Geothermal ERA-NET

International Collection of Geothermal Energy Statistics

Towards reducing fragmentation and improving consistency

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Executive Summary

The aim of this report is to give an overview of the international collection of geothermal energy statistics by various international organizations, offices and associations to enable interoperability of energy statistics, increase reliability and decrease fragmentation. The report lists the data collection with respect to primary and secondary energy, direct use and final use. It also compares actual data reported and finally calls for a Joint Activity within the Geothermal ERA-NET aiming at solving the concluded and identified issues.

The data collecting organizations are categorized as either official (collected by IEA, OECD, UNECE, Eurostat and the UN in a unified manner) or industrial (collected by IEA-GIA, IGA and EGEC separately). Within the geothermal sector official statistics have sometimes had a stigma to be incomplete, complicated and not easily accessible. However, review of data has not illustrated the stigma to have any merit in comparison to statistics produced by industries, associations and organizations representing the geothermal industry sector (henceforth referred to as "industry statistics"), which were thought to be more reliable. Industry statistics are fragmented between organizations in terms of terminology and methodology. Submissions of data forming the industry statistics are based on member participations and vary from one organization to another. Although some particular aspects are present in more detail in industry statistics than in official statistics, industry statistics do not allow drawing an energy balance between primary energy and final use and their independence is not legally established.

Comparison of reported industry statistics and official statistics show drastic differences beyond acceptable levels. Actions are needed to reduce these differences if the statistics are to be taken seriously. The most plausible explanation is concluded to be the methodology of data collection and treatment from statistical units leading to drastic and random differences. A clear lack of review across organizations contributes to these differences, as well as the fact that sometimes internal review processes of each organization is unsatisfactory. No organization consistently presents the lowest or the highest values, the difference essentially being random with no obvious trend.

The conclusion is that data requirements of official statistics contain information on aspects of geothermal energy sufficient for a transparent and detailed data presentation. It can therefore be used to customize questionnaires of other organizations of the geothermal industry having basic unified parameters with further details if deemed important by the respective organization. This could enable use and comparison of energy statistics, increase reliability, security and decrease fragmentation in line with the aim of these organizations, motions and regulations.

The GeoStat Joint Activity is proposed under the framework of the Geothermal ERA-NET having the main international organizations collaborating on reviewing and unifying statistics using the existing framework and regulation. This should be an iterative review process of data submissions to existing international organizations to make the statistics interoperable. The proposed GeoStat Joint Activity aims at defining clear and measurable indicators for each objective identifying how GeoStat could contribute. Objectives being; 1) annual benchmarking of maximum statistical differences until year 2020, 2) reduction of duplication of effort on domestic level and 3) increasing collaboration on domestic level and 4) simplifying the process across organizations. The indicators established by the participating partners of GeoStat.

Acknowledgements

This report is a collective work between international organizations over the past years through international cooperation and discussions and has been extensively reviewed by nominated specialists respectively with the joint aim of reducing fragmentation and improving consistency across organizations and representatives of nations.

Special thanks go to the insight and discussions to the team of specialists of the International Energy Agency (IEA), review lead by Vladimir Kubecek, Section Head at the Energy Statistics Division and Loïc Coënt. The IEA contributed to this report as external reviewers and validated the calculations behind the data comparison to other international organizations and gave valuable clarification to terminology and interpretation.

The International Geothermal Association (IGA) in particular former IGA President, Prof. Roland N. Horne, nominated Luis Carlos Gutiérrez-Negrín, President of the Mexican Geothermal Association and the Information Committee of IGA who nominated the Committee Member Varun Chandrasekhar and Managing Director of the GeoSyndicate Power Pvt. Ltd. Together they validated the data from IGA, reviewed the structure and suggested improvements to enhance understanding of different methodologies, building a stronger bridge between for which we are thankful.

The IEA Geothermal Implementing Agreement (IEA-GIA), in particular Josef Weber, Annex X Leader for Data Collection and Information reviewed the report and provided suggestions for improvement which were accommodated for in the report and taken under consideration. A meeting was held with IEA-GIA and IEA in Paris in year 2014 that assisted the collaboration with IEA. Also participants of Annex VIII for Direct Use of Geothermal Energy reviewed the report and contributed to improvements. A special meeting was conducted in Japan in year 2014 within Annex VIII were a draft report was extensively introduced and discussed. Within the Annex special thanks go to the Annex Leader Katharina Link and Ruggero Bertani, representative of Italy, and Yoonho Song, representative of South-Korea.

The European Geothermal Energy Council's (EGEC) Secretary General Philippe Dumas reviewed the report and provided suggestions for improvement which were taken into consideration. EGEC requested to be omitted from data comparison due to variations in terminology but the authors decided not to do so but rather explain the differences that exist which is the aim of the report.

The statistical office of the European Union (Eurostat), in particular Fernando Diaz Alonso, responsible for the annual renewable energy data collection, Marek Sturc, responsible for the calculation of the share of energy from renewable sources, and Hionia Vlachou, reviewed some parts of this report and provided suggestions for improvement, which were accommodated for in the report and taken into consideration.

The entities forming the Geothermal ERA-NET were also asked to review. Annamária Nádor, Senior Geologist of the Geological and Geophysical Institute of Hungary and Adele Manzella, Coordinator of Geothermal Projects at the Institute of Geosciences and Earth Resources IGG CNR reviewed the report and provided suggestions for improvement which were accommodated for in the report and taken into consideration.

The cooperation and contribution of the persons and organizations aforementioned does not imply their agreement with all the contents included in this report.

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Introduction

The aim of this report is to give an overview of the international collection of geothermal energy statistics by various international organizations, offices and associations to enable interoperability of energy statistics, increase reliability and decrease fragmentation in line with the aim of these organizations, motions and regulations.

This work is conducted within the scope of the Geothermal ERA-NET supported by the European Commission. One of the goals of the Geothermal ERA-NET is to validate the feasibility of a European Geothermal Information Platform (EGIP). As part of such a platform, geothermal energy statistics is subject to be part of such a holistic approach of accessibility of data. The aim is hence to get an overview of what is being collected today and how the Geothermal ERA-NET can contribute without duplicating further the work that is already multiplied across various international bodies.

The main international organizations and offices have already joined forces in collecting energy statistics with annual questionnaires with historical revisions. The international organizations that collectively and consistently gather this data are; the *Energy Data Centre of the International Energy Agency* (IEA), the *Organization for Economic Co-operation and Development* (OECD), the *Statistical Division of the United Nations Economic Division for Europe* (UNECE), the *Statistical Office of the European Communities* (Eurostat) for e.g. policy making of the *Commission of the European Communities* (EC) and finally the *Statistics Division of the United Nations* (UN). Two of those questionnaires collect geothermal energy statistics; "*Annual Questionnaire on Electricity and Heat*" collecting information on energy products and "*Annual Questionnaire on Renewables and Wastes*" collecting in addition the direct use of geothermal energy. It is important to note that the term direct use is used differently in these questionnaires –which is common within the industry as will be further explained. In addition to the aforementioned questionnaires, official statistics carried out by the IEA sends out mini questionnaires requesting preliminary data earlier in the year. The mini questionnaires are the *"Renewables and Wastes Mini Questionnaire"* and the *"Electricity and Heat Mini Questionnaire"*. Terminology of the questionnaires is outlined in a report (*Energy Statistics Manual*) published by IEA/OECD in collaboration with these international bodies (IEA/OECD, 2005). Terminology and explanations of energy statistics are also outlined in the "*International Recommendations for Energy Statistics" (IRES)*, and in the "*International Standard Industrial Classification of All Economic Activities*" (ISIC), Rev. 4, both published by the UN. Recently the *International Renewable Energy Agency* (IRENA) has started to accumulate data which is somewhat linked to this joint work but has not been formalized completely and therefore is beyond the scope of this report. In this report the aforementioned, recognised national energy statistics by IEA, OECD, UNECE, Eurostat and the UN will be referred to as official statistics. The legal basis for the European Union official statistics in the energy domain is Regulation (EC) 1099/2008 on energy statistics. The role of policy making is within the EC although the data of Eurostat is the basis of establishing future trends.

Countries that are members of aforementioned organizations and agencies are obliged to complete the questionnaires in accordance with the respective laws of the organizations. In addition non-member countries do also complete these questionnaires in relation to various joint activities they have with these organizations. With official data from most countries in the World for all energy sources, these organizations are able to disseminate a world outlook on energy and predict future trends, taking other parameters into account like population growth and gross domestic product, for example.

European Union (EU) Member States together with the *European Free Trade Association – European Economic Area* (EFTA-EEA) Countries are required to complete these questionnaires in accordance with European Regulation (EC) No. 1099/2008 on energy statistics. EU candidate countries and potential candidate countries, although not required by law, also complete these questionnaires. The objective of the Regulation is namely to establish a common framework for the production, transmission, evaluation and dissemination of these statistics to assist political decision-making by the EU and its Member States and to promote public debate on energy use and future trends. In order to do so the EU must offer guarantees of comparability, transparency, flexibility and ability to evolve with a greater focus on increased knowledge and monitoring of final energy use and renewable energy in particular as stipulated in the aim of the regulation. The Regulation further defines and stipulates the responsibility of the countries and in two annexes of the regulation the terminology is defined, which is comparable to the aforementioned Energy Statistics Manual (IEA/OECD, 2005) and is referred to as the official statistics.

Article 22 of the "*Directive 2009/28/EC of the European Parliament and of the Council*" states that all Member States of the European Union are required to submit a report to the Commission on progress in the use and promotion of renewable sources by 21st December 2011 and every two years thereafter. The final report, the sixth one, shall be submitted by 31st December 2021. Clause 1.l) states that the countries shall report in detail "The estimated excess production of energy from renewable sources compared to the indicative trajectory which could be transferred to other Member States, as well as the estimated potential for joint projects, until 2020". Therefore the estimated excess production can be sold to other member states. The financial stakes can act as a motivation for getting the most accurate data possible and reaching or exceeding the estimated production.

In each country the role of submitting official statistics is normally done within the respective legal framework. As an example, in Iceland one of the responsibilities of Orkustofnun is to gather energy statistics as stipulated in 2nd paragraph of Act no. 87/2003 on Orkustofnun, for which the institution can enforce by means of fines on companies that are obliged to submit the data. In accordance with Regulation (EC) No. 1099/2008 on energy statistics, Member States, or in the case of Iceland, Orkustofnun, are required to meet the necessary requirements. Therefore Orkustofnun gathers and maintains an energy statistics database that is coherent and follows the framework set out in Regulation (EC) No 1099/2008. Since that is done in collaboration with other institutions, it is required to complete aforementioned joint questionnaires.

The excel files for the official statistics questionnaires *Annual Questionnaire on Renewables and Wastes* and the *Annual Questionnaire on Electricity and Heat* are imported into SHARES tool, developed by Eurostat. The SHARES tool is a spreadsheet based document linking annual energy questionnaires together, focused on harmonizing the calculations of the share of energy from renewable sources among EU Member States. Member states go through the same method in order to calculate the desired values, therefore any irregularities from varying parameters and rules used in different calculation methods are prevented. There are three more questionnaires not concerning geothermal energy used imported to the SHARES tool. The subjects of the questionnaires are coal, oil and natural gas. The legal basis for the implementation of all methodologies and calculations is based on Directive 2009/28/EC and Regulation (EC) No 1099/2008.

Within the geothermal industry Orkustofnun participates in several associations and partnerships and collaborates with many others like the Geothermal Implementing Agreement within the IEA (*IEA-GIA or IEA Geothermal*), *International Geothermal Association* (IGA), *European Geothermal Energy Council* (EGEC*), Geothermal ERA-NET, Euroheat & Power*, to name a few. As part of the role of these organizations, data collection on geothermal energy statistics is often the focus of the work, in particular of the IEA-GIA, EGEC and IGA. In this report these datasets will be referred to as industry statistics. However, the industry statistics between these multinational associations are not coherent from one to the other and are also different from the official statistics. The fact is that the industry statistics are quite fragmented (e.g. have different scopes or cover different parameters), although consistent within the respective association. EGEC statistics for example are only on geothermal power plants and geothermal district heating plants. With time, databases have been developed and special annual questionnaires have been established within each association, which make up what is here referred to as industry statistics.

The industry statistics questionnaires and data examined in this report for IEA-GIA are the questionnaire "*Questionnaire for the report on Trends in Geothermal Applications 2012*" and the report "*Trends in Geothermal Applications: Survey Report on Geothermal Utilization and Development in IEA-GIA Member Countries in 2010*". For IGA, the IGA Geothermal Database on its website is used for comparison along with the tables in the end of the Icelandic country report "*Geothermal Development in Iceland 2005–2009*", updated every five years for the World Geothermal Congress (see tables in Appendix II). The tables in the back, although implementing Icelandic data, present the data collection of IGA. For EGEC the "*EGEC Deep Geothermal Market Report 2011*" is used for a data comparison. For official statistics the *Annual Questionnaire on Renewables and Wastes* and *Annual Questionnaire on Electricity and Heat* are used in the comparison along with the book from IEA Statistics on "*Renewables Information*". The purpose of the Annual Questionnaire on Renewables and Wastes is to get an overview of all renewable energy, while the Annual Questionnaire on Electricity and Heat gathers information on energy products excluding direct use of geothermal energy. The data compared in this report is from the year 2010 for comparison purposes because this is the only data existing in the IGA database. Some of the data of IGA is estimated based on data from the year 2009. The exception is the data from EGEC, which is for year 2011 since EGEC started the work at that time.

In some cases the data collection is similar but often there are important differences that result in the data not being interoperable across organizations, and when numbers are compared from one to the other drastic differences can be found - which can be difficult to resolve. The factors for this fragmentation are complex but following are some important issues to keep in mind when reading this report. In the conclusion of this report it is suggested how these issues can be mitigated or prevented.

When new international bodies are formed or roles are passed from one person to another a lack of overview becomes an issue within the respective body, and data is started to be collected as a task of the respective members. This may soon develop into an annual questionnaire, and further on can become one of the identities the international body is recognised for and justifies its existence and expense.

In most countries geothermal energy only represents a minor share in the energy mix of the country, and so the institution responsible for the data collection overlooks this source of energy within the budget allocated for the overall task of gathering national energy statistics. This can lead to the data being incorrect, but only perhaps by a fraction of a percentage and hence falls under statistical differences. However, the respective geothermal organization has access to such figures from its members, and a growth can be more visible for them than when taking into account the total energy use of the country. Due to various reasons the national body responsible and the geothermal based organization may not interact, and in many cases are unaware of the work conducted by the other.

Methodological
In some countries the final energy use is often estimated with surveys rather than accumulation of actual data, such as in the case of a few important geothermal based district heating systems within a relatively large country, which might fall out of such random surveys and thus the estimated national energy statistics loses an important feature of its national energy portfolio.

Heat use of geothermal energy enables different uses of this energy source compared to other energy sources. Therefore the geothermal industry categorizes the final use of energy in another manner in order to bring out the importance of geothermal energy in the industry statistics that is different from the conventional way in the official statistics. This causes difficulties when comparing the categories when they overlap.

Some industry statistics do not recognise the difference between companies using heat for their own use, and how much they sell to a third party and utilities, in comparison to the official statistics.

Conceptual
The industry statistics of some associations and by some countries account for bathing in natural spas as part of the direct use of geothermal energy while others might account for it as heat for sale, and others do not include it at all. This can offset the total final use completely in some countries for geothermal energy and possibilities of comparing data between countries.

Since Iceland is a member of OECD, Orkustofnun has for a long time submitted data to official organizations. Orkustofnun is one of few institutions in the world that in the past has accumulated, interpreted and disseminated both the official statistics and the industry statistics on geothermal and therefore has a broad overview of the various data being collected by different organizations. Taking into account the fact that the point of international collaboration is to reduce fragmentation, it is the opinion of Orkustofnun that this is one of the key issues that need to be resolved. The aim of this report is hence to highlight the difference between official and industry statistics by comparing data requirements and presentations of different organizations, to enable analysis for the comparability, transparency, flexibility and our ability to reflect on where we are, where we are going and how geothermal energy can facilitate in that respect. The final goal is to reduce discrepancies and facilitate harmonization of geothermal energy statistics.

1 Primary Energy

The primary energy of geothermal energy is its maximum usable thermal energy above a reference state. The principle adopted by the IEA is that the primary energy form should be the first energy form downstream in the production process for which multiple energy uses are practical. The application of this principle leads to the choice of the following primary energy forms: heat for nuclear, geothermal and solar thermal, and electricity for hydro, tide/wave/ocean, wind and solar photovoltaic. The IEA recommends geothermal primary energy to be calculated based on the physical energy content if data is available or by assuming 10% and 50% efficiency, in case the particular efficiencies are not known on national/unit level, for electricity and heat respectively (International Energy Agency, 2013). However, the method used by each country varies and as an example New Zealand assumes 15% efficiency for electricity generation if data is not available (Energy Information and Modelling Group, 2010).

Orkustofnun calculates primary energy based on measurements of the physical condition of the fluid from the ground above a reference state. The reference state used is based on the International Standard Atmosphere physical condition (ISO, 1975). The state is near the average temperature and pressure of earth on the surface, and therefore is something all nations could agree to simplify the country comparison of energy statistics. The reference state is also used for other types of primary energy sources, like standard conditions for natural gas (Eurostat, IEA, OECD, 2005). Exceptions can be found in Iceland where energy is used under the reference state in fish farming, agriculture and snow melting but at the same time in warmer countries having a reference state of 15°C is too low. Geothermal primary energy is not presented in the IGA geothermal database but IEA-GIA has accumulated this information from its members and this information is available in the publications of IEA. Following are definitions and clarifications of terminology:

> **Geothermal primary energy** is the energy released from geothermal fluid on its way from its initial state to its reference state where the reference state is assumed to be 15°C and 1 bar_a.
>
> **Gross geothermal primary energy use** is the primary energy of geothermal fluid of a reservoir processed on a given period.
>
> **Net geothermal primary energy use** is the gross geothermal primary energy use minus the primary energy of the re-injected fluid in the geothermal reservoir (Haraldsson and Ketilsson, 2010a).

2 Secondary Energy and Direct Use

Geothermal primary energy is used for transformations to secondary energy products and for own use, referred to as direct use in official statistics. The purpose of this chapter is to compare requirements of data by different questionnaires regarding secondary energy products and direct use.

First, transformation for secondary energy production and direct use are defined. Then, producers are defined along with the categorization of secondary energy production by plants and steam and binary cycles. Finally the variations in data reporting of different organizations are discussed.

A table with a comparison of secondary energy products and direct use by different organizations can be seen in Appendix V: Comparison of Secondary Energy and Direct Use Data Requirements of Organizations.

2.1 Secondary Energy Products and Direct Use

Official statistics have questionnaires for collecting data regarding other energy sources than geothermal energy. Therefore, a common ground on how data is collected is needed for a comparison of energy sources. One way of coordinating their data gathering methods, based on different sources, is to provide clear definitions related to the transformation of energy and what is understood by primary and secondary energy products.

> **Transformation of energy** involves the use of a primary fuel product to create or generate a secondary energy product.

Geothermal primary energy can be transformed into electricity, but the transformation of geothermal energy into heat is not a physical transformation. Instead it can be viewed as a plant and a producer (explained in the next subchapters) turning the primary energy into a secondary energy product, defined to satisfy the data collection methods of official statistics within a broader context of various energy sources.

> **Secondary energy products**, i.e. heat and electricity are transformed from primary energy. Heat is not transformed in the physical sense but it can be.

The rest of the utilized geothermal primary energy is considered direct use:

> **Direct use** is the use of geothermal primary energy which did not go through the transformation.

These definitions generally apply, but the classifications of what is considered direct use and secondary energy products are further defined according to the plants and producers producing them. The next subchapters examine this subject.

The terminology mentioned so far is fundamentally different from the general use of these terms in the geothermal energy sector. In the case of heat pumps for own use of the heat it should be reported as direct use, but if the heat is sold there is a special reporting in the questionnaires for heat pumps operated to sell heat.

2.2 Producers

Economic entities involved in production, transformation and consumption of energy are vast. The entities vary from small local energy producers or distributors to large and complex corporations engaged in many different activities carried out at or from many geographical locations. Because of the diversity of economic entities involved in production, distribution and consumption of energy, energy data compilers should be aware of the different types of statistical units in order to organize data collection as well as to ensure that data is interpreted and used correctly in conjunction with other statistics. A statistical unit is defined as an entity about which information is sought and for which statistics are ultimately compiled. It is also the unit at the basis of statistical aggregates. The statistical units defining the classifications of secondary energy products and direct use are the types of producers along with geothermal plants discussed in the next subchapter. In general the producers are classified based on the purpose of their production (Eurostat, IEA, UNECE & OECD, 2013):

> **The principal or primary activity** of a producer is the activity whose value added exceeds that of any other activity.
>
> **Main Activity Producer** is a statistical unit producing electricity or heat as its principal activity. Formerly known as public utilities, these entities may be privately or publicly owned companies.
>
> **Autoproducers** produce energy, wholly or partly for their own use as an activity which supports their primary activity. They may be privately or publicly owned.

It is important to note that the sale of energy from the Main Activity Producer to the final consumer need not take place through the public grid.

Main activity- and autoproducers are defined according to the legal framework of the respective country. The UN suggests that large enterprises engaged in many economic activities that belong to different industries should be broken into one or more establishments, provided that smaller and more homogeneous units can be identified in order to meaningfully compile data on energy production or other activities attributed to energy industries from them (United Nations Statistics Division, 2011).

The definitions of the consumer groups (utilization categories) required by official statistics should be based on the UN's ISIC classification of productive activities (United Nations, 2008). If the productive activity is not on the list it should be evaluated.

The reporting requirements of official statistics for secondary energy products regarding main activity- and autoproducers state that main activity producers should report all electricity and heat produced. Autoproducers should report all electricity, but only the heat sold.

As an example, imagine a farmer. His main activity is agriculture. To support this activity, he produces heat for agriculture and residential heating, but he sells the excess heat to neighbouring farms. All heat for his greenhouse and space heating is reported as direct use and the heat sold to neighbouring farms is reported as the secondary energy product heat, as well as the heat input to transformations is reported as primary energy content.

2.3 Categorization of Secondary Energy Products

The types of geothermal plants producing heat and/or electricity in official statistics are electricity plants, combined heat and power plants (CHP) and heat plants.

Electricity plants are designed to produce electricity

CHP plants are designed to produce both heat and electricity

Heat plants are designed to produce only heat.

For industry statistics, types of power plants are further categorized based on the process type. They are divided into two main groups, steam cycles and binary cycles. The steam cycles are generally used when exploiting high temperature geothermal systems while binary cycles are generally used when the temperature is lower. The main characteristic of steam cycles is the use of the geothermal fluid itself in the turbines of the power plant, while binary cycles use a different fluid, called working fluid.

When the geothermal reservoir does not produce dry steam, the fluid is boiled, then steam is separated from brine and expanded in a turbine and brine is generally re-injected to the reservoir or flashed again at a lower pressure one or more times (Valdimarsson, 2011). There are a few types of power plants based on steam cycles from which information is gathered, like condensing plants (single, double and triple flash), dry steam and back pressure.

Binary cycles use a secondary working fluid in a closed power generation cycle. A heat exchanger transfers heat from the geothermal fluid to the working fluid and the cooled brine is then re-injected or rejected to the environment (Valdimarsson, 2011). There are a few types of binary cycles, i.e. Organic Rankine Cycle (ORC), Kalina and Hybrid. All of these types are being gathered in industry statistics although there are variations within.

Figure 1 and Figure 2 show the reporting to different organizations based on producer and plant.

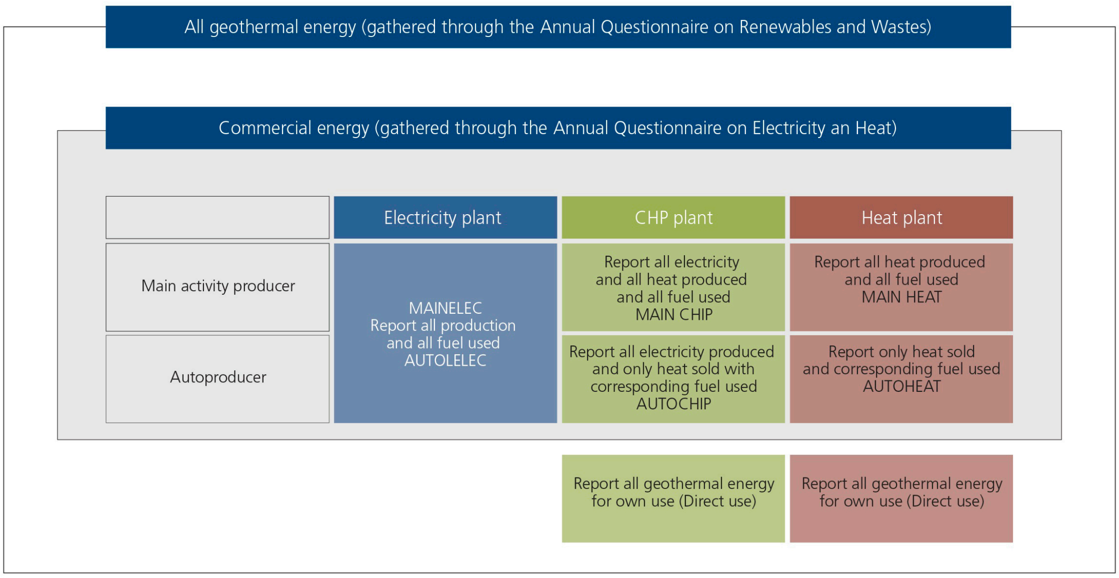


Figure 1: Reporting for official statistics.

	Electricity/ CHP plants	CHP/ Heat plants
Producer	Report all electricity production	Report all heat production

Figure 2: Reporting for industry statistics

2.4 Variations in Terminology

The secondary energy and direct use reporting of different organizations are compared in the following subchapters. The energy products reported by organizations are explored along with electrical and thermal capacity. Losses during transport and distribution and heat pumps information reported by different organizations are examined.

One of the most important differences in the definitions is the categorization of producers and plants. As mentioned before, for official statistics the heat (secondary energy product) is reported separately from the direct use of geothermal energy while for industry both are reported together as direct use of geothermal energy. The *Annual Questionnaire on Electricity and Heat* only requests information on secondary energy products (electricity and heat sold in the case of geothermal), whereas the *Annual Questionnaire on Renewables and Wastes* also takes into consideration direct use.

The fundamental difference in official statistics is that renewable heat for direct use by autoproducers is only reported in the *Annual Questionnaire on Renewables and Wastes* and categorized as geothermal final use. Therefore it can be stated that the purpose of the *Annual Questionnaire on Renewables and Wastes* is to get an overview of all renewable energy, while the *Annual Questionnaire on Electricity and Heat* gathers mainly information on energy statistics for secondary energy products from geothermal energy. Even though that is the case, the EU takes both questionnaires into account when calculating the shares of renewables in the SHARES document, hence all the necessary parameters are taken into account when calculating shares of renewables in the SHARES tool. This is done due to irrelevant differences for geothermal between questionnaires and to significant differences for other energy sources.

The identifications in the brackets in Figure 1 are from the IEA database. In Appendix VII there are all of the identifications in the database and explanations.

In some cases an autoproducer is an enterprise producing heat for sale but the heat production is not its principal activity (United Nations Statistics Division, 2011). For the institution gathering information on the statistical unit in question, this can in some cases be difficult to decide when in fact the main activity is to sell heat or not. Normally the ISIC classification can be used to differentiate but in some cases the entity in question is owned by a larger enterprise whose primary activity is different. In the case study three companies are analysed having similar activities but are categorized differently.

Company A: An innovative aquaculture and café company also sells heat to a neighbouring village using the same production well. The amount of energy delivered to the village is ten times higher than what is delivered to the aquaculture although the income is mostly from the aquaculture and café.

Company B: Among other unrelated investments, a large company operates a greenhouse and sells energy to a neighbouring village using the same production well. The amount of energy delivered to the village is five times higher than what is delivered to the greenhouse and the energy production to the village generates also more income. The company is an enterprise having investments in various industries but its overall principal activity is offshore petroleum exploration.

Company C: A field operator of a high-temperature field produces steam that is sold to a power plant operator and to a cheese factory using steam to boil milk for the production process. The field operator only extracts energy from the ground and sells it to the power plant operator and the cheese factory. This is the principal activity of the company.

To determine what should be classified as a secondary energy product (heat) and direct use the companies have to be classified as main-activity producers or autoproducers based on the principal activities of the overall entity in question (see Figure 3 for illustration). Note that for these three examples the categorization of the statistical unit makes no difference on the final use category.

Regarding own use of energy (gross and net production) the *Annual Questionnaire on Renewables and Wastes* and the *Annual Questionnaire on Electricity and Heat* request information on gross electricity and heat production. The latter also requests information on net heat and electricity production. They are defined as follows.

Gross electricity production: "Gross electricity production is the sum of the electrical energy production by all the generating sets concerned (including pumped storage) measured at the output terminals of the main generators." (Eurostat, IEA, UNECE & OECD, 2012).

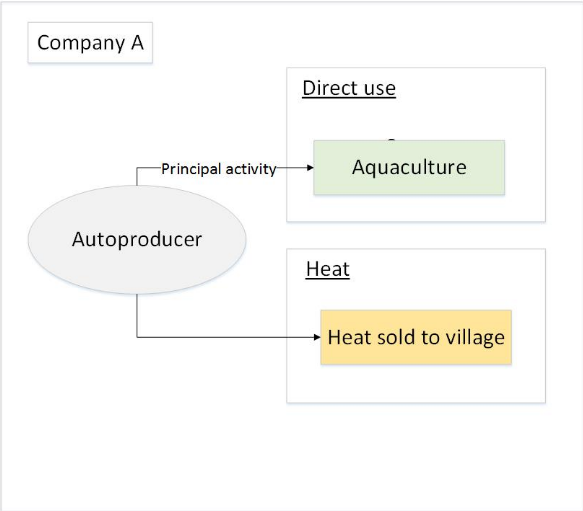
Gross heat production: "Gross heat production is the total heat produced by the installation and includes the heat used by the installation's auxiliaries that use a hot fluid (space heating, liquid fuel heating etc.) and losses in the installation/network heat exchanges, as well as heat from chemical processes used as a primary energy form. Note that for autoproducers, heat used by the undertaking for its own processes is not included here; only heat sold to third parties should be reported. As only heat sold to third parties is reported, gross heat production for autoproducers will be equal to net heat production." (Eurostat, IEA, UNECE & OECD, 2012).

Net electricity production: "Net electricity production is equal to the gross electricity production less the electrical energy absorbed by the generating auxiliaries and the losses in the main generator transformers." (Eurostat, IEA, UNECE & OECD, 2012).

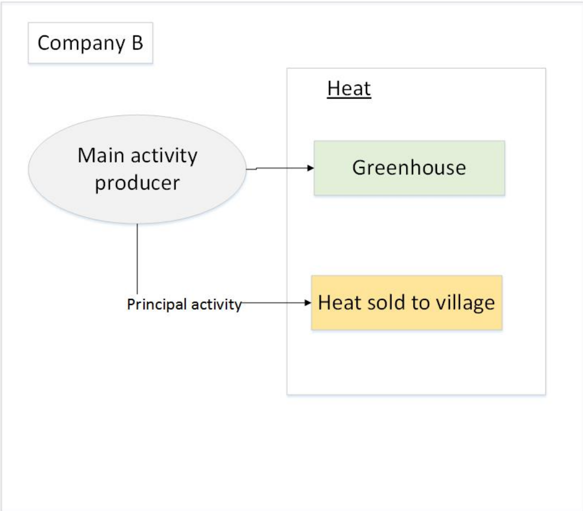
Net heat production: "Net heat production is the heat supplied to the distribution system as determined from measurements of the outgoing and return flows" (Eurostat, IEA, UNECE & OECD, 2012).

Is the principal activity of the statistical unit to produce heat?

Company A – No: Since the principle activity (the activity generating the most income) is the own use of geothermal energy for aquaculture, it is an autoproducer. The part of the geothermal energy used for aquaculture is defined as direct use, and the part sold is reported as heat sold by the autoproducer.



Company B - Yes: Since there are unrelated economical activities of the enterprise, a smaller statistical unit can be identified when the principal activity is in fact production of heat as a secondary energy product. Since the principal activity (the activity generating the most income) is selling heat to a neighbouring village, the company is a main activity producer. Hence, the energy sold to the village is reported as heat, the energy used for the greenhouse is the own use of the main activity producer but is also reported as heat. Hence the energy sold to the village is reported as heat sold but the energy used for the greenhouse is own use of the main activity producer.



Company C - Yes: The company is considered a main-activity producer selling heat to the cheese factory. However, since the company operating the power plant will report the electricity generated from geothermal, it is important not to account for that energy twice. Hence only the heat produced for the cheese factory is reported and the energy sold to the power plant is omitted. However, the primary energy is reported by this company at the wellhead operated by the company. The statistical unit running the power plant will however report the electricity generated and hence duplication of the primary energy and secondary energy product is prevented.

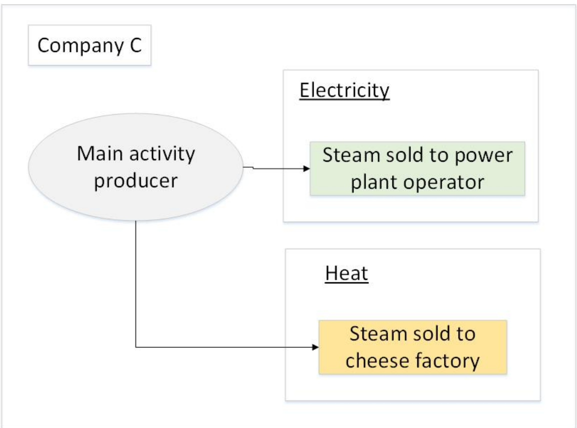


Figure 3: Three companies are classified as either autoproducers or main activity producers. Direct use or the secondary energy products, heat and electricity are reported based on the principal activity of the company.

2.5 Electrical Capacity

There are different ways to define capacity of a power plant. The turbine manufacturer declares name plate capacity given a certain inlet and outlet pressure and temperature. However, the field may have higher or lower pressure with respect to the reference inlet and outlet turbine reference pressure. For example, a 40 MW_e name plate capacity turbine can be calibrated to produce 45 MW_e, which is then referred to as installed capacity. The generator although will be the controlling factor as to how much electricity can be generated.

In time the field may slowly deplete and the capacity of the power plant decrease. Therefore running capacity or operational capacity is preferable to illustrate the capacity of the respective power plant.

There are a few points worth mentioning regarding the difference in reporting of electrical capacity by different organizations. Data on name plate capacity is not gathered as such by any of the organizations compared. Installed capacity is gathered by IGA and IEA-GIA gathers gross installed capacity which is not defined further in the respective questionnaire or in the derived report. Often what is considered as installed capacity is equal to name plate capacity. Official statistics report net maximum electrical capacity which is defined as follows:

> **Net maximum capacity:** "is the maximum active power that can be supplied, continuously, with all plant running, at the point of outlet (i.e. after taking the power supplies for the station auxiliaries and allowing for the losses in those transformers considered integral to the station). This assumes no restriction of interconnection to the network. Does not include overload capacity that can only be sustained for a short period of time (e.g. internal combustion engines momentarily running above their rated capacity). The net maximum electricity-generating capacity represents the sum of all individual plants' maximum capacities available to run continuously throughout a prolonged period of operation in a day." (Eurostat, IEA, UNECE & OECD, 2012).

The capacity should include both electricity and CHP plants. If, for some reason, only gross capacity data can be provided, it should be stated clearly. It is assumed that all equipment is working properly and that the power can be disposed of without restrictions and that optimum conditions prevail as regards temperature and purity, and assuming that the output and method of production in a CHP plant are those which provide maximum electricity production (Eurostat, IEA, UNECE & OECD, 2012).

The IGA Geothermal Database states the operating/running capacities of plants. Total operating capacity of countries is reported by IEA-GIA. Some industrial representatives have argued that it is preferable to gather statistics on running capacity since original name-plate or installed capacity is often no longer relevant and gives the wrong image when electricity generation is put in context with the electric capacity

All the statistics organizations relate their capacity reporting to the end of the year, more specifically on the 31st of December. *The Annual Questionnaire on Electricity and Heat* requires also peak load demand and capacity at time of peak, but these do not base their capacity reporting on the 31st of December. The peak load demand is based on the national energy grid, and is therefore not divided by energy source. The peak load demand and available capacity at time of peak are defined below:

Peak load demand: “The peak load demand is the highest simultaneous demand for electricity satisfied during the year. Note that the electricity supply at the time of peak demand may include demand satisfied by imported electricity or alternatively the demand may include exports of electricity. Total peak load on the national grid is not the sum of the peak loads during the year on every power station as they may occur at different times.” (Eurostat, IEA, UNECE & OECD, 2012).

Available capacity at time of peak: “The available capacity of an installation at peak period is the maximum power at which it can be operated under the prevailing conditions at the time, assuming no external constraints. It depends on the technical state of the equipment and its ability to operate, and may differ from the *Net maximum capacity* due to outages at the time of peak load.” (Eurostat, IEA, UNECE & OECD, 2012).

2.6 Thermal Capacity

Currently, there is no reporting of thermal capacities to official statistics except for heat pumps. However, the European Union through Eurostat, has informed EEA states that based on Article 24 of Directive 2012/27/EC on Energy Efficiencies a questionnaire is being formed that will include questions concerning total thermal capacities on a national level of all heat producing plants and in particular for CHP plants with the aim of identifying possibilities of increased efficiencies for this sector.

Euroheat and Power collects statistics for District Heating and Cooling and accumulate thermal capacities or Total installed District Heating capacity in MW_{th}. The Euroheat and Power methodology is explained in report (Euroheat & Power, 2008). Since geothermal is not specifically categorized this data is omitted from comparison, although important to recognize the terminology of establishing thermal capacities.

IEA-GIA, IGA and EGEC all accumulate thermal capacities. However, only IGA defines it clearly; namely the difference in temperature of inlet and outlet multiplied with the maximum mass flow rate, converted then into MW_{th}.

Taking definitions of electrical capacities of official statistics into account it is suggested by the authors to accumulate two parameters: (1) Net maximum capacity being the maximum heat that can be supplied to consumers continuously throughout a prolonged period of operation in a day, taking the technical state of the equipment, its ability to operate and both distribution and transport losses into account, and (2) Peak load demand being the highest simultaneous demand for heat satisfied during the year. It shall be noted that this needs further discussions amongst stakeholders since this has not been defined explicitly.

The geothermal field capacity is the capacity of the wells in the geothermal field. The statistics about field capacity is not gathered but some studies have been made, e.g. one for the International Finance Corporation (IFC) of the World Bank Group which published a report with analysis of wells from 14 countries (IFC, June 2013). A research based on the IFC report was also done for all high temperature wells drilled in Iceland (Sveinbjörnsson, 2014). The IGA keeps a database of field capacities that essentially is similar to this. Since this information is gathered to estimate production capacities of geothermal systems and successes of drilling wells this is thought to be out of scope of this report and hence omitted for further discussion.

2.7 Losses

Losses of energy occur between production and the final stages of utilization. The quality of energy is based on its exergy (the energy available to be used or in other words, work potential). A high quality form of energy does not lose its exergy easily, while a low quality form of energy does the opposite. Electricity is a high quality form of energy capable of being transported long distances between countries without large losses of exergy. Heat, on the other hand is a low quality type of energy, losing a significant part of its exergy in the process from production (or extraction in the case of geothermal heat) to utilisation. To keep track of heat and electricity lost, data on distribution and transport losses should be reported. For electricity, losses in transformers which are not considered as integral parts of the power plants should also be included.

Losses are an important parameter to report and collect. It can be used for analysing exergy changes on a defined period, encouraging the minimization of exergy losses.

Comparing the questionnaires has the following results. All losses due to transport and distribution should be reported to the *Annual Questionnaire on Renewables and Wastes*.

The same applies to the *Annual Questionnaire on Electricity and Heat*, except that only losses due to transport and distribution of electrical energy and commercial heat are included, but not losses due to transport and distribution of direct uses. For electricity, losses in transformers are also included. Distribution losses are not required in industry statistics data submissions.

2.8 Heat Pumps

Geothermal heat pumps for residential space heating are a common application of geothermal energy. They use the near-surface heat as a renewable heat source.

Mandatory guidelines have been established for member states of the EU on calculating renewable energy from heat pumps from different heat pump technologies pursuant to Article 5 of Directive 2009/28/EC. Though this is not a requirement for countries outside of EU but it can serve as guidelines as to how to report direct use of heat pumps and heat sold. The guidelines are quite detailed with analysis and categorisation of known heat pumps in the market for consistency purposes. For further information see Directive 2009/28/EC. The following outline of methodology is used: in accordance with Annex VII of the Directive, the amount of renewable energy supplied by heat pump technologies (E_{RES}) shall be calculated based on the following formula:

$$E_{RES} = Q_{Usable} * \left(1 - \frac{1}{SPF}\right)$$

$$\text{and } Q_{Usable} = H_{HP} * P_{Rated}$$

where:

- Q_{Usable} – The estimated total of usable heat delivered by heat pumps [GWh].
- H_{HP} – Equivalent full load hours of operation [h].
- P_{Rated} – Capacity of heat pumps installed, taking into account the lifetime of different types of heat pumps [GW].
- SPF – The estimated average seasonal performance factor (The European Commission, 2013).

The IEA-GIA requests numerous data on small heat pumps (≤ 20 kW in residential buildings) and medium to large heat pump systems (> 20 kW). They divide heat pumps into two categories to distinguish the small heat pumps in private houses and their utilization in commercial and public buildings.

For small heat pumps they collect the following data:

- Number of pumps
- Installed capacity (MW_{th})
- Heat use (geothermal contribution) (GWh/year)
- Total heat use (GWh/year)
- Full load hours (hrs/year)
- Number of heat pumps with cooling option (cumulative)
- Actual full load cooling hours of a usual unit/ year (hrs/year)
- Geothermal cooling (GWh/year)

For the large ones they collect the following data:

- Number of office buildings using geothermal heat
- Total installed capacity in large GSHP systems (MW_{th})
- Total heat use (including auxiliary power) (GWh/year)
- Annual heat use (geothermal contribution) (GWh/year)
- Actual full load cooling hours of a mean unit/ year (hrs/year)
- Geothermal cooling (GWh/year)

IGA requests the type of heat pump installation, among the following types:

- Vertical ground coupled
- Horizontal ground coupled
- Water source (well or lake water)
- Others

Along with the equivalent full load operating hours per year and thermal energy use, IGA also requests the COP which IGA defines as:

> **COP** is output thermal energy/input energy of compressor for the respective climate.

Note that SPF in EU Directive 2009/28/EC differs from COP not only in terms of its seasonal averaging nature but also it accounts for electricity to run circulation pump for heat exchangers or groundwater extraction/injection.

The *Annual Questionnaire on Electricity and Heat* requests information on gross and net production of heat output, sold to third parties, for heat pumps. Electricity used in heat pumps to produce heat is also reported. The own use of energy with heat pumps should be reported as own use in the *Annual Questionnaire on Electricity and Heat* but as in the case of geothermal, if the statistical entity is considered an autoproducer the use is accounted for as direct use.

3 Final Use

Final energy use is categorized differently by organizations. Within EEA, the overall share of renewables is calculated based on ratio of renewables in final utilization. Hence, it is of financial concern for each EEA country to certify the calculation with reference to Directive 2009/2008/EC.

Energy for different uses to the end users is regarded as final use. Organizations categorize final use differently. They can for example vary in number of available categories, the names of categories, and the amount of energy in each category. This makes it hard to compare final use between organizations.

It is clear that for official statistics all end use of geothermal energy should be reported in one way or another, regardless of whether or not the energy is sold to a third party. But anyway the categorization is different for industry statistics.

The goal of this chapter is to point out how utilization categories differ between organizations as well as present the way Iceland submits data based on different requirements. For explanation purposes, the utilization categories of IGA and the official statistics are compared.

3.1 Utilization Categories

Utilization categories differ between organizations as mentioned above. In addition, the way each country interprets the categories is in some cases different. Therefore the available categories for the organizations are compared.

Table 1 shows the categories used when presenting information on geothermal energy by different organizations. It shows the main subcategories used when requesting direct use of geothermal energy in the *Annual Questionnaire on Renewables and Wastes*. The same categories are used when requesting heat and electricity in the *Annual Questionnaire on Electricity and Heat*. Industry and transport sectors have a few sub-categories and they are listed in Appendix II: Geothermal Energy Utilization Data.

Official statistics have many subcategories for industry and transport. The main category used for final use in the *Annual Questionnaire on Renewables and Wastes* is the "*Other*" category and its subcategories. IGA has a number of categories that differ from the official statistics categories. IEA-GIA also has a number of categories, differing from the aforementioned ones.

The final use of some countries is presented in a number of categories in the IGA geothermal database, but it is listed only in the category *Other: Non Specified* in the IEA Renewables Information 2012. However, it is accessible through other published material.

There are variations on how countries interpret data, and on how they are presented by different organizations. There are also many examples on different usage of categories. Chapter 4 explores how geothermal energy utilization differs among several organizations. The following subchapter explains how Iceland reports final use data to different organizations.

Table 1: Official statistics: Eurostat, IEA, OECD, UNECE and industry statistics of IGA and IEA-GIA.

Official statistics	Industry statistics	
Eurostat, IEA, OECD, UNECE	**IGA**	**IEA-GIA**
Other: Residential	Individual space heating	Space heating
Other: Fishing	District heating	District heating
Other: Agriculture/forestry	Air conditioning (cooling)	Greenhouses
Other: Commercial and public services	Greenhouse	Aquaculture/ Fish farming
Other: Non-specified	Fish farming	Agriculture, crop drying
Industry sector	Animal farming	Industry
Transport sector	Agricultural drying	Snow melting
	Industrial process heat	Bathing/ Swimming
	Snow melting	Other
	Bathing and Swimming	
	Geothermal heat pumps	
	Other uses	

3.2 Data Gathering from Statistical Units

As the previous subchapter stated, different international organizations have different utilization categories. For national agencies gathering, interpreting and disseminating the information to these organizations, a level of complexity arises due to the different utilization categories being used. To illustrate how these issues can be mitigated for other countries, a case study is reviewed based on the way Orkustofnun handles different utilization categories for Iceland accumulating data from around 200 statistical units.

Geothermal energy utilization of geothermal plants in Iceland is calculated by sending questionnaires to geothermal plants asking for actual data on geothermal utilization. The data collection of Orkustofnun is presented in more detail in Appendix III: Orkustofnun Data Collection. Since Iceland is a member of OECD and the EEA, Orkustofnun has for a long time submitted data to official statistics organizations. Since these organizations have different utilization categories from industry statistics, Orkustofnun has to accumulate the data in a more complex way to be able to categorize the statistical units in more than one way. Utilization categories of different organizations can be seen in Appendix II: Geothermal Energy Utilization Data with a summary of those that are used by Orkustofnun in Figure 5 showing the base categories (the diagram in the center) and how they overlap with categories of IGA (the middle diagram) and official statistics (the outer diagram).

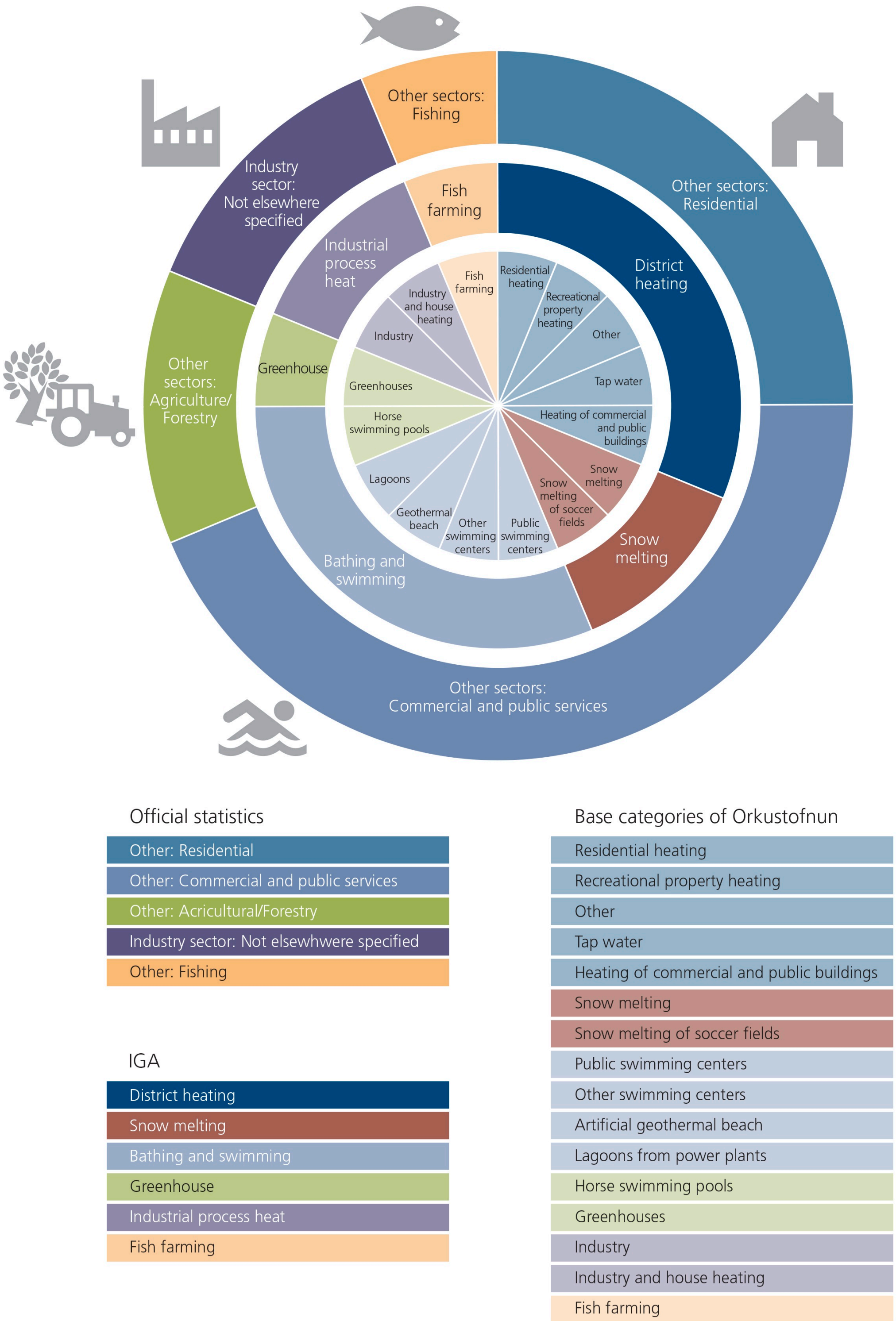


Figure 4: Base category relations to official and industry statistics. Note that the weight of categories is made equal for presentation purposes.

The categorizations for official and various industry statistics demand different base category combinations. For example, the category "District Heating" of IGA includes the base category "Heating of commercial and public buildings", while official statistics do not include it in their corresponding category "Other sectors: Residential". Therefore the categories "District heating" of IGA and "Other sectors: Residential" are not comparable. Otherwise, the categories are mostly comparable between agencies.

The objectives of industry statistics are to encourage research, the development and utilization of geothermal resources worldwide. Therefore industry statistics strives to highlight the qualities and usage of geothermal energy. For example, industry statistics publishes data on swimming pools and snow melting services which are practical uses of geothermal energy. Meanwhile, Orkustofnun returns data to official statistics, which has no categories for swimming pools and snow melting. The only way to present data for official statistics is by merging them under some specific official statistics category.

Each additional category adds extra cost to entities handling data because of added complexity. Therefore, a clear reason for each category should exist. For example, does it matter to break down the percentage of utilization by swimming pools and snow melting systems separately or jointly in the commercial and public services category? They could be presented in the same category and each category mentioned without knowing the exact percentage. Data and category differences of organizations makes comparison of data between organizations difficult, making it hard to choose which data is reliable. Instead of increasing the number of utilization categories with the following data handling cost utilization categories should be similar between organizations.

Definition of final heat use with geothermal energy for bathing in partly natural environment is a common issue of discussion within IEA-GIA and is one of the sources of differences in data reporting. Should heat evaporated from half man-made structures and natural pools account as heat or not? Take the Blue Lagoon in Iceland as an example. It is a man-made lagoon buying and utilizing waste water of a nearby geothermal power plant. To enter the site an admission fee needs to be paid. Since the energy is sold and bought it is considered as a commercial secondary energy product, and so is reported. How the buyer of the energy chooses to conserve energy is irrelevant for the data reporting. But it is a matter of energy efficiency, and the first step is to report and account for the energy used, even though the energy is being used extravagantly but nevertheless being used instead of being wasted.

Small natural pools are another matter. They are hot, natural and artesian flowing geothermal waters on the surface which are not sold, having no regulatory body surveying it as a bathing area and have no entrance fee. Then it is clear that the energy is neither a commercial product nor being used directly for a clear purpose. Hence the energy is simply part of the ambient air and surface. Orkustofnun hence does not report heat use of natural springs except where it is clear that the energy itself is a commercial product for a clear purpose. These two examples are illustrated in figure 5.

Figure 5: Above the Blue Lagoon and below a natural spring in Iceland.

4 Energy Statistics Comparison

This chapter examines geothermal energy use (Geothermal energy for heating and electricity from geothermal plants) of several countries with respect to different organizations to point out data differences between organizations.

4.1 Geothermal Energy for heating

As mentioned in chapter 2 secondary energy product and direct use are reported separately in official statistics. Therefore the total final energy use of geothermal origin (direct use and secondary energy) is regarded as total geothermal energy use. Industry statistics report heat for sale and direct use of geothermal energy together as geothermal energy utilization.

The data of different organizations is shown with respect to groups of countries. First, data from EEA/EFTA countries, then data from IEA-GIA countries and finally data from OECD countries from the *Renewables Information* annual publication by IEA (International Energy Agency, 2012).

A baseline is determined to show the differences of agencies to one specific organization. IGA is appointed to be the baseline organization. The baseline organization gets the value 1 for all countries. Data of other organizations get the value of a country reported by its organization divided by the reported number of the baseline organization. For example, a value of 1.1 represents 10% more final use of the particular organization than the baselines. Figures in this chapter use this methodology for the aforementioned groups of countries. Some organizations do not have values for some countries. That is the reason why values of countries in those type of figures for some organizations are not present.

Comparison of total utilization between datasets of different countries can be seen in the figures in this chapter for every group of countries. Tables with data on geothermal utilization of countries can be seen in Appendix II: Geothermal Energy Utilization Data.

The groups of countries in question are the following. Non-OECD countries are omitted.

> **EEA/EFTA countries:** Data for the countries of the European Economic Area (EEA) are presented with data from IGA as a baseline. The countries of EEA are the EU countries and the EFTA countries Norway, Iceland and Liechtenstein. Switzerland is an EFTA member but not a part of EEA.
>
> **IEA-GIA countries:** The *Trends in Geothermal Applications* report by IEA-GIA has data on IEA-GIA participant countries. IEA-GIA countries are used in the comparison.
>
> **OECD:** The *IEA Renewables Information* report by IEA has data on the OECD countries. OECD countries are used in the comparison.

The following figures represent the differences between data. The first figure presents the difference between organizations with respect to the baseline organization, IGA. The rest of the figures show the values of each organization with respect to groups of countries.

Figure 6 shows countries in the group of countries mentioned with IGA data as a baseline. Countries with no data or a value of zero for all organizations except for IGA are not shown in the figure. Those countries are Chile, Canada, Estonia, Finland, Ireland, Israel, Sweden, Bulgaria, Croatia and Latvia. There is no data on Liechtenstein, Malta, Cyprus and Luxembourg.

The figures show that very different data are presented by different organizations with the exception of a few countries. Iceland, France, Italy and Germany are the only countries whose data is presented on by all organizations in question. Of these countries, only Iceland has similar data between organizations. Data on USA is very different between organizations while data on Norway, presented by IGA and by IEA-GIA is identical, as it should be. Average absolute deviation from the baseline for all the groups of countries can be seen in Table 2. The absolute deviations of all countries based on the organization and average deviations can be seen in Appendix VI: Average Absolute Deviation.

The difference between data for each country is not consistent among organizations. For example, data on different countries from the *IEA renewables information* does not always have the highest or the lowest value. No organization consistently presents the lowest or the highest numbers, but it fluctuates from country to country. It is also difficult to compare utilization categories between organizations for individual countries because the correlation of data seems so little.

Even though there is accordance of data within a country it does not mean that the statistics regarding geothermal energy are correct. In many countries, geothermal energy is only a small part of the total energy utilization. Nevertheless it is essential for all purposes that one version of data is used universally, and so a trend in energy utilization can be tracked. It is important for the countries reporting total energy utilization that the data gathering methods are correct.

Table 2: Average absolute deviation for groups of countries.

Group of countries	**Average deviation**
IEA Renewables countries	325%
EEA/EFTA	503%
IEA-GIA	184%

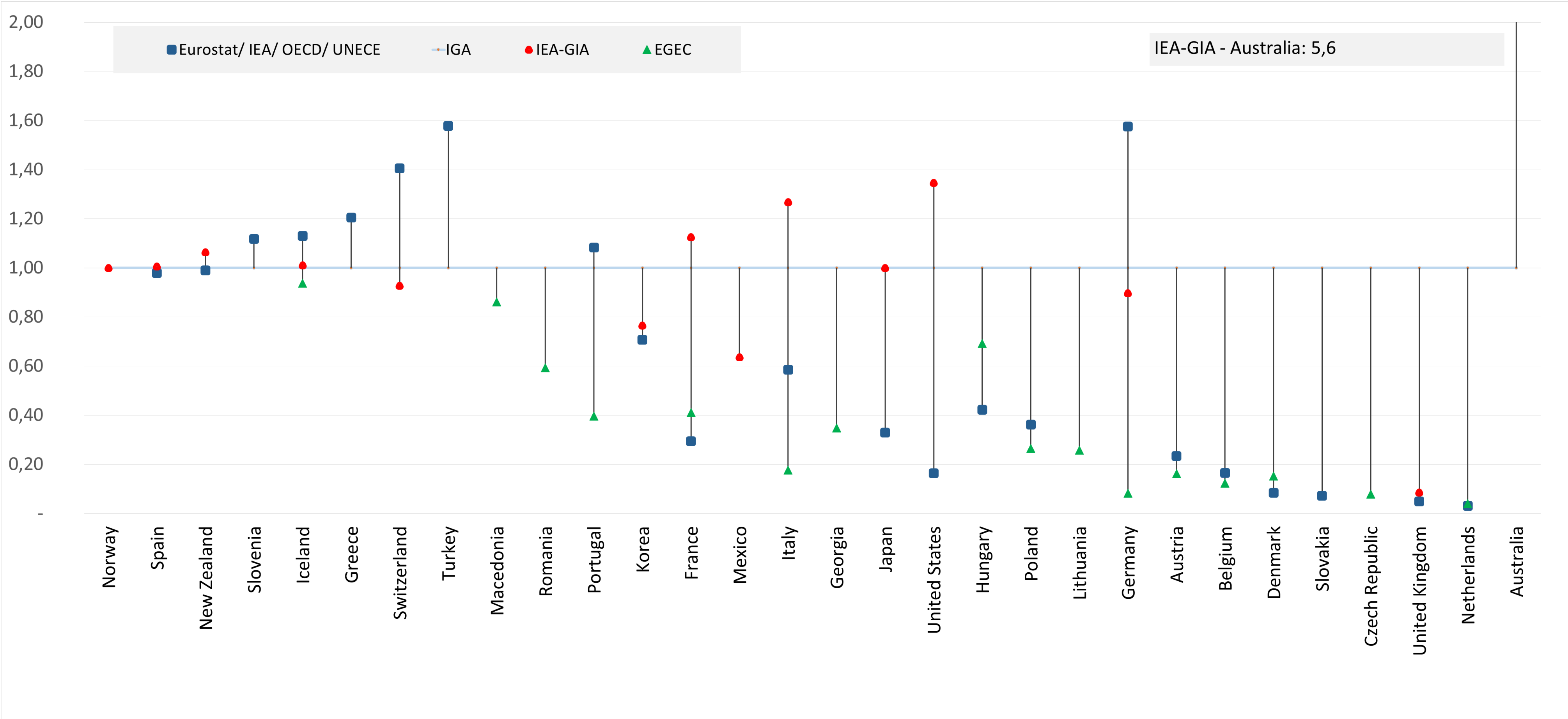


Figure 6: Total final energy use of geothermal origin. Data is presented in a ratio having IGA data as the numerator and data from other organizations as the denominator. Note that the vertical axis shows a ratio between two numbers but not absolute variation of each number. The minimum and maximum ratio is 0,03% for the Netherlands and 560% for Australia, respectively. That translates to a 3194% difference in data for the Netherlands and 560% for Australia. Hence the absolute maximum difference is for the Netherlands. The reason for having IGA as the baseline is because it has values for most of the countries.

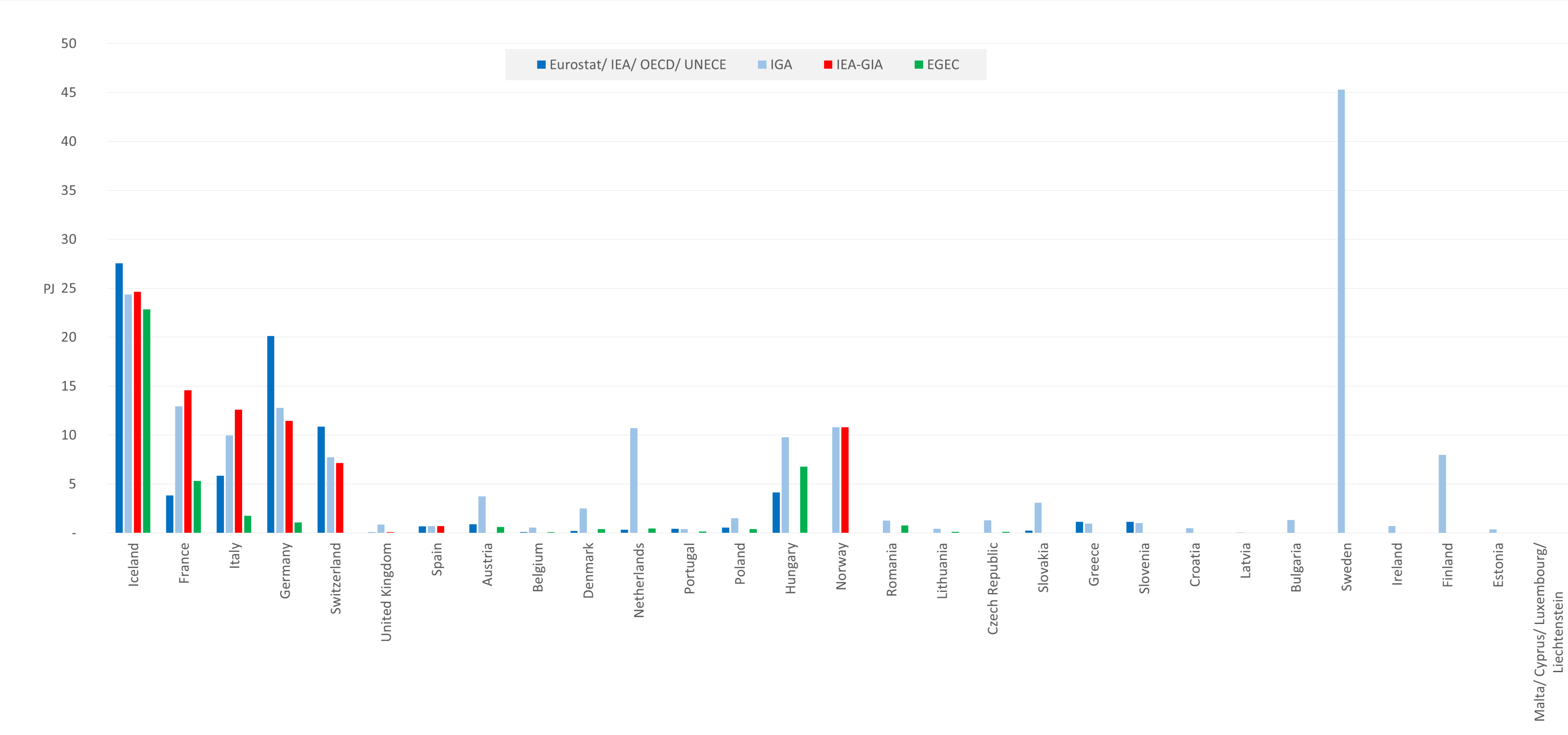


Figure 7: Total final energy use of geothermal origin for EEA/ EFTA countries. Comparison of utilization data.

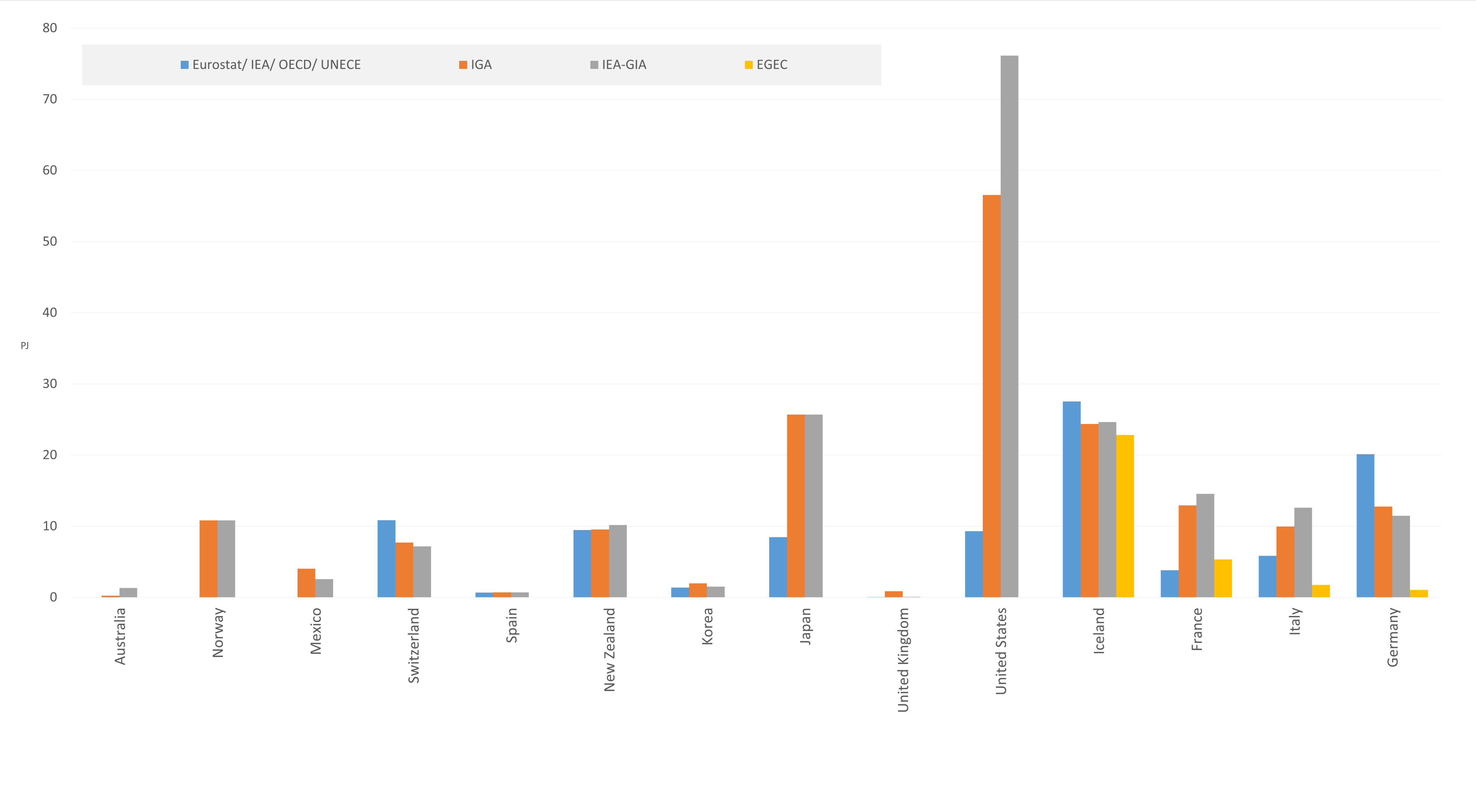


Figure 8: Total final energy use of geothermal origin of IEA-GIA countries. Comparison of utilization data

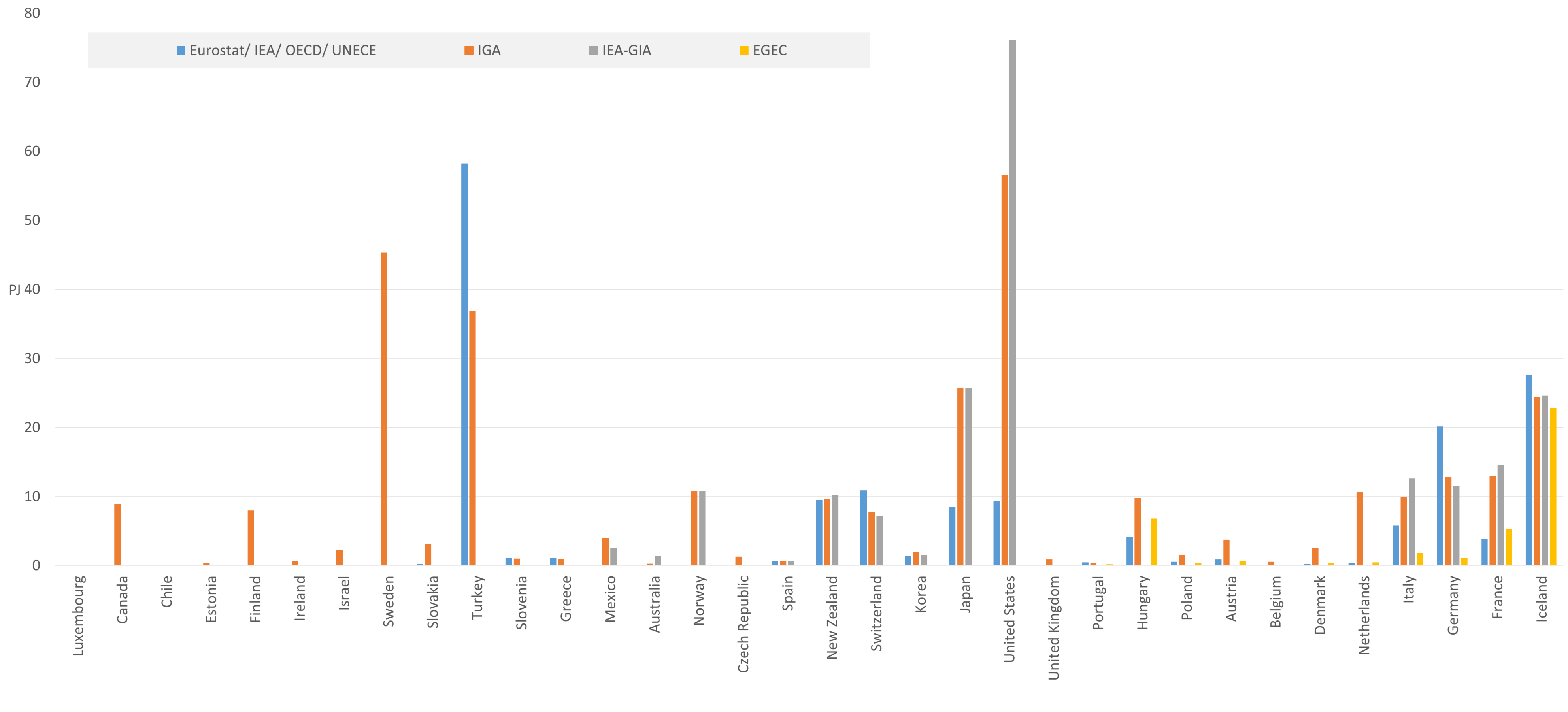


Figure 9: Total final energy use of OECD countries in the IEA Renewables Information annual publication. Comparison of utilization data.

4.2 Electricity from geothermal power plants

There are also differences when comparing the production of geothermal electricity for IEA and IEA-GIA. Table 3 shows the comparison of data from the years 2000–2012 for several countries. The fields where IEA-GIA data is below 0,9 or above 1,1 of IEA data are highlighted in red. The reason, e.g. for France, is the electricity generation of the overseas departments, Guadeloupe and Martinique in the Caribbean.

Table 3: Geothermal electricity production of IEA and IEA-GIA.

IEA													
Geothermal electricity [MWh/a]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
AUSTRALI	-	-	-	-	-	-	-	-	-	403,000	500,000	500,000	500,000
GERMANY	-	-	-	-	198,000	180,000	365,000	416,000	17.600,000	18.800,000	27.700,000	18.800,000	25.400,000
FRANCE	-	-	-	-	-	-	-	-	-	-	-	169,000	-
ICELAND	1.323.000,000	1.451.000,000	1.433.000,000	1.406.000,000	1.483.484,000	1.657.997,000	2.631.272,000	3.578.547,000	4.037.656,000	4.553.087,000	4.465.322,000	4.701.463,000	5.209.543,000
ITALY	4.705.000,000	4.507.000,000	4.662.000,000	5.341.000,000	5.437.266,000	5.324.460,000	5.527.366,000	5.569.128,000	5.520.315,000	5.341.822,000	5.375.916,000	5.654.263,000	5.591.685,000
JAPAN	3.347.942,000	3.431.499,000	3.374.025,000	3.483.962,000	3.373.646,000	3.225.727,000	3.080.853,000	3.043.724,000	2.749.767,000	2.886.608,000	2.632.165,000	2.676.246,000	2.609.499,000
MEXICO	5.901.000,000	5.567.000,000	5.397.616,000	6.281.663,000	6.576.805,000	7.298.506,000	6.685.363,000	7.403.854,000	7.055.760,000	6.739.666,000	6.618.460,000	6.506.614,000	5.816.642,000
NZ	2.921.400,000	2.838.444,000	2.813.972,000	2.750.310,000	2.789.015,000	3.159.489,000	3.367.915,000	3.554.936,000	4.203.833,000	4.864.738,000	5.882.885,000	6.119.988,000	6.193.705,000
USA	14.621.000,000	14.246.000,000	14.939.000,000	14.870.341,000	15.486.502,000	16.778.466,000	16.580.928,000	16.797.640,000	16.872.844,000	17.045.894,000	17.576.826,000	17.892.149,000	18.135.290,000
IEA-GIA													
Geothermal electricity [MWh/a]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
AUS	900,000	na	1.000,000	1.000,000	1.000,000	500,000	700,000	500,000	800,000	600,000	-	600,000	500,000
DEU	-	-	-		1.500,000	1.500,000	1.500,000	400,000	18.000,000	19.000,000	27.500,000	18.700,000	25.400,000
FRA	24.600,000	na	24.600,000	na	na	102.000,000	102.000,000	95.000,000	90.000,000	89.000,000	14.900,000	56.600,000	50.600,000
ISL	1.138.000,000	na	1.395.000,000	1.433.000,000	1.433.000,000	1.483.000,000	2.631.000,000	3.600.000,000	4.000.000,000	4.553.000,000	4.465.000,000	4.701.000,000	5.210.000,000
ITA	4.403.000,000	na		5.036.000,000	5.127.000,000	5.340.000,000	5.200.000,000	5.233.000,000	5.181.000,000	5.200.000,000	5.376.000,000	5.315.000,000	5.235.000,000
JPN	3.532.000,000	na	3.437.000,000	3.437.000,000	3.486.000,000	3.467.000,000	3.228.000,000	3.102.000,000	3.064.000,000	2.765.000,000	2.908.000,000	2.652.200,000	2.688.800,000
MEX	5.681.000,000	na	5.398.000,000	6.283.000,000	6.360.000,000	6.282.000,000	6.685.000,000	7.393.000,000	7.056.000,000	6.740.000,000	6.618.000,000	6.524.000,000	5.817.000,000
NZL	2.756.000,000	2.678.000,000	2.655.000,000	2.594.000,000	2.631.000,000	2.981.000,000	3.177.000,000	3.354.000,000	3.966.000,000	4.589.000,000	5.550.000,000	5.774.000,000	5.843.000,000
USA	15.470.000,000	13.741.000,000	14.491.000,000	14.424.000,000	14.811.000,000	14.692.000,000	14.568.000,000	14.500.000,000	15.000.000,000	15.000.000,000	15.009.000,000	16.700.000,000	16.791.000,000

5 Conclusion

The aim of this report was to give an overview of the international collection of geothermal energy statistics by various international organizations, offices and associations to enable interoperability of energy statistics, increase reliability and decrease fragmentation in line with the aim of these organizations.

Official statistics are gathered in a unified manner from legally responsible national agencies. This is the case for the IEA, Eurostat, OECD and UNECE. The data accumulated overall covers the main aspects of geothermal energy in a comparable manner for all primary energy forms with some degree of freedom for methodology of calculations within clear and acceptable constraints with examples in the report. Review of national reporting illustrates however that some countries are not reporting correctly within given terminology. Official statistics for geothermal have had a stigma within the geothermal industry to be unreliable, complicated and not accessible. Review of data has not illustrated the stigma to have merit in comparison to industry statistics which have thought to be more reliable. For Member States of the European Union the importance of official energy statistics has increased due to the 2020 targets. The efforts carried out by Eurostat and the Member States have also contributed to improve data quality and reliability over the last years.

Industry statistics are fragmented between organizations in terms of terminology. Submissions of data are based on member participations and sometimes experts are appointed by national geothermal associations gathering data on an individual level. It hence relies on experts within the respective association to supply correct data. Some go into more details than others concerning particular aspects but none serve as a basis for an energy balance between primary energy use and final use. However, for particular aspects more details are accumulated within some industry statistics. The added value can though be questioned in some cases compared to the added value of unified terminology, at least for basic parameters.

Comparison of reported national statistics of industry and official statistics show a difference in orders of magnitude in some cases and typically factors of two to five although for some countries it is 5-10%. From the comparison there is no clear trend of one being lower relative to another. This cannot be explained only by the observed differences in time periods or terminology. The most plausible explanation is concluded to be the methodology of data collection and treatment from statistical units leading to drastic and random differences in addition to variations in given assumptions which are not given in definitions of terminology but rather how this is interpreted and practiced from one expert to the other. There is a clear lack of review across organizations within industry statistics and in particular with official statistics leading to these differences. Internal review processes of each organization is evidentially unsatisfactory. No organization consistently presents the lowest or the highest values, the difference essentially being random with no obvious trend although some factors are known to perturb some parameters, further outlined in this report.

The conclusion is that data requirements of official statistics contain information on aspects of geothermal energy sufficient for a transparent and detailed data presentation. It can therefore be used to customize questionnaires of other organizations with basic parameters with unified definitions and only asking for further details when the added value justifies the additional complexity. It is also concluded that the differences shown are beyond acceptable levels and actions are needed to reduce these differences if the statistics are to be taken seriously.

Figure 10 shows how the data is collected from the statistical units; autoproducers and the main activity producers. For the official statistics, the data is gathered by the National Statistics Energy Agencies for IEA, Eurostat, UNECE and OECD. For the Industry statistics the data is collected from the producers by the National Geothermal Associations, Clusters, lobby groups and sometimes by the respective national statistics energy agencies or departments, for IGA, IEA-GIA and EGEC separately leading to differences between.

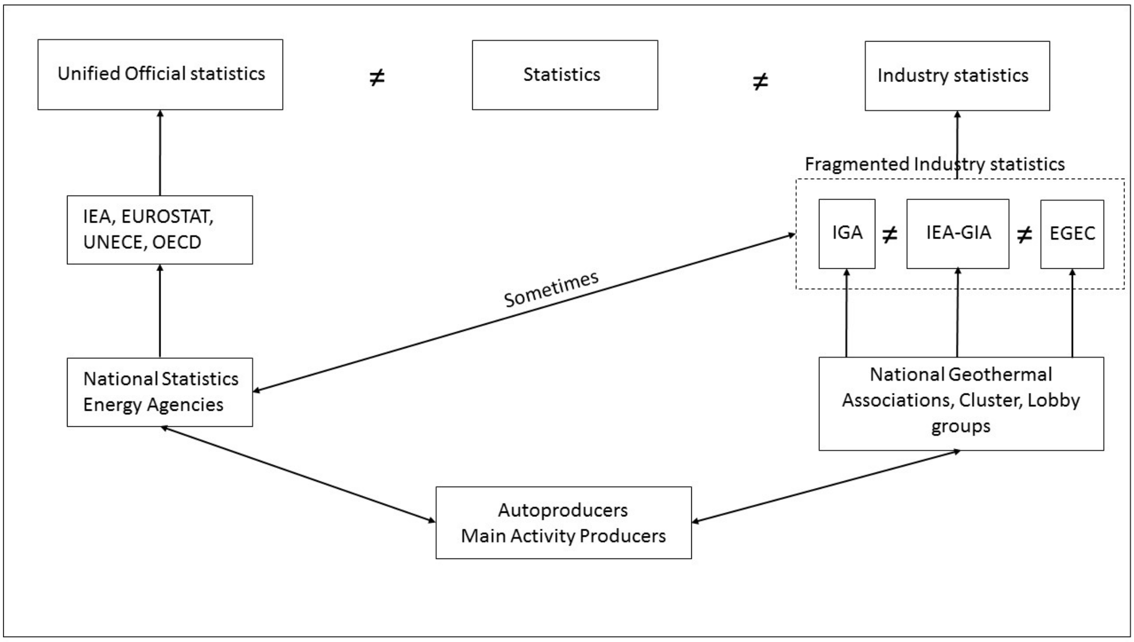


Figure 10: Here the current duplicated mechanism is shown leading to statistics not being comparable.

6 Recommendations

It is pointed out that international cooperation is needed on reviewing submissions of geothermal energy statistics to different organizations. Such review could lead to both unified statistics as well as unified terminology.

The GeoStat Joint Activity is proposed under the framework of the Geothermal ERA-NET having the main international organizations collaborating on reviewing and unifying statistics using the existing framework and regulation. Figure 11 illustrates the added value of the activity in comparison to the current framework concluded in Figure 10. This should be an iterative review process of data submissions to existing international organizations to make the statistics interoperable.

It is recommended that this report should be disseminated to respective stakeholders on an individual basis and through seminars both online and in person. Meetings with IEA and Eurostat can serve an important role to disseminate and review how IEA and Eurostat current terminology is being interpreted by the annual reporting entities and how it can be compared to the basis of the industry statistics.

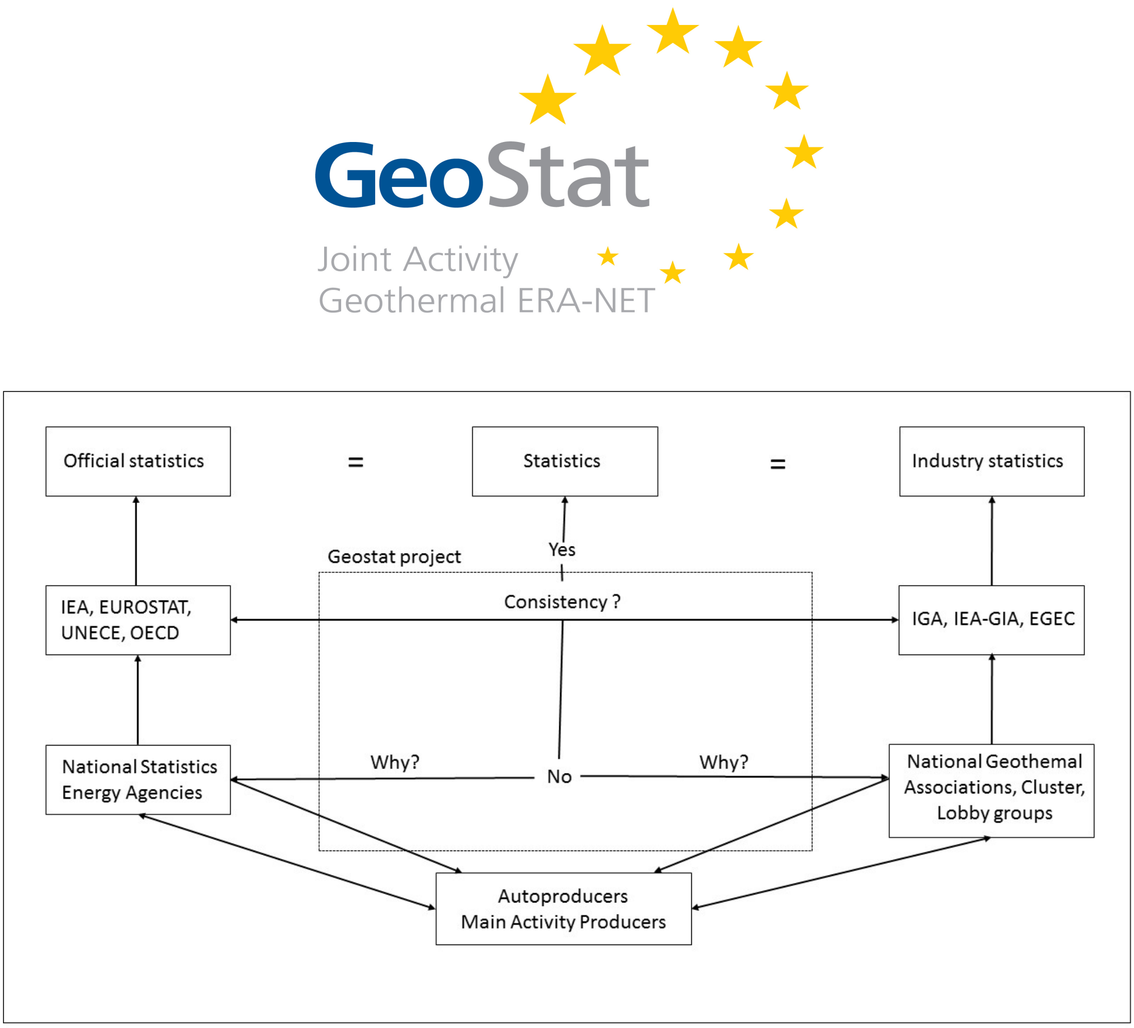


Figure 11: The added value to existing framework previously shown in Figure 10 (simplified) with proposed logo of the GeoStat Joint Activity of the Geothermal ERA-NET.

Here are proposed objectives with measurable indicators and how GeoStat can achieve those:

1. **Participating countries to aim at reducing the difference between industry and official statistics below a defined benchmark for year 2020. The following indicators are proposed on a national level annually:**

    a. Total Net Maximum Electrical Capacity
    b. Total Electricity Generation
    c. Total Geothermal Direct Use and Heat in Final Use

    GeoStat could facilitate by aiming at identifying the source of error in each case with dissemination and discussions on terminology and definitions and direct comparison of statistics for each nation.

2. **Participating countries to aim at reducing duplication of efforts domestically. Measureable indicators suggested:**

    a. Number of months until Joint Questionnaires sent to IEA and Eurostat on Renewables and Electricity and Heat are made available to the public by the sender

    GeoStat could assist in making the files accessible electronically on a website with other sources accessible on a national basis.

3. **Collaboration between entities on a domestic level having the following indicator:**

    a. The respective experts responsible for each data submission for both official and industry statistics know about each other, by organising meetings with the relevant persons from the various organizations.

    GeoStat to make the connections between experts on a domestic level.

4. **Simplified process across organizations and reducing duplication of efforts with the following indicators:**

    a. While respecting the impartiality and independence of official statistics, associations and lobby groups could analyse official statistics and provide comments for improvement.
    b. Terminology of industry to follow official statistics when possible.
    c. Terminology of official statistics be clear and understandable.

    GeoStat to make the connections and starting the review process in cooperation with the partners. To make the terminology clearer. GeoStat to write a short manual with terminology and definition already identified in this report. In particular for thermal capacity.

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Appendix I: Terminology and Abbreviations

Abbreviations

CHP: Combined Heat and Power

EC: European Commission

EEA: The European Economic Area

EFTA: The European Free Trade Association

EGEC: the European Geothermal Energy Council

EGIP: European Geothermal Information Platform

ERA-NET: Networking the European Research Area

EU: European Union

IEA: International Energy Agency

IEA-GIA: International Energy Agency - Geothermal Implementing Agreement

IEA Geothermal: Another reference name to IEA-GIA

IGA: International Geothermal Association

IPGT: International Partnership for Geothermal Technology

IRENA: International Renewable Energy Agency

OECD: The Organization for Economic Co-operation and Development

OS: Orkustofnun, the national Energy Authority of Iceland

TFC: Total Final Consumption

TPES: Total Primary Energy Supply

UN: The United Nations

UNECE: The United Nations Economic Commission for Europe

Terminology

Autoproducer: "Autoproducer undertakings generate electricity and/or heat, wholly or partly for their own use as an activity which supports their primary activity. They may be privately or publicly owned" (Eurostat, IEA, UNECE & OECD, 2013).

Base Categorization: A detailed categorization used to unify categories based on the different categorizations of different organizations.

Combined heat and power (CHP) plants refer to plants which are designed to produce both heat and electricity (Eurostat, IEA, UNECE & OECD, 2013).

Direct use: Direct use is defined as the direct use of geothermal energy for district heating, agriculture, etc. Official statistics defines it as the geothermal energy by autoproducers not for sale to third parties.

EEA: The European Economic Area (EEA) provides free movement of goods, services, persons and capital through three of four member states of the European Free Trade Association (EFTA) (Iceland, Liechtenstein and Norway) and 27 of 28 member states of the European Union (EU), with Croatia provisionally applying the agreement pending its ratification by all EEA countries.

EGEC: "EGEC, the European Geothermal Energy Council, was founded in 1998 as an international non-profit association in Brussels. EGEC has now more than 129 members from 28 European countries: private companies, national associations, consultants, research centers, geological surveys and other public authorities. EGEC is a member of EREC, the European Renewable Energy Council, which groups together all of the main European renewable energy industry and research associations. EGEC is also a member of the International Geothermal Association (IGA)." (The European Geothermal Energy Council, 2014)

Electricity plants refer to plants which are designed to produce electricity only (Eurostat, IEA, UNECE & OECD, 2013).

ERA-NET: "A new scheme designed to support the long-lasting coordination of European research programmes across national boundaries, aimed at the funders and managers of national and regional research programmes. The ERA-NET scheme represents a significant step towards the creation of a fully functioning European Research Area." (European Commission, 2004).

Euroheat & Power: "It is the international association representing the District Heating and Cooling (DHC) and Combined Heat and Power (CHP) sector in Europe and beyond." (Euroheat & Power, 2014).

European Commission: "The European Commission represents the interests of the EU as a whole. It proposes new legislation to the European Parliament and the Council of the European Union, and it ensures that EU law is correctly applied by member countries." (European Commission, 2014).

European Geothermal Information Platform (EGIP):
"The EGIP pilot is the result of a Joint Activity carried out in the frame of the *Geothermal ERA-NET* coordination project supported by European Union's Seventh Programme. The core function of the EGIP is to organize geothermal data and information at a European scale. The EGIP pilot is aimed to demonstrate the platform capabilities and usefulness to the main geothermal actors in Europe (i.e., scientists, politics and industrials). (EGIP , 2014)

European Union (EU): "The EU is a unique economic and political partnership between 28 European countries" (European Union, 2014).

Eurostat: "Eurostat is the statistical office of the European Union situated in Luxembourg. Its task is to provide the European Union with high quality statistics at European level that enable comparisons between countries and regions." (Eurostat, 2014).

Final use: Consumption of geothermal energy by different end-use sectors.

Geothermal ERA-NET: The Geothermal ERA-NET is a cooperation initiative started on May 1st 2012 and will last for four years. It is different from other conventional research projects since in this case the grant is for cooperation and coordination of the research plan of the countries involved, but not for direct research. The Geothermal ERA-NET is the first step towards a coordinated research in the EU, through the SET-Plan (European Strategic Energy Technology Plan)." (Geothermal ERA-NET, 2014).

Geothermal plants: The types of geothermal plants are heat plant, electricity plant and combined heat & power plant (CHP).

Gross electricity production: "*Gross electricity production* is the sum of the electrical energy production by all the generating sets concerned (including pumped storage) measured at the output terminals of the main generators." (Eurostat, IEA, UNECE & OECD, 2012).

Gross geothermal primary energy use: It is the primary energy of geothermal fluid of a reservoir processed on a given period (Eurostat, IEA, OECD, 2005).

Gross heat production: "*Gross heat production* is the total heat produced by the installation and includes the heat used by the installation's auxiliaries that use a hot fluid (space heating, liquid fuel heating, etc.) and the losses in the installation/network heat exchanges, as well as heat from chemical processes used as a primary energy form. Note that for autoproducers, heat used by the undertaking for its own processes is not included here; only heat sold to third parties should be reported. As only heat sold to third parties is reported, gross heat production for autoproducers will be equal to net heat production." (Eurostat, IEA, UNECE & OECD, 2012).

Heat plants refer to plants designed to produce heat only (Eurostat, IEA, UNECE & OECD, 2013).

Industry statistics: Datasets on geothermal energy statistics for IEA-GIA, EGEC, IGA and other agencies not part of official statistics (See definition on Official Statistics).

International Energy Agency (IEA): "The IEA is an autonomous organization which works to ensure reliable, affordable and clean energy for its member countries and beyond. The IEA's four main areas of focus are: energy security, economic development, environmental awareness, and engagement worldwide." (International Energy Agency, 2014).

IEA Geothermal (IEA-GIA Geothermal Implementing Agreement): The Geothermal Implementing Agreement (GIA), or IEA Geothermal, provides a flexible and powerful framework for international geothermal collaboration among countries, industries and industry organizations, and operates under the auspices of the International Energy Agency (IEA), Paris, France (IEA-GIA, 2014).

International Geothermal Association (IGA): "The IGA is a non-political, non-profit, non-governmental organization. The objectives of the IGA are to encourage research, the development and utilization of geothermal resources worldwide through the publication of scientific and technical information among the geothermal specialists, the business community, governmental representatives, UN organizations, civil society and the general public." (International Geothermal Association, 2014).

International Renewable Energy Agency (IRENA): "The International Renewable Energy Agency (IRENA) is an intergovernmental organization that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity." (International Renewable Energy Agency, 2014).

IPGT: "The International Partnership for Geothermal Technology is composed of Australia, Iceland, United States, Switzerland, and New Zealand. The purpose of the IPGT is to accelerate the development of geothermal technology through international cooperation. EGS is in an early stage of development and groups throughout the world are working to develop effective methodologies and practices." (International Partnership for Geothermal Technology, 2014).

Main activity producers "generate electricity and/or heat for sale to third parties, as their primary activity. They may be privately or publicly owned. Note that the sale need not take place through the public grid." (Eurostat, IEA, UNECE & OECD, 2013).

Net electricity production: *"Net electricity production* is equal to the gross electricity production less the electrical energy absorbed by the generating auxiliaries and the losses in the main generator transformers." (Eurostat, IEA, UNECE & OECD, 2012).

Net geothermal primary energy use: is the gross geothermal primary energy use minus the primary energy of the re-injected fluid in the geothermal reservoir (Eurostat, IEA, OECD, 2005).

Net heat production: *"Net heat production* is the heat supplied to the distribution system as determined from measurements of the outgoing and return flows" (Eurostat, IEA, UNECE & OECD, 2012).

Official statistics: Recognised national energy statistics by the IEA, OECD, UNECE, Eurostat and the UN.

Orkustofnun (OS - the national energy authority): "An Icelandic government agency under the Ministry of Industries and Innovation. Its main responsibilities are to advise the Government of Iceland on energy issues and related topics, license and monitor the development and exploitation of energy and mineral resources, regulate the operation of the electrical transmission and distribution system and promote energy research." (Orkustofnun (The National Energy Authority), 2014).

Primary energy: The primary energy of a geothermal fluid is its maximum usable thermal energy.

Reference state: According to regulation (EC) No 1099/2009, energy production from geothermal fluid is defined as the difference between the enthalpy of fluid from a borehole and the enthalpy of the disposal fluid. The state of the disposal fluid, temperature and pressure, is defined as the reference state.

Re-injection: Action of returning the liquid extracted from a geothermal reservoir to the same reservoir through one or more wells. The action can be made by gravity or by pumping.

The European Free Trade Association (EFTA): "The European Free Trade Association (EFTA) is an intergovernmental organization set up for the promotion of free trade and economic integration to the benefit of its four Member States. The member states are Iceland, Switzerland, Norway and Liechtenstein." (European Free Trade Association, 2014).

The Organization for Economic Co-operation and Development (OECD): "The mission of the Organization for Economic Co-operation and Development (OECD) is to promote policies that will improve the economic and social well-being of people around the world." (OECD, 2014).

The United Nations Economic Commission for Europe (UNECE): "UNECE's major aim is to promote pan-European economic integration. To do so, it brings together 56 countries located in the European Union, non-EU Western and Eastern Europe, South-East Europe and Commonwealth of Independent States (CIS) and North America. All these countries dialogue and cooperate under the aegis of UNECE on economic and sectoral issues. However, all interested United Nations member States may participate in the work of UNECE. Over 70 international professional organizations and other non-governmental organizations take part in UNECE activities." (UNECE, 2014).

Transformation processes: Transformation of energy to secondary energy products (Eurostat, IEA, UNECE & OECD, 2013).

Transformation sector: All the activities based on transformation of energy (Eurostat, IEA, UNECE & OECD, 2013).

UN: "The United Nations is an international organization founded in 1945 after the Second World War by 51 countries committed to maintaining international peace and security, developing friendly relations among nations and promoting social progress, better living standards and human rights." (United Nations, 2014).

Vigor: A book keeping system maintaining data on sales of hot water. Data is according to the base categories.

Official Statistics: Geothermal Utilization Categories

Information on energy utilization for official statistics is presented in the following categories (Eurostat, IEA, UNECE & OECD, 2013)

Final energy consumption observed is equal to total energy consumption in industry, transport and other sectors. It is defined as Gross consumption minus the Transformation sector, the Energy sector, Distribution losses and Statistical differences.

Industry
Report renewable energies and waste consumed by industrial undertakings in support of their primary activities. Report quantities consumed in boilers or CHP plants for the production of heat used by the plant itself. Quantities consumed for the production of heat that is sold, and for the production of electricity should be reported under the appropriate Transformation sector.

- **Iron and Steel:** ISIC Group 241 + Class 2431 (NACE Groups 24.1, 24.2, 24.3 + Classes 24.51 and 24.52).
- **Chemical (including Petrochemical):** ISIC and NACE Divisions 20 and 21.
- **Non-Ferrous Metals:** ISIC Group 242 + Class 2432 (NACE Group 24.4 + Classes 24.53 and 24.54).
- **Non-Metallic Minerals:** ISIC and NACE Division 23. Report glass, ceramic, cement and other building materials industries.
- **Transport Equipment:** ISIC and NACE Divisions 29 and 30.
- **Machinery:** Report fabricated metal products, machinery and equipment other than transport equipment. ISIC and NACE Divisions 25, 26, 27 and 28.
- **Mining (excluding energy producing industries) and Quarrying:** ISIC Divisions 07 and 08 + Group 099 (NACE Divisions 07 and 08 + Group 09.9).
- **Food Processing, Beverages and Tobacco:** ISIC and NACE Divisions 10, 11 and 12.
- **Pulp, Paper and Printing:** ISIC and NACE Divisions 17 and 18. Includes production of recorded media.
- **Wood and Wood Products (other than pulp and paper):** ISIC and NACE Division 16.
- **Construction:** ISIC and NACE Divisions 41, 42 and 43.
- **Textile and Leather:** ISIC and NACE Divisions 13, 14 and 15.
- **Not Elsewhere Specified - Industry:** If your country's industrial classification of fuels consumption does not correspond to the above ISIC or NACE codes, please estimate the breakdown by industry and include in "Not elsewhere specified" only consumption in sectors which is not covered above. ISIC and NACE Divisions 22, 31 and 32.

Transport
Report fuels used in all transport activities (non-stationary) irrespective of the economic sector in which the activity occurs. Report fuels consumed in the following ISIC and NACE categories: Divisions 49, 50 and 51.

- Rail: Report all consumption by rail traffic, including industrial railways. Consumption by rail transport as part of urban or suburban transport systems should be reported in “non-specified (Transport)”.
- Road: Report fuels for use in road vehicles. Includes fuel used by agricultural vehicles on highways. Excludes military use in road vehicles (see Other Sector - Not Elsewhere Specified). Excludes liquid biofuels reported as “For Blending to Motor Gasoline / Diesel” and biogases reported as “For Blended Natural Gas”.
- Domestic Navigation: Report fuels delivered to vessels of all flags not engaged in international navigation. Domestic navigation is determined on the basis of port of departure and port of arrival and not by the flag or nationality of the ship. Note that this may include journeys of considerable length between two ports in a country (e.g. San Francisco to Honolulu).
- Not Elsewhere Specified - Transport: Report fuels used for transport activities not included elsewhere. Please state on the Remarks page what is included under this

heading.

Other Sectors

- **Commercial and Public Services:** Report fuels consumed by business and offices in the public and private sectors. ISIC and NACE Divisions 33, 36, 37, 38, 39, 45, 46, 47, 52, 53, 55, 56, 58, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 71, 72, 73, 74, 75, 77, 78, 79, 80, 81, 82, 84, 85, 86, 87, 88, 90, 91, 92, 93, 94, 95, 96 and 99.
- **Residential:** Report fuels consumed by all households including "households with employed persons." ISIC and NACE Divisions 97 and 98.
- **Agriculture/Forestry:** Report fuels consumed by users classified as agriculture, hunting and forestry by ISIC as follows: ISIC Divisions 01 and 02 (NACE 01 and 02).
- **Fishing:** Report fuels delivered for inland, coastal and deep-sea fishing. Fishing should cover fuels delivered to ships of all flags that have refueled in the country (include international fishing). Also include energy used in the fishing industry as specified in ISIC and NACE Division 03.
- **Not Elsewhere Specified**: – Other Sectors: Report activities not included elsewhere. This category includes military fuel use for all mobile and stationary consumption (e.g. ships, aircraft, road and energy used in living quarters), regardless of whether the fuel delivered is for the military of that country or for the military of another country. Please specify on the Remarks page what is included under this heading.

Industry Statistics: Geothermal Utilization Categories

IEA-GIA: Questionnaire for the Report on Trends in Geothermal Applications 2012

- District Heating
- Cascaded uses
- Space heating
- Bathing/ swimming
- Greenhouses
- Agriculture, crop drying
- Aquaculture/ Fish farming
- Industry
- Snow melting
- Other (Ganz, 2012)

IGA Geothermal Database

- Individual space heating
- District heating
- Air conditioning (cooling)
- Greenhouse
- Animal farming
- Fish farming
- Agricultural drying
- Industrial process heat
- Snow melting
- Bathing and swimming

- Geothermal heat pumps
- Other uses (International Geothermal Association, 2014)

Iceland Base Categories

- Residential
- Recreational property heating
- Other
- Tap water
- Heating of commercial and public buildings
- Snow melting
- Snow melting of soccer fields
- Public swimming centers
- Other swimming centers
- Artificial geothermal beach
- Lagoons from power plants
- Horse swimming pools
- Greenhouses
- Industry
- Industry and house heating
- Fish farming

Appendix II: Geothermal Energy Utilization Data

Information on geothermal energy utilization data is presented in this appendix. Information from the IEA Renewables Information 2011 is presented in the first subchapter. Table 5. Renewable and waste balance. Geothermal data for all countries is placed in a table. Information from the IGA Geothermal Database is presented in the second subchapter. Information from the report "IEA-GIA – Trends in Geothermal Applications 2010" is presented in the third subchapter. All data is from the year 2010 and all units are presented in TJ/ year.

IEA Renewables Information 2012 for data in 2010

Table 4: IEA Renewables Information: Utilization data - Part 1.

	TFC + Heat	TFC	Industry	Transport equipment	Paper, pulp and print	Other	Residential	Commercial and public services	Agriculture/forestry
Turkey	58238,60663	58239,82582	0	0	0	58239,82582	58239,82582	0	0
Iceland	27533,41707	17333,77994	544,2974376	0	0	16789,4825	11932,67459	3182,046558	460,5593703
Germany	20117,87967	19092,27935	0	0	0	19092,27935	19092,27935	0	0
Switzerland	10843,85271	10844,07972	795,5116396	0	0	10048,56808	8708,759002	1297,940044	41,86903366
New Zealand	9462,203521	9462,401608	6112,878915	0	6112,878915	3391,391727	293,0832356	2344,665885	711,7735723
United States	9294,730892	9294,925473	4438,117568	0	0	4856,807905	1381,678111	3475,129794	0
Japan	8457,367749	8457,5448	0	0	0	8457,5448	0	4814,938871	3642,605929
Italy	5822,519647	5233,629208	125,607101	0	0	5149,891141	41,86903366	3182,046558	586,1664713
Hungary	4126,738617	3893,820131	41,86903366	41,86903366	0	3810,082063	0	3265,784626	544,2974376
France	3810,002303	3810,082063	0	0	0	3810,082063	2260,927818	1256,07101	251,214202
Korea	1381,649187	1381,678111	41,86903366	0	0	1381,678111	83,73806733	1297,940044	0
Slovenia	1135,572086	1088,594875	0	0	0	1088,594875	376,821303	418,6903366	293,0832356
Greece	1130,440244	1130,463909	0	0	0	1130,463909	711,7735723	0	334,9522693
Austria	872,9452574	334,9522693	0	0	0	334,9522693	0	334,9522693	0
Spain	669,8905148	669,9045386	0	0	0	669,9045386	376,821303	125,607101	167,4761347
Poland	544,2860432	544,2974376	0	0	0	544,2974376	460,5593703	125,607101	0
Portugal	418,6815717	418,6903366	0	0	0	418,6903366	0	418,6903366	0
Netherlands	334,9452574	334,9522693	0	0	0	334,9522693	0	0	334,9522693
Slovakia	222,7363143	83,73806733	0	0	0	83,73806733	0	41,86903366	41,86903366
Denmark	212	0	0	0	0	0	0	0	0
Belgium	90	0	0	0	0	0	0	0	0
United Kingdom	41,86815717	41,86903366	0	0	0	41,86903366	0	0	0
Australia	0	0	0	0	0	0	0	0	0
Canada	0	0	0	0	0	0	0	0	0
Chile	0	0	0	0	0	0	0	0	0
Czech Republic	0	0	0	0	0	0	0	0	0
Estonia	0	0	0	0	0	0	0	0	0
Finland	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	0
Israel	0	0	0	0	0	0	0	0	0
Luxembourg	0	0	0	0	0	0	0	0	0
Mexico	0	0	0	0	0	0	0	0	0
Norway	0	0	0	0	0	0	0	0	0
Sweden	0	0	0	0	0	0	0	0	0
Bulgaria		0	0	0	0	0	0	0	0
Croatia		0	0	0	0	0	0	0	0
Cyprus		0	0	0	0	0	0	0	0
Latvia		0	0	0	0	0	0	0	0
Malta		0	0	0	0	0	0	0	0
Liechtenstein		0	0	0	0	0	0	0	0
Lithuania		0	0	0	0	0	0	0	0
Romania		0	0	0	0	0	0	0	0

Table 5: IEA Renewables Information: Utilization data - Part 2.

	Fishing	Non-specified	Electricity Generated - Gwh	Electricity plants	CHP plants	Heat generated - TJ	CHP plants	Heat plants
Turkey	0	0	668	668	0	0	0	0
Iceland	1214,201976	0	4465	2995	1470	10200	9500	700
Germany	0	0	28	28	0	1026	0	1026
Switzerland	0	0	0	0	0	0	0	0
New Zealand	0	0	5883	5829	54	0	0	0
United States	0	0	17577	17577	0	0	0	0
Japan	0	0	2632	2632	0	0	0	0
Italy	1339,809077	0	5376	5376	0	589	0	589
Hungary	0	0	0	0	0	233	0	233
France	0	0	0	0	0	0	0	0
Korea	0	0	0	0	0	0	0	0
Slovenia	0	0	0	0	0	47	0	47
Greece	83,73806733	0	0	0	0	0	0	0
Austria	0	0	1	1	0	538	0	538
Spain	0	0	0	0	0	0	0	0
Poland	0	0	0	0	0	0	0	0
Portugal	0	0	197	197	0	0	0	0
Netherlands	0	0	0	0	0	0	0	0
Slovakia	0	0	0	0	0	139	0	139
Denmark	0	0	0	0	0	212	0	212
Belgium	0	0	0	0	0	90	0	90
United Kingdom	0	41,86903366	0	0	0	0	0	0
Australia	0	0	0	0	0	0	0	0
Canada	0	0	0	0	0	0	0	0
Chile	0	0	0	0	0	0	0	0
Czech Republic	0	0	0	0	0	0	0	0
Estonia	0	0	0	0	0	0	0	0
Finland	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0	0
Israel	0	0	0	0	0	0	0	0
Luxembourg	0	0	0	0	0	0	0	0
Mexico	0	0	6618	6618	0	0	0	0
Norway	0	0	0	0	0	0	0	0
Sweden	0	0	0	0	0	0	0	0
Bulgaria	0	0	0	0	0	0	0	0
Croatia	0	0	0	0	0	0	0	0
Cyprus	0	0	0	0	0	0	0	0
Latvia	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0
Liechtenstein	0	0	0	0	0	0	0	0
Lithuania	0	0	0	0	0	0	0	0
Romania	0	0	0	0	0	0	0	0

All units are in TJ/year (International Energy Agency, 2012).

IGA Geothermal Database for year 2010

Table 6: IGA Geothermal Database: Utilization data - Part 1.

	Total	Individual space heating	District heating	Air conditioning (cooling)	Greenhouse	Fish farming	Animal farming
Turkey	36885,9	2417	7386,4		9138		
Iceland	24361		17483		677	1835	
Germany	12764,5	2,9	1054,4				
Switzerland	7714,6	14,7	33,5	11			
New Zealand	9552	181			379	273	
United States	56551,5	1360,6	773,2	47,6	799,8	3074	
Japan	25697,94	969,49		516,27	451,73	141,86	
Italy	9941	1769	963		1329	1632	
Hungary	9767	232	930		2388	44	17
France	12929		4900		155	212	
Korea	1954,65	53,43	31,28		1,33		
Slovenia	1015,1	317,8	44	2	94,6		
Greece	937,8	16,5			340	71,5	
Austria	3727,7		602,4		29		
Spain	684,05	76,21			92,42		
Poland	1501,1		393		2	2	
Portugal	386,4		12,9		13,8		
Netherlands	10699,4		89,7		189,9		
Slovakia	3067,2	381,1	232		461,1	271	
Denmark	2500	1700	800				
Belgium	546,97	53,8			22,1		
United Kingdom	849,739		72,545		7,914		
Australia	235,1					43,5	
Canada	8873						
Chile	131,82						
Czech Republic	1290						
Estonia	356						
Finland	7966						
Ireland	691,91						
Israel	2193				512	989	
Luxembourg	0	NA	NA	NA	NA	NA	NA
Mexico	4022,786	4,397			0,059		
Norway	10800						
Sweden	45301	828					
Bulgaria	1304,62	128,56			88,68		
Croatia	468,89	253,05					
Cyprus	0						
Latvia	31,81	8,9	4,75			6,44	
Malta	0						
Liechtenstein	0						
Lithuania	411,58		105,8				
Romania	1262,43	164,83	531,72		20,78	9,7	
Macedonia	601,41	6,6	518,37		61,14		
Georgia	689,24	360,09	239,79		59,36		

Table 7: IGA Geothermal Database: Utilization data - Part 2.

	Agricultural d	Industrial process heat	Snow melting	Bathing and Swimming	Geothermal heat p	Other uses
Turkey				17408	536,5	
Iceland		1642	1448	1256	20	
Germany				1339,2	10368	
Switzerland			0,3	1045,4	6602	7,7
New Zealand		6104		1733	39	843
United States	292	227,1	20	2557,2	47400	
Japan		30,92		23519,81	67,86	
Italy		130		3157	961	
Hungary	123	159		5356	518	
France				162	7500	
Korea				507,61	1361	
Slovenia				313,2	243,5	
Greece	1,8			238	270	
Austria		31,3		185	2880	
Spain				52,5	462,92	
Poland				55,2	1044,5	4,4
Portugal				358,6	1,1	
Netherlands					10419,8	
Slovakia				1708,5	13,5	
Denmark						
Belgium	13,1			8,1	439,77	10,1
United Kingdom				15,88	753,4	
Australia				61,6	130	
Canada				360	8487	26
Chile				131,82		
Czech Republic					1200	90
Estonia					356	
Finland					7966	
Ireland				7,91	684	
Israel				692		
Luxembourg	NA	NA	NA	NA	NA	NA
Mexico	0,101			4018,229		
Norway					10800	
Sweden					43969	504
Bulgaria				768,32	286,23	32,83
Croatia				215,84		
Cyprus						
Latvia				9,5	2,22	
Malta						
Liechtenstein						
Lithuania					305,78	
Romania	12,7	6,84		486,16	29,7	
Macedonia				15,3		
Georgia				30		

Some of the data of IGA is estimated based on data from the year 2009.
All units are in TJ/year (International Geothermal Association, 2014).

Table 8: IEA-GIA - Trends in Geothermal Applications for year 2010: Utilization data - Part 1.

	Total	District heating	Space heating	Cascaded uses	Bathing/ Swimming	Greenhouses
Turkey	0					
Iceland	24621,8	0	18813,6	0	1551,6	702
Germany	11448,7	1080	2,9	0	1365,8	0
Switzerland	7151,3	0	0	37,1	856,8	0
New Zealand	10156	0	900	1530	1008	378
United States	76119,3	624,2	855,7	0	2424,6	1132,6
Japan	25698	969,5	0	0	2790,1	451,7
Italy	12599,6	1974,9	1075	0	4199,9	1499,9
Hungary	0					
France	14557,2	5430,2	0	0	0	0
Korea	1496,6	31,3	53,4	0	507,6	1,3
Slovenia	0					
Greece	0					
Austria	0					
Spain	687,6	0	36	0	68,4	79,2
Poland	0					
Portugal	0					
Netherlands	0					
Slovakia	0					
Denmark	0					
Belgium	0					
United Kingdom	73	73				
Australia	1314,7	0	1143,5	0	131,2	0
Canada	0					
Chile	0					
Czech Republic	0					
Estonia	0					
Finland	0					
Ireland	0					
Israel	0					
Luxembourg	0					
Mexico	2558,2	0	0	0	2558,2	0
Norway	10800	0	0	0	0	0
Sweden	0					
Bulgaria	0					
Croatia	0					
Cyprus	0					
Latvia	0					
Malta	0					
Liechtenstein	0					
Lithuania	0					
Romania	0					

Table 9: IEA-GIA - Trends in Geothermal Applications for year 2010: Utilization data - Part 2.

	Agriculture, crop drying	Aquaculture/ Fish farming	Industry	Snow melting	Other	Geothermal heat pumps
Turkey						
Iceland	0	1753,2	799,2	979,2	0	23
Germany	0	0	0	0	0	9000
Switzerland	0	86,4	0	0	0	6171
New Zealand	0	0	6228	0	72	40
United States	305,3	2797,6	76,7	16,6	0	67886
Japan	0	141,8	30,9	516,3	20729,7	68
Italy	0	1800	349,9	0	0	1700
Hungary						
France	0	0	0	0	0	9127
Korea	0	0	0	0	0	903
Slovenia						
Greece						
Austria						
Spain	0	0	0	0	0	504
Poland						
Portugal						
Netherlands						
Slovakia						
Denmark						
Belgium						
United Kingdom						0
Australia	0	0	0	0	0	40
Canada						
Chile						
Czech Republic						
Estonia						
Finland						
Ireland						
Israel						
Luxembourg						
Mexico	0	0	0	0	0	0
Norway	0	0	0	0	0	10800
Sweden						
Bulgaria						
Croatia						
Cyprus						
Latvia						
Malta						
Liechtenstein						
Lithuania						
Romania						

All units are in TJ/year (Ganz, 2012).

Data on the UK is an estimate based on 2011 data (the same number as in 2011).

EGEC – EGEC Deep Geothermal Market Report 2011

Table 10: EGEC Deep Geothermal Marked Report 2011: Utilization data.

	Existing geothermal district heating plants
Turkey	
Iceland	22829
Germany	1054,4
Switzerland	
New Zealand	
United States	
Japan	
Italy	1760
Hungary	6766,7
France	5315
Korea	
Slovenia	
Greece	
Austria	602,4
Spain	
Poland	397
Portugal	153,3
Netherlands	435
Slovakia	
Denmark	380
Belgium	67,68
United Kingdom	
Australia	
Canada	
Chile	
Czech Republic	101
Estonia	
Finland	
Ireland	
Israel	
Luxembourg	
Mexico	
Norway	
Sweden	
Bulgaria	
Croatia	
Cyprus	
Latvia	
Malta	
Liechtenstein	
Lithuania	105,8
Romania	749
Macedonia	518,32
Georgia	239,79

All units are in TJ/ year (EGEC, 2011).

Appendix III: Orkustofnun Data Collection

Orkustofnun sends out questionnaires to heat utilities, operators and autoproducers asking for detailed data. This chapter serves as an insight to how Orkustofnun gathers data to submit information requested by different organizations. Orkustofnun sends out two questionnaires. The first one, questionnaire A, asks for information on geothermal energy production to gather information on indigenous primary energy production. The second one, questionnaire B, asks for data on geothermal energy utilization.

Questionnaire A

Questionnaire A is sent to relative entities. It includes pre-registered information on wells and geysers related to the plant. More specifically:

- Wells and geyser identity
- Plant site identity
- Plant identity

It also includes information for plants to fill out regarding production and re-injection. Specifically: (units in parenthesis)

- Temperature of geothermal fluid [°C]
- Volume [Various units]
- Specific enthalpy [kJ/ kg]
- Usage [Hours/year]
- Explanation if something was out of the ordinary

The information linked to each well is linked to the unique identity number for the respective well stored in the National Well Registry that Orkustofnun operates and maintains making the data geographically viewable.

Questionnaire B

Questionnaire B is sent to plants with information from the previous year for comparison purposes. It requests that information on utilization is registered. Specifically: (units in parenthesis)

- Plant site identity
- Utilization site identity
- Utilization categories
- Volume [Various units]

It also requests information on revenues:

- Base tariff (irrelevant of use over a defined period in time)
- Utilization tariff per energy unit (typically per kWh)
- Other tariff related information

- VAT and energy tax

And other information

- Input temperature
- Output temperature
- Total number of meters
- Total number of users
- Explanation if something was out of the ordinary

The information is based on the accounting system of the respective heat utility. Each registered meter is categorized and the amount of energy billed on that meter is summed up for all meters operated by the utility. Hence the information is as reliable as can be.

Processing and Reviewing of Data sent to Orkustofnun

The utilities submit the filled out questionnaire through an online gateway after registration and identification. The staff working on the questionnaires is notified automatically with an email. The data is processed and error checked before it is placed in the database according to the flow diagram in figure 12. The purpose of the workflow of the diagram is to minimize errors in the database. Data is summarized into different views in the database to fulfil the requirements of data submissions to different organizations.

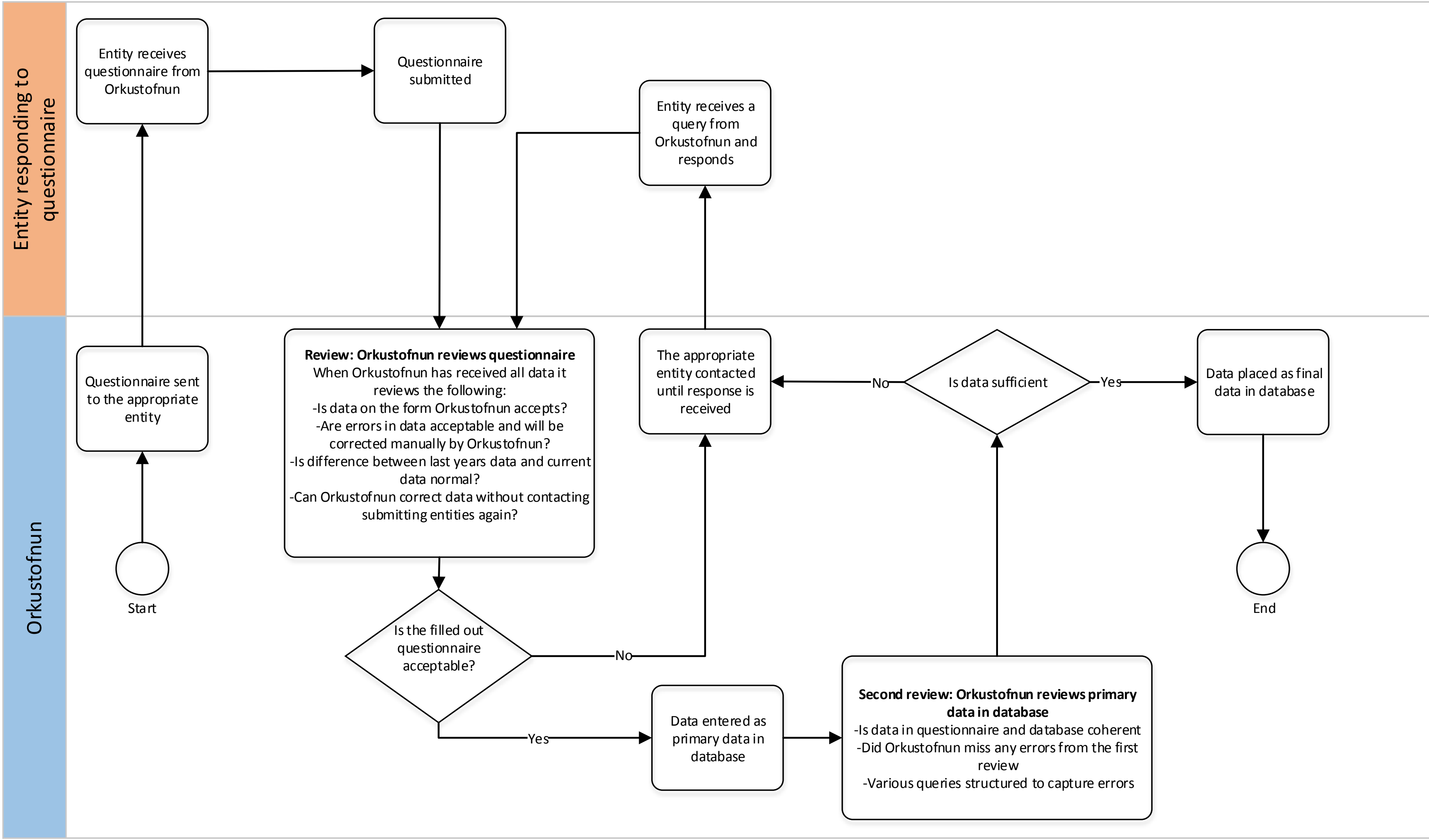

Figure 12: Flow diagram illustrating the data processing that takes place in Orkustofnun prior to the information being stored in the central database.

The entities in question are the suppliers of geothermal energy to the user. Whether geothermal power plants or district heating systems.

Primary energy is calculated from Questionnaire A. The final utilization is calculated from Questionnaire B. The used energy is defined as the difference between energy to and from the user. The primary energy is calculated by multiplying mass to specific enthalpy, more details can be seen in Appendix IV: Energy Calculations.

The main challenge of keeping detailed track of primary energy and energy utilization data is gathering information from all the geothermal plants. There can be quality differences between data from different producers, because some producers often don‘t have detailed monitoring of their primary energy production and geothermal energy utilization. Therefore data has to be estimated for those small producers.

Not all producers can give information on utilization in the form of mass or volume nor can they give information on enthalpy, because they don’t have the proper resources to do so. The solution to this problem can be sending surveys that request information the producers are capable of giving. For example, greenhouse users are asked for the sizes of their greenhouses in square meters. The average geothermal utilization of a square meter of a greenhouse can be estimated from current data, and so geothermal utilization can be calculated inversely. Similar methods can be used to estimate geothermal usage from industries and fisheries.

By relying on actual data and not estimates, a step can be taken towards more accurate data. Data quality will increase by sending smaller producers more detailed questionnaires they can easily understand and answer.

Appendix IV: Energy Calculations

Energy is calculated by multiplying mass to enthalpy, where enthalpy is defined as follows:

> **Enthalpy** is the amount of heat content released or used in system at constant pressure.

Enthalpy is often represented with a unit mass (specific enthalpy). When calculating primary energy and energy utilization, the difference between enthalpy of the input fluid and the output fluid is used. When quantity is stated as a volume in survey, mass is calculated from density for a fluid at a certain temperature. Orkustofnun uses a macro in MS excel to find the density at the production fluid temperature. The SI unit of density is kg/m^3.

Specific heat capacity is the energy needed to heat the mass of a material by one degree Celsius [°C].

$$c = \frac{Q}{m\Delta T}$$

Where:
c = Specific heat
Q = Energy
m = Mass
ΔT = Difference in temperature$_{in}$ and temperature$_{out}$.

The SI unit for specific heat is J/(kg*K). The specific heat of water is c_{water}= 4.186,8 J/(kg*K). By multiplying the specific heat capacity of water with the difference of temperature in the production and the disposal fluid, specific enthalpy can be calculated with the following formula.

$$H_{water} = c_{water}\Delta T$$

Where:
H_{water} = Specific enthalpy for water

The SI unit of specific enthalpy is J/kg. The formula works on the range of 0–100 °C when pressure is 1 atm, in other words, when H_2O is in liquid state. Sometimes, generally for CHP plants, the enthalpy is stated in the survey instead of temperature. If survey states volume as quantity, then energy can be calculated with the following formula

$$Q = VH_{water}\rho(T)$$

Where:
V = Volume
E = Energy
ρ = density

If survey states mass as quantity, then energy can be calculated with the following formula

$$Q = mH_{water}$$

Appendix V: Comparison of Secondary Energy and Direct Use Data Requirements of Organizations

Each organization is consistent in gathering data from different countries, however the methods and questionnaires between organizations differ. Table 11 is intended to show the data collection of different organizations. For readability purposes the information in the table is presented with different coloured fields, fields in red represent heat data and fields in yellow represent electricity data.

Table 11: Comparison of secondary energy data requirements of organizations.

	Official statistics Annual Questionnaires		Industry statistics	
	Renewables	Electricity and Heat	IGA Database	IEA-GIA Trend Report
Detailed data: Down to the Turbine, Field and Plant				
Individual turbines -Installed capacity [MW_e]			x	
Individual geothermal field -Installed capacity [MW_e]			x	
Individual geothermal field -Produced energy [MWh/ year]			x	
Individual geothermal plant -Installed capacity [MW_e]			x	
Individual geothermal plant -Running capacity [MW_e]			x	
Individual geothermal plant -Produced energy [MWh/ year]			x	
Installed Electrical Capacity, Capacity at Peak and Peak Load Demand				
Total net maximum electrical capacity [MW_e]	x	X		
Total geothermal electrical capacity [MW_e]			x	x
Total installed capacity [MW_e]			x	
Capacity at peak [MW_e]		x		
Peak load demand [MW_e]		x		
Operating/ Running Electrical Capacity				
Total operating capacity by end of year [MW_e]				x
Total running capacity of plants [MW_e]			x	
Secondary Energy Production				
Total geothermal electricity produced [GWh/ year and TJ/ year]			x	x
Gross electricity production [GWh]	x	x		
Net electricity production [GWh]		x		
Gross heat production [TJ]	x	x		

	Official statistics Annual Questionnaires		Industry statistics	
	Renewables	Electricity and Heat	IGA Database	IEA-GIA Trend Report
Net heat production[TJ]		x		
Distribution Losses				
Distribution losses – Direct use[TJ]	x			
Distribution losses -Heat [TJ] -Electricity [GWh]		x		
Direct Use				
Direct use by categories other than heat pumps [TJ/year] (thermal)	x		x	x
Heat Pumps				
Gross production of heat for heat pumps [TJ]		x		
Net production of heat for heat pumps [TJ]		x		
Gross production of electricity for heat pumps[GWh]		x		
Net production of electricity for heat pumps[GWh]		x		
Small heat pumps: Number of pumps				x
Small heat pumps: Installed capacity (MW_{th})				x
Small heat pumps: Total heat use (GWh/ year)				x
Small heat pumps: Full load hours (hrs/ year)				x
Small heat pumps: Number of heat pumps with cooling option (cumulative)				x
Small heat pumps: Actual full load cooling hours of a usual unit/ year (hrs/ year)				x
Small heat pumps: Geothermal cooling (GWh/ year)				x
Large heat pumps: Number of office buildings using geothermal heat				x
Large heat pumps: Total installed capacity in large GSHP systems (MW_{th})				x
Large heat pumps: Total heat use (including auxiliary power) (GWh/ year)				x
Large heat pumps: Annual heat use (geothermal contribution) (GWh/ year)				x
Large heat pumps: Actual full load cooling hours of a mean unit/ year (hrs/ year)				x
Large heat pumps: Geothermal cooling (GWh/				x

	Official statistics Annual Questionnaires		Industry statistics	
	Renewables	Electricity and Heat	IGA Database	IEA-GIA Trend Report
year)				
Type of heat pump installation [Vertical ground coupled, horizontal ground coupled, water source (well or lake water), others]			x	
COP: output thermal energy/ input energy of compressor for the respective climate			x	
Typical heat pump rating or capacity (kW)				x
Number of units				x
Heating equivalent full load (hr/ year)				x
Thermal energy used (TJ/ year)				x
Cooling energy (TJ/ year)				x
Thermal Capacity				
Direct use by categories other than heat pumps - Installed capacity [MW_{th}]			x	x

Appendix VI: Average Absolute Deviation

The average absolute deviation is calculated based on difference in reporting of geothermal utilization of organizations.

The method for calculations is the following: absolute deviations from one organization to another are obtained and an organization is selected to be the baseline organization. The baseline organization gets the value 1 for all countries. Data of other organizations get the value of a country reported by its organization divided by the reported number of the baseline organization. The deviation from the baseline is calculated, and the average absolute deviation from the baseline is calculated for every country. Finally the total average absolute deviation of all respective countries is calculated.

Table 12: Absolute deviation of different datasets, average absolute deviation of a country and average absolute deviation for OECD countries. Data from the IEA Renewables Information annual publication is the baseline.

	IGA	IEA -GIA	EGEC	N	Average deviation of a country
Spain	2%	3%	0%	1	2%
New Zealand	1%	7%	0%	1	4%
Slovenia	12%	0%	0%	2	12%
Iceland	13%	12%	21%	-	15%
Greece	21%	0%	0%	2	21%
Korea	41%	8%	0%	1	25%
Switzerland	41%	52%	0%	1	46%
Turkey	58%	0%	0%	2	58%
Portugal	8%	0%	173%	1	91%
Hungary	137%	0%	64%	1	100%
Poland	176%	0%	37%	1	106%
Italy	71%	116%	231%	-	139%
Austria	327%	0%	45%	1	186%
France	239%	282%	39%	-	187%
Japan	204%	204%	0%	1	204%
Belgium	508%	0%	33%	1	270%
Denmark	1079%	0%	79%	1	579%
United States	508%	719%	0%	1	614%
Germany	58%	76%	1808%	-	647%
United Kingdom	1930%	74%	0%	1	1002%
Slovakia	1277%	0%	0%	2	1277%
Netherlands	3094%	0%	30%	1	1562%
Norway	0%	0%	0%	3	IGA and IEA Geothermal have the same values
Australia	0%	0%	0%	3	#DIV/0!
Canada	0%	0%	0%	3	#DIV/0!
Chile	0%	0%	0%	3	#DIV/0!
Czech Republic	0%	0%	0%	3	#DIV/0!
Estonia	0%	0%	0%	3	#DIV/0!
Finland	0%	0%	0%	3	#DIV/0!
Ireland	0%	0%	0%	3	#DIV/0!
Israel	0%	0%	0%	3	#DIV/0!
Luxembourg	0%	0%	0%	3	#DIV/0!
Mexico	0%	0%	0%	3	#DIV/0!
Sweden	0%	0%	0%	3	#DIV/0!
			N		22
			Average deviation		325%

Table 13: Absolute deviation of different datasets, average absolute deviation of a country and average absolute deviation for EEA countries with IGA data as a baseline.

	IEA Renewables 2011 (Dat	IEA-GIA	EGEC	N	Average deviation of a country
Spain	2%	1%	0%	100%	1%
Iceland	13%	1%	7%	0%	7%
Slovenia	12%	0%	0%	200%	12%
Greece	21%	0%	0%	200%	21%
Switzerland	41%	8%	0%	100%	24%
Romania	0%	0%	69%	200%	69%
Portugal	8%	0%	152%	100%	80%
Hungary	137%	0%	44%	100%	91%
France	239%	13%	143%	0%	132%
Italy	71%	27%	465%	0%	187%
Poland	176%	0%	278%	100%	227%
Lithuania	0%	0%	289%	200%	289%
Germany	58%	11%	1111%	0%	393%
Austria	327%	0%	519%	100%	423%
Belgium	508%	0%	708%	100%	608%
Denmark	1079%	0%	558%	100%	819%
Czech Republic	0%	0%	1177%	200%	1177%
Slovakia	1277%	0%	0%	200%	1277%
United Kingdom	1930%	1064%	0%	100%	1497%
Netherlands	3094%	0%	2360%	100%	2727%
Estonia	0%	0%	0%	300%	#DIV/0!
Finland	0%	0%	0%	300%	#DIV/0!
Ireland	0%	0%	0%	300%	#DIV/0!
Luxembourg	#DIV/0!	#DIV/0!	#DIV/0!	0%	#DIV/0!
Norway	0%	0%	0%	300%	#DIV/0!
Sweden	0%	0%	0%	300%	#DIV/0!
Bulgaria	0%	0%	0%	300%	#DIV/0!
Croatia	0%	0%	0%	300%	#DIV/0!
Cyprus	#DIV/0!	#DIV/0!	#DIV/0!	0%	#DIV/0!
Latvia	0%	0%	0%	300%	#DIV/0!
Malta	#DIV/0!	#DIV/0!	#DIV/0!	0%	#DIV/0!
Liechtenstein	#DIV/0!	#DIV/0!	#DIV/0!	0%	#DIV/0!
				N	20
				Medium deviation	503%

Table 14: Absolute deviation of different datasets, average absolute deviation of a country and average absolute deviation for IEA-GIA participating countries with IEA-GIA data as a baseline.

	IEA Renewables 2011 (D	IGA	EGEC	N	Average deviation of a country
Spain	3%	1%	0%	1	2%
New Zealand	7%	6%	0%	1	7%
Iceland	12%	1%	8%	-	7%
Korea	8%	31%	0%	1	19%
Switzerland	52%	8%	0%	1	30%
Mexico	0%	57%	0%	2	57%
Japan	204%	0%	0%	1	102%
France	282%	13%	174%	-	156%
Italy	116%	27%	616%	-	253%
Germany	76%	11%	986%	-	358%
United States	719%	35%	0%	1	377%
Australia	0%	459%	0%	2	459%
United Kingdom	74%	1064%	0%	1	569%
Norway	0%	0%	0%	3	IEA-GIA og IGA have the same values
				N	13
				Average	184%

Appendix VII: Identification for IEA database

INDPROD	Indigenous Production	
STATDIFF	Statistical Differences	
TOTTRANF	**Transformation Sector**	
MAINELEC	Main Activity Producer Electricity Plants	(INPUTS)
MAINCHP	Main Activity Producer CHP Plants	
MAINHEAT	Main Activity Producer Heat Plants	
AUTOELEC	Autoproducer Electricity Plants	
AUTOCHP	Autoproducer CHP Plants	
AUTOHEAT	Autoproducer Heat Plants	
DISTLOSS	Distribution losses	
FINCONS	Total Final Consumption	
TOTIND	**Industry Sector**	
IRONSTL	Iron and Steel	
CHEMICAL	Chemical and petrochemical	
NONFERR	Non-Ferrous Metals	
NONMET	Non-Metallic Minerals	
TRANSEQ	Transport Equipment	
MACHINE	Machinery	
MINING	Mining and Quarrying	
FOODPRO	Food, beverages and tobacco	
PAPERPRO	Paper, pulp and printing	
WOODPRO	Wood and Wood Products	
CONSTRUC	Construction	
TEXTILES	Textiles and Leather	
INONSPEC	Not elsewhere specified (Industry)	
TOTOTHER	**Other Sectors**	
COMMPUB	Commercial and Public Services	
RESIDENT	Residential	
AGRICULT	Agriculture/Forestry	
FISHING	Fishing	
ONONSPEC	Not elsewhere specified (Other)	
OUTPUT	(this are just the parameters used during the extraction)	
PRODUCT		
BALANCE		
TIME		
MAINELEC	Main Activity Producer Electricity Plants	(OUTPUTS - ELECTRICITY)
MAINCHP	Main Activity Producer CHP Plants	
MAINHEAT	Main Activity Producer Heat Plants	
AUTOELEC	Autoproducer Electricity Plants	
AUTOCHP	Autoproducer CHP Plants	
AUTOHEAT	Autoproducer Heat Plants	
PRODUCT	(this are just the parameters used during the extraction)	
BALANCE		
TIME		

MAINELEC	Main Activity Producer Electricity Plants	(OUTPUTS - HEAT)
MAINCHP	Main Activity Producer CHP Plants	
MAINHEAT	Main Activity Producer Heat Plants	
AUTOELEC	Autoproducer Electricity Plants	
AUTOCHP	Autoproducer CHP Plants	
AUTOHEAT	Autoproducer Heat Plants	

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