something so we could understand which one of our methods are actually working. Since we as an industry don't know, we seem to always be looking for that silver bullet. As you talk more to people in this industry, you will find over and over again that people are searching for that magic formula to see what will make the consumer take action. You will see that people will throw a lot of different messaging on the wall to see what sticks. When you are a mass programmer like we are, you have to try multiple messaging tactics in the same communication. So for residential home improvements, you'll see us talking about utility savings, about comfort, sometimes about indoor air quality, and sometimes you'll see us talking about the environment. Comfort, Savings, Sometimes Air Quality, and then as a kicker Environmental – literally in that order. We've done a lot of work with market research firms – as others have – trying to figure out with different demographic groups, what the motivating behaviors and messages are. It varies.

What inspires them to take action? The real answer is that it depends. I get a little frustrated that everyone is out there looking for the secret sauce. I'm not convinced that there is even one secret sauce. And what's more, there are just so many benefits for what we are offering can give them.

John Passe's Experience/Opinion: Theory on Why Consumers Make Energy Efficiency to their Home. It's the same reason why they make any changes to their home. And that answer is that they feel some kind of pain. It could be a pain of "I don't like this kitchen, it's too small, I don't have enough cooking space." Or "This house is too small, I have a growing family, I want to expand, etc.". They don't like the color of the room, they don't like the wallpaper. It's a physical pain or an emotional pain. There is an emotional pain there that they want to fix – so they will take action to keep up with the guys down the block. So, from an energy efficiency side, the physical pain is like a comfort. "I am uncomfortable in this room, the basement is too cold in winter for the kids to play downstairs, I can't sit in my favorite chair because it's too drafty." There is a physical pain for them to overcome. There could also be a financial pain. "My utility bills are too high." There could also be an emotional pain about the environment. There are some people out there that feel some kind of commitment to protect the environment and they feel badly when they know they're wasting energy. So they are trying to make that pain go away. Some of the interesting things are, particularly when you deal with the utility bill savings issue, there are lots of low-cost, no-cost things that the consumer can do. And they do have a meaningful impact on their efficiency, and their utility bills. But the fact is that it does require some investment to make real changes. Insulation costs money. Air ceiling costs money. HVAC replacement costs a lot of money. So that fact is that in order to make some of the pain go away, there is a financial pain to take the action. And there is a little bit both of a financial cost benefit that happens in the consumers' brain, and the

emotional and physical cost benefit that happens as well. We actually don't think for the most part that consumers really make these changes for energy savings. We think for the most part people do it for comfort – for the bigger things. For the bigger things like insulation. If you think about the cost of doing these kinds of things (if you can afford to replace your HVAC system, or proactively put insulation into your attic or walls), you have money to pay your utility bills. That's not such a driver. Now if you can convince them of the long term payback, then sure. But these things are all long term paybacks. Windows, by the way, which are one of the most popular energy efficiency improvements, rarely pay off, unless they were going to be replaced anyway. Unless you are already planning to replace your windows, from a cost-benefit, windows are very expensive. Windows are usually replaced in the house because of aesthetics (and because of draftiness), but also the window manufacturers are fantastic at marketing the energy efficiency savings and they are often overstated.

We never recommend windows replacement as a starting point. Typically what we recommend is air sealing of the envelope, then insulation, and then (if we're talking envelope) then windows. But only after you seal the envelope and have the insulation where you can. Everyone can come up with a storm window solution, they already came up with an alternative. But it's really an aesthetic issue, people love new windows – they're gorgeous – they look great in a new house. But it does actually add value to the home. It's one of the few energy efficiency improvements that we know is a valued improvement when it comes to the time of sale. No one particularly cares that your blower door number is .35 or that you have R35 in the attic. Yeah, because the appraisers will actually value it as well – which is what the energy efficiency world is trying to have appraisers do. To understand the value of these other things – and that it will bring value to energy efficiency.

(2) What would you do with your data?

(3) What do you wish you could do with your existing data?

To be honest we are getting into privacy issues which are probably something you don't really want to get into. That's probably the worst impediment that we have – being the government is difficult with that. What we would like to do is, because we are the government, is beyond what we are allowed to do. We cannot really look at specific homeowners data, we can only aggregated data. So I guess one of the things we'd like to do is really more logistical than it is the data. To better house the data, to be able to mine it better, both of those things are really more logistical than it really is a data problem. It's really just how to better use it, and evaluate it, and house it, and things like that. And where does it come from and how do we get it, and if we do need to aggregate it, how do we use that information to improve our programs, and what information do we give to homeowners and what you do with it. It's not so much a data issue, it's what you do with it. We can't even do something like tracking cookies on our websites. We can't do anything like that.

New England Gas Company
Matt Zenni
January 2012

(1.) What data would you want?

I would want to know what motivates people to act. We have no idea what gets people to act. I know why a specific customer acts on a specific project. But I don't know why on a community base why people act.

Community A adopts the stretch codes but Community B does not. Why is this? Looking cross-sectional between community groups - see if there is some common technology being used between community groups. What is the commonality? I have the data that I need to work with an individual customer. If you're looking at what data you would need to motivate a village. Village data = Age and type of structures. In one neighborhood all the houses are like 50 or 60 years old. There is something that we can do with the houses that haven't done some updates. It's a slippery slope for us because we don't want this to cross into demographic profiling. We wouldn't want this to turn into a race issue.

(3.) What would you want to do with this data?

I would want to find out if there was some way of getting involved with the hard to reach customers. And if there were similarities between certain hard to reach community groups across communities, I would want that too.

Peregrine
Josh Sklarsky
31 January, 2012

Process of Data Lifecycles

The is the action of getting the data, then there is the collecting of the data, then there is the analysis and/or the display of the data, and then it gets fed back into. We are involved with that data collection, the manipulation of that data, and then the displaying of that data, and the generating useful information off of that. Then we hand it off to different parties. So after that, this is the real question, where does it go after this? Who does it go to and what are you hoping to see as results?

Different Data Displayed to Different Communities

The information is great for knowing what is going on in a particular area or for a particular set of buildings. But just giving it back to people who generating it...well just giving the data isn't enough, there must be something else to go along with it. The consumer of the data and any analysis done on it

should be targeted towards those groups who are in a position to do the outreach or influence policy or something. You want to give this to people who will be able to translate it to certain people.

You don't just want to give it out to the entire city and let them see the whole thing. You want to give the information to the people in the city who will know how to translate that to the right people. The people who will say that it is the emission factors, it's the emissions that matter to the environmental people so we will be talking to them about that. It's the money that we're spending or could be saving that is important to the people who deal with the finances, so we talk to them about that.

Understanding the audience is a large part of interpreting that data, and sometimes having a member of the community is important to understand the community in discussion.

We have found that there isn't a single way to represent energy consumption data or use patterns to everyone. There are some things that we do for groups across various fields that are good, but then there are certain things (because we have a better understanding of energy data because we look at it all the time) that are useful for us to look at but not necessarily the consumers of energy or the people who are using the energy. But there are maybe things that we could look at as far as use patterns that we can pick out, but something that is not necessarily in the form of a graph or something that they can use. We may have to reinterpret the data based on the needs of the user.

In MassEnergyInsight, each town has the same visual data, but they organize it differently. Part of this is due to how they are interested in looking at things – they may want to look at their data by building sector, etc. And we help them organize their reports to reflect this – how to divide their energy use by certain buildings.

Each city can choose a baseline year. And then see every year compared to that. Some of the reports that we create are based on state guidelines. Within MassEnergyInsights, there is more than just what the municipalities see – there are some custom reports that we make for the State. So that the state can see some aggregate data for their state, such as water treatment plants, and then the state will do some analysis on this. We've done benchmarks on the schools for the States: so we take the entire set of schools for the state and we've benchmarked them so that we can give the report to any city to show municipalities how their schools stack up against each school.

We do custom reports for several other clients of ours – we do custom reports for some of our clients who own a lot of property, and some campus or universities, etc.

Custom Information Distribution

Since we have all the data, we can slice it and dice it any way we want to try and identify what the problems or trends are. We receive calls from cities that are curious to know why their data is looking the way it is, etc. We'll create a report to look at oddities, requests, and outliers. We'll try to pinpoint what building it was, and what time something changed, and what date, etc. Our engineer (in house) will then speak with someone in the city to relay this information and work with them to create a strategy to address the exposed issue.

We do policy and program design and interagency work, etc. Sometimes we happen to be working with municipalities that are working with MassEnergyInsight, but we work on other types of projects.

Showing People that they are Above Average

If you show customers that they are above average in terms of energy consumption. Well, I can't directly answer that question – there has been a ton of research on the behavioral side. However, most of the research has been on the individual behavior, and not on the group or social psychology side of it – so that would be interesting. My initial response is that some of that doesn't really matter when you are talking about groups and organizations. If you are moving away from an random way of grouping or classifying people together, say if it's any geographic grouping of people (like a condo association) and the goal is not to do energy, they may have a different reaction than say a city's energy efficiency program (whether it is a city group or a mission driven organization) Whether it is a city group or a goal/mission driving organization. The mission doesn't always have to be driven by cutting costs and creating savings. For PR purposes, it may be inspiring to them to boast about their achievement and continue to move forward on it.

Doing MassEnergyInsight for Communities? What would that look like?

The **size of the group and what is at stake** are two very important things to take into consideration in terms of how to use this tool and to be sure that it is used properly. It still takes time and investment to pull together data and display energy visualization – even when the tools are meant to help this. It's still a lot of work, especially in collecting the data. MEI is tied to green communities, where it has a grant and other carrots there, so there is more incentive there. Other communities, getting their data from a small MLP that won't have a large data dump, getting data can be more difficult. If there were a standard interface for all utility companies such that the data were to be given to the utility companies, or if they were required to give the data, this would be easier. Stake: MEI has funding available, so there is this kind of incentive attached. If it is a large institution where energy savings are substantial, or if they are required to engage with energy savings activities, this is what is at stake. If there is a smaller group, there might be less at stake in terms of the absolute difference that it can make (or less motivation). That also speaks to the amount of time and motivation that might be available to manage this data.

There are two sides to this: there is getting that data, and then making sure that it is right. There is a lot that can go wrong. There is duplicate data and there is overlapping data. (Three electric meters and one gas meter for a building with three rental units – do you collapse the three electric accounts into one because there is only one gas account?).

(1.) What data would you want?

The more data you have the better, it's always easier to exclude data than to include it. I'd want as much data as possible, particularly about the building and the space being used, and as much data about

the meter as possible. Are you assuming that these are smart meters where higher interval data is available, maybe? But sometimes that amount of data is too much (**for computers to handle**). I think the most important thing would be to have consistent ways of identifying where the data came from, and then to know with some level of certainty of where that data came from and what it is attached to – where it is located on a map. It's really important – using addresses to match things up between assessor's databases and meter data – this is actually a very large challenge.

But then all of the other standard information that you are able to get from utility companies: kw hours, dollars spent, delivery supply and breakout, demand charges, peak demand, etc.

There is a lot of promise to come out of interval data, especially for individuals. I don't know how much more valuable more data would be (diminishing returns). If you're working with communities, you may not need the really high frequency data – but then again, it depends on what you're trying to do.

(2.) What would I want to do with this data?

A lot of the things we are doing, a lot of the things we've been talking about. Something to harp on from earlier, **who the audience is very important**. Making data publically available is great, but just giving it out to whoever wants it or to give it back to whoever wants it, or to those who create it isn't exactly going to make the change. But to make the data relevant to those who will use it for things that they may wish to do may be important – providing reports on data to companies to retrofits and audits that are going to knock on doors, using it for policy and program designers to better inform their programs – is sometimes more useful than just making a display of it.

(3.) What do you wish you could do with your existing data?

Not quite sure I have an answer.

One Editor for this Tool Having one editor for this kind of tool may not necessarily be important. You do often run into problems when multiple sources are working on one data set, but it's seemingly nbd.

APPENDIX B :: Data and Content of GIS Mapping

Information Display

Mapping is a mechanism that primarily intends to inform consumers of their community-level energy data in a digestible format. Providing access to the necessary information is the first step in designing an efficiency program. Mapping is a way of surfacing a lot of information, as is indicative of community-scaled scopes, simultaneously such that patterns, trends, and cultures can be observed.

While utility companies sometimes aggregate their consumers' energy data before distributing it to their energy program consultants (O'Neill & Donnelly, 2012; Sklarsky, 2011), aggregate data should not be inputted into a mapping tool of this kind. Individual and household data should be inputted into this online energy platform and the tool itself will aggregate and disaggregate the data according to the level of granularity required by the parameters of the mapping display. Holding the assumption that energy data is available for every meter true, advanced metering infrastructure (AMI) will be able to provide the most granular of data, in real time streams, from which the mapping tool can build upon. As AMI and smart grid infrastructure becomes more ubiquitous, highly granular data will universally become consistently and reliably available.

Spatial Data

We argue that spatializing data is the next step in progressing our understanding of energy efficiency adaptation and the key to unlocking the next iteration of energy innovation. This paper uses the term specialize to describe the method of displaying information in the geographical location that it applies to or originates from – essentially mapping the information.

- GIS data bases and shape files
- Urban Density
- LIDAR imagery showing Pervious vs. Impervious Surfaces (Greenroofs, Non-point Water Sources)

Energy Consumption Data

Consumers' energy has previously been stored in the protective hands of the energy providers and their contractors. This data is rarely displayed publically and thus its spatial visualization in a map is the proposed new element. While maps are usually static, this data has an element of time and needs to be represented to show the fluxuations of energy use per period of time. Users will decide when to aggregate the data back to in order to establish an average energy use versus when to demonstrate peaks and troughs. Source: Energy Utility Companies.

- Gas
- Electric

- Oil

Non-Consumption Energy Data

In addition to utility consumption data, energy data that does not track the consumption use patterns is available that can greatly contribute to the comprehension of energy efficiency potential.

- Transmission and Distribution Locations
- Home Audit Data
- Inspection Permits
- Appliance Service and Warranty Data

Other Data

While energy data is the primary information used to impact energy efficiency behavior, the real opportunity to improve our understanding of energy consumption lies in aligning utility bill data sets with other sets of existing data (Donnelly & Sklarsky, 2010). Not only is funding for energy efficiency often lumped into other packaged missions, such as “green retrofits”, where efficiency is not the explicit goal, but causation for energy patterns will likely stem from other motivations. Unexpected roadblocks, such as high water tables in the target area, can greatly inhibit a retrofit project. Source: US Census, Building Assessor Records, GIS, Real Estate Assessor Records.

- Census Data (Median Household Income, Race, Age, etc.)
- Assessor Parcel Data
- Weather Data
- Environmental Measurement Data (Ambient Heat Temperatures, Water Pollution Levels)
- Real Estate Assessor Data (Rented vs. Owned Properties, High turnover vs. Low Turnover)

Classification

Grouping properties by sector is key since each sector requires different expertise to manage and each sector exhibits different energy patterns and characteristics. These classifications and the data behind each grouping are the units of information that will compile to form a robust benchmarking system. Displaying the data in categories is attempting to visualize the benchmarks.

(Buildings)

- Residential
- Commercial
- Industrial
- Municipal
- Street Lights
- Small
- Medium
- Large
- Multi (family)

(People)

- Income, Ethnicity, Household size, Average Age, etc.

(Location)

- Specific climate areas, habitat (mountains vs. shore), etc.
- Location to highways, wetlands, transmission and distribution infrastructure, etc.

Zoning Map

Overlaying the energy map with zoning ordinances, target areas, and other regulatory enactments assigned to the landscape is useful to know what the parameters and potentials are for the area of interest.

- As-of-Right Siting (possibility for collaboration)
- Brownfield Sites (funding & tax incentives available for remediation)
- Enterprise Zones (political support funding available for improvements & outreach)
- Historic Districts (building codes & opportunities to leverage remodeling efforts)
- School Districts (important for some outreach strategies)
- Government Target Zones & Bid Districts (political support & possible funding)

Political Map

The politics of a community can either be the greatest inhibitor or enabler of many energy efficiency initiatives. This category of information aims to map the boundaries of the political interest in an area such that non-community members can quickly assess the political environment of an area.

- City, Neighborhood, Campus Boundaries with corresponding
 - Political Leaders
 - Point of Contacts
 - Utility Provider
- Existing Efficiency Programs and the Scope of their Territory

Calculator

Especially for the data and the classification visualizations, calculating bulk quantity estimates is important to project program application costs, value engineering finances, and “biggest bang for your buck” assessments.

Community Scale

The scale of the mapped data on the information display will be defined by the scale of the self-identified community. Community groups vary greatly in scale, forming around a variety of self-identified communities, university campuses, street corridors, neighborhoods, whole villages, or social networks of friends. Since the context is different in each setting, the data display will need to be as

versatile as the group interests are unique (Michaels H. G., et al., 2011). In order to meet the unpredictable and diverse needs of current and yet-to-form community groups, the boundaries of the community will be set by the consumer groups themselves. Users can either draw the perimeter of their territory, select areas by zoning codes, or they can input property addresses to identify their community. Once the community is defined, the appropriate correlation of data granularity will ensue. All data will be aggregated to some degree before being displayed, but the display could assign a higher degree of granularity, or less aggregated, when “zoomed-in” and lower degrees of granularity when “zoomed-out” such that salient patterns and trends can surface.

Incentive Features

Information is only valuable in helping people form true beliefs which, in return, promotes effective, goal-achieving actions (March & Smith, 1995). While there is widening recognition that providing information technology to consumers is essential, it is not enough to enable a movement of energy efficiency in isolation. Pairing information with incentives to mobilize consumers into action appears to be the key recipe to take efficiency to the next step.

Goal Setting

To the extent possible, communities should define their own approaches to meeting an informed set of goals (Michaels, Song, Mackres, & Metzner, 2010). Letting customers reach their own conclusions is a type of feedback that more effectively motivates individuals (or individual communities) to mobilize than to simply tell them what is right and wrong. Setting goals engages people to draw their own social comparisons and tap into their natural compulsion to “keep up with the Joneses” (Michaels H. G., et al., 2011). Defining the goals themselves may occur as a joint effort between the expressed self-identified community problems and the energy-educated program administrators and services providers.

Actionable Items

Offering individuals advice on what energy-wise actions they may take to live more energy efficiently offers consumers a guide to take the next step. Matching the most impactful actions to the most feasible customers, either through a filtered search option or to engineer tailor advice to targeted audiences using benchmarks and algorithms, has delivered relatively high levels of success (Center for Energy for Energy and Environment, 2009; Laskey & Kavazovic, 2010). Actions can be offered both on an individual-level, embedded in the contextualized information, and more publically at the community-level to equip community groups mobilize change.

Rebate Redemptions & Program Incentives

Financial and other non-monetary incentives can prove to be powerful motivators for both individual customers and communities. Community incentives could be come in the form of donations to schools and public programs, as specialized incentive programs that target certain communities, such as municipalities or institutional communities, or as portfolio incentives, which is a combination of

targeted standard community incentives and certain custom incentives for unique opportunities within the community. In this way, incentives can fit most economies of scale.

Feedback Tools

The feedback tools are meant to work in both directions – from energy consumers to energy suppliers and vice versa.

A. From Consumers to Energy Suppliers/Efficiency Providers

Feedback tools that collect data provided user involvement and input can be beneficial to service providers, such as utility companies and ESCOs.

Measurement and Verification

Measurement and verification (M&V) is the assessment processes conducted after energy retrofits or energy program actions have been implemented to gauge the amount of energy saved by comparing the before and after energy use levels. This mapping tool can essentially serve as a public tracking device, where quantitative energy measurements can be inputted from energy projects throughout many communities. Having such transparency on such a large collection of energy retrofits can more readily identify truly successful actions as opposed to hypothesized successful efforts. This large scale M&V component can foreseeably inform energy policy as the results will be more statistically significant and cross-comparable than current M&V sources.

Benchmark

With access to millions of records, benchmarks can be established with great accuracy. Using the accessible energy data in concert with a broadly accepted and functioning asset rating system, a robust benchmarking system can be established to easily match building types, demographic, location, and climate typology.

Home Audit Data

Stakeholders and energy providers who design energy programs may be interested to know the age of household appliances (such as stoves, refrigerators, and boilers, and building assets, heating and cooling systems, upgraded insulation, and new roofs), to best strategize when opportune points of intervention may arise. When these appliances and assets are nearing the end of their functional lifespans, program directors may best optimize their efforts by offering rebates for energy-smart products and incentives to upgrade building features for energy efficiency. Additionally, having customers enter their own electricity and gas usage will help contextualize energy use more efficiently and accurately, especially in cases of rental properties that may not have subdivided meters and tenant occupied commercial buildings that have many micro-cultures within each floor.

History of Actions

In the same spirit as the individual home audit data, communities can input their in-place and past program policies. Communities which have previously hosted energy programs have the option to input this information such that a history of past engagements can be documented. Having a record of past experiences informs the current or future efforts to establish an efficiency program. A history of past actions will show how energy-wise the community may be, to what degree the community has been previously prodded, and perhaps what has and has not been effective in the area.

Action Mobilizers

Many energy efficiency suppliers and service providers are fundamentally interested in what compelled people to act in advocacy for energy efficiency? And to that answer, what do communities at large feel they need in order to be compelled to embrace energy efficiency services, goods, and measures? This feedback option would harvest information that explains what the action motivators are for communities.

B. From Energy Service Suppliers to Consumers

This will help community groups and 3rd party associations self-organize and incite activity.

Contextualization

This is a hybrid approach between individual-scaled and community scaled to display information. An individual is delivered billing and account data that reflect their personal habits as it compares to the aggregate community data. Studies have found that people, either aware of it or not, are strongly compelled to “keep up with the Joneses” such that contextualizing and individual’s information can animate them to achieve greater energy efficiency (Laskey & Kavazovic, 2010).

Normative Messages

Descriptive social norms are an individual’s perceptions of expected social behaviors (Michaels H. , et al., 2011). They have been found to have great influence over consumers’ behavior in terms of conservation and be one of the strongest motivators for action. Companies have achieved encouraging levels of success using descriptive norms as a central element in their approach garner energy efficient behaviors from their customers (Laskey & Kavazovic, 2010). Tailored to a community-based audience, descriptive norms can direct messages from energy suppliers to their customers to suggestively shepherd them toward preferable actions and outcomes. Normative messaging is delivered as contextual information, where each community receives information unique to itself, with a weighted analysis per the objectives of the energy supplier. In many instances, program administrators have found that couching energy information under a different topic will garner a much greater response. Energy workshops attract a much greater and more willing audience if they are framed as solutions to a problem that the community has already found (Biddulth, 2012).