



The Residential Energy Map: Catalyzing Energy Efficiency Through Remote Energy Assessments and Improved Data Access

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ABSTRACT

Renters and homebuyers are increasingly using online interactive maps to inform their housing choices. By publicly disclosing energy consumption and an energy performance rating in an online energy map, energy efficiency will be positively impacted through improved decision making and establishing new social norms. Privacy is the most significant barrier to displaying building-level energy consumption and performance information.

This paper explores how an energy map could catalyze energy efficiency upgrades, specifically in the residential market. This research examines existing energy maps, existing energy assessment platforms and what data they use, and evaluates the state of energy data access in the United States. It seeks to answer what data is necessary to map building level energy performance, what policies are necessary to access that data, and how should energy information be displayed in a map for the most meaningful impact. The paper concludes with recommendations for states and the federal government to improve access to energy consumption data. Recommendations are also made for an effective energy map.

Our research particularly considered how city partnerships with efficiency programs provided by energy utilities could be designed to help form a solution, with Cambridge, Massachusetts partnering with NStar Electric and Gas as a potential pilot site.¹

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Summary

Although energy efficiency has potential to be a significant energy resource in the United States, many energy efficiency projects continue to go unrealized. This is especially true in the residential sector, where efficiency programs, frequently administered by utilities, see very low participation rates. However, growing access to data and the growing prevalence of mapping technologies provide new avenues for introducing energy performance information in ways that could encourage increased energy efficiency implementation.

Renters and homebuyers are increasingly using online interactive maps to inform their housing choices. If energy data is mapped or incorporated into an existing real estate map, energy efficiency could become a valued asset that influences housing decisions and encourages building upgrades by property owners. However, major obstacles remain in accessing the data necessary to create meaningful energy maps. Privacy is the most significant barrier to displaying building-level energy consumption and performance information.

This paper explores how an energy map could catalyze energy efficiency upgrades, specifically in the residential market. This research examines existing energy maps, existing energy assessment platforms and what data they use, and evaluates the state of energy data access in the United States. It seeks to answer what data is necessary to map building level energy performance, what policies are necessary to access that data, and how should energy information be displayed in a map for the most meaningful impact.

The paper concludes with recommendations for states and the federal government to improve access to energy consumption data:

- States mandate that utilities disclose energy use of all customers
- The Federal government recommends using one software and database platform
- With Federal support, cities and utilities create pathways for correctly cross referencing multiple databases
- States require only monthly energy updates and include opt-out policies in their disclosure laws to address privacy concerns
- States require energy disclosure for all building sizes
- State energy disclosure laws require that information be made publicly available via an online map.

By publicly disclosing energy consumption and an energy performance rating in an online energy map, energy efficiency will be positively impacted through improved decision making and establishing new social norms. Based on the energy maps evaluated, recommendations are also made for an effective energy map:

- Display data at a building level. For multi-family buildings, the information displayed could be an average for all the units
- Display gross consumption and an energy performance rating
- Use a relative energy performance rating which can be applied to across residential building types

- Enable customizable information displays for different audiences. Both lay people and policymakers or energy specialists should be able to use the map
- Update energy data regularly, ideally every month
- Allow people to opt-out of having their information on the map
- Connect users to other websites and services for energy efficiency
- Facilitate energy competitions and customized building comparisons
- Is accompanied by a marketing campaign to raise awareness of the map and its functions
- Access data from a database which provides a standardized taxonomy like SEED
- And has an API which enables it to be embedded on other sites such as Trulia or Craigslist.

By publicly disclosing energy consumption and an energy performance rating in an online energy map, energy efficiency will be positively impacted through improved decision making and establishing new social norms.

As more energy data becomes available, the more we will understand where efficiency potential can be found in our homes, businesses, and cities. Greater information access will lead to a more efficient use of resources and a better valuation of energy efficiency measures. Energy efficiency will be central to securing clean and reliable energy systems across the United States.

Introduction

On May 9, 2013, a new milestone was reached – for the first time in recorded history, carbon dioxide concentrations in the atmosphere exceeded 400 parts per million. The last time concentrations were this high was over 3 million years ago (Vastag & Samenow, 2013). Reaching 400 ppm is significant – CO₂ concentrations will definitely continue to rise and this means we need to aggressively find ways to reduce dependence on carbon-based fuels.

Energy efficiency is one method of reducing carbon dependence. Energy efficiency technologies are far cheaper to implement than other green energy sources like wind and solar. As seen in Figure 1, the levelized cost to utilities for energy efficiency is significantly lower than other new energy sources such as wind, solar, coal, natural gas, or nuclear. And there is significant potential for energy efficiency projects in the United States. A 2009 energy efficiency report by McKinsey estimated that it would be possible to reduce 2008 energy consumptions levels by 23% by 2020 using current energy efficiency technologies (McKinsey Global Energy and Materials, 2009). However, many of these energy efficiency opportunities go unrealized because of structural barriers and lack of knowledge.

Within energy efficiency opportunities, residential buildings are commonly overlooked. Low-hanging fruit tend to be commercial and industrial buildings where utilities can focus on a few big properties owned by only a few entities, and see major returns on their investments. However, McKinsey found that residential buildings account for 35% of end-use energy efficiency potential and 33% of primary energy potential (McKinsey Global Energy and Materials, 2009). This is a significant sector which should not be ignored.

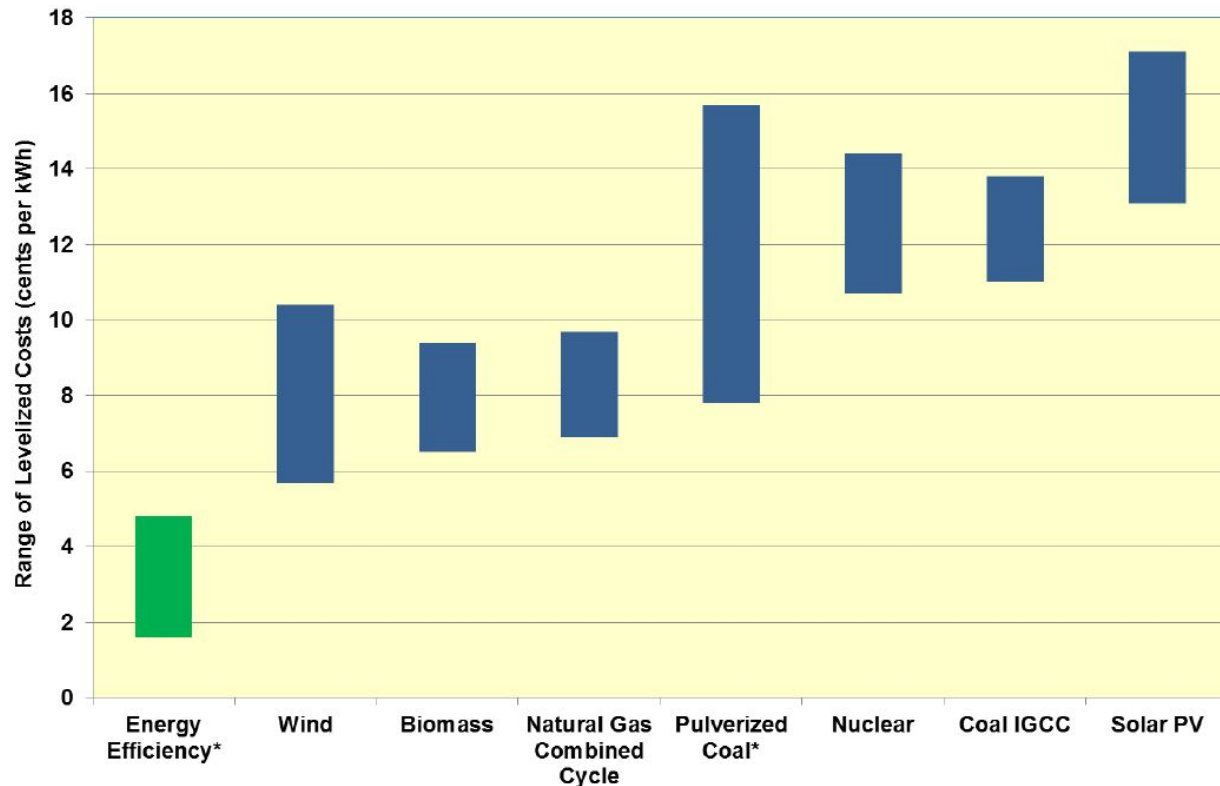


Figure 1 - Levelized Utility Cost of New Energy Resources (Elliott, 2013). This chart was developed for testimony in Ohio, but the general trend of energy efficiency being less expensive than other new energy sources is true across the country.

The residential market is challenging to reach for many reasons, including:

- The sheer quantity of individual buildings and individual owners requires sophisticated marketing and outreach campaigns.
- The audit and retrofit process can be time intensive and require multiple interactions with the utility and contractors. This can discourage some property owners who drop out.
- Energy use and cost are difficult for residential owners and occupants to understand. It's hard to "see" energy use and energy efficiency potential and to access energy use information.

There is no magic bullet to dramatically improve energy efficiency uptake in residential buildings; there will need to be outreach, financing, process, and information improvements across many different areas to overcome existing barriers.

Currently though, there are cities seeking to overcome the information and knowledge barrier. Fourteen U.S. cities have implemented energy disclosure and/or benchmarking requirements (Cluett & Amann, 2013). The basic premise behind disclosure laws is that exposing energy consumption information will lead to increased energy efficiency technology adoption possibly through improved property buying decisions, establishing new social norms for energy performance, or through mandated benchmarking and improvement indexes.

There is a growing body of research which shows that using energy information and feedback systems are effective ways to improve energy conservation and efficiency programs. Showing individuals their energy information in comparison to neighbor's consumption levels can influence people to use less energy. In 2004, Robert Cialdini of the University of Arizona demonstrated that homeowners were more likely to engage in energy conservation behaviors if told their neighbors were implementing conservation measures than if told about potential monetary savings, environmental benefits, or social responsibility (Cialdini & Schultz, 2004).

Energy information and feedback is an effective way to motivate people to act. While utilities already have access to the energy information needed for these programs, energy information is not made readily available to the general public. There are opportunities to increase data access and optimize when, where, and how to best introduce the data. Perhaps there are moments when if presented with the suitable energy information, individuals would be more likely to act on it in a way that improves building energy performance.

One field that remains largely unexplored in the energy industry is mapping. Mapping technologies are growing more and more prevalent in other fields, and because of their close connection to real estate, they offer the opportunity to positively impact energy efficiency. Energy maps could potentially catalyze efficiency improvements in the residential market.

Mapping is a rapidly expanding arena with many practical applications. It is now common place for drivers to use voice spoken directions from their Google Maps application on their smart phones while navigating down city streets. Internet users consume more and more spatial information. Infographic maps frequently accompany popular news stories. Many maps cater to specific interests and industries. Some new mapping applications help people to search for particular businesses in an area or learn more about a particular neighborhood. Yelp.com maps local businesses and allows users to rate them and comment on them. Perhaps maps could influence decision making when it comes to energy efficiency.

Particularly relevant to energy use is that many maps deal with issues related to neighborhood livability and real estate. Walk Score is an online map which allows users to understand the walkability – as

calculated by the Walk Score algorithm – of different neighborhoods (Walk Score, 2012). Demand for Walk Score’s geospatial analysis is great and it has been incorporated into more than 10,000 websites, most of them likely dealing with real estate (Coldewey, 2011). Zillow has an interactive map which displays estimated home values and rental prices, among other details such as square footage, number of bedrooms, and number of baths (Zillow, 2013). Trulia is another popular real estate website which publishes estimated housing values on a map (Trulia, 2013). Since people are interested in the geographic location of their house or potential home, maps are a natural platform to choose to display and analyze housing-related information.

There is an interesting opportunity to combine energy performance with maps to present information to buyers and renters when they are making housing decisions. By giving decision makers the right information at the right time, on platforms (i.e., online maps) they are already using, energy maps could have the potential to dramatically impact energy efficiency. If energy consumption and building performance information were incorporated into the real estate maps people use when buying and renting homes, they could act on that information to make their housing decisions. The growing popularity of maps suggests their potential to help people understand new information and encourage them to take certain actions. An energy map could enable homebuyers to identify and purchase more efficient buildings. And, displaying energy consumption data and relative energy performance on a public map may create social pressure to upgrade buildings and reduce energy use.

However, there is a surprising dearth of building-level energy consumption maps. Given the prevalence of home-related maps and the growing awareness of energy issues, it seems likely that there would be an audience for data rich energy consumption maps. But building energy maps lag behind other maps in quantity, relative impact, and data granularity.

Data access is the primary obstacle to making more meaningful energy maps. Electric and gas utilities are reluctant to release customer data for a number of possible reasons including privacy and safety concerns for ratepayers, fear of opening themselves up to litigation, and the future possibility to generate revenue through selling energy data. Primarily, privacy is the most stated reason for withholding data from the general public (ratepayers are able to access their individual data through bills or an online portal).

However, significant amounts of other personal data – such as property assessed value and water consumption data – are publicly available which suggests privacy concerns may be overstated. Furthermore, residential energy data could be released in such a way to mitigate concerns about safety and privacy. And, since electricity consumption has externalities, such as pollution and grid instability, communities and individuals ought to be able to understand where excess energy consumption occurs.

With better energy disclosure policies, more effective energy mapping tools could be developed which could impact the energy consumption and efficiency behaviors.

Related Work in Energy Mapping

Energy mapping is a relatively new field – many mapping applications are confined to academia or used for internal analysis in the private sector. However, to achieve maximum impact, energy efficiency mapping tools need to be available to the general public and they need to display information for individual buildings. A survey of the energy mapping field conducted by a MIT graduate student in 2012 examined eight energy maps. Of those eight, only two displayed building-level data and of those, only one was a publicly available for use online (Reul & Michaels, 2012). The majority of the maps analyzed aggregated data to the block or county level. While this may be helpful for policy makers, it does not provide helpful information to homeowners and tenants who are incurring the costs of energy consumption. An effective energy map would display data at the building level and provide comparison between similar building types so owners would know if they are performing in relation to their neighbors. This section evaluates how five energy maps are addressing concerns of data access, individual privacy, and visual display.

New York City Building Energy Consumption Map

Researchers at Columbia University created an interactive map in early 2012 which shows building energy consumption at the block level in New York City (see Figure 2). Their study built a model to estimate energy end-use intensities in buildings for space heating, water heating, electricity for cooling, and electricity for other applications. The Columbia Team was able to access robust energy and building data, which is unusual in many other cities. The City provided annual energy data by zip code after gathering the data from the major utilities. Additionally, the researchers were able to use the geo-rectified database called PLUTO which updates building stock information annually (Howard, Parshall, Thompson, Hammer, Dickinson, & Modi, 2012).

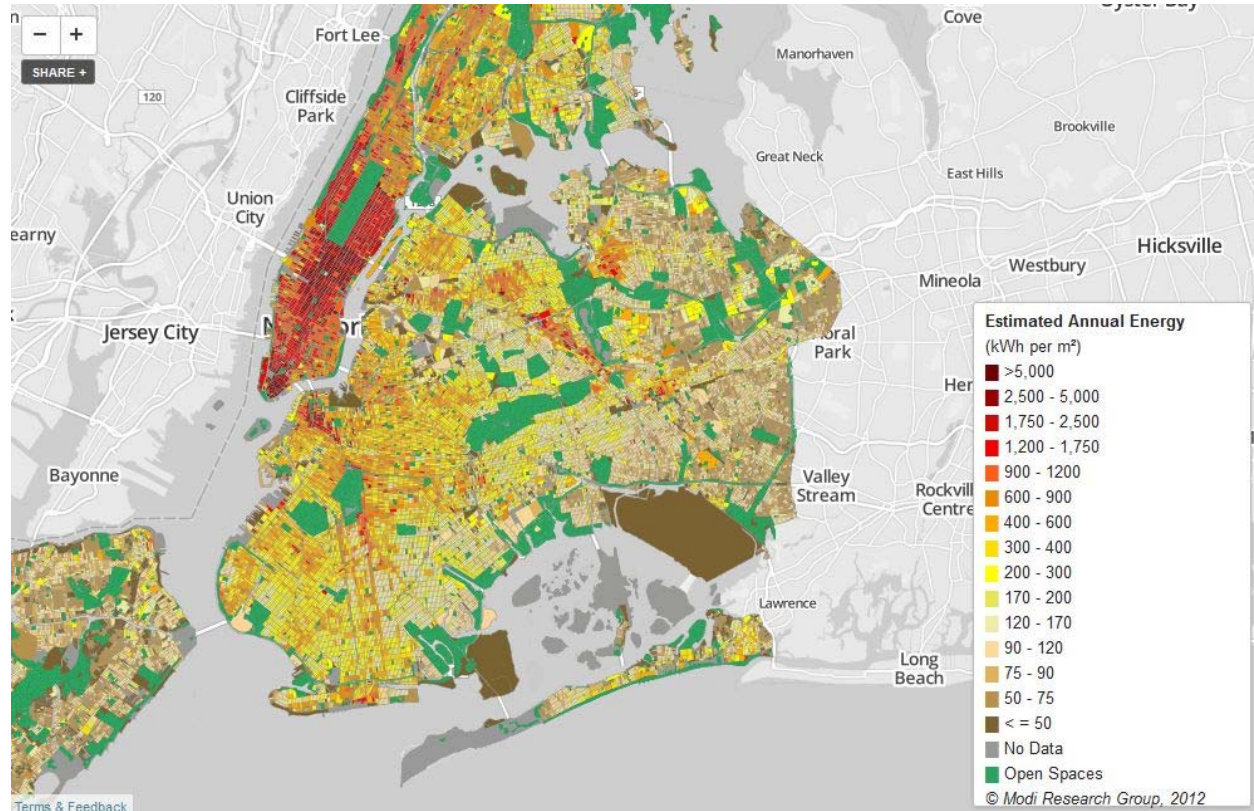


Figure 2 - Screen capture of the energy map created by engineers at Columbia University (Columbia Engineering, 2012).

The lead researcher Bianca Howard noted, “The lack of information about building energy use is staggering...We want to start the conversation for the average New Yorker about energy efficiency and conservation by placing their energy consumption in the context of other New Yorkers. Just knowing about your own consumption can change your entire perspective,” (Columbia Engineering, 2012). One of the stated intentions behind this map was for New York residents to understand the energy consumption of the buildings they live in; however, the complexity of the analysis conducted is geared more towards a research or policy-oriented audience, the map does not show building-level data, and commenters noted how it was not useful to individual occupants. The general public would not be able to understand much of the information presented nor have an idea of what actions should be taken given the information in the map. Indeed, the authors note that the map is a “...valuable tool for determining cost-effectiveness and policies for implementing energy efficiency and renewable energy programs,” (Howard, Parshall, Thompson, Hammer, Dickinson, & Modi, 2012), emphasizing it was designed for policymakers, not the general public.

While the New York City Building Energy Consumption map made a graphically compelling visualization of energy data, it was not necessarily informative or empowering for people seeking to improve the energy efficiency of their buildings. The aggregated data masked identify individual buildings which may be ripe for efficiency upgrades. A map which provides a more granular view of energy use at the building scale would enable people to take more specific actions in the buildings they own and occupy.

Los Angeles Electricity Consumption Map

In March 2013, researchers at UCLA published an interactive map of block-level energy use in Los Angeles. Using data from the Los Angeles Department of Water and Power (the municipal utility) and the American Community Survey, the map displays energy use and characteristics at the block group level (see Figure 3).

The map shows average monthly electricity consumption between January 2011 and June 2012. For each block, users are able to see more detailed information including land use composition, average income, average year built, and block group square meters (California Center for Sustainable Communities, 2013). Researchers were able to access the energy data from the local utility because it was municipally owned. Moving forward, the research team hopes to expand the map into territories covered by private utilities and access data through non-disclosure agreements (La Monica, 2013).

This map offers a more detailed perspective than the Columbia energy map by including land use, income, and building age information. Additionally, the map shows changes over an 18-month period, so users can see seasonal variation in energy consumption. During summer months, electricity consumption increases across the city. Also interesting to note is which block groups exhibit seasonal variation and which do not. The L.A. map certainly offers new lenses to examining energy consumption at the city scale.

However, by aggregating data to the block level, the information does not speak to individual building owners or tenants. An owner could not use the map to understand how their building is performing nor how to take action to improve their building. MIT Technology review noted, “For consumers, the interactive map shows how each block compares to others and consumption patterns by season. But the Web app is more directly aimed at the municipal utility, the Los Angeles Department of Water and Power (LADWP), and city planners,” (La Monica, 2013). It seems privacy concerns influenced the decision to display block level data.

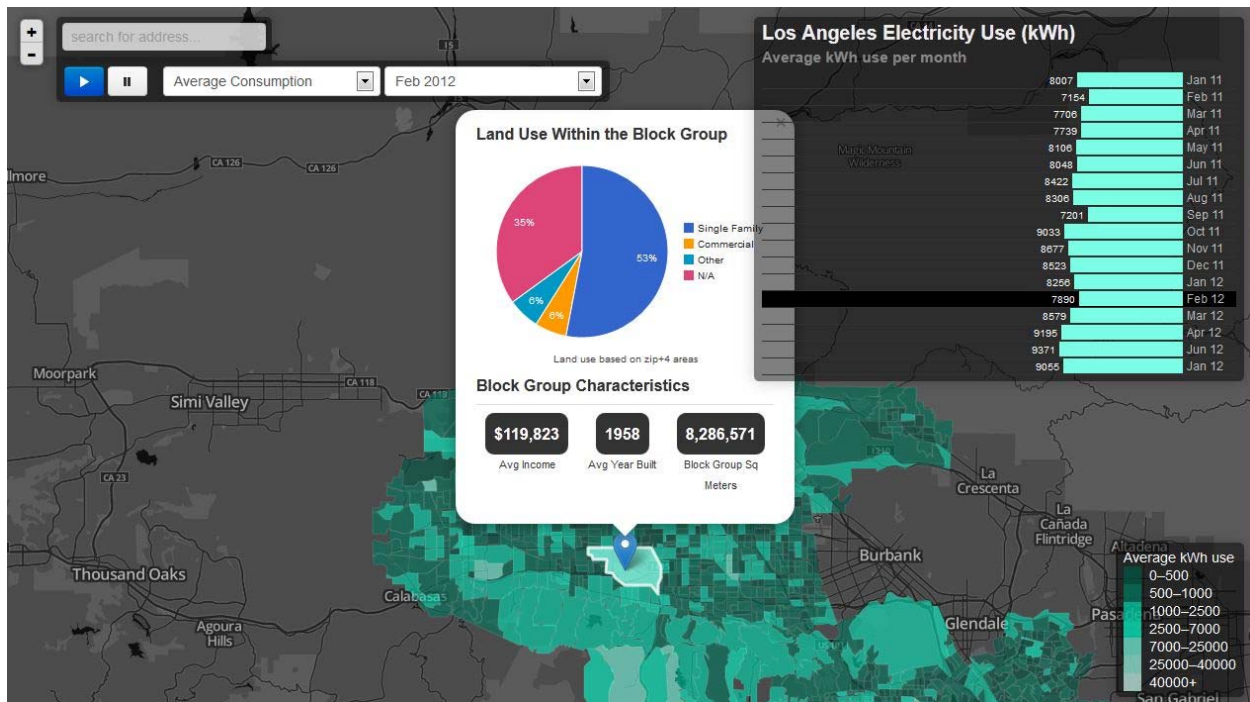


Figure 3 - Map of Los Angeles electricity use at a block level created at UCLA (Murdock, 2013).

EnergyView: Cambridge Energy Map

In 2011, researchers at MIT conducted another academic study which included mapping energy consumption. This map moved beyond aggregated data and showed individual building performance; however, because of a non-disclosure agreement related to the utility-provided energy data, this map was not publicly published. Conducting the analysis in Cambridge, Massachusetts, the researchers used monthly electric and gas bills for 6,500 buildings from the local utility. They also collected building characteristic information online tax assessor records and other geographical information from GIS records. Using these data sets, they built a model to predict energy consumption. The resulting EnergyView map (see Figure 4) compared actual performance to predicted performance, enabling users to view outliers (i.e., buildings which perform much better or worse than similar buildings were color coded with varying intensities of green or red, respectively) (Kolter & Ferreira, 2011).

The researchers experienced difficulty in matching utility data with tax assessor and GIS records. The utility – in this instance NSTAR – tracks accounts by meter number. There is no indication whether a meter is for an apartment, common spaces, or perhaps a detached garage. Sometimes a single home will have multiple meters attached. The utility addresses do not necessarily match city addresses and so it can be difficult to correlate a meter with the tax assessor records which relays the building characteristics. Matching utility data to the tax assessor records is also difficult because tax assessor records are catalogued by taxable entity while utility records are kept by meter number, resulting in two distinct databases which do not necessarily have linking identifiers (Ferreira, 2013).

With their model, the researchers were able to explain 75% of the variance in energy usage by the building characteristics collected from public records (i.e., tax assessor and GIS). The remaining variance is presumably due – at least in part – to occupant behavior. EnergyView visualizes actual usage to predicted building usage. The authors postulated that utilities or community-organizations could use the map to target outreach efforts and resources to neighborhoods or buildings which displayed poor expected performance (Kolter & Ferreira, 2011).

EnergyView underscores the benefit of granular, building-level data. Other maps, such as the Columbia and Los Angeles maps, aggregate data at a block level. While this may be useful for policy makers, a building-level understanding of energy performance is necessary for owners and tenants to take action. Aggregated data does not speak to the problems of specific buildings and does not help target specific homes which would benefit the most from efficiency upgrades. EnergyView was an important test in an academic setting of creating a map that assessed energy efficiency potential and enabled users to identify specific buildings which might be good targets for efficiency upgrades. Unfortunately, due to privacy concerns and a non-disclosure agreement signed with the utility, the map was never made publicly available.

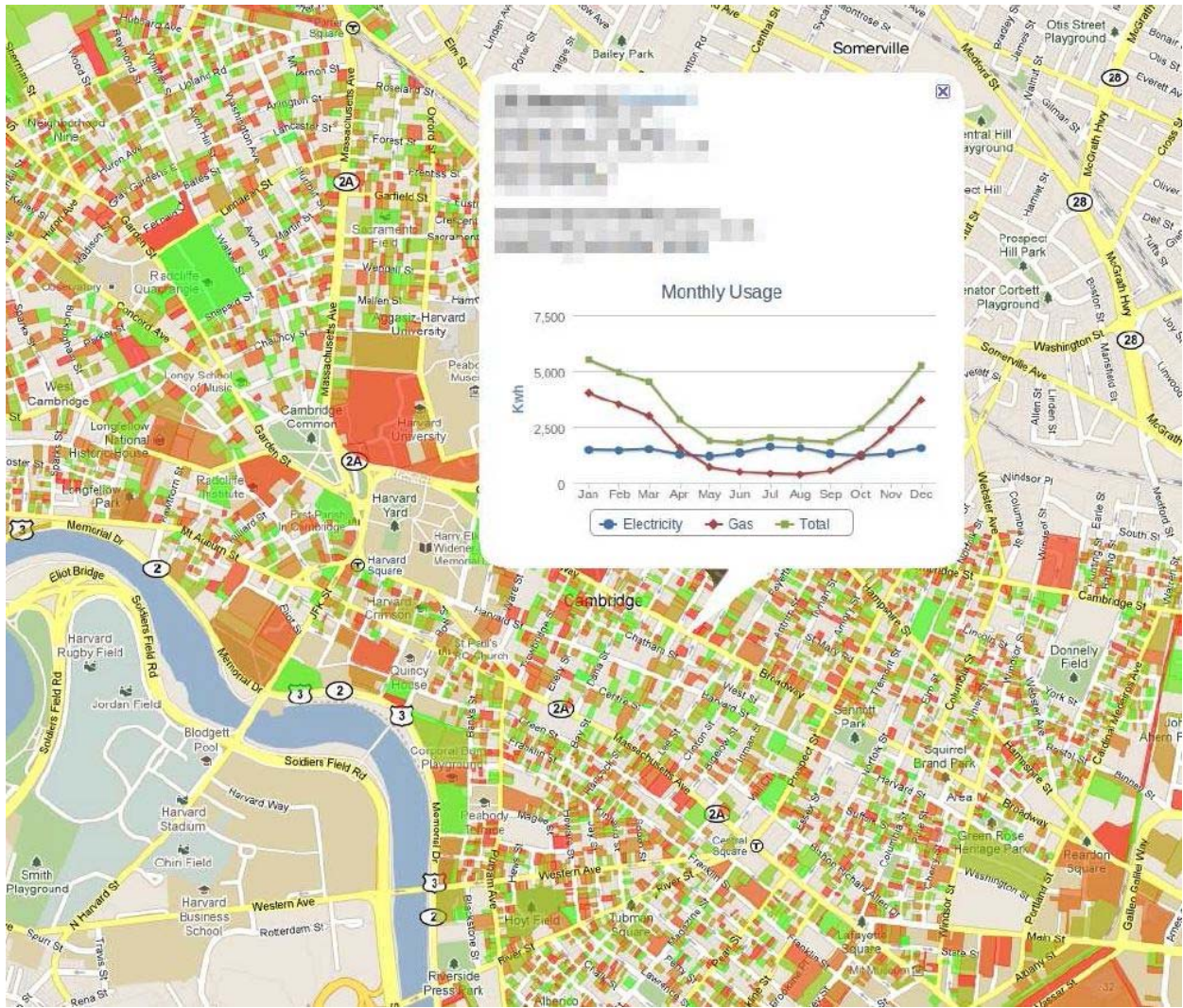


Figure 4 - Mock-up of the EnergyView map developed by researchers at MIT (Kolter & Ferreira, 2011).

Gainesville Green and Tools For Tenants

EnergyIT is the only company currently which has developed public maps displaying energy data for individual homes. Around 2006, EnergyIT launched the first iteration of Gainesville Green, an interactive map (see Figure 5) which allows users to view gross electricity, natural gas, and water consumption (Davis, 2013). The map displays the nearest 100 homes and color codes the dropped pins from dark red to dark green to illustrate high bills to low bills, respectively. Users have the option of normalizing the data per 1000 square feet, choosing a comparison between the nearest 100 homes or similar homes, and viewing historic yearly data starting in 1999. Users can also add individual homes to a group and then compare only homes within that group (EnergyIT, 2011).

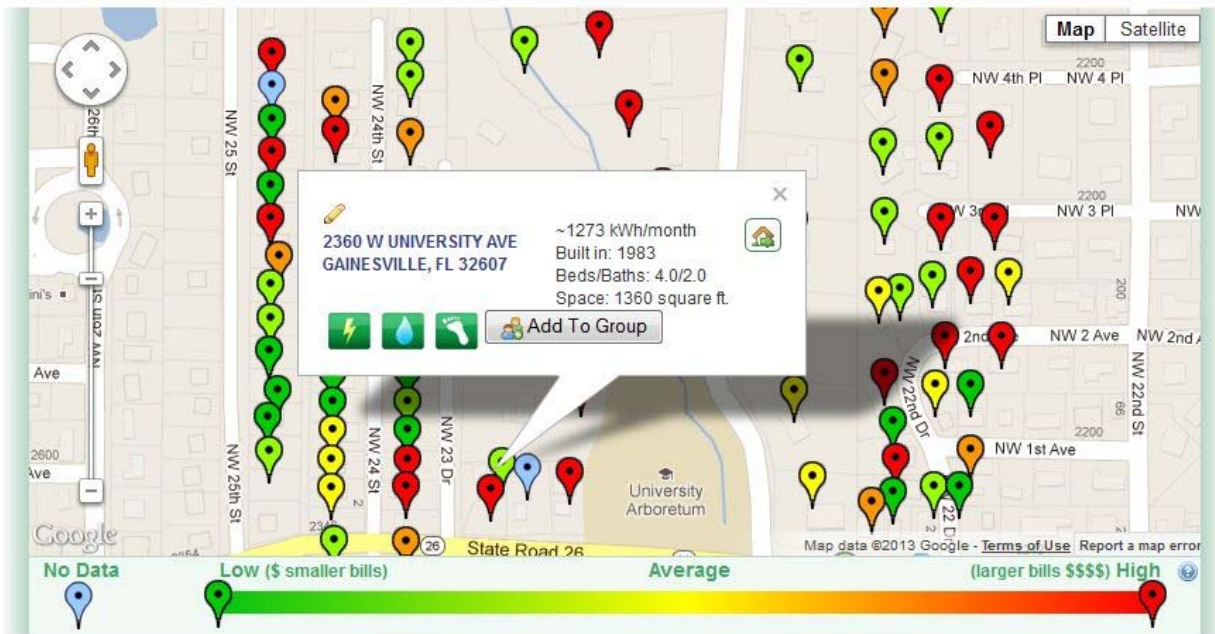


Figure 5 - Gainesville-green.com allows users to compare the energy use of specific homes in Gainesville, Florida (EnergyIT, 2011).

Notably, Gainesville Green shows total monthly electricity and gas consumption and allows the user to normalize that data by 1,000 square feet (EnergyIT, 2011). EnergyIT does not include an energy rating or score on the map. Ryan Davis, Director of Programming at EnergyIT, explained that the early iterations of Gainesville Green displayed more sophisticated energy analysis that pulled incorporated data from tax assessor records. However, after receiving SBIR funding to conduct user testing on the web map, EnergyIT discovered that most people – those without detailed energy knowledge – did not respond to the sophisticated energy performance ratings. Focus group evaluations of Gainesville Green suggested users from the general public were most concerned with energy costs – they cared more about dollar amounts than kilowatt-hours or carbon savings. Subsequently, EnergyIT went through a process of simplifying their online map to meet the interests of users. They proceeded to filter out the complex features and leave gross energy consumption and dollars as the default display on the map (Davis, 2013).

However, Davis also noted that other more specialized audiences responded to the analysis. EnergyIT realized the more complex analyses layered on top of their information benefitted policymakers, planners, and engineers but was too complex for a general audience. Policymakers are interested in more

sophisticated performance ratings as are energy efficiency contractors who can use the information to target potential clients (Davis, 2013). This lends credence to the argument that an energy map should display an energy performance rating, or in an ideal situation, users could choose to toggle between displaying gross energy consumption and an energy performance rating.

EnergyIT was awarded a Department of Energy grant to build a second similar map – Tools for Tenants (www.toolsfortenants.com) – which addresses rental properties in Gainesville. This was part of an initiative with the local utility to try to reduce energy consumption in the hard-to-reach rental market. Tools for Tenants was an attempt to give renters information on energy costs which might then influence their housing decisions. EnergyIT hypothesized this could eventually incent landlords to improve their building's energy performance (Davis, 2013).

Tools for Tenants displays largely the same information as Gainesville Green with some key differences. There is no option to normalize data by square feet in Tools for Tenants. EnergyIT used the tax appraiser database to find square footage for the homes displayed in Gainesville Green. However, the appraiser database does not have square feet for the rental market. EnergyIT attempted to manually build the data set but discovered that it was time-consuming and the data grew stale very quickly. Similar to Gainesville Green, Tools for Tenants allows users to select apartment buildings for a group comparison.

Reaction to Gainesville Green and Tools For Tenants has largely been positive. Individuals in Gainesville have the option to opt out of having their home's energy by displayed on the map, but only a small percentage has chosen to do so. At one point, an energy efficiency firm used Gainesville Green to identify homes for outreach. A property owner of large apartment buildings also contacted EnergyIT inquiring how it could reduce the energy consumption of its buildings after he had seen his buildings on the Tools For Tenants map. And people regularly comment that they like the graphic display of the map (Davis, 2013).

An important takeaway from Gainesville Green is knowing what audience the map is targeting and making sure the data is curated to speak to them. Homeowners and tenants are most interested in energy costs, while policymakers, researchers, and contractors desire a greater level of analysis. It is also good to include an opt-out policy which allows people to withdraw their building from the map. While a some people may choose to remove their information from the map, the Gainesville Green experience suggests most people will not opt-out. Also, an energy map should be publicized in a marketing campaign and in public outreach efforts to ensure the widest possible audience.

Cambridge Solar Map

While building-level energy consumption maps are rare, citywide photovoltaic (PV) potential maps are more common. The Cambridge Solar Map (see Figure 6) was developed by researchers at MIT's Sustainable Design Lab and the design firm Modern Development Studio for the city of Cambridge, Massachusetts. Built on the Google Maps API, the Solar Map enables users to scan the city or search specific addresses and see a detailed color-rating of solar potential across all building roofs. The map also includes information on estimated annual kilowatt-hour production, potential savings, photovoltaic system cost including incentives and rebates, and carbon emissions reductions (Modern Development Studio, LLC, 2012).

MIT's Sustainable Design Lab was able to create a highly-detailed model to estimate roof-specific photovoltaic production capacity by using LiDAR data. In 2010, Cambridge paid for a LiDAR survey conducted by aircraft. LiDAR is a laser technology which collects highly accurate information on vertical heights and their geolocations. Along with a climate-adjusted solar radiance simulation, this 3D data

enabled the researchers to conduct refined analysis of PV potential of all roofs in Cambridge (Jakubiec & Reinhart, 2012).

The Solar Map has several relevant points which relate to an energy consumption map or energy efficiency map. It targets specific buildings, it provides energy estimates, and cost/savings estimates. The researchers also noted on the importance spatializing information to individual buildings, "...homeowners and businesses can engage with the map through the ability to identify their roof specifically and notice how its unique form produces varied suitability for photovoltaic installation. Essentially, users of the map feel like the simulation results are personalized to their building which is important to produce confidence in the results and to increase interest in the goals of the map," (Jakubiec & Reinhart, 2012, p. 9). This suggests that the personal interaction people might have with a similar building-specific energy consumption map could also increase their likelihood to act on the information.

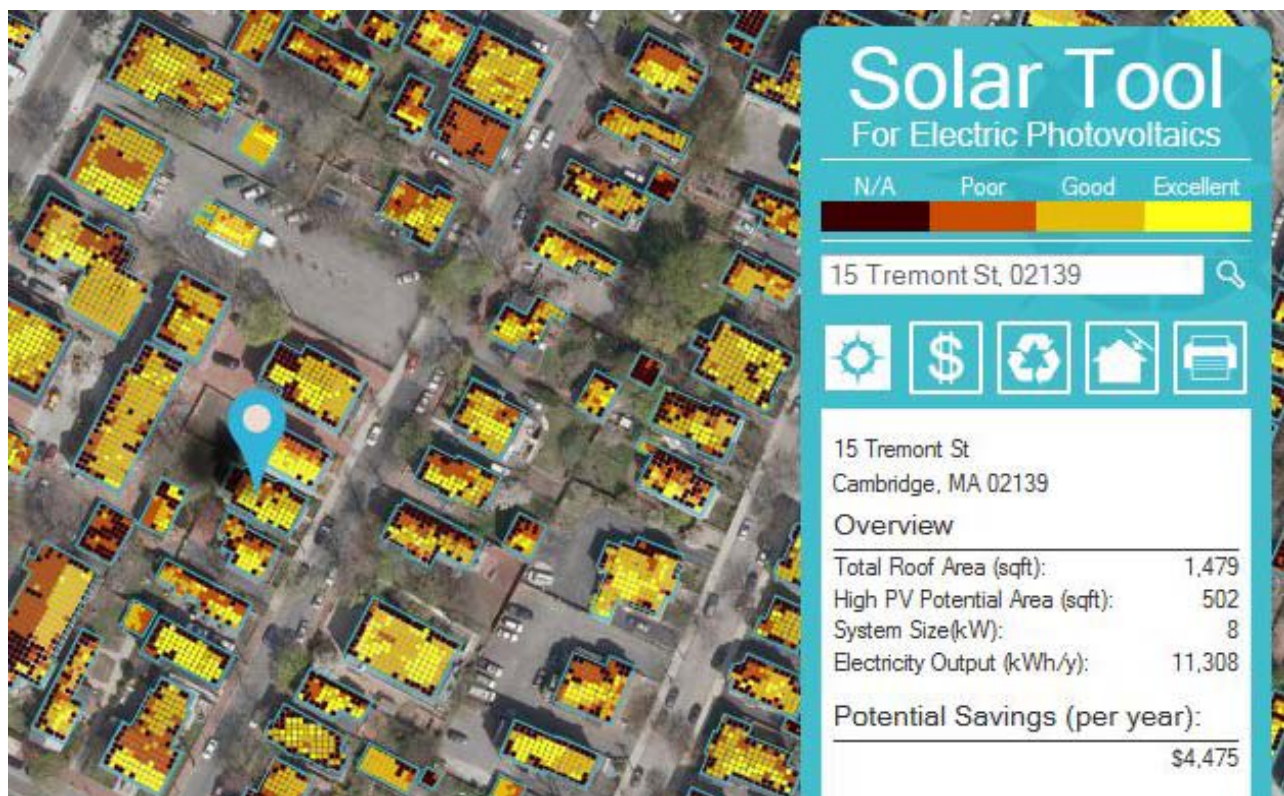


Figure 6 - Screen capture of the Cambridge Solar Map displaying roof area, solar energy potential in kWh, and potential savings for a sample building (Modern Development Studio, LLC, 2012).

Lessons Learned on Energy Maps

From the evaluation of existing energy maps, there are some key takeaways about strategies to make an energy map as impactful and compelling as possible:

- Present building level data instead of aggregated data to encourage efficiency changes by individual property owners.
- Include information which is relevant to different user groups, such as renters, homebuyers, property owners, and policymakers. Present information in a way that is understandable to the desired target audience.
- Allow individual property owners to opt-out of having their building's information included on an energy map.
- Publicize the map in marketing and outreach campaigns to reach a large audience and maximize the map's potential impact.

Remote and Relative Energy Assessments

As noted in the introduction, there is a growing body of research which suggests that descriptive social norms are quite effective at influencing people's energy behaviors. A study conducted in 2004 by researchers at Arizona State University and California State University demonstrated that telling people their neighbors implemented energy conservation measures made them more likely to reduce their own energy consumption than telling them about potential monetary savings, environmental benefits, or social responsibility (Cialdini & Schultz, 2004). A 2011 report by Energy and Environmental Economics noted that information and feedback energy efficiency programs regularly see between 2% and 7% reductions in energy consumption (Mahone & Haley, 2011). Incorporating a comparison of energy performance on an energy map could be an effective way to leverage descriptive social norms and encourage people to adopt energy efficiency strategies.

Creating a map which displays comparisons of energy performance of different buildings requires analyzing and scoring multitudes of buildings without going inside them. In this paper, analyzing building energy performance without collecting data at the site of the building is referred to as a remote energy assessment. Since these touchless assessments use less detailed data than onsite energy audits, their ratings will necessarily be less precise and potentially less accurate than an in-home audit. Even without the detail of an onsite audit though, a citywide remote assessment of residential building stock could still offer meaningful ratings which encourage energy efficiency by showing the relative energy performance of buildings. In this paper, a relative energy assessment means showing how one building performs relative to another building with similar characteristics.

To maximize the impact of an energy map and maximize its ability to influence users through descriptive social norms, it would need to visually display a relative energy performance rating for all residential buildings within a particular municipality or region. This performance rating would need to be conducted remotely and its output would need to be a relative energy assessment so that users could compare different building types. The relative energy assessment score would need to be easily understood and trusted by the general public.

This section examines four existing relative energy assessment platforms and evaluates how appropriate they would be for an energy map. Relative energy assessments compare the energy performance of similar buildings. Remote energy assessments are those that can be conducted without an in-home audit. For the purposes of an energy map, a remote energy assessment would need to be used and ideally it would produce a relative energy performance rating. This section explores whether it would be possible

to conduct a relative energy assessment remotely, what data sources are needed for a remote and relative energy assessment, and which existing assessment platforms would be suitable for an energy map.

Remote Energy Assessments

Identifying potential data sources for conducting remote assessments is important. If privacy is a concern, it would be best if the data used in any remote assessment is already publicly available to avoid litigation and the expense of paying for access to private data sets.

Energy audits employ both operational data (i.e., energy use) and asset data (i.e., building characteristic). A remote energy assessment requires access to both types of data.

Operational data are energy use data. Typical energy audits require 12 months of historic energy use. This would include all applicable energy types such as electricity, natural gas, fuel oil, propane, and potentially others. Accessing operational data for a city-wide remote assessment, with the intention of creating an energy performance map of buildings, would most likely require a mandatory disclosure policy. Without mandatory disclosure, there would not be enough energy data to create a data rich energy map that offered meaningful information and insight, nor would there be enough data to conduct a remote assessment. Many barriers exist to accessing data and implementing a mandatory disclosure policy. However, if done correctly, increasing access to energy data could lead to significant transformations of the energy efficiency market through new tools – such as an energy map – and through enabling other energy innovations. Disclosure will be discussed in greater detail later on.

Asset data, which are building characteristics, are typically collected during an energy audit. However, some asset data are already available through publicly accessible tax assessor records. If tax assessor records are online, programs can be written to screen scrape information, making it available for use in remote assessment. While not as robust as an in-person data collection, tax assessor records can offer numerous valuable data points. For example, the Cambridge, Massachusetts, online Tax Assessor Database includes many relevant building characteristics, such as year built, property class, building type, gross square footage, heating type, heating fuel, and whether there is central air conditioning (City of Cambridge, 2013). Other potential building asset sources include LiDAR data, which captures building heights. GIS records might also convey other parcel information.

Data challenges for remote assessment include incomplete information, inaccurate information, and obstacles to cross referencing different data sets. While tax assessor records do offer considerable amounts of information, they currently do not offer as much information as an in-home audit. They do not identify whether the building has insulation, how old the heating system or boiler is, nor where there are air leaks, among other things. And this information can be vital for understanding building performance. For example, building systems, which include HVAC and hot water systems, can account for significant potential energy savings. Ed Connelly of New Ecology noted sometimes seeing 50% improvement in building performance from upgrading building systems alone. Electricity use can depend heavily on occupant behavior. Tax assessor records do not note the number of occupants nor uses within a building. For example, an apartment with a home office and many computers would likely be consuming more electricity than a similar apartment occupied by a traditional office worker (Connelly, Personal interview with President of New Ecology, 2013).

Moreover, the data in tax assessor records may not be accurate. Depending on when the latest assessment was conducted, information could be many years out of date or it could have been recorded incorrectly. In-home audits are able to verify building characteristic information and trained auditors are able to identify building features that a lay person may not recognize.

Another important challenge to note is the difficulty in correlating utility energy data with tax assessor records. Utility information is linked to meter number and assessing information is linked to parcels. Assessor information is different for residential properties, condominiums, and commercial properties because they are recorded by taxable entity. Utility addresses may not match tax assessor addresses, and utility meters do not necessarily associate with taxable entities. There are many-to-many relationships in which the entities of interest relate to one another in utility and city databases. Utility databases and tax assessor databases were not built with the intention of relating to each other, so it can be difficult to match records. Further confounding this problem is that buildings can have multiple meters and utility records do not indicate whether a meter is associated with a residential unit, common space, or perhaps a detached garage (Ferreira, 2013; Davis, 2013).

Relative Energy Assessment Comparisons

Currently, due to incomplete and inaccurate data sets, it may not be possible to conduct highly accurate city-wide remote assessments. With the intention of creating a public energy map, it would be necessary to display assessments that people trust. If there is a significant amount of error in remote assessments, then the map will not be effective at motivating people to pursue energy efficiency. However, there are several methods for analyzing relative energy performance. These are not as detailed as full audits and cannot prescribe specific energy efficiency upgrades, but they do allow users to broadly compare the energy performance of different buildings. In order to be useful for map display, these relative performance assessments would need to be easily understood (i.e., a lay person could quickly understand which buildings perform better and which perform worse), they would need to work across different residential building types, and their mandatory data points would need to be found on publicly available data sets like tax assessor records, with the assumption that utilities provide monthly energy consumption data. Potential assessment methods include Opower’s model to compare similar buildings, the Department of Energy’s Home Energy Yardstick, the Home Energy Rating System (HERS), and the Home Energy Saver.

Opower

Opower is an energy analytics firm focused on behavioral changes. They currently contract with more than 80 utilities to send personalized home energy reports to 15 million ratepayers. Homeowners receive the reports in the mail, which compare their homes' energy use to similar homes in their area. They are compared to the average home performance and efficient home performance in their neighborhood (Opower, 2012). A sample comparison report is shown in Figure 7.

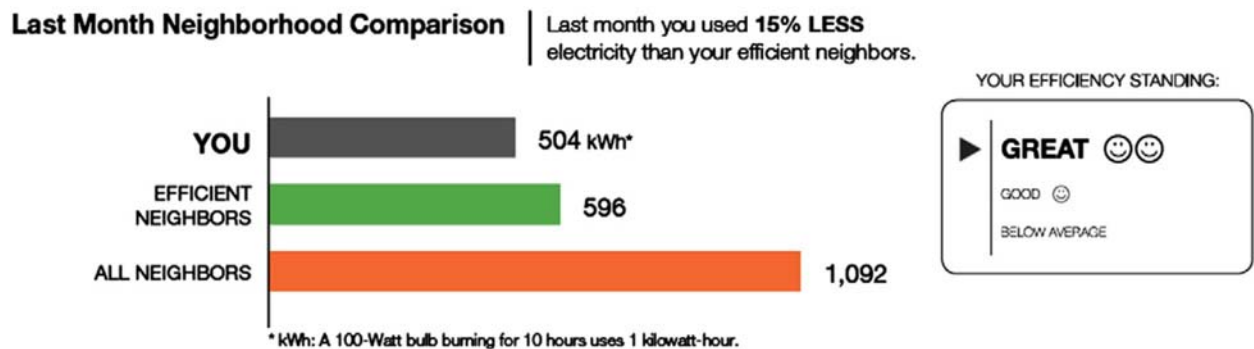


Figure 7 – Example electricity portion of a home energy report generated by Opower (Allcott, 2011).

Opower compares a household's energy use to a custom comparison group. The comparison group contains about 100 nearby houses that share similar characteristics, such as square footage and heating type (Allcott, 2011). If not enough similar homes are found, Opower loosens the constraints until they can build a big enough comparison group for their algorithms (Laskey & Kavazovic, 2011). If they are provided with hourly usage data, Opower's algorithms can disaggregate heating usage, cooling usage, and other loads (Laskey & Kavazovic, 2011). However, most of their analyses are conducted with monthly energy usage data which is collected approximately every 30 days by a meter reader. Opower contracts directly with utilities which provides them monthly meter data, program participation, rebate redemptions, and billing and account data (Opower, 2013). Opower does not publish how they collect the building characteristics, but they report that they source housing data, demographics, weather, and GIS data from third parties (Opower, 2013).

The strength of Opower's methods is in leveraging social norms to influence behavior. Households see their energy use relative to the mean of their comparison group (i.e., "all neighbors" in Figure 7) and to the 20th percentile of the comparison group (i.e., "efficient neighbors" in Figure 7). Their strategy has reportedly reduced energy consumption by 2.0% across participating households (Allcott, 2011).

A strategy similar to Opower's could potentially be used to generate relative performance ratings for residential buildings across a city and then color code those ratings for display in a map. Opower currently analyzes large data sets covering 15 million household which demonstrates that such a large analysis is possible. However, they display information only to utilities and individual households. If they are paying third parties for building characteristic and demographic information, it may not be possible to publicly display their results. Opower's algorithms are not published so it is uncertain whether they could be adjusted to leverage publicly available data. Moreover, it is unclear whether Opower's analysis covers all building types or what happens when individual buildings have incomplete data sets. While their method is promising, it is hard to say whether it could be applied to every residential building in a given geographic area.

Home Energy Yardstick

An Environmental Protection Agency program dedicated to helping consumers identify energy efficient products, Energy Star offers a quick online energy assessment through its tool called the Home Energy Yardstick. It ranks homes on a scale of 1 to 10 (10 being a better performer) by comparing them to similar homes. The average home scores a 5. The algorithm used accounts for local weather, home size, and number occupants. The Yardstick only collects the following data points from online users:

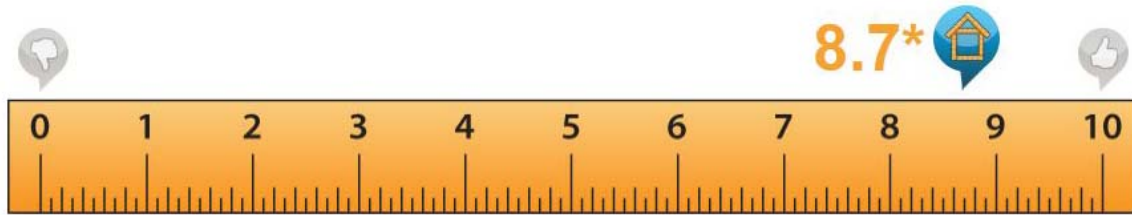
- Zip code
- Number of full-time occupants
- Square footage of home
- Select fuel types (electricity, natural gas, fuel oil, propane, kerosene, on-site coal, on-site wood)
- And 12-months' of energy data for selected fuel types (users have the option of uploading Green Button files if they are available for them or manually entering monthly data) (Energy Star, 2013).

Users receive a report (see Figure 8) which shows them their 1 to 10 rating on a ruler. The report also contains a graph of their monthly energy use and it disaggregates baseload from heating and cooling energy loads.

Your Score

Share:   

March 2012 - February 2013



Your Energy Use

Annual Electricity Use: 2,247 kWh

Annual Natural Gas Use: 805 Therms

Annual pollution resulting from energy use in this household is 5 MtCO₂eq of greenhouse gas emissions - the equivalent of 0.93 car.

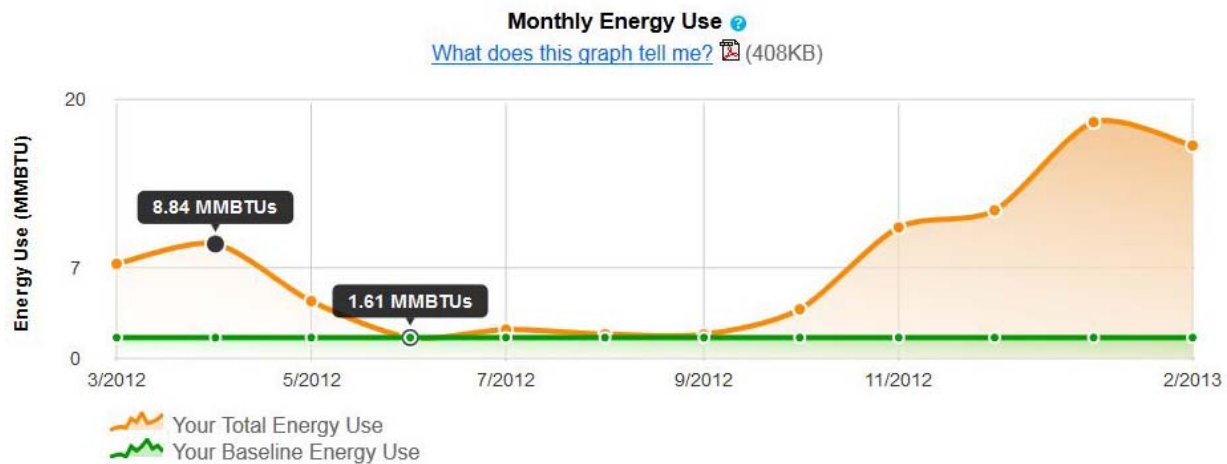


Figure 8 - Energy Star Home Energy Yardstick sample report (Energy Star, 2013).

The Home Energy Yardstick does not offer as comprehensive an assessment as an audit or as a more detailed self-audit online tool. However, for online users it quickly produces a relative benchmark for them to understand their household energy consumption. Also, by identifying heating load and cooling load, building owners may be able to understand opportunities for improving the energy performance of their buildings.

In terms of energy mapping, the Home Energy Yardstick is a promising relative assessment platform to consider. If utilities provide energy data, then it could be possible to collect square footage from tax assessor records. The output is easy to understand since people are used to scales of 1 to 10 and it would be possible to create a color scale for the Yardstick Score. However, challenges to using the Yardstick include not being able to remotely collect number of occupants and the inability to benchmark multifamily

buildings with the tool. If the Yardstick’s algorithms were modified to eliminate occupant data and to include multifamily buildings, this could be a potential candidate for conducting city-wide relative energy assessments.

Home Energy Rating System (HERS)

A home energy rating is an index which measures a home’s energy performance. California has implemented a Home Energy Rating System to establish an energy score before energy implementing rebate-eligible efficiency upgrades. All homes are scored on a scale of 0 to 250, with 0 indicating the best energy performance for that type of building.



Figure 9 - California HERS scale (Center for Sustainable Energy California, 2013).

The California HERS demonstrates the ability to rate different home types on one scale and correlate that to a performance color, which would be suitable for mapping homes. However, this system requires a detailed in-home audit and would not be suitable for quickly assessing many buildings across large geographic areas. Moreover, the scoring system of HERS seems counterintuitive to other common rankings. A higher score indicates worse performance. This is opposite of the Home Energy Yardstick. A system such as this could be challenging for a mildly interested layperson to understand. While HERS exemplifies a good color scale, it would not be practical for energy mapping applications nor conducting a city-wide remote assessment.

Home Energy Saver and SEED

The Home Energy Saver (HES) is a tool developed by Lawrence Berkeley National Laboratory for the U.S. Department of Energy. Homeowners are able to conduct a quick online assessment of their home by entering only zip code, address, year the house was built, number of occupants, and energy prices (estimated energy prices are prepopulated). With this information, HES provides an estimate of yearly energy costs, break down by type (e.g., heating, cooling, hot water, large appliances, small appliances, and lighting) and estimated energy costs if the homeowner upgrades the building (see Figure 10). Users have the option of submitting more details about square footage, air conditioning, refrigeration, and other things, to make the results more accurate (Lawrence Berkeley National Laboratory, 2013).



Figure 10 - Example of a Home Energy Saver report for a Boston-area home (Lawrence Berkeley National Laboratory, 2013).

This tool differs from Opower, Home Energy Yardstick, and HERS in a couple notable ways: 1) actual energy bills are not used, and 2) a comparative rating is not generated to indicate whether a home performs better or worse than a similar home. Moreover, this tool cannot assess multifamily buildings, though that functionality may eventually be incorporated (Lawrence Berkeley National Laboratory, 2012). It does complement an asset-rating system – Home Energy Scoring Tool – which provides a performance label, but that requires an in-home audit (Department of Energy, 2013).

HES thus lacks some of the advantages of other tools described, but it offers a comprehensive and standardized database on the backend – the SEED platform and Buildings Performance Database (Boston Green Ribbon Commission, 2012). An energy map which collects monthly energy data would need access to a database which stores the energy information and building characteristic information. This database would play an integral role in the development of the map and of other energy innovations. As a warehouse of information, it would enable other technological innovators to utilize the information for new innovations. And, such a database could cut down on costs of creating a map and provide a data platform for other energy innovations

The Standard Energy Efficiency Data (SEED) platform is software tool developed by the Department of Energy. SEED enables state and local governments to store and analyze large amounts of building and energy information. Users can automatically import data from the EPA Portfolio Manager and also export data to the Department of Energy’s Buildings Performance Database (Department of Energy, 2012). SEED is free – so cities or states that decide to use it could significantly reduce their financial burden to build a platform that could store the data for an energy map. Moreover, since it is free and more agencies and

organizations are likely to use it, it could end up providing the most common format for storing energy data. This means more innovations are likely to come from it and more cities would be wise to use it.

If HES could be combined with another DOE relative energy performance comparison, such as the Home Energy Yardstick, this could be a good option for cities or states considering the creation of an energy map. By using HES and thus entering data into SEED, the data is likely to be in a standard format and can be leveraged for other uses and innovations in the future. Moreover, this could significantly reduce the expense of developing a data storage mechanism for any participating municipality.

Lessons Learned on Remote and Relative Energy Assessments

From the evaluation of remote assessments and relative assessments, there are some key takeaways about using a remote and relative assessment in an energy map:

- If energy data is accessible, then it could be feasible to conduct a remote and relative energy assessment of most residential buildings in a given area.
- Use publicly available data for building characteristics in any assessment. These will likely come from tax assessor records, GIS records, and LiDAR scans if available. Using publicly available data avoids potential privacy complaints and eliminates the need of purchasing access to private data sets.
- Utility energy databases and city databases are difficult to cross reference. Rectifying the databases may be time intensive.
- Use a remote and relative assessment system which is simple to understand by the general public and facilitates color coding of building performance which would appear on maps.
- Use the Standard Energy Efficiency Data (SEED) platform created by the Department of Energy to store and manage energy data across jurisdictions. This will save the cost of developing individual platforms in different municipalities and help to standardize energy data taxonomy.
- The Home Energy Yardstick is a promising choice for a remote and relative energy assessment system. If it can be adjusted to calculate a performance rating without requiring occupancy data, all its other inputs can be gathered remotely or from utility energy data. Moreover, it is an Energy Star product and Energy Star is a trusted label. And it produces an easy to understand score on a 1 to 10 scale which could easily be converted to a red-to-green color ramp for an online map.

Recommendations for Accessing Energy Data and Creating a Residential Energy Map

This section lays out the recommendations for State-led energy disclosure policies, how the Federal government could support such initiatives, and explains what components would make an effective energy map.

Energy data will be at the heart of many energy efficiency projects in the future. As smart technologies roll out, smart meters will collect granular data on residential energy consumption. Smart appliances and lights will signal their minute-to-minute consumption giving homeowners greater control of energy consumption, even when they are away from home. This plethora of energy data will foster new innovations and hopefully make huge strides in energy efficiency achievements. The energy map is one such new technology which could leverage energy data to encourage energy efficiency upgrades. Currently though, energy data is held by utilities and for the most part is not made publicly available. This stifles innovation and prevents critical decision makers – homebuyers, renters, and property owners – from seeing that information and making active decisions based on it.

Energy information has the power to transform the energy efficiency market, beyond even the applications of mapping. Information presented to the right people at the right time can increase interest in energy efficiency. An energy map which displays energy consumption and relative energy performance of buildings can influence people to improve their buildings or to rent a more efficient apartment over a less efficient apartment. An energy map could enable energy agencies to identify neighborhoods and buildings for efficiency outreach. If energy map information was integrated into existing real estate maps such as Walk Score, Zillow, Trulia, or Craigslist, then building energy information would be provided in at a time when people are deliberately thinking about housing decisions and could have an even greater impact.

But, in order to develop an effective energy map, there will need to be mandated energy disclosures instituted across states and cities. Climate change, the growing cost of energy, and grid instability are all reasons why utilities should be obligated to disclose building-level energy consumption data. The rest of the section elucidates the potential impacts of an energy map, how energy disclosure should occur, and how energy data should be presented in a map for the most effective outcomes.

Energy Map Impacts

By publicly disclosing energy consumption and an energy performance rating in an online energy map, energy efficiency will be positively impacted through improved decision making and establishing new social norms.

Having access to energy consumption data online will enable renters to choose rental units which consume less energy and cost them less money. If landlords notice that they have a harder time attracting or retaining tenants because of their building's poor energy performance, they will be more likely to upgrade their buildings. And the map would still be helpful to homebuyers who would be able to incorporate the value of energy performance into their home buying decisions.

The energy map could also improve energy efficiency performance through social norms. A three-year study conducted in San Diego by Robert Cialdini and Wesley Schultz showed that descriptive normative information had greater impact on household's energy conservation measures than information on saving money, helping the environment, or social responsibility. Their results showed that descriptive norms – when people learned that their neighbors were using fans instead of air conditioners – made more significant changes to consumers' energy behaviors than other factors (Cialdini & Schultz, 2004).

Descriptive normative information is relevant to the proposed residential energy map. A color coding scheme – likely red to green for bad to good performers – conveys normative information about other buildings. Neighbors may see that they perform worse than their neighbors and make efforts to improve. Or property owners may notice their portfolio of buildings does not perform as well as other properties and may feel pressure to improve their performance. The map is in essence displaying descriptive normative information across a city.

Data Disclosure and Data Management Platforms

Although the impact and potential for a residential energy map are great, there are many obstacles to making an energy map a reality. These challenges include energy data access, privacy concerns, compliance with potential mandated disclosure laws, ensuring residential buildings are included in mandated disclosure, and using a standardized taxonomy and database for energy information across jurisdictions. However, many of these concerns could be addressed through effectively implemented state energy disclosure mandates that targets utilities for compliance – not individual building owners. The disclosure policies should establish appropriate opt-out measures to address privacy concerns of any individual residential ratepayers and requires energy disclosure of all building types. The Federal government could support disclosure efforts by recommending a standard energy database for use across jurisdictions, suggesting a pathway to facilitate cross-reference multiple city-level databases, and providing research and funding to disclosure efforts.

1. States mandate that utilities disclose energy use of all customers

Since states regulate utilities, states should mandate disclosure of all building-level energy consumption data. Moreover, disclosure policies should require utilities to disclose the information, not individual building owners. Disclosure policies which require building owners to release information to cities put an undue burden on cities and on building owners.

2. The Federal government recommends using one software and database platform

The Federal government should recommend one database to be used across states which will receive the disclosed information and the platform which will make the information accessible to cities, states, entrepreneurs, and other parties. This will likely be the Department of Energy's Building Performance Database and the Standard Energy Efficiency Database (SEED) platform. The DOE has built its own database, the Buildings Performance Database, which integrates with SEED, their standardized software and taxonomy for collecting energy information. Using these platforms lowers the cost for states and cities making it more likely that compliance with mandated disclosure would be successful across the country.

3. With Federal support, cities and utilities create pathways for correctly cross referencing multiple databases

Currently, utilities and cities do not necessarily use the same master address file which means it can be difficult to correlate a meter to a specific building. Cross-referencing multiple databases such as energy records and tax assessor records, which is necessary for remote energy assessments, can sometimes result in many records going unmatched. When suggesting a database for disclosure, the Federal government could suggest modifications to the Buildings Performance Database which would facilitate correlating different city databases, for example the database could include a field for master address IDs that utilities and cities could use in their databases.

4. States require only monthly energy updates and include opt-out policies in their disclosure laws to address privacy concerns

Mandated energy disclosure will cause some building owners to protest due to privacy or safety concerns. In their energy disclosure policies, states could require disclosure no more often than on a monthly basis so that real-time information remains private. Also, residential disclosure should come with an opt-out policy so that individual ratepayers could decide to withdraw their information from the public program.

5. States require energy disclosure for all building sizes

By releasing energy data from all residential and commercial buildings, more people would benefit from increased data access, more building owners may pursue energy efficiency upgrades, and more entrepreneurs will be able to use the data to develop energy innovations. Moreover, when people are searching for housing they search across building types. Including all buildings in mandated disclosure will enable individuals to evaluate all relevant building types.

6. State energy disclosure laws require that information be made publicly available via an online map

To maximize the positive benefits of disclosing energy data, the states should require that data be made available on an online energy map that displays total monthly consumption and a relative energy performance score. An online map is an ideal platform for many reasons. People are familiar with using online maps, so the technology will be familiar to them. Moreover, a map can visualize the information in a way that is easier to understand than simply providing all the information in a spreadsheet.

Energy Map Components

When energy data is available, an energy map could be made which would impact energy efficiency by allowing homebuyers and renters to seek out higher performing buildings, creating new social norms which pressure property owners to upgrade their buildings, and enabling energy agencies and firms to target individual buildings and neighborhoods which consume excess energy. Previous EESP research also noted that an effective energy map should have three components: 1) An information display that combines energy data with other relevant data sources such as GIS and tax assessor records; 2) Affiliated programs and incentives which inspire users, professionals, or community groups to take action; and 3) A feedback input option which enables energy suppliers to receive augmented data such as age of appliances in homes (Reul & Michaels, 2012). This section builds on those findings to suggest more specific energy map components. These components should be included in energy maps required by state energy disclosure laws.

Residential energy information should be displayed in an interactive map where online users could view gross monthly electricity and gas bills as well as view a standardized energy performance rating for single-family homes and multifamily buildings. Buildings could be color-coded for relative energy performance compared to similar buildings in the area (e.g. red is a high energy user, yellow is moderate, and green is low). Building an interactive map would help prospective renters identify high energy consuming apartments and help prospective buyers choose more energy efficient buildings. An energy map would create social incentives for landlords and homeowners to upgrade their buildings. Moreover, other interested parties such as government agencies and energy contractors could use the map to target neighborhoods for energy efficiency outreach.

A relative energy performance score which is easily understood and can be color-coded for map display should be used. This assessment system must rely on publicly available data to determine building characteristics. While not as detailed as an in-home audit, a remote assessment could provide useful information to renters and homeowners. The Department of Energy's Home Energy Yardstick could be a

good candidate for a preliminary assessment system, but as more data becomes available, more complex systems could be utilized.

Based on research collected and discussed earlier in this paper, I expand on previous EESP research and propose specific features for a functional energy map which could catalyze change in the energy efficiency market.

An effective Energy Map:

- Displays data at a building level. For multi-family buildings, the information displayed could be an average for all the units
- Displays gross consumption and an energy performance rating
- Uses a relative energy performance rating which can be applied to across residential building types
- Enables customizable information displays for different audiences. Both lay people and policymakers or energy specialists should be able to use the map
- Updates energy data regularly, ideally every month
- Allows people to opt-out of having their information on the map
- Connects users to other websites and services for energy efficiency
- Facilitates energy competitions and customized building comparisons
- Is accompanied by a marketing campaign to raise awareness of the map and its functions
- Accesses data from a database which provides a standardized taxonomy like SEED
- And has an API which enables it to be embedded on other sites such as Trulia or Craigslist.

Conclusion

A residential energy map has the potential to change the energy efficiency market. Energy is a transparent and confusing issue for many people. By visually representing energy consumption spatially in a map, people will more closely engage with the information and make decisions using it. And there is a unique opportunity to integrate energy data into maps dealing with real estate. This connection would increase the likelihood that energy performance be valued in housing and would have the potential to influence decisions made by homebuyers and renters.

Online maps are already frequently used when people make housing decisions through websites like Walk Score, Craigslist, and Zillow. If energy consumption and relative energy performance could be integrated into maps like these, people would be receiving critical energy information at the moment they make housing decisions. Right now, energy use is unseen and unknown to many people, but placing it on a map would bring it to the surface and potentially at the moment when it would influence their housing decisions. Renters may choose to move to a more efficient, less costly apartment. Homebuyers may choose to purchase a more efficient home. And property owners may choose to upgrade their buildings when they notice their buildings perform worse than their neighbor's building and they are losing prospective buyers or renters to "greener" properties.

Energy maps will become more prevalent as more energy and building characteristic data becomes available. Although there has been some resistance to publicly disclosing energy data, this is not likely to prevent energy data from becoming available in the long run. More and more personal information is being recorded and detailed property information, such as assessed property value, is already publicly available. Disclosure policies like BERDO, which recently passed in Boston, are opening the doors to rich energy data sets and this trend of making more data publicly available will continue. A Federal recommendation to disclose energy data could catalyze improved access to data and catalyze the onset of the benefits that result.

Furthermore, technological advances will diminish the transaction costs of collecting and correlating building characteristic information from databases such as tax assessor records to energy information. This means remote energy assessments will become less costly to do. Data sets will likely become more rich and accurate if energy performance information becomes highly valued. For example, tax assessor records may change to incorporate new data points which relate to energy consumption features. Remote and relative energy assessments will become easier, cheaper, and more accurate. Displaying the results of remote assessments in a map will demand that people pay more attention to energy efficiency. And as richer data sets become available, these remote assessments will become more accurate and specific, suggesting that in the longer term this may also reduce the need for an in-home audit.

As energy data comes online, which will inevitably happen, more innovative approaches to managing and reducing energy consumption will appear. The promise of rich data sets will encourage entrepreneurs and innovators to develop new applications and technologies to monitor and reduce energy use. Smart meters will continue to roll out and individual households will have the ability to analyze their own energy use at an incredibly granular level. Homeowners will be able to communicate with smart appliances which are recording and relaying their own energy consumption. Sophisticated energy management strategies will be employed by individuals, businesses, utilities, cities, and states.

Fundamentally, as more energy data becomes available, the more we will understand where efficiency potential can be found in our homes, businesses, and cities. Greater information access will lead to a more efficient use of resources and a better valuation of energy efficiency measures. Energy efficiency will be central to securing clean and reliable energy systems across the United States.

As carbon dioxide levels continue to increase and we feel the impacts of climate change through dramatic weather events like Hurricane Sandy, increased attention must be paid to aggressively and dramatically diminishing our dependence on fossil fuels. Bold steps will need to be taken and the sooner we take action, the better off we will be. Making changes like mandating energy disclosure and fostering the development of an energy map may seem small, but they will set the stage for greater changes and more meaningful impacts which will bring us closer to a more stable, cleaner energy future.

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