IMPLEMENTATION OF GREEN BOOKKEEPING AT REYKJAVIK ENERGY

Dr. Loftur R. Gissurarson, Gudjon Jonsson & Thorlakur Bjornsson
Reykjavik Energy
Sudurlandsbraut 34, 108 Reykjavik
ICELAND
loftur.gissurarson@or.is
Web-page: www.or.is/

Abstract

Reykjavik Energy is the largest power company in Iceland. It produces geothermal hot water for heating, cold tab water for consumption and electricity for the greater Reykjavik area. The company has an audited quality control system according to HACCP and ISO 9001 and is currently working towards an environmental quality control system according to ISO 14001. In order to regulate and record significant environmental aspects in a systematic way, Reykjavik Energy has completed its first environmental report as a result of green bookkeeping to comply with environmental policy and various regulations. It will be published along with the company's annual report from now on. The environmental report of Reykjavik Energy is conceptualized as a journal that covers main issues of environmental concerns. It enlists a record of all results needed and required by: 1. Icelandic environmental and pollution laws and regulations. 2. The environmental policy of Reykjavik city. 3. Conventional green bookkeeping reports. 4. The environmental policy of Reykjavik Energy. 5. The environmental standard ISO 14001. Results are published covering variables such as amount of waste and pollutants from staff and production processes (oil, metals, batteries, and so on). Relevant greenhouse gases are recorded, such as CO_2, CH_4, N_2O, SF_6, and acid gases are monitored, SO_2 and NOx and other gases of environmental concern such as H_2S. Reykjavik Energy is a profitable company, that also accepts full responsibility for its potential environmental consequences. Iceland aims to be the first nation to use only renewable energy as an energy resource. Reykjavik Energy aims to fully cooperate and participate in this ambitious goal.

INTRODUCTION

Reykjavik Energy is the largest power company in Iceland. It provides electricity, geothermal hot water and cold water for consumption to the capital city, Reykjavik, and neighbouring communities. (See Appendix A for main indicators of Reykjavik Energy.)

Iceland belongs to the Nordic countries, populated by approximately 300.000 people. About half of the population lives in the capital city, Reykjavik, and surrounding neighbouring communities. The culture is western, dominant religion is protestant, education and technology levels are high and unemployment rate is about 1%. Iceland is a member of NATO , EFTA, and belongs to the European economic area (EEA).

Iceland lies in the north-Atlantic Ocean, close to the Artic circle. The climate is oceanic but much milder than might be expected considering the northerly location of the country. The mean annual temperature for Reykjavik is 5 ^{o}C, the average January temperature being 0.4 ^{o}C and July 11.2 ^{o}C. Heating of building is therefore necessary all the year around.

The country has one of the highest frequencies in the world of natural phenomena which usually cause major disasters in other more densely populated countries. Lives and properties can be threatened by volcanic activity, strong motion earthquakes, glacier bursts from sub glacial volcanic activities, and so

forth. The island is situated on the mid-Atlantic Ridge and the seismic activity there is mainly related to the ridge.

Iceland has agreed to the United Nations' treaty on climate change, to monitor trends and natural efforts, but not the Kyoto Protocol.

The Kyoto protocol dictates that emission in Iceland must not increase by more than 10% of what it was in 1990 during the next target period, 2008-2012. Most countries must reduce their emission but we want even further concessions, given our unusual situation. The Icelandic issue is the request that NEW high energy consuming industry (e.g. aluminium factory) should, to a large extent, not be included in the emission calculations; firstly because our renewable energy sources guarantee that global emission is minimized given the probability that fossil or nuclear fuel would be used if the industry in question were situated elsewhere and secondly because the economic benefits of even one such industry are great for a small economic system which is lacking in versatility. The topic of planting trees - which are sparse in Iceland and are of course carbon dioxide consuming - in order to compensate for emission, is also part of the Icelandic issue.

Once the Icelandic issue has been solved satisfactorily, it will join the other nations that have signed the agreement.

Reykjavik Energy

Reykjavik Energy entered its first year of operations in 1999 following the merger of Reykjavik city's Electric Power Works and District Heating Utility. In the year 2000 Reykjavik Waterworks also merged with Reykjavik Energy. These founding partners were leading players in the Icelandic energy sector, and joined to create a dynamic new company to handle procurement, sale and distribution of electricity, cold water and geothermal hot water (see Table 1 for financial parameters). The merger was intended to yield benefits for the citizens of Iceland's capital and the entire greater Reykjavik area in the long term.

Table 1. Financial parameters of Reykjavik Energy	
Total Revenue	101.000.000 US$
Profit before taxes	3.900.000 US$
Total assets	495.000.000 US$
Equity ratio	68,6%
Capital dividend	1,1%
Present market	150.000 consumers

Reykjavik city owned Reykjavik Energy till the end of 2001. The company has now been corporated. New laws are being processed at the Icelandic parliament (Althingi), that state that the energy sector is to be deregulated in line with similar development in Europe. Although Reykjavik city is still the chief owner of the company, it is possible that it will be on the market within a few years.

All the activities of Reykjavik Energy are based on sensible and efficient harnessing of Icelandic energy resources, guided by respect for nature and legislation on environmental conservation. Reykjavik Energy has an audited quality control system according to HACCP and ISO 9001: 2000 and is currently working towards an environmental management system according to ISO 14001. The management's tool for following through and obtaining set goals for the company is based on the methodology of Balanced Scorecard. The company has produced its own BSc software to keep track of set goals with real-time on-line results.

The cold tap water is pumped from holes drilled into the ground. It is pure and free of organic and chemical pollution. Therefore, it is pumped untreated and unsterilized directly to the homes of consumers. Icelandic regulations regard the cold drinking water as food product and waterworks companies are by definition food-production companies. Drinking water produced by Reykjavik Energy is tapped on bottles by private companies and sold abroad to Europe and the United States.

Houses in Iceland are heated with geothermal energy (hot water). The design is quite simple. A well is drilled about 500 – 2000 meters into the geothermal reservoir area and a pump installed. Then the hot water is pumped to the city and used directly for heating of homes, as tap water for washing and bathing and so on. The water remains hot (about 80^{o}C) by geothermal heat. The same reservoir areas have been used for up to 70 years without significant indication of decline in water levels. The harvested area is continuously recharged with ground water from the surrounding areas.

Reykjavik Energy generates electricity to the city of Reykjavik and neighbouring communities through two hydro powerstations and one geothermal powerstation at Nesjavellir, about 25 km outside Reykjavik. Electricity is also purchased from The National Power Company (Landsvirkjun). The Nesjavellir powerplant generates 90 MW of electricity alongside 250 MW of thermal energy. Reykjavik Energy has signed an agreement with China to build a geothermal district heating system in Peking, that will include providing the new Olympic park with hot water. Reykjavik Energy will provide the technology to ensure that the natural geothermal source will remain renewable.

Present status of environmental affairs

Geothermal energy plays a crucial role in Iceland's energy economy. The dominant use is for space heating, where almost 90% of houses in the country (homes, commercial and industrial buildings) are heated with geothermal water. In Reykjavik city 100% of homes use this renewable energy source for heating today. Most of the geothermal production is from low-temperature fields. The water from these fields contain relatively low content of dissolced solids and it can be used directly for district heating and hot tap water.

Iceland is now the world's leading country in geothermal district heating developments. Reykjavik Energy utilizes four low temperature geothermal fields (<150^{o}C) and one high temperature field (>200^{o}C) for the district heating. The cost of the geothermal energy is low comparing to other alternatives and as geothermal replaced burning of fossil fuel (oil, coals and gas) for district heating in Reykjavik, it has reduced the emission of greenhouse gases dramatically, decades before the international community began contemplating such actions, see Figure 1. In Reykjavik geothermal energy has economical and environmental advantages which other energy sources can not compete with.

The pumping did lower the water levels in the harvested area at one point. However, with reduced pumping the water level rose again and balance has been maintained for a number of years indicating that the geothermal energy is sustainable. Extensive monitoring programme of the exploitation has been carried out for the last decades and records have been kept on water production, temperature, water level variation and fluid chemistry. The data has been incorporated into simulation models, which are used to predict changes in water level and chemistry. The company has also started to return excess water back to the ground (instead of into the sea) in order to keep the balance intact, although this aspect needs to be, and will be, improved in coming years.

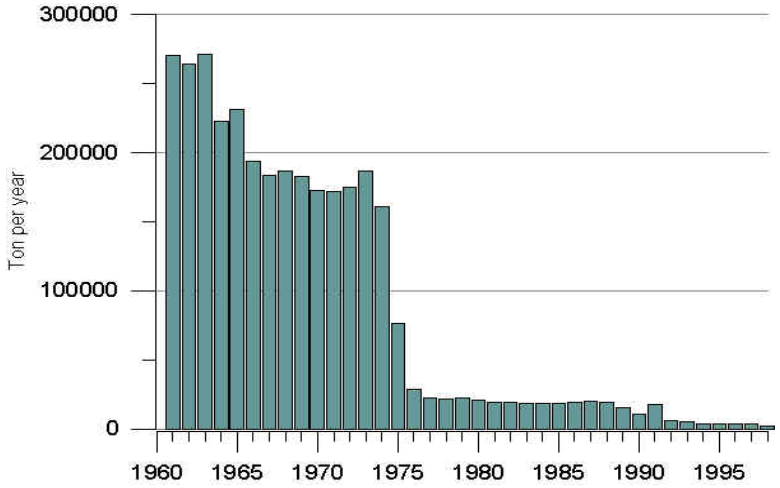

Figure 1. Reduction of carbon dioxide emission in Reykjavik due to introduction of geothermal heating.

Our company is now taking the environmental issue one step further, asking what can we do more, apart from cleaning up and recycling waste from the company's operations. We will elucidate further on the issue in the discussion.

GREEN BOOKKEEPING

Top management at Reykavik Energy has decided to implement the environmental management system ISO 14001. An environmental policy has been defined, and documented environmental objectives and targets have been established and maintained. However, the environmental policy is under review at present and environmental management programme has not yet been established.

Reasons for specially recording and reporting environmental issues at Reykjavik Energy are:

- ✓ To increase sorting and recycling of waste when possible.
- ✓ To decrease emission of greenhouse gases and acid gases when possible.

Some variables are under direct control. The company can control emission of acid gases and greenhouse gases from cars and engines and waste disposal from daily operations. Dangerous waste results from the use of dangerous and toxic materials and if we exchange these substances for nontoxic we reduce and in some cases eliminate dangerous waste.

Other variables are not under direct control. There is not much that Reykjavik Energy can do to reduce emmission of greenhouse gases from the Nesjavellir powerplant apart from shutting down parts of the station. The need for energy and size of the plant determine the emission. Natural occurrances (such as weather conditions and possible natural hazards) and system failures determine the use of backup powerstations. Reliable maintenance programs can decrease the need for fossil fuel backup power for general machines, although machines used for drilling and field operations always require fossil fuel.

The environmental report of Reykjavik Energy

In order to regulate and record significant environmental aspects in a systematic manner, Reykjavik Energy has completed its first environmental report based on green bookkeeping to comply with various regulations and policies. It will be published along with the company's annual report from now on.

The environmental report of Reykjavik Energy is conceptualized as a journal that covers all issues of environmental concerns. It enlists a record of all results needed and required by:

- ✓ Icelandic environmental and pollution laws and regulations.
- ✓ The environmental policy of Reykjavik city.
- ✓ Conventional green bookkeeping reports.
- ✓ The environmental policy of Reykjavik Energy.
- ✓ The environmental standard ISO 14001.

Results are published covering variables such as amount of waste and pollutants from staff and production processes (metal, oil, batteries, and so on). Relevant greenhouse gases are recorded, such as CO_2, CH_4, N_2O, SF_6, and acid air gases are monitored, SO_2 and NOx, and amount of H_2S is also registered.

Furthermore, the environmental report describes the safety record of employers, number of trees planted by the company, the biological and chemical composition of drinking water, size of area covered by a snow-melting system put up by the company, and a number of other acitvities. Reykjavik Energy is a profitable company that also accepts full responsibility for its potential environmental consequences. We try to consider most of our operations as an investment in environmental issues.

KEY INDICATORS

We have chosen following key indicators for continuous registration: (1) Solid waste and scrap metals. (2) Dangerous waste. (3) Greenhouse gases. (4) Acid gases. (5) Hydrogen sulfide. (6) Safety records.

Since 2000 is the first year of registration, we do not yet have figures to compare with - with the exeption of the outlet of carbon dioxide (CO_2) and hydrogen sulfide (H_2S) at the Nesjavellir geothermal powerplant, where the total outlet has been registered since 1994.

Solid waste and scrap metals

The aim of Reykjavik Energy is to reduce waste and recyle as much as possible. The solid waste is sorted according to local practise and the figures for 2000 are shown in Table 2.

Table 2. Solid waste

Component	Amount (kg)	% of total waste
Unsorted	69245	55
Timber	34870	28
Soil	19070	15
Cardboard paper	1580	1
Office paper	1800	1
Scrap metal:		% of metals
Transformers	54610	20
Discarded cars	4330	1
Mixed, shredable	219140	79

Dangerous waste

Dangerous waste is sorted according to local practise and the results for 2000 are shown in Table 3.

Table 3. Dangerous waste		
Component	Amount (kg)	% of total dangerous waste
Paint	3210	34
Oil-polluted soil	2510	26
Discarded oil	2090	22
Accumulators and lead	1444	15
Discarded oil, PCB	271	3
Batteries	8	<0,1
Inorganic waste	7	<0,1

Reykjavik Energy wants to minimize the use of dangerous substances and systematically use less dangerous substances when it is possible.

Greenhouse gases

We have chosen to report emission of greenhouse gases according to sources. They are as follows:

- ✓ Emission from the geothermal powerplant at Nesjavellir.
- ✓ Emission from a number of (diesel) backup powerstations.
- ✓ Emission from a (diesel) backup powerstation for the district heating system.
- ✓ Emission from all vehicles owned by or used at Reykjavik Energy.

There is an ongoing international debate whether emission from geothermal powerplants should be included in the total value of emission of greenhouse gases from each country. Emission from this type of industry can be considered as a natural occurrance which is accelerated by drilling holes into the ground. The total emission will be the same as through natural means. Some countries do not include estimated emission from these powerplants in their registration (for instance, Italy).

It is the aim of Reykjavik Energy to minimize greenhouse gases as possible. The results for the year 2000 are shown Table 4.

Table 4. Emission of greenhouse gases			
Component	Source	Amount (t)	% total in Iceland
Carbon dioxide	Nesjavellir	13241	0,5
	Backup electricity	145	< 0,01
	Backup hot water	106	< 0,01
	Vehicles	161	< 0,01
Methane	Nesjavellir	70	0,6
	Backup electricity	8 (kg)	< 0,01
	Backup hot water	13 (kg)	< 0,01
	Vehicles	32 (kg)	< 0,01
Nitrous oxide	Backup electricity	59 (kg)	< 0,01
	Backup hot water	43 (kg)	< 0,01
	Vehicles	22 (kg)	< 0,01
Sulfurhexafluoride	Switches, switchyards	0	n.a.

Emission of greenhouse gases at Reykjavik Energy is an insignificant contribution to the total emission of the country.

The release of carbon dioxide, one of the greenhouse gases, is of concern world wide due to its negative impact on the environment. The energy production at Nesjavellir is relatively clean compared to other energy sources. Only part of the hot water comes from the Nesjavellir powerplant, most of the water is pumped from the four low enthalpy fields within or close to the city of Reykjavik. These areas are free of CO_2 emission.

It may be worth mentinoning, that the total emission of greenhouse gases from Reykavik Energy for a whole year, is equal to emission of these gases released during a few seconds of volcanic eruption.

Acid gases

We have chosen to group the emission of acid gases according to sources that are as follows:

- ✓ Emission from a number of (diesel) backup powerstations.
- ✓ Emission from a (diesel) backup powerstation for the district heating system.
- ✓ Emission from all vehicles owned by or used at Reykjavik Energy.

It is the aim of Reykjavik Power to minimize the acid gas as possible. The results for year 2000 are presented in Table 5.

Table 5. Emission of acid gases

Component	Source	Amount (kg)	% total in Iceland
Sulfur dioxide	Backup electricity	140	<0,01
	Backup hot water	100	<0,01
	Vehicle	3	<0,01
Nitrogen oxides	Backup electricity	2600	<0,01
	Backup hot water	1900	<0,01
	Vehicles	800	<0,01

All these figures for acid gases are low. Reykjavik Energy has not needed to use its (diesel) backup powerstation for the district heating system for a number of years. Reliable maintenance program has been established for all backup powerstations at the company.

Hydrogen sulfide

Hydrogen sulfide is a precursor for the acid gas sulfur dioxide. It is thought that in the clean and relatively cold air in Iceland the chemical reaction needed for the changes of hydrogen sulfide to sulfur dioxide, is very slow and changes have not been measured in the concentration of sulfur dioxide in the area around Nesjavellir.

The total outlet of hydrogen sulfide for the year 2000 is estimated to be 5550 tons. This emission is about 40% of the total emission of hydrogen sulfide in Iceland.

Safety records

About 500 employees work at Reykjavik Energy. In the year 2000 twelve accidents occurred at the company where the employee consequently had to be absent more than one day. Calculated accident rate per 100 work positions at the company equals 2,1.

Nineteen minor incidents were reported and workers made 30 comments on safety issues during the year 2000.

SUMMARY OF KEY INDICATORS FOR OUTLET TO AIR 2000

In table 6 we have summarized the key indicators for outlet to air for the year 2000.

Table 6. Summary of key indicators for outlet to air				
Greenhouse gases: 2000		RE [t]	Iceland [t]	Ratio [%]
Carbon dioxide	CO_2	13.652,4	2.739.000	0,498%
Methane	CH_4	82,7	12.571	0,658%
Nitrous oxide	N_2O	0,1	426	0,029%
Sulfurhexafluoride	SF_6	0,0	- - -	n.a.
Acid gases: 2000		RE[t]	Iceland [t]	Ratio [%]
Sulfur dioxide	SO_2	0,24	36.000	0,001%
Nitrogen oxides	NOx	5,24	26.000	0,020%
Other: 2000		RE[t]	Iceland [t]	Ratio [%]
Hydrogen sulfide	H_2S	5.550	13.905	39,91%*)

*) Estimated as outlet from main geothermal area used for power generation.

Reykjavik Energy does not affect the emission of hydrogen sulfide which can be toxic and is a corrosive substance in the geothermal field. Reykjavik Energy considers the environmental impact not serious enough in the area to justify expensive "cleaning" processes of hydrogen sulfide from the insoluble gas. Today there is not known any commercial way to clean hydrogen sulfid in such a low concentration, as is the case in the insoluble gas at Nesjavellir. Reykjavik Energy follows closely research in that area and has plans to produce hydrogen from hydrogen sulfide as a power source.

DISCUSSION

Iceland aims to be the first nation to use only renewable energy as an energy resource. Reykjavik Energy plans to fully cooperate and participate in this ambitious goal. The company's policy states that Reykjavik Energy will care for its customers and aims to provide quality service that compares with the best offered by comparable utilities, guided by firm ethical considerations. The company strives to be a responsible member of the community and has a forward looking vision in its operations.

Since the energy used by industrial companies in Iceland is from sustainable sources (hydro power and geothermal power), the total emission of greenhouse gases is very low compared to industry using energy produced by conventional fossil fuel sources. The netto outcome of emission of greenhouse gases worldwide therefore decreases if industries requiring high energy are situated in Iceland instead of countries that only have access to power generated by conventional fossil fuel.

Hydrogen sulfide emission

There is a concern that hydrogen sulfide H_2S oxidizes to sulfur dioxide SO_2, causing acidification to rain and soil. The background level of sulfur dioxide in Iceland is low, or about 0,2 $\mu g/m^3$, whereas in Europe it can be as high as 40 – 60 $\mu g/m^3$ and in cities over 100 $\mu g/m^3$. Studies have shown that the Icelandic soil is basic and lacks sulfur. Therefore, if the level of sulfur in air increases, it will not affect the environment

as seriously compared to soil where there is no buffer capacity and the runoff can acidify fresh water and harm the bioflora of the water. Reykjavik Energy monitors the levels of hydrogen sulfide at Nesjavellir and observes any possible effects it can have on the environment.

Expansion into new areas

Reykjavik Energy has been expanding into a variety of fields. In 1999, the company created a data transmission company, Lina.Net, which has put down high-speed fiber-optic net throughout Reykjavik city. Another subsidiary is called NetOrka (NetEnergy) which will provide customers with access through the internet to all information pertaining to their energy, including breakdowns showing how much energy has been used. This prospective database will also enable customers to compare their energy profile to established standard patterns.

Currently Reykjavik Energy is introducing the fourth-product (in addition to electricity, hot water and drinking water), which is a modem that will allow computers to connect to the internet only through a plug-in to the electricity socket. The electricity distribution network is used as an effective carrier for the internet and other data transmissions. Although this new technology (PLC – powerline communications) does not have the same bindwith capacity as that provided by fibre-optic technology, it is extremely cost-effective, and an ideal way for both domestic users and smaller companies to extend their communication possibilities.

Reykjavik Energy has started putting down hot water pipes under streets and pedestrian paths (and also to re-use excess water from domestic heating) systematically in order to keep the surface of asphalt and concrete streets in city the free from snow and ice.

The environmental policy of Reykjavik city states that it aims at being a completely "clean" city using only renewable source such as hydrogen energy source instead of fossil sources (petrol). A company has been founded by Reykjavik Energy, other Icelandic partners and international companies (Daimler-Bens, Shell Int., Norsk Hydro) in order to advance the science of hydrogen gas separation and storage and to develop commercially available hydrogen for the infrastructure of a future hydrogen economy.

REFERENCES

Gislason, G. (2000). *Nesjavellir Co-Generation Plant, Iceland. Flow of Geothermal Steam and Non-Condensable Gases.* Proceedings World Geothermal Congress 2000. (pp. 585-590). Kyushu – Tohoku, Japan, May 28 – June 10.

Gunnlaugsson, E., Frimannsson, H. & Sverrisson, G.A. (2000). *District Heating in Reykjavik – 70 Years Experience.* Proceedings World Geothermal Congress 2000. (pp. 2087-2092). Kyushu – Tohoku, Japan, May 28 – June 10.

Gunnlaugsson, E., Gislason, G., Ivarsson, G. & Kjaran, S.P. (2000). *Low Temperature Geothermal Fields Utilized for District Heating in Reykjavik, Iceland.* Proceedings World Geothermal Congress 2000. (pp. 831-835). Kyushu – Tohoku, Japan, May 28 – June 10.

The Kyoto Protocol, International Climate Policy for the 21st Century. (1999). Sebastian Oberthur, Hermann Ott, Springer Verlag.

APPENDIX A

REYKJAVÍK ENERGY: INDICATORS			
	Unit	31.12.2000	31.12.1999
Inhabitants in Electric Distribution area		153.017	150.955
Inhabitants in Geothermal Utility area		164.106	160.862
Inhabitants in water supply area		111.342	109.795
Electricity consumption	(kWh/inhabitant)	5.275	5.005
Geothermal water consumption	(m^3/inhabitant)	369	348
Cold water consumption	(l/sec.)	700	650
Employees		474	400
Electricity sales	(GWh)	807	756
Geothermal water sales	(in thousands of m^3)	60.610	55.980
Cold water sales	(in thousands of m^3)	21.920	20.498
Average price of electricity (less VAT)	kr./kWh	5,76	5,57
Average price of geothermal water (less VAT)	kr./m^3	50,49	49,32
Average price of tap water (less VAT)	kr./m^3	15,26	*)
Substations		11	11
Substations, installed capacity	MVA	430	412
Distribution indoor stations		609	573
Distribution pole-mounted stations		151	156
Distribution indoor stations, installed capacity	MVA	388,5	392,7
Distribution pole-mounted stations, installed capacity	MVA	8,6	9,3
Underground- and submarine cables, 132 kV	km	48,4	48,4
Underground cables, 33 kV	km	19,6	13,8
Underground cables, 6-11 kV	km	503	467,9
Underground cables, 400/230 V	km	2.758,1	2.676,4
Overhead lines,132 kV	km	24,4	24,4
Overhead lines, 33 kV	km	6,5	6,5
Overhead lines, 6-11 kV	km	135,7	147
Overhead lines, 400/230 V	km	89,5	100,2
Street lighting poles		30.018	29.212
Street lighting luminaires		31.389	30.614
Street lighting, installed capacity	kW	5.281	5.224
Pipeline system, geothermal water	km	1.730,0	1.670,5
Pipeline system, potable water	km	875,6	848,8
Intakes, potable water		18.294	17.737
Service connections, electricity		27.158	26.628
Service connections, geothermal water		28.489	27.158
Service connections, potable water		14.196	13.940
Meters for geothermal water		37.299	*)
Meters for potable water		1.598	1.560
Meters for electricity		78.277	77.027
Maximum power demand	MW	156,5.	149,3
Total electrical energy requirement	GWh	850,5.	796,2
Down time:			
Down time in low, high and medium voltage system	minutes	31	30
*) not available			