HEAT - HOME ENERGY ASSESSMENT TECHNOLOGIES: *A WEB2.0* RESIDENTIAL *WASTE HEAT ANALYSIS USING GEOBIA AND AIRBORNE THERMAL IMAGERY*

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ABSTRACT:

We report on the HEAT (Home Energy Assessment Technologies) pilot project conducted over the City of Calgary, Alberta, Canada, and discuss plans for the 2010 full city implementation. HEAT represents a Free and Open Source (FOSS) Geomatics solution for residential waste heat monitor with high-resolution airborne thermal imagery that is intended to (i) support Canadian urban energy efficiency programs; (ii) evaluate and monitor residential thermal envelopes (i.e., waste heat) using a new Canadian thermal airborne sensor; and (iii) provide free online results and tools to help individuals conserve energy, save their money and reduce their Green House Gas (GHG) footprint. A demo version of this service can be accessed at http://www.wasteheat.ca - login: beta, pwd: beta. We welcome your constructive feedback.

1. INTRODUCTION

Since 1990, Canada has implemented numerous programs to encourage energy efficiency. For example, in Calgary Alberta, $50 million was spent between 2003-08 on *energy performance programs* to assess and upgrade city-owned facilities, with an estimated $7 million saved in energy costs per year, and a reduction of ≈ 80 KT of CO_2 emissions (DEEAEP, 2010) The key to these savings was that *appropriate information provided action to enhance energy efficiency and reduce environmental impact* (Darby, 2006). But how does a local home owner concerned with reducing her environmental footprint (in terms of energy use/emissions) know that her home – not the energy saving devices used inside it – is energy efficient?

Here we report on the goals, methods and results of the HEAT project (Kyle, 2009): namely to develop a *Geomatics turn-key solution* (software, hardware, data provision and web-portal/service) that will provide residents *free of charge* a way to automatically assess their homes' thermal waste energy footprint (i.e., a detailed heat map of their house showing hot and cold areas) to identify where potential energy saving renovations could be made (i.e., windows, roof, etc) without the need for costly and potentially unnecessary in-situ thermal surveying taking place; and all as easily as clicking on their house in Google Maps. With this knowledge, home owners can participate in government grant/tax incentive programs to carry out the energy saving renovations on identified areas, from certified service providers (Hay and Kyle, 2010).

2. STUDY AREA & DATA COLLECTION

2.1 Study area

The study area is located in the community of Brentwood, situated in the northwest quadrant of Calgary, Alberta Canada. This site represents 450 residential buildings, the majority of which were built between 1961 and 1965 - suggesting that they are good candidates for potential energy saving renovations.

2.2 Thermal data

A 600 x 2000 pixel TABI-320 (Thermal Airborne Broadband Imager) geometrically corrected mosaic of the study area was provided by ITRES Research Limited. The TABI-320 is a pushbroom thermal infrared sensor that produces an image 320 pixels wide. The sensor is sensitive to the 8μm - 12μm range of the electromagnetic spectrum, and contains flight information that is later used to geo- and ortho-correction the imagery. The image was delivered in ENVI format with a spatial resolution of 1.0 m and a radiometric resolution of 0.1°C. A new larger area dataset will be acquired by the TABI-1800 during the winter of 2010. This new sensor is capable of collecting 1800 pixels per swath, effectively 5+ times the current capabilities of the TABI-320 (TABI, 2010).

3. METHODS AND RESULTS

3.1 HEAT Innovations

A number of specific results and innovations unique to this project include the following: **(1)** the development of a new commercial waste-heat monitoring market for the TABI-1800. **(2)** The development of automated/semi-automated *Geographic Object Based Image Analysis* solutions (i.e., GEOBIA

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tools/software) (Hay and Castilla, 2008) to generate GIS ready house polygons directly from the airborne thermal imagery rather than from pre-existing city cadastral datasets. This is critical when cadastral data are unavailable, thus allowing web accessible results within a week of data acquisition. **(3)** Web 2.0 compliant project development using Free and Open Source Software (FOSS) and OGC (Open Geospatial Consortium) standards for geospatial and location based services (Figure 1). We note that *(i)* Python (a dynamic object- oriented programming language) is used for rapid program development. *(ii)* PostgreSQL (an Object-Relational Database) is used with Python bindings, and *(iii)* PostGIS (a spatially enabled PostgreSQL) allows for the handling of geo-databases. **(4)** Incorporating *volunteered geospatial information* (i.e., *citizen sensors*) in to the HEAT web-service by requesting user information on roof material and house size (when not available from city cadastral data) that will allow for corrected emissivity to the walkability index developed by *Walkscore* (2010) which is used by millions.

4. DISCUSSION AND CONCLUSION

Based on location-aware web services and high resolution airborne thermal imagery, the HEAT pilot project presents a Geomatics solution with a high potential for commercialization and advanced spatial decision making, that are applicable through a range of scales from the individual home owner, the neighbourhood, the community, to an entire city (Hay et al., 2010). Based on the ease and ubiquity of internet access, we forecast this project to provide community, commercial, and environmental utility on a global basis while promoting Canadian excellence in Thermal Imagery and location-aware web services.

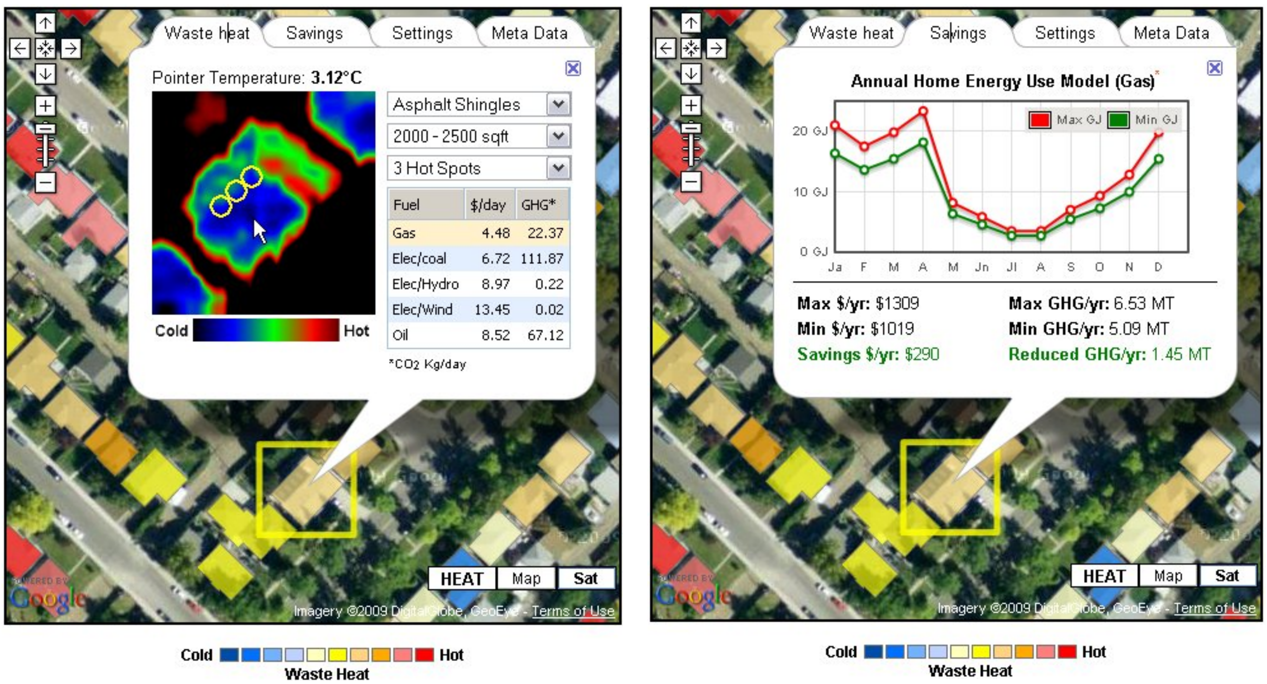

Figure 1. Yellow circles (***Left***) automatically define the 3 hottest locations on a home – which in this case fall above 4 sky-lights. The colored polygons (that overlay the image) are from a residential database, and are color based on the average roof-top temperature. This allows for neighborhoods to be evaluated at coarser scales. The mouse-over pointer value (3.12 ºC) is dynamic, and the energy use-model estimates GHG and cost/day to heat this home to the maximum defined temp using different fuel types. When Natural Gas (in tan highlight) is double clicked, a model is generated (***Right*** *– Savings tab*) for this home/year with total costs as well as GHG and savings based on reducing waste heat to the min roof temperature defined by the thermal sensor (prices shown are examples only).

and green house gas estimates, thus tailoring individuals home waste-energy footprint information and potential savings (Figure 1). (5) The ability to define the three hottest locations on each home, and to compile the top 1000+ hottest homes in a city (Figure 2). (6) Monitoring may be applied yearly to provide evidence of successful Government and municipal energy incentive retrofit programs. (7) Multiscale analysis can also be conducted ranging from individual homes to neighborhoods, communities and cities, with opportunities to promote national and international intra- and inter-city heat waste competitions. (8) There is also potential to influence Calgary public energy use by developing a web-enabled *Thermal Energy Index* as part of Calgary's public cadastral information. This will be similar

To evaluate the current version of HEAT, please login as *beta* to (http://www.wasteheat.ca) with the password *beta* (no italics). Please note that this system is in continual development, so we invite you to provide us with your constructive comments and feedback and welcome collaborative opportunities and partnerships.

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