Instructions for a waste heat cadastre creation based on CE-HEAT cadastre development process

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EXECUTIVE SUMMARY

This paper describes the features and technical specifications agreed by CE-HEAT partnership for the development of regional waste heat cadastres.

The document can be used as an informative guide by institutions who are considering to develop a waste heat cadastre.

The waste heat cadastres provide geolocated information on waste heat available in a given regions and can contribute to match energy supply with demand. Such cadastres enable potential investors to study network solutions and investigate which waste heat sources can be recovered together in order to meet a higher or more constant demand.

The considerations for defining the cadastres' characteristics are the following: analysis of user experience (Chapter 1); Technical interoperability and interface specification (Chapter 2,3); and the calculation of data shown in the waste heat cadastres (Chapter 4).

1. USER EXPERIENCE

One of the key considerations in the waste heat cadastres' development is a satisfying user experience. This can be reached through:

> User friendly website

> Intuitive icons

> Data easy to find

> Complete data, equipped with appropriate measurement units

In order to provide comprehensive data on waste heat source and available potential, a minimum set of data requirements was agreed as follows:

1.1. Information on waste heat in the cadastre

The data provided in the cadastre will be divided in:

> Data concerning the company

> Data concerning waste heat

1.1.1. Data concerning the company

- **Company name;**

- **Sector / branch (NACE codes)** - NACE codes (Nomenclature of Economic Activities) provide a hierarchic four level structure for statistics purposes [e.g. Manufacture of other products of first processing of steel C24.3 and Casting of metals C24.5];

- **Company website;**

- **Total amount of waste heat**: total MWh/year available in this site, calculated as sum of the amount of the singles plant waste heat amount relative to this site.

1.1.2. Data concerning waste heat

- **Company name;**

- **Medium of waste heat** - Air, Liquid, Solid [e.g. Air/Fumes];

- **Temperature [°C];** [e.g. 1000 – 1200°C];

- **Heat power [kW];** in the Countries where this information is not provided by the companies, the following formula will be used:

$$heat\ power = \dot{m}\rho \sum x_i h_i(t) = \dot{m}\ \rho \sum x_i c_{pi}(T - T_0) \cong \dot{m}\ \rho\ c_p(T - T_0)$$

Where:
reference temperature $T_0 = T_a = 25°$ C,

specific heat capacity $c_{p\ air} = 0{,}281$ Wh/kg K, $c_{water} = 1{,}163$ Wh/kg K,

flow $\dot{m}$ provided in m^3/h

ⓘ The power of waste heat is estimated through temperature and flow.

□ **Potential energy [kWh/year];** in the Countries where this information is not provided by the companies, it will be calculated as:

$$Potential\ energy = \dot{m}\ \rho\ c_p(T - T_0) \cdot h\ \text{for gaseous medium}$$

$$Potential\ energy = \dot{m}\ \ \rho\ c\ \ (T - T_0) \cdot h\ \text{for liquid or solid medium}$$

Or, if the heat power is provided, as:

$$Energy = heat\ power \cdot h$$

ⓘ The potential energy is the maximum energy available, estimated through heat power and release profile.

□ **Release profile [h/year];** - 24h/Day, 8h/Day, other

□ **Reference date:** date to which the data collected refer.

Required data can be obtained directly from the enterprises or calculated through for example existing emissions data via included formulae.

2. INTEROPERABILITY TECHNICAL SPECIFICATIONS

An important feature for the cadastres is the possibility to share data and to guarantee the interoperability of waste-heat cadastres within CE-HEAT project and other energy cadastres.

In order to reach this goal, the cadastres developed within CE-HEAT project can provide an export consisting of:

1. A table named **PLANTS** in **csv**, **excel** or **json** format. The fields for each record should be:

Description	Field name	Field type	Unique
Primary key	id	Integer	Yes
Company name	name	String (max 256 ch)	No
Ateco/Nace	sector	String (max 256 ch)	No
Website link	website	String (max 256 ch)	No
Geographic localization (coordinates)	x	Double precision ***	No
Geographic localization (coordinates)	y	Double precision ***	No
Geographic localization	latitude	Double precision ***	No
Geographic localization	longitude	Double precision ***	No

2. A table named **WASTE_HEAT** in **csv**, **excel** or **json** format. The fields for each record should be:

Description	Field name	Field type	Unique
Foreign key	plant_id	Integer	Yes
Primary key	id	Integer	Yes
Waste heat source type	type	Multiple choice [string]*	No
Source process	process	String (max 256 ch)	No
Measurement unit	measurement_unit	Multiple choice [string]**	No
Waste heat quantity per year	quantity_year	Double precision	No
Waste heat temperature	temp_celsius	Double precision	No
Hours per year	h_year	Double precision	No
Baseline year	year	Integer	No
Geographic localization (coordinates)	x	Double precision ***	No
Geographic localization (coordinates)	y	Double precision ***	No
Geographic localization	latitude	Double precision ***	No
Geographic localization	longitude	Double precision ***	No
* Multiple choice from the following list of strings:	Fumes Water Solid (e.g. scoriae from steel making plants) Other		
** Multiple choice from the following list of strings:	mc/h kWh MWh kW MW		
*** The coordinate reference system must be ETRS89/UTM in compliance with INSPIRE Directive 2007/2/EC (use xy coordinates OR latitude and longitude)			

In addition, cadastres should be equipped with WMS and WFS services. These services allow to share data also with other cadastres and not only within the partnership.

WMS (Web Map Service) → enable the service on your Geoserver or other geographical service in use. This feature is useful to transfer raster data and visualize them on a map. The computational load is on the server side. End users will experience faster services without interactivity and without sharing data, only a raster map with coloured points.

WFS (Web Feature Service) → enable the service on your Geoserver or other geographical server in use. This feature is useful to transfer vectorial data and visualize them on a map. The computational load is on the client side. End users will experience more interactivity and could share data.

3. USER INTERFACE TECHNICAL SPECIFICATIONS

This chapter provides an overview of features adopted to guarantee a common user experience when consulting waste-heat web-cadastres. The following figures represent a facsimile of the waste heat cadastre of Friuli Venezia-Giulia region, Italy.

Waste-heat web cadastres should provide the following features:

> different icons depending on map scale;

> at bigger scale, simple points represent plants with potential waste heat (figure 1);
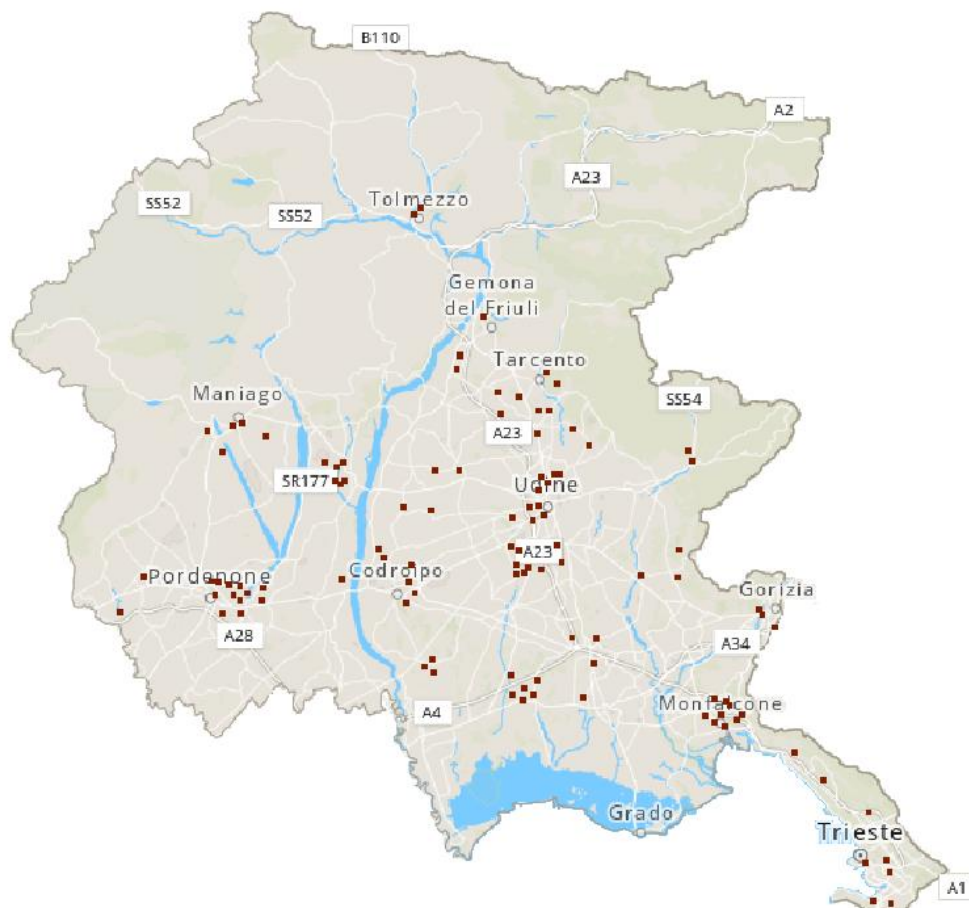
Figure 1 points representing potential waste heat sources.

In this figure it's possible to see an example of the first view when you enter the cadastre (Friuli Venezia Giulia Region) displaying geo-referenced plants

- basic information (mainly records from table "PLANTS") will be displayed by a pop-up window when clicking on the over-mentioned points (figure 2);
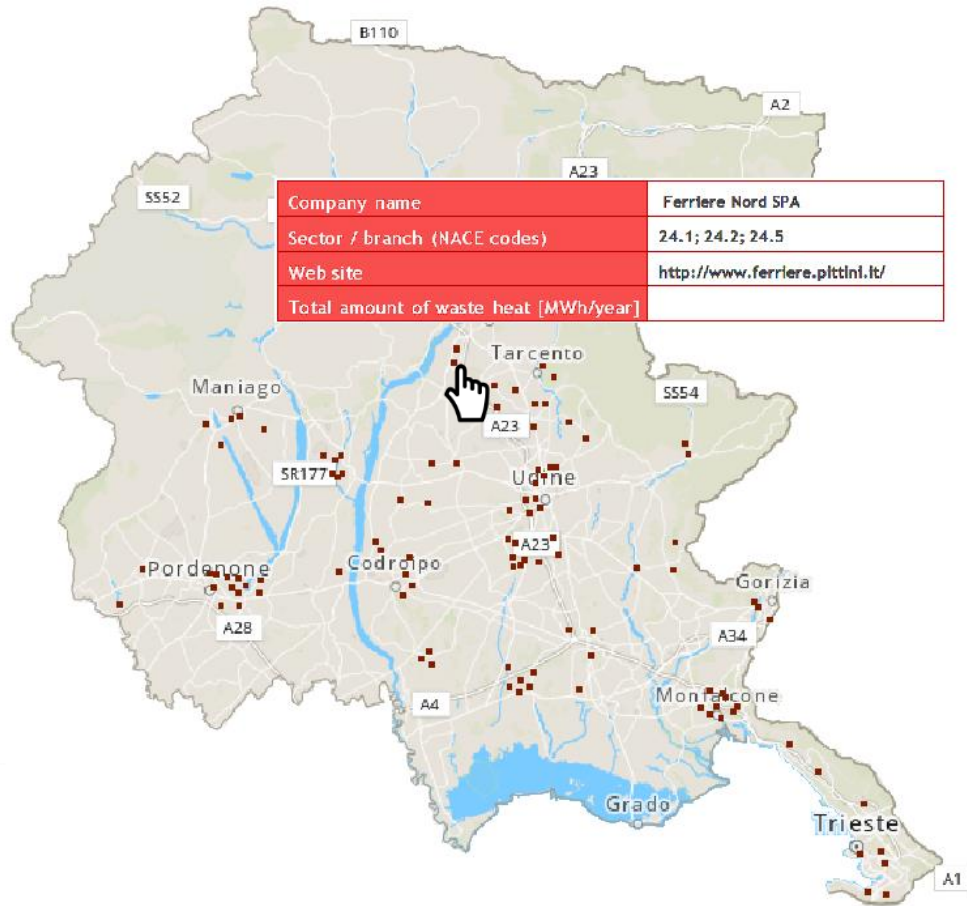
Figure 2 pop-up window with basic information on the waste heat source.

In this figure it's possible to see the pop-up window displayed when you click on one of the points representing potential waste heat sources.

- at lower scale, rounded icons coloured in red, orange and yellow representing different waste-heat temperature (figure 3);
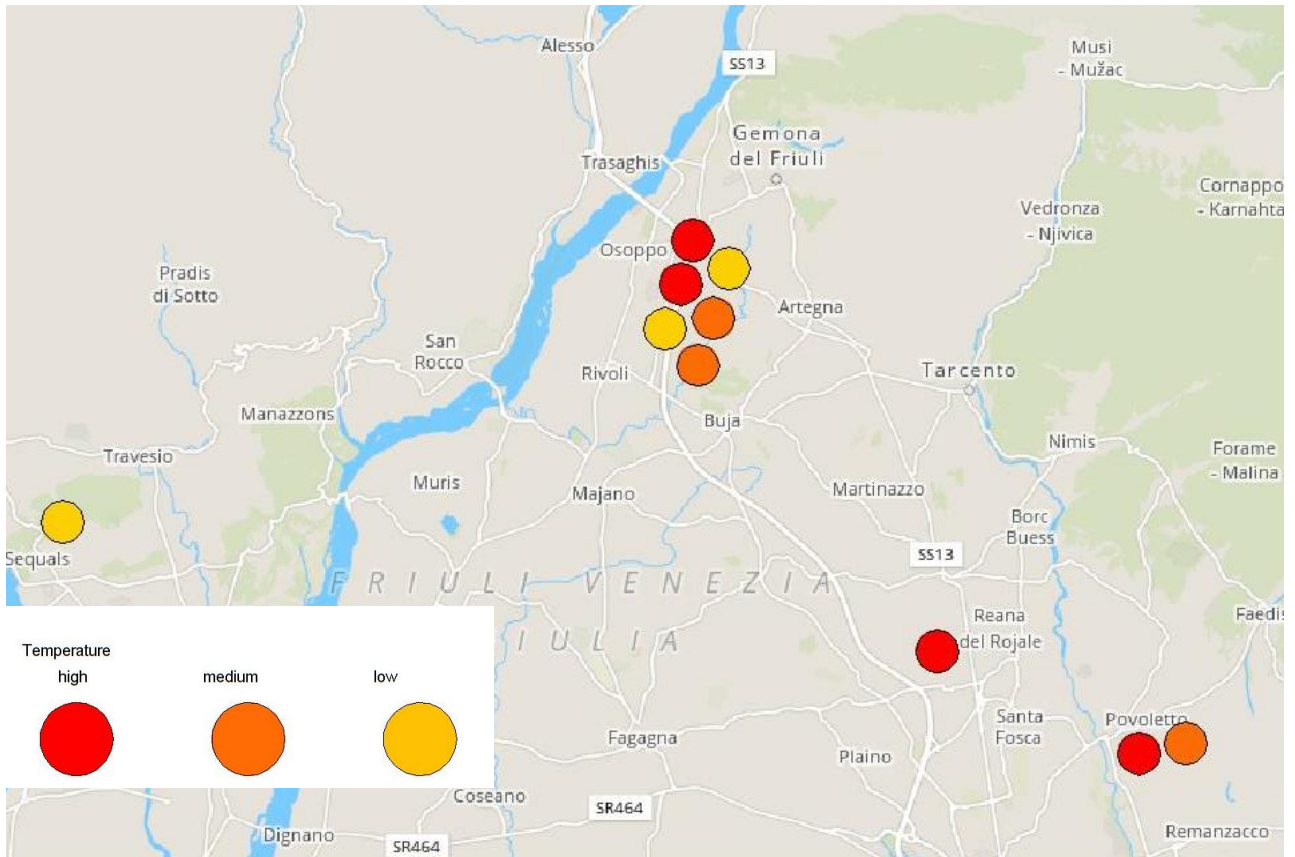
Figure 3 icons displaying symbols related to waste-heat temperature at lower scale.

In this figure, at adequate scale, it's possible to distinguish waste heat sources of different temperature belonging to the same plant

- advanced information (mainly records from table "WASTE_HEAT") will be displayed by a pop-up window when clicking on the waste-heat icons of different temperatures (figure 4);

Company name		Ferriere Nord SPA
Medium of Waste Heat		Fumes
Temperature	[°C]	315°C
Heat power	[kW]	4250
Potential energy	[MWh/year]	24470
Release profile	[h/year]	5760
Reference data	[year]	2015
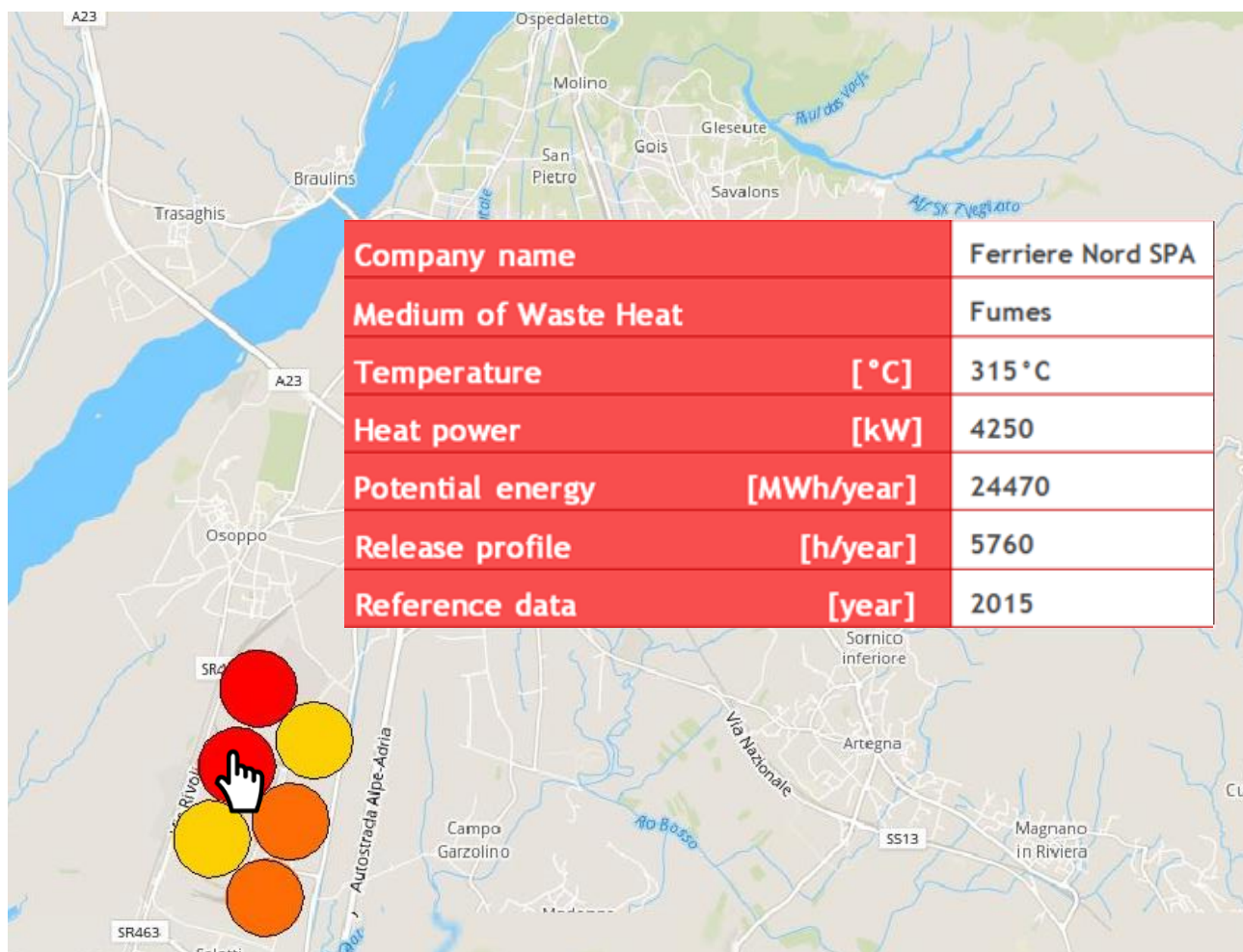
Figure 4 pop-up window with advanced information on the waste heat source.

In this figure it's possible to see the pop-up window displayed when you click on one of the icons representing waste heat sources of different temperatures.

- OPTIONAL, but SUGGESTED when feasible: at lower scale, icons can provide further information, beyond the mere temperature: the vector (fumes, water, solid or other) and the energy yearly available (small symbols, medium symbols or big symbols) of waste heat. See figure 5, below.
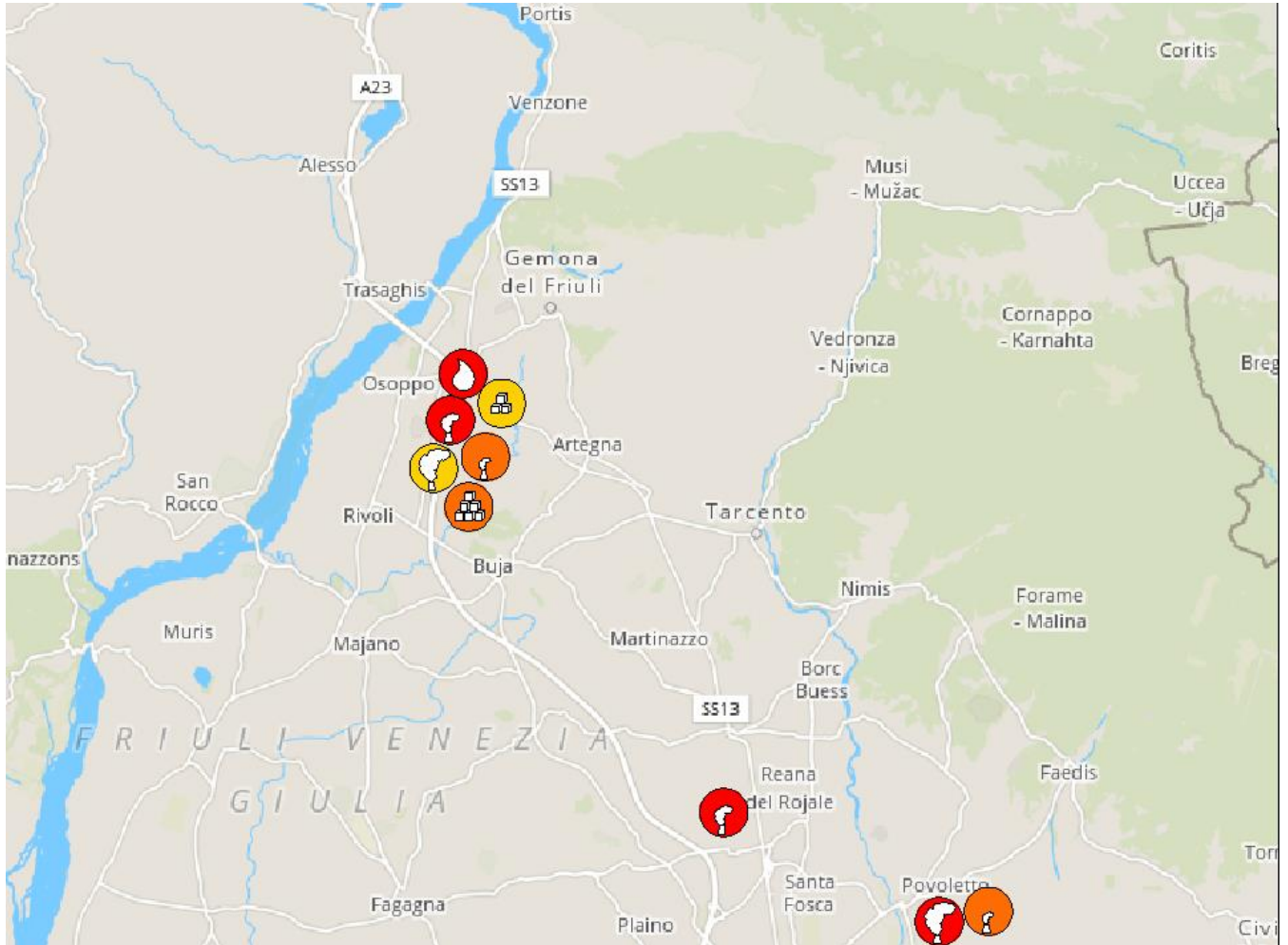
Figure 5 icons displaying symbols related to waste-heat temperature, vector and quantity at lower scale.

Here the icons provide more information concentrated in each symbol, namely temperature, vector and quantity of waste heat.
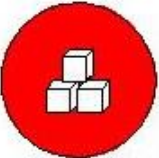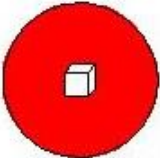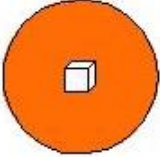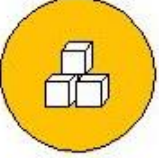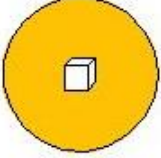
The web application running behind each web-cadastre can define automatically which icon shall be displayed at each different scale, by using a simple algorithm based on the following matrix and symbols:

Temperature

high	medium	low
$T[°C] \geq 300°C$	$100°C \leq T[°C] < 300°C$	$T[°C] < 100°C$
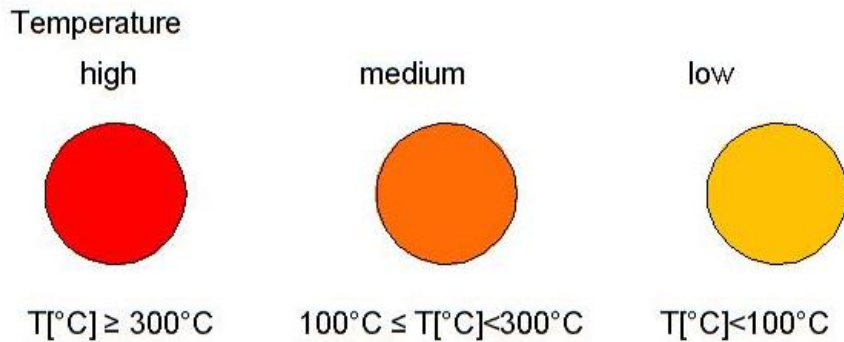
In the following tables the icons representing further information are explained.

Fumes	High quantity $E \leq 2\,GWh$	Medium quantity $2\,GWh < E \leq 20\,GWh$	Low quantity $20\,GWh < E$
High temperature $T[°C] \geq 300°C$			
Medium temperature $100°C \leq T[°C] < 300°C$			
Low temperature $T[°C] < 100°C$			

Water	High quantity $E \leq 2$ GWh	Medium quantity 2 GWh $< E \leq 20$ GWh	Low quantity 20 GWh $< E$
High temperature $T[°C] \geq 300°C$			
Medium temperature $100°C \leq T[°C] < 300°C$			
Low temperature $T[°C] < 100°C$	🔸	🔸	🔸

Water is never available at these temperatures

Solid	High quantity $E \leq 2$ GWh	Medium quantity 2 GWh $< E \leq 20$ GWh	Low quantity 20 GWh $< E$
High temperature $T[°C] \geq 300°C$	🟥	🟥	🟥
Medium temperature $100°C \leq T[°C] < 300°C$	🟧	🟧	🟧
Low temperature $T[°C] < 100°C$	🟨	🟨	🟨

Other	High quantity $E \leq 2$ GWh	Medium quantity 2 GWh $< E \leq 20$ GWh	Low quantity 20 GWh $< E$
High temperature $T[°C] \geq 300°C$			
Medium temperature $100°C \leq T[°C] < 300°C$			
Low temperature $T[°C] < 100°C$			

4. DATA CALCULATION

In order to fill in the tables with the waste heat characteristics, some data should be calculated.

The temperature and the vector will be always input data, the available annual energy should be calculated via the following matrix:

Quantity measurement unit [input data]	Vector [input data]	Formula to calculate E [GWh]
MWh	whichever	$E = Q \times 10^{-3}$
kWh	whichever	$E = Q \times 10^{-6}$
MW	whichever	$E = Q \times 10^{-3} \times h$
kW	whichever	$E = Q \times 10^{-6} \times h$
mc/h	fumes	$E = 0{,}166 / (T + 273) \times Q \times (T - 25) \times h \times 10^{-6}$
mc/h	water	$E = 1{,}163 \times Q \times (T - 25) \times h \times 10^{-6}$

Where:

Q is the quantity,

T is the temperature in [°C],

h is the release profile (number of hours per year).

The data shown in the tables (pop-up) are mainly input data, the only exceptions are:

Field to be calculate	In which table – pop-up	formula
Potential energy [MWh/year]	WASTE_HEAT	$E \times 10^3$
Heat power [kW]	WASTE_HEAT	$E \times 10^3 / h$
Total amount of waste heat [MWh/year]	PLANTS	$\sum_{i=1}^{n} E_i$ Where n is the number of waste heat sources related to the plant

5. CONCLUSIONS

This paper can be regarded as a handbook for stakeholders interested in the development of a waste heat cadastre, or more in general, of an energy cadastre.

The goals taken into consideration are the following:

- to match demand with supply to foster networking among end users,

- to provide preliminary information to investors,

- to raise awareness among politicians about waste heat potential and mainstream it in local planning

- to raise awareness among the general public about the opportunities linked to waste heat.

Waste heat cadastres should be integrated, when possible, into existing energy cadastres.

This will enable to:

> reach those stakeholders that are already interested in energy saving and environmental issues

> set up a cadastre with complete energy datasets

Regional cadastres developed as part of CE HEAT project are available at the following links:

EZVOD+DEM		APE FVG	EHIP
http://borzen.maps.arcgis.com/apps/webappviewer/index.html?id=9a8d05acccff4a908f66de6958c9a3bc		atlanteenergetico.it	https://aot.eihp.hr
TB	**ThEGA**	**NCEU + UJEP**	**POLTEGOR**
https://gis.bgld.gv.at/WebGIS/synserver	www.thega.de/abwaerme	http://www.portalodpadnihotepla.cz/	www.geoportal.dolnyslask.pl

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