HEAT – Home Energy Assessment Technologies:
Geomatics Solutions to Improve Urban Energy Efficiency Through Residential Waste Heat Monitoring

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Abstract

The HEAT pilot project is a FREE GeoWeb mapping service, designed to help residents visually evaluate the amount and location of waste heat leaving their homes and communities as easily as clicking on their house in Google Maps. HEAT incorporates Geomatics solutions for residential waste heat monitoring using GEOBIA (*Geographic Object Based Image Analysis*), the GeoWeb and Canadian built *TABI (Thermal Airborne Broadband Imager)* technologies to provide users with timely, in-depth, easy to use, location-specific waste-heat information, as well as opportunities to save their money and reduce their green-house-gas (GHG) emissions.

Background and Relevance

HEAT is a FREE GeoWeb mapping service [1], designed to help residents visually evaluate the amount and location of waste heat leaving their homes and communities as easily as clicking on their house in Google Maps. HEAT incorporates Geomatics solutions for residential waste heat monitoring using GEOBIA [2], Canadian built TABI technology and a GeoWeb delivery system using Google Maps as the front-end. A back-end geospatial information system provides users with timely, in-depth, easy to use, location-specific waste-heat information; as well as opportunities to save their money and reduce their *green-house-gas* (GHG) emissions. We suggest that with this new geointelligence (i.e., tailored geospatial knowledge), home owners can better participate [3] in government grant and tax incentive programs to carry out energy saving renovations at identified waste heat locations, by certified service providers**.**

Methods and Data

The (2010) *Phase I pilot* is located in the Brentwood community of Calgary, Alberta Canada where it includes 358 residential buildings (built 1961 -1965), suggesting that they are good candidates for potential energy saving renovations. A corresponding 600 x 2000 pixel TABI-320 geometrically corrected mosaic 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 8□m - 12□m range of the electromagnetic spectrum, and contains flight information that is later used to geo- and ortho-correction the imagery. The image was delivered with a spatial resolution of 1.0 m and a radiometric resolution of 0.1°C. During the *Phase II pilot*, a new larger area (24 x 35 km full city) dataset will be acquired by the TABI-1800 [4] during the winter (Feb – March) of 2011. This new sensor is capable of collecting 1800 pixels per swath, effectively 5+ times the capabilities of the TABI-320, and will be evaluated with cadastral data for over 110,000 homes provided by The City of Calgary. During 2012, *Phase III* will be developed for 300,000+ homes over the entire city (25 x 35 km).

HEAT Web 2.0 architecture is based on OGC (*Open Geospatial Consortium*) standards [5] and includes (i) a geospatial database, (ii) an image processing pipeline, (iii) a web server platform capable of running server side scripting languages, and (iv) an Ajax supported web browser. A combination of PostgreSQL and PostGIS provide the geospatial database backend to the HEAT web service. Open source geospatial libraries such as GDAL/OGR for raster and vector file handling, and PROJ.4 for coordinate system conversion are used within the thermal image processing pipeline and by the geospatial database itself. Google Maps is used as the front end, and Python is used for rapid program development. Image processing is conducted using ENVI and IDL, with feature extraction based on a combination of in-house and commercial GEOBIA software and cadastral data

Results and Discussion

HEAT incorporates (i) *volunteered geospatial information,* (ii) defines the 6 hottest locations on each home (i.e., 3 along the roof edge, and 3 within the roof envelope), (iii) locates the hottest (3+) homes in a neighborhood, and (iv) incorporates multiscale monitoring ranging from individual homes to neighborhoods and cities. This may be used to provide evidence of successful energy incentive retrofit programs, along with opportunities to promote national and international intra- and inter-city waste heat competitions. Potential City Savings ($) and reductions in CO_2e (Carbon Dioxide equivalent) are also calculated based on *fuel-type* and *temperature models*. Users can mouse-over the list of communities, highlighting each community HEAT map. Statistics such as number of homes, total heated area and approximate cost to heat all homes in a community are shown.

Clicking on an area will zoom into the *Residential HEAT Map*, which displays individual homes classified into 10 temperature classes based on their *average roof top temperature*. Clicking on a classified house polygon will show a detailed TABI waste heat *signature* for a specific home, with the top 6 hotspots automatically illustrated (as colored circles) (Figure 1). The cost of heating the home per day, along with estimated CO_2e for different fuel types is also modeled. Clicking on a fuel type will bring up the *$avings tab*, which provides information on the cost of heating the home and CO_2e generation for specific fuel types. It also shows the *potential savings* and *reduced* CO_2e when the average roof temperature is reduced to the minimum roof temperature. Ideally, the roof temperature should equal the ambient atmospheric temperature. Anything above this is *waste-heat*.

Users can also click a button that links their thermal perspective with Google Streetview. In many cases, this immediately provides visual evidence linking the ‘edge’ hotspots, with doors and windows located directly beneath them. Thus, providing additional evidence of locations where waste-heat solutions could be applied. As a result of this new geointelligence, value-added services related to low CO_2e fuel sources (i.e., wind, solar etc), energy efficiency and waste-heat reduction could be promoted from the web service (i.e., installing thermal windows, doors, siding, roofing, insulation etc).

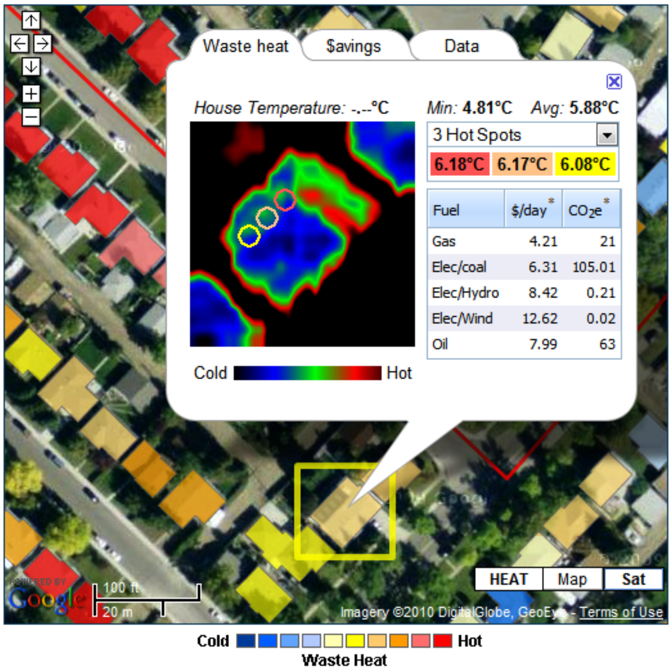

Fig 1: Three circles (inset) automatically define the 3 hottest locations on a home – which in this case fall above 4 sky-lights (inside yellow box). Individual homes (i.e., colored polygons) are designated one of 10 colour classes based on their average *roof top temperature*.

Conclusions

Based on location-aware web services and high resolution airborne thermal imagery, the HEAT pilot project presents free Geomatics solutions 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 neighborhood, the community, to an entire city. Tools have been developed that allow a resident to examine the 100+ hottest homes in a community, as well as the top 6+ hottest waste heat locations (and their temperatures) leaving their home. CO_2e estimates, based on different fuel sources (i.e. gas, oil, wind and hydro electricity, etc) are also provided. An *annual home energy use model* also provides estimates of the money saved and the CO_2e reduction if a home owner is able to take action to reduce the temperature leaving their home (as waste heat), from the average to the minimum roof temperature defined by the TABI sensor. Ideally these free tools will help residents reduce the amount of waste heat and green house gases leaving their home, as well as provide them with opportunities to save their money through energy efficiency. They may also provide agencies evidence of successfully implementing energy retrofit programs, along with opportunities to promote national and international intra- and inter-city waste heat competitions. Renovation contractors may also find these tools useful for identifying neighbourhoods where upgrades are required for marketing purposes; residential construction companies may be able to verify the (waste heat) quality of their homes, and police agencies may be able to use this geointelligence for identifying grow-ops. Additional uses may be found by municipal planners looking to identify the 'best' communities to focus energy efficiency incentives upon, and organizations mapping urban ecological footprints [6].

To evaluate the current GeoWeb version of HEAT, please login to (http://www.wasteheat.ca) as *beta*, with the password *beta* (no italics).

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