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MAPPING ELECTRICITY USE IN A NATIONALLY REGISTERED HISTORIC DISTRICT: THE SPANISH TOWN NEIGHBORHOOD IN THE CITY OF BATON ROUGE, LA

LEITNER M.

Louisiana State University, BATON ROUGE, UNITED STATES

ABSTRACT

This paper presents a spatial analysis of electricity use values for the residents of the Spanish Town historic district, located in downtown Baton Rouge, Louisiana. Acquired by volunteer survey, the energy-use values were attached to individual addresses, statistically analyzed, and mapped to illustrate those areas with the greatest energy use. By mapping those addresses with the highest electricity values for 2009, a research base can be established against which, potential photovoltaic (PV) electrical output can be measured. The data analysis in this report will allow future PV assessments of the neighborhood a basis of comparison to test whether applied PV technologies would reduce residential electrical costs to the consumer, without compromising the historic integrity of these locally and federally protected structures.

INTRODUCTION

In 2008, renewable energy amounted to 7% of the total United States energy consumption. Only one percent of the renewable energy is taken in by solar energy. Worldwide the United States ranks 9th among all installed collectors, behind countries like China, Turkey, or Austria. The solar energy sector in the United States offers a huge potential.

In this paper we discuss the analysis and mapping of electricity use values for the residents of a historic district in Baton Rouge, LA. We also speculate on the potential of installing PV technologies in the same neighborhood dependent on tree canopy coverage and restrictions that need to be considered, when making additions and/or renovations to a nationally registered historic district. This analysis is a first step towards the development of a conceptual framework and the modeling of a new international geospatial energy index developed for communities and municipalities. Such a future index would be based on mobility behavior, energy consumption for heating, cooling and electricity, the current usage of renewable energy (solar, wind, photovoltaic), and the thermal insulation status of buildings. Energy index input data would be collected by analog and web-based questionnaires for individual buildings and households to assess the status-quo of energy consumption. The overall goal of future studies would be to investigate similarities and differences in energy efficiency awareness and energy consumption behavior across neighborhoods worldwide.

STUDY AREA

The Spanish Town neighborhood, located in downtown Baton Rouge, Louisiana, was listed on the National Register of Historic Places in 1978. Included in the district are two individually-listed structures, the Stewart-Doughtery and Potts Houses. Spanish Town claims 14 irregular blocks covering approximately 50 acres, surrounded by State-owned and commercial lands. Today its registered boundaries include State Capitol Drive to the north, Interstate I-110 to the east, North Street to the south and North Fifth Street to the west (Figure 1). It's close-quartered, single-story structures, narrow, one-way streets and extensive landscaping facilitate a greater social space and use among the residents as well as creating a unifying streetscape to the neighborhood, defining its character. There are 268 buildings within the Spanish Town boundaries, of which approximately 4% are non-contributors, or modern intrusions, to the overall historic composition (LDHP not dated).

Spanish Town, Baton Rouge's oldest neighborhood, was laid out in 1805 as residential lots to accommodate the refugee Canary Islanders fleeing American rule over the newly ceded Louisiana territory. At the time of Spanish Town's founding, East Baton Rouge Parish belonged to Spanish-controlled West Florida. Abandoning their homesteads at Galvez Town (located at the confluence of the Amite and Manchac rivers to the southeast), the Islanders petitioned Governor Carlos de Grand Pre "so that they might continue to live on Spanish soil and to help defend" Fort San Carlos (CPPC 1973).

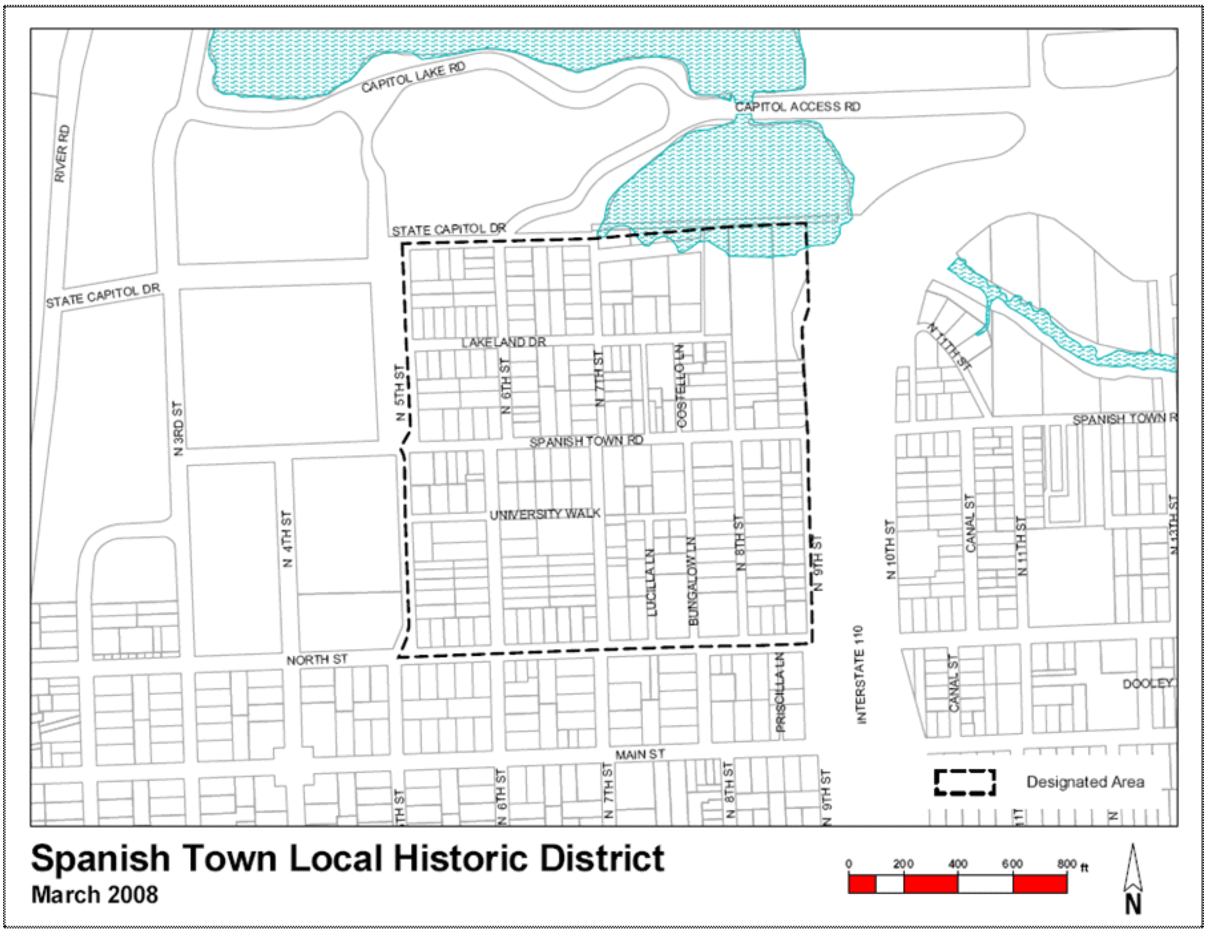

Figure 1: Official LDHP Spanish Town Boundary map (CPPC 2008)

The official Spanish Surveyor, V.S. Pintado, designed the original neighborhood which consisted of only Spanish Town Road laid between 18 long, narrow lots existing between present-day North Fifth to North Twelfth streets and State Capitol Drive to North Street. The neighborhood's footprint was soon expanded by 20 more lots to the east and four garden lots to the west, used to provide food for military personnel stationed at nearby Fort San Carlos (CPPC 1973, LDHP not dated).

In 1810 the United States annexed West Florida, ending Spanish rule in Louisiana. Yellow fever and cholera epidemics significantly reduced the local population in 1828 and 1832, respectively. This allowed French and American families to settle into the Spanish Town neighborhood and build newer, larger structures. Included in these additions are the Charlet House, the Steward-Dougherty House, the Grace-Persac House, and the Potts House, each currently standing in the district. The arrival of the Civil War brought about the ugliest period of the district's history. Federal troop destruction, looting, and fires destroyed several buildings in the southeast section. Homeowners fled from the nearby battlefields. Emancipation allowed freed slaves to occupy those abandoned homes north of Spanish Town Road (CPPC 1973).

In 1885, Fort Baton Rouge (site of the present-day Pentagon Barracks), became the new military campus of Louisiana State University, recently relocated from Pineville, Louisiana. Fraternity houses, professor homes, and campus landscaping brought about a rebirth to the Spanish Town neighborhood. The greatest number of existing structures was constructed during this revival. The LSU-facilitated construction period is considered to span from 1885 to 1925. It was also during this time that lots were subdivided into the pre-automobile alleys and narrow streets that now characterize the present-day district, including Bungalow (1915) and Lucilla (1921) lanes. University Walk is the only namesake evidence that remains of LSU's tenure at Spanish Town (LDHP not dated).

When the university relocated to the south of Baton Rouge in 1925, the Louisiana State Legislature soon appropriated funds and lands to construct the State Capital Complex on the former campus site. With the university left many of the Spanish Town residents, causing a second decline in the district's history. However, this downturn proved to be more short lived than the post-Civil War period, and the completion of the State Capital building in 1934 created an influx of state employees purchasing Spanish Town homes (CPPC 2008, LDHP not dated).

The historic significance and complete character of the neighborhood are important elements in determining which PV technologies are able to and readily accepted for cleaner electrical energy use. Mapping current electrical energy use of the historic district allows for more productive and accurate PV assessment plans for future energy renovations amongst the neighborhood, without compromising its historic integrity. The remainder of this paper presents the first step into determining those potential, non-intrusive PV developments.

LITERATURE REVIEW

Several articles on mapping energy use and potential PV yield have been published. Studies in Western Europe (Suri et al. 2007), Eastern Europe (Hofierka and Kaňuk 2009), Canada (Wiginton et al. 2010, Nguyen and Pearce 2010), India (Ramachandra and Shruthi 2007), and the United States (Fthenakis et al. 2009) have all illustrated the vast amount of potential electrical energy to be collected from solar radiation. Suri et al. (2007) collected climatic data from 1981-1990 for all of Europe, solar radiation values from a PVGIS model, and input all statistics into a database. Using this database, the authors were able to assess PV potential for 30 countries (25 European Union members, and 5 potential future EU members). They found potential output values to vary by national incentive. To help increase incentive and public awareness an online mapping system was developed as the final product of the case study (Suri et al. 2007). Nguyen and Pearce (2010) completed a similar-scaled study which resulted in mapping large-scale potential PV yield for solar farms in southeast Ontario, concluding that the region had the ability to produce approximately two thirds of its electricity needs from solar farms. Wiginton et al. (2010) took the case study from Nguyen and Pearce (2010) one step further, by applying object-specific image recognition to the same Ontario region. This allowed the detection of unobstructed rooftop area to be added to the calculations in potential PV development. The total amount of rooftop area calculated by the object-recognition model was then found to have a constant ratio based upon population and culturally defined space use. Using this formula, the study concluded that approximately 30% of Ontario's energy demands could be met with province-wide rooftop PV deployment (Wiginton et al. 2010). Hofierka and Kanuk (2009) applied three dimensional building models to solar radiation calculations. They argued that 3-D models would allow for not only rooftop PV yield amounts, but façade potential, as well. Their case study of Bardejov, Slovakia illustrated that an estimated two thirds of the city's energy needs could be obtained through solar technology applications.

PV potential mapping in the U.S. has also proven to be cheap, effective, and productive through simulation studies. Fthenakis et al. (2009) showed that by integrating PV technologies with correct storage and solar intensity, the U.S. could potentially supply 69% of its total electrical needs by the year 2050. The scenario was extended to 2100, and returned that over 90% of the electrical needs of the U.S. could be supplied through solar energy (Fthenakis et al. 2008). Finally Herbst (2009) acknowledged that while PV potential is becoming cost-effective, there is little use without greater public knowledge. She authored an article on the success of public solar outreach programs like that of the Department's of Energy's "Solar American Cities" and its online database. Potential customers can view the site, and, much like Suri et al. (2007) can input a tailored formula and view approximate calculations for PV output to their homes. Herbst (2009) argues that with greater public knowledge, comes greater solar use.

METHODS AND TECHNIQUES

Energy use values for Spanish Town residents were collected by an anonymous, voluntary, mail-out survey. A total of 292 residential addresses (multiple-residence apartment buildings included) were collected in the field on March 7th, 2010 and mailed to those validated numbers on March 12th, 2010. The survey consisted of approximately 60 questions inquiring about the heating and water systems, fuels and amounts used, and structural characteristics of each residential address. In total, 27 surveys were completed and returned, which indicates a return rate of slightly less than 10%. Of those returned, 25 provided enough information to be used in the analysis below.

Returned information was entered into a spreadsheet, with energy use values attached to each address and imported into ESRI's ArcCatalog 9.3 software program. From there an Address Locator file was created and used to geocode, or geographically plot, each address' coordinate location. Maps were then created to illustrate those areas with the greatest energy use values by categorically labeling where larger symbols represented greater electrical use (Figure 2). The results were plotted onto a 2008 Digital Orthophoto Quarter Quadrangle (DOQQ) image of downtown Baton Rouge. Using post-Hurricanes Gustav and Ike DOQQ images is of utmost importance when considering current tree cover and it's shading effects on potential PV output, since both hurricanes "reduced" the number of trees in the city by a substantial amount. By mapping those returned values onto current remote sensing imagery, a basis for comparison against PV output potential is created.

RESULTS AND ANALYSIS

Electricity values were mapped using the natural breaks classification method (Figure 2). Each electricity value symbol is plotted over the associated address. The DOQQ background image clearly shows the tree coverage information, providing a first impression of which addresses would be best suited for potential PV output. Those addresses with little or no tree coverage were considered the best candidates for PV output potential, through greatest access to unobstructed sunlight. For this reason, tree cover was closely examined to provide preliminary estimates of which houses, for which electrical use values were provided, stood to gain the most from PV installation. For this basic analysis, only those rooftops with little or no surrounding trees were chosen as the best preliminary candidates for potential PV output. It turns out that the following five of a total of twenty-five houses (for which electrical use values were provided) should gain the greatest benefit from potential PV output, including 6.. University Walk, 8.. North 6th Street, 6.. North 8th Street, 8.. North 6th Street, and 8.. North 8th Street. For reasons of privacy, only the first of three digits of each house number is shown here. Unfortunately, information about tree heights was not included in this study. Therefore, an estimate of tree canopy cover for each rooftop has not been considered here.

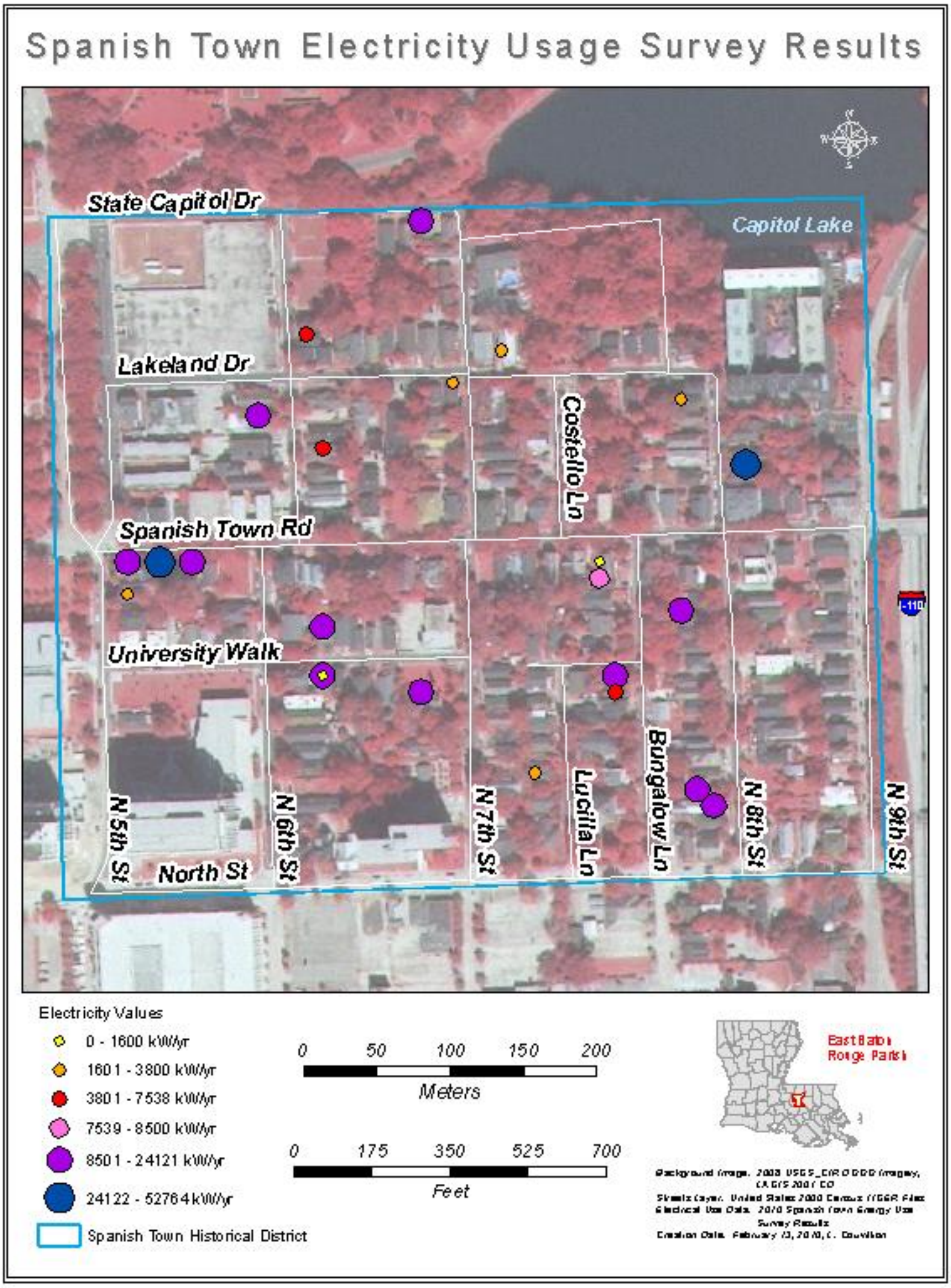

Figure 2: Electrical use values (in kilowatts per year [kW/yr] plotted for a total of 25 returned surveys.

CONCLUSION AND FUTURE RESEARCH

From the results reported above about 20% (five of twenty-five) of all surveyed homes would potentially gain the greatest benefit from PV installation. For the other twenty homes the shade from the surrounding tree canopy may actually reduce electrical consumption as opposed to those homes with unobstructed "view" to the sun. In other words, greater shade coverage would keep a residence cooler, creating less need for greater electrical cooling use.

Clearly, this research is at a very early stage and more information and further analysis is needed. The returned surveys provide a base to build upon, but for the most accurate assessment of PV potential savings, more return data may be needed. A larger sample would allow for greater coverage and higher overall accuracy in both analyses and results.

Future research should include potential PV output measurements as illustrated in studies by Suri et al. (2007), Wiginton et al. (2010), and Ramachandra and Shruthi (2007). Lidar and Digital Elevation Model (DEM) imagery, the Solar Analyst tool (of ArcGIS) and the r.sun solar radiation model (of the Geographic Resources Analysis Support System [GRASS] GIS) can all be used to calculate potential PV output of the Spanish Town neighborhood, simply based upon its geographic location and elevation. By comparing those potential PV output values against reported values, like those collected for this report (e.g., energy usage), the cost of PV system installation and maintenance can be tested for possible savings to the consumer resident. If a one-time installation cost can offset the potential PV electrical output from free, solar energy collection, not only could it save the consumer resident electrical costs, but encourage the use of clean, renewable energy while reducing harmful carbon emissions, ultimately reducing destruction to the natural environment.

Additional factors to include in future research include the additions and renovations allowed to a nationally registered historic district. Those structures within the locally and/or federally recognized historic district are often subject to restrictions on construction and alterations allowed to the buildings (CPPC 2008). A study of restrictions imposed upon the structures of Spanish Town must be completed in order to assess which PV technologies would be allowed before potential PV output should be measured. For example, solar panels may be considered too intrusive to the visual characteristics of the structure. Instead, solar tiles or window films may be more readily acceptable and allowed by district regulations. This data must also be collected to allow for the greatest accuracy when comparing potential PV output against current electrical use. If PV technologies can be applied to these historic homes, it will not only create an environmentally healthy energy output, but may significantly reduce the cost of electricity to the resident without compromising the historic integrity of the structure.

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