

## Empowering Urban Energy Efficiency™ with Residential Waste Heat Monitoring

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## HEAT Overview

- The Real HEAT Story
- The HEAT Science Story
- Data
- Methods
- System Components
- User Interaction
- Challenges
- What's Next?
- Collaborative Opportunities
- Conclusion
- Further Information

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## The REAL HEAT Story



**WASTE HEAT**

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## What is Waste Heat?



- Waste heat refers to heat produced from machines that have **no useful application**.
- In this project, waste heat represents **expensive heated air** that **escapes** through poorly insulated doors, windows, walls, ceilings, ductwork and electrical fixtures (i.e., pot lights), instead of staying and keeping you warm.
- This is **costly** to the home owner, generates considerably more green-house-gas (GHG) emissions than necessary, and is **invisible** to the human eye.

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## The Science Story: Canada's Urban Energy Use




- Over the last 5 years, urban energy demand in Canada has **risen nearly 20%**.
- On average, buildings emit 35% of all Canadian green house gasses, use 33% of Canada's total energy production and consume 50 % of Canada's natural resources<sup>[1]</sup> of which the majority is used in **space and water heating**.
- Space heating provides one of the **best opportunities** for energy cost **savings** through improvements in building design and local alternative energy sources.

Source: G.J.Hay, Calgary Jan, 2011 (-31C)

[1] (CU) Canadian Urban Institute, 2008, Energy Mapping Study, submitted to the city of Calgary.

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## Obstacles to the problem



- The most cited obstacle to energy efficiency improvements is the **lack of interest** from clients and/or consumers<sup>[1]</sup>.
- **What does energy efficiency look like?**
- **Where is it located?**
- Darby (2006) – meaningful user feedback **enhances** energy efficiency


Source: <http://www.searchenginemonitor.com.au/photo-gallery/>

[1] <http://jamesonmarketing.wordpress.com/2007/11/27/jan-will-never-USE%2FAD%2Fthe-not-interest/>

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## HEAT Science Question

- Can Geospatial Technologies provide **meaningful user feedback** to improve urban energy efficiency, reduce GHG's and save money?



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## The HEAT Geoweb Service




- The HEAT pilot project is a **FREE** GeoWeb mapping service, designed to help residents:
  - improve** their Home Energy Efficiency,
  - save** their money, and
  - reduce** their green-house-gas (GHG) emissions...
- How? By **visualizing** the **amount** and **location** of waste heat leaving their **homes and communities**, as easily as clicking on their house in Google Maps.

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## Why HEAT?

- Individuals**
  - Many ways to identify energy efficient appliances, but *how do I know* if my home is energy efficient?
    - Where is 'energy' leaving my home?
    - How can I find out for *free*?
    - What can I do about it?
- Municipalities and Governments**
  - Grants and tax credits:** Encourage a switch to more energy efficient alternatives - but where does the problem lie?
    - What *monitoring* mechanisms are in place to ensure that 'upgrades' work?
    - How can we *evaluate* neighbourhoods, communities, cities, etc?
- Planet**
  - Cut** Greenhouse Gas (GHG) Emissions
  - Reduce** Energy (Ecological) Footprints
  - Save** money Globally
  - Provide new green sector *employment*



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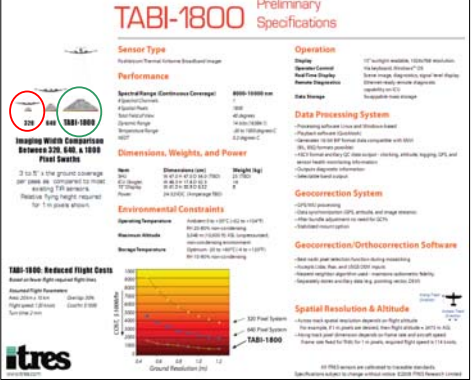
## Data - Thermal



- Phase I:** Brentwood community of Calgary, Alberta
  - TABI 320 - ITRES Research Limited, Calgary
  - 368 homes
  - One Channel (8-10 μm)
  - 0.1°C temp. resolution
  - 1.0 m spatial resolution
  - Collected on July 28 2006 (4:00 am)


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## TABI-1800 Preliminary Specifications



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## Data – Cadastral



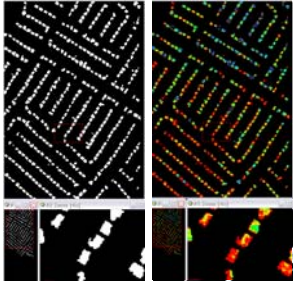
- 2007 City of Calgary
  - Communities
  - Land Parcels
  - 368 residential buildings + characteristics e.g.: area, age, etc...
- Need a **solution** when cadastral data not are not available.

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## GEOBIA


### Geographic Object Based Image Analysis

- Essentially **automated image processing** methods based on how an **analyst** would interpret an image.
- Methods that evolve:
  - **pixels**
  - **image objects** (e.g., houses)
  - **geointelligence** (i.e., spatial content in context)

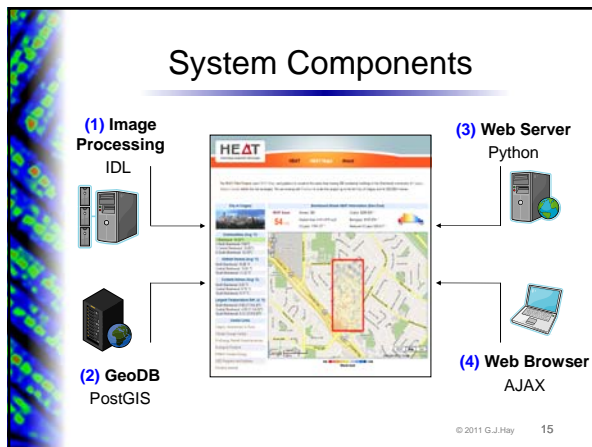
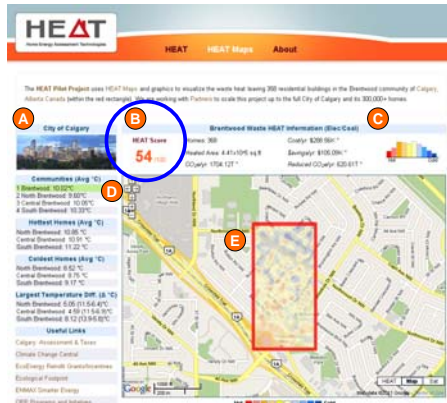


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## Free & Open Source Software

-  Standards organization for geospatial and location based services
-  Dynamic object-oriented programming language, rapid program development
-  Object-Rational Database, Python bindings
-  Spatially enabled PostgreSQL allowing it to handle geodatabases

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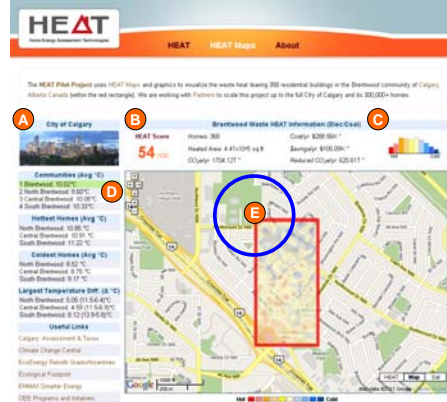



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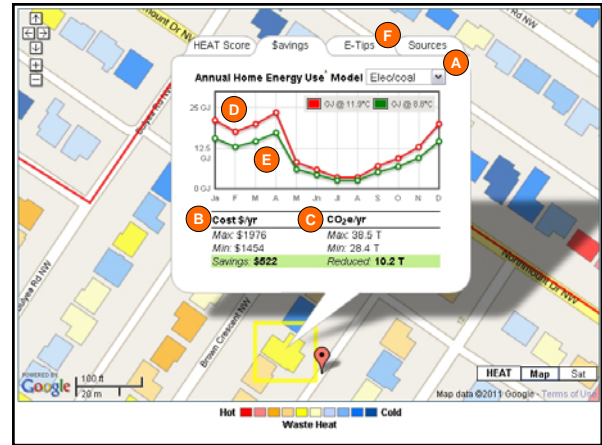
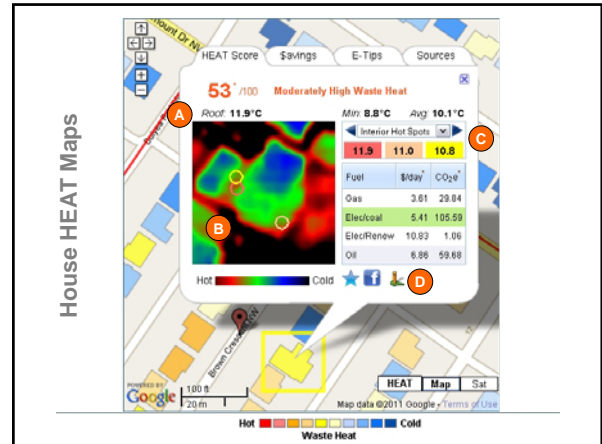
## What are HEAT Scores?

- HEAT Scores are values that allow you to meaningfully **compare** the waste heat of one or more houses with all other houses, in your community and city.
- If the HEAT Score for a house is 74/100, this means that *"...this house wastes more HEAT than 74% of all other houses in this city"*.
- A **relative descriptor** is also associated with each HEAT Score, which for 74% would state *"...Moderately High Waste HEAT..."*
- Heat Scores can be **calculated** for homes, communities and cities.
  - The **City HEAT Score** is calculated based on the average HEAT Score of all houses in the City.
  - **Community HEAT Scores** are calculated based on the average HEAT Score for all homes in each community.

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## Challenges

- Home energy use/efficiency **models**
  - Little consistency for fuel types and home construction
  - Working with Avalon Master Builder –Developer of NetZero and LEED homes
- Home temperature **anomalies**
  - Away on vacation (home thermostat turned down)
  - Garage door wide open at time of image acquisition
  - Locally variable winds or heat-island effects \*\*\*
- Seasonal/Geographic **variations** in energy use/efficiency:
  - Summer vs. Winter? Hot vs. Cold?
  - Snow, natural insulator, summer has air-conditioning issues
- Sensor **limitations**:
  - Temperature Range (-20°C)
  - Flight time temperature variability – Object Based Mosaicing
  - Microclimatic variability – TURN (Thermal Urban Road Normalization)
- Lack of **cadastral** data sets
  - Solution: use **GEObIA** for automated home polygon generation from thermal and optical images.
- Privacy** issues
  - Adopt Google Privacy Issues
  - Link with companies for energy use information
  - Option to remove house information

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## Privacy

- Sent:** Wednesday, March 09, 2011 7:35 AM
- Subject:** RE: HEAT request for (limited) Full City of Calgary Assessment Dataset
- "...Good morning Dr Hay: This is an interesting application. In reviewing the information provided it has raised a number of questions regarding privacy. It will show which homes are most likely **vacant** at the time (those which are coolest), which homes likely have **seniors** or **babies** living in them (those which are warmest), and what the **address** is to that target home, and it even provides a **map** to those **potentially vulnerable sites** ... The address and mapping to those sites mentioned previously would place individuals in harms way. **The City will not provide the additional information for reasons stated...**"

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## Privacy

- Remove house information from our system – once verified.

This image shows a screen shot of the Privacy GUI that will appear when a user clicks on the space that was originally a house polygon (within the blue circle), but which has now been removed at the request of the owner.

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## Privacy+

- We acquire a thermal image flow over your house at a single instance in the past. This is **not real-time data**.
- Cadastral information are **publicly available** on the City of Calgary Tax Assessment website.
- We **do not collect**, or have access to any information regarding the **number of occupants** in a house, their **age, gender, race, income, culture, religion** or the **occupancy status** of the home, and note that there is **no scientific evidence** that links thermal airborne imagery with any of these attributes.

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## What's Next?

*An Urban Energy Facebook - Personalized Energy Monitoring*

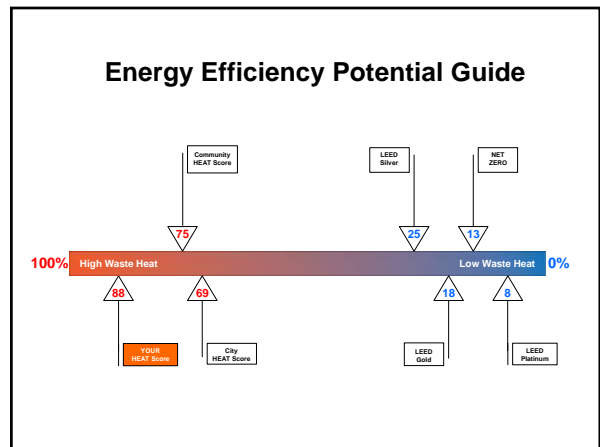
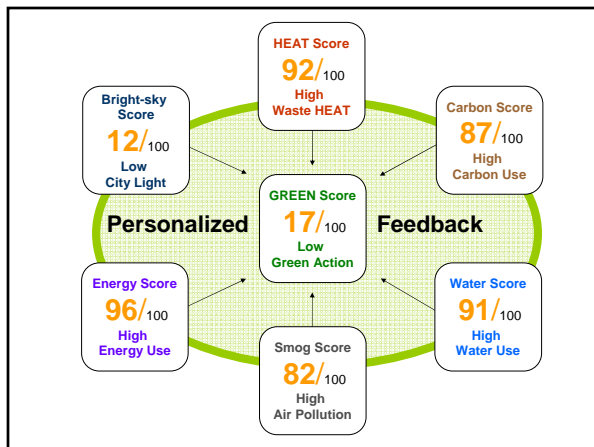
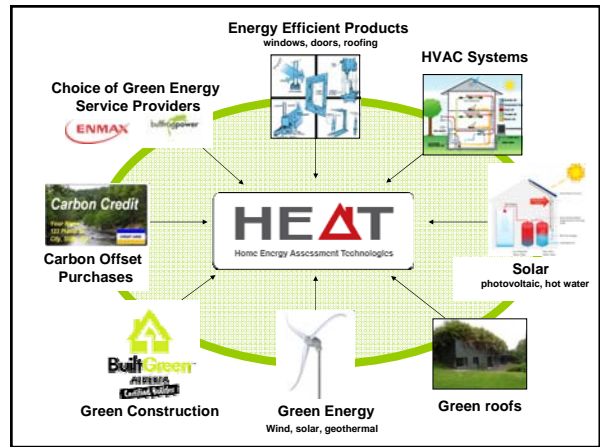
**TABI Monitoring**

**eMonitor**

**Thermal Gun**

**UAV - Thermal**

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## Collaborative Opportunities

1. Developing **energy models** for homes, communities and cities.
2. Establishing **monitoring** programs in other cities.
3. Developing **privacy/** Geoweb policy and **VGI** implementation.
4. Energy **Decision Support** - evaluating different user group responses.
5. Developing additional **related Energy Scores** to the HEAT, Carbon and Water Scores already underway (not discussed in the provided literature).
6. Developing/testing different image-analysis / **feature-detection strategies**.
7. Developing related **Urban data products** from the thermal imagery such as enhanced object-based Impervious Surface Maps.
8. ...and many more...

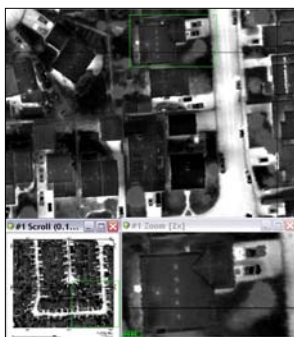
## Sabbatical Opportunity

Cool Score  
94/100  
High Cooling Use

- I am going on Sabbatical in July/August 2011-212 to Brisbane Australia, developing and applying the HEAT project over the City of Brisbane.
- Opportunity to collaborate with the Perth group?
- Instead of HEAT Scores, **we could be develop a Cool Score resulting from Cool Wasted Air leaving poorly insulated buildings**.
  - associate wasted energy costs from cooling
  - increased GHG generation...?

## TABI 1800 Imagery

March 31, 2011 – City of Calgary, Alberta Canada



- The new TABI 1800 sensor has a 50 cm spatial resolution, and a 0.05C thermal resolution.
- Each flight line is 1800 pixels wide. At 1.0m that's 1.8 km.
- We recently flew the City of Calgary (March 31, 2011) in 23 by 35km flight lines at 70cm spatial resolution in just under 4.5 hrs
- (Figure) 15 cm sample



## Conclusion



- The HEAT pilot project is a **FREE** GeoWeb mapping service, designed to help residents (i) **improve** their Home Energy Efficiency, (ii) **save** their money, and (iii) **reduce** their green-house-gas (GHG) emissions by **visualizing** the amount and location of waste heat leaving their homes and communities, as easily as clicking on their house in Google Maps.
- **Our Mission** is to **show** 'what urban energy efficiency looks like', **'where** it is located', **'what** it costs' and **'what** to do about it'. We believe that if people could see the waste heat they generate and if they knew how much it cost (financially and to the environment), that they would want to take action. **We want to show them how.**
- **Our Vision** is to empower the urban energy efficiency movement by providing free, accurate and regularly updated waste heat solutions for the world.



## Further Information



- **HEAT Cover** story in GIM International (March 2010)
  - Email Dr Geoff Hay (ghay@ucalgary.ca) for a copy.
- **New paper:** 2011 in a Special Urban Remote Sensing Issue for the online journal *Remote Sensing*

*Geoffrey J. Hay, Christopher Kyle, Bharanidharan Hemachandran, Gang Chen, Mir Mostafizur Rahman, Tak S. Fung and Joseph L. Arvai. Geospatial Technologies to Improve Urban Energy Efficiency. In review April 20. Remote Sens. 2011, 3, 1-x manuscripts: doi:10.3390/rs20x000x.p.25*
- Visit our **DEMO** at <http://www.wasteheat.ca>
  - (username: **beta**, password: **beta**)

## Not Used

