Thermographic surveying of the built environment in the territory of the municipality

In a nutshell

SUMMARY
It is best practice to use thermography to collect data at various scales and to provide visual information on heat radiation, in order to understand where energy efficiency solutions need to be deployed as a priority and to engage residents and local organisations on the energy efficiency of buildings. A thermographic survey of a large area can be carried out by aerial thermography.
Target group
Local authorities
Applicability
This best practice is applicable to local authorities. The thermographic survey needs to be performed under specific conditions in terms of climate (i.e. temperature, wind), period of the year (i.e. winter) and time of the day (i.e. early morning).
Environmental performance indicators
• Percentage of the built area of the territory of the municipality covered by thermographic surveying (%) • Potential energy savings identified thanks to the analysis of the thermographic survey (kWh/year, EUR/year)
Benchmarks of excellence
Recent (<5 years) high-resolution (<50cm) thermographic data is available for 100 % of the built area in the territory of the municipality.

Description

Municipalities have an opportunity to enable large-scale energy efficiency efforts on the territory under their responsibility, both by prioritising their own efforts and also through the action of the citizens and businesses living and operating in the area.

One of the ways to enable these performance improvements is to understand how the built environment is a source of energy loss and where energy efficiency solutions need to be deployed as a priority. Thermography is a tool which enables the collection of data at various scales and provides visual information on "hotspots" of heat radiation, highlighting potential inefficiencies.

Principle of thermography

Current thermographic methods use infrared (IR) cameras to record the differences in heat radiated by different landscape features, such as buildings, paved roads (covering piping) and light fixtures. The images provided by the IR cameras provide a picture of temperature differences against the background. For this reason, thermography when used to detect energy leakages is used in winter when ambient air is cold, buildings are heated and the temperature contrast between the two is high.

Following the collection of infrared camera images, the data is then processed to produce images of buildings with a colour scale to illustrate the intensity of temperature differences and therefore (Axelsson, 1988) heat loss. When image capture is aerial, the data can be superimposed on a map of the territory. The main output of the thermographic survey will then be (literally, in this case) a "heat map" of a geographical area where the location of heat losses (hinting typically at poorly insulated buildings) can be visualised instantly. Buildings can then be outlined for further analysis; a typical example is provided below:

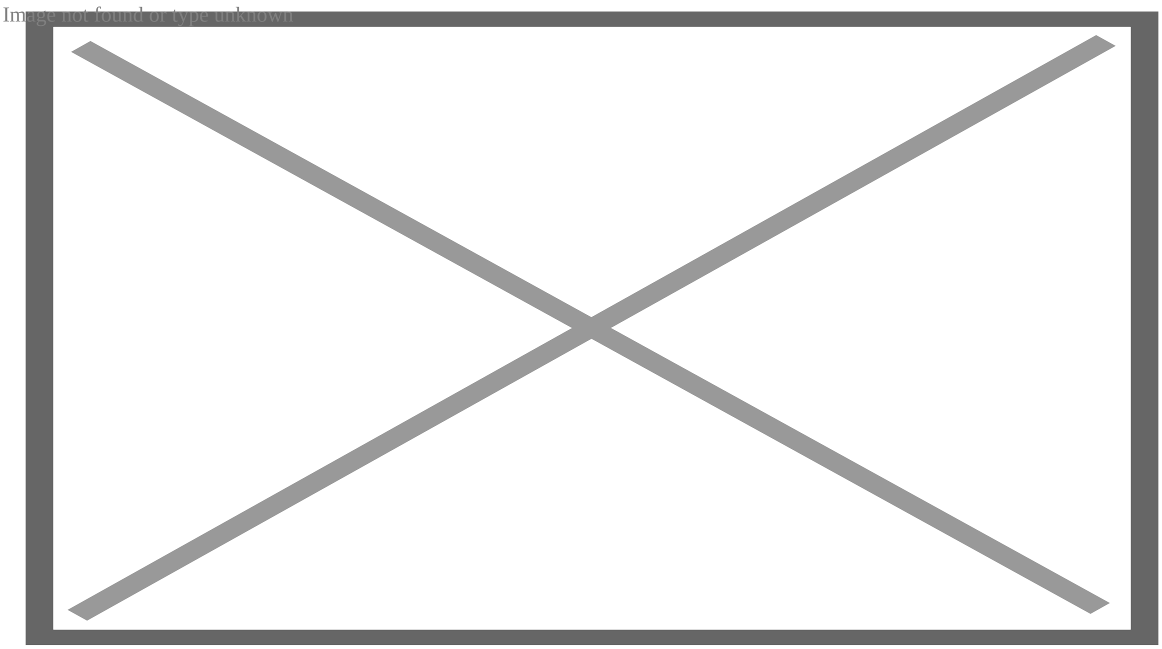

Figure 1: example of thermographic mapping output (source TCC sas). Left: satellite picture; centre: thermographic map; right: processed buildings map

Further data processing can then be used to complement the thermographic data, e.g. to include further relevant cartographic features allowing the interpretation of the data or the illustration of specific phenomena (heat distribution networks, fuel poverty…).

Application and options

Thermographic data can be collected using different methods, usually yielding complementary results. In particular two main surveying methods can be highlighted, land-based or aerial thermography. Land-based methods are preferable for smaller areas (e.g. streets inside a neighbourhood) and will provide information about building facades as well as building roofs (e.g. if the collection equipment is equipped with extension poles). They can be used to provide finer information about a group of buildings.

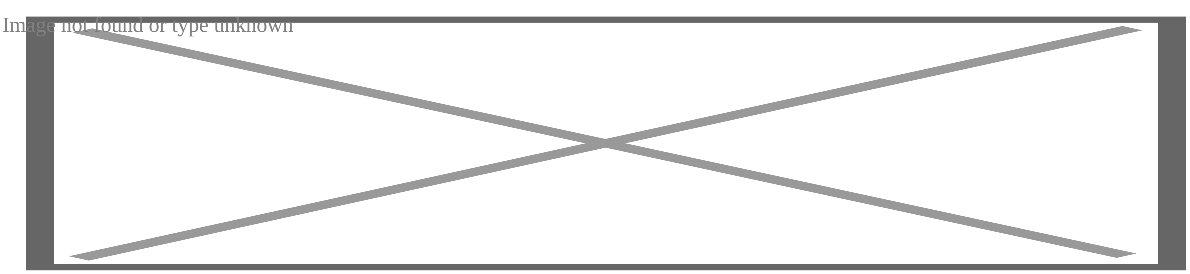

Figure 2: example of land-based thermographic imaging (source TCC sas)

Aerial thermography allows the collection of data from above and will provide imaging for building roofs. However, a roof typically represents 25-30% of the energy losses of a building and aerial thermography will provide a good initial hint for further investigation of a built area. While individuals and businesses can invest in the thermal photography of their own building to audit their insulation, from a municipality's perspective, aerial thermography will provide an overview of the whole territory and achieve economies of scale by providing data for a whole town and enabling comparisons between different areas in the same territory. This will in turn enable informed policy- and decision-making.

Aerial surveys can be conducted using various methods including tethered balloons (aerostats), drones, helicopters, or airplanes.

Thermography is only the start

Once the thermal imaging has been performed, the data can be used as a basis for energy conservation efforts: however as thermal imaging will not improve environmental performance in itself, the tool is only as good as the follow up action that will be undertaken on the basis of the diagnosis. The following key actions can be taken to build on the output of a thermographic survey:

Direct impacts:

- diagnosis of energy efficiency/insulation of public buildings (see best practice on improving the efficiency of public buildings)

- diagnosis of the insulation of district heating and cooling networks (see best practice on implementing district heating and/or cooling networks)

- diagnosis of the efficiency of street lighting (see best practice on implementing energy efficiency street lighting)

Indirect impacts:

- Awareness raising campaigns (see below)

- Communication on the municipality's broader efforts in terms of energy efficiency

Policy actions:

- Encourage energy efficiency actions to tackle the issues highlighted by the thermography, e.g. provide counselling on insulation, subsidise insulation projects

- Identify and address risks of fuel poverty. Economic and geographical data (e.g., "heat maps" of median household income by neighbourhood) can be combined with thermographic data to help assess the areas where risks of fuel poverty are high and design policy actions. To identify risks of fuel poverty, care must be taken to assess a variety of cases e.g. households where energy costs represent a large part of the budget because they cannot afford insulation investments with long term paybacks (which will show up 'red') or households who simply cannot afford to heat their dwellings (which will show up 'blue'). A simple reading of the thermographic map will not provide this kind of essential information and further analysis by social services is generally warranted.

The major steps to be followed in a thermographic survey project are depicted below:

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Figure 1: simplified steps for carrying out a thermographic survey

In this context the importance of the follow-up communication campaign that will be led to share the results of the actual survey is paramount, as it will leverage individuals and businesses to deliver the largest gains in terms of energy efficiency.

Communication and information strategy

The output of the thermographic survey is a very valuable communication tool in an outreach effort to raise awareness regarding the municipality's energy efficiency. In particular it offers:

- Technical information in a user-friendly and visually appealing format

- Global (town level) trends as well as individual information on a citizen's own house / office

Maximum value can be derived from the data if adequate technical and economic information or counselling from engineers or trained municipal staff can be provided to assist in interpreting the data and taking action to address any identified issue. This counselling should ideally include advice also on financing and subsidies/tax breaks that are available (at local but also e.g. national level) to implement energy efficient solutions. This aspect of the follow-up can in fact represent a much larger budget than the thermography itself, even when the latter is carried out aerially.

The dissemination of thermographic data will also be much more effective if it is part of a broader, communication effort on the challenges of climate change and energy efficiency (see best practice on Environmental education and information for citizens and businesses) and the municipality's coherent strategy to tackle these aspects (see best practice on Establishing and implementing a municipal energy and climate action plan).

Practical dissemination of the information can take many forms, e.g. workshop / information sessions; dedicated helpdesk in town hall offices or dedicated venue, staffed by trained advisors; online tool, presenting the global data for the entire town but also allowing a personalised search by address (example opposite).

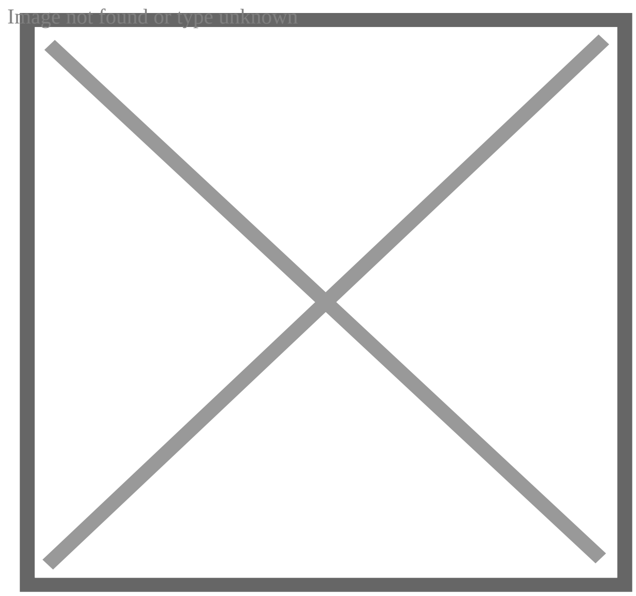

Figure 2: zooming on an individual address for survey results (Aberdeen city council, in (CSE, 2004)

Environmental benefits

This technique is an energy auditing / diagnosis tool which will not achieve environmental benefits in itself.

The benefits will be derived from action taken both at the local government and individual level to tackle the energy efficiency issues highlighted by the survey. For this reason it is important to consider thermographic surveys and the valuable data that it can provide as part of a broader strategy and policy approach to energy efficiency and energy conservation (see best practice on Establishing and implementing a strategy for climate change adaptation within the territory of the municipality).

Side effects

The potential cross-media effects for this technique are low. As for any awareness campaign the message has to be formulated carefully to avoid any backfiring in citizens' behaviours (e.g., residents of a building or neighbourhood which has been displayed as good-performing on the global map could relax their energy conservation efforts).

Applicability

This best practice is applicable to local authorities. The thermographic survey needs to be performed under specific conditions in terms of climate (i.e. temperature, wind), period of the year (i.e. winter) and time of the day (i.e. early morning).

Economics

Costs

Preparatory studies will outline the needs and appropriate scale for a thermographic survey, which will in turn determine the scale of costs to be considered. Land-based surveys involve the utilisation of specialised equipment and trained specialists for a few hours to a few days, plus the additional costs of specialist data processing.

Aerial surveys (with manned aircraft) will be a larger-scale and more expensive option. Dourdan (FR, pop. 10'000) spent 14.5k€ + tax on a cartography project including some technical support to dissemination). Birmingham city council (CSE, 2004) had an aerial survey covering approximately 400,000 residential properties carried out in 2002 for 37 k£ (52 k€ then). Other documented costs from France (including also some follow-up such as data interpretation and analysis as well as dissemination, (DA, 2008;, ADEME, 2015) appear in the 100-300k€ range and rapidly diminishing with the size of the surveyed territory. For instance, data indicates 100k€ for a town of 30'000 (Aix-les-Bains); 170k€ for a town of 53'000 (Annecy); 200k€ for a town of 210'000 (Dunkerque) and 262k€ for an urban area of over 700'000 (communauté urbaine de Bordeaux).

The follow-up communication costs from the local authorities can vary widely. According to J-C Barré of TCC, cartography itself represents 30-40% of a thermographic survey budget.

N.B. Interreg financing may also be available to support thermographic surveys.

Benefits

Thermographic data collection works by measuring observable temperature differences (and heat radiation) between the built environment and the background. Therefore, the data can be processed to calculate an estimation of the loss which could be avoided if buildings were insulated well enough to radiate little or no energy. The simplified example below (data collected for the city of Aix-lesBains, France) performs an estimate multiplying each surface by its measured radiative emission level:

Table 1: Estimation of the energy loss which could be avoided from buildings (city of Aix-lesBains, France)

Loss range	Ref value (W/m^2)	Surface (m2)	Loss (Wh)	Heating day (Wh)	Heating season (kWh)
Not noticeable	2	242 191	484 382	2 906 292	435 944
Low	5	523 121	2 615 605	15 693 630	2 354 045
Medium	11	369 452	4 063 972	24 383 832	3 657 575
Large	15	110 777	1 661 655	9 969 930	1 495 490
Very large	20	72 655	1 453 100	8 718 600	1 307 790
Excessive	22	41 156	905 432	5 432 592	814 889
Total		1 359 352	11 184 146	67 104 876	10 065 731

Then, by plugging in data on energy costs, an estimate of savings can be obtained (in the example below – continued from above – 6c/kWh for gas and 10c/kWh for electricity):

Table 2: Money savings which could be achieved thanksto better building insulation (city of Aix-lesBains, France)

	Heating season (kWh)	Estimate of losses (assuming gas heating)	Estimate of losses (assuming electrical heating)
Not noticeable	435944	26 157 €	43 594 €
Low	2354045	141 243 €	235 404 €
Medium	3657575	219 454 €	365 757 €
Large	1495490	89 729 €	149 549 €
Very large	1307790	78 467 €	130 779 €
Excessive	814889	48 893 €	81 489 €
Total	10065731	603 944 €	1 006 573 €

The study concludes a rough estimate in the order of 1m € of annual energy losses at roof level for the city. N.B. reducing this loss substantially would require massive upgrading of energy performance across building.

Driving forces for implementation

The technique is an enabler for energy efficiency in buildings, street lighting and district heating/cooling networks, and therefore follows the same driving forces.

The main drivers behind this technique are therefore:

- Direct savings in the operation of public buildings, lighting and heat networks

- Raising awareness across the residents and businesses of the local area

- Targeting and addressing fuel poverty

Reference organisations

- Dunkerque city council, France
- Bordeaux city council, France (makes available an online tool to look up results at individual house level: http://www.bordeaux-metropole.fr/plan-climat/thermographie-aerienne)
- Aix-les Bains, France

Literature

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