DIRECT USE INDUSTRIAL APPLICATIONS OF GEOTHERMAL ENERGY IN ICELAND

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Abstract: In Iceland direct use geothermal energy is supplied through the hitaveitas [1], and also directly from the different steam fields. A survey was made in order to determine what fraction of this energy was used industrially in 1993. The result indicated that in the twenty seven official hitaveitas listed, the weighted average industrial use was 10% of the energy extracted, while this varied greatly between them. The part the hitaveitas played in the industrial geothermal energy supply was 42% while the steam fields supplied 58% directly. The principal application through hot water in the hitaveitas is in the food industry, while by the application of steam chemical and mineral industries predominate. It is *suggested* that direct use industrial centers, would benefit greatly through the organization of steam hitaveitas in suitable locations.

INTRODUCTION

Direct use of geothermal energy in Iceland takes place mostly through two different channels at the present time. *One* is through the supply of hot water through the district heating systems, the second is by steam supply from the geothermal steam fields.

According to the 1994 survey by the Association of Icelandic Hitaveitas [1], twenty seven public district heating system were in operation in Iceland in 1993. The principal aim is of course community space heating, while some related applications also exist. *All* of these are based on the supply of hot water where the heat is of geothermal origin and the water in most cases is also.

In order to collect information regarding the industrial uses for this hot water, every one of these hitaveitas was contacted. This paper reports the overall findings of this survey together with the same for direct industrial applications of steam.

In this paper an industrial application is defined as the total direct use which an industrial concern makes of the geothermal supply. This may include hot tap water and space heating.

[1] Hitaveita: Icelandic word meaning Geothermal District Heating System

OVERALL RESULTS

The original data received for evaluation of the energy used is reported in terms of cubic meters per year for water and tons for the steam. The general assumption made here, is that the useful temperature drop of the water is 40°C in *cases* of general use, but 55°C in cases where hot tap water is of predominant significance.

In Table 1, the overall results are summarized for 1993. The total uses amounts to 3505 TJ/yr. Those of hot water amount to 1450 TJ/yr *or* 41% of the total, while steam use amounts to 2055 TJ/yr and 59% of the total energy used for direct applications in industry.

Table 1.
Direct Energy Used in Different Industries in 1993

Type of Industry	Water TJ/yr	Steam TJ/yr	Total TJ/yr
Food	796	69	865
Textiles/Clothing/Hides	161	9	170
Timber/Paper	162	-	162
Chemicals	154	1100	1254
Minerals	36	877	913
Mechanical manufacture.	45	-	45
Diverse manufacture.	96	-	96
Totals	1450	2055	3505

Table 2. Industrial Uses of Geothermal Steam In 1993

Location	Type of operation	Steam used t/h	TJ/yr
Hveragerði	Wool Scouring	1	9
Námafjall	Diatomite Production	59	875
"	Brick manufacture	1	2
Reykjanes	Salt production	65	1100
"	Animal Food Production	4	69
Total		130	2055

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Only two steam fields supply significant quantities of steam for direct use, those of Nhafjall and Reykjanes. A small amount is also used in Hveragerbi as shown in Table 2. About 20% of all geothermal steam produced in Iceland is used directly for industrial purposes. But no major pipelines exist for long distance delivery as is the case with hot water.

Table 3.
Industrial Use of Hot Water in Hitaveitas, Iceland

Geothermal Energy for Industrial purposes		
Hitaveita	TJ/yr	% of total uses
Reykjavík	676	7.0
Seltjarnarnes	0.6	0.2
Mosfellsbær	14	5.7
Suðurnes	71	5.9
Akranes/Borgarfj.	75	20.6
Reykhólar[1)]	115	87.4
Suðureyri	0.7	3.8
Laugarbakki	0	0
Hvammstangi	11	18.5
Blönduós	32	27.5
Sauðárkrókur	114	49.5
Seyluhreppur	0	0
Siglufjörður	(0)	(0)
Ólafsfjörður	12	6.4
Dalvík	55	38.1
Hrísey	4	24.0
Akureyri	96	15.0
Húsavík	31	13.2
Reykjahlíð	0	0
Egilsst./Fellabær	12	10.1
Rangæinga	17	19.4
Brautarholt	1	16.6
Flúðir	12	34.7
Laugarás	0.7	9.0
Selfoss	23	6.5
Hveragerði	0.5	0.2
Þorlákshöfn	33	38.3
Laugar[2)]	190	-
Total	1450	10.1%

1) Including Seaweed Rant

2) Fish Drying plant only

While some of the hitaveitas are quite small, Hitaveita Reykjavikur is by far the largest and 47% of all industrial uses of hot water in Iceland take place there as shown in Table 3. However some of the smaller ones use relatively more for industrial purposes. Thus, while the weighted average of energy supplied by all hitaveitaa is 10.1%, Hitaveita Akureyrar commands 15% and for instance Hitaveita Sauðárkróks uses 49% of the total energy supplied for industrial purposes.

FOOD INDUSTRY

Since 80% of the exports of Iceland involve food products of some sort, this is an important sector of national involvement. Fish and fish products predominate the export, while farm products, such as meat and dairy produce, are of importance locally.

The principal use of geothermal energy as regards fish products, is in fish processing, where hot tap water is required in large quantities, and also in fish drying operations, where several types of fish products are processed.

Most fish processing plants are located at the coast, where the hitaveitas will supply plentiful hot geothemal water in several important fish processing centers. An important aspect in tap water use, is the sterile condition of geothmal water.

In 1992 there were a total of 8-10 concerns in Iceland which produce dried fish products, all except one using geothermal energy (Arason and Arnason, 1992). The present survey identified 9 concerns using geothermal energy for this purpose.

Wherever supply of hot geothemal water coincides with meat processing needs in Iceland, this is surely used, and then principally as tap water. The same applies to the dairy industry, where hot water is used for tap water and for space heating.

All counted, the food industry consumed 25% of all direct use geothermal energy. Of this 94% is supplied through the hitaveitas. More than 70% of them report some such uses.

TEXTILE AND HIDE INDUSTRY

The textile industry in Iceland includes wool processing beginning with scouring of the wool and ending with Fished garments in many cases. One single scouring plant serves the entire country at present. The plant receives geothermal steam and hot water from the Hveragerði steam field

Spinning and weaving also largely takes place in a single plant located at Álafoss in the neighbourhood of Reykjavik. Here hot geothermal water is used for space heating and hot tap water supply. There several small manufacturing units are in operation, largely for knitted garments.

Two hide processing plants are in operation using geothermal hot water for process applications and space heating.

The textile and hide industry combined consume 4.8% of the total geothermal energy supplied for industry. The greatest part is through the hitaveitas.

TIMBER AND PAPER INDUSTRY

The timber industry largely involves a multitude of small wood manufacturing shop all of them using hot water from district heating systems where ever such services are offered. An important member in the family of timber manufacturers is a wood-gluing plant located at the town of Flúðir in Southern Iceland. Here large beams and othcr prefabricated elements *out* of timber are glue laminated in large quantities and distributed all over the country. A large cardboard box manufacturer also is in operation in Iceland.

As an example of geothermal uses in the paper industry *bookmaking* is a common one. Containem for eggs are also made out of waste paper in one plant.

The energy supplied to the timber and paper industry in Iceland amounts to 162 TT/yr, or 5% of the total direct energy for all industrid purposes. All of this is supplied by the hitaveitas.

CHEMICAL INDUSTRY

The largest chemical concern using geothermal *energy* in Iceland is the Salt plant at Reykjanes[2], manufacturing common salt, and a special multi component food additive. The raw materials are geothermal brine and sea water. Geothermal *steam* is used throughout (Kristjánsson, 1992).

A seaweed processing plant is in operation at Reykhólar in Western Iceland. Here hot geothermal water is utilized for the drying of the seaweed.

Processing of fish oil for human consumption is a significant industry in Iceland. Large quantities of hot water are used in this industry. Several smaller applications also exist such as those in paint manufacturing industry.

This is the largest industrial direct use concern, representing 36% of all the energy consumed. Of this 89% is supplied by geothermal steam.

MINERAL INDUSTRIES

The diatomite plant at Mývatn Northern Iceland has represented the largest single user of geothermal steam for industrial purposes until just recently, when it was superseded by the Reykjanes Salt plant. Filtered diatomite is the principal product (Sigurðsson, 1992).

Light weight *cemented* bricks are produced where steam is used for *curing* and *drying*. Hot water is used for concrete mixing in cold weather by some concerns.

Of all industrial direct uses, 26% are represented by this sector, and 96% is supplied through geothermal steam.

MANUFACTURE IN LIGHT INDUSTRY

Several manufacturing concerns of diversified nature are supplied by hot water through the hitaveitas. All together the energy consumed for direct use in this sector amounts to 3% of the total. *All* of this is supplied by hitaveitas.

RUBBER, STEEL CONSTRUCTION, NON-FERROUS CONSTRUCI' AND DIVERSE MANUFACTURE

These are all small users, even though a multitude of such concerns exist. All of these are supplied through the hitaveitas. The total energy in this sector amounts to 4% of the total.

THE INDUSTRIAL SIGNIFICANCE OF HITAVEITAS

After considering the above the reader will be aware of the significance of hitaveitas for supplying heat to a multitude of varied industries. In spite of the limited usefulness of the hot water for this purpose the hitaveitas still carry a significant part of the energy supplied to industry. Water, generally of 80°C, has indeed a rather narrow field of usefulness in each case.

The more concentrated *energy* supply is by steam, where heat may be supplied at temperatures up to 180°C, and even higher. Yet these conditions also have their own limitations of logistic nature as has been explained earlier (Líndal and Kjartansson, 1992). An interesting co-ordination of all the optimum conditions for industry would be found in an hitaveita supplying steam instead of water.

Steam may be transmitted for long distances, under favourable conditions (Thorhallsson and Ragnarsson, 1992). Thus steam supply conditions should be possible in some instances. Industrial direct use centers served by steam hitaveitas should be possible, and have indeed been suggested in Iceland.

FURTHER CONSIDERATIONS

In spite of several disappointments and temporary setbacks in the development of the use of geothermal energy for industrial purposes in Iceland, it is clear that the significance of this resource for industry has been established. In Iceland there exist at present several important manufacturing plants, which owe their existence to the geothermal energy supply.

[2] This plant has been shut down temporarily at the time this paper is composed.

At this moment, there exist several development studies, which are to a large extent based on geothennal *energy*. Indeed the use of hot water and of geothermal steam appear to be becoming a fixed part of the planning of most industrial developments in Iceland.

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