Mapping and discussing industrial waste heat (IWH) potentials for different countries

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Abstract

In accordance to the current worldwide trend of reducing CO_2 emissions and to make the industry more competitive incrementing its efficiency, some countries are starting to quantify their quantity of Industrial Waste Heat. In fact, to be able to recover and reuse this waste heat from industrial processes as a source for other processes or activities, the availability of reliable data of the Industrial Waste Heat potential found in a region is a key point. For that, after an exhaustive literature research, this article shows industrial waste heat data from 33 countries and 6 subregions of different countries. Their feasibility is assessed in the discussion part as it is expected and shown in most of the cases that the amount of industrial waste heat is proportional to some parameters regarding the country and its industry like: the Energy Consumed by the Country, the Energy Consumed by the Industry and the amount of Industrial Waste Heat Intensive Industry in the country. Country scale has been chosen and it is shown that at other scales these parameters are not always available. Nevertheless, some of the studied cases found show data not fitting into this pattern (approximately 1/6 of the data found). That can be explained taking into account that in most of the studies the methodology to account the quantity of industrial waste heat is not explained. Factors like the reference year of the data, the boundaries of the analysis, the type of waste heat considered, etc. affect to the report of quantity of industrial waste heat. Therefore, the authors provide a set of parameters and recommend checking these in order to confirm the reliability of data referring to Industrial Waste Heat quantities.

1. Introduction

In 2011, the International Energy Agency accounted for 31,342 million tons of CO_2 emissions [1]. In the current trend of reducing the CO_2 emissions, Industrial Waste Heat (IWH) is a potential energy source. Moreover, industrial sector is one of the top-three energy consuming sectors worldwide [2,3]. Therefore, the amount of IWH is expected to be important. This heat can be recovered and reused in other processes onsite (to preheat incoming water or combustion air, preheating furnace loads, etc.), or transformed into electricity, cold or other type of heat. If this waste heat is not captured and used, it is released to the atmosphere, for that, it is considered to be without extra CO_2 emissions. In fact, the Intergovernmental Panel on Climate Change (IPCC) finds IWH recovery as one of the tools for CO_2 mitigation.

However, it is not always easy to identify and to use IWH. A previous study in this field has categorized and reviewed different methods to account waste heat potential of a region [4]. However, the methods are manifold and so are the results and the considered constrains: e.g. costs, economies-of-scale, temperature restrictions, chemical composition, application-specific constraints, and inaccessibility or transportability [5]. Which one of these parameters taken into account has a large influence on the resulting IWH potential? Moreover, once the availability and the characteristics of the IWH source are known, there are various feasible technologies to use it. Depending on the application these can be active technologies which transform waste heat to heat, to cold or to power, or passive technologies like heat exchangers or thermal energy storage. In Brueckner et al. [6] heat transformation technologies are presented as well as an economic analysis of them.

Finally, how much IWH is available worldwide? Nowadays there are IWH potential analysis in the literature, where the applied method, the type of IWH potential (defined in [4]), and whether the IWH is released to the ambient as gas or liquid is unknown making complicated to rely on the presented numbers. For that, this paper focuses on a review of different results for different regions, presenting a method to judge the plausibility of the IWH quantities.

As an example of the data that can be found in the literature, four cases comparing a region with one or more of their subregions are presented. Case 1 compares Germany with the federal states of Nord Rhine Westphalia and Baden-Württemberg. Case 2 compares France with the region Nord-Pas-De-Calais and the department of the Dordogne. Case 3 compares Canada with the province of Québec and Case 4 compares Spain with the autonomous community of the Basque Country. For each of the cases, the industrial energy consumption, the estimated IWH and their correlation are shown.

1.1 CASE 1: GERMANY AND THE SUBREGIONS OF BADEN- WÜRTTEMBERG AND NORTH RHINE WESTPHALIA

In Table 1 the Energy Consumed by the Industry and the IWH potential of Germany, Baden-Württemberg and North Rhine Westphalia (NRW) is listed.

In 2002 in North Rhine Westphalia, the IWH potential was estimated using a waste heat to input energy ratio for different industrial sectors. These figures were developed based on data from the city of Duisburg and then transferred to the state. In the evaluation of the waste heat two different temperature levels for its usage were considered: ~50 PJ/y at 70 °C and ~25 PJ/y at 120 °C. NRW is one of the 16 federal states of Germany, with a population of 17.55 million people in 2012 [7]. As it can be seen from the amount of industrial energy consumption, it is one of the major industrial areas in Germany. Since its industry demands almost 1/3 of Germany's industrial energy demand [8], 51 PJ of IWH appear to be rather low in comparison to the estimations for Germany. The calculated waste heat potential per industrial waste heat falls into that line as well with a low share of 7 %.

For Baden-Württemberg an economic feasible potential was estimated in 2011 [14]. The estimation of the waste heat potential was based on case studies of realized and thus economic feasible projects for each sector. It showed a waste heat potential for Baden-Württemberg of approximately 29 PJ/y (4.6 PJ/y <100 °C, 0.8 PJ/y at 100-500 °C, 24 PJ/y >500 °C). In total this equals 29 PJ/y. Baden-Württemberg (with 10.57 million inhabitants in 2012 [7]) is also one of the German federal states with a very prominent automotive and mechanical engineering industry. The estimated value being an economic feasible potential, a share of 14 % is high. The studies for Germany and NRW considered a theoretic to technical potential and should therefore have both higher ratios.

Table 1 Energy Consumed by the Industry and Industrial Waste Heat for Germany, Baden-Württemberg and North Rhine Westphalia.

	Germany	Baden-Württemberg	North Rhine Westphalia
Energy Consumed by the Industry (PJ)	2533 (2010 [9])	293 (2011 [10])	809 (2002 [11])
Industrial Waste Heat potential (PJ)	476 (2010 [12]) – 525 (2010-2012 [13])	29 (2011 [14])	51 (2002 [15])
Share	19 - 20 %	14 %	7 %

1.2 CASE 2: FRANCE AND THE SUBREGIONS OF DORDOGNE AND NORD-PAS-DE-CALAIS

France accounted for 65.7 million people in 2012 [16] and a total energy consumption of 6649 PJ [9]. The French industry yearly consumes 1522 PJ (2009) [9]. Three different studies accounting for the IWH potential of France are found ranging from 302 to 396 PJ per year [13,17,18].

Dordogne is one of the 96 departments of France and it is located in the region of Aquitaine. The population in this department is 414,149 inhabitants [19]. In this department, industry accounts the 25 % of the total energy consumption (11 PJ [19]). The main industries are chemical, agriculture, and iron and steel industry [19]. An analysis of 20 industries of this region was performed in 2012 by [20] and 0.87 PJ were identified as yearly IWH.

On the other hand, Nord-Pas de Calais is one of the 27 regions into which France is divided, and it has 4.02 million people [16]. The industrial sector in this region consumes yearly 126 PJ [21]. ADEME [21] estimated the IWH potential for this region using ratios derived from a first collection of questionnaires and then applying these ration to the whole industry sector. A yearly potential of 126 PJ was found.

IWH potentials are expected to be proportional to the Energy Consumed by the Industry, for that, the relation of both parameters are also shown in Table 2. 20 to 26 % of the French industrial energy demand is wasted while for Nord-Pas de Calais it represents a quite high 46 % and for Dordogne 9 %. In the case of Nord-Pas de Calais, the IWH is also a third of the total IWH amount of France, while the Energy Consumed by the Industry only equals round about 20 % of the French one. Therefore, the authors would not entirely trust the given value.

Table 2 Energy Consumed by the Industry and Industrial Waste Heat for France, Nord-Pas de Calais and Dordogne.

	France	Nord-Pas de Calais	Dordogne
Energy Consumed by the Industry (PJ)	1522 (2009) [9]	277 (2009) [21]	11 (2009) [19]
Industrial Waste Heat potential (PJ)	302 (2010-2012) [13] – 360 (2009) [18] – 396 (n.a.) [17]	126 (2012) [21]	1 (2012) [20]
Share	20 - 26 %	46 %	9 %

1.3 CASE 3: CANADA AND THE SUBREGION OF QUÉBEC

Canada consumes 8720 PJ per year (2012) and has a population of 34.9 million people [22]. The industrial sector of Canada consumes yearly 3238 PJ (2008) [23]. According to [24,25], 2300 PJ per year are wasted as heat in Canada.

Québec is the largest province in Canada. It has a population of 7.90 million [26]. In 2009, 37.6 % of the total energy consumed in Québec is destined to the industry (533 PJ). 2/3 of this energy is used in the paper industry, the iron and steel industry, and the chemical industry [27]. In 2010, [28] apply the factors derived from the energy-intensive US industry in 1982 [29] to calculate the IWH potential and found 276 PJ.

According to the data found Table 3, more than 70 % of the energy consumed by the industry in Canada is accounted as wasted. In the case of Québec, this relation represents almost 50 %. So both country and subregion show a very large share of waste heat in relation to the industrial energy demand and are plausible in comparison to one another.

Table 3 Energy Consumed by the Industry and Industrial Waste Heat for Canada and Quebec.

	Canada	Quebec
Energy Consumed by the Industry (PJ)	3238 (2008)[23]	533 (2009) [27]
Industrial Waste Heat potential (PJ)	2300 (n.a.) [24,25]	276 (2008) [28]
Share	71 %	52 %

1.4 CASE 4: SPAIN AND THE SUBREGION OF BASQUE COUNTRY

Spain has a total population of 46.2 million people in 2012 [30] and its industrial sector consumes yearly 3793 PJ [9]. From this energy, 226 PJ are wasted as heat [13].

The Basque Country is an autonomous community of Spain. It had a total population of 2.18 million people in 2011 [31]. It is one of the most industrialized autonomous communities of Spain together with Catalonia and Madrid consuming 101 PJ per year [32]. Bonilla et al. [33] predicted the IWH potential in 10 sectors of the Basque Country according to the use of different heat recovery technologies, with a result of 51 PJ.

In Table 4 it can be seen that, the Basque Country industry consumes 10 % of the Spanish industrial energy demand but accounts for 23 % of the IWH potential. According to the collected data, 50 % of the energy consumed by the industry in the Basque Country is wasted while regarding to Spain it is only the 23 %.

Table 4 Energy Consumed by the Industry and Industrial Waste Heat for Spain and Basque Country.

	Spain	Basque Country
Energy Consumed by the Industry (PJ)	980 (2010) [9]	101 (1997) [32]
Industrial Waste Heat potential (PJ)	226 (2010-2012) [13]	51 (<2007) [33]
Share	23 %	50.5 %

In general, for the four cases considered, a lower IWH potential is expected for the subregions compared to the countries, and this value is expected to depend on different factors: the Energy Consumed by the Country, the Energy Consumed by the Industry and the composition of the industrial sector. In many cases, it is impossible to find this data on a regional level. Therefore, this paper focuses on country data or in groups of countries (US and EU) where the data needed is available. Thus, this study aims to compare IWH potential data from different countries worldwide using the methodology, proposed by the authors, taking into account the above mentioned parameters in order to assess its feasibility.

2. INDUSTRIAL WASTE HEAT MAPPING

Figure 1 shows the yearly IWH potential for the 33 countries considered in this analysis (including US and EU as countries). In some cases, more than one value is found per country and either both values found or a range of waste heat potential found are shown. Europe is plotted in two different ways: as a general average value in the worldwide map and divided into its 27 member states in ascending order in the bar diagram (except for Malta, from which there is no data available). It can be seen a clear lack of information in Asia, South America, Africa and in Oceania.

Two studies were found regarding IWH potential in the US. [38] accounted for 1501 PJ per year including in the study 8 industrial sectors (chemicals, petroleum refining, forest products, iron and steel, food and beverage, cement, aluminium and foundries) which represent 80 % of the US industrial energy use. They estimate IWH potential by using waste heat recovery efficiencies of the industrial equipment from the literature. [39] analysed some of the most energy-intensive processes which consume about 40 % of the annual energy delivered to the industry, and they accounted for 1583 PJ.

Three studies were also found regarding the UK. [40] cited a bottom-up study made by Connective Energy in 2007 which account for 144 PJ/y. However, the original source has been not found so the authors have decided not to plot this value. In 2012, McKenna et al. [34] estimates the technical recovery potential in the UK in the range 36-71 PJ including in the boundaries of the study 60 % of the UK industry which represented 90 % of the energy-intensive industry. They based the study on site-specific data contained in the EU Emissions Trading Scheme National Allocation Plant (EUETS NAP) in the period 2000-2003. Two years later, Hammond et al. [35] analyse 425 manufacturing industry sites from the UK in the period 2000-2004 based on emissions, output data, the efficiencies of the heat recovery technologies (heat exchangers, heat pumps, absorption chillers, heat-to-power technology and transport for off-site uses), and the work done previously by McKeena et al. [34], to finally account for an IWH potential of 37-73 PJ.

In France, Berthou et al. [18] estimates a yearly IWH potential of 360 PJ in the French industry for a temperature range between 40 and 250 ºC based investigations and surveys done by CEREN (Centre d'Etudes et de Recherches Economiques sur l'Energie).

In the case of Norway [41], four waste incineration plans and 72 companies (food, wood processing, paper production, chemical, cement and construction, aluminium and iron industry sector) which represent 69 % of the final energy consumption of the industrial sector were analysed accounting for 70 PJ/y.

Chung et al. [37] collect data from 2/3 of the Korean factories from national statistics which consume 68 % of the total industrial energy consumption and estimate yearly 384 PJ.

In Sweden, [42] estimated the potential use of waste heat in district heating systems, 994 companies were considered. A total IWH potential of 34.2 PJ/y was found. Later in 2009 the industrial waste heat potential was estimated at 22.3 - 28.4 PJ/y by [43]. Both studies were published by the Swedish district heating association. The lower value in the later study is explained by a new definition of the industrial sectors considered. A more recent study in Sweden [44] in based on a questionnaire carried out in the industrial sector in two representative counties in Sweden. The results obtained in these counties were later extrapolated to country level. For flue gas between 160-350 °C a technical potential of 7.2 PJ/y was evaluated, as a general waste heat potential 76 PJ/y.

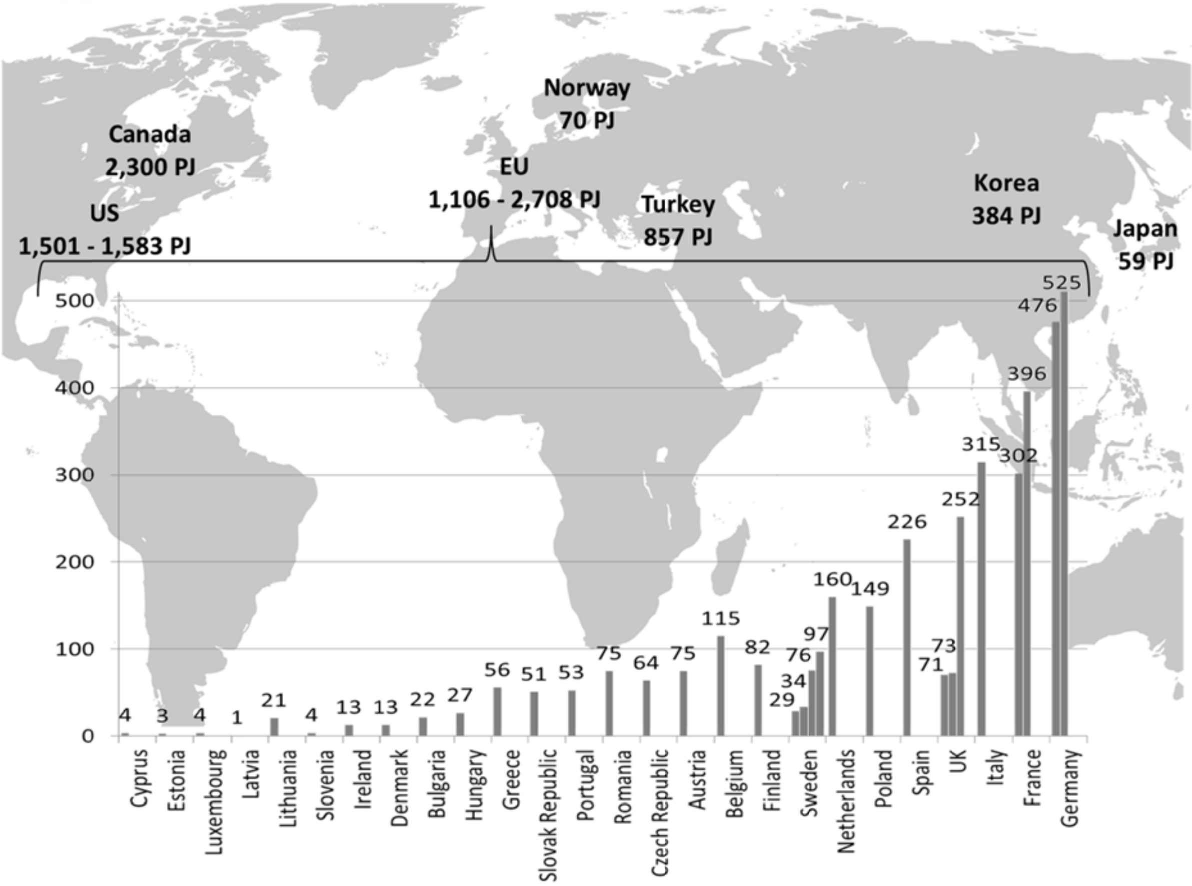

Figure 1 Yearly Industrial Waste Heat potential worldwide, in PJ. In some cases, more than one potential is found and shown.

In Germany in 2010, Pehnt et al. [12] extracted the energy factors from studies in Norway, Vienna and the US and used them to estimate the industrial waste heat in Germany. For Norway, the reference temperature for the factors were based on was 0 °C. Based on these factors, a waste heat potential for Germany of 316.8 PJ/y above 140 °C was found and 158.4 PJ/y in the 60-140 °C range. This equals a total waste heat potential of 476 PJ/y.

Regarding the EU, two estimations were found. In 2006, [45] published an IWH estimation which consisted in applying Swedish heat recovery factor [42] to account for the IWH potential of 32 countries (EU27, Croatia, Turkey, Iceland, Norway and Switzerland) resulting 1106 PJ/y. In 2013, [13] analysed the IWH potential for all the countries composing the EU27. The values published can be seen in the diagram bar and as an addition as 2708 PJ/y.

In the case of Turkey, Utlu [46] estimated the technical IWH potential of the Turkish industry in 2011 (chemical and petrochemical, petrochemical feedstock, cement, fertiliser, iron and steel metals, non-iron metals, sugar and other industries) by using an exergy analysis.

Other reports have been found citing an IWH potential but without explaining the methodology nor the boundaries to account it, this is the case of Canada (2300 PJ [24,25]), Japan (59 PJ [47]), France (396 PJ [17]).

In the Annex, the authors list the data (with the exact reference and the year of the data) used to perform this analysis.

3. DISCUSSION

In order to compare and assess the reliability of the data found in the literature, the IWH potential is compared to the Energy Consumed by the Country, to the Energy Consumed by the Industry and to the percentage of IWH Intensive Industries in a country.

3.1. INDUSTRIAL WASTE HEAT VS ENERGY CONSUMED BY THE COUNTRY

Figure 2 shows the IWH potential (left axis) and the Energy Consumed by each Country (right axis) considered in the analysis. In the case of countries with more than one data for the IWH potential, more than one vertical bar is shown.

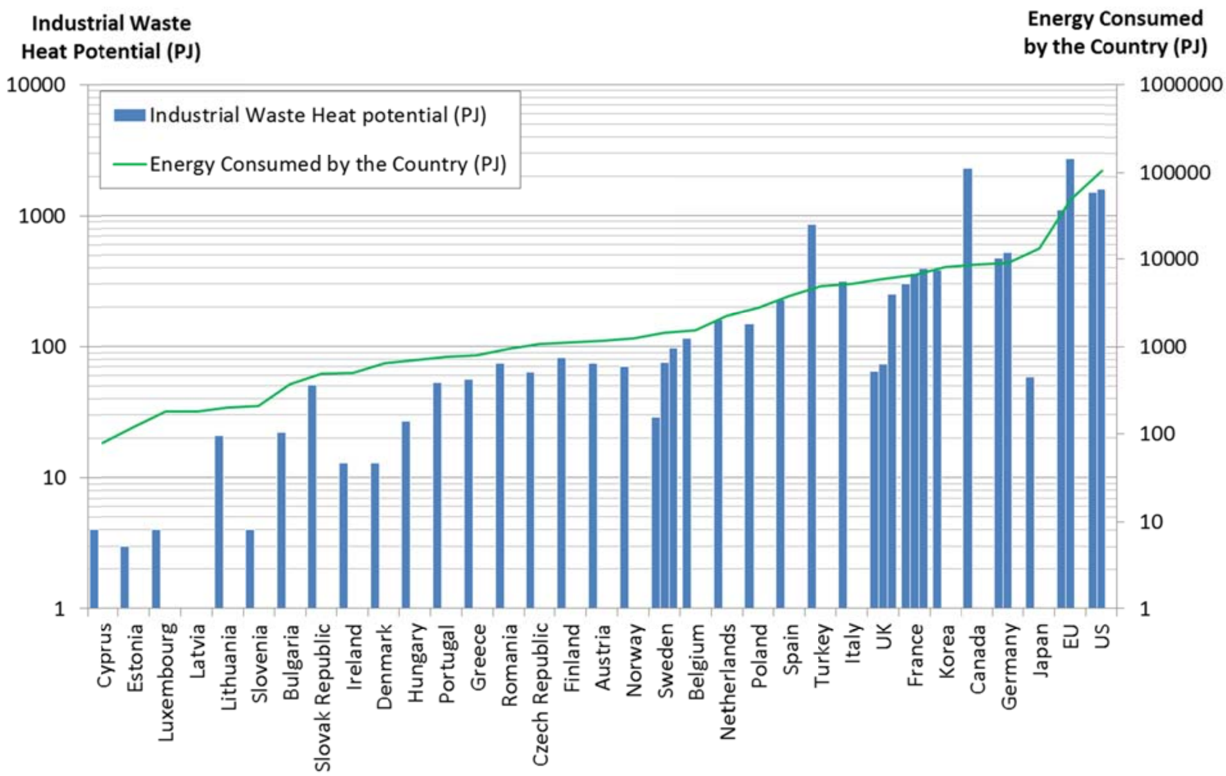

Figure 2 Industrial Waste Heat potential (in PJ) and energy consumed by the country (in PJ). In some cases, more than one potential is found and shown.

In Figure 2 the countries are ordered by increasing Energy Consumed by the Country. It is shown that, in general, the more energy consumed by the country, the more IWH potential can be found. However, 8 of the 42 values do not fit into this pattern. When comparing with the neighbor values and the trend of the Energy Consumed by the Country parameter, it can be seen that, in the case of Lithuania (21 PJ [13]), Slovak Republic (51 PJ [13]), Turkey (857 PJ [46]), Canada (2300 PJ [24,25]) and EU (2708 PJ [45]) IWH values are higher than expected. The opposite is observed with one of the values from Sweden (29 PJ [43]), two from UK (65 PJ [34]) and 73 PJ [35]) and Japan (59 PJ [47]), in these cases IWH values are lower than expected.

3.2. INDUSTRIAL WASTE HEAT VS ENERGY CONSUMED BY THE INDUSTRY

Figure 3 shows the relation of the IWH potential (left axis) and the Energy Consumed by the Industry (right axis). As in the previous figure, some countries have more than one IWH value. A kind of relation between these two variables is expected, the higher the industrial energy consumption, the more waste heat potential in the country can be expected.

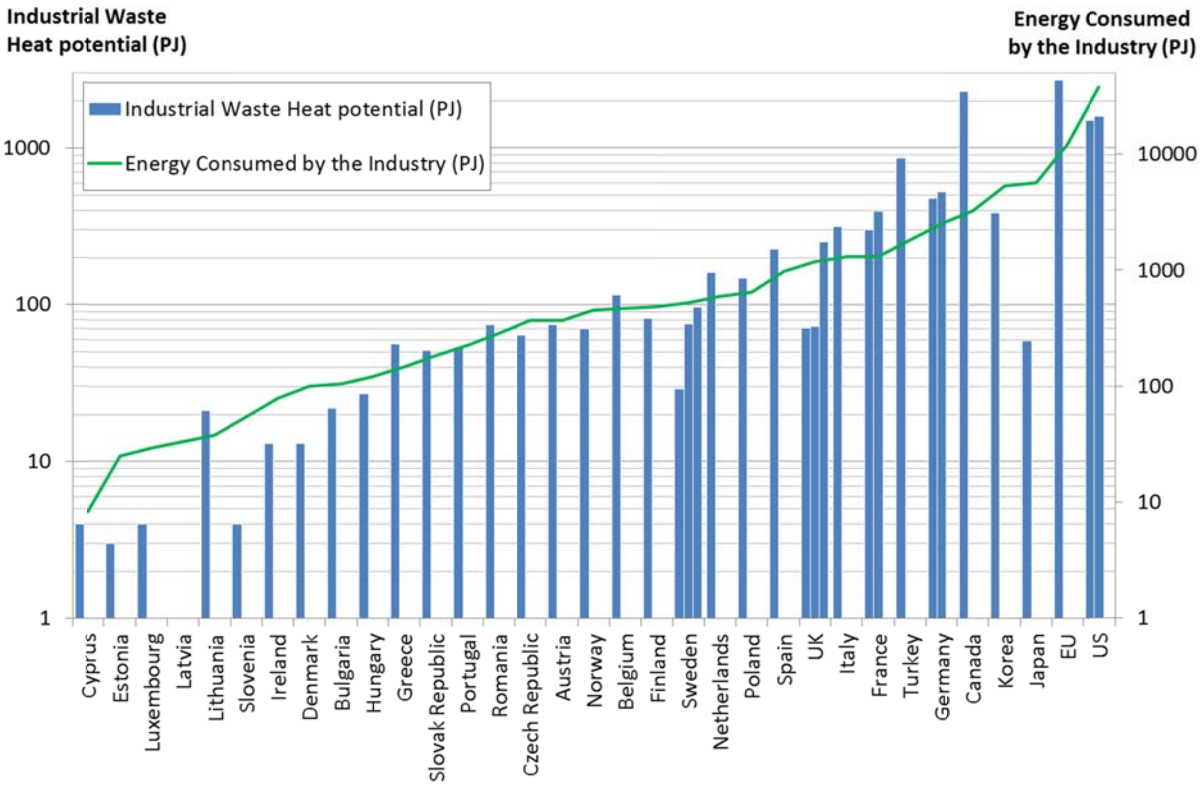

Figure 3 Industrial Waste Heat potential (in PJ) and industrial energy consumption (in PJ). In some cases, more than one potential is found and shown.

It is shown that, in general, the more Energy Consumed by the Industry, the more IWH potential is found. However, analysing the data in relation with its neighbour values, Cyprus (4 PJ [13]), Lithuania (21 PJ [13]), Canada (2300 [24,25]) and EU (2708 PJ [45]) have higher IWH potential than expected and, for Latvia (1 PJ [13]), Sweden (29 PJ [43]), two values from UK (65 PJ [34] and 73 PJ [35]), and Japan (59 PJ [47]), the values found are lower than expected.

3.3. INDUSTRIAL WASTE HEAT VS THE INDUSTRIAL WASTE HEAT INTENSIVE INDUSTRIES

As mentioned earlier, there are five different sectors that usually produce a lot of IWH (IWH Intensive Industries): metal industry, chemical industry, food and drinks, pulp and paper and non-metal minerals. A direct relationship between the IWH potential and the quantity of sectors with commonly high IWH generation is expected. For that, Figure 4 shows the countries ordered from lower to higher percentage of these sectors. The grey bars are composed by the rest of sectors which are not considered as IWH Intensive Industries (Mining and quarrying, food and tobacco, textile and leather, transport equipment, machinery, wood and wood products, construction and non-specified industry).

Most of the countries have a similar percentage of IWH Intensive Industries: the average share of IWH Intensive Industries on the Energy Consumed by the Industry is 73.6 %. Industry profile in Cyprus and in Luxemburg is composed only by IWH Intensive Industries: chemical and petrochemical in Cyprus and non-ferrous metals and non-metallic minerals in Luxemburg. Unlike these countries, in Norway less than 10 % of the industrial profile corresponds to IWH Intensive Industry.

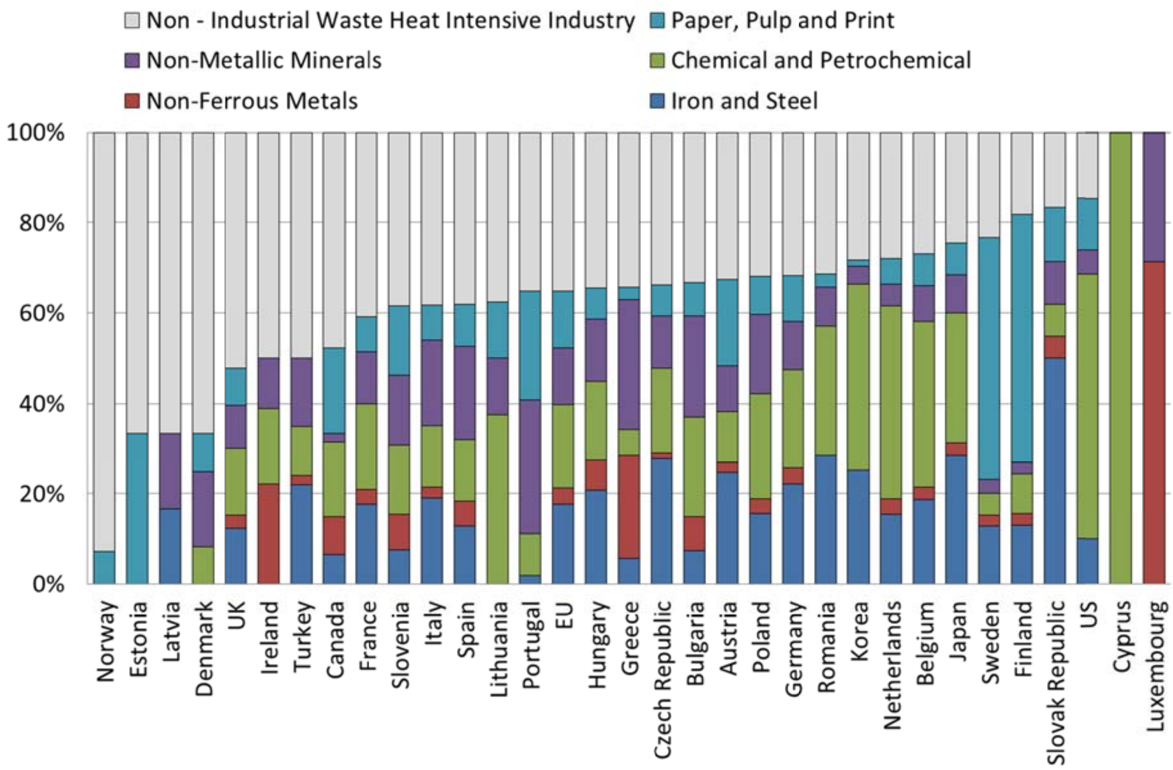

Figure 4 Percentage of Industrial Waste Heat Intensive Industries.

In Figure 5 the countries are sorted by their share of IWH Intensive Industries, compared to the IWH per Energy Consumed by the Industry. It can be seen, that also a clear correlation was expected, the hypothesis could not be proofed by the investigated study results: a clear correlation could not be found. This result is striking and may be due to different reasons: for one, some or many of the studies may be too rough. On the other hand, the influence of the IWH Intensive Industries may be different in different countries: For example the pulp and paper industry might be producing a 10 % waste heat share in one country and 40 % in another, while dominating the waste heat production in both countries. This may be due to differences in the technology use and its efficiency. Correlating the final energy consumption of the country to the IWH Intensive Industries leads to the same result. In any case, these results should be investigated in more detail in future research.

The IWH per Energy Consumed by the Industry as well as per Energy Consumed by the Country are shown in Table 5. The values are listed in ascending order of IWH per Energy Consumed by the Industry. The maximum values for both ratios correspond to Canada. These values are unexpectedly high; however, how the IWH potential is accounted for this country is not explained in the literature source. One of the lower values is from Latvia and one of the higher values is from Cyprus, this is surprising because the IWH potential from Latvia and Cyprus came from the same source.

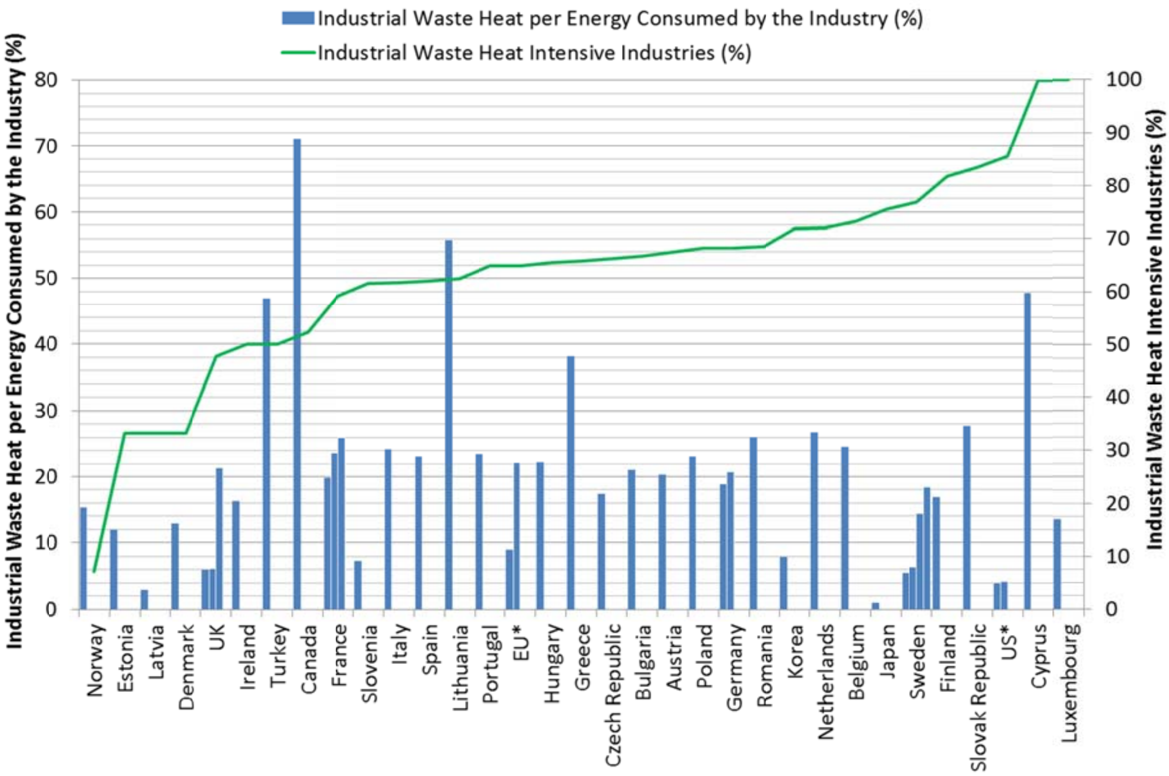

Figure 5 Industrial Waste Heat per Enegy Consumed by the Industry and percentage of Industrial Waste Heat Intensive Industries.

Table 5 Industrial Waste Heat per Energy Consumed by the Industry and Industrial Waste Heat per Energy Consumed by the Industry ratios.

	Industrial Waste Heat per Energy Consumed by the Industry (%)	Industrial Waste Heat per Energy Consumed by the Country (%)
Japan	1.0	0.4
Latvia	3.0	0.6
US	4.0 - 4.2	1.5
Sweden	5.5 - 18.4	2.0 – 6.7
UK	5.5 - 21.3	1.1 – 4.2
Slovenia	7.3	1.9
Korea	8.0	4.7
EU	9.1 – 22.2	2.3 – 5.6
Estonia	11.9	2.5
Denmark	12.9	2.0
Luxembourg	13.6	2.2
Norway	15.4	5.7
Ireland	16.3	2.6
Finland	16.9	7.4
Czech Republic	17.4	6.0
Germany	18.8 – 20.7	5.2 – 5.8
France	19.8 – 26.0	5.0 – 6.5
Austria	20.4	6.4
Bulgaria	21.0	6.0
Hungary	22.2	3.9
Spain	23.1	6.0
Poland	23.1	5.4

Portugal	23.4	7.0
Italy	24.2	6.0
Belgium	24.5	7.5
Romania	26.0	8.0
Netherlands	26.7	7.1
Slovak Republic	27.7	10.5
Greece	38.2	7.0
Turkey	46.9	17.4
Cyprus	47.8	5.0
Lithuania	55.7	10.4
Canada	71.0	26.4

Taking into account the difficulties found to perform this study, the authors recommend the institutions publishing IWH data that they also specify the following parameters:

- Type of IWH potential (physical, technical or economical [6]).
- Methodology used to account the IWH potential (bottom-up or top-down [4]).
- Reference temperatures at which the energy content is calculated.
- Year of the data used instead of only the publication year.
- If the IWH released to the ambient is in liquid or gas state.
- The boundaries and scope of the study (industrial sectors that they consider).

4. CONCLUSIONS

Data accounting for the Industrial Waste Heat (IWH) from 33 countries (and 6 subregions) worldwide is collected from in the literature (based on the energy data published by national or international official agencies, scientific articles and company reports). However, a lack of specifications when reporting these data is detected. The main difficulties found when joining all the information are the lack of information about the methodology used and the lack of data referring to the same year. Most of the documents found in the literature don't mention the methodology (survey, estimation, etc.) or the boundaries used to get the values related to energy waste and consumption. Besides, often the year of publication of the reports is the only date shown and the important date, the date from the collection of the data is missing. For that, the authors propose a methodology to compare and discuss the reliability of the IWH potentials published.

The methodology proposed is based on considering other factors concerning the country: the Energy Consumed by the Industry, the Energy Consumed by the Country and the percentage of IWH Intensive Industries. Country scale has been used in this study as it is shown that at subregion country scale, these parameters are not always available. These parameters are expected to be proportional to the quantity of IWH. Also, two ratios are defined and calculated for each country analysed: the IWH per Energy Consumed by the Industry and the IWH per Energy Consumed by the Country. By using these ratios the waste heat becomes independent of the size of the region considered and the data becomes more comparable.

The results show that, according the assumptions and methodology proposed by the authors, most of the countries have reliable IWH data. However, the values from Lithuania, Canada, one of the EU, one from Sweden, two from UK and for Japan don't follow any of the expected trends. So, in order to analyze the reliability of the IWH values of these countries, the authors recommend further research. The same recommendation is proposed to be extended for Cyprus, Latvia, Slovak Republic and Turkey considering that they don't follow most of the trends expected. That makes more than 1/6 of the data found in the literature not plausible. A very unexpected result of the investigation is that no correlation between the share of the IWH Intensive Industries and the share of IWH per Energy Consumed by the Industry could be found.

In addition, correlating the Energy Consumed by the Country to the IWH Intensive Industries leads to the same result.

Reliable and well described data is needed to be published in order to perform further suitable analysis of the quantity of IWH available in different regions, which is essential to promote the use of this energy.

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ANNEX

	IWH potential (PJ)	Year	Final country energy consumption (PJ)	Year	Final industrial energy consumption (PJ)	Year	IWH intensive industries (%)	Year
Cyprus	4 [13]	<2013	80 [9]	2010	8 [9]	2010	100	2010
Estonia	3 [13]	<2013	121 [9]	2010	25 [9]	2010	67	2010
Luxembourg	4 [13]	<2013	180 [9]	2010	29 [9]	2010	100	2010
Latvia	1 [13]	<2013	180 [9]	2010	33 [9]	2010	50	2010
Lithuania	21 [13]	<2013	201 [9]	2010	38 [9]	2010	88	2010
Slovenia	4 [13]	<2013	209 [9]	2010	54 [9]	2010	69	2010
Ireland	13 [13]	<2013	494 [9]	2010	80 [9]	2010	72	2010
Denmark	13 [13]	<2013	649 [9]	2010	100 [9]	2010	63	2010
Bulgaria	22 [13]	<2013	368 [9]	2010	105 [9]	2010	78	2010
Hungary	27 [13]	<2013	699 [9]	2010	121 [9]	2010	79	2010
Greece	56 [13]	<2013	795 [9]	2010	147 [9]	2010	83	2010
Slovak Republic	51 [13]	<2013	486 [9]	2010	184 [9]	2010	86	2010
Portugal	53 [13]	<2013	762 [9]	2010	226 [9]	2010	76	2010
Romania	75 [13]	<2013	942 [9]	2010	289 [9]	2010	77	2010
Czech Republic	64 [13]	<2013	1072 [9]	2010	368 [9]	2010	73	2010
Austria	75 [13]	<2013	1168 [9]	2010	368 [9]	2010	74	2010
Norway	70 [34]	2008	1237 [48]	2011	456 [48]	2011	7	2011
Belgium	115 [13]	<2013	1524 [9]	2010	469 [9]	2010	83	2010
Finland	82 [13]	<2013	1110 [9]	2010	486 [9]	2010	85	2010
Sweden	34 [42] 22 – 29 [43] 76 [44] 97 [13]	n.a. 2008 n.a. <2013	1440 [9]	2010	528 [9]	2010	80	2010
Netherlands	160 [13]	<2013	2261 [9]	2010	599 [9]	2010	85	2010
Poland	149 [13]	<2013	2776 [9]	2010	645 [9]	2010	80	2010
Spain	226 [13]	<2013	3793 [9]	2010	980 [9]	2010	72	2010
France	302 [13] 360 [18] 396 [17]	<2013 n.a. n.a.	6649 [9]	2010	1306 [9]	2010	76	2010
UK	36 - 71 [34] 37 - 73 [35]	2006 2010 <2013	5987 [9]	2010	1181 [9]	2010	58	2010

	252 [13]							
Italy	315 [13]	<2013	5225 [9]	2010	1302 [9]	2010	71	2010
Turkey	857 [43]	2010	4941 [49]	2010	1828 [49]	2010	50	2010
Germany	476 [13] 525 [12]	<2013 2010	9102 [9]	2010	2533 [9]	2010	76	2010
Canada	2300 [24]	<2012	8720 [9]	2012	3238 [22]	2012	52	2012
Korea	384 [37]	2012	8129 [37]	2010	5357 [37]	2010	73	2010
Japan	59 [47]	2000	13365 [50]	2000	5720 [50]	1991	79	1991
EU	2708 [13]	<2013	48286 [9]	2010	12209 [9]	2010	75	2010
US	1501 [38] 1583 [39]	<2004 <2008	102658 [51]	2011	37982 [51]	2011	92	2011