Master‘s thesis

Harnessing tidal energy in the Westfjords

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Declaration

I hereby confirm that I am the sole author of this thesis and it is a product of my own academic research.

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March 2010

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Abstract

This thesis presents for the first time a serious and original attempt to provide direction for harnessing tidal power in the western fjords of Iceland. It focuses on the barrage method as the most likely technology to meet this goal. The feasibility of utilizing tidal energy as a renewable energy source in this area is approached from a scientific as well as a practical viewpoint.

Evaluating measurements of tidal currents, Fourier analysis of water heights time series, estimations of energy potential in selected locations in the Westfjords, evidence points toward the tidal barrage as the most promising approach to electrical generation in designated fjords. Preliminary findings indicate favorable conditions in a few specific areas.

In Gilsfjörður, a tidal barrage is already in place, making the addition of a power plant both cost-effective and practical. In another, a new road crossing is planned over three fjords, Þorskafjörður, Djúpifjörður and Gufufjörður. Combining road construction in the common mouth of those fjords, with tidal power plant development, addresses a range of local and regional issues, and would result in a maximum potential of about 70 MW of renewable periodic energy, producing a total of 144 GWh per year.

Keywords: Coastal zone, renewable energy, tidal barrage, tidal power, Westfjords.

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List of abbreviations and symbols

A	Surface area of the reservoir (km^2)
Ar	Swept rotor area (m^2)
C_D	Discharge coefficient
CO_2	Carbon dioxide
Dw	Energy unit
G	Acceleration of gravity (9.81 m/s^2)
H	Head (m) Difference in water levels across sluice or turbine
HAT	Highest astronomical tide
Hav	Average head (m), with $H \approx 0.7 \cdot$ Rmean
Htr	Tidal range (m)
H_2S	Hydrogen sulfide
K1	Lunisolar diurnal component
K2	Lunisolar semi-diurnal component
L	Water level (Above datum) (m)
MHWST	Mean high water spring tide
MHWNT	Mean high water neap tide
MHWS	Mean high water spring
MHWN	Mean high water neap
MLWN	Mean low water neap
MLWS	Mean low water springs
MSL	Mean sea level
M2	Principal lunar semi-diurnal component
M4	Lunar quarter diurnal component
N2	Lunar elliptic component

N/A	Not applicable
O1	Lunar diurnal component
P	Power (kW, MW, GW)
P	Potential power
R	Tidal range (m)
S	Surface area of the reservoir (m^2)
S2	Principal solar semi-diurnal component
T	Tidal period (6 hours)
m	Mass
mkr	Icelandic kronur in millions
m/s	Meters per second
ρ	Density of sea water (kg/m^3)
t	Time (s,m,h)

1 Introduction

In the Westfjords of Iceland, there remain relatively few opportunities for traditional hydropower production utilizing river energy. As a result, power from other parts of Iceland must be brought to the Westfjords. The biggest hydropower plant in the Westfjords is Mjólkárvirkjun, 8.1 MW in size. Total installed hydropower in the area is 12.5 MW. In 2006, the maximum measured load in the Westfjords was 39.4 MW, and the total reserve diesel generator power from eight generators which are scattered around the area is 20.2 MW. About 6 MW are required to fulfill the peak need. Estimated increase in electricity consumption by the year 2012 is 8 percent, which is about 3 MW at maximum load. In 2006, the total electricity consumption in the Westfjords was 226 GWh and of that 180 GWh, 80% was imported power from Landsnet [1].

The distribution system is fragile and Landsnet is planning to update the system because of frequent failures, as can be seen in report from the government owned company which is the main electricity distributor in Iceland. Estimated cost of a new power line to the Westfjords is between 6 and 6.4 billion Icelandic kronur. Delivery reliability is worse in the Westfjords than the rest of Iceland. As can be seen in Figure 1, the GE1 power line has the highest failure rate of all lines in Iceland, and the power lines MU1 and GL1 come in third and fourth respectively. All three lines are in the Westfjords. Taken from Table 1, power outages in the area were estimated to cost the local communities about 584 million Icelandic kronur in 2005. If reserve diesel generators are taken into account, this cost will decrease to 185 million kronur, cost of investment and operation of generators is not included. The carbon dioxide emissions associated with diesel generator replacing hydroelectric are an extra environmental burden [2]. Even though new power plants will be built in the Westfjords, the transmission system needs to be partly rebuilt. Some of the lines lie over high mountains and are subject to icing which causes line breakdown.

Table 1 Cost of power outages for the years 2005-2007 and estimate for the year 2012.

Year	Landsnet cost (mkr)	Community cost (mkr)	
		Relative to full outage of primary usage	Relative to full outage and taking into account usage of reserve generators
2005	9.9	582	185
2006	10.8	529	105
2007	7.5	120	40
2012	15.3	516	105

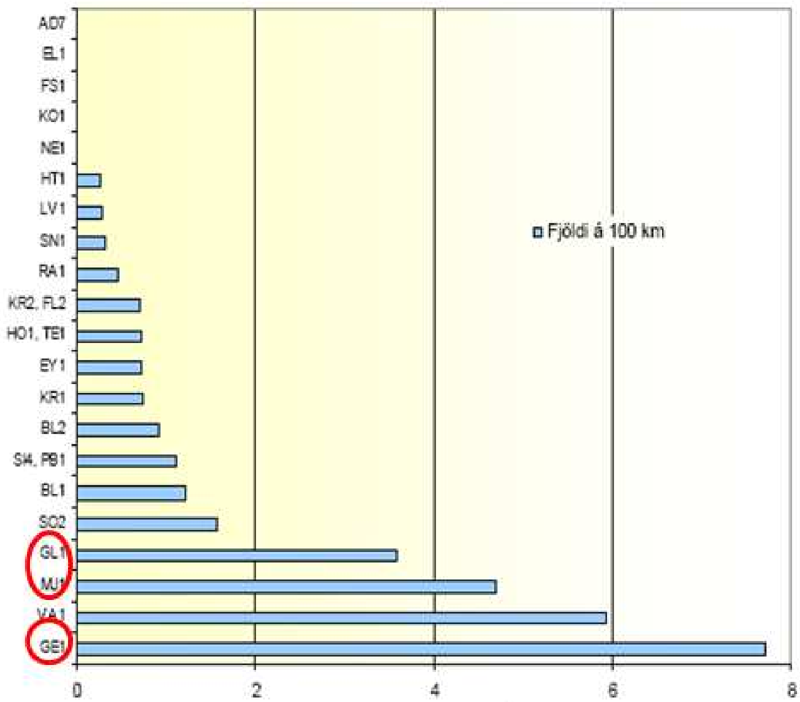


Figure 1 Line failure - mean number/100km/year (Landsnet-07032).

Some would argue that Iceland owns so much potential renewable energy resources in the form of river hydropower and geothermal energy that there is no need to look at other alternatives.

For the Westfjords, other alternatives need to be taken into consideration because of the lack of further possibilities for traditional generation of hydropower. Harnessing tidal energy is the option for renewable energy investigated in this thesis. Intermittent production is counterbalanced by the advantages of a free and endless energy source, long life of the power plant (barrage method) and limited pollution to the environment. Tidal power plants and river hydropower also go well together. It is precisely known when the tide turbines are producing energy and, at that time, the river hydropower plant's water supply can be regulated to begin collecting water in reserve.

There are increasing conflicts in Iceland about new river hydropower plants, primarily because of the non-reclaimable land lost to dams and water reservoirs. There are also disputes about ownership of land and water rights. Discussion about H_2S pollution from the geothermal power plant in Hellisheiði, as well as the discussion of global warming and the role of CO_2, have increased interest in using alternative renewable energy.

Harnessing tidal energy in the Westfjords close to the users may alleviate the costly need to completely rebuild the distribution system. It will also increase delivery security of electricity in the area and may increase electricity security for the rest of Iceland by increasing the number of different options to produce energy. Finally, tidal energy may increase opportunities in the area for industries that need secure electricity.

1.1 Field research

Current velocity is a big factor for harnessing tidal current energy but very little information about currents that are close to shore is available in Iceland. Some measurements have been conducted as a part of other surveys, e.g., for fish farming.

To obtain more information about the velocity of the currents close to land, the author of this thesis took measurements from a boat in five different locations known by local fishermen as heavy current areas. Two of the measurements failed because of errors in the measuring equipment, but the other three are part of the thesis findings. More research needs to be done in current measurements around Iceland to obtain a more complete picture of promising locations for tidal current turbines. The Icelandic Maritime Administration tidal current computer program can be used to estimate current speed inside fjords. To be able to utilize the computer program, detailed information is needed about the structure of ocean floor and coastline as well as some current measurements in those fjords to adjust the computer program.

1.2 The Westfjords

The Westfjords is one of the most remote areas of Iceland, situated in the northwest part of the country between 65°- 66°30´N and 24°34´- 21°12´W. The total population in January 2009 was 7.185. The fishing industry is the area's main industry, and there are hopes for a substantial increase in the tourism sector. We can see in Figure 2 that this area includes many fjords and about 1/3 of Iceland's coastline belongs to the Westfjords area. One of the fjords, Breiðafjörður, embraces the highest tidal range in Iceland, which is up to 5 meters.

Figure 2 The Westfjords.

1.3 Definition of the problem

The primary goal of this assignment is to determine if it is feasible to build one or more tidal power plants in the Westfjords. This project also examines the ethical and environmental issues associated with tidal harnessing. These issues include possible sacrifices to biology, biodiversity and measures that must be taken into consideration to minimize potential consequences.

1.4 Questions to be answered

The power of the ocean is a huge renewable resource, and there is increased interest throughout the world in harnessing it. The feasibility of harnessing tidal energy for power production in the Westfjords has not yet been examined. This project concludes the first such examination, and focuses primarily on the technical feasibility of such a project, rather than related economic factors.

Research questions answered include:

- Is it feasible to harness tidal energy in the Westfjords?
- If feasible, where are the most favorable locations in the Westfjords?

1.5 Study approach

In the world today, there is increasing pressure on cooperation with stakeholders to minimize conflicts regarding projects that affect nature and the environment, often owned and used in common by many local governments and individuals.

Insight into options and restrictions of a co-management scheme to oversee Icelandic coastal areas is limited. Therefore, the “Harnessing Tidal Energy in the Westfjords” project is approached both from a scientific as well as from a practical point of view to determine if such a project is feasible.

The purpose of a feasibility study is to decide if a business opportunity is possible, viable and practical. A feasibility study enables a realistic view at both the negative and positive aspects of the opportunity.[1]

This project includes a review of international and regional literature, principally peer-reviewed articles but also material such as consulting and internal reports. Findings from previous research concerning tidal power plants and integrated coastal zone management will be incorporated. Applicable data from official research agencies will be collected and analyzed. Applicable reports about current measurements and environmental impact assessment for the area will be analyzed and some stakeholders will be interviewed. Tidal current measurements in selected locations will reveal further information.

- The following alternatives are compared: tidal barrage, tidal current, upgrading the grid or making no changes.
- Are the circumstances favorable; sufficient current velocity, distance from local grid, satisfactory tidal range and will it improve the local grid.
- Environmental impact will be assessed in terms of change of water quality, potential fish- kill impact of the installed technology, impact on biology and biodiversity and altered tidal patterns.
- Social impact will be analyzed by the number of new jobs in construction and in operation, the increase in tourists visiting the power plant and the likelihood of attracting new industry.

[1] http://wiki.answers.com/Q/What_is_a_feasibility_study

1.6 Summary of the sections

Chapter 2 contains a study of applicable literature. The theory of the tides is described as well as a short overview of tidal power harnessing history. Functioning of the first tidal mills and information about some selected tide mills in the world will be reviewed in their historical context to give a picture of the magnitude. Methods of power generation from hydropower will be reviewed. Current status will be reviewed. Existing power plants will be examined, as well as new and future projects. Advantages and disadvantages of various power generation methods from tidal power will be discussed.

Chapter 3 reviews the regulatory framework, acts, regulations and taxes that related to the subject.

Chapter 4 identifies stakeholder groups and their interests.

Chapter 5 concerns connection to the electrical distribution grid.

Chapter 6 compares different existing sites and potential sites.

Chapter 7 identifies the best site location found in this study and reviews current measurements already available and those measurements done specifically for this thesis.

Chapter 8 examines how to use or store the energy.

Chapter 9 discusses barrage power plants in Gilsfjörður and Þorskafjörður.

Chapter 10 concludes the discussion and makes related recommendations.

2 Theoretical overview

2.1 The tides

Tide refers to the vertical movements, the rise and fall of the sea, compared to the land. The horizontal movement of the water to and from the coast caused by this rise and fall is called tidal current. These are mostly caused by the gravitational attraction of the moon and sun, on oceanic waters where the moon is the strongest, and in lesser degree by the rotational force of the earth. The earth rotates relative to the moon in one lunar day (24 hours and 50 minutes). Tidal bulges travel around the earth at 6 hours and 12.5 minute intervals. The range between high and low tide varies. When the tide's range is at its maximum, it is called a spring tide and occurs around the new and full moon when the sun, moon and earth form a line a condition known as syzygy. The tide's range at its lunar monthly minimum is called the neap tide and occurs when the moon is at the first- or third quarter, when the sun and moon are at an angle of 90 degrees to each other as seen from the earth.

In most parts of the world, tides occur twice a day but, in some geographical areas, there is only one tide a day. Tides are measured according to their recurrence phase within a tidal day, which is the period between two sequential high and low tides. There are three major types of tide: diurnal, semidiurnal and mixed tides. On the Atlantic coastline of Europe and the USA, as well as Iceland and the Westfjords, semidiurnal tides occur, which means that in one tidal day there are two high and two low tides, both at similar levels. One high and one low in a tidal day are called diurnal tides and occur, for instance, on the coasts of Alaska and Korea. Mixed tides, a combination of diurnal and semidiurnal tides patterns where each high tide reaches different heights and each low tide falls to different levels are found on the west coast of the USA. The tidal amplitude can increase due to resonance between waves, a funnel effect and the Coriolis force caused by the rotation of the earth. When the tidal range is below 2 meters it is called a microtidal regime and is thought to be unsuitable for energy extraction. If the range is between 2 and 4 meters it is called a mesotidal regime and a macrotidal regime if the range exceed 4 meters [3].

Meteorological conditions such as change in barometric pressure and wind also influence tidal current as well as the coastal geomorphology, water depth and ocean floor topography. Tidal currents have periods and cycles similar to those of the tides, and are subject to similar variations, but the flood and ebb of the tidal current do not necessarily occur at the same time as the rise and fall of the tide. Tidal current speed and strength increase and decrease along with the variations in the range of tide. Thus, the stronger spring and perigean[2] currents occur near the times of the new and full moon and near the times of spring and perigean tides. The weaker neap and apogean[3] currents occur at the times of neap and apogean tides. Tropical tides occur semi-monthly when the effect of maximum declination of the moon is greatest and tends to increase in the diurnal range. Tropic currents with increased diurnal speeds or with larger diurnal inequalities in speed occur at times of tropic tides. Equatorial tides (Figure 4) occur semi-monthly as a result of the moon being over the equator and is the minimum tendency of the moon to produce diurnal inequality in the tide. Equatorial currents with a minimum diurnal effect occur at times of equatorial tides [4].

Figure 3 represents the interaction between the sun, moon and earth and how they affect the tides. The moon rotates around the earth in a 29.5 day cycle and two high tides occur every 24 hours and 50 minutes. Spring tide occurs shortly after the new, and full moon and neap tide occurs shortly after the first and third quarter [5].

[2] When the moon is closet to the earth.

[3] When the moon is furthest from the earth.

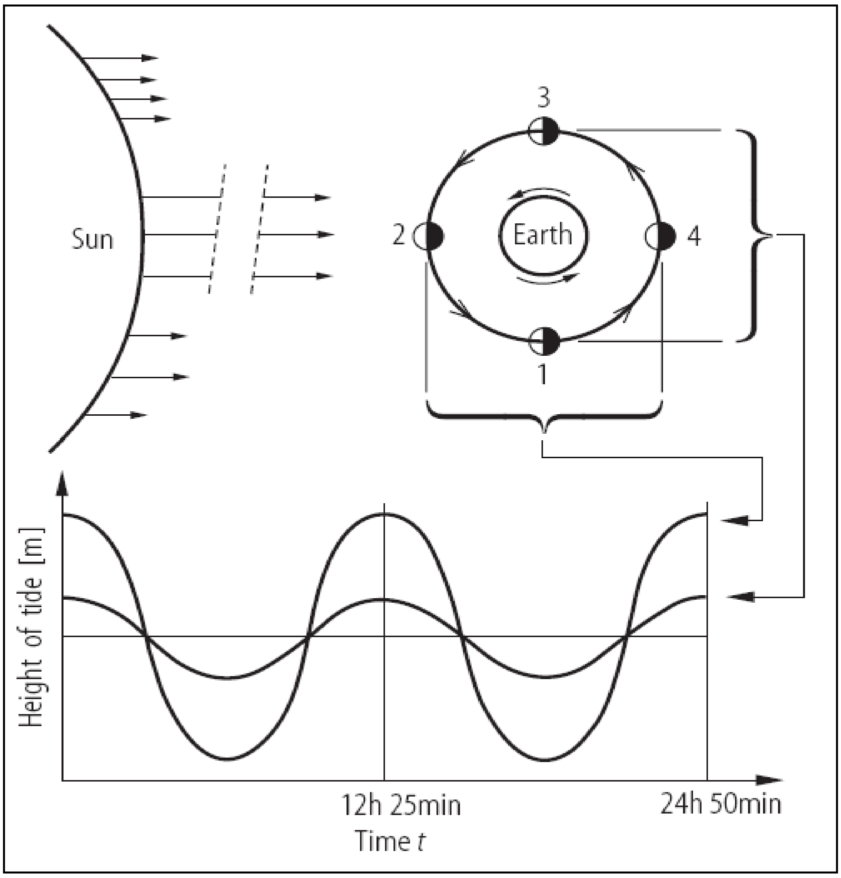


Figure 3 Interaction between the sun, moon and earth.

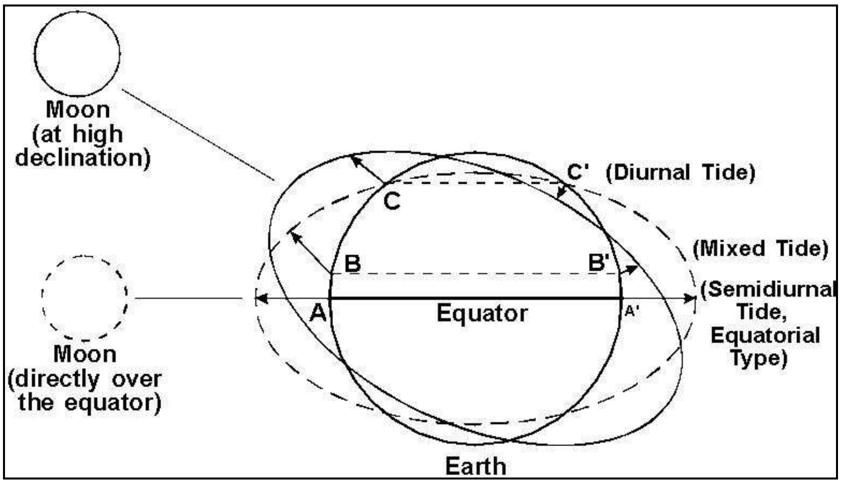


Figure 4 Lunar declination tide component.

2.2 A short overview of tidal power harnessing history

Aristotle (384-322 BC) observed that the constantly fluctuating ocean with its ebbing and rising always occurred about with the moon or phases of the moon. We can say that this cosmology was the beginning of tidal science.

Humans harvested this untamed power. For a long period, millers harnessed the energy of the ocean by using tidal mills, mostly for grinding grain by utilizing the mechanical energy generated by the tides. Through scientific methods, we can get a pretty clear picture of age, function and the essence of the process.

2.3 The functioning of the first tidal mills

Tide mills operate by storing water behind a dam during high tide. As the tide recedes, the water is released from behind the dam, passing through a water mill wheel in order to power the grinding stones of the mill. Dams with swinging gates were usually built along shallow creeks. As the tide comes in, water enters the mill pond through a one-way gate which opens inward, away from the sea. Water then fills the millpond behind the dam. When the tide begins to fall, the gate closes automatically, forcing the water to flow seaward through the millrace of the tidal mill. When the tide is low, the stored water can be released to turn a water wheel, which is either vertical Figure 5 or horizontal see Figure 6.

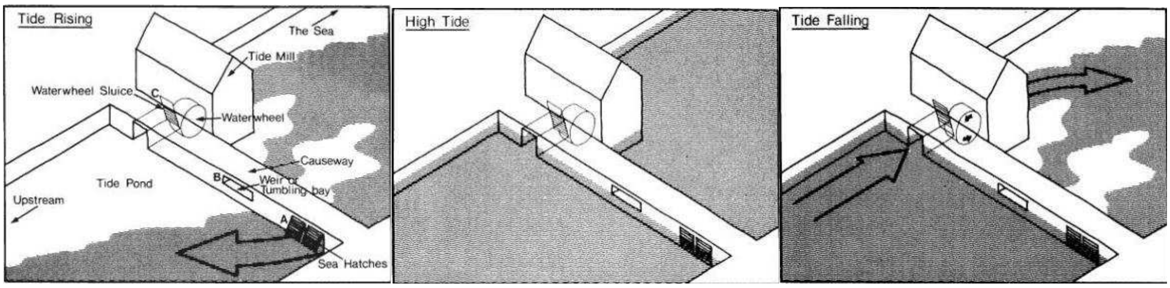


Figure 5 Functioning of the vertical 19th century Moulin du Prat mill [6].

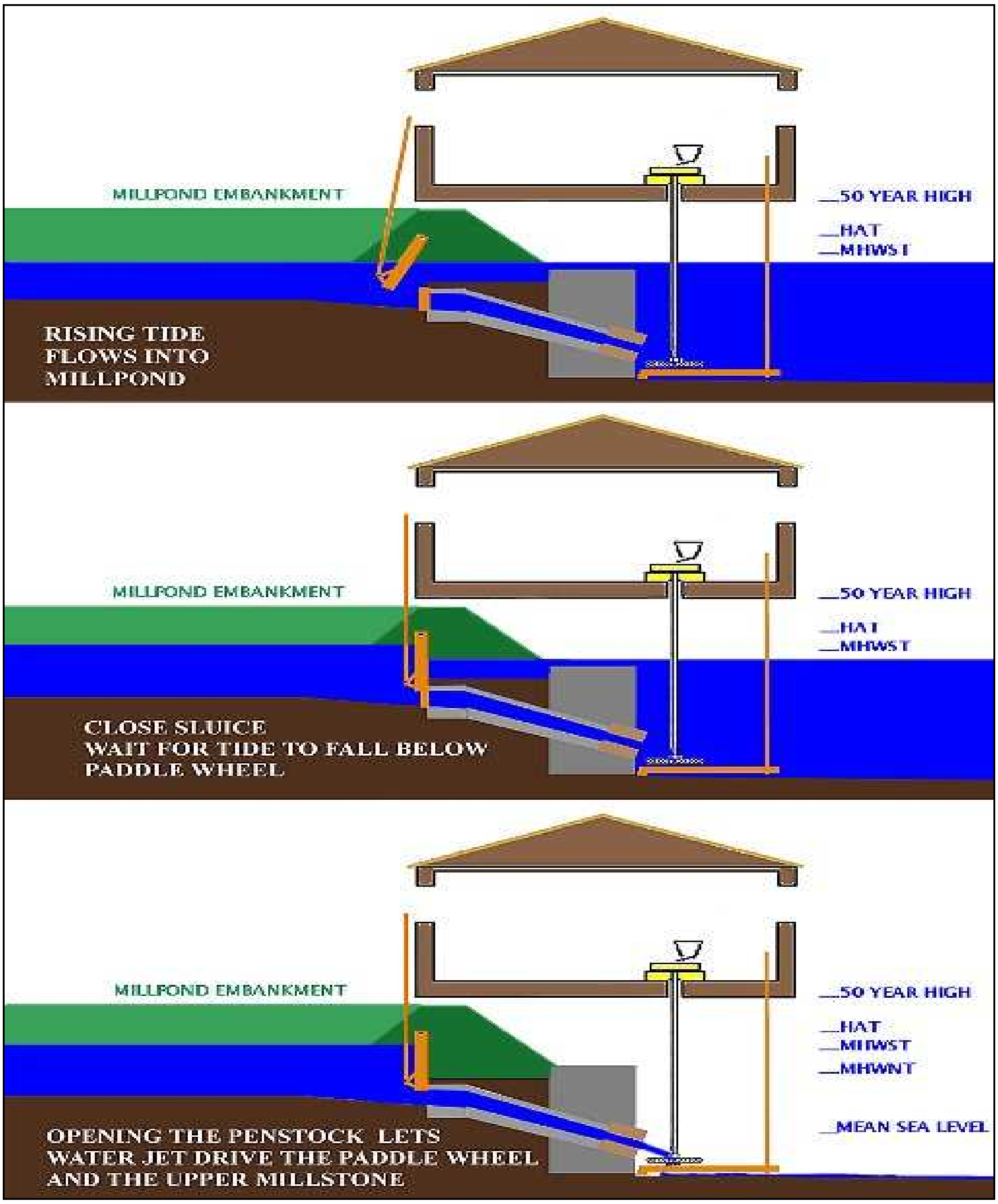


Figure 6 The functioning of the Nendrum horizontal mill [7].

2.4 Tidal mills

In the following paragraphs, information about known tidal mills in the world will be reviewed. This is not a complete list of all tidal mills but gives a picture of the magnitude. Common for those predecessors is that they are located in areas with high tidal range as can be found in the Westfjords of Iceland.

The earliest scientifically dated tide mill was found in Nendrum in Northern Ireland in 1999. Thomas McErlean, Norman Crothers and their team were investigating a fish pond as part of an on-going archaeological survey of the shores of Strangford Lough, when they found unusually well-constructed walls. Excavation uncovered the remains of two successive mills. The earlier was dated to the year 619 by dendrochronology study of timbers, and the later mill was dated from 789. The earlier one was operated by a large millpond compared to the later mill, which had a smaller one. The wheelhouse along with its stone sluiceway delivered the water jet to the paddles of the horizontal millwheel. Three of the paddle blades survived in a very good state of preservation, as we can see in Figure 7. The size of the millstones is 83 cm in diameter, and the horizontal water wheel is estimated to have developed about 7/8 Hp or 653 Watts at its peak power [8].

Figure 7 Nendrum tide mill. The wheelhouse and three paddle blades [9].

In the tenth century, the Arab geographer, Al Magdisi Sams al Din was the first one to mention tidal mills. He described a tidal mill found on the Tigris- Euphrates delta in Iraq and explained how it worked [10]. In 1044, a tidal mill was operating in Italy in the lagoons at the head of the Adriatic [11]. In the Doomsday Book, which is the record of the great survey of England, executed for William the Conqueror and completed in 1086 is the earliest documented information about tide mills in England. The oldest was built at the entrance of the port of Dover between the years 1066 and 1086. The book also mentioned the mills on the River Lea at Three Mills Island, now part of London's docklands.

Woodbridge Tide Mill, dating from 1170, an excellent example, survives in Suffolk, England.

The only operational tide mill in the United Kingdom is the Eling mill in Hampshire.There has been a mill on the site for over 900 years [12]. The mill was restored and 1980 it was re-opened as both a working mill, and a museum. Eling Tide Mill is a water mill that harnesses the power of the tide and is situated on the edge of Southampton Water. Many tide mills have been located around Europe’s coastline in the past and some are still in working condition as the mediaeval tide mill at Rupelmonde near Antwerp. As early as in the twelfth century the first tidal mills in France were developed on the Atlantic coast. The first tide mill in the Netherlands was located in Zuicksee in 1220 [13].

The first mill in North America was a double function mill built by Samuel de Champlain, the French founder of the first permanent European settlement in Canada with help from the Micmac Indians. Built in 1613 in Port Royal, Nova Scotia this mill used the power from world’s highest tides in the Bay of Fundy [14].

The Birlot Tide mill shown in Figure 8 on the Island of Brehat was build between 1633 and 1638. It was renovated in 1744 and again between 1995 and 2007 [15].

Figure 8 The Birlot Tide mill [16].

The tide mill in Ria Formosa, Portugal, built in 1885 and shown in Figure 9, was one of about thirty mills that were active in that area. It was discontinued in 1970. Presently it is one of the three tide mills in the country that are still working. Tide mills in Portugal can be traced back to the thirteenth century. In the 1950s, most were already abandoned due to the competition of mechanical mills.

Figure 9 Tide mill in Ria Formosa Natural Park [17].

In Iceland the first tidal mill was built in Brokey in the year 1901 by the farmer Vigfús Hjaltalín (1862-1952). This mill was used until 1924 for grinding grain. Around 1924 the price of grain exceeded the price of ground grain so it was not economically feasible to grind your own flour. The water wheel was 160 cm in diameter and was active for three hours in the ebb period and about two hours in the flood period. Both the axle and the paddle blades on the horizontal water wheel were made from wood, and iron strips were used to reinforce the paddle blades. In Figure 10 a remaining part of the mill can be seen. (oral information, Páll Hjaltalín, 29 September 2009).

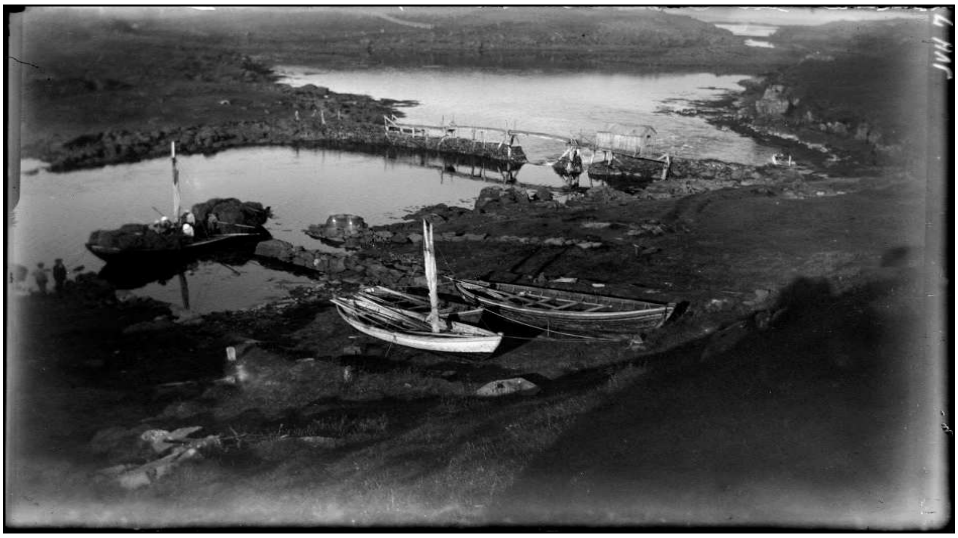


Figure 10 Tidal mill in Brokey. Photographer, Jón V. Hjaltalín (National Museum of Iceland).

Throughout the Middle Ages and in the seventeenth and eighteenth centuries there seems to have been a steady increase in number of tidal mills on the coastline, on both sides of the Atlantic Ocean and the North Sea. It is estimated that more than 800 mills were built. In the nineteenth century the number of tidal mills declined as mechanical mills took over. About the middle of the twentieth century, electricity gradually superseded tidal power and almost all were abandoned by the middle of the twentieth century. The last tidal mill, the Bauchett mill, closed in 1980 [18].

Figure 11 shows distribution of tidal mills around the Atlantic coast of Europe.

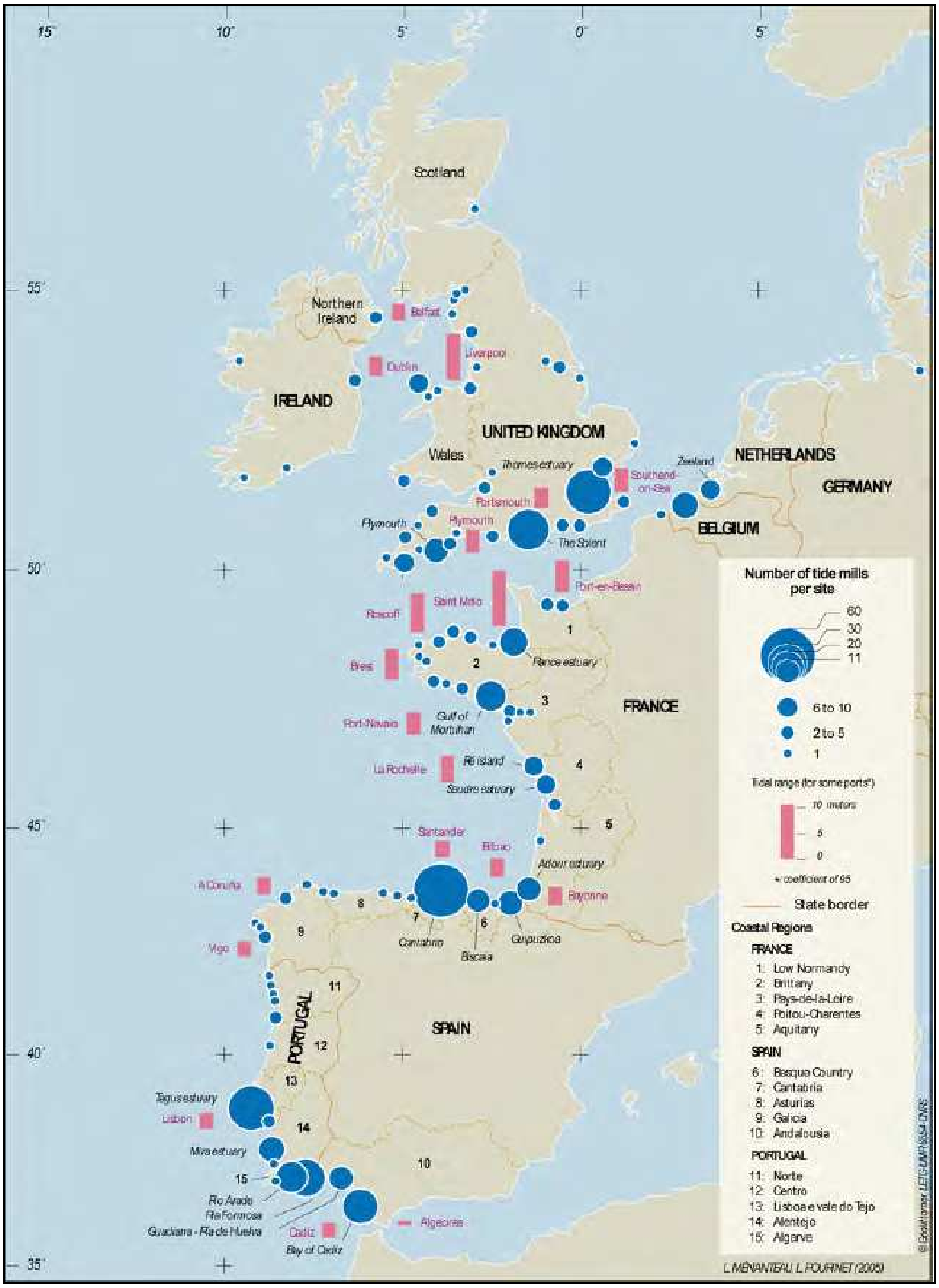


Figure 11 Distribution of tidal mills around Atlantic coast of Europe [19].

2.5 Tidal power plants

At the end of the nineteenth century the first ideas were developed about how to gain electric energy from the tides. In 1931 Paul Shishkoff demonstrated a 220 kW prototype at the River Avon on the Severn Estuary in UK [20]. The first attempt to build a large tidal power plant was not until 1960 when the French government decided to build the La Rance tidal power plant, in operation since 1966, with installed capacity of 240 MW.

In 1968 the pilot project at Kislaya Guba in Russia with installed capacity of 400 kW went into operation. In 1984 the 20 MW pilot tidal power plant at Annapolis in Canada went online.

In 2005 the construction of Sihwa tidal power plant started in South Korea and has a target completion date of August 2010. Installed capacity is 254 MW, utilizing ten 25.4 MW turbines.

There are three tidal power plants in the world that have been in use for many years and are connected to the electricity grid. The largest one is located on the estuary of La Rance River in France. The generating capacity is 240 MW on the incoming and outgoing tide. The Annapolis tidal power plant in Canada comes in second place with a generating capacity of 20 MW while the smallest one is located in Russia in Kislaya Guba on the White Sea, with a capacity of 0.4 MW.

La Ranch

La Rance Tidal Barrage (Figure 12) was built in the 1960's near St. Malo in France. A dam 800 meters long was built in front of a 22 km^2 basin. The average tidal range is 8 meters and its maximum is 13.5 meters.

Figure 12 La Rance tidal power station (Michel Coupard/Stillpictures).

The plant consists of 24 units of 10 MW bulb turbine generators (Figure 13) using 5.35 meter diameter Kaplan wheels which generate electricity both in and outgoing tide and can also been used for pumping. The average power generated is about 68 MW for an annual output of about 544 GWh of electricity, sufficient to power 4% of the homes in Brittany.

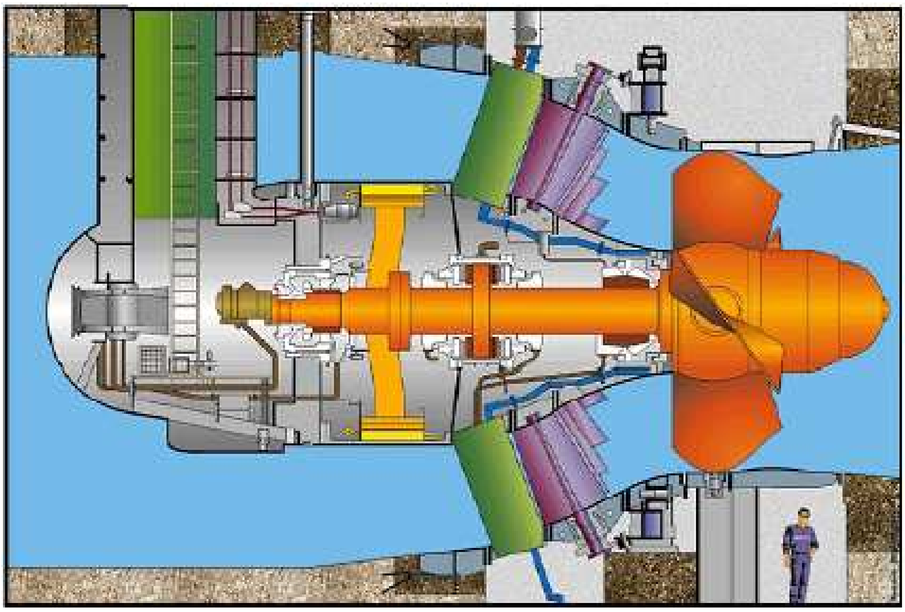


Figure 13 La Rance power station (Bulb turbine, ALSTOM).

In November 2006 the La Rance tidal power plant celebrated 40 years of active service during which time about 21 billion kWh of electricity were generated without major incident or mechanical breakdown [21]. The initial capital cost of the power plant 100 million US dollars at that time rate of currency, was repaid after 6 years production and the cost of electricity production is now below 0.03 US dollar per kWh [22].

Figure 14 illustrates the operational modes of La Rance power plant in ebb generation and in two way generation. It is also possible to increase the reservoir level by pumping water on the high tide into the reservoir with the turbines. This may be done to generate more electricity in periods when the price is the highest.

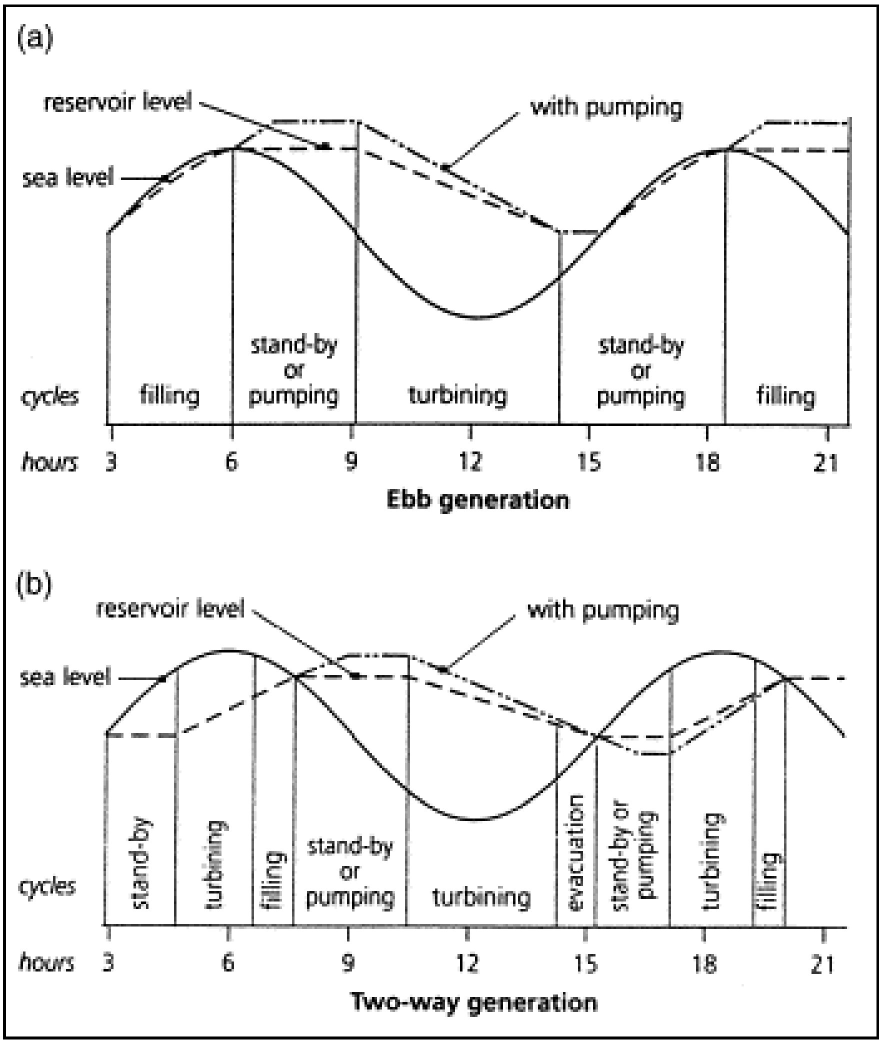


Figure 14 Alternative operational modes at La Rance [23].

Kislaya Guba

The first Russian tidal power plant project began in 1968, in Kislaya Guba (Figure 15). It is sometimes referred to as the women's tidal power plant and was completely built by female engineers. It is located on Kola Peninsula close to the White Sea in a 40 meter wide and 3-5 meter deep inlet surrounded by high cliffs. The lagoon inside the dam is a 1.1 km^2 and 35 meter deep area, and the average tidal amplitude is 2.5 meters. At high tide the current speed is about 4 m/s. The power house was built near Murmansk and towed by a tug and then sunk in place. The turbines are of the bulb type, the same type as used in the Ranch River power plant. The runner diameter is 3.8 meters and the rotation speed of the turbine and the generator are 69 and 600 rpm respectively. The plant's installed capacity is 400 kW [24].

Figure 15 Kislaya Guba tidal power plant [25].

Annapolis

The Annapolis Royal tidal power station (Figure 16) was the first tidal power plant in North America, a government pilot project initially designed to explore harnessing energy from the ocean. Construction of the Annapolis project began in 1980, and was completed 1984. It is located on Hogs Island in the Annapolis River canal which opens into the Bay of Fundy. The Bay of Fundy is known for producing the world's highest tides in the Minas Basin. Average range is 12 meters, but it can reach up to 16 meters in height. The straight flow (Figure 17) rim turbine utilizes a 7 meter tidal range to produce enough electricity to power about 4.000 homes. The barrage is 225 meters long, and the basin area is 15 km^2. The installed capacity is 20 MW and yearly production is more than 30 GWh. In harmony with the high-tide rhythm of the sea, the Annapolis station feeds the grid every 12 hours and 25 minutes. The Annapolis station comes on for five hours, and then it is off for seven hours before it comes on again.

Figure 16 Annapolis tidal power plant [26].

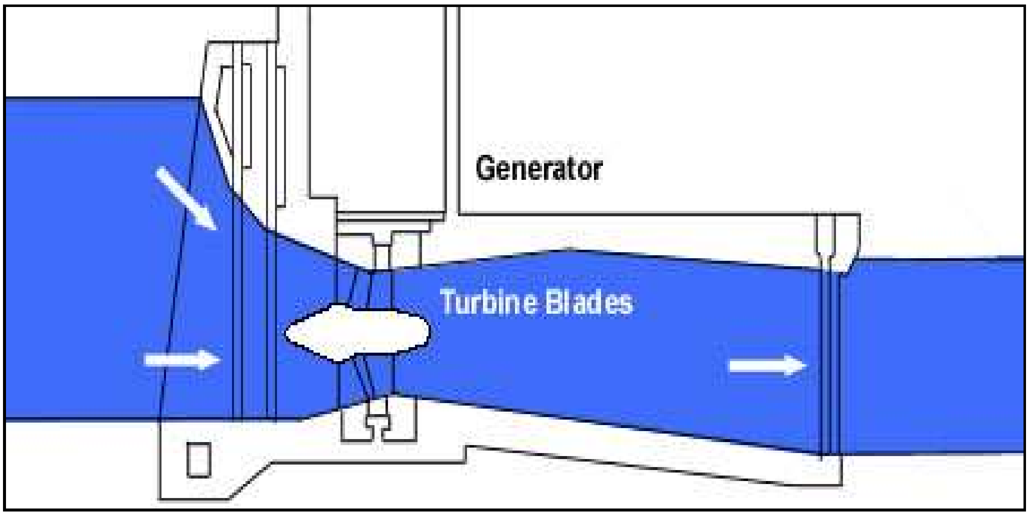


Figure 17   Rim Turbine (copyright Boyle, 1996).

Sihwa Lake tidal power plant

Figure 18 Bird's eye view of Sihwa tidal plant, South Korea (Daewoo).

When completed in August 2010, the South Korean Sihwa Lake (Figure 18) will be the world's largest tidal power plant, with a planned generation capacity of 254 MW and annual production of 553 GWh. Ten bulb turbines of 25.4 MW each will be driven by 60 billion cubic meters of annual tidal flow [27]. The cost of the project is estimated to be 350 million US dollars.

Sihwa Tidal Power Plant uses an existing barrage constructed in 1994 for flood mitigation and agricultural purposes. The tidal barrage provides indirect environmental benefits as well as renewable energy generation. After the Sihwa Lake seawall was built, pollution built up in the newly created freshwater reservoir, making the water useless for agriculture. Seawater was reintroduced into the reservoir in 2004 in the hope of flushing out contamination. The plant is a flood generation system which means that power is only generated on tidal inflows. This approach has been chosen to balance a complex mix of existing land- and water use, conservation, environmental and power generation considerations. Mean tidal range is 5.6 m, with a spring tidal range of 7.8 m and the basin area is about 43 km^2 [28].

South Korea has other large tidal power schemes planned, including a 300 MW turbine field in the Wando Hoenggan waterway and a proposal for a seawall and 600 MW barrage at Incheon [29].

2.6 Tidal technology - overview

Tidal power, also called tidal energy, is a form of hydropower that converts kinetic energy of the tides into electricity.

When generating electricity, no new energy is created. Energy cannot be created or destroyed its form can only change or be converted to another form. Water must be in motion in order to generate electricity. This is kinetic (moving) energy. When flowing water turns a turbine in a hydroelectric power plant, the form is changed to mechanical energy. The turbine turns the generator rotor which then converts this mechanical energy into electricity. For a more reliable water supply, reservoirs are used, which act much like a battery, storing energy to be released as needed to generate power. To get the energy from the water, water has to flow from a higher point to a lower point.

When water flows through a pipe or penstock from the reservoir to the turbine, the water’s force on the turbine blades turns the rotor the moving part of the electric generator. When coils of wire on the rotor sweep past the generator’s stationary coil (stator), electricity is produced.

This concept was discovered by Michael Faraday in 1831 when he found that electricity could be generated by rotating magnets within copper coils.

Diverse technology for harnessing renewable and sustainable coastal zone energy has been developing during the last decades, and to-day the tides, tidal currents and wave energy are utilized to harness alternative renewable energy [30].

2.7 Why harness tidal power?

Compared with other power production tidal power is extremely clean power, as can be seen from Table 2. Emission by fuel type in the table includes fuel mining, transport, plant construction and plant operation. (oral information, Norm R. Catto, 9 February 2009)

Table 2 Emission by fuel type.

Nuclear	1-5 g C/kWh
Tidal/Wind	1-10 g C/kWh
Biodiesel	10-20 g C/kWh
Hydro	5-60 g C/kWh
Solar	25-75 g C/kWh
Natural gas	125-180 g C/kWh
Light petroleum	210-240 g C/kWh
Bituminous coal	270-360 g C/kWh

Advantages

- Predictable output for as long as desired.
- If crossing over a fjord the barrage can be used as a road.
- Tidal power plants have no related fuel cost.
- Melt from glaciers and variations in precipitation or drought do not have any impact on tides.
- A diversity of power generation is attractive for the country's energy mix.
- Long-lived construction (equipment 40 years and structure estimated to 100 years).
- Inexpensive electricity (La Rance barrage power plant).
- No potential risk (barrage power plant).
- Renewable energy source.
- Limited pollution to the environment.
- Tidal power does not produce CO_2.
- Tourist attraction (barrage power plant, Annapolis 35.000 visitors/year).
- Tidal power plants and river hydropower go well together.

Disadvantages

- Environmental and ecological effects.
- Intermittent production.
- Variable output.
- Not dispatchable - can only be delivered when available.
- Low head means large discharge which requires expensive structures.
- Salt in seawater is corrosive.
- No fishing allowed around current turbines.

Unlike wind and solar renewable energy, tidal power production is entirely predictable. It can be used as a base-load power supply in a similar way as river hydropower and is immune from sunlight requirements and climate conditions. In spite of the potential negative effects, tidal energy remains a source of completely clean, renewable energy with very low risk. This makes tidal energy an excellent choice for the future.

2.8 Tidal Barrage - tidal power plants.

The barrage method to generate electricity from tides is a very similar method as that used for low head river hydroelectric generation. It must be taken into account that tidal water both ebbs and flows. There are alternative methods of operation: generate at ebb tide, generate during flood or generate during both flood and ebb tides. The simplest generating system for tidal plants is known as an ebb generating system. A dam or a barrage across an estuary or a fjord is needed. The tidal basin fills through sluice gates on the barrage (Figure 19) on the incoming high tides and exits through the turbine system on the outgoing tide. Double functioning turbines can also been used for generating and pumping. Studies have shown that the lowest unit cost of energy is obtained either with simple ebb generation or ebb generation with pumping at high tide [31].

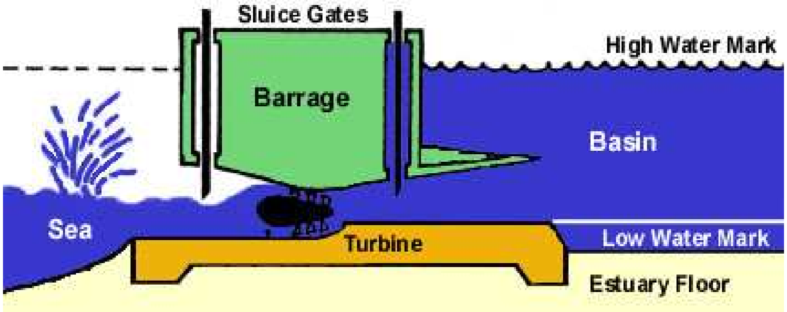


Figure 19 Ebb generating system with a bulb turbine (NSW).

Several different turbine configurations are possible but bulb turbines are most commonly used in existing tidal power plants. They can produce energy from a head between 2 and 10 meters. Bulb turbines (Figure 13) are used in La Rance, Kislaya Guba and Sihwa tidal power plants. Bulb turbines can be used for pumping also. A straflo or rim turbine as used in Annapolis Royal power plant (Figure 17) has the generator mounted at right angles to the turbine blades inside the barrage. These turbines are unsuitable for use in pumping. Tubular turbines (Figure 20) where the blades are connected to a long shaft and the generator is sitting on top of the barrage, is easily accessible for maintenance. Average daily load factor for tidal power plants is between 42 – 56 percent of installed turbine capacity and can even go down to between 21 and 34 percent in a longer perspective [32].

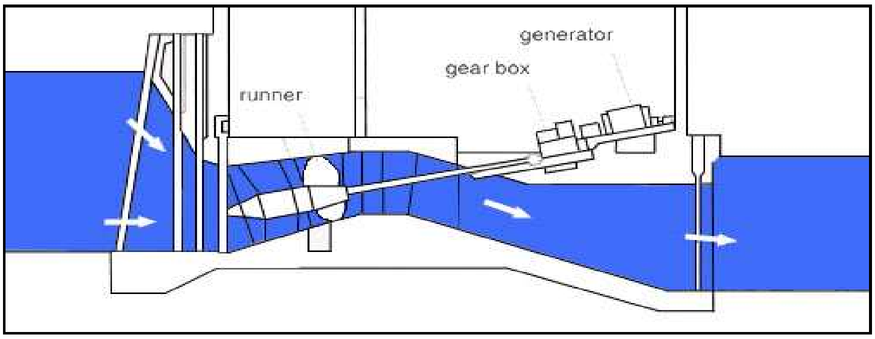


Figure 20 Tubular turbine (copyright Boyle, 1996).

Tidal lagoons

Offshore tidal power generation from "tidal lagoons" is a new approach to tidal power generation. Tidal lagoons use a rubble mound impoundment structure and low-head hydroelectric generating equipment situated up to a kilometer or more offshore in a high tidal range area (Figure 21). Shallow tidal flats provide the most economical sites because of lesser volume and lower cost of the lagoon structure.

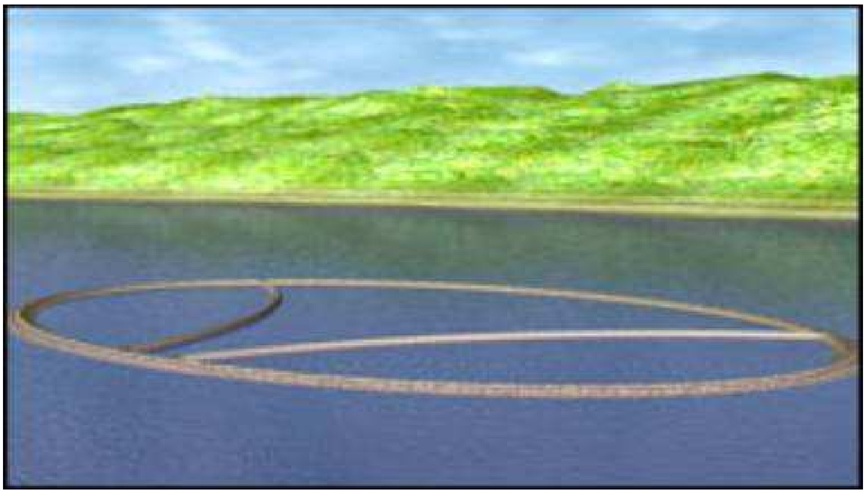


Figure 21 Tidal lagoon proposed for the Swansea Bay area in Wales (BBC).

2.9 Social implications (tidal barrage)

While building a barrage tidal power plant, many social consequences on the surrounding area can come into play. During construction, which might take several years, many new jobs will be created and both traffic and people will increase in the area. La Rance took over five years to build and Sihwa took about the same time to build. Using the barrage as a road may shorten distances between places sparing both time and money. The calmer bay inside the barrage may bring new job opportunities to the area in form of recreation and aquaculture. The power plant can be on display for tourists with restaurant and bird watching facilites. The barrage will affect boat traffic so a lock may need to be built. About two percent of the total kelp harvest comes from the area inside the Þorskafjörður barrage. There will be an increase in the local hospitality industry that will accommodate tourists and other visitors brought to the area by an opportunity to see this form of power generation. This will boost the local and national economy.

2.10 Ecological and environmental aspects (tidal barrage)

Gibrat (the "father" of the La Ranch tidal power plant) states that power generation from tidal power plants are an "entirely clean" form of energy from the environmental impact point of view. This may be true for a single-basin double-effect scheme which allows the natural phenomena of the tide to be used for power generation while maintaining the natural rhythm of the level variations in the basin. This can be obtained by changing the phase timing of these variations slightly [33]. Installation of tidal barrage may have an impact on ecology and environment in the surrounding area. Each site is different, and it not easy to predict consequences since there are very few projects to compare with. A barrage crossing a fjord may change the tidal pattern which can tune the bay either closer to resonance with a larger tidal range or away from resonance which causes a smaller tidal range. This may also change the patterns of tidal currents which in turn change the sedimentation. Water mixing and temperatures inside the barrage may change as well. The intertidal wet or dry habitat will change forcing flora and fauna to move or adapt. By keeping the water exchange at its maximum the consequences may be lessened [34]. Fish may be killed in the turbines and their migration to feeding grounds and spawning areas is hindered. Dadswell and Rulifson argue that limited number of studies suggest that rate of mortality of fish passing through the turbines in tidal power plants of gated barrage design are beyond acceptable limits. Fish bypass and guidance system may work for some tidal power plants but they are site specific and must consider fish species and the site characteristics. The critical design factors for fish passage through turbines are number of blades and rotational speed, turbine diameter, discharge, pressure flux and cavitations potential. Lower-head means fewer turbine blades and slower rotational speed which is better for the fish. On the other hand, the main advantage of tidal power plants is absence of harmful emissions like CO_2, which lead to greenhouse effects, which in turn can result in catastrophe for mankind as sea level rise [35].

To gain actual information about environmental impact from tidal power plants, three existing plants were studied.

No environmental impact assessment was made before or during the construction of the La Rance river tidal plant. A local fish, the lansón, disappeared due to habitat loss, but the oyster culture was enhanced. During the construction period some sand from beaches close to the construction site disappeared, a situation partially redressed after the plant was completed. The tidal range has reduced for about 0.7 m, to 12.8 m. The fishing industry has remained unaffected. The use of a cofferdam during construction was damaging for the environment but once in the operation stage an increasingly diverse fauna and flora colonized the area, showing a variable degree of biological adjustment [36]. The ecosystems remain strongly dependent on the operating conditions of the power station and to-day La Rance only runs in ebb generation mode to minimize environmental consequences [37].

An environmental assessment was conducted about 20 years after the Kislaya Guba tidal power plant began operation. It was observed that the considerably reduced water exchange between the bay and the open sea forced the salinity to drop, in the upper 15 m of the water column, while hydrogen sulfide accumulated below that level. The flora and fauna were different on each side of the power plant. In 1987 water exchange was increased and six years later the fauna and flora did not differ substantially in distribution inside or outside of the bay.

The study of Kislaya Guba conducted by Marfenin, et al., reveals that construction of tidal power plants may have major impacts at least where small power plants are placed in narrow entrance in a bay like in Kislaya Guba. An environmental impact assessment is strongly recommended prior to construction [38]. Both environmental impact assessment and strategic impact assessments were conducted in advance of construction of the Annapolis tidal power plant. Studies have shown that pathways for fish, included in the project at the Annapolis power plant are not very effective in sparing marine life and mortality. Depending on such factors as marine species and size and turbine operation the mortality was from 20 to 80 percent. Freezing at the surface is more common with a power plant, but mainly due to a lower heat flux from the bay bottom.

2.11 Economics (tidal barrage)

The economic sacrifices are large capital costs in the beginning and long construction time (over five years for La Rance and Sihwa) plus intermittent energy production. On the positive side, once built the cost of maintenance and operation is very small. A barrage type structure is highly durable and has a long economic life, between 75 to 120 years and endless free fuel. It should be noted that in the electrical power industry the profitability is only 6.9 percent or less (1984). The basic indicator of economic assessment in designing barrage tidal power plant is the ratio between benefits and costs (R=B/C) where the benefits are the product multiplied by the price for the product and the costs are the annual operational and maintenance expenses and costs of the loan. If the ratio (R) is greater than 1 the capital investment is considered to be viable. The R index for proposed Severn tidal power plant scheme is computed from 1 to 1.7 depending upon the interest rate and for Fundy power plant it lies within 1.3 and 2.45. However all tidal power plants are different so one may be viable but others not [39].

2.12 Tidal currents a different concept of tidal power plants.

Tidal fences

Along with concerns about the environmental effects of tidal barrage, the combination of global warming caused by increased CO_2 in the atmosphere, and the search for new ways to produce renewable energy have led to development of technologies that aim to have smaller environmental impact. Two key areas of development are in tidal fences and tidal turbines.

Tidal fences are composed of a number of individual turbines mounted within the fence structure. They completely fence a channel forcing all of the water through them as shown in Figure 22.

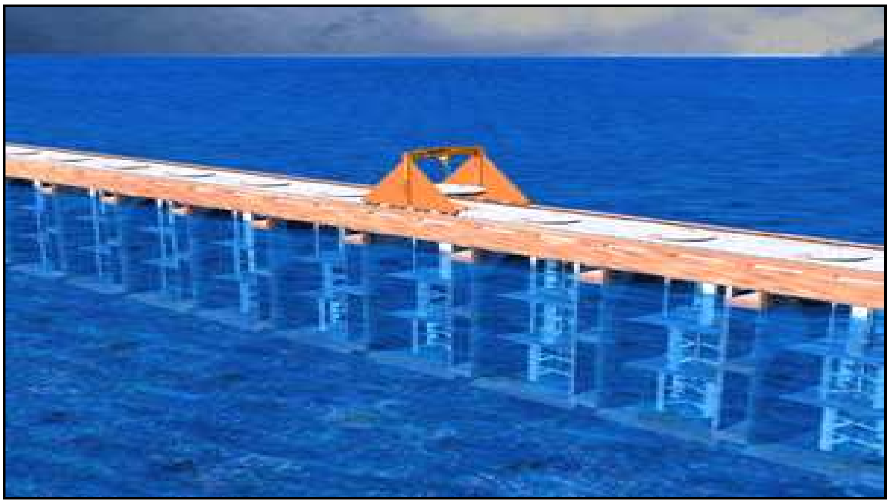


Figure 22 Artist's impression of a tidal fence in operation (Blue Energy Canada).

Unlike tidal barrage power stations, tidal fences can also be used in unconfined basins, such as between two islands or an island and the mainland. Tidal fences have also much less impact on the environment as they do not require flooding of a basin and their footprints are smaller. It is easier to remove them and reclaim the land if necessary. Tidal fences also have the advantage of being able to generate electricity from the time the first module is installed rather than after complete installation. To be feasible maximum current speed needs to be more than

2 m/s in the area before installation of the fence. Tidal fences affect the environment as they can disrupt the movement of large marine animals and also interrupt navigation [40].

Tidal turbines

Unlike tidal barrage and fence tidal systems installations, tidal current turbines in open flow can generate power from flowing water with reduced environmental effects. They have a smaller footprint, which allows over a much wider range of sites than those available for conventional tidal power generation. They need strong tidal currents with a large amount of kinetic energy. The equipment is usually of a windmill type suitable for underwater use and follows the same physical principles. The blades are much shorter because seawater is 800 times denser than air.

The world's first tidal turbine, shown in Figure 23, was tested in 1994, when a 10 kW proof-of-concept turbine was operated in the Corran Narrows, Loch Linnhe in Scotland. The swept rotor area is 10 m^2.

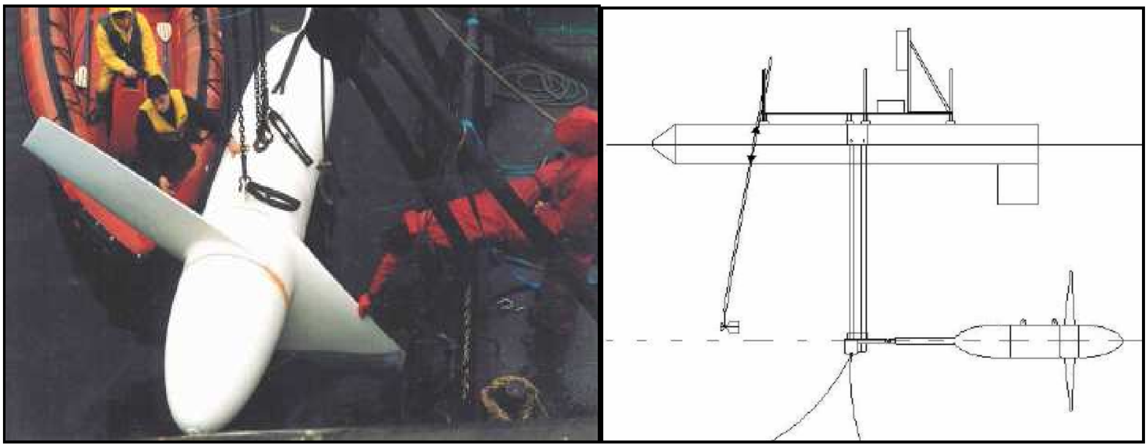


Figure 23 World's first tidal turbine (IT Power. Scottish Nuclear & NEL).

It resembles a horizontal axis wind turbine, as seen in an artist's impression in Figure 24. Tidal turbines optimize currents at between 2 and 3 m/s to generate between 4 and 13 kW/m^2. Current moving faster than 3 m/s can overly stress the blades, while lower velocities are uneconomic.

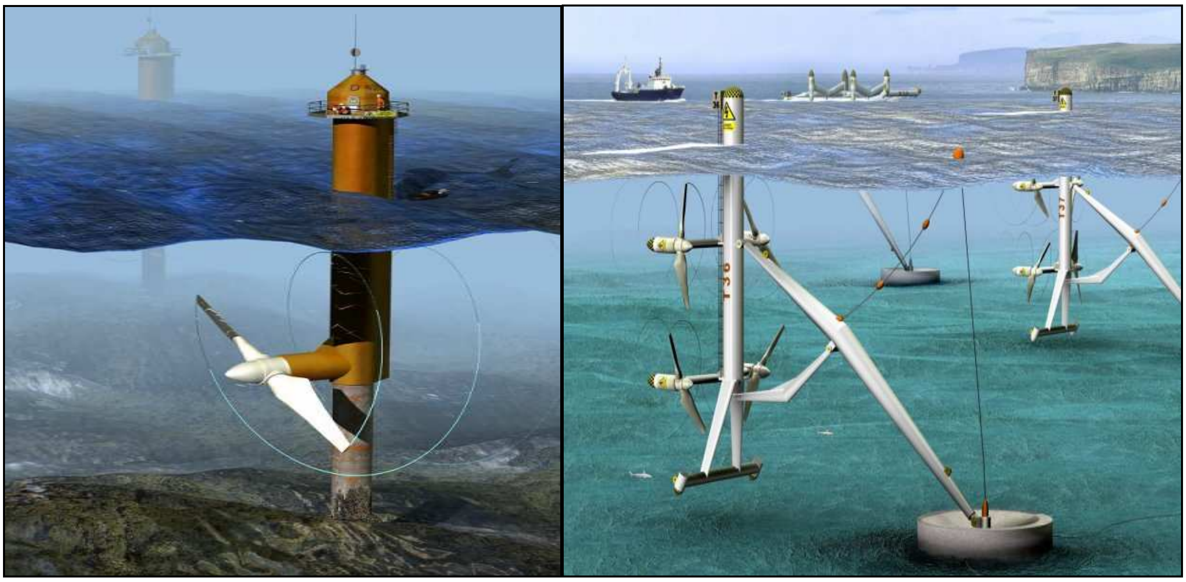


Figure 24 An axial flow turbine and 4 MW Pentland Firth turbines (Tidal Stream).

Hammerfest Strøm installed a 300 kW prototype in 2003 in Kvalsund close to Hammerfest in northern Norway. In Figure 25 the prototype is sitting on the seabed at a depth of 50 meters utilizing current speed of 2 m/s in both directions. This turbine was the first in the world to produce electricity from the kinetic energy in tidal currents and deliver it to the national grid. After four years of collecting information, the turbine was removed from service for inspection and then reinstalled in the summer 2009 [41].

Figure 25 300 kW prototype (Hammerfest Strøm).

Lunar Energy's 1 MW Rotech Tidal Turbines (Figure 26) can be linked together and vary in size from 100 to 500 RTT units [42].

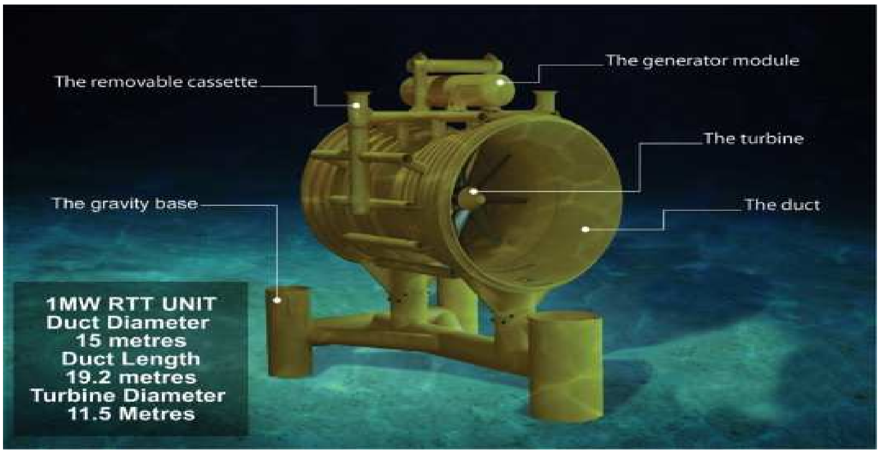


Figure 26 Lunar Energy's turbine (Lunar Energy).

Marine Current Turbines installed the SeaFlow, a 300 kW prototype turbine, in May 2003 (Figure 27). This is the world's first offshore tidal turbine, installed off Lynmouth, Devon. The swept rotor area is 95 m^2.

Figure 27 A hybrid image of the Seaflow turbine installed at Lynmouth (MCT).

Figure 28 is a picture from Marine Current Turbines (MTC) of SeaGen, the world's first commercial-scale tidal energy system, in its final stage. SeaGen has been ready since January 2009to generate power into the grid on a fully automated basis for about 18 hours a day. This 55 meter high and 415 ton turbine produces around 3800 MWh per year. The swept rotor area is 400 m^2 [43].

Figure 28 SeaGen, 1.2MW in Strangford Lough, Northern Ireland (MCT).

Table 3 illustrates how the Marine Current Turbines project costs decrease over time. Angle Skerries commercial is scheduled to be online in 2010.

Table 3 Marine Current Turbines initial project costs.

Location	Rated power (MW)	Capital cost (£k/MW)	Life cycle unit cost (p/kWh)
Strangford	1.2	5,191	16.8
Anglesey Skerries demo	10.5	2,537	11.7
Anglesey Skerries commercial	51	1,489	7.9
Anglesey Skerries when fully developed	100	923	5.2

Figure 29 compares the production cost with other known electricity production technology. In the year 2009 the costs decrease to the same cost as off-shore wind. Cost for the project number 2 in the year 2010, a 50 MW turbine farm, is projected to go below production costs for on-shore wind turbines.

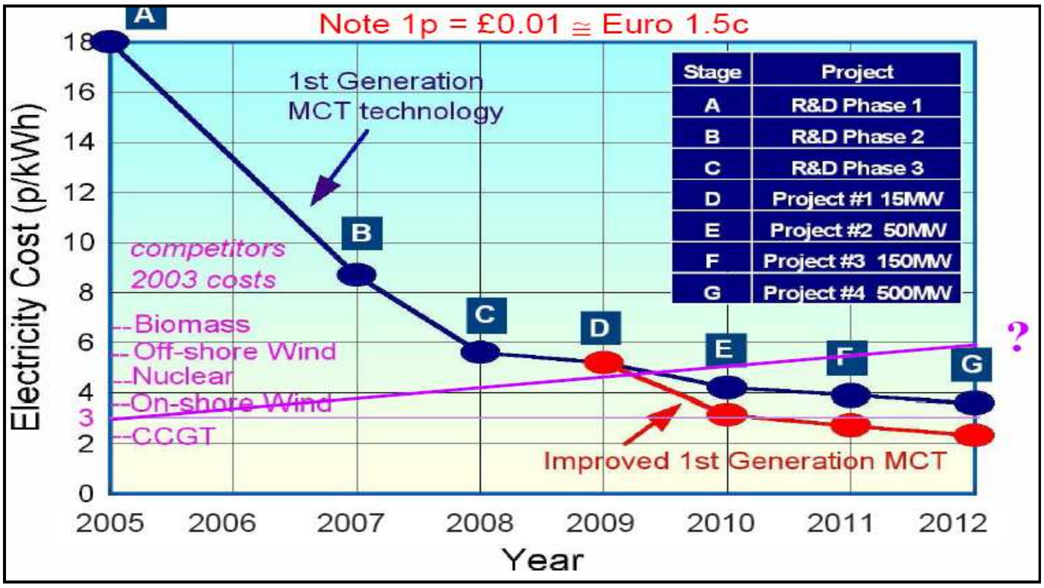


Figure 29 Production cost compared with other energy production.[4]

[4] Marine Current Turbines: a progress report, Peter Frankel – Technical Director – MCT Ltd (2007) Life-cycle unit cost projections from due diligence report by Black and Veatch (assumes cost of capital at an 8% discount rate)

The Energy Systems Research Team at the University of Strathclyde has developed a contra-rotating marine current turbine (Figure 30 and Figure 31) with integral power take off. Using patented new rotor technology, this design enables more energy to be delivered from the flowing stream while reducing mechanical complexity. A 2.5 m diameter rotor prototype has had successful sea trials and has now being engineered into a complete system with a direct drive generator and tension mooring system. The author of this thesis took the following photos on a visit to the University of Strathclide in April 2009.

Some benefits of this turbine are:

- Higher power output compared to an equivalent sized conventional device.
- Reduced environmental impact.
- Low maintenance due to simple direct drive and no requirement for a complicated gearbox.
- No expensive piled seabed structure required.
- Suitable in waters deeper than 40m.

Figure 30 Contra rotating turbine.

Figure 31 From visit to the University of Strathclyde.

In October 2009, a new 1 MW "open-centre" tidal turbine designed by Open Hydro was installed at the Minas Passage in the Bay of Fundy (Figure 32). The open-centre turbine has a slow-moving rotor and lubricant-free construction with just one moving part and no seals. It is a self-contained rotor with a solid state permanent magnet generator encapsulated within the outer rim, optimizing maintenance requirements. OpenHydro's technology will be tested for up to two years. During this time, data will be collected to determine the environmental performance and future feasibility of tidal power in the Bay of Fundy [44].

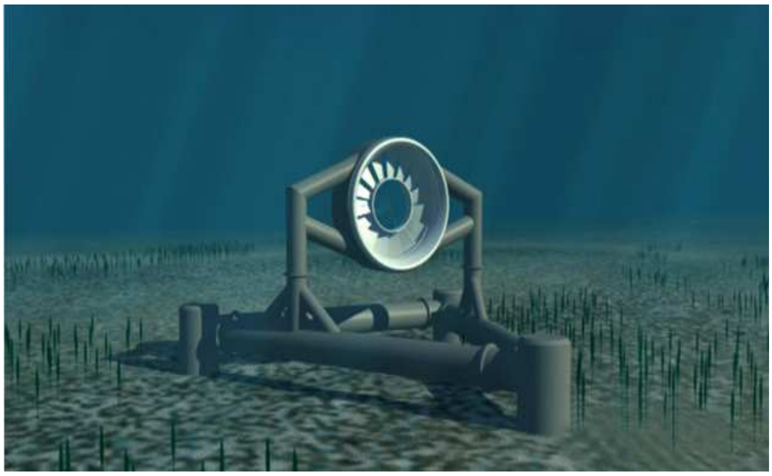


Figure 32 OpenHydro's turbine (OpenHydro).

Stingray

The Stingray (Figure 33) developed by Engineering Business is designed to extract tidal flow energy. The supporting arm oscillates, which in turn forces hydraulic cylinders to extend and retract. This produces high-pressure oil that is used to drive a generator. (Engineering Business Ltd, 2005

Figure 33 The Stingray before deployment for submerged testing (Engineering Business).

Sea Snail

The Sea Snail in Figure 34 uses hydrofoils to harness the sea's own power to produce a downward directional thrust to anchor the device to the ocean floor. A turbine is mounted onto this 30 ton platform. Robert Gordon University has a 150 kW prototype device deployed in the Eynhallow Sound, Orkney. (Highlands and Islands Enterprise, 2005).

Figure 34 RGU's 30 ton Sea Snail prototype (Robert Gordon University).

Cross flow turbines

Gorlov's helical turbine is a revised Darrieus turbine. It has twisting blades in the shape of a helix which gives it 35 percent efficiency, higher than in other cross-flow turbines that are between 20-25 percent. They always turn in the same direction independent of the current direction and start to produce energy at 0.5 m/s current speed. The turbines can be used both in vertical or horizontal position and connected together in a row. Power production is relative to current velocity by a power of three [45].

Figure 35 Twin rotor Gorlov Helical turbine (SmugMug, Inc).

Axial-flow rotor turbine

Verdant Power's axial-flow rotor turbine kinetic hydropower systems (Figure 36) generate electricity from the kinetic energy present in flowing water. The systems have a modular, self-contained turbine/generator unit that is designed for direct submersion without costly structural works. The units range from 25 kW to 250 kW. Mechanical power is applied directly through a speed increaser to an internal electric generator or through a hydraulic pump that in turn drives an onshore electric generator. (Verdant Power, 2008).

Figure 36 16 foot axial-flow rotor turbine installed in NY East River (Verdant Power).

2.13 New and future projects

New technology for harnessing tidal power is being developed today, and the UK, Canada and Norway are some of the leading nations in this area. Some prototypes are already in place producing energy for the grid, and construction costs are dropping because of improvement of material and construction techniques, even while energy prices are increasing throughout the world.

Hammerfest Strøm was the first company in the world to connect a 300 kW tidal turbine to the town of Hammerfest in 2003. This device supplies 700 MWh of electricity to 35 Norwegian homes. In 2006 Atlantis Resources connected its 100 kW Nereus turbine to the national grid at San Remo near Melbourne, Australia. In 2008, Marine Current Turbines connected its SeaGen tidal current turbine to the grid in Northern Ireland. The SeaGen turbine is located near the Strangford Lough and has a capacity of 1.2 MW of power, supplying electricity to the equivalent of 1000 homes. In 2008, the Irish company Open Hydro, connected its 250 kW Open-Centre Turbine located off Orkney, Scotland, to the national grid, supplying electricity to 100 homes [47].

The footprint of these new installations is minimal, and it is easy to reclaim the sea bottom if needed. Generally, the research period for harnessing tidal energy is out of its initial testing phase of testing equipment and has reached its “time for delivery”. In Iceland no such work has been performed.

2.14 Social implications (tidal current power plant)

Constructing a tidal current power plant has some positive and some negative social impacts on the surrounding area. Some new jobs may be created but not necessarily in the area of the power plant. Installation takes only few days. This may put the focus on the area which in turn can help to boost up optimism and the local economy. Underwater turbines will not affect boat traffic and make no noise like windmills do. Fishermen are not allowed to catch fish close to the turbines and recreational divers must keep a safe distance. Anchoring is also prohibited in the area.

2.15 Ecological and environmental aspects (tidal current power plant)

By law, environmental impact assessment must be completed, but installation of a tidal current power plant has very little or no impact on ecology and environment in the surrounding area. Fish and mammals avoid the slow turning turbine. The Seagen’s maximum rotation speed is 15 revolutions per minute and statistically 17 out of 18 randomly drifting objects 20 cm in size pass through the turbine without making contact with the blades [46].

There would be no or little change to the flora and fauna in the tidal range. The equipment’s footprint is small, and it is easy to reclaim the sea bottom. How much kinetic energy is extracted from the tidal current depends on size and number of turbines. Energy extraction from the tidal current may disturb the tidal regime and decrease its velocity, which in turn affects the sedimentation and tidal range in the area. Decreasing the amount of energy tapped will help to preserve the current tidal regime [34].

2.16 Economics (tidal current power plant)

Tidal current turbines are still in their early stage. The cost of utilizing tidal streams are very site specific. The early stage of this development means that there are few projects available for comparison. The economic advantages include small capital cost and short construction time. Disadvantages are intermittent energy production and a short lifetime, around 20 years.

3 Icelandic circumstances

3.1 Coastal zone

In the year 1281, the coastal zone in Iceland was defined by the Jónsbók laws and called the Net Laws. The Net Laws' seaward boundary is today determined to be 115 meters from the low-water mark. Clark, R. defines the coastal zone as:

> *"… the places where agency authority changes abruptly, where storms hit, where waterfront development locates, where boats make their landfalls, and where some of the richest aquatic habitats are found. It is also the places where terrestrial-type planning and resource management programs are at their weakest"*

The coastal zone includes beaches, dunes, tidal flats, reefs, estuaries, shallow waters and intertidal zones [36].

3.2 Regulatory framework

Iceland is part of European Economic Area (EEA), which came into effect in 1994. It is estimated that 40% of the European Union (EU) directives that are included in the EEA agreement fall under environmental category [48].

Iceland is signatory of several international agreements including The Rio Declaration of 1992, ratified by the Icelandic Parliament in 1994, and the Kyoto Protocol of December 11, 1997, which became effective on February 16, 2005. In the Kyoto Protocol, the use of renewable energy is required, including the goal of sustainable energy production.

The coastal zone of Breiðafjörður has been declared a preservation area by special laws, and power plants in Þorskafjörður and Gilsfjörður are within that zone. Regarding tidal power plants in Breiðafjörður, all new construction needs approval and licens from the Ministry for the Environment.

Based on existing laws, an agreement with landowners regarding compensation, as well as an agreement with the transmission system owner, must be reached prior to an application to build a power plant. Environmental impact assessment must also be completed, and based on the agreements reached and the environmental assessment, the Ministry of Industry Energy and Tourism grants or denies a license for the power plant. Local authorites are responsible for planning on land and within the jurisdiction of the Net Laws[5]. For instance, when applying for an aquaculture pen located outside the jurisdiction of the Net Laws, only a license from the local health control is required. Tidal current power plants placed outside the area regulated by Net Laws follow the same Acts as barrage plants regarding land-based structures. National governmental agencies have jurisdiction in the exclusive economic zone, from the Net Laws' seaward boundaries out to 200 nautical miles. It is not clear how the laws apply to tidal current power plants located outside the Net Law zone.

Iceland's National Planning Agency is responsible for the administration, monitoring and implementation of the Planning and Building Act (1997).

Local authorities are responsible for the process of the Strategic Environmental Assessment Act (2006) and the Environmental Impact Assessment Act (2000).
Municipal plans express the local authority's policy on land use in the municipality and extend its jurisdiction to 115 meters into the sea from low-water mark.

3.3 Acts and regulations

In a feasibility study, the laws and regulations play a major role in that they may affect planning, timeframe, the economy and ownership. Analysis of these areas must be included in any study.

[5] Net Law is a zone of the ocean measured from the low water mark and reaching 115 meters out to sea. Property of landowners.

A review of current Icelandic laws and regulations finds no specific laws regarding tidal harnessing or tidal power plants. One law, The Act on the Survey and Utilization of Ground resources 1998 No. 57 10 June, also covers surveys of hydropower (tidal hydropower included) for the generation of electricity [49].

Some laws, such as The Building Act and The Electricity Act, as well as laws regarding environmental issues and international treaties, also have an impact on planning and implementation.

Figure 37 shows the legally obligated interaction between an applicant for barrage tidal power plant and stakeholders. The applicants need three licenses to build a tidal power plant in Breiðafjörður.

All structures on land have to follow The Building Act. Power cables and connections to the grid have to follow The Electricity Act. Laws regarding environmental issues demand environmental impact assessments. By international treaties, Iceland has undertaken to decrease CO_2 in the atmosphere.

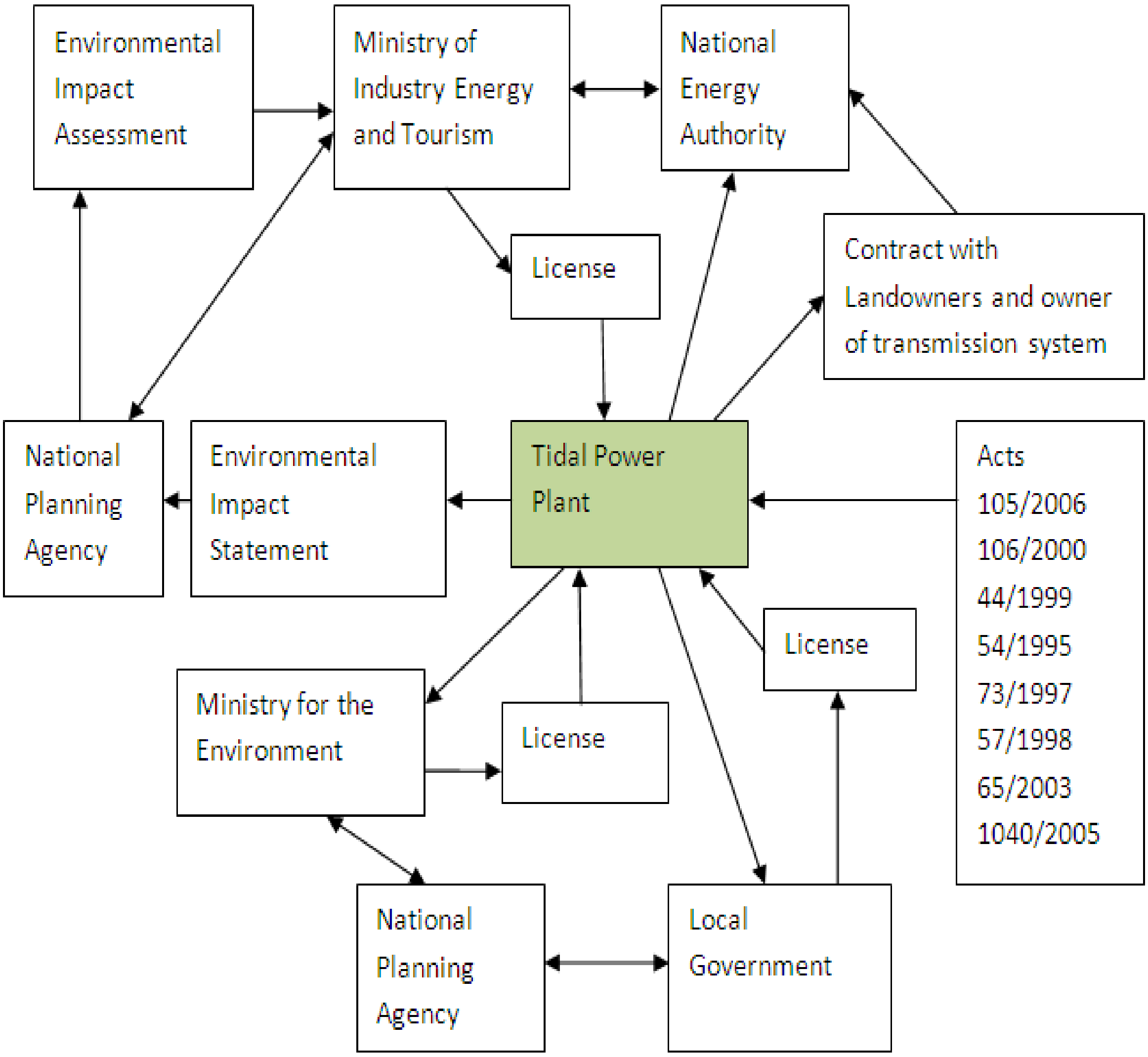


Figure 37 Interaction between an applicant for barrage tidal power plant and stakeholders, obligated by laws.

Act on the survey and utilization of ground resources No. 57/1998.

Below is article 18 of the Act on the survey and utilization of ground resources that states what should be included in the power development license issued by the Minister of Industry Energy and Tourism. This act pertains to tidal power plants after amended by Act No. 5/2006 (entered into force on 18 February 2006)

A prospecting and/or utilization license shall specify:

1. *That the articles of association of the license holder, in the case of a company, are approved by the Minister;*
2. *The term of the license, special provisions on when work should be begun, at the latest, and when it should be concluded;*
3. *The boundaries of the area;*
4. *What resources under this Act the license covers, provisions on quantity and rate of utilization;*
5. *That Orkustofnun approves of the preliminary drawings of any proposed structures;*
6. *The obligation of the license holder to inform and notify, including the obligation to provide samples and documents and how this obligation should be met;*
7. *Safety and environmental protection measures;*
8. *Purchase of insurance for any potential liability of the license holder for damages;*
9. *Monitoring and payment of cost of monitoring;*
10. *Payment of license fee to meet the cost of the preparation and issue of the license;*
11. *The manner of disposal of extracting structures and extracting equipment following the end of the license term;*

12. *Cleanup of work areas and land that has been altered in the course of prospecting or utilization.*

Planning and Building Act No. 73/1997

The Planning and Building Act ensures that the development of settlement and land use in the country as a whole will be in accordance with development plans that are based on the economic, social and cultural needs of the population, and also their health and safety.
It also encourages rational and efficient utilization of land and natural resources along with ensuring the preservation of natural and cultural values. Its purposes include prevention of environmental damage and over-exploitation based on the principles of sustainable development. The act ensures security under the law in the handling of planning and building issues so that the rights of individuals will not be neglected even though the common interest is the guiding principle. The law requires professional development and active monitoring to ensure that requirements regarding safety, durability, appearance and suitability of buildings and other structures are fulfilled [50].

The Electricity Act No. 65/2003

The Electricity Act states that to construct and operate an electric power plant exceeding 1 MW in size, a power development license granted and issued by the Minister of Industry Energy and Tourism is required.

An agreement must be reached with the land owners regarding compensation in advance of the application and receiving such a license, as well as an agreement with the transmission system owner. For power plants exceeding 7 MW of installed capacity, a direct connection to the main distribution system is an obligation, but for smaller plants connection to the distribution system is optional. The minister may even with an existing governmental regulation, establish special conditions before granting such a license, for example, regarding the supply of electricity to the grid, security, reliability and efficiency as well as the utilization of renewable energy sources. The minister can also set conditions in relation to environmental protection, land use and the technical and financial capacity of the power development license holder. The cost of the license is ISK 100,000 plus ISK 10,000 per MW [51].

Below is article 6 of the Electricity Act that states what should be included in the power development license issued by the Minister of Industry Energy and Tourism [52].

A power development license shall specify, inter alia:

1. *The size of the power station and the demarcations of the power development area.*
2. *The time at which the development shall begin at the latest and when it shall be completed.*
3. *The obligation of the power development license holder to provide information and reports to Orkustofnun and to the transmission system operator, to the extent necessary for those parties to perform their respective roles.*
4. *Safety and environmental protection measures.*
5. *Conditions relating to the technical and financial capacity of the license holder.*
6. *Disposal of facilities and equipment when their use is discontinued.*
7. *Other matters pertaining to the conditions of the license and the license holder's obligations hereunder.*

   A provision may be included stipulating that the power development license shall be reviewed after a specified period of time in the event that the grounds for the conditions of the license have changed materially.

Provision of the regulation regarding the Act of Electricity No. 1040/2005

This regulation gives more information about what is required in the application for a power development license. The power development license application must include research results regarding the type of energy to be harnessed as well as a description of infrastructure and location of the power plants, an economic analysis, contracts with both the owner of the distribution grid and land owner(s) and also an environmental impact report. Following is the power development license application in article 4. (Thesis author's translation)

The application shall be written and accompanied with the following:

1. *Name of the applicant, identification number, address and management information about the company.*
2. *Research results regarding the project.*
3. *A description of the power plant, including a map showing the position and arrangement of buildings, the principal numerical information regarding the power plant and demarcation of the area to be used.*
4. *Construction plan, when the process will start, when it will be finished and when it will start producing.*
5. *An economic plan for the project.*
6. *A contract about connection to the grid.*
7. *Information about whether an agreement for compensation has been reached with the land owner(s) and owner(s) of natural resources for the utilization of the land and resources.*
8. *Information about the primary environmental issues of the power plant and its influence on the respective natural resources and area, including influence on any prior utilization on the location, as appropriate. Information about whether the process is subject to obligatory evaluation according to the law of environmental influence. If so, the findings of the evaluation of the*

environmental impact must accompany the application as well as the decision of the environmental authorities about the environmental impact.

9. *Information about other possible licenses that the applicant believes are needed from other authorities, and whether the process falls within the local plan of the area* [53].

Environmental laws and regulations

The Nature Conservation Act No. 44/1999

The purpose of this act is to direct the interaction of man with his environment so that it harms neither the biosphere nor the geosphere, nor pollutes the air, sea or water. The Act is intended to ensure, to the extent possible, that Icelandic nature can develop according to nature's laws and ensure conservation of its exceptional or historical aspects. The act shall facilitate the nation's access to and knowledge of Icelandic nature and cultural heritage and encourage the conservation and utilization of resources based on sustainable development.

Environmental Impact Assessment Act No. 106/2000

The Environmental Impact Assessment Act deals with the possible impact of different projects on the environment and ensures, before consent is granted for a project, that an assessment of the impact has been carried out. The aim is to minimise as far as possible the negative environmental impact of the project and to promote co-operation of stakeholders and concerned parties with regard to the project. The act requires that the public is informed about the environmental impact of project and gives the public the opportunity to be heard. It states that an environmental impact assessment is obligatory for all power plants exceeding the size of 10 MW [54].

The Environmental Impact Assessment of Projects Act No. 105/2006

This act deals specifically with the process for an initial environmental impact statement and, if approved, a full scale environmental impact assessment. The initial impact statement should include a description of the project, the area, the design within the area and whether the project is consistent with current development plans. It shall state which part of the project and environment will be emphasized in the subsequent environmental impact assessment, what data exists and a plan for the presentation and co-operation with others concerned as well as the public. Consultation with the Icelandic National Planning Agency is obligatory and the environmental impact statement will either be approved or denied. If it is approved the next step is completing an environmental impact assessment, a more detailed report.

The developer is responsible for both the environmental impact statement and any associated costs. The final decision comes from the Minister of Industry Energy and Tourism and after consulting the National Planning Agency, either approves or denies the project [55].

Protection of Breiðafjörður, Act No. 54/1995.

All islands, islets and skerries, as well as the shores at the head of Breiðafjörður, are declared a preservation area. If not included in an approved plan all new construction needs approval from the Icelandic Ministry for the Environment.

Subsidies – taxes

Electric generating companies must pay an 18 percent profit tax, and the value added tax in Iceland is 25.5 percent [56].

99.9% of Iceland's electricity production is from renewable energy sources and no subsidies for power plants producing renewable energy exist.
In the United Kingdom, the Renewables Obligation (RO) was introduced in 2002, and is designed to optimize electricity production from renewable sources [57]. Green Certificates are used in Europe, and Renewable Energy Certificates are used in the USA. One certificate represents generation of 1 MWh of electricity; these certificates represent the environmental value of renewable energy generated. The certificates can be traded separately from the energy produced. Several countries use green certificates as a means to make the support of green electricity generation closer to a market economy instead of a more bureaucratic investment support and feed-in tariffs. Such national trading schemes are in use in Sweden, Belgium, Poland, the UK, Italy, and some US states [58]. In Germany, by law since 1990, power utilities are obliged to buy at a fixed price all electricity produced with renewable energy. At the same time grid owners were obliged to adjust their system to accommodate this green electricity.

As a member of the Europe single electricity market has provided new opportunities for Icelandic as well as Westfjords tidal energy producers. Today's energy production in Europe is slightly based on renewable energy sources and a new directive, RES-E (2001/77/EC), was introduced to encourage green energy production. The member states apply various measures to increase green energy production, which one is trade in green certificates.

> "*Energy production using renewable sources is divided into two components – the electricity itself and its green attributes, or green value. Both of these two components count as commodities, with green certificates confirming the green value of electricity that has been generated from renewable energy sources.*
>
> *Green certificates provide a guarantee of origin, enabling electricity producers that rely largely on renewable energy sources to sell green credits for their product in the*

internal European market. These are purchased by other producers in the internal market who wish to increase the ratio of green value in their energy production by buying more green credits. Trading green certificates is already possible in a number of EU states."[6]

[6] http://www.landsvirkjun.com/customers/green-certificates/

4 Identification of stakeholders

Population growth and economic development worldwide will continue to be concentrated in coastal areas. The increased pressure on the coastal zone caused by human activities such as sewage outlets, new roads, harbours or diverse types of power plants poses a permanent threat to sustainable use of the coastal zone and to its geological, biological and geomorphological values. This will increase pressure from human use which in turn can create conflicts between different stakeholder groups.
In May 2002 the European Parliament and the EU Council adopted recommendation 2002/413/EC about the implementation of Integrated Coastal Zone Management (ICZM) with the aim of utilizing its strategy to guide EU coastal countries to a more sustainable future. Outside the EU, countries like Canada, Australia and Norway have also adopted ICZM [59].

Using ICZM strategy, identification of stakeholders is one of the first steps taken for each project. Every stakeholder is invited to the table and informed about the project and urged to make a statement about their concerns. This procedure will take some time, but in the end fewer major stakeholders remain. By using this methodology more reconciliation will be achieved for each project. Democracy and cooperation will enable clear communication between various stakeholders [36]. Table 4 shows stakeholder groups involved in the case.

Table 4 Name and nature of stakeholders involved.

Name of the stakeholder group	Interest group	Com-Panies	Organi-zations	Indivi-duals	Autho-rities
Government					X
Neighbors	X			X	
Tourists			X	X	
Landowners	X		X	X	
Consumers	X			X	
Citizens	X	X		X	
Political parties			X		X
NGO´s		X	X	X	
TPP industry		X			
Power company		X			X
Fishing industry	X	X		X	
Seaweed harnessing	X	X		X	

A preliminary list of stakeholder groups includes:

- Government: Department of Environment and Department of Industry will present acts, regulations, directives, and international treaties and provide a license for work to proceed.
- The local municipality is responsible for the Building Act on land and to 115 meters offshore. The local municipality is also responsible for the environmental impact assessment. Increase in jobs and services in the area following construction of a barrage power plant is very positive for the community and will help to alleviate the continuing depopulation in the area.
- Politicians need to be informed and educated about the project. Some of them may be against the project whilst others may be for. Political support is very important.
- Power companies are the main buyers of the energy. The distribution company is a public company that owns and runs the high voltage distribution system in Iceland, as well as handling its power system operation. They need information about location, production capacity and other statistical information as well as technical information.
- For the fishing and seaweed industry, the impact appears to be in the areas of new navigation courses and abandonment of fishing and seaweed grounds. It is possible to install a lock for ships in the barrage so the seaweed harvesting and fishing will not be affected.
- The tourist industry may be worried about negative effect on their industry. On the other hand the industry may be positively affected by the better roadway built from the new barrage across a fjord. Tourism can be expected to increase as people visit the power plant, as learned from the Annapolis power plant. New recreation opportunities may also arise in the much calmer bay inside the barrage.
- NGOs, for example, the Icelandic nature conservation organization, Saving Iceland and Bird watchers Association ask for information about environmental consequences. A road barrage (proposed in chapter 9) in a new location across Þorskafjörður will resolve ongoing conflict about damaging Teigsskógur forest. Eagle nesting places will also be saved and there will be only two shoreline cuts instead of six.

5 Connection to the grid

The electric transmission system in Iceland with voltage higher than 66 kV is run by Landsnet, a public company owned by Landsvirkjun, RARIK, Orkuveita Reykjavíkur and Orkubú Vestfjarða. Landsnet also controls and synchronizes the country’s power system operation. The power system is continuously monitored, and power production from power stations can be increased or decreased instantly. Meteorological information is loaded into the system a week ahead, and the system takes into consideration prognosis for drought and precipitation. (oral information, Guðlaugur Sigurgeirsson,16 October 2009). In the same way, predicted production for tidal power plant could be included in the system in as long timeframe as needed.

All hydropower stations are connected together with control lines, and their production is monitored and adjusted to the users’ needs. Since you cannot put more power into the system than is used at that moment, adjustments are constantly needed. This action is usually done automatically from the Landsnet control system but can also be done manually. By stepping up or down the water stream into the turbines, it is possible to increase or decrease power production in matter of seconds. When the tidal power plant is producing energy, the ordinary hydro power plants collect water in their reservoir.

The power plant in Gilsfjörður is within 3 km from the Geiradalur substation (Figure 38) so connection costs are minimal. The power plant in Þorskafjörður is about 30 km from the substation. In Figure 39 the Landsnet transmission system shows the blue arrow pointing at a proposed tidal power plant in Gilsfjörður. This figure can be accessed through the internet and shows the current status on transport and power use. Figure 40 is a diagram of the Icelandic electrical sector [61].

Landsnet is legally obligated to connect all applicants to the grid if the grids capacity is sufficient and the quality of the power is within required specifications. The technical characteristics of the tidal turbines are the same as for ordinary hydro turbines so the quality of the power should meet required specifications.

The yearly energy production in Þorskafjörður power plant is less than imported energy from Landsnet and most of it could be dispatched into the system for use in the Westfjords. This means less load and less loss on the transmission lines because of shorter distance from the energy source. Tidal power is not easily dispatched and because of its characteristic it should be considered as base-load and, when producing, all of its energy should be dispatched into the system. Other power sources on the grid would then only supply backup power when there is a deficit from the tidal source. The production time and amount of energy dispatched are exactly known and thus differs from energy produced with wind turbines, another source of intermittent renewable energy.

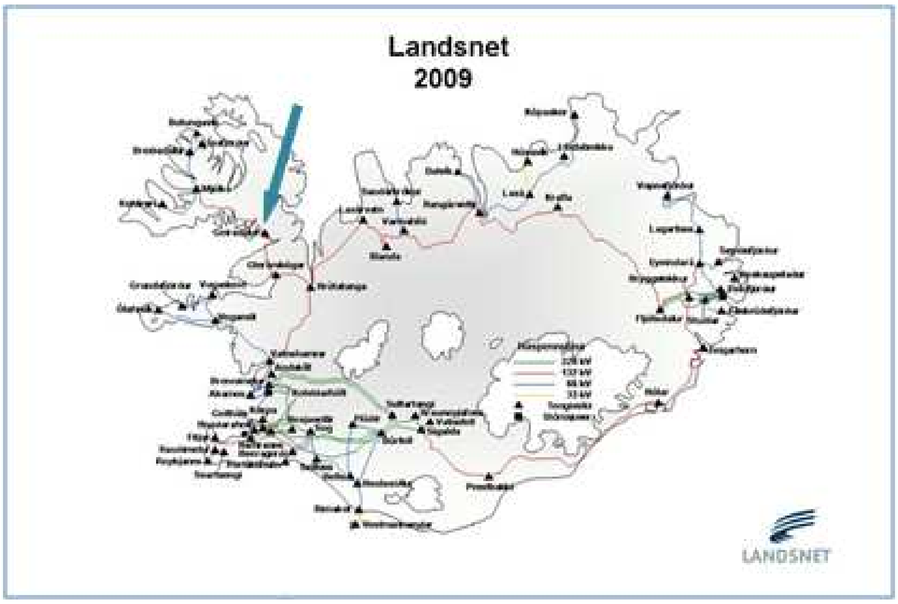


Figure 38 **Landsnet, distribution system (Landsnet).**

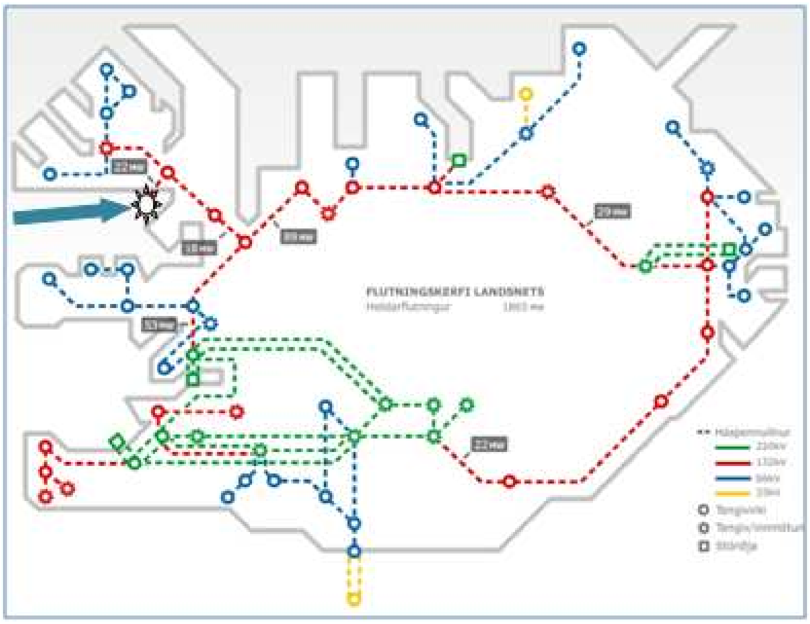


Figure 39 Landsnet, distribution system with proposed tidal power plant in Gilsfjörður (Landsnet).

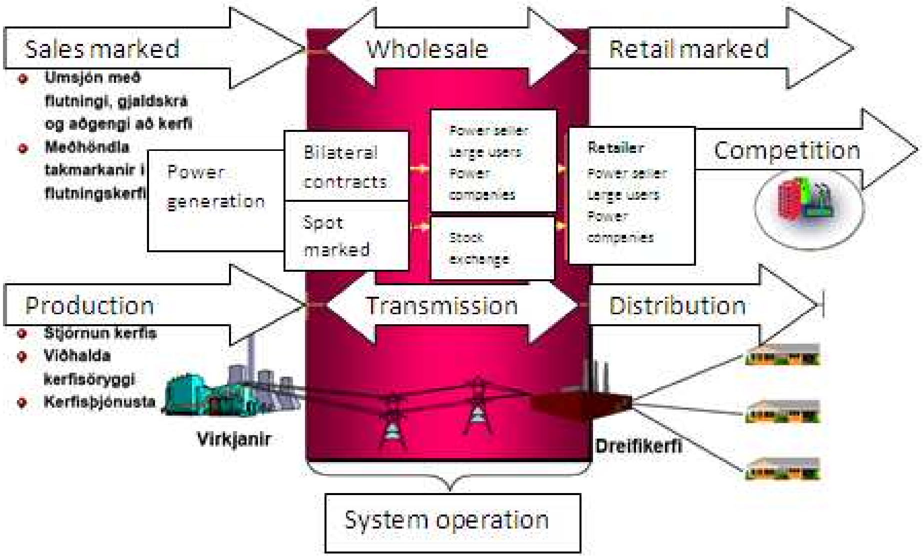


Figure 40 Diagram of the Icelandic electrical sector (Landsnet).

Table 5 shows the in-feed charge that concerns all who produce energy into RARIK transmission system.

Table 5 In-feed charge to RARIK.

Delivery charge to RARIK. Fixed price in ISK.		
Rated generator power	Without tax	With tax (25.50%)
Under 100 kW	186.039	233.479
Under 500 kW	316.263	396.910
500 – 999 kW	421.053	528.422
1000 – 1999 kW	560.930	703.967
2000 – 3499 kW	910.624	1.142.833
3500 – 4999 kW	1.435.163	1.801.130
5000 – 6999 kW	1.959.704	2.459.429

Table 6 lists RARIK's payment amounts due to power plants smaller than 300 kW (due to less out-feed from Landsnet).

Table 6 Delivery charge from RARIK.

Delivery payment from RARIK. Fixed price in ISK/kW/year (1.1.2010)		
Plant size < 300 kW:	Without tax	With tax (25.50%)
Power	4,433	5,563
Energy	0,32099	0,400
Transmission loss	0,06404	0,08037

For power plants bigger than 300 kW these prices decreases proportionally and disappear with 3.100 kW [62]. Table 7 is the current rate list from 1.1.2010 for Landsnets's transmission charges.

Table 7 Landsnet transmission charges.

Landsnet Transmission charges (1.1.2010)	
Delivery charge	4.317.536 kr per year
Ancillary services	245.52 kr per MWh
Transmission losses	64.04 kr per MWh

6 Comparison example

To find out approximate power production in the Westfjords, some proven mathematical formulas can be used. By using those formulas, the maximum potential power for a fjord can be calculated, as well as yearly energy production. The medium tidal range and the size of the impounded area must be known. These formulas will be used in this chapter to compare known barrage tidal power plants both in use and proposed scheme. In chapter 7.4 these formulas will be used for selected locations in the Westfjords, as well as selected tidal power plants already in use.

Approximation formulas for potential power (barrage power plant):

Approximation for potential power for a single basin one way operation.

Potential tidal power can be determined in a mathematical calculation. Given that the surface area is the same between full stored water level and emptied floor the ebbing water could be expressed as equation 1. (Weicheng Wu, 1999) [63].

$$dw = pghdv = pgShdh \qquad (1)$$

dw = energy unit

g = acceleration of gravity ($9.8 m/s^2$)

h = instant water level height

p = density of sea water (about $1.04 \times 10^3 kg/m^3$)

S = surface area of the reservoir (m^2)

v = velocity

Power could be written as equation 2.

$$P = \int dw = \int pgSHtr^2/2T \qquad (2)$$

P = potential power

T = tidal period (6 hours)

Htr = tidal range (m)

Equation 2 simplified into equation 3.

$$\boldsymbol{P = 0.226xSxHtr^2\ (Watts)} \qquad \textbf{(3)}$$

Bernshtein (Bernshtein, 1965) [64].

Hav = average head (m), with H ≈ 0.7 · Rmean

A = surface area of the reservoir (km^2)

$$\boldsymbol{P = 0.170 \cdot AHav^2\ (MW)} \qquad \textbf{(4)}$$

Approximation for annual energy output in single basin one way operation:

According to Tester the yearly maximum potential energy recoverable from a single tidal cycle can be calculated for barrage power plant. The water impounded at peak high tide is on average a height R/2 above the minimum low water point in which case:

$$\hat{E} = mg\ R/2 = (\rho AR)g\ R/2 \qquad (5)$$

COP= coefficient of performance, 0.33 for single basin (0.2–0.35)

R = tidal range (m)

A = km^2

The world mean periode for tides is 12 hours 24 minutes

p = density of sea water (about 1.025 kg/m^3)

g = acceleration of gravity ($9.8 m/s^2$)

Substituting parameters; *pg* and *COP* into formula (5) gives us formulas (6 and 7)

$$\hat{E}=1397\ R^2\ A\ (kWhr\ per\ cycle) \qquad (6)$$

$$\bar{E}=0.986x10^6 COP\ R^2 A\ (kWh/year) \qquad (7)$$

There are about 706 tidal cycles per year and formula (8) represents the annual average energy output for a single basin one way operation.

Jefferson Tester (Tester, 2005) [65].

$$\bar{E}=0.99x0.33x\ R^2 xA\ (GWh/year) \qquad (8)$$

Approximation for tidal current turbine power:

Tidal current power can be calculated by following formula:

Kinetic energy = $1/2mV^2$

Tidal current energy = 1/2 $pAVtV^2$=

$$P = 1/2\ p\ ArV^3 \qquad (9)$$

Where: m = *pAVt*

P = power in the tidal current (W)

p = water density (kg/m^3)

Ar = swept rotor area (m2)

V = velocity (m/s)

To use the formula (9), the rotor swept area must be known and the efficiency coefficient of the turbine and tidal current velocity.

The World Energy Council has published a list of prospective sites in the world for tidal energy projects. By using equation 3 for Table 8 (Weicheng Wu, 1999), potential power can be calculated for each site. Prospective sites in Iceland are compared in Table 19.

Table 8 Potential Tidal Power Projects. (World Energy Council)

Location	Potential power (MW) $P=0.226SHtr^2$	Installed capacity (MW)	Mean tidal range (m)	Basin area (km^2)	Approx. annual output (TWh/Y)	Annual plant load factor (%)
Argentina						
San José	5.914	5.040	5.8	778	9.4	21
Golfo Nuevo	7.351	6.570	3.7	2376	16.8	29
Rio Deseado	213	180	3.6	73	0.45	28
Santa Cruz	2.822	2.420	7.5	222	6.1	29
Rio Gallegos	2.250	1.900	7.5	177	4.8	29
Australia						
Secure Bay (Derby)	1.550	1.480	7.0	140	2.9	22
Walcott Inlet	2.879	2.800	7.0	260	5.4	22
Canada						
Cobequid	8.339	5.338	12.4	240	14.0	30
Cumberland	2.416	1.400	10.9	90	3.4	28
Shepody	2.599	1.800	10.0	115	4.8	30
India						
Gulf of Kutch	960	900	5.0	170	1.6	22
Gulf of Khambat	21.815	7.000	7.0	1970	15.0	24
Korea (Rep.)						
Garolim	499	400	4.7	100	0.836	24
UK						
Severn*	5.758	8.640	7.0	520	17.0	23
Mersey*	582	700	6.5	61	1.4	23
Duddon	141	100	5.6	20	0.212	22
Conwy	33	33	5.2	5.5	0.060	21
Russian Fed.						
Mezen	26.783	15.000	6.7	2 640	45	34
Tugur	11.286	7.800	6.8	1 080	16.2	24
Penzhinsk	602.985	87.400	11.4	20 530	190	25

*Severn and Mersey do not match the formula; installed capacity is higher. That is probably because produced power in those areas will not only come from barrage power plant but also from tidal gates, water wheels, tidal lagoon and flow stream turbines.

7 Site decision

Some of the Westfjords, such as Gilsfjörður, Dýrafjörður, Önundarfjörður and Mjóifjörður in Ísafjarðardjúp, have been crossed by new roads. In each crossing except Gilsfjörður bridges were constructed to give sufficient water exchange and to minimise damage to the environment. Those places where tidal flow is very active provide a basis for harnessing electricity. The Gilsfjörður project had a different approach. The fjord was dammed but with an overflow so only the last meter of high tide enters the fjord today with minimum water exchange as a result.

To calculate the potential power in those fjords, the average tidal range and size of the area impounded is needed. It was possible to collect information about tidal range in some locations from Landhelgisgæslan, Sjómælingasvið. This organization has recently been measuring the tide components in many locations but has not processed them all yet. Tidal information for Reykhólar, Þingeyri and Bolungarvík, shown in Table 9, was available (oral information, Björn H. Pálsson, 2 November 2009). Figure 41 shows the tidal data reference plane. To find the size of the area impounded by road crossings over the fjords, the ArcGIS v. 931 geographic information system was used.

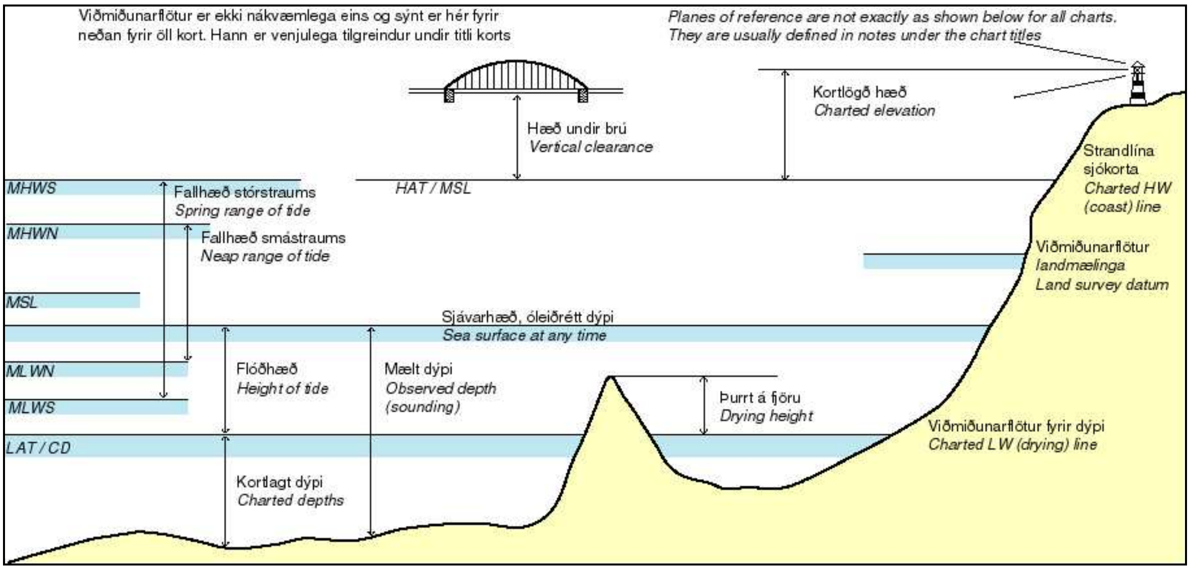


Figure 41 Tidal data (Landhelgisgæslan, Sjómælingasvið).

Table 9 Average tidal heights and lows on selected sites [66].

Tidal datum tidal heights	Reykjavík Height (m)	Reykhólar Height (m)	Þingeyri Height (m)	Bolungavík Height (m)	
Mean high water spring (MHWS)	4.00	4.38	2.90	2.17	The height of an average Spring tide high water level
Mean high water neap (MHWN)	3.00	3.25	2.11	1.57	The height of an average Neap tide high water level
Mean sea level (MSL)	2.18	2.30	1.52	1.15	The mean water level at the site
Mean low water Neaps (MLWN)	1.30	1.39	0.94	0.72	The height of an average Neap tide low water level
Mean low water Springs (MLWS)	0.20	0.15	0.15	0.12	The height of an average Spring tide low water level

Complete tide table for 2009 is in appendix A.

7.1 Current measurements

The following measurements are open water current measurements related to the tidal current turbines approach. Very little real information about currents close to the coast and inside fjords is available for Iceland. The Icelandic road administration has made some measurements associated with roads crossing the fjords. The mouth of the bridges in crossings over fjords is designed to allow current velocity between 2 – 3 m/s. (See photos of bridges in appendix C.)

Some studies have been done associated with research for fish farming by the Norwegian company Aqvaplan-niva and Náttúrustofa Vestfjarða. The engineering company VISTA conducted current measurements for Orkubú Vestfjarða in Sýreyjarsund off Flatey to estimate possibilities for a tidal current turbine. An estimate can be done by simulation but to gain real information measurements have to be done. The author of this thesis, in cooperation with VaxVest, made tidal current measurements to collect information about currents in the Westfjords. These point measurements gives information about certain scenarios but need to be conducted for a much longer period, at least between two spring tides to collect accurate information. To choose sites to measure with strong tidal currents, information was obtained from experienced boat captains from the area. The result was to measure in two different locations, in Ísafjarðardjúp and in Breiðafjörður. Two boats, Ramóna from Bolungarvík with the captain Friðrik Jóhannsson and Súlan from Reykhólum with the captain Björn Samúelsson were used for this project. Following is information about current measurements in the Westfjords that was available as well as measurements conducted for this thesis.

The company named Aqvaplan-niva conducted current measurements in four fjords in the Westfjords (Figure 42) for fourteen days in October and November 2002. The measurement depth was 10 meters and measurements were at 10 minute intervals. Equipment used was SENSORDATA SD6000, a mini current meter. The following information about the current measurements is from the report "Akvaplan-niva rapport nr / report no: APN-413.02.2422" [67].

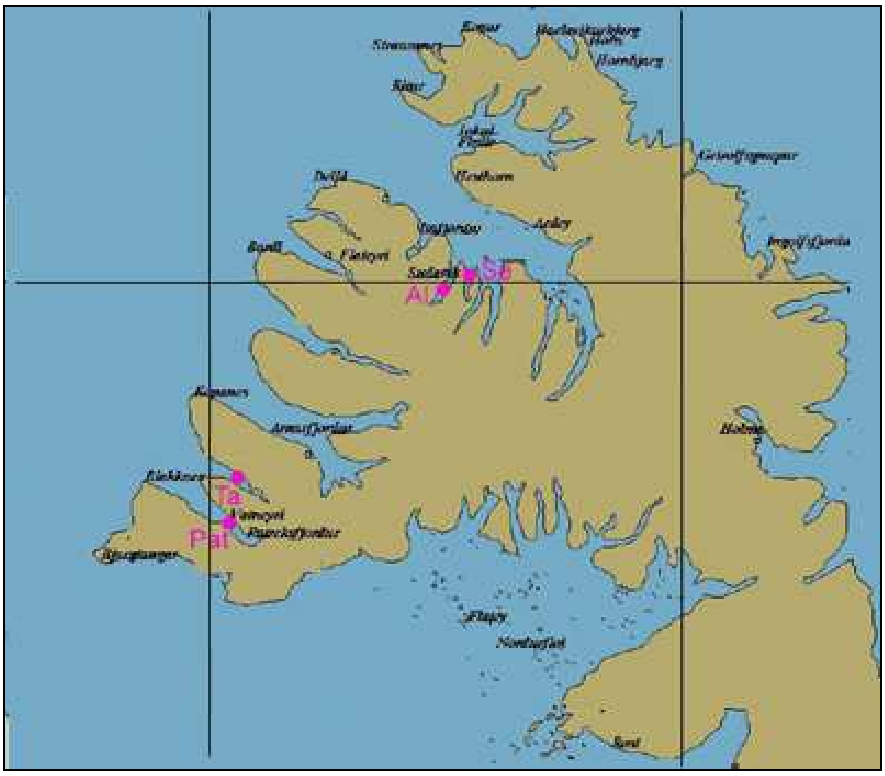


Figure 42 Current measurements in Seyðisfjörður (SE), Álftafjörður (Al), Tálknafjörður (TA) and Patreksfjörður (Pat).

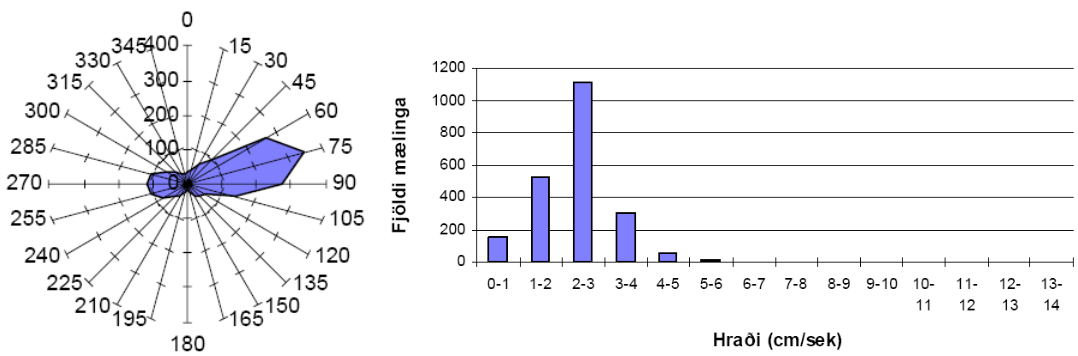
Figure 43 shows results from measurements in Álftafjörður, Seyðisfjörður, Patreksfjörður and Tálknafjörður. In

Table 10, percentages of measurements falling within certain velocity range can be seen. In those fjords the current is flowing very slowy.

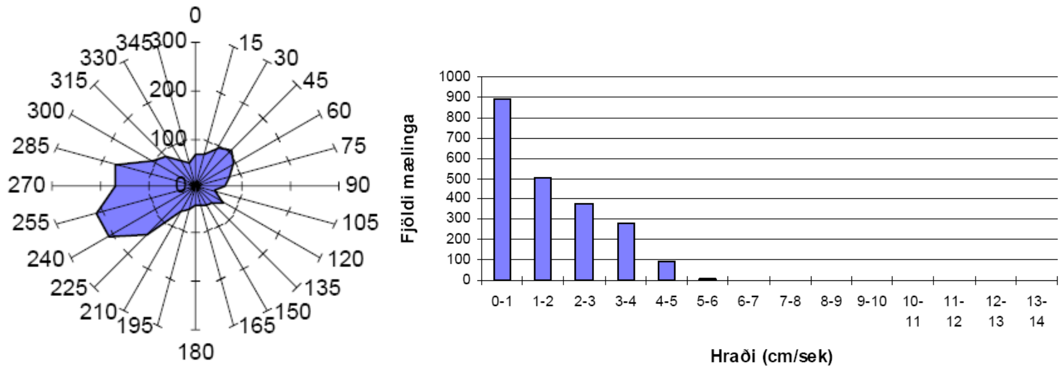
Table 10 Percentages of measurements falling within a certain velocity range.

	< 3cm/s	3-10 cm/s	Location
Álftafjörður	83%	17%	66°00.60´N / 23°00.20´V
Seyðisfjörður	82%	18%	66°00.02´N / 22°55.77´V
Patreksfjörður	24%	76%	65°34.23´N / 24°00.37´V
Tálknafjörður	58%	38%	65°37.23´N / 23°48.90´V

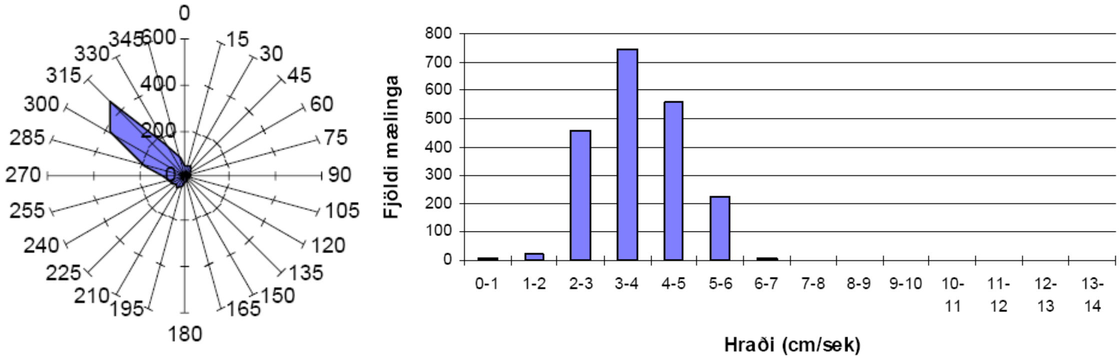
Álftafjörður



Seyðisfjörður



Patreksfjörður



Tálknafjörður

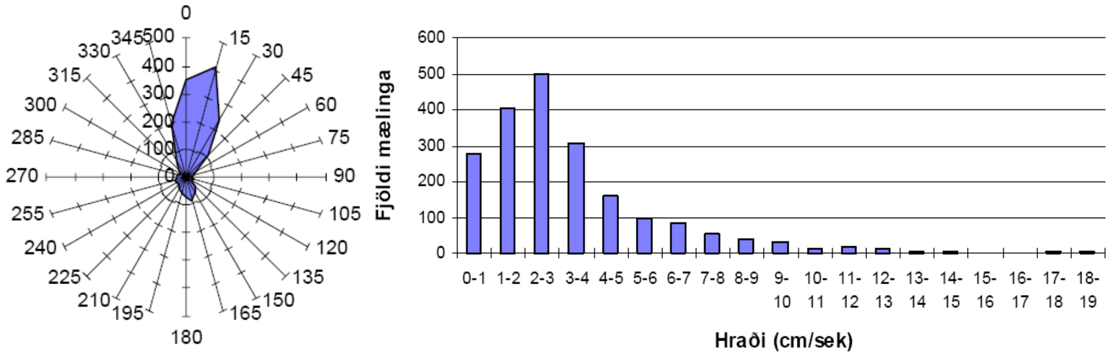


Figure 43 Álftafjörður, Seyðisfjörður, Patreksfjörður and Tálknafjörður, current direction and velocity.

Náttúrustofa Vestfjarða conducted current measurements in Skutulsfjörður, 7 – 8 May 2008. The following information about the current measurements is from their report. NV nr. 14-08. Equipment used for the current measurements was the Compact-EM (Miniature Electromagnetic Current Recorder).

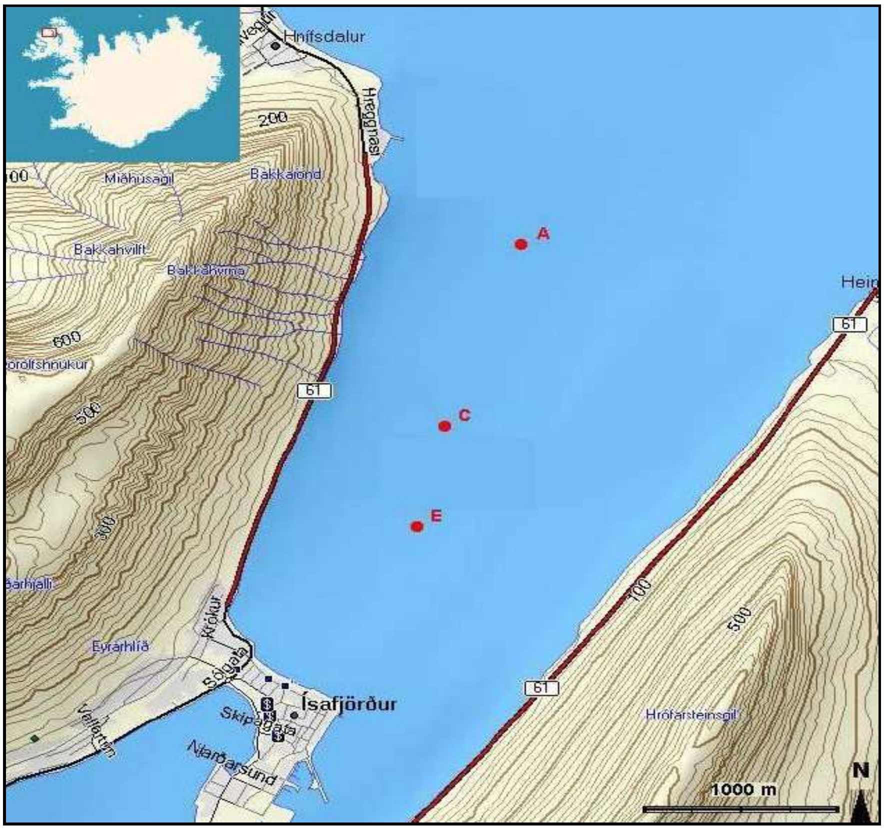


Figure 44 **Measuring points in Skutulsfjörður (Náttúrustofa Vestfjarða).**

Measurements in Skutulsfjörður were conducted at points A, C and E (Figure 44) at the ebb tide on 7 May and high tide on 8 May 2008. Maximum spring tide range was 4.3 m in Reykjavík on 6 May. Reykjavík is used as reference point, multiplied by 0.6 the maximum spring tide for Skutulsfjörður can be found. Maximum ebb in Ísafjörður was at 15:31 on the 7 May and high tide at 10:13 on 8 May. The main results from the measurements are in Table 11. Each measurement lasted for 10 minutes at two second intervals at five meters depth.

Figure 45 shows that 90% of the measurements at locations C and E are in the velocity range of 0 to 5 cm/s. At site A, the velocity range was 6 cm/s or more in 63 percent of the measurements. The radar chart on Figure 45 shows the ebb current direction.

Table 11 Results from measurements.

Ebb	Velocity (< 5 cm/s)	Velocity (> 6 cm/s)	Location	Direction Degrees
A	37%	63%	66°05.908´N / 23°05.452´W	310-060
C	90%	10%	66°05.317´N / 23°06.042´W	310-060
E	90%	10%	66°04.980´N / 23°06.242´W	310-060
High tide				
A	58%	42%	66°05.908´N / 23°05.452´W	200
C	47%	53%	66°05.317´N / 23°06.042´W	200
E	80%	20%	66°04.980´N / 23°06.242´W	200

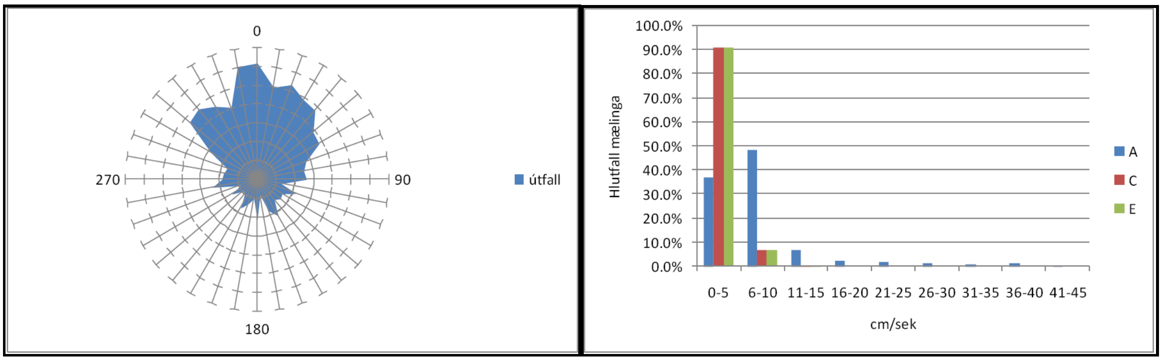


Figure 45 Skutulsfjörður. Ebb current direction in degrees and velocity in cm/s in Skutulsfjörður 7 May 2008

Results shown in Figure 46, show that 80% of the measurements at location E are in the velocity range of 0 to 5 cm/s. At site A, the velocity range was 6 cm/s or more in about 42 percent of the measurements. The radar chart on Figure 46 shows the high tide current direction [68].

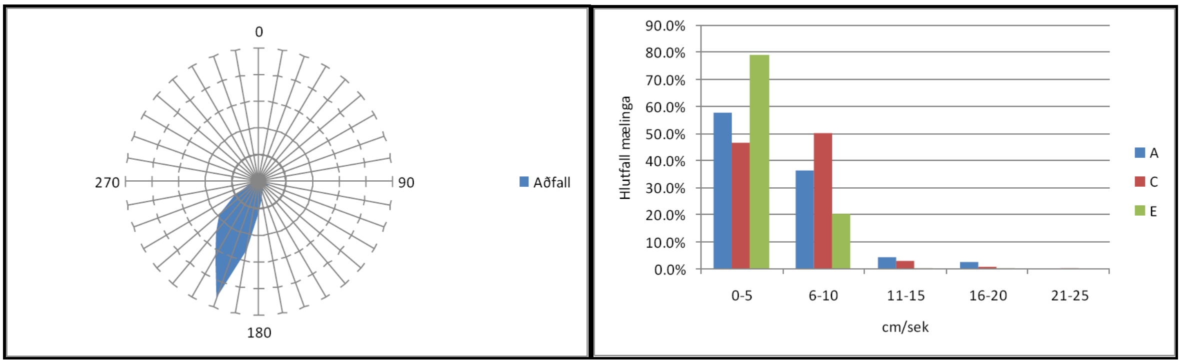


Figure 46 Skutulsfjörður. High tide current direction in degrees and velocity in cm/s in Skutulsfjörður 8 May 2008.

The engineering firm VISTA conducted current measurements for Orkubú Vestfjarða in the strait between Flatey and Sýrey in Breiðafjörður on 10 June 2009. The following information is from the VISTA report to Orkubú Vestfjarða about the current measurements.

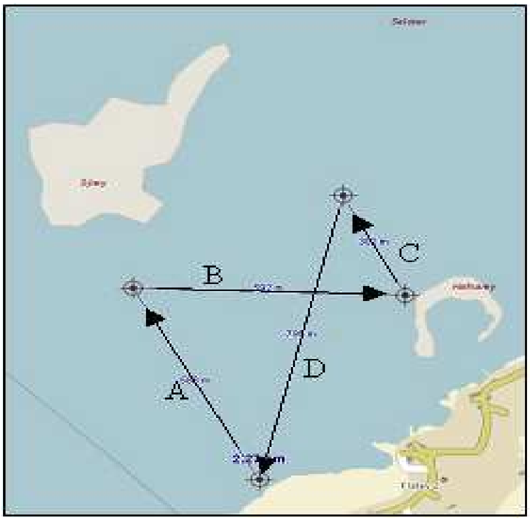


Figure 47 Sýrey and Flatey. Track from the boat (Orkubú Vestfjarða).

Figure 47 the track from sailing route is shown and in Table 12 are the measurements. Tidal current was at its maximum between 09:31 and 10:20. Maximum measured current was 1 m/s in the middle of the strait a short time after high tide [69].

Table 12 Result from measurements.

	Time at day	Velocity (m/s)	Location	Direction (magnet)
Track B	09:39:52	**0.803**	65°22.729´N / 22°55.548´W	241
Track C	09:42:21	**0.785**	65°22.761´N / 22°55.312´W	263
Track D	09:47:51	**0.789**	Data missing	247
Track A	09:53:51	**0.731**	Data missing	237
Track B	10:00:21	**0.723**	Data missing	239
Track C	10:02:51	**0.694**	Data missing	263
Track D	10:08:51	**0.680**	65°22.668´N / 22°55.714´W	238
Track A	10:14:51	**0.619**	65°22.614´N / 22°55.893´W	234

Measurements conducted for this thesis

Three sets of measurements were conducted in Ísafjarðardjúp off the mountain Deild (Location 1). In Breiðafjörður measurements were taken in the common mouth of Þorskafjörður, Gufufjörður and Djúpifjörður (Location 2) and in Langeyjarsund off Skáleyjar (Location 3). Table 13 shows the maximum measured current in each location. Measurements were taken one meter from the bottom. Equipment used for the current measurement was the Compact-EM (Miniature Electromagnetic Current Recorder).

The time was chosen as close to spring tide as possible, but the weather conditions had to be taken into consideration. Therefore, measurements were conducted on 17 and 18 August. Maximum spring tide current was between 20 and 22 August but the weather forecast was for severe weather. Storm surge is not taken into consideration. Two of the three measurements in Ísafjarðardjúp failed because of failure in the measuring equipment.

Table 13 Maximum measured current and direction.

Location	Time at day	Velocity (m/s)	Location	Direction (corrected)
1	12:49:50	**0.385**	66°11.775´N / 23°29.175´W	220°
2	19:12:25	**0.823**	65°30.265´N / 22°24.100´W	230°
3	20:22:25	**0.661**	65°26.641´N / 22°39.471´W	150°& 330°

Measurements in Ísafjarðardjúp were conducted on 17 August 2009, between 12:40 – 13:40. Maximum ebb at 0.7 m at Suðureyri (the closest known tidal information's) was at 11:28 and flood at 17:49; maximum flood range was 2.1 m.

Measurements began off the mountain Deild at location 1, one hour after maximum ebb and continued for one hour. The depth was 15.5 m and average ocean temperature was 10.3°C. Mean current velocity was 26.8 cm/s and maximum current velocity was 40 cm/s. Figure 48 shows that most of the measurements are in the velocity range of 26 to 30 cm/s or about 40 percent.

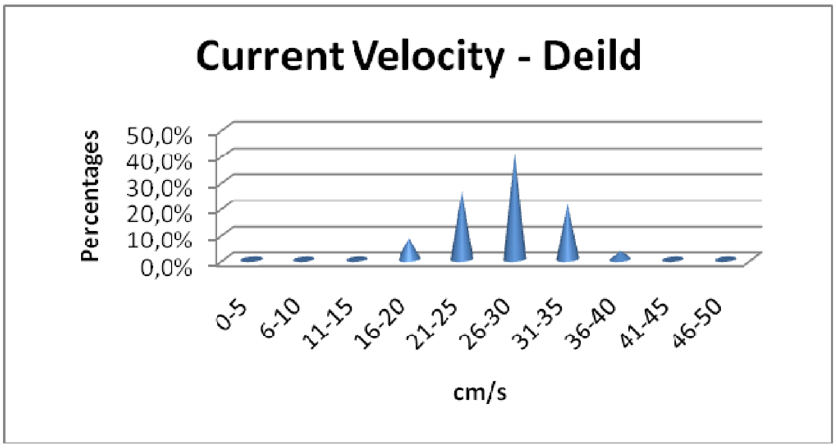


Figure 48 Current velocity in cm/s. Measurements in Ísafjarðardjúp.

The radar chart on Figure 49 shows that ebb current direction is decisively in in the same direction.

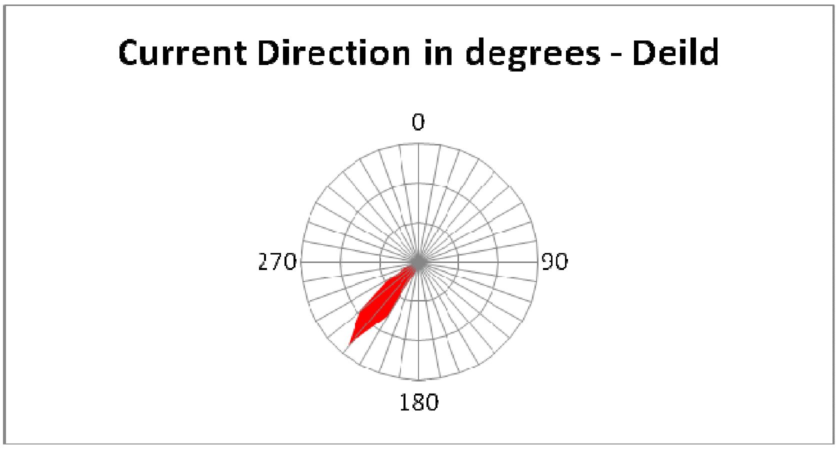


Figure 49 Current direction in degrees, Ísafjarðardjúp.

Measurements were also taken at 66°12.207´N / 23°28.525´W and 66°12.065´N / 23°25.118´W. These measurements in Ísafjarðardjúp failed because of failure in the measuring equipment.

Measurements in Breiðafjörður at location 2 were conducted on 18 August 2009, between 18:30 – 19:40. Maximum ebb at 0.7 m in Flatey (the closest known tidal information's) was at 11:27 and flood at 17:40 and maximum flood range was 4.2 m.

Data in Þorskafjörður was taken at 65°30.265´N / 22°24.100´W (Figure 50), depth was 13.7 meter and average ocean temperature was 12.38°C.

Measurements began about one hour after high tide, or around 18:30. For the first 10 minutes, the average current was 44 cm/s and for the last 10 minutes it was 70 cm/s. The maximum current was close to 85 cm/s. The current velocity was still increasing at the end of the measuring period, two hours after high tide. Figure 51 shows that more than 50 percent of the measurements fall in velocity range 51 – 70 cm/s. Figure 52 shows the direction of the ebb current.

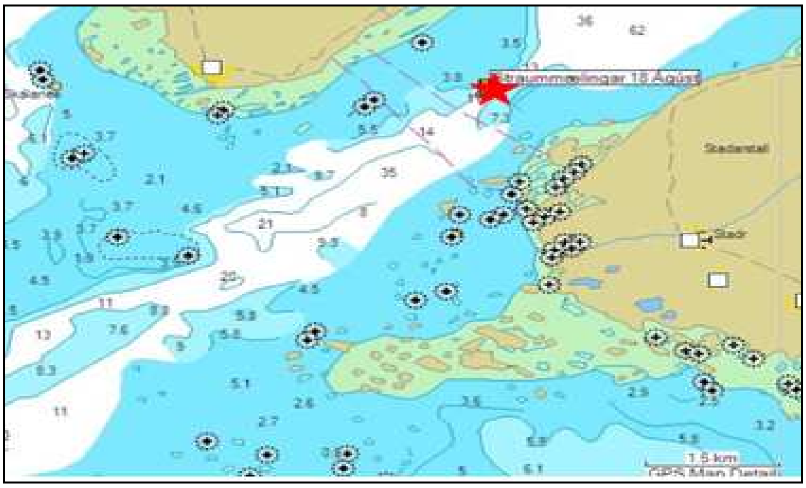


Figure 50 Common mouth of Þorskafjörður, Gufufjörður and Djúpifjörður. Measuring site marked with a red star.

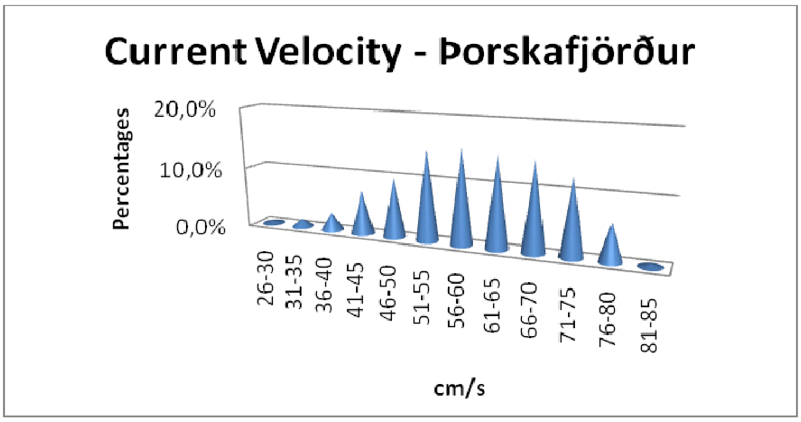


Figure 51 Current velocity in Þorskafjörður in cm/s. (marked with red star on Figure 50)

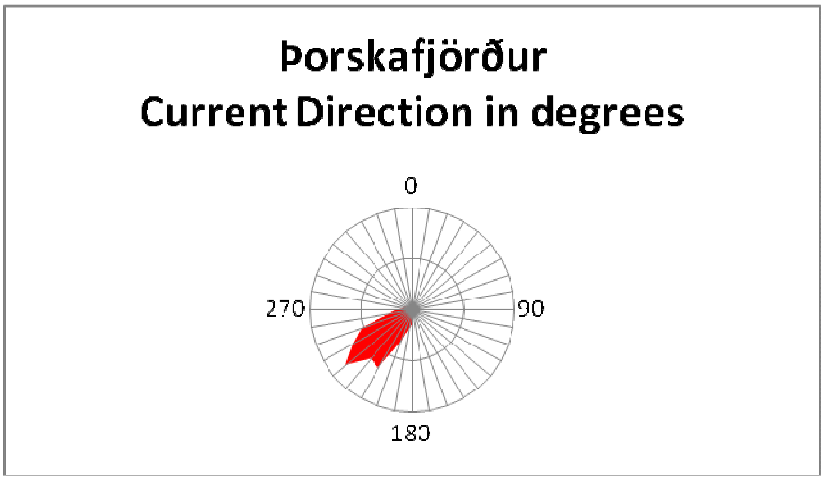


Figure 52 Current direction in degrees, Þorskafjörður. (marked with red star on Figure 50).

Measurements in Breiðafjörður at location 3 were also conducted on 18 August 2009 in Langeyjarsund off Skáleyjar, at 65°26.641´N / 22°39.471´W, depth 7.4 m, average ocean temperature 11.7°C.

Measurements began at 20:16 and continued for 20 minutes. Figure 53 illustrates that most of the measurements are in the velocity range 36 to 45 cm/s or about 28 percent and maximum current velocity was 70 cm/s. The radar chart in Figure 54 shows that the current reflects. Data from the measurement equipment showed at times reflection occurs in the channel. Further investigation is needed to determine if this is the main characteristic of the channel or if this occurred only where measurements were taken.

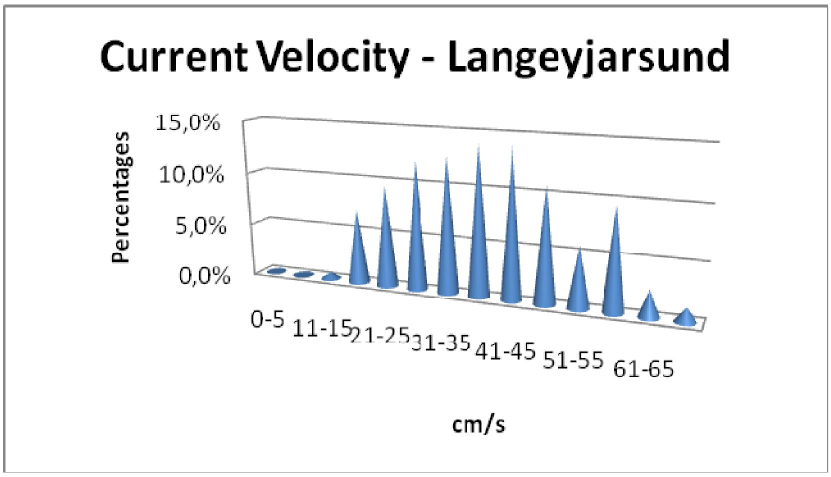


Figure 53 Current velocity in cm/s. Measurements in Langeyjarsund.

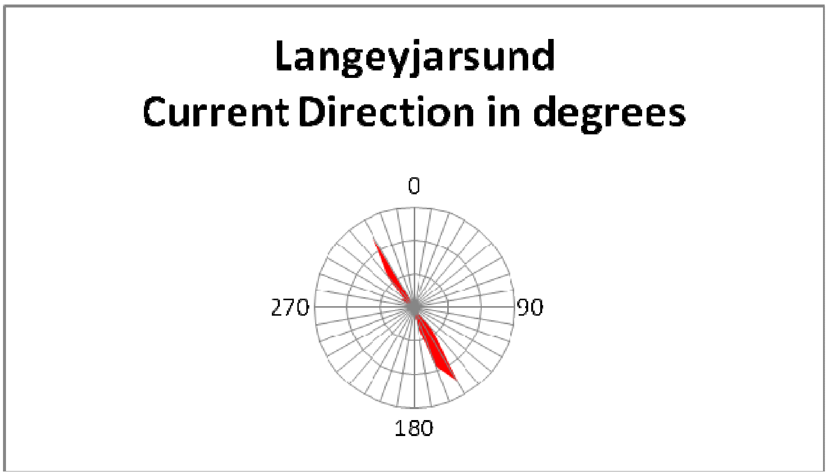


Figure 54 Current direction in degrees, Langeyjarsund.

Note the strong unidirectional character of the current in Langeyjarsund. The geometric effects of a bentic structure created flow back and forth. This unexpected character of the current, underlines why thorough research in advance of any project is important.

Conclusion

Results from current measurements are informative and are a catalyst to conduct further and more detailed measurements around the Westfjords. The measuring period should be at least two weeks or between two consequent spring tides. Fourier analysis on sinusoidal tidal range data collected from diverse locations would be helpful to understand better the dynamic response of the coastline.

In general the currents inside the fjords seem to be very slow or between 0 – 30 cm/s.

Maximum measured velocity reached almost 1 m/s in Þorskafjörður and in Sýreyjarsund off Flatey. Current that slow is not feasible for generating electricity with today's technology. See raw data in appendix D.

7.2 Fourier analysis

Table 14 List of main tidal components.

Symbol	Main components	Period (hour)
M_2	Principal lunar semi-diurnal component	12.4206
S_2	Principal solar semi-diurnal component	12.0000
N_2	Lunar elliptic component	12.6600
M_4	Lunar quarter diurnal component	6.2103
O_1	Lunar diurnal component	25.8200
K_1	Lunisolar diurnal component	23.9300
K_2	Lunisolar semi-diurnal component	11.9650

Table 14 is a list of the main tidal components and their recurrence in hours [70]. Information about changes in tidal range has been measured and collected in Reykjavík harbor since 1956. In an unpublished report conducted by Ólafur Guðmundsson and Páll Einarsson, that information was analyzed by running the computer programme Fast Fourier Transform on data collected between 1956 and 1989. Inaccuracy in the data caused by both technical and human errors was corrected, and the standard deviation for the whole time series was 10 cm. That may tell us that more information is included in this data than only the tides, like the effect of weather conditions such as atmospheric pressure and wind.[7]

In the context of tides, the input variable (frequency) is measured in degrees per hour which gives an angular speed. One day is 360 degrees and a speed of 15 degrees per hour is equivalent to one cycle per day (K_1, O_1) and speed of 30 degrees are equivalent to two cycles per day (N_2, M_2, S_2).

[7] This data is presented here with the kind permission of Ólafur Guðmundsson.

Using data from Reykjavík harbor, the only long-term data available in Iceland, collected over 34 years and about 283.000 readings resulted in Fourier transform data, shown in Figure 55. The larger the peak is the more significant that frequency is to the overall signal. The peaks near 30 degrees per hour reflect that the tide has two cycles per day. The peaks near 15 degrees per hour are associated with once per day, which results in one of the two high tides during the day being significantly higher than the other.

Close to 30 degrees per hour, we can actually see three peaks on the graph on Figure 55. The peak at 30 degrees is the solar component S_2 effect every 12 hours. The major peak, labeled $M_{2,}$ is the strongest component in the tidal oscillations spectrum. It is lunar and has the largest effect on tides. Because the moon is moving relative to the earth, the earth has to turn a little bit extra to catch up to the moon’s position, which takes about (2x12.42) or 24.84 hours, giving a smaller speed of about 28.98 degrees per hour. The component N_2 accounts for the elliptic orbit of the moon to the earth.

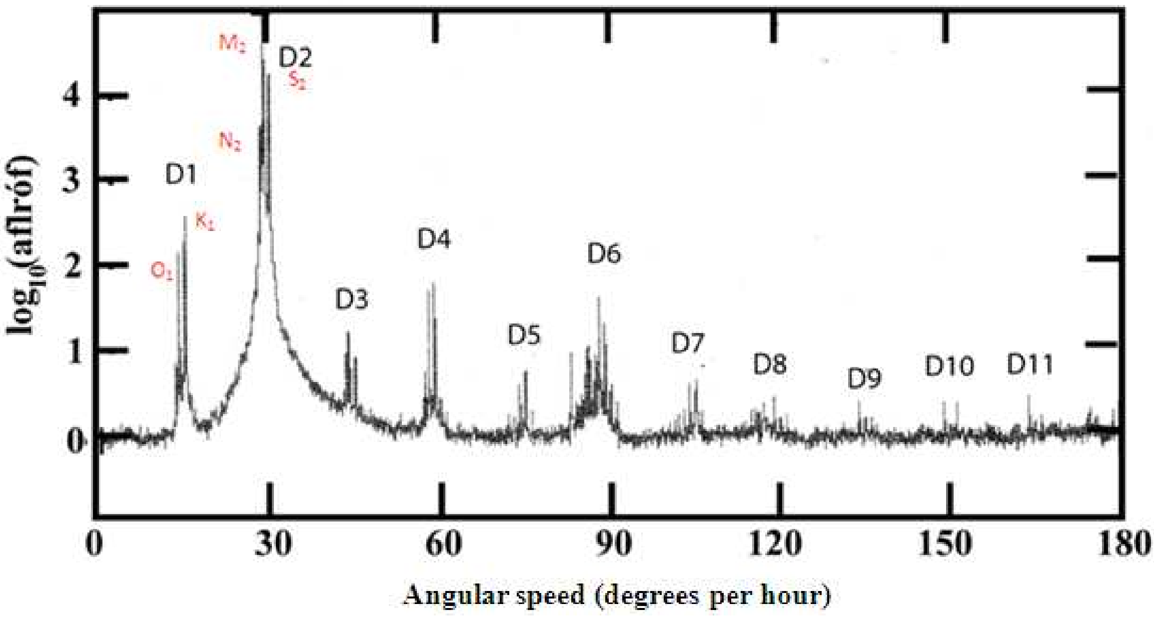


Figure 55 Fourier analysis.

Table 15 Harmonic tide components greater than 5 cm in Reykjavík harbor.

Symbol	Frequency	H (m)	δh Error (m)	Av. H̃ (m)	δh̃ Error (m)	Δϕ (°)	δΔϕ Error (°)	Av. Δϕ̃ (°)	δΔϕ̃ Error (°)
M_2	28.9841042	1.3128	0.0004	1.3129	0.0098	183.4	0.0	183.4	0.9
S_2	30.0000000	0.5141	0.0004	0.5139	0.0050	220.0	0.0	220.0	1.2
N_2	28.4397295	0.2571	0.0004	0.2572	0.0055	161.4	0.1	161.4	1.2
K_2	30.0821373	0.1457	0.0004	0.1460	0.0049	218.4	0.2	218.5	1.8
K_1	15.0410686	0.1081	0.0004	0.1079	0.0032	117.2	0.2	117.6	1.8
O_1	13.9430356	0.0680	0.0004	0.0682	0.0025	65.1	0.4	65.3	3.1

Harmonic analysis (Table 15, complete table is in appendix B) can identify the magnitudes of the components included in the collected tidal height information and helps to produce accurate energy predictions years in advance based on the individual characteristics of the generation technology available. All energy estimates should specify the amount of harmonics identified and the probability of the predictions occurrence [71].

Figure 56 and Figure 57 show charts of amplitude and phase of the two major tidal components M_2 and S_2 based on a satellite observation. Notice that the western part of Iceland is marked with red and yellow color which means the highest tidal amplitude. In both figures it can be seen how the oceans waves propagate around amphidromic points where the tidal wave amplitude is close to zero [34].

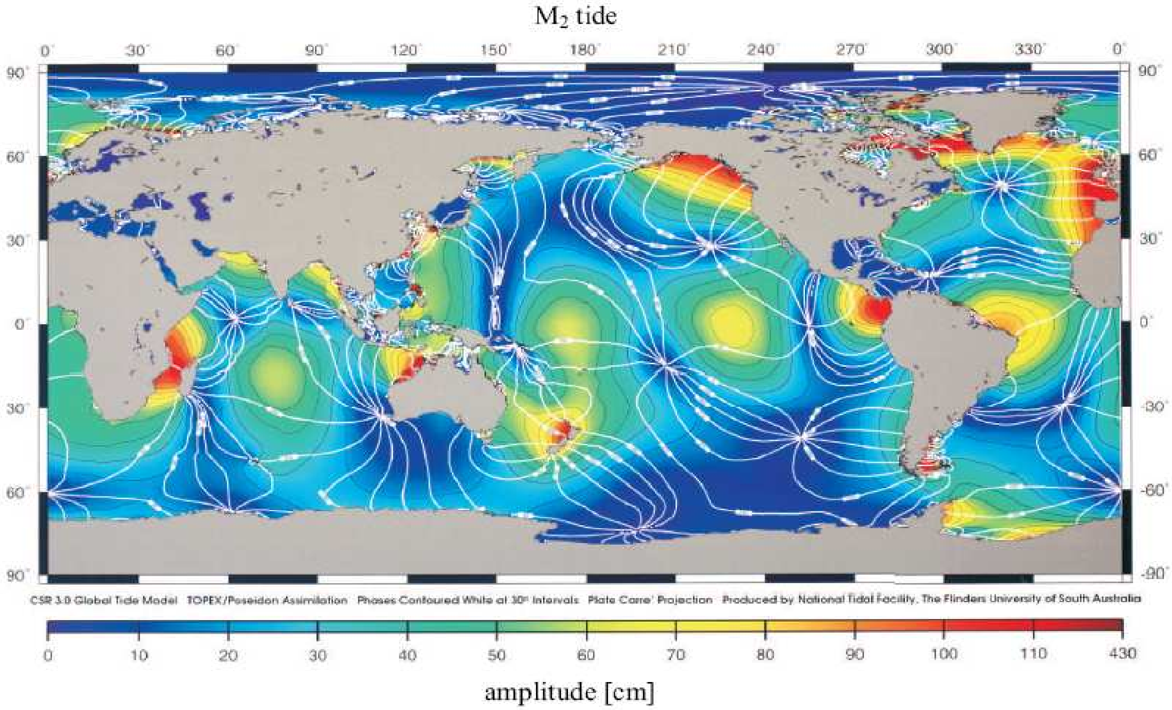


Figure 56 **M_2 tide in the world oceans. Amplitude (dark lines) is given in cm and phase (white lines, degree) is referenced to Greenwich. (Musiela, NTF, Australia)**

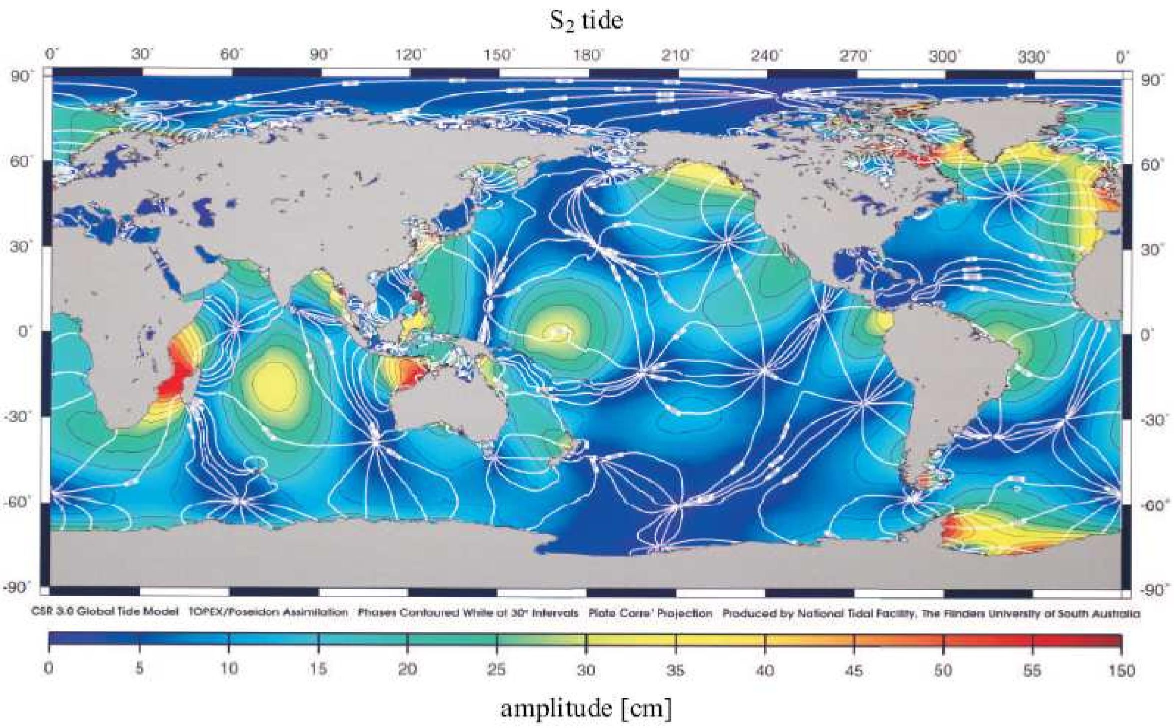


Figure 57 **S_2 tide in the world ocean. Amplitude (dark lines) is given in cm and phase (white lines, degree) is referenced to Greenwich. (Musiela, NTF, Australia)**

7.3 Simplified tidal economic model (STEM) for tidal current turbines

STEM is a computer program designed to simulate tidal currents and electrical power output for tidal current turbines in a 12 month time series of hourly current speeds. Preset economic parameters in STEM include: interest rate at 5 percent, depreciation period of 20 years, installed power 1 MW, 10 turbines in the array, turbine cost £ 1 million, site specific cost £ 5 million and yearly operations and maintenance cost £ 30 thousand [72].

Figure 58 shows the results of using harmonic tide components from the Fourier analysis in Table 15 in STEM and approximated current information from current measurements in Þorskafjörður as well as position in latitude and longitude.

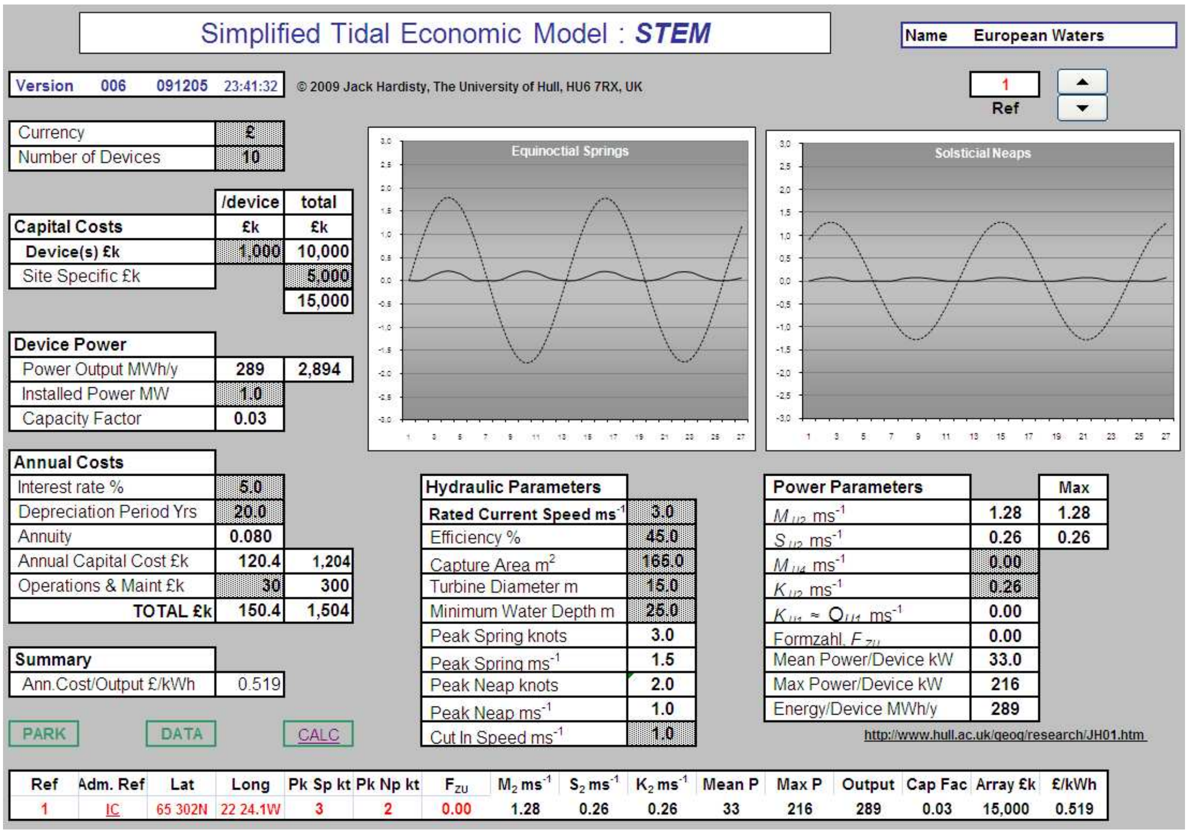


Figure 58 STEM display screen

The broken line in the chart in Figure 58 simulates tidal current speed through 27 hours for an Equinoctial tide (left) and Solstice tide (right). The solid line is the output power. The mean power output is 33 kW and maximum power is 216 kW. Annual energy output is 289 MWh and the overall capacity factor is 0.03. It should be noted at this outputs are from ten 1 MW tidal current devices. The cost of each kWh is calculated to be 0.519£ or around 105 IKR. (£=203; 5 December 2009). The project in this example is not economical feasible because of high cost. Figure 59 shows a sample of data input into STEM.

							M_2	S_2	K_2
Ref	Adm. Ref	Lat	Long	Pk Sp kt	Pk Np kt	F_{ZU}	m	m	m
1.0	IC	65 302N	22 24.1W	3.0	2.0	0	1.31	0.51	0.15

Figure 59 Input data into STEM from current measurement and Fourier analysis.

The graphs in Figure 60 illustrate information from STEM about calculated current speed in m/s and time in hours.

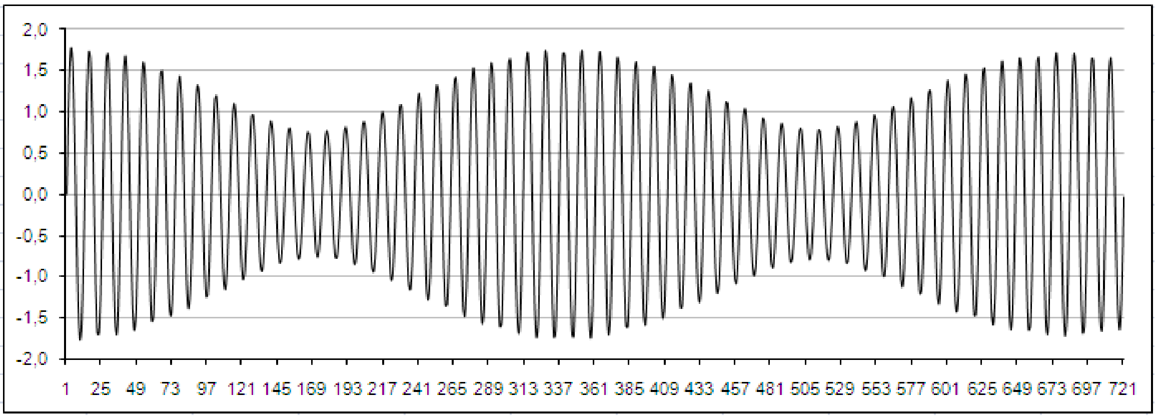


Figure 60 Defant graph. Y axis - current velocity in m/s; X axis - time in hours.

Figure 61 shows the results of inputting STEM known current velocity through bridges openings in crossings over fjords where the maximum is according to the Icelandic road administration, between 2 and 3 m/s (4-6 knots).

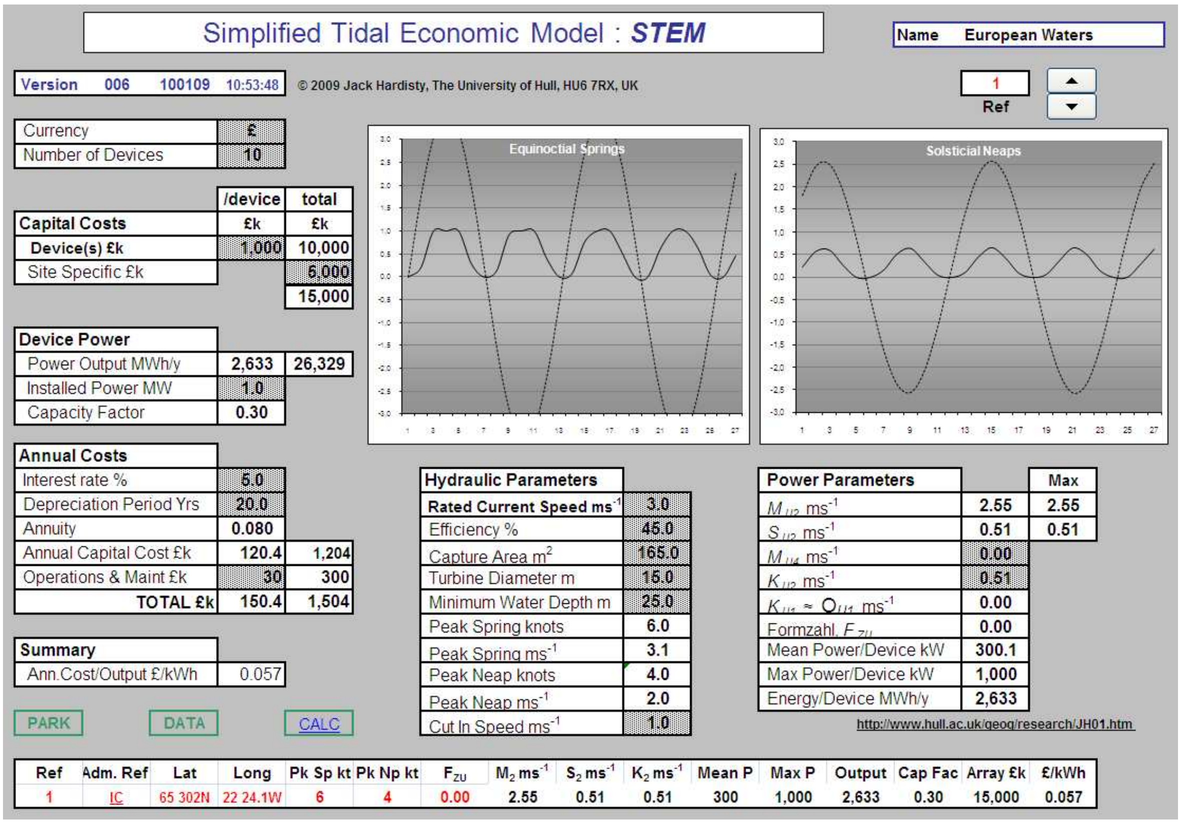


Figure 61 **STEM calculation. Currents through bridges openings are a maximum of 3 m/s (6 kt)**

The broken line in the chart in Figure 61 simulates tidal current speed through 27 hours for an Equinoctial tide (left) and Solstice tide (right). The solid line is the output power. The mean power output in this case is 300 kW and maximum power is 1.000 kW. Annual energy output is 2.633 MWh and the overall capacity factor is 0.30. It should be noted at this outputs are from ten 1 MW devices. The cost of each kWh is calculated to be 0.057£ or around 11.5 IKR. (£=203; 5 December 2009). The wholesale price of electricity in Iceland is between 4 and 4.08 IKR/kWh. The project in this example is not economically feasible at this time because of high cost but is much better than in the previous case.

Figure 62 is a graph of information from STEM and reflects calculated current speed in m/s and time in hours.

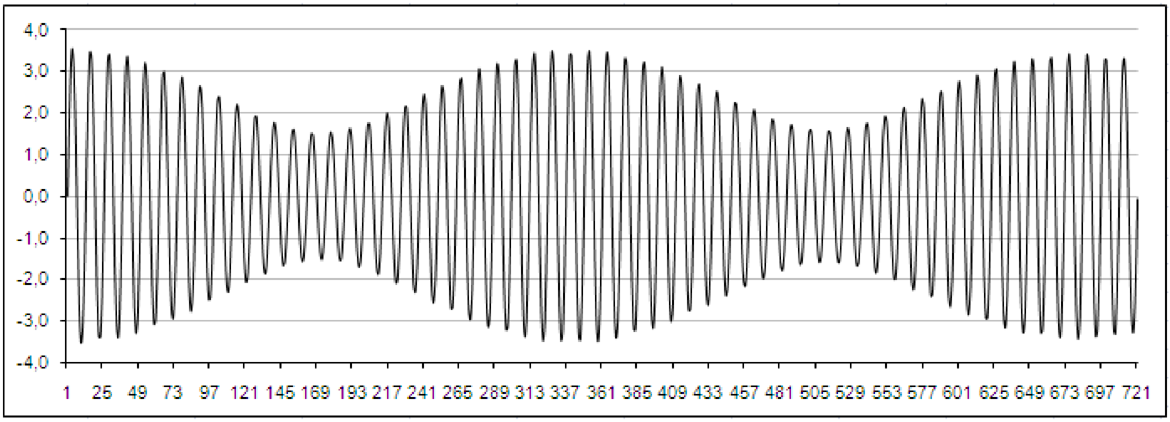


Figure 62 **Defant graph. Y axis - current velocity in m/s; X axis - time in hours.**

It should be noted that the harmonic tide components put into STEM are from Fourier analysis for data collected in Reykjavík harbour (only available data), not from Þorskafjörður. The maximum current speed measured in Þorskafjörður was around 1 m/s is approximated to 1.5 m/s at peak spring tide (about 3 knot) and 1 m/s at peak neap tide (about 2 knot). Taking this into consideration, the results are inaccurate but give some idea of how this might be done with real data. All other parameters in the STEM model are preset by the author of the STEM model. Appendix E shows samples of calculations that STEM carries out.

7.4 Selected locations

In Figure 63 location of the selected fjords, for further investigation is shown. Hvammsfjörður, Hraunsfjörður and Kolgrafarfjörður are outside the Westfjords area but are included in the study for comparative purposes.

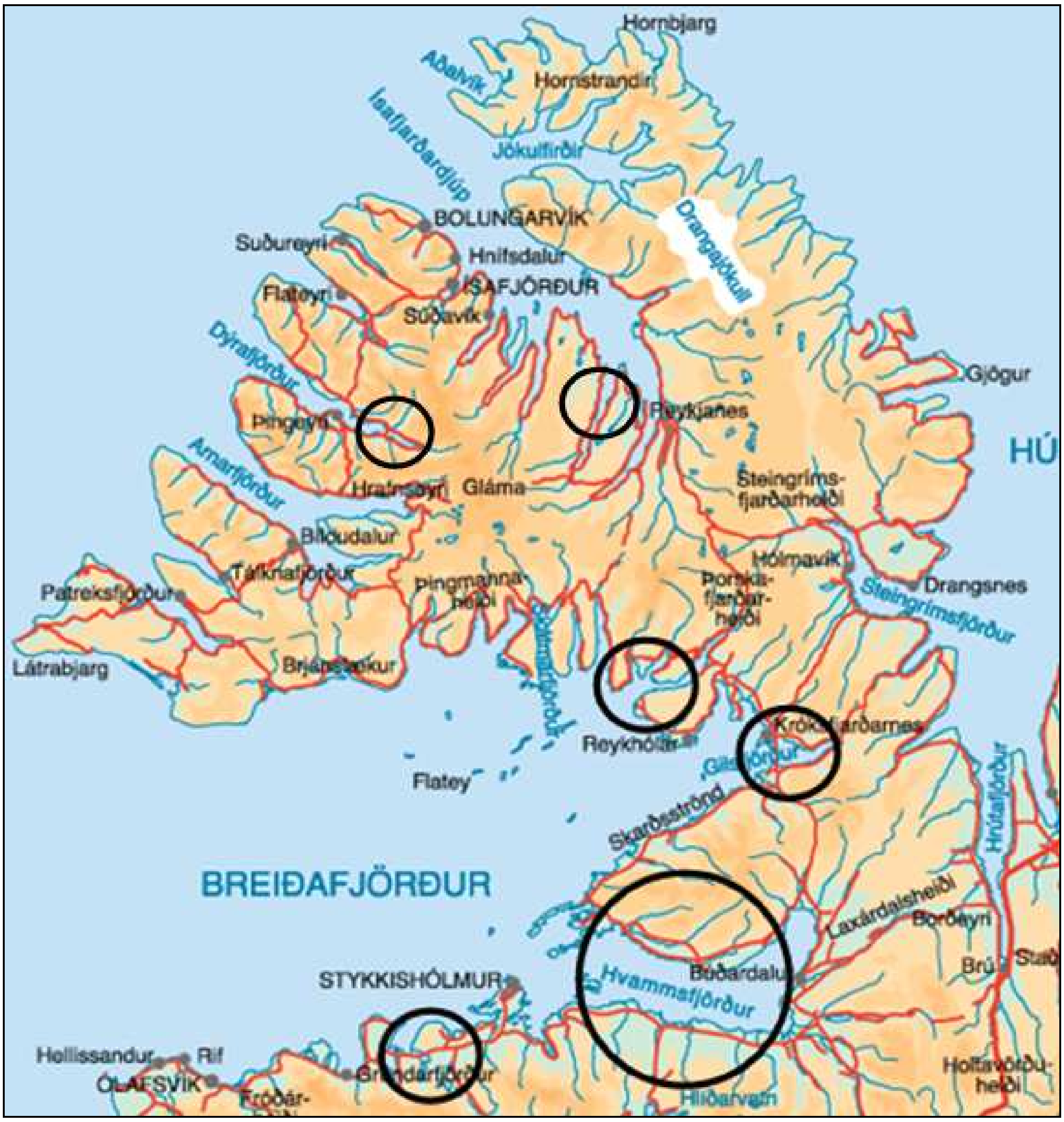


Figure 63 Fjords in black circles from the bottom; Kolgrafarfjörður and Hrausnfjörður, Hvammsfjörður, Gilsfjörður, Þorskafjörður, Dýrafjörður, Mjóifjörður.

On Figure 63, the following fjords are located: Gilsfjörður, Þorskafjörður, Mjóifjörður, Dýrafjörður, Kolgrafarfjörður, Hraunsfjörður and Hvammsfjörður. To be able to calculate potential energy in those fjords, the size of the impounded area must be known as well as the medium tidal range. Figure 64, 65 and 66 shows the impounded area. Table 16, 17 and 18 give the results of calculations for those fjords.

By using formula **(3)** $\boldsymbol{P = 0.226SHtr^2}$ ***(W)*** and **(4)** $\boldsymbol{P = 0.170AHav^2}$ ***(MW)*** the potential tidal power in selected areas can be calculated. Installed power is less than potential power as illustrated in Table 19. Average potential annual energy output (MWh/year) may be calculated by using equation **(8)** $\boldsymbol{\bar{E}=0.99x0.33x\ R^2xA}$ ***(GWh/year)***. Formula **(8)** gives information about the expected energy production.

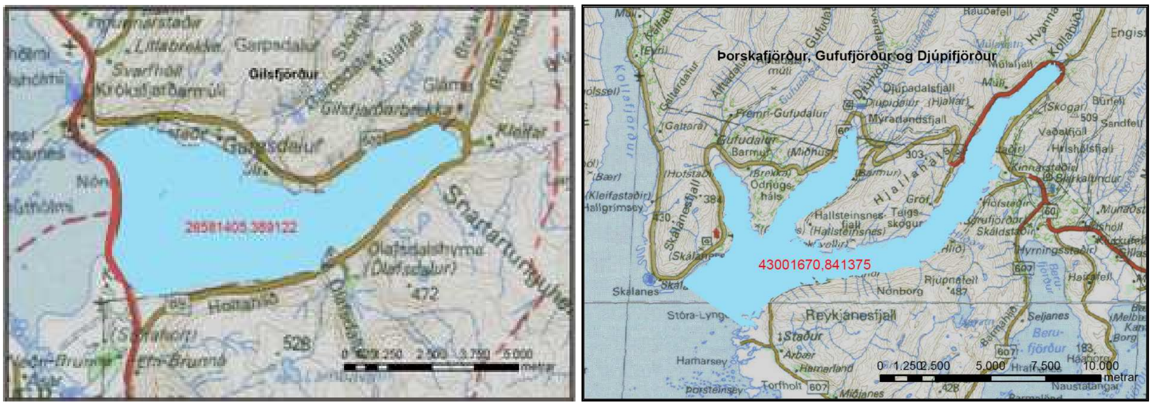


Figure 64 Gilsfjörður and Þorskafjörður.

Table 16 Different formulas for calculations: Gilsfjörður, Þorskafjörður.

Location	**Potential power (MW)** $P=0.226SHtr^2$	**Potential power (MW)** $P=0.170AHav^2$	**Mean tidal range (m) (MHWS)**	**Basin area (km²)**	**Average potential annual output (GWh/year)** $\bar{E}=0.99x0.33x\ R^2xA$
Gilsfjörður	61	46	3.2	26.5	89
Þorskafjörður	100	75	3.2	43	144

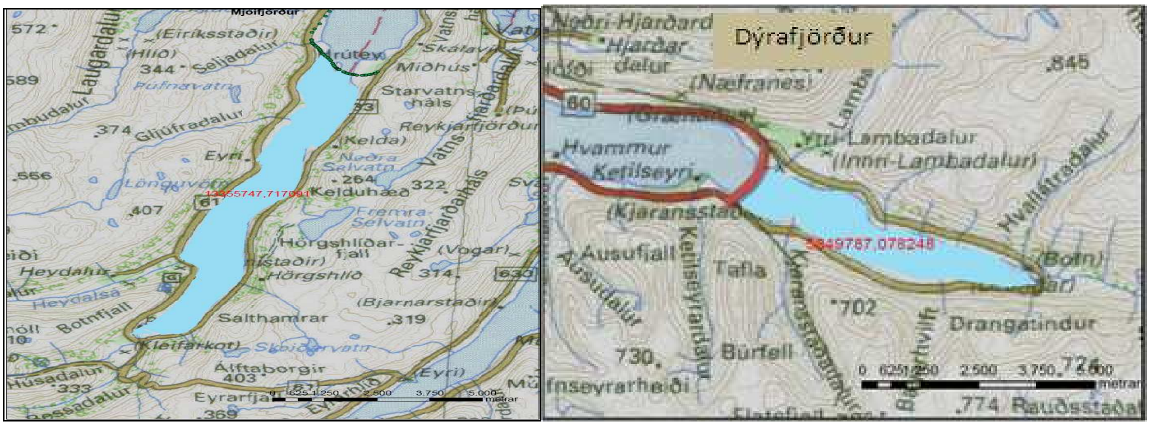


Figure 65 Mjóifjörður and Dýrafjörður.

Table 17 Different formulas for calculations: Mjóifjörður, Dýrafjörður.

Location	Potential power (MW) P=0.226$SHtr^2$	Potential power (MW) P=0.170AHav^2	Mean tidal range (m) (MHWS)	Basin area (km^2)	Average potential annual output (GWh/year) $\bar{E}=0.99x0.33x R^2xA$
Dýrafjörður	11	8.2	2.90	5.8	16
Mjóifjörður	14	10.6	2.17	13.3	20

Figure 66 Kolgrafarfjörður, Hraunsfjörður and Hvammsfjörður.

Table 18 Different formulas for calculations: Kolgrafarfjörður, Hraunsfjörður and Hvammsfjörður.

Location	**Potential power (MW)** $P=0.226SHtr^2$	**Potential power (MW)** $P=0.170AH\,av^2$	**Mean tidal range (m) (MHWS)**	**Basin area (km^2)**	**Average potential annual output (GWh/year)** $\bar{E}=0.99x0.33x\,R^2xA$
Hvammsfjörður	809	609	3.2	350	1.170
Kolgrafarfjörður	26	20	3.2	11.4	38
Hraunsfjörður	7.4	5.6	3.2	3.2	11

Hvammsfjörður (Figure 66) has the greatest potential power of the selected fjords and has been surveyed for several years by the company Sjávarorka, which plans to harvest its tidal energy in the future. Þorskafjörður (Figure 64) was next in magnitude of calculated potential power. Since the Icelandic road administration plans to cross Þorskafjörður, Djúpifjörður and Gufufjörður with a new road, moving the road line further out and crossing those fjords in their common mouth would allow a tidal power plant to be constructed rather than merely a bridge. The third location in Gilsfjörður (Figure 64) is already dammed with a road and an overflow, but power plant in that crossing is a possibility.

The other fjords of Mjóifjörður, Dýrafjörður (Figure 65), Kolgrafarfjörður and Hraunsfjörður (Figure 66) have less potential power and are probably not suitable for a barrage scheme. Other technologies such as tidal current turbines are possible.

To predict the potential power and the annual energy output, several different formulas can be used if the basin area and tidal range are known. Two approximation formulas are listed here and are calculated for existing tidal power plants as well as on selected locations in the Westfjords in order to test their applicability. The relevant parameters for these approximations are listed in Table 19. For currently operating tidal power plants such as La Rance and Sihwa, the calculated potential power and installed capacity are pretty close. The Annapolis pilot project was designed as 20 MW but could have been much bigger.

Table 19 Predictions with approximation formulas.

Location	Potential power (MW) $P=0.226SHtr^2$	Installed capacity (MW)	Mean tidal range (m) (MHWS)	Average Basin area (km^2)	Average potential annual output (GWh/year) $\bar{E}=0.99x0.33x R^2xA$
La Ranch (France)	363	240	8.45	22.5	524
Sihwa (Korea)	304	254	5.60	43	440
Annapolis (Canada)	138	20	6.40	15	200 (30)
Kislaya Guba (Russia)	1.4	0.4	2.40	1.1	2
Hvammsfjörður	809	-	3.2	350	1170
Kolgrafarfjörður	26	-	3.2	11.4	38
Hraunsfjörður	7.4	-	3.2	3.2	11
Gilsfjörður	61	-	3.2	26.5	89
Þorskafjörður	100	-	3.2	43	144
Dýrafjörður	11	-	2.9	5.8	16
Mjóifjörður	14	-	2.17	13.3	20

8 Proposition of how to use/store the energy

In chapter 1 of the thesis is information about the power production in the Westfjords in the year 2006, when total installed hydro power capacity was 12.5 MW with a maximum load of 39.4 MW. Total production was 46 GWh per year but the total yearly consumption was 226 GWh, requiring the imported energy from Landsnet of 180 GWh. In chapter 8, it was calculated that possible yearly power production in Þorskafjörður could be 144 GWh and in Gilsfjörður 89 GWh.

Tidal power plants in Þorskafjörður and Gilsfjörður could produce more electricity than needed to fulfill the Westfjords' needs. Because of periodic dispatchability nature the tidal power plant should be considered a base load, or "must-run" plant, and all its energy should be utilized when producing energy.

Many big water reservoirs are part of the Icelandic power system and the synchronization of the power system means scheduled intermittent power can be easily utilized. While the tidal power plant in production, water at other power plants can be collect into reservoirs. Collected water may then be used when the tidal power plant is not functioning, leveling out the swing.

While there are reservoirs in the Westfjords, like the one at the Mjólká power station (Figure 67), it is likely that, because of the small size of these local reservoirs (see Table 20), other locations in Iceland would be chosen to store water, like the reservoir at Blanda in the north or the Búrfell power station in the south. This process of water collection in diverse areas would be directed by the transmission system operation, taking into account other factors such as precipitation and snowmelt in the area.

On the other hand, with sufficient local production to meet energy needs in the Westfjords, excess energy could be exported or used in industries in the Westfjords that could utilize intermittent power such as to produce hydrogen.

Orkubú Vestfjarða was established in January 1978 and took over the Mjólká power station as well as other power stations in the Westfjords. The Westfjords distribution grid was connected to the national grid in 1980.

Figure 67 Mjólká power station (Orkubú Vestfjarða).

Two of the main rivers on the Gláma plateau are the Mjólká and Hofsá which get most of their water from springs as well as from melting snow caps. These snow caps have been diminishing over the last decades and Gláma is no longer classified as a glacier. The average flow of Mjólká is 2.3 m^3/s. During the driest quarter, from the middle of January to the middle of April, about 12 percent of the average yearly water runs to sea, whereas during the wettest quarter, about 40 percent of the water runs to sea. Table 20 displays more data for the Mjólká power plant [80].

Table 20 Orkubú Vestfjarða, data for power stations.

Power plants	GWh/y (GWh)	Head (m)	Discharge (m^3/s)	Reservoir (Gl)
Mjólká II	42	478	1.7	4.2
Mjólká I	15	200	1.5	0.4
Þverá	8.5	59	4.5	25.3
Tungudalur	4.6	105	0.7	N/A
Fossavatn	3.5	302	N/A	N/A
Nónhornsvatn	1.4	380	N/A	N/A
Reiðhjalli	2.1	280	0.22	N/A
Blævardalsá	0.9	N/A	N/A	N/A
Mýrará	0.3	N/A	N/A	N/A

A plan for the Mjólká which includes building a new reservoir and upgrading the turbines has been proposed. The average electricity production from Mjólká I and II is today around 54 GWh per year.

9 Barrage power plant in Gilsfjörður and Þorskafjörður

It is apparent from the calculations and other data that few Westfjords sites are suitable for barrage power plants. The most important existing conditions for choosing a location for a barrage power plant include: tidal range, size of basin area, length of barrage, distance to grid connection, actual energy situation, the economy of the particular region and impact on the environment [73]. Two locations stand out as compatible with those considerations: Gilsfjörður and Þorskafjörður (See Table 21). Gilsfjörður has already been crossed with a road barrage (Figure 68). Preparation for a road crossing of Þorskafjörður, Djúpifjörður and Gufufjörður has begun, but disagreement between the stakeholders has delayed final determination of the road line. Part of the proposed road in Þorskafjörður crosses an old-growth birch forest (Teigsskógur). The owners appealed through the courts, and the approval of the license was withdrawn. A revised road plan which includes a barrage power plant would preserve the forest.

Gilsfjörður:

By constructing a tidal power plant in the existing road barrage crossing at Gilsfjörður an annual renewable potential power of 89 GWh could be generated. As discussed in section 8.1, damming Gilsfjörður changed the environment considerably both inside and outside the dam.

Tidal power plants require maximum water exchange, and building a power plant will increase the water exchange in the fjord, allowing flora and fauna to recover as it did at Kislaya Gupa. It is possible, however, that flora and fauna may have already adapted to the new situation. Scientific determination is needed.

Þorskafjörður:

An annual renewable potential power of 144 GWh could be generated by construction of a tidal power plant, along with the new road barrage crossing Þorskafjörður previously discussed. This new road crossing the fjord is urgently needed - transportation in this area and in the Westfjords in general would be greatly improved. This tidal power plant would be a single high basin plant because of natural circumstances and either double or single functioning. [33].

In Figure 68, a tidal power plant has been added to the existing road barrage in Gilsfjörður.

Figure 68 Conceptualization of Gilsfjörður tidal power plant. (Google Earth 2009).

Figure 69 shows how a tidal power plant might look in Þorskafjörður. A barrage with a new road and imaginary tidal power plant has been added to that picture.

Figure 69 Conceptualization of Þorskafjörður tidal power plant. (Google Earth 2009).

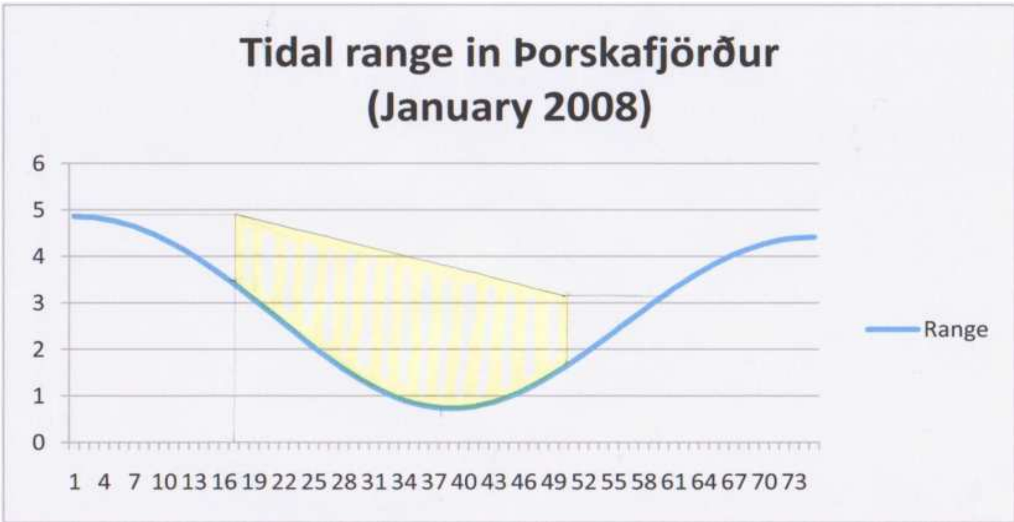


Figure 70 Diagram showing the mode of operation through one tidal cycle of a single, high-basin tidal power plant. The blue line is the tidal range in Þorskafjörður. The minimum operating head is assumed to be 1.9 m. The yellow sector is the working period of the tidal turbine 5.5 hour. Y axis is the range in meters and X axis is time (12.25 h).

Figure 70 shows the operation mode through one tidal cycle. The turbine starts operating at its minimum operating head of 1.9 m and stops when the generating head has come down again to 1.9 m. The yellow sector is the production period for about 5.5 hours.

Table 21 Barrage power plant in Gilsfjörður and Þorskafjörður.

	Average basin area	Mean tidal range	Barrage length	Average potential energy output	Distance to grid connection	Impact on the environment
Gilsfjörður	26.5 km^2	3.2	3.5 km	89 GWh/year	15 km	Restore
Þorskafjörður	43 km^2	3.2	2 km	144 GWh/year	30 km	Little

9.1 Environmental aspects

Using available surveys conducted for Djúpifjörður, Gufufjörður and Gilsfjörður (which is already dammed), it is possible to estimate results of a new barrage power plant. The University of Iceland, Faculty of Life and Environmental Science, conducted an environmental impact assessment (EIA) five to six years after Gilsfjörður was dammed and compared them with assessment conducted before the damming. Table 22 shows the results of the assessment. In general, effect on birds was much less than predicted, and depletion of kelp inside the dam had not been foreseen. A crossing with full water exchange would have much less effect in the environment.[78].

Table 22 Results from environmental impact assessment in Gilsfjörður.

Subject	Impact	Comment	Findings
Nesting Eagles	None or not considerable	Eagle nests occasionally in some islands in Gilsfjörður	In the period of eleven years before the dam, eagles nested seven times and had eleven young birds. After the dam for period of seven years, successful nesting was three times with four young birds
Red knot	Indication of decrease in Red knot population in the area	Red knots are a migrating bird and stay in the area for feeding during part of May	Mud flats disappeared inside the dam but a new one developed seaward of the dam. Red knots moved to that mud flat for eating
Common eider	None	Slightly increasing	Number of nests was similar between years giving the same amount of collected eiderdown 16 – 18 kg each year
Cormorant	None or not considerable		
Salinity	Decrease in salinity landward of dam	Rapid fluctuation in salinity in the spring	Mean surface salinity decreased 28% and mean bottom salinity decreased 23%
Seaweed	Increase		
Marine eelgrass	Increase		Not found before the dam, found in four of six sites after the dam
Kelp	Decreased considerable	Change in salinity may be the reason	Kelp has almost completely disappeared inside the dam and decreased close to the dam on the seaward side
Tide	Change	Max tidal range inside the dam is 0.5 m. It was 5 m.	Low water spring is now 75 cm lower outside dam
Ice	Change		The dam has ice for longer periods than areas away from the dam
Fish	No information		

No traditional saltwater fishing occurs in those fjords. Prawn fishing has been tried without good results. (oral information, Konráð Eggertsson, 29 December 2009). Trout and salmon fishing are in the rivers. The yearly catch of salmon in the rivers in Þorskafjörður and Gufufjörður is less than 100 salmon in each river. Ther is no information about the salmon catch in Djúpifjörður's river [74].

Table 23 lists the magnitude of impacts from the environmental impact assessment conducted for Djúpifjörður and Gufufjörður. In Þorskafjörður the scale of small organism fauna was little in terms of quantity and number of species. In Djúpifjörður the small organism fauna was rich, but all species found are common and numerous in the entire Breiðafjörður area. The value to the environment of the small organism fauna in Gufufjörður is considered to be little [75]. A new road that crosses these fjords will destroy the beaches, but the beach structure and the small organism fauna are very common in the Breiðafjörður area [75].

Table 23 Results from environmental impact assessment in Djúpifjörður and Gufufjörður

Subject	Impact	Comment
Small organisms	None or not considerable	Very common in the entire Breiðafjörður area
Beaches	None or not considerable	Beach structure is common to the beaches of the area
Birds	Little	Little and only on common species in the area
Eagles	Much	Two to three nests may be endangered
Birch	50 hectares will be destroyed	By law, new trees must be planted for those destroyed
Mammals		No information
Fish	None or not considerable	Juvenile rombus habitats are in those fjords

General impact on birds will be limited to only one common species that are common in the area [76]. The originally planned road line that crossed the three fjords would affect nesting eagles, forcing permanent abandonment of some nests [77].

Around 50 hectares of birch forest will be lost under the road and gravel mines associated with the road construction.

In Þorskafjörður, about 3000 tons of seaweed are harvested each year from boats, about 1.5 to 2 percent of total seaweed harvest in the Breiðafjörður area. (oral information, Björn Samúelsson, 20 October 2009). To continue seaweed harvesting after installation of a barrage, locks need to be installed to allow boats to pass through. Low head turbines are considered fish friendly but to minimize fish killing in the turbines, the propeller should be designed with as few blades and as slow rotation as possible. High frequency repellent, such as used with good results in Annapolis, and installed fish pathways should be used. With full water exchange water quality should not change considerably. In all cases, environmental impact assessments must be completed in accordance with existing laws.

9.2 Social aspects

The population of Reykhólar, the closest community to the proposed barrage scheme, has decreased in the last ten years from 307 in 1999, to 266 in 2008. The most important industry in the area is agriculture, second is the kelp industry, and third is diverse service.

Building a barrage tidal power plant so close to the community will have many social consequences. During the construction period, many new jobs will be created and both population and traffic will increase in the area. After the construction there will be less than ten permanent jobs associated with the operation of the tidal power plant. Using the barrage as a road will shorten distances between locations, saving both time and carbon emission. The new road will put Reykhólar on the map and the passing traffic will boost the local economy.

A calmer bay within the barrage may bring new job opportunities to the area in the form of recreation and aquaculture.

The power plant will constitute a point of interest for tourists, together with restaurant and bird watching facilities. An increase in tourism will mean more jobs and more investment injected into the local hospitality industry, helping to reverse depopulation in the area. As the barrage will affect boat traffic, it is important to inform all stakeholders about the project from the very beginning in order to identify potential conflicts and resolve them.

A stakeholder meeting was held in Reykhólar village at which the thesis author introduced the idea of combining both the road and the tidal power plant at a new location. The presentation included the current energy status of the Westfjords, a history of tidal harnessing and tidal power plants as well as diver’s technology used in current data-gathering. Also discussed were techniques of barrage tidal power plant construction and environmental information collected both from previous projects and local research. Approximately 11 percent of the total population in the area attended the meeting. After the presentation and following discussion, the participants were requested to complete a questionnaire. Responses to some of the questions follow here. For more details about the questionnaire and the responses, see appendix F.

The stakeholders interviewed, including landowners, a kelp harvester, local government and citizens of Reykhólar, were positive about barrage power plant project, especially when coupled with the newly proposed road location, by-passing the Teigsskógur forest, and thus resolving an ongoing dispute concerning the forest.

Figure 71 classifies participants into stakeholder groups. The majority of the participants were local residents and local farmers, with landowners in second place. Of those who answered the questions, 85% supported the power plant and 5% opposed it. Additionally 83% felt the project would have economic benefits.

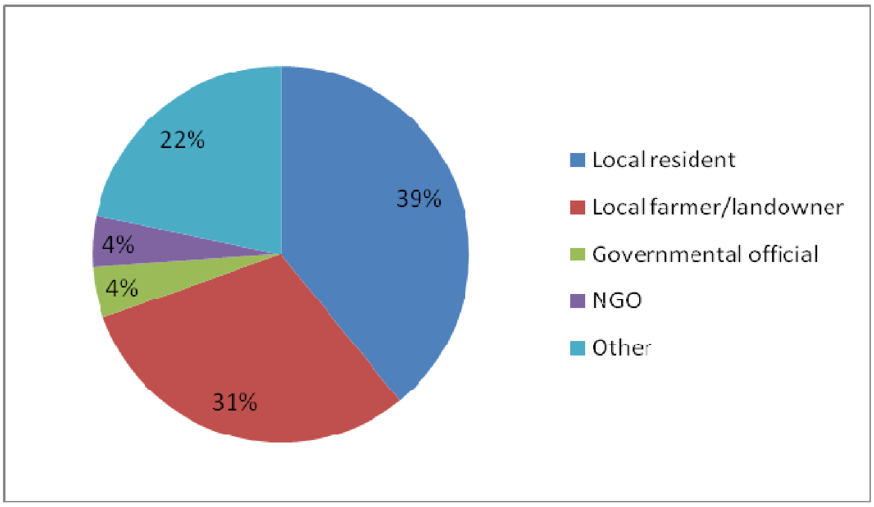


Figure 71 Stakeholder group

31% believed that a tidal power plant would have a negative impact on the environment, where as 37% did not believe it would have a negative impact (Figure 72).

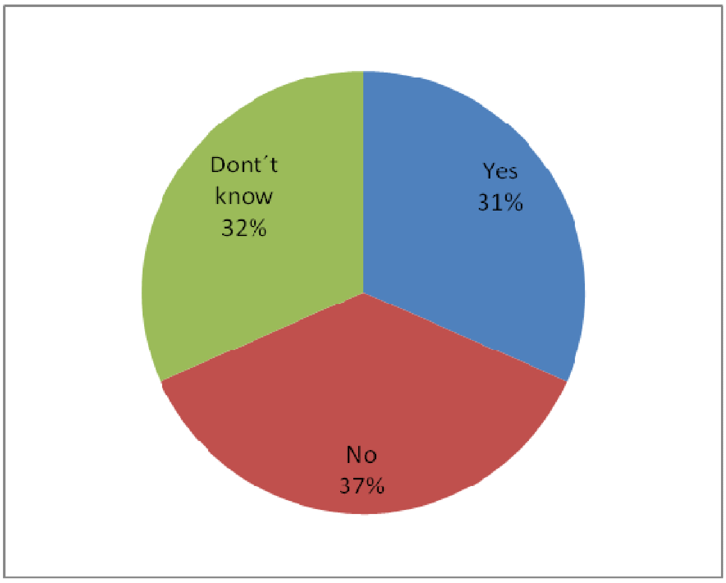


Figure 72 **Do you think the project will have negative impact on the environment?**

The majority of those who thought the project would have negative effect on the environment were worried primarily about the negative impact on seaweed harvesting, and secondarily about the impact on wildlife. Pollution from the project during construction was the third greatest concern about the project. See Figure 73.

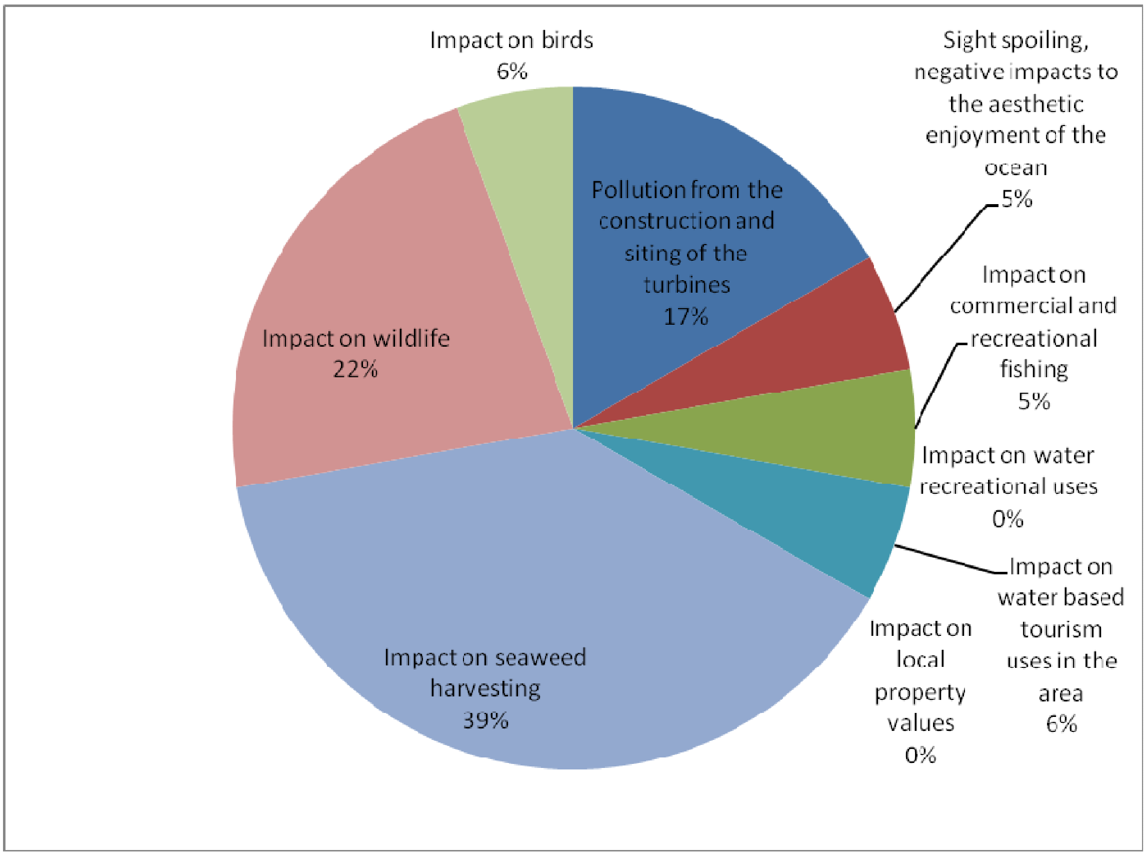


Figure 73 **Negative impact on the environment. If yes, in what way? (More than one answer allowed)**

9.3 Economic

Tidal barrage power schemes have a high capital cost but a very low operational and maintenance cost. Because of the high cost in the beginning, tidal power plants may not produce returns for many years. But the very long life of the construction and low operational cost as well as predictable renewable energy and free fuel, give tidal barrage power plant a head start on many different renewable technologies.

The average wholesale price for per kWh in Iceland is about 4 IKR or about US$ 0.03 (December 2009) which is little higher than the cost of kWh in La Rance tidal power plant (US$ 0.027). Table 24 gives information about the cost per kWh for different renewable technologies.

Table 24 Renewable technologies cost summary (2009)[8] [79]

Renewable Technologies Costs	Levelized cost US$ / kWh
Hydro	0.01 – 0.14
Geothermal energy	0.05 – 0.11
Wind onshore	0.06 – 0.13
Biomass	0.07 – 0.14
Marine current	0.09 – 0.41
Wave	0.13 – 0.44
Wind offshore	0.14 – 0.23
Solar thermal	0.14 – 0.19
Solar PVE	0.20 – 0.27

[8] Levelized cost is the levelized cost of generation only.

One of the major factors in the decision to build a tidal power plant is the construction cost. Each project is site specific, and it is not possible to say how much a project will cost unless it is designed first. This is a topic for another investigation and will not be explored in this hesis.

The Gibrat ratio (k = length (m) / E_{nat}) can be used as preliminary indicator on how desirable a proposed location is for a tidal power plant. The length of the structure divided by the natural energy gives a ratio, and the lower the ratio the more desirable the site. In the case of Þorskafjörður, the structure length is considered to be 500 meters or about the same as is needed to support full water exchange in the fjord. Natural energy is calculated ($E_{nat} = 1.4xR^2xA$ were R is medium range (m) and A is basin size in km^2) to be 616 GWh. The Gibrat ratio for Þorskafjörður with this assumption is 0.81.

$$E_{nat} = 1.4x3.2^2x43 = 616 \qquad K = 500/616 = 0.81$$

The Gibrat ratio for La Rance is: $E_{nat} = 1.4x8.45^2x22.5 = 2249$ => 800/2249 = 0.36, for Severn 0.87 and for Passamaquoddy in the Bay of Fundy 0.92.

According to Weicheng Wu construction cost of conventional tidal power plants is between (US$ 350 – 400/kW in 1999) US$ 455 – 520/kW in to day’s dollar value and the benefit to cost ratio is 2.45, 2.60 and 3.0, respectively (B_9 scheme in the Bay of Fundy). The cost benefit ratio is higher than one, so construction of a conventional tidal power plant is viable [63].

It would be less costly to partly rebuild the transmission system in the Westfjords than to completely replace it. Since the barrage will serve both as part of the new road and as a tidal power plant, the money spent on the barrage have a double function.

Tidal power plants as tourist attractions have positive effects on the economy. The Annapolis tidal power plant attracts 30.000 visitors per year and La Rance attracts 200.000 visitors per year.

9.4 If nothing is done

If nothing is done, the population in the area will probably continue to decrease. Opportunities to explore new technologies to harness tidal energy will this time be lost. Possibilities to harvest renewable energy to strengthen the electricity infrastructure and industry in the Westfjords will be fewer. As mentioned before, the cost of rebuilding the transmission system is estimated to be between 6 and 6.4 billion IKR. The old winding road line would have to be used with its known potential for avalanches, which cause safety hazards and frequent road blocks. The existing longer roads result in increased carbon dioxide emissions, though other negative consequences to the environment will be absent. Diesel generators in periods of power outages must continue to be used to produce electricity.

10 Discussion/conclusion

It is important for coastal nations to explore, plan and harness their coastal zones. In chapter 3.1, it was mentioned that, in 1281, a coastal zone was defined in Iceland and called the Net Laws, today determined to be 115 meters seaward from the low-water mark. Since then not much has happened in coastal zone planning in Iceland. In order to harness coastal resources in the most sensible way possible, planning of the coastal zone outside the Net Laws is essential. Thorough research on benthic and marine life as well as study of the tidal regime and morphology in the coastal zone is also needed. Lack of baseline information makes it difficult to compare the feasibility of diverse projects. Available research is generally associated with road construction and aquaculture. Nor is it clear which government agencies have jurisdiction for projects outside the Net Laws. Projects may affect the sea surface, the sea bottom or anywhere in between. There may or may not be issues of pollution associated with a given project, and multiple stakeholders may be impacted in a variety of ways. With such complexities involved, the careful planning and administration of the coastal zone is essential to avoid potential conflict in the future.

Few sites in the world are suitable for barrage power plants. The tidal range must be high in the area and some kind of natural lagoon or fjord that can be crossed in an economical way should be present. Some tidal power plants have been run for decades with good energy production. Others are in the construction phase. Some potential sites are in areas that are environmentally too sensitive for barrage power plants. Barrage tidal power plants are a proven method of electricity generation and are considered both safe and economically viable. If the barrage already exists or will be built because a new road is necessary, it makes sense to consider a tidal power plant as part of that barrage.

The Icelandic road administration is planning a new road across Þorskafjörður, Gufufjörður and Djúpifjörður. In-depth analysis should be completed to determine if a tidal power plant would be cost-effective when built in conjunction with a new road.

Available research shows that building roads across fjords has little effect on the environment. Though a new road barrage may cause damage to beaches at the road line, the overall beach structures as well as a plethora of organic flora and fauna in the Breiðafjörður area, is durable and abundant. With full water exchange, water quality will be unaffected and tidal regime will not alter significantly.

Construction which crosses Þorskafjörður and includes a tidal power plant will be economical for the Icelandic road administration because no standard bridge is necessary. Instead of a passive bridge, the bridge-barrage will produce electricity. The road to Ísafjörður, the biggest community in the Westfjords, will be about 15 km shorter, and the ongoing dispute about a proposed road through Teigsskógur will be resolved. This area is outside both earthquake and volcanic eruption zones, unlike most other power plants in Iceland. Employment in the area will increase and help combat economic downturn and depopulation. Also, more electric power is needed in the system for diverse industries that are proposed in Iceland.

By installing a tidal power plant into the existing road in Gilsfjörður, the investment already made in the barrage will mean construction can begin quickly and be of shorter duration. With a tidal power plant, the water exchange in Gilsfjörður will be increased to its maximum, with the associated positive benefits to water quality. The decreased salinity of the fjord since the crossing was completed will increase to its prior level. The tidal range within the dam area will also be closer to conditions prior to construction, and flora and fauna in the area will revitalize.

Tidal power plants around the world attract tourists which in turn will boost the local economy.

Data collected for this thesis indicates that the stream velocity is too slow for the marine current turbine technology of today to be economically feasible.

Table 25 compares four alternatives: tidal barrage, tidal current, upgrading of the grid and or making no changes, by grading social and technological impact as well as impact on economy and environment. The ranking for each criterion is from 1 if it is considered to have no change, is not applicable or is the poorest choice to 5 if it is considered to have much positive change or is the best choice and is based on information in the thesis. The maximum score for each criterion is 25 and the highest cumulative number is the most feasible choice. The comparisons are adversely affected by the lack of information about the environmental and social issues, as well as actual cost figures for construction.

Table 25 Comparison of alternatives in determining feasibility

Criterion	No Change	Grid Upgrade	Current Tidal		Barrage Tidal	
			Mjóifj.	Þorskafj.	Gilsfj.	Þorskafj.
Economic						
Local economy	1	3	2	1	4	5
National economy	1	3	2	1	2	3
Benefit cost ratio	1	1	1	1	4	5
Gibrat ratio	1	1	1	1	3	4
Economic life span	1	1	2	2	5	5
Total	**5**	**9**	**8**	**6**	**18**	**22**
Social						
Jobs	1	2	1	1	4	5
Population growth	1	1	1	1	3	4
Transportation	1	1	1	1	1	5
Tourism	2	1	1	1	3	5
Learning	1	1	4	4	5	5
Total	**6**	**6**	**8**	**8**	**16**	**24**
Technical						
Current velocity	1	1	4	2	4	4
Tidal range	1	1	1	1	4	4
Distance from grid	1	1	2	3	5	4
Improve grid	1	5	2	2	5	5
Proven technology	1	5	2	2	5	5
Total	**5**	**13**	**11**	**10**	**23**	**22**
Environment						
Bioimpact	5	5	5	5	4	4
Biodiversity	5	5	5	5	4	4
Fish stocks	5	5	4	4	3	3
Birds	5	5	4	4	5	5
Reclamation of land	5	5	5	5	1	1
Total	**25**	**25**	**23**	**23**	**17**	**17**
Cumulative	41	53	50	47	74	85

According to this study, a tidal current turbine under the bridge over Mjóifjörður, where the design of the bridge mouth allows 3 m/s maximum current velocity, comes in forth place. However it is not yet feasible to install tidal current turbines in the Westfjords because of the high cost per kWh produced. More detailed studies may alter these conclusions.

The most feasible choice indicated above is the construction of a barrage tidal power plant in Þorskafjörður with a similar construction in Gilsfjörður running a close second.

While it is not yet feasible to install current turbines to harness tidal energy in the Westfjords, it is possible to build a barrage tidal power plant in Þorskafjörður in association with a new road. Further studies are needed to gather better information about design, research and construction cost. Further research is also indicated to analyze how the construction of road barrage power plant might alleviate the area's most critical problem, depopulation.

Following are also recommended:

- A baseline and a long term environmental study.
- Further research and measurements of tidal currents.
- Study of alternatives for storage and utilization of energy.
- Study of the consequences of climate change on sea levels and its effect on tidal power plants.
- That adoption of integrated coastal zone management in the Westfjords.
- Meetings with stakeholders during early stages of any project for information distribution and as a forum for public discussion.

11 Summary

Insufficient electricity production in the Westfjords and high failure rate of the local transmission systems promotes new possibilities for electricity generation in the area, including the harnessing of tidal energy. To be able to draw conclusions about the harnessing of this energy source, information about tidal range and current velocity is needed. While some information about tidal range is available for some locations and estimation is possible using information collected in Reykjavík harbor, specific information about measured tidal currents in the Westfjords is scarce and requires in-depth research beyond the scope of this project's limitations, specifically in longer measuring periods and more diverse sampling locations, which may reveal faster currents. The maximum speed measured was around one meter per second so using tidal current turbines for harnessing energy in that slow flowing current is not feasible. Harnessing tidal energy using barrage is a proven method, and the study in this thesis shows that two locations are especially applicable. Those locations are in Gilsfjörður and in the common mouth of Þorskafjörður, Djúpifjörður and Gufufjörður.

Available assessments indicate that effects on the environment associated with a fjord-crossing road are considered negligible. Stable beach structure and prolific small organism flora and fauna are prevalent in the area and, with full water exchange, water quality should not be altered. The social and economic effects could be positive for the area, with more job opportunities associated with the tidal power plant as well as an increase in the need for accommodations and other services related to the tourist industry. Roads will improve, and the main route to Ísafjörður (Westfjord's main town) will be about 15 km shorter.

In Gilsfjörður, the barrage is already in place as part of the existing roadway. A power plant will contribute to increased water exchange in the basin, which in turn will reestablish the previous sea level and salinity, with a corresponding restoration of the environment in the fjord.

Building a tidal power plant in the planned road across Þorskafjörður, Djúpifjörður and Gufufjörður and using the common mouth of those fjords as new location for the road barrage should be seriously pursued. Three problems are resolved by a road across the common mouth: a needed road would be built, a tidal power plant will generate electricity, and finally, Teigsskógur would be preserved. Increased employment opportunities and a direct connection to the main road would strengthen Reykhólar village.

This study sheds light on the feasibility of harnessing tidal power in the coastal zone of the Westfjords of Iceland. More investigation may confirm these preliminary findings. The conclusion confirms it is technically and environmentally feasible to build a tidal power plant in Þorskafjörður in association with a new road barrage, and recommends further study to gain more in-depth information concerning design, research and construction cost.

12 References

[1] Flutningskerfi Vestfjarða, Landsnet-07032.

[2] Bætt afhendingaröryggi raforku á Vestfjörðum, Landsnet-09009.

[3] Charlier, R.H., Finkl, C.W. (2009). *Ocean energy,tide and tidal power,* p. 66. Berlin: Springer verlag.

[4] The American practical navigator, an epitome of navigation, originally by Nathaniel Bowditch, LL.D. 1995 Edition.

[5] Song, W., Walsum, W. Hydroelectric power, (200?). Landolt Börstein, new series VIII/3C

[6] Diagrams from Eling tide mill trust Ltd.

[7] Horizontal tide mill at Nendrum. Available at: http://dnausers.d-n-a.net/dnetclgs/tmill/tm1.htm. [Accessed 10 June 2009].

[8] Harnessing the tides. Available at: http://www.rsai.ie/index.cfm?action=obj.display&obj_id=200. [Accessed 4 July 2009].

[9] Horizontal tide mill at Nendrum. Available at: http://dnausers.d-n-a.net/dnetclgs/tmill/tm1.htm. [Accessed 4 July 2009].

[10] Charlier, R.H., Finkl, C.W. (2009). *Ocean energy,tide and tidal power* p. 31. Germany: Springer verlag, Berlin.

[11] White, L. T. (1964). *Medieval technology and social change*, p. 85. USA: Oxford University Press: reprint.

[12] Ealing tide mill. Available at: http://s277147633.websitehome.co.uk/Elingmill.html. [Accessed 4 August 2009].

[13] Tide mill. Available at: http://www.absoluteastronomy.com/topics/Tide_mill. [Accessed 8 July 2009].

[14] Charlier, R.H., Finkl, C.W. (2009). *Ocean energy,tide and tidal power,* p. 32. Germany: Springer verlag, Berlin.

[15] The Birlot tide mill. Available at: http://www.bretagnenet.com/moulin_brehat/english/english.htm. [Accessed 8 July 2009].

[16] Tide mill Ile de Brehat. Available at: http://www.holidayfrancephotos.com/category/search-results/detail/1861?searchstring=sea. [Accessed 8 July 2009].

[17] Ria Formosa natural park. Available at: http://www.algarveretreats.co.uk/ [Accessed 8 May 2009].

[18] Charlier, R.H., Finkl, C.W. (2009). *Ocean energy,tide and tidal power,* p. 33. Germany: Springer verlag, Berlin.

[19] Charlier, R.H., Finkl, C.W. (2009). *Ocean energy,tide and tidal power,* p. 64. Germany: Springer verlag, Berlin.

[20] Early projects. Available at: http://en.wikipedia.org/wiki/Severn_Barrage#cite_note-raeng-5 [Accessed 5 January 2010].

[21] Weicheng, W. (1999). Towards digital earth. *The prospects of the tidal energy development in the pacific countries.* Science Press.

[22] Charlier, R.H. (2006). Forty candles for the Rance river TPP tides provide renewable and sustainable power generation. *Renewable and sustainable energy reviews 11 (2007) 2032-2057.*

[23] Charlier, R.H., Finkl, C.W. (2009). *Ocean energy,tide and tidal power,* p. 75. Germany: Springer verlag, Berlin.

[24] Chaineux, M. C., Charlier, R.H. (2007). Women's tidal power plant forty candles for Kislaya Guba TPP. *Renewable and sustainable energy reviews 12 (2008) 2515-2524*

[25] Kislaya Guba experimental tidal power station. Available at: http://wikimapia.org/4030539/Kislaya-Guba-Experimental-Tidal-Power-Station. [Accessed 10 October 2009].

[26] GMW Holdings LLC, 2008. [electronic print] Available at: http://images.marinas.com/med_res_id/101111 [Accessed 14 August 2009].

[27] Sihwa lake power plant. Available at: http://en.wikipedia.org/wiki/Sihwa_Lake_Tidal_Power_Plant. [Accessed 7 September 2009].

[28] Sihwa tidal power plant: a success of environment and energy policy in Korea. Available at: http://www.eer.wustl.edu/McDonnellMayWorkshop/Presentation_files/Saturday/Saturday/Park.pdf. [Accessed 7 September 2009].

[29] Tide and tidal power plants in Korea. Available at: http://www.oreg.ca/docs/May%20Symposium/KOREA.pdf Tidal and Tidal Current Power Study in Korea [Accessed 7 September 2009].

[30] Charlier, R.H., Finkl, C.W. (2009). *Ocean energy,tide and tidal power,* p. 19. Germany: Springer verlag, Berlin.

[31] Binnie and Parters (1987) The UK potential for tidal energy from small estuaries. *Report for the UKAEA energy technology support unit no. etsu5tp.*

[32] Halla Jónsdóttir, Geir Guðmundsson. (2004). *Orka í streymi vatns IT0406EUT06/8UI2089.*

[33] Bernshtein, L.B. (ed) (1996). *Tidal power plants*,p. 382. Korean ocean research and development institude.

[34] Kowalik, Z. (2004). Tide distribution and tapping into tidal energy. *Oceanologia*, 46(3):291-331.

[35] Dadswell, M.J. (1995). Macrotidal estuaries: a region of collision between migratory marine animals and tidal power development. *Biological Journal of the Linnean Society*, 51:93-113.

[36] Cicin-Sain, B., Knecht, R.W. (1998). *Integrated coastal and ocean management, concepts and practices*. USA: Island press.

[37] Parker, D.M. (1993) Environmental implications of tidal power generation. *IEEE proceedings a science measurement and technology;* 140 (1):71–5.

[38] Retiere, C. (1994) Tidal power and the aquatic environment of La Rance. *Biological journal of the Linnean society*; 51 (1-2):25–36.

[39] Bernshtein, L.B. (ed) (1996). *Tidal power plants*,p. 121-123. Korean ocean research and development institude.

[40] Tidal barrage and tidal turbine. Available at: www.rise.org.au/info/Tech/tidal/index.html [Accessed 10 August 2009].

[41] Prototype. Available at: http://www.hammerfeststrom.com/content/view/66/101/lang,en/ [Accessed 27 November 2009].

[42] Sea farms. Available at: http://www.lunarenergy.co.uk/seaFarms.htm [Accessed 10 October 2009].

[43] Turning the tides. Available at: http://www.marineturbines.com/ [Accessed 27 November 2009].

[44] In-stream tidal turbine project overview. Available at: http://www.nspower.ca/en/home/environment/renewableenergy/tidal.aspx [Accessed 10 October 2009].

[45] GCK Technology. Available at: http://www.gcktechnology.com/GCK/pg2.html [Accessed 10 October 2009].

[46] Fraenkel, P.L. (2006). Tidal current energy technologies.*Ibis*, 148: 145-151

[47] Tidal power, an update. Available at: http://www.renewableenergyfocus.com/view/3268/tidal-power-an-update/ [Accessed 6 January 2010].

[48] Embassy of Iceland – Brussels, Belgium, Environment, 200? Available at: http://www.iceland.org/be/the-embassy/mission-to-the-eu/policy-areas/environment/. [Accessed 6 March 2009].

[49] Act on the survey and utilization of ground resources. Available at: http://eng.idnadarraduneyti.is/media/Rafraen_afgreidsla/Log_57_1998_ENS_020107.pdf. [Accessed 6 March 2009].

[50] The planning and building act no. 73/1997. Available at: http://www.skipulag.is/focal/webguard.nsf/key2/english.html. [Accessed 10 August 2009].

[51] Provision of the regulation regarding the act of electricity no. 1040/2005. Available at: http://www.stjornartidindi.is/Advert.aspx?ID=bf366397-93bb-4014-951e-8553e02d6a61 [Accessed 10 August 2009].

[52] The electricity act, no. 65/2003, Available at: http://eng.idnadarraduneyti.is/laws-and-regulations//nr/1266. [Accessed 10 August 2009].

[53] Provision of the regulation regarding the act of electricity no.1040/2005. Aavailable at: http://www.stjornartidindi.is/Advert.aspx?ID=bf366397-93bb-4014-951e-8553e02d6a61 [Accessed 10 August 2009].

[54] The enviornmental impact assessment act (EIA). No. 106/2000. Available at: http://www.skipulag.is/focal/webguard.nsf/key2/english.html [Accessed 10 August 2009].

[55] The environmental impact assessment of projects act no. 105/2006. Available at: http://www.althingi.is/lagas/nuna/2006105.htlm. [Accessed 22 October 2009].

[56] The power companies taxability act, no. 50/2005. Available at: http:/www.altingi.is/altext/stjt/2005.050.html [Accessed 15 October 2009].

[57] Renewables obligation, available online at: http://en.wikipedia.org/wiki/Renewables_Obligation_Certificates. [Accessed 11 August 2009].

[58] Green certificate. Available at: http://en.wikipedia.org/wiki/Green_certificate. [Accessed 15 October 2009].

[59] Wennersten, R. (eds), (2008). *Conflict Resolution in Coastal Zone Management*. Germany: Peter Lang.

[60] Marfenin, N.N., Malutin, O.I., Pantulin, A.N., Pertzova, N.M. (1997) A tidal power environmental impact assessment: Case study of the Kislogubskaia experimental tidal power station (Russia). La Houille Blanche-Revue Internationale de l'Eau; 52(3):101–7.

[61] Landsnet, raforkukerfið, kerfisstjórnun. Available at: http://landsnet.is/raforkukerfid/kerfisstjornun/aflflutningurnuna/ [Accessed 16 October 2009].

[62] Rafmagn, tenging virkjana. Available at: http://www.rarik.is/skjolrarik?ccs=754 [Accessed 2 Januar 2010].

[63] Weicheng, W. (1999). Towards digital earth. *The prospects of the tidal energy development in the pacific countries.* Science Press.

[64] Bernshtein, L.B. (1965) Tidal energy for electric power plants.

[65] Tester, J. W., Drake, E. M., Golay, M. W., Driscoll, M. J., Peters, W. A. (2005). *Sustainable energy, choosing among options.* USA: MIT press.

[66] Informations from Landhelgisgæsla Íslands, Sjómælingasvið.

[67] Hradfrystihusid Gunnvør h/f, Miljøundersøkelser i fire fjorder på Island 2002 Seydisfjördur, Alftafjördur, Talknafjördur og Patreksfjördur. Akvaplan-niva report no: APN-413.02.2422.

[68] Þorleifur Eiríksson, Kristjana Einarsdóttir, Cristian Gallo og Böðvar Þórisson. (2008). *Botndýrararannsóknir í Skutulsfirði.* Náttúrustofa Vestfjarða, NV nr. 14-08.

[69] VISTA. (2009). *Straummælingar sjávarfalla í sundi milli Flateyjar og Sýreyjar, 10. Júní 2009.*

[70] Hardisty, J. (2009). *The analysis of tidal stream power*. p. 48 and 137-140. UK: Wiley Blackwell.

[71] Guðmundsson, Ó. Einarsson, P. (2006). *Úrvinnsa sjávarfallagagna: Sjávarföll og hægfara sjávarborðsbreytingar í Reykjavíkurhöfn*. Jarðvísindadeild Háskólans. (Unpublished report).

[72] Simplified tidal economic model (STEM). Available at: http://bcs.wiley.com/he-bcs/Books?action=resource&bcsId=4843&itemId=047072451X&resourceId=15854 [Accessed 29 September 2009].

[73] Bernshtein, L.B. (ed) (1996). *Tidal power plants,*p. 44-45. Korean ocean research and development institude.

[74] Guðni Guðbergsson. (2005). Lax og silungsveiðin 2004.

[75] Þorleifur Eiríksson og Böðvar Þórisson. (2005). *Fjörur í Gufudalssveit, Þorskafjörður, Djúpifjörður og Gufufjörður*. Náttúrustofa Vestfjarða, NV nr. 07-05.

[76] Þorleifur Eiríksson og Böðvar Þórisson. (2005). *Fuglalíf í Gufudalssveit og nágrenni.* Náttúrustofa Vestfjarða, NV nr. 06-05.

[77] Kristinn H. Skarphéðinsson. (2005). *Ernir og vegagerð í Djúpafirði.* Náttúrufræðistofnun Íslands, NÍ-05004.

[78] Agnar Ingólfsson, (2005). *Umhverfisrannsóknir í Gilsfirði. Þriðja rannsóknarlota: Ástand umhverfis og lífríkis fimm til sex árum eftir þverun fjarðarins*. Líffræðistofnun Háskóla Íslands. Flölrit nr. 74.

[79] What does clean energy cost? Available at: http://www.altenergystocks.com/archives/2009/06/what_does_clean_energy_cost_1.html [Accessed 19 February 2010].

[80] Orkubú Vestfjarða. Available at: http://ov.is/virkjanir/ [Accessed 22 October 2009].

Appendices:

A Tide table for Reykjavík.

ALMANAK YFIR SJÁVARFÖLL

Almanakið sýnir útreiknaða hækkun og lækkun sjávar í Reykjavík fyrir hvern dag ársins. Breyting sjávarfallabylgjunnar frá degi til dags og hlutfallsleg stærð hennar við stórstraum og smástraum kemur greinilega fram á línuritinu.

Hverjum sólarhring er deilt niður í tveggja klukkustundar bil og er sjávarhæðin sýnd í metrum miðað við núllflöt sjókorta. Með hjálp línuritsins má því áætla sjávarstöðuna á hverjum tíma. Sé þörf á meiri nákvæmni er vísað til töflu yfir sjávarföll við Ísland, en í þeirri töflu er tími og hæð flóðs og fjöru gefinn upp nákvæmlega.

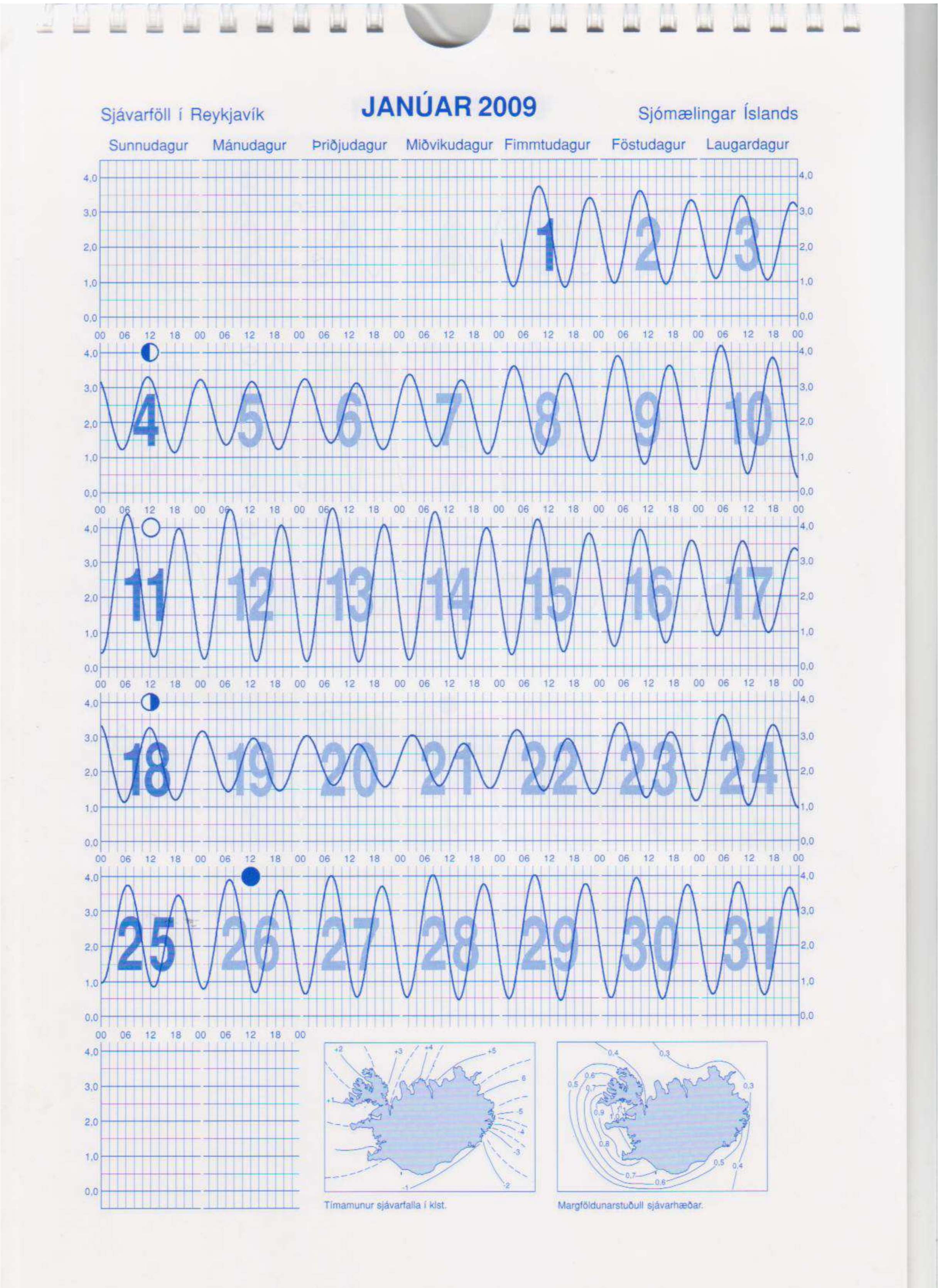
Stórstreymt er einum til tveim dögum eftir að tungl er nýtt eða fullt en smástreymt einum til tveim dögum eftir fyrsta og síðasta kvartil. Í almanakinu er sýnt hvenær kvartilaskipti tungls verða.

● nýtt tungl, ◐ fyrsta kvartil, ○ fullt tungl, ◑ síðasta kvartil.

Veður hefur talsverð áhrif á sjárvarstöðun frá degi til dags, sérstaklega loftþrýstingsbreyting. Þannig hækkar sjávaryfirborð um 0,1 metra, falli loftvog um 10 millibör og öfugt.

Til þess að geta gert sér hugmynd um sjávarfallabygjuna á öðrum stöðum við Ísland en í Reykjavík, eru tvö kort neðst á blaði hvers mánaðar. Annað kortið sýnir mismun flóðtíma umhverfis landið miðað við Reykjavík, en hitt sýnir hlutfallstölu, sem gefur flóðhæðina á þeim stað sem hlutfallstalan á við, sé hún margfölduð með flóðhæð Reykjavíkur.

Við Ísafjarðardjúp er tímamunurinn t.d. +2 klukkustundir og hlutfallstalan er 0,6. Það táknar að flóðbylgjan er tveim klukkustundum síðar við Ísafjarðardjúp en í Reykjavík og að flóðhæðina í Ísafjarðardjúpi megi finna með því að margfalda flóðhæðina í Reykjavík með 0,6.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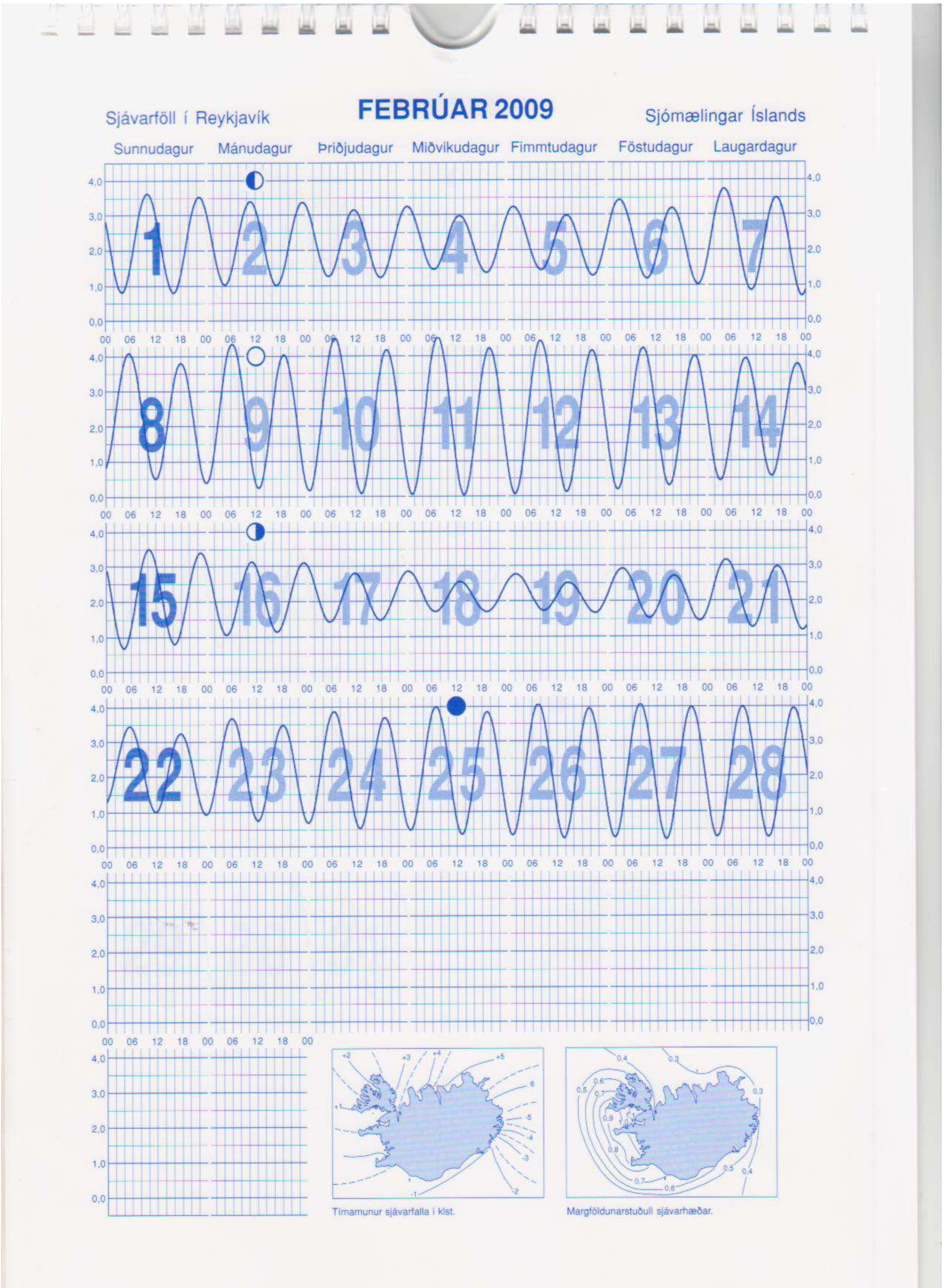
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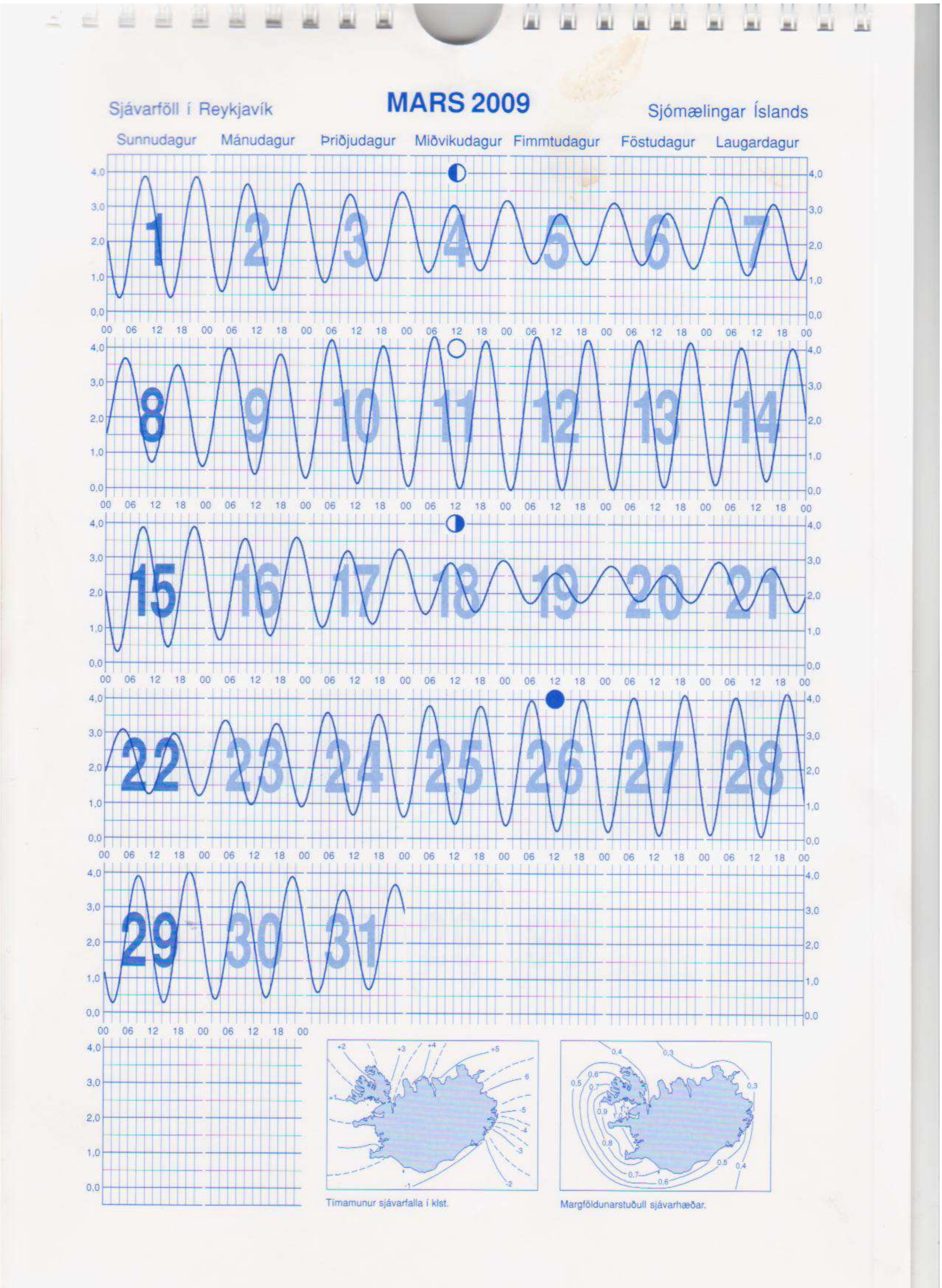
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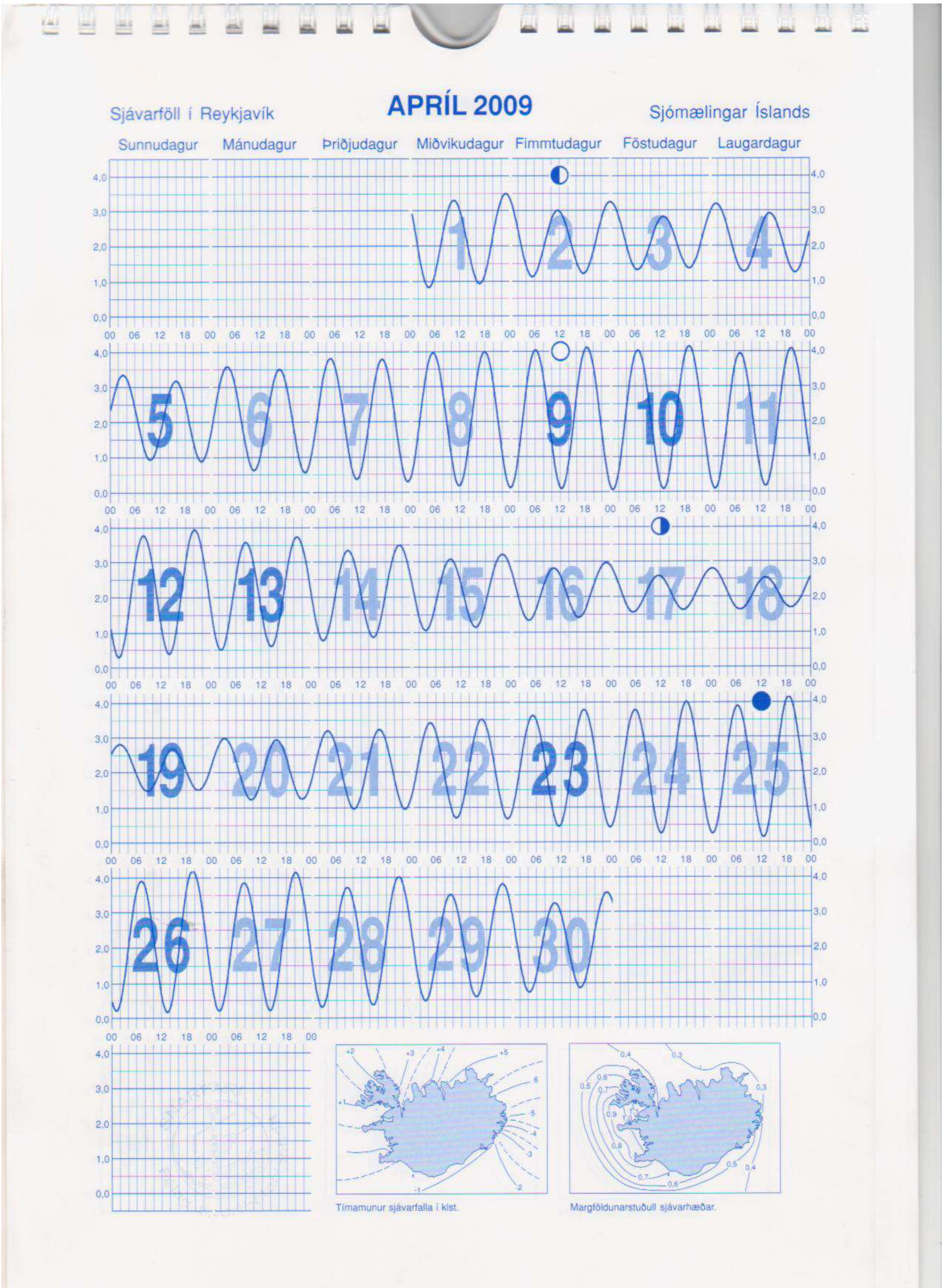
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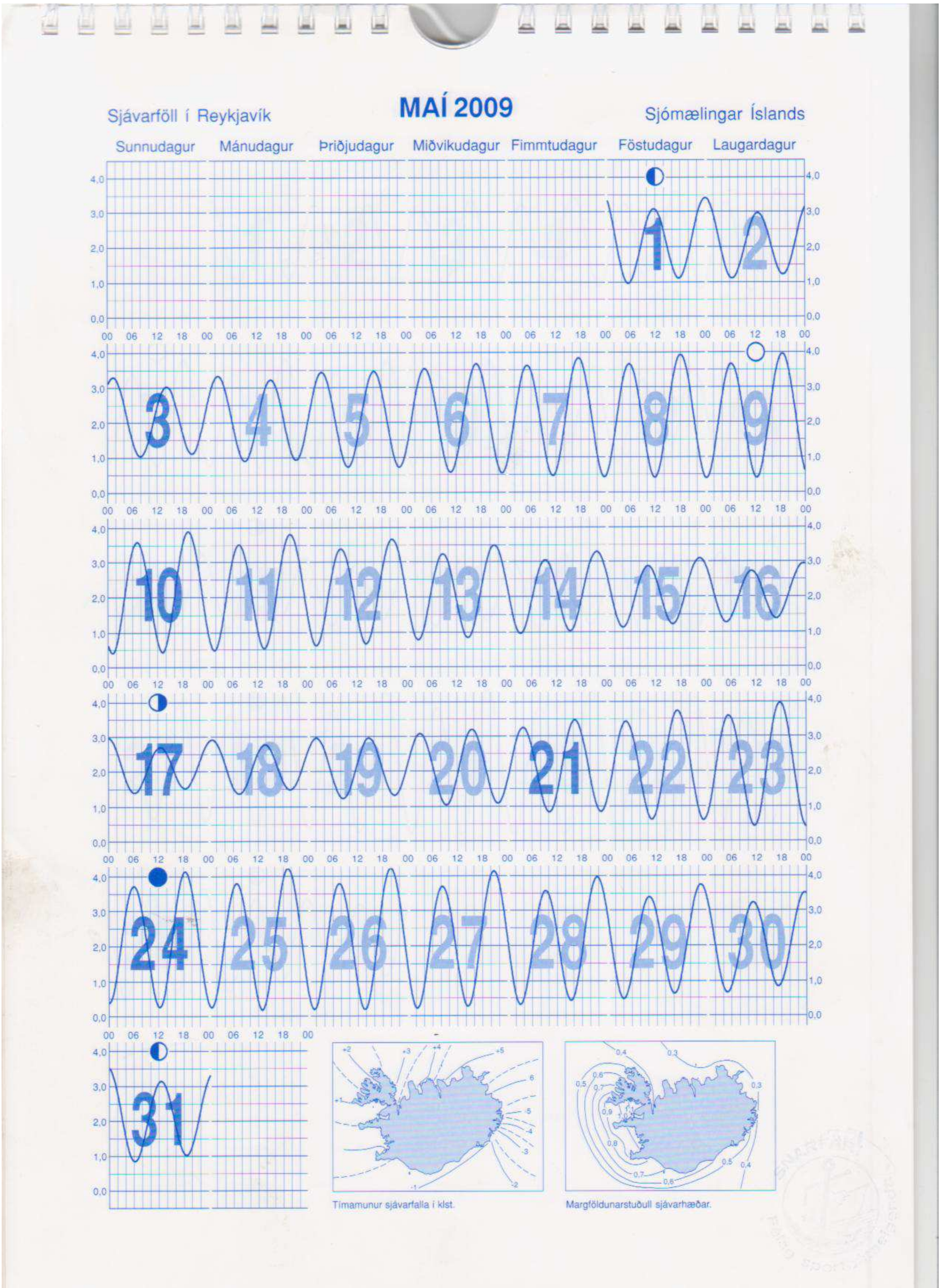

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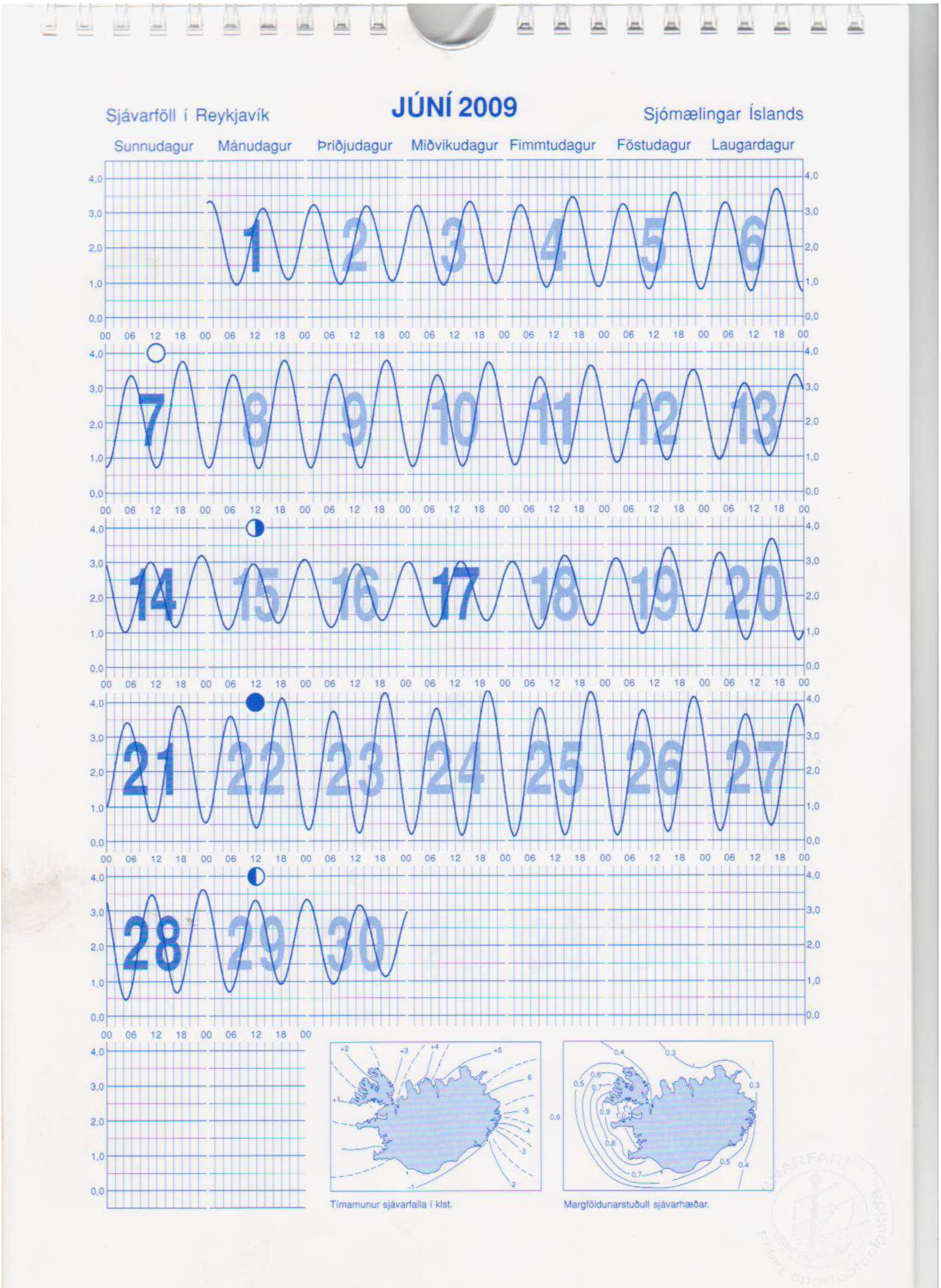
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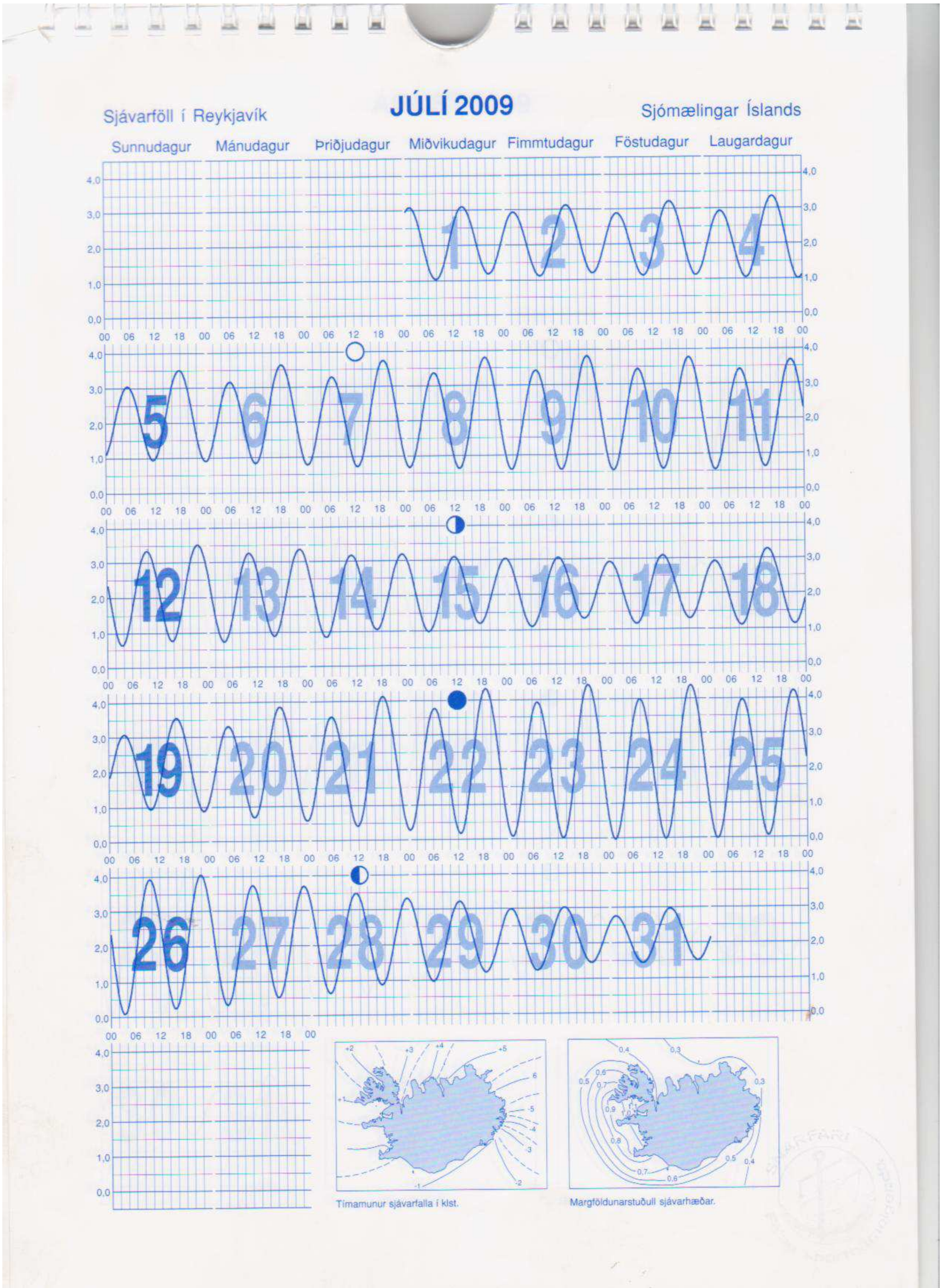
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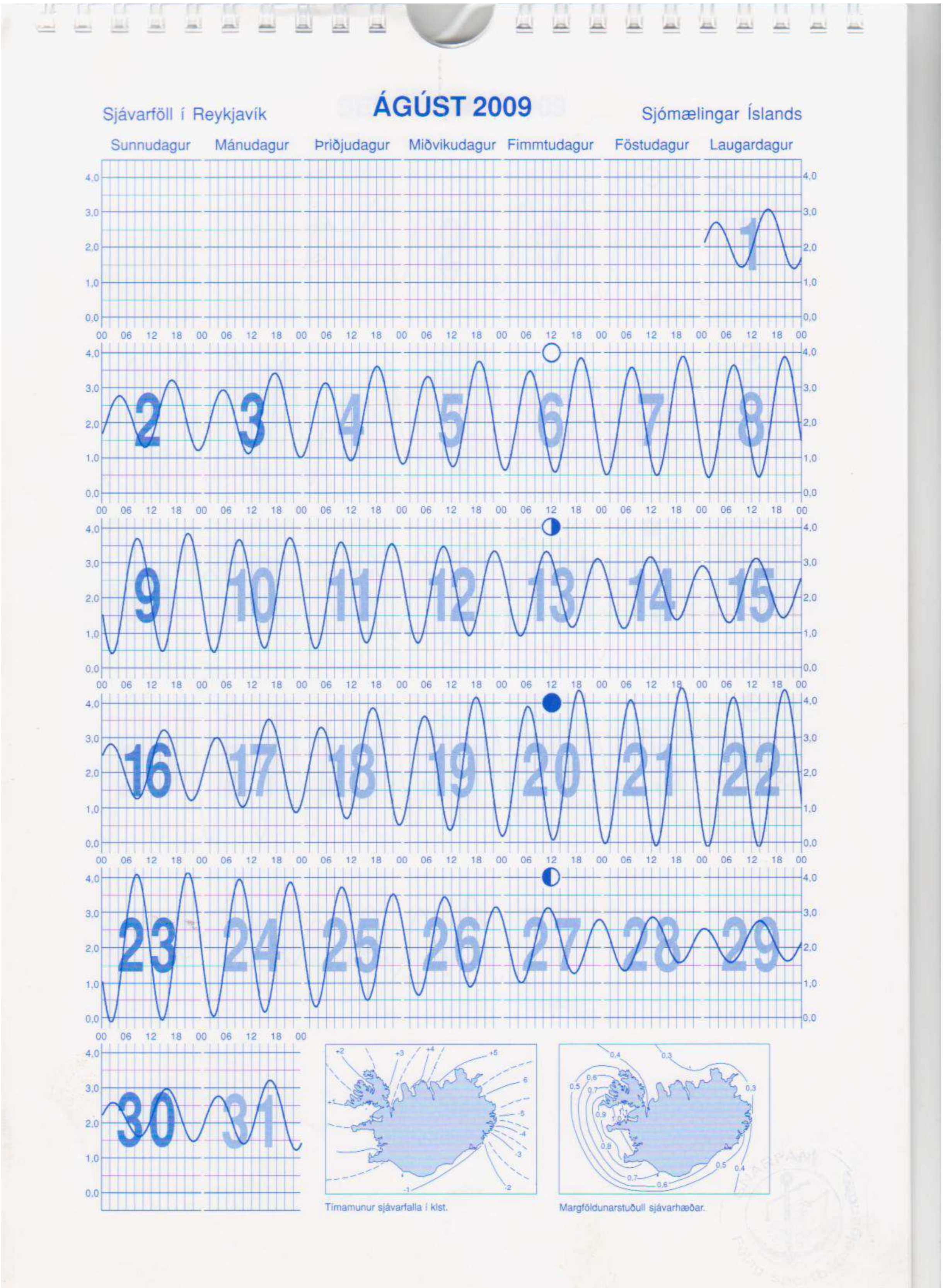
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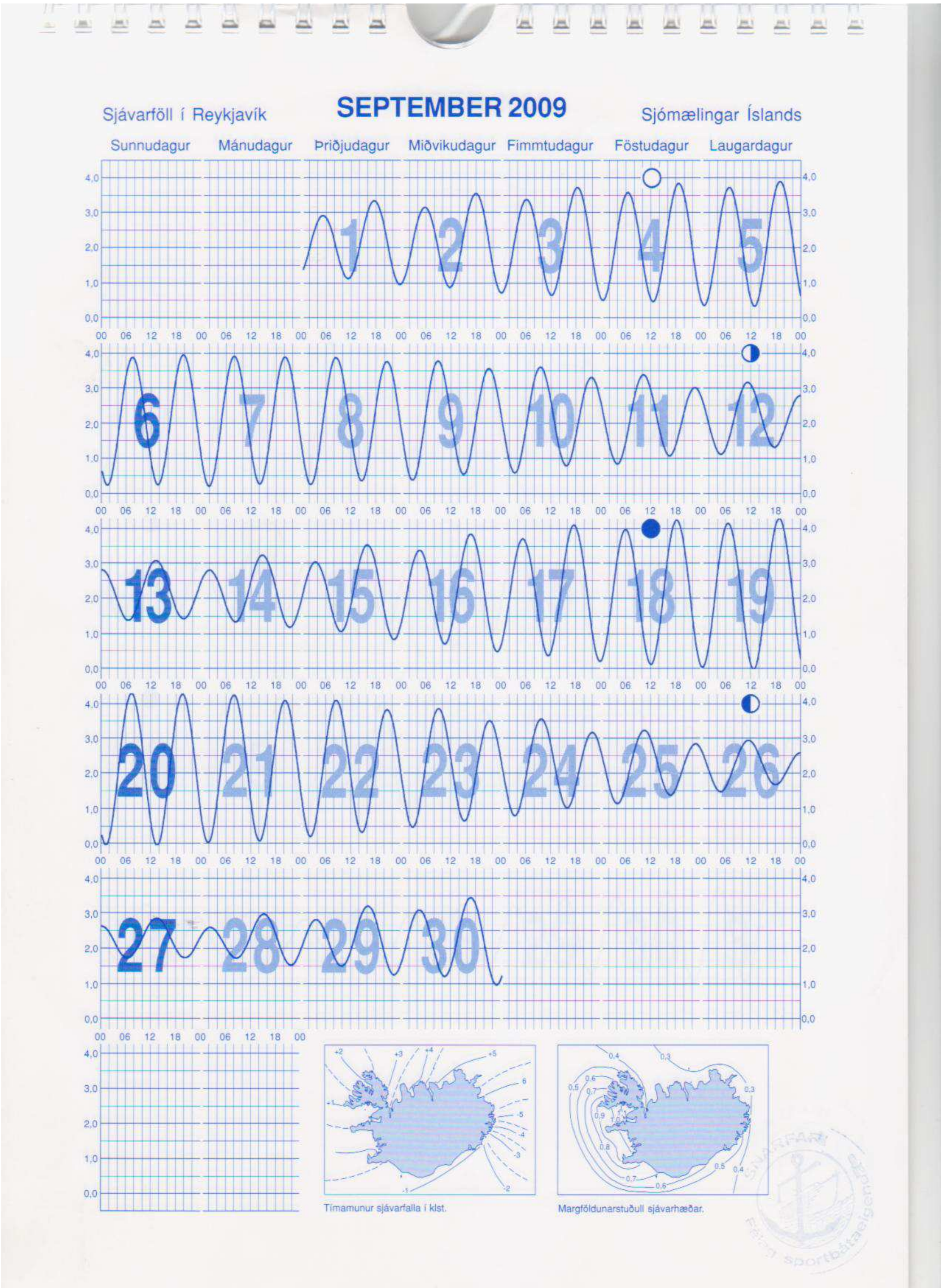
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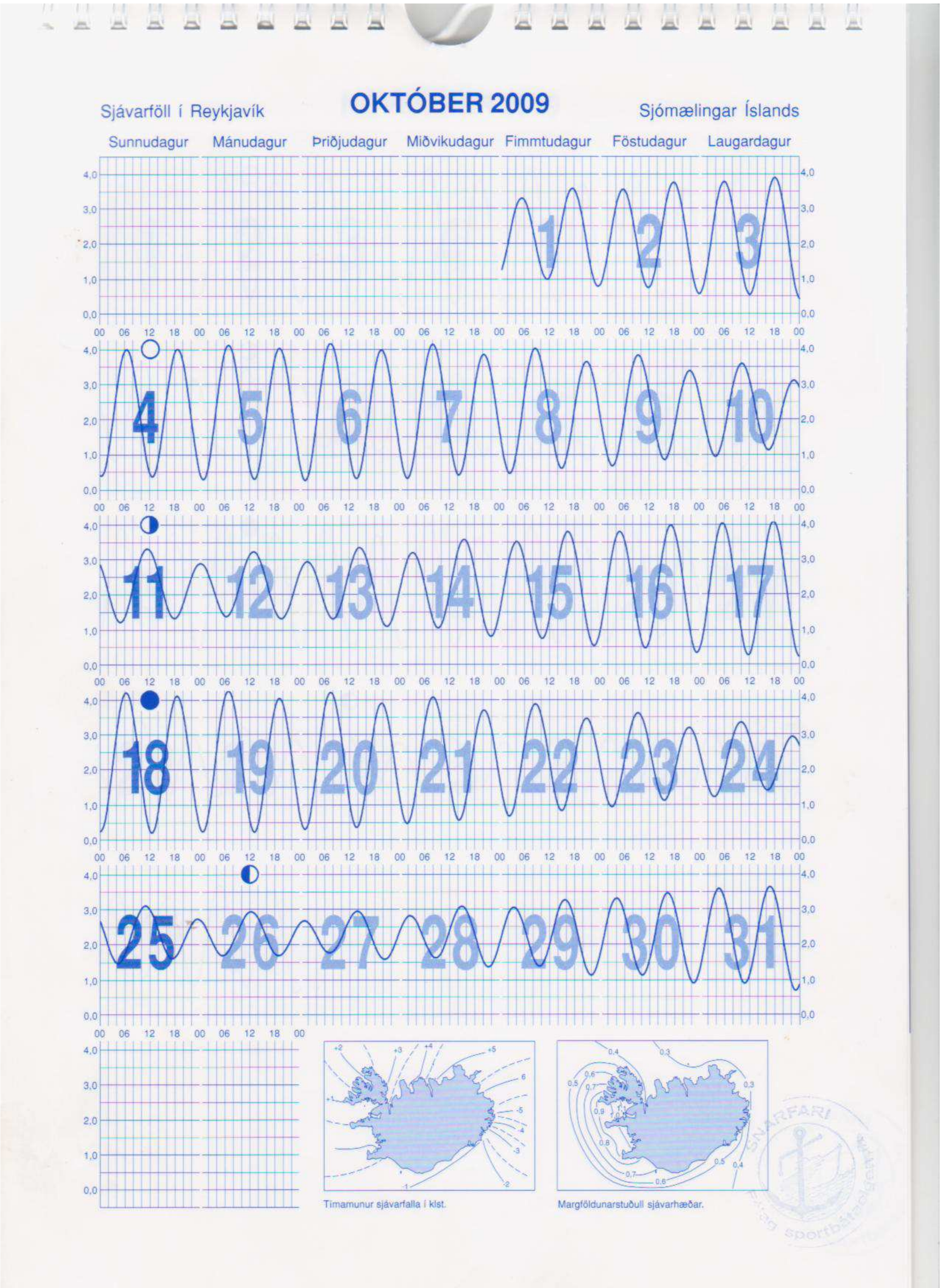
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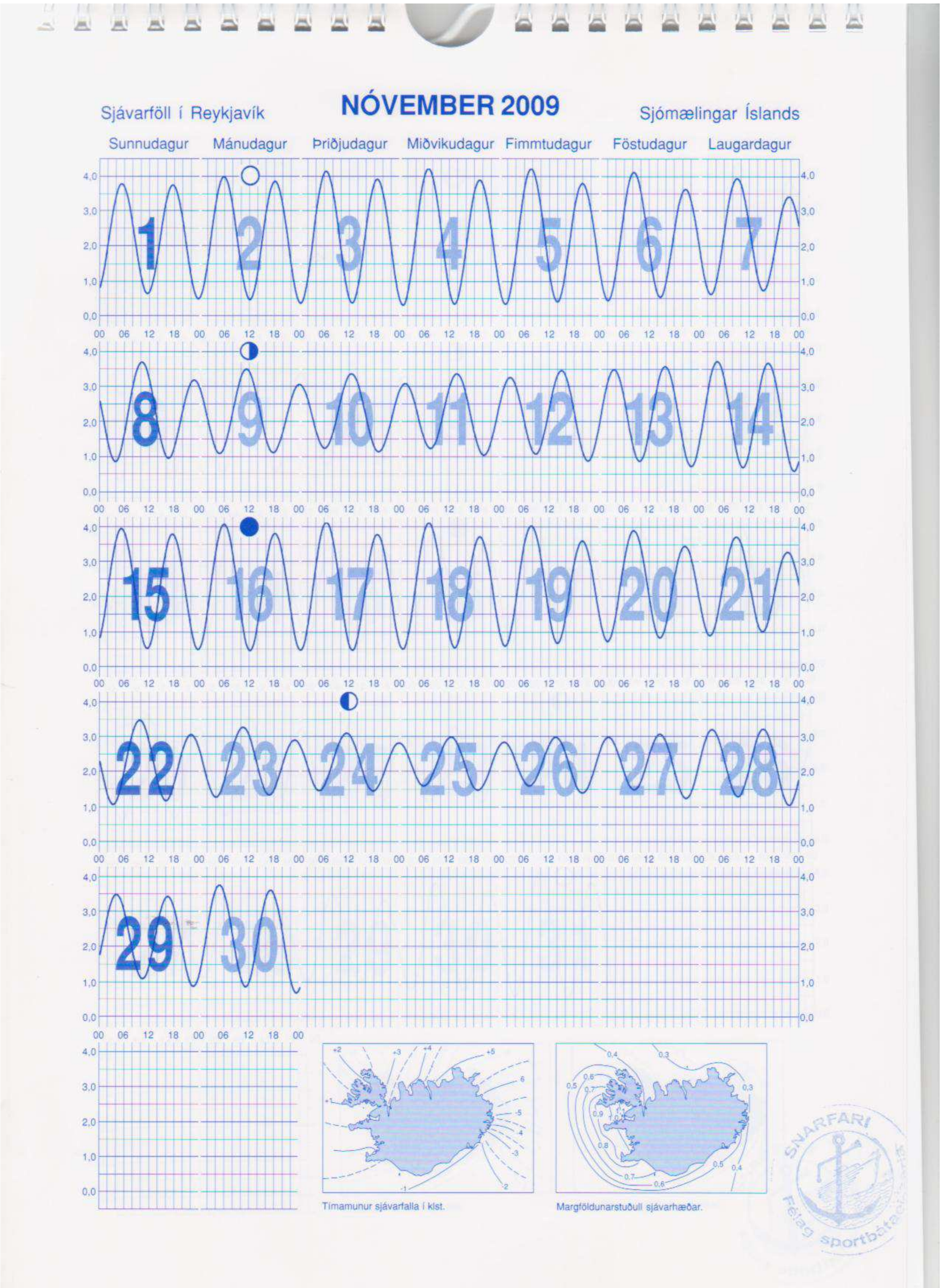

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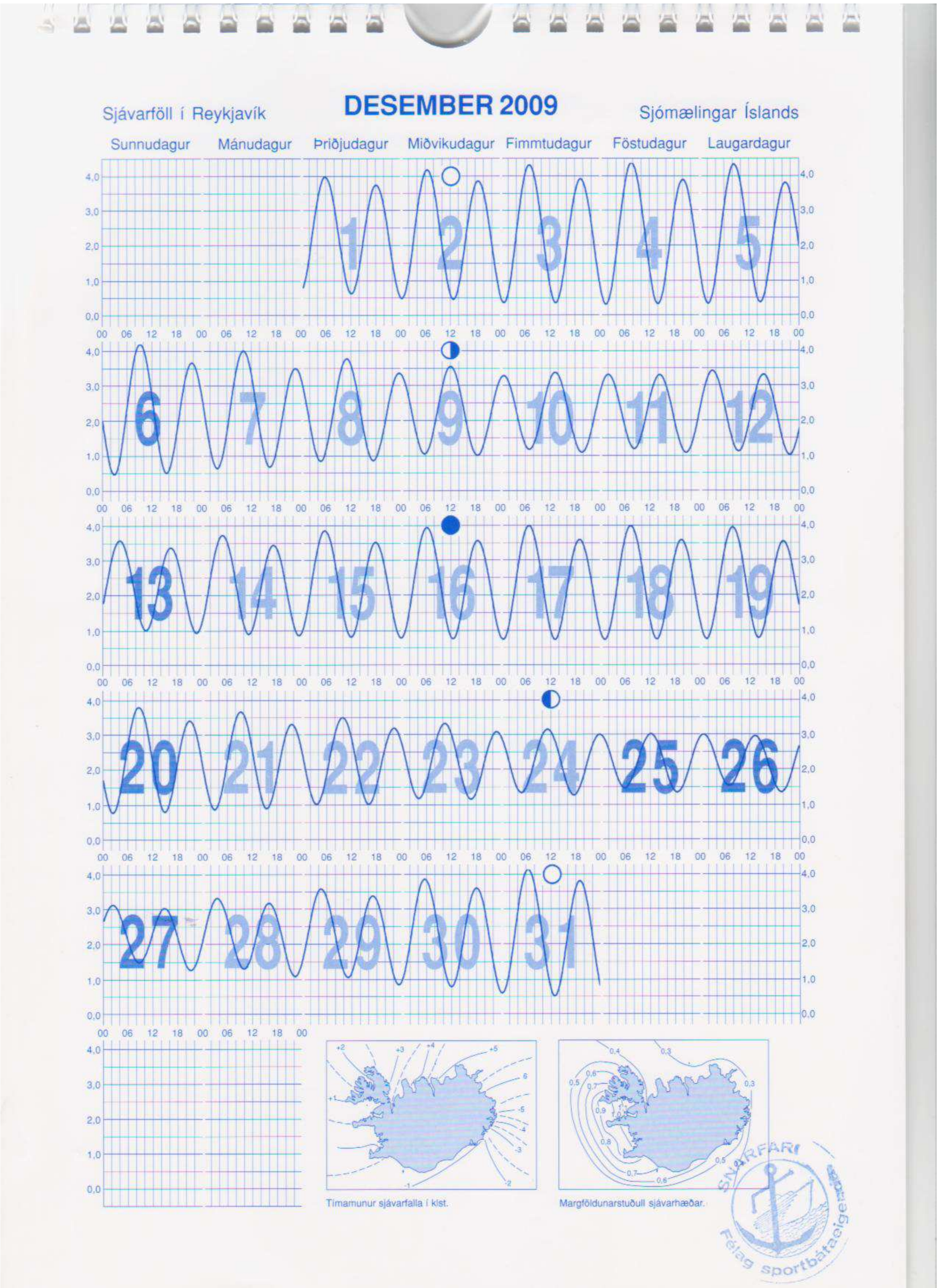
Föstudagur
Laugardagur
Tímamunur sjávarfalla í klst.
Margföldunarstuðull sjávarhæðar.
SNARFARI
Félag sportbáta



Sjávarföll í Reykjavík
DESEMBER 2009
Sjómælingar Íslands
Sunnudagur
Mánudagur
Þriðjudagur
Miðvikudagur
Fimmtudagur
Föstudagur
Laugardagur
Tímamunur sjávarfalla í klst.
Margföldunarstuðull sjávarhæðar.
SNARFARI
Félag sportbátaeigenda

B Harmonic tide components, Reykjavík harbour.

Þáttur	tíðni	h	δh	$\tilde{h}$	$\delta\tilde{h}$	$\Delta\phi$	$\delta\Delta\phi$	$\Delta\tilde{\phi}$	$\delta\Delta\tilde{\phi}$
Z_o		2.1825	0.0003	2.1848	0.0544				
S_a	0.0410667	0.0797	0.0004	0.0891	0.0310	307.0	0.3	311.3	32.9
S_{sa}	0.0821373	0.0110	0.0004	0.0431	0.0239	185.3	2.3	199.3	88.6
M_m	0.5443747	0.0072	0.0004	0.0249	0.0159	223.7	3.5	223.3	90.6
M_{sf}	1.0158958	0.0065	0.0004	0.0205	0.0099	348.8	3.9	354.1	87.5
M_f	1.0980331	0.0166	0.0004	0.0252	0.0125	217.9	1.4	217.1	60.2
$2Q_1$	12.8542862	0.0024	0.0004	0.0033	0.0015	283.7	10.4	280.8	58.7
σ_1	12.9271398	0.0020	0.0004	0.0032	0.0016	304.9	12.6	297.6	71.1
Q_1	13.3986609	0.0134	0.0004	0.0135	0.0026	9.6	1.9	9.6	11.5
ρ_1	13.4715145	0.0019	0.0004	0.0028	0.0016	8.7	13.1	3.9	68.3
O_1	13.9430356	0.0680	0.0004	0.0682	0.0025	65.1	0.4	65.3	3.1
MP_1	14.0251728	0.0024	0.0004	0.0034	0.0019	61.8	10.3	57.5	55.6
M_1	14.4920521	0.0029	0.0004	0.0048	0.0026	83.8	7.7	86.4	55.3
NO_1	14.4966939	0.0057	0.0004	0.0082	0.0038	94.7	4.4	114.8	59.1
χ_1	14.5695476	0.0015	0.0002	0.0026	0.0014	83.8	7.7	86.4	55.3
π_1	14.9178647	0.0029	0.0004	0.0038	0.0023	106.5	8.8	108.9	46.3
P_1	14.9589314	0.0354	0.0004	0.0360	0.0034	110.6	0.7	110.8	4.9
S_1	15.0000000	0.0036	0.0004	0.0057	0.0034	134.1	7.0	133.9	63.3
K_1	15.0410686	0.1081	0.0004	0.1079	0.0032	117.2	0.2	117.6	1.8
ψ_1	15.0821352	0.0030	0.0004	0.0038	0.0018	118.1	8.5	119.7	58.5
ϕ_1	15.1232059	0.0024	0.0004	0.0037	0.0020	141.7	10.5	133.7	55.0
θ_1	15.5125896	0.0008	0.0004	0.0026	0.0013	124.8	29.9	129.7	76.4
J_1	15.5854433	0.0052	0.0004	0.0057	0.0019	116.0	4.8	110.9	35.4
SO_1	16.0569644	0.0018	0.0004	0.0032	0.0018	129.0	13.6	141.1	74.8
OO_1	16.1391017	0.0037	0.0004	0.0045	0.0024	115.2	5.8	115.6	30.5
OQ_2	27.3416965	0.0013	0.0004	0.0039	0.0019	146.5	18.9	154.3	84.6
MNS_2	27.4238337	0.0090	0.0004	0.0094	0.0023	105.2	2.8	106.1	15.0
$2N_2$	27.8953548	0.0345	0.0004	0.0344	0.0033	142.0	0.7	142.4	5.0
μ_2	27.9682084	0.0395	0.0004	0.0398	0.0030	131.5	0.6	132.1	6.6
N_2	28.4397295	0.2571	0.0004	0.2572	0.0055	161.4	0.1	161.4	1.2
ν_2	28.5125831	0.0475	0.0004	0.0477	0.0049	166.9	0.5	166.5	4.6
OP_2	28.9019670	0.0027	0.0004	0.0082	0.0051	55.2	9.3	52.8	81.2
M_2	28.9841042	1.3128	0.0004	1.3129	0.0098	183.4	0.0	183.4	0.9
MKS_2	29.0662415	0.0013	0.0004	0.0074	0.0053	210.0	19.2	215.5	89.2
λ_2	29.4556251	0.0072	0.0004	0.0090	0.0041	194.2	3.5	201.5	45.4
L_2	29.5284789	0.0345	0.0004	0.0353	0.0080	202.7	0.7	202.4	12.4
L_2	29.5377625	0.0087	0.0001	0.0089	0.0020	202.7	0.7	202.4	12.4
T_2	29.9589333	0.0278	0.0004	0.0284	0.0050	214.1	0.9	214.5	10.1
S_2	30.0000000	0.5141	0.0004	0.5139	0.0050	220.0	0.0	220.0	1.2
R_2	30.0410686	0.0049	0.0004	0.0083	0.0050	246.0	5.1	251.3	56.3
K_2	30.0821373	0.1457	0.0004	0.1460	0.0049	218.4	0.2	218.5	1.8
MSN_2	30.5443747	0.0018	0.0004	0.0038	0.0028	43.3	13.9	64.4	76.5
KJ_2	30.6265119	0.0078	0.0004	0.0081	0.0022	62.1	3.1	60.8	24.1
$2SM_2$	31.0158958	0.0031	0.0004	0.0044	0.0022	27.9	8.0	30.1	54.6
MO_3	42.9271398	0.0021	0.0004	0.0034	0.0017	125.7	12.2	115.6	62.5
M_3	43.4761563	0.0114	0.0004	0.0115	0.0011	221.1	2.2	221.0	6.8
SO_3	43.9430356	0.0017	0.0004	0.0023	0.0016	155.0	15.0	140.9	58.5
MK_3	44.0251728	0.0015	0.0004	0.0022	0.0013	55.0	16.6	52.3	60.8
SK_3	45.0410686	0.0052	0.0004	0.0055	0.0012	276.2	4.8	274.8	17.5
MN_4	57.4238337	0.0053	0.0004	0.0054	0.0017	189.4	4.8	189.6	12.6
M_4	57.9682084	0.0184	0.0004	0.0186	0.0038	195.8	1.4	195.2	6.4
SN_4	58.4397295	0.0018	0.0004	0.0021	0.0008	206.7	13.9	203.5	35.2
MS_4	58.9841042	0.0204	0.0004	0.0206	0.0028	231.9	1.2	231.9	8.3
MK_4	59.0662415	0.0051	0.0004	0.0054	0.0016	249.6	4.8	250.3	14.4
S_4	60.0000000	0.0024	0.0004	0.0028	0.0012	271.5	10.6	273.2	32.2
SK_4	60.0821373	0.0018	0.0004	0.0022	0.0011	286.1	13.8	288.1	28.9

$2NM_6$	85.8635632	0.0022	0.0004	0.0032	0.0014	15.2	11.6	28.6	63.0
$2MN_6$	86.4079379	0.0046	0.0004	0.0051	0.0015	70.3	5.4	70.1	20.8
M_6	86.9523126	0.0022	0.0004	0.0030	0.0017	121.2	11.2	131.3	50.6
MSN_6	87.4238337	0.0049	0.0004	0.0051	0.0012	65.8	5.1	66.1	14.9
$2MS_6$	87.9682084	0.0130	0.0004	0.0132	0.0019	75.0	1.9	75.4	12.9
$2MK_6$	88.0503457	0.0045	0.0004	0.0049	0.0011	74.0	5.6	77.2	22.8
SNK_6	88.5218668	0.0003	0.0004	0.0026	0.0014	149.9	78.2	150.4	97.3
$2SM_6$	88.9841042	0.0089	0.0004	0.0090	0.0014	173.7	2.8	175.1	10.8
MSK_6	89.0662415	0.0043	0.0004	0.0045	0.0011	164.6	5.7	164.1	16.8
S_6	90.0000000	0.0015	0.0004	0.0018	0.0009	244.4	17.2	245.4	54.2

C Photos of bridges in crossings over fjords.

Önundarfjörður

Kolgrafarfjörður

Dýrafjörður

D Current measurement data.

Data from Deild

YYYY/MM/DD	hh:mm:ss	Velo[cm/s]	Dir[Deg]	Leiðrétt - 20°	EW[cm/s]	NS[cm/s]	Temp[Deg
17.8.2009	12:39:15	15.2	278.1	258.1	-15.1	2.2	10.34
17.8.2009	12:39:20	22.1	255.7	235.7	-21.4	-5.5	10.34
17.8.2009	12:39:25	27.9	258.6	238.6	-27.4	-5.5	10.34
17.8.2009	12:39:30	27.8	279.1	259.1	-27.5	4.4	10.34
17.8.2009	12:39:35	38.3	256.9	236.9	-37.3	-8.7	10.34
17.8.2009	12:39:40	33.9	260.9	240.9	-33.5	-5.4	10.34
17.8.2009	12:39:45	33.9	251.9	231.9	-32.2	-10.6	10.34
17.8.2009	12:39:50	28.3	250.9	230.9	-26.7	-9.3	10.34
17.8.2009	12:39:55	34.3	238.5	218.5	-29.2	-17.9	10.34
17.8.2009	12:40:00	33.4	245.8	225.8	-30.4	-13.7	10.34
17.8.2009	12:40:05	36.5	239.2	219.2	-31.3	-18.7	10.33
17.8.2009	12:40:10	20.3	250.3	230.3	-19.2	-6.8	10.33
17.8.2009	12:40:15	24.9	253.1	233.1	-23.8	-7.2	10.33
17.8.2009	12:40:20	24.9	236.2	216.2	-20.7	-13.9	10.33
17.8.2009	12:40:25	29	257.5	237.5	-28.3	-6.3	10.33
17.8.2009	12:40:30	21.2	276.7	256.7	-21	2.5	10.33
17.8.2009	12:40:35	21.1	248	228	-19.5	-7.9	10.33
17.8.2009	12:40:40	28.1	244.5	224.5	-25.4	-12.1	10.34
17.8.2009	12:40:45	28.6	251.8	231.8	-27.2	-8.9	10.33
17.8.2009	12:40:50	26.9	271.6	251.6	-26.9	0.7	10.33
17.8.2009	12:40:55	24.6	264.2	244.2	-24.5	-2.5	10.33
17.8.2009	12:41:00	26.5	242.8	222.8	-23.5	-12.1	10.33
17.8.2009	12:41:05	31.3	239.8	219.8	-27	-15.8	10.33
17.8.2009	12:41:10	23.5	262.3	242.3	-23.3	-3.2	10.33
17.8.2009	12:41:15	30	250.2	230.2	-28.2	-10.2	10.33
17.8.2009	12:41:20	30.3	243.6	223.6	-27.1	-13.5	10.33
17.8.2009	12:41:25	26.8	258.5	238.5	-26.2	-5.3	10.33
17.8.2009	12:41:30	24.2	242.2	222.2	-21.4	-11.3	10.33
17.8.2009	12:41:35	35.4	257.5	237.5	-34.6	-7.7	10.33
17.8.2009	12:41:40	30.4	248.9	228.9	-28.3	-10.9	10.34
17.8.2009	12:41:45	23.5	254.3	234.3	-22.6	-6.4	10.33
17.8.2009	12:41:50	26.4	256.1	236.1	-25.6	-6.4	10.33
17.8.2009	12:41:55	31.4	236	216	-26	-17.6	10.33
17.8.2009	12:42:00	30.3	239.9	219.9	-26.2	-15.2	10.33
17.8.2009	12:42:05	26.3	240.1	220.1	-22.8	-13.1	10.34

17.8.2009	12:42:10	30.8	268.8	248.8	-30.7	-0.6	10.33
17.8.2009	12:42:15	33.1	226.5	206.5	-24	-22.8	10.33
17.8.2009	12:42:20	27.2	249.4	229.4	-25.5	-9.5	10.33
17.8.2009	12:42:25	29.9	231.4	211.4	-23.3	-18.7	10.33
17.8.2009	12:42:30	22.5	265.4	245.4	-22.4	-1.8	10.34
17.8.2009	12:42:35	20.8	263	243	-20.7	-2.5	10.33
17.8.2009	12:42:40	25.4	248.3	228.3	-23.6	-9.4	10.33
17.8.2009	12:42:45	26.3	239.9	219.9	-22.7	-13.2	10.33
17.8.2009	12:42:50	26.5	236.4	216.4	-22.1	-14.7	10.33
17.8.2009	12:42:55	26.8	248.1	228.1	-24.9	-10	10.33
17.8.2009	12:43:00	18.6	273.3	253.3	-18.6	1.1	10.33
17.8.2009	12:43:05	29.7	252.5	232.5	-28.3	-8.9	10.33
17.8.2009	12:43:10	27.6	268.5	248.5	-27.6	-0.7	10.33
17.8.2009	12:43:15	30.3	262.9	242.9	-30	-3.7	10.33
17.8.2009	12:43:20	27.3	243.3	223.3	-24.4	-12.3	10.33
17.8.2009	12:43:25	33.5	256.8	236.8	-32.7	-7.6	10.33
17.8.2009	12:43:30	22.1	256.8	236.8	-21.6	-5.1	10.33
17.8.2009	12:43:35	30.9	267.9	247.9	-30.9	-1.1	10.33
17.8.2009	12:43:40	27.7	230.9	210.9	-21.5	-17.5	10.33
17.8.2009	12:43:45	26.2	253.6	233.6	-25.2	-7.4	10.34
17.8.2009	12:43:50	24.1	266.7	246.7	-24	-1.4	10.33
17.8.2009	12:43:55	26.2	244.1	224.1	-23.6	-11.4	10.34
17.8.2009	12:44:00	33.1	239	219	-28.3	-17	10.34
17.8.2009	12:44:05	31.7	231.8	211.8	-24.9	-19.6	10.33
17.8.2009	12:44:10	29.6	241.7	221.7	-26.1	-14.1	10.33
17.8.2009	12:44:15	29.1	241.2	221.2	-25.5	-14	10.33
17.8.2009	12:44:20	25.1	259.3	239.3	-24.7	-4.7	10.33
17.8.2009	12:44:25	27.4	238.1	218.1	-23.2	-14.5	10.33
17.8.2009	12:44:30	27.3	258.2	238.2	-26.7	-5.6	10.33
17.8.2009	12:44:35	23.3	252.1	232.1	-22.2	-7.2	10.33
17.8.2009	12:44:40	25.6	253.4	233.4	-24.6	-7.3	10.34
17.8.2009	12:44:45	25.5	254.2	234.2	-24.6	-6.9	10.34
17.8.2009	12:44:50	29.6	240.5	220.5	-25.8	-14.6	10.34
17.8.2009	12:44:55	29.1	255.3	235.3	-28.2	-7.4	10.34
17.8.2009	12:45:00	30.5	240.6	220.6	-26.6	-15	10.34
17.8.2009	12:45:05	21.6	254	234	-20.8	-6	10.34
17.8.2009	12:45:10	31.2	253.7	233.7	-29.9	-8.8	10.33
17.8.2009	12:45:15	27.2	235	215	-22.3	-15.6	10.33
17.8.2009	12:45:20	30.1	256.2	236.2	-29.2	-7.2	10.33
17.8.2009	12:45:25	30.9	232.9	212.9	-24.6	-18.6	10.33
17.8.2009	12:45:30	29.8	246.3	226.3	-27.3	-12	10.33
17.8.2009	12:45:35	28	242.6	222.6	-24.9	-12.9	10.33
17.8.2009	12:45:40	32.4	252.9	232.9	-30.9	-9.5	10.33

17.8.2009	12:45:45	22	243.5	223.5	-19.7	-9.8	10.33
17.8.2009	12:45:50	32.1	237.2	217.2	-27	-17.4	10.33
17.8.2009	12:45:55	24.2	239.6	219.6	-20.9	-12.3	10.33
17.8.2009	12:46:00	33.7	247.4	227.4	-31.1	-12.9	10.33
17.8.2009	12:46:05	31	256.7	236.7	-30.2	-7.1	10.33
17.8.2009	12:46:10	36.2	239.1	219.1	-31	-18.6	10.33
17.8.2009	12:46:15	26.5	256.5	236.5	-25.8	-6.2	10.33
17.8.2009	12:46:20	35.7	245.2	225.2	-32.4	-15	10.33
17.8.2009	12:46:25	29.1	242.1	222.1	-25.7	-13.6	10.33
17.8.2009	12:46:30	32	250.4	230.4	-30.1	-10.7	10.33
17.8.2009	12:46:35	25.5	239.2	219.2	-21.9	-13.1	10.33
17.8.2009	12:46:40	17.2	265.3	245.3	-17.1	-1.4	10.33
17.8.2009	12:46:45	28.1	245.3	225.3	-25.6	-11.7	10.33
17.8.2009	12:46:50	25.3	264.2	244.2	-25.2	-2.6	10.33
17.8.2009	12:46:55	23.2	231.3	211.3	-18.1	-14.5	10.33
17.8.2009	12:47:00	27.4	236.1	216.1	-22.7	-15.3	10.33
17.8.2009	12:47:05	26.1	264.1	244.1	-26	-2.7	10.33
17.8.2009	12:47:10	33.7	236.9	216.9	-28.2	-18.4	10.33
17.8.2009	12:47:15	22.3	255.9	235.9	-21.6	-5.4	10.33
17.8.2009	12:47:20	31.2	229.6	209.6	-23.7	-20.2	10.33
17.8.2009	12:47:25	23.3	250.5	230.5	-22	-7.8	10.33
17.8.2009	12:47:30	24.6	240.1	220.1	-21.4	-12.3	10.33
17.8.2009	12:47:35	32.9	243.9	223.9	-29.6	-14.5	10.33
17.8.2009	12:47:40	29.2	260.4	240.4	-28.8	-4.9	10.33
17.8.2009	12:47:45	28.9	250	230	-27.2	-9.9	10.33
17.8.2009	12:47:50	30.2	236.3	216.3	-25.1	-16.8	10.33
17.8.2009	12:47:55	28.7	262	242	-28.4	-4	10.33
17.8.2009	12:48:00	24.8	249.9	229.9	-23.3	-8.5	10.33
17.8.2009	12:48:05	30	259.3	239.3	-29.5	-5.6	10.33
17.8.2009	12:48:10	28.8	244.4	224.4	-26	-12.4	10.33
17.8.2009	12:48:15	32	263.1	243.1	-31.7	-3.8	10.33
17.8.2009	12:48:20	26.9	256.6	236.6	-26.1	-6.2	10.33
17.8.2009	12:48:25	28.2	228.5	208.5	-21.1	-18.7	10.33
17.8.2009	12:48:30	14.4	239.9	219.9	-12.5	-7.2	10.33
17.8.2009	12:48:35	23.3	247.5	227.5	-21.5	-8.9	10.33
17.8.2009	12:48:40	21.4	244.3	224.3	-19.3	-9.3	10.33
17.8.2009	12:48:45	23.2	260.2	240.2	-22.9	-3.9	10.33
17.8.2009	12:48:50	24.6	216.1	196.1	-14.5	-19.9	10.33
17.8.2009	12:48:55	19.2	247.5	227.5	-17.8	-7.4	10.33
17.8.2009	12:49:00	23.1	247.7	227.7	-21.4	-8.8	10.33
17.8.2009	12:49:05	22.2	244	224	-19.9	-9.7	10.33
17.8.2009	12:49:10	24.5	245.2	225.2	-22.3	-10.3	10.33
17.8.2009	12:49:15	29.2	260.4	240.4	-28.8	-4.9	10.33

17.8.2009	12:49:20	28.5	240.9	220.9	-24.9	-13.8	10.33
17.8.2009	12:49:25	27.3	260.9	240.9	-26.9	-4.3	10.33
17.8.2009	12:49:30	29.1	252.8	232.8	-27.8	-8.6	10.33
17.8.2009	12:49:35	32.6	230.4	210.4	-25.1	-20.8	10.33
17.8.2009	12:49:40	27.7	234.9	214.9	-22.7	-16	10.33
17.8.2009	12:49:45	30.8	239.4	219.4	-26.5	-15.7	10.33
17.8.2009	12:49:50	38.5	238.6	218.6	-32.8	-20.1	10.33
17.8.2009	12:49:55	31.6	236.3	216.3	-26.3	-17.5	10.33
17.8.2009	12:50:00	31.7	238.4	218.4	-27	-16.6	10.33
17.8.2009	12:50:05	23.5	259.6	239.6	-23.1	-4.3	10.33
17.8.2009	12:50:10	26.6	232.6	212.6	-21.1	-16.1	10.33
17.8.2009	12:50:15	27.6	253.1	233.1	-26.4	-8	10.33
17.8.2009	12:50:20	33	240.3	220.3	-28.7	-16.4	10.33
17.8.2009	12:50:25	29.2	251	231	-27.6	-9.5	10.33
17.8.2009	12:50:30	28.6	250.7	230.7	-27	-9.5	10.33
17.8.2009	12:50:35	28	267	247	-28	-1.5	10.33
17.8.2009	12:50:40	32.7	253.4	233.4	-31.3	-9.4	10.33
17.8.2009	12:50:45	29.1	260.2	240.2	-28.7	-5	10.33
17.8.2009	12:50:50	29.6	283.8	263.8	-28.7	7.1	10.33
17.8.2009	12:50:55	28.5	239.3	219.3	-24.5	-14.6	10.33
17.8.2009	12:51:00	28.4	268.3	248.3	-28.4	-0.8	10.33
17.8.2009	12:51:05	25.2	246.2	226.2	-23.1	-10.2	10.33
17.8.2009	12:51:10	24.6	271.3	251.3	-24.6	0.6	10.33
17.8.2009	12:51:15	29.5	241.8	221.8	-26	-14	10.33
17.8.2009	12:51:20	22.6	248.3	228.3	-21	-8.4	10.33
17.8.2009	12:51:25	19.3	277.6	257.6	-19.1	2.5	10.33
17.8.2009	12:51:30	22.5	248.5	228.5	-20.9	-8.2	10.33
17.8.2009	12:51:35	25.9	240.4	220.4	-22.5	-12.8	10.33
17.8.2009	12:51:40	15.4	244.6	224.6	-13.9	-6.6	10.33
17.8.2009	12:51:45	33	236.1	216.1	-27.4	-18.4	10.33
17.8.2009	12:51:50	18	255.3	235.3	-17.4	-4.6	10.33
17.8.2009	12:51:55	24.9	224.5	204.5	-17.5	-17.8	10.33
17.8.2009	12:52:00	20	253.2	233.2	-19.1	-5.8	10.33
17.8.2009	12:52:05	24.4	244.6	224.6	-22.1	-10.5	10.33
17.8.2009	12:52:10	22.6	261.5	241.5	-22.3	-3.4	10.33
17.8.2009	12:52:15	24.7	250.4	230.4	-23.3	-8.3	10.33
17.8.2009	12:52:20	23.2	249.9	229.9	-21.8	-8	10.33
17.8.2009	12:52:25	26.5	241.7	221.7	-23.4	-12.6	10.33
17.8.2009	12:52:30	29.8	243.2	223.2	-26.6	-13.4	10.33
17.8.2009	12:52:35	22.8	240.1	220.1	-19.7	-11.3	10.33
17.8.2009	12:52:40	31.3	241.6	221.6	-27.5	-14.9	10.33
17.8.2009	12:52:45	29.9	242.1	222.1	-26.4	-14	10.33
17.8.2009	12:52:50	27.9	241.1	221.1	-24.5	-13.5	10.33

17.8.2009	12:52:55	32.1	230.1	210.1	-24.6	-20.6	10.33
17.8.2009	12:53:00	30.9	253.9	233.9	-29.7	-8.5	10.33
17.8.2009	12:53:05	30.8	234.6	214.6	-25.1	-17.8	10.34
17.8.2009	12:53:10	25.4	250.3	230.3	-23.9	-8.6	10.33
17.8.2009	12:53:15	30.8	256.3	236.3	-29.9	-7.3	10.33
17.8.2009	12:53:20	24.5	263.5	243.5	-24.4	-2.8	10.33
17.8.2009	12:53:25	29.3	218.2	198.2	-18.1	-23	10.33
17.8.2009	12:53:30	18.8	272.5	252.5	-18.8	0.8	10.33
17.8.2009	12:53:35	24.3	244.1	224.1	-21.8	-10.6	10.33
17.8.2009	12:53:40	25.9	235.2	215.2	-21.2	-14.8	10.33
17.8.2009	12:53:45	17.2	270.8	250.8	-17.2	0.2	10.33
17.8.2009	12:53:50	24.6	237.3	217.3	-20.7	-13.3	10.33
17.8.2009	12:53:55	31.2	229.1	209.1	-23.6	-20.4	10.33
17.8.2009	12:54:00	26.1	226.5	206.5	-18.9	-17.9	10.33
17.8.2009	12:54:05	29.8	259.5	239.5	-29.3	-5.4	10.33
17.8.2009	12:54:10	28.4	255.1	235.1	-27.5	-7.3	10.33
17.8.2009	12:54:15	23.7	264.2	244.2	-23.6	-2.4	10.33
17.8.2009	12:54:20	38	248.5	228.5	-35.3	-13.9	10.33
17.8.2009	12:54:25	29.9	243.5	223.5	-26.7	-13.3	10.33
17.8.2009	12:54:30	30.7	257.4	237.4	-30	-6.7	10.33
17.8.2009	12:54:35	32.9	242.6	222.6	-29.2	-15.1	10.33
17.8.2009	12:54:40	24.6	214.3	194.3	-13.9	-20.3	10.33
17.8.2009	12:54:45	18.9	252.5	232.5	-18.1	-5.7	10.33
17.8.2009	12:54:50	19.4	243.7	223.7	-17.4	-8.6	10.33
17.8.2009	12:54:55	21.5	267.9	247.9	-21.5	-0.8	10.33
17.8.2009	12:55:00	20.8	233	213	-16.6	-12.5	10.33
17.8.2009	12:55:05	19.9	244.7	224.7	-18	-8.5	10.33
17.8.2009	12:55:10	23.8	231.8	211.8	-18.7	-14.7	10.33
17.8.2009	12:55:15	31.2	242.5	222.5	-27.7	-14.4	10.33
17.8.2009	12:55:20	19.6	245.7	225.7	-17.8	-8	10.33
17.8.2009	12:55:25	19.9	225.3	205.3	-14.2	-14	10.33
17.8.2009	12:55:30	20.6	242.1	222.1	-18.2	-9.6	10.33
17.8.2009	12:55:35	31.7	247	227	-29.2	-12.4	10.33
17.8.2009	12:55:40	34.5	231.2	211.2	-26.9	-21.6	10.33
17.8.2009	12:55:45	26.9	240.2	220.2	-23.4	-13.4	10.33
17.8.2009	12:55:50	31	242.7	222.7	-27.5	-14.2	10.33
17.8.2009	12:55:55	17.8	228.3	208.3	-13.3	-11.8	10.33
17.8.2009	12:56:00	32.2	244	224	-28.9	-14.1	10.33
17.8.2009	12:56:05	26.4	236.6	216.6	-22	-14.5	10.33
17.8.2009	12:56:10	23	248.6	228.6	-21.5	-8.4	10.33
17.8.2009	12:56:15	27	250.3	230.3	-25.4	-9.1	10.33
17.8.2009	12:56:20	28.3	245.7	225.7	-25.8	-11.7	10.33
17.8.2009	12:56:25	27.5	226.7	206.7	-20	-18.9	10.33

17.8.2009	12:56:30	22.4	251.7	231.7	-21.3	-7	10.33
17.8.2009	12:56:35	35.8	254.6	234.6	-34.5	-9.5	10.33
17.8.2009	12:56:40	28.3	235.8	215.8	-23.4	-15.9	10.33
17.8.2009	12:56:45	24.4	254.8	234.8	-23.5	-6.4	10.33
17.8.2009	12:56:50	27.8	257.3	237.3	-27.2	-6.1	10.33
17.8.2009	12:56:55	22.7	268	248	-22.7	-0.8	10.33
17.8.2009	12:57:00	24.6	243.7	223.7	-22.1	-10.9	10.33
17.8.2009	12:57:05	25.2	245.7	225.7	-23	-10.4	10.33
17.8.2009	12:57:10	36	230.2	210.2	-27.7	-23.1	10.33
17.8.2009	12:57:15	20.3	253.6	233.6	-19.5	-5.7	10.33
17.8.2009	12:57:20	33.1	243	223	-29.5	-15	10.33
17.8.2009	12:57:25	21	240	220	-18.2	-10.5	10.33
17.8.2009	12:57:30	30	245	225	-27.2	-12.7	10.33
17.8.2009	12:57:35	29.5	262	242	-29.2	-4.1	10.33
17.8.2009	12:57:40	28.3	248.6	228.6	-26.3	-10.3	10.33
17.8.2009	12:57:45	22.9	260.1	240.1	-22.6	-3.9	10.33
17.8.2009	12:57:50	27.5	243.6	223.6	-24.6	-12.2	10.33
17.8.2009	12:57:55	27.5	245.1	225.1	-24.9	-11.6	10.33
17.8.2009	12:58:00	25.2	244.8	224.8	-22.8	-10.7	10.33
17.8.2009	12:58:05	30.3	237.5	217.5	-25.6	-16.3	10.33
17.8.2009	12:58:10	17	254.6	234.6	-16.4	-4.5	10.33
17.8.2009	12:58:15	24.6	232.3	212.3	-19.4	-15	10.33
17.8.2009	12:58:20	26.7	241.9	221.9	-23.6	-12.6	10.33
17.8.2009	12:58:25	15.4	266.6	246.6	-15.4	-0.9	10.33
17.8.2009	12:58:30	17.5	262.9	242.9	-17.4	-2.2	10.33
17.8.2009	12:58:35	19.5	234.6	214.6	-15.9	-11.3	10.33
17.8.2009	12:58:40	28.1	251.7	231.7	-26.7	-8.8	10.33
17.8.2009	12:58:45	17.2	247.1	227.1	-15.8	-6.7	10.33
17.8.2009	12:58:50	29.8	240.4	220.4	-25.9	-14.7	10.33
17.8.2009	12:58:55	26.9	235.9	215.9	-22.3	-15.1	10.33
17.8.2009	12:59:00	26.1	242.7	222.7	-23.2	-12	10.33
17.8.2009	12:59:05	27.6	242	222	-24.4	-13	10.33
17.8.2009	12:59:10	29.4	247.8	227.8	-27.2	-11.1	10.33
17.8.2009	12:59:15	21.2	246.9	226.9	-19.5	-8.3	10.33
17.8.2009	12:59:20	26.5	243.5	223.5	-23.7	-11.8	10.33
17.8.2009	12:59:25	21.6	250.6	230.6	-20.4	-7.2	10.33
17.8.2009	12:59:30	26.1	249.7	229.7	-24.5	-9.1	10.33
17.8.2009	12:59:35	25	250.7	230.7	-23.6	-8.3	10.33
17.8.2009	12:59:40	28.9	243.6	223.6	-25.9	-12.8	10.33
17.8.2009	12:59:45	19.2	267.1	247.1	-19.2	-1	10.33
17.8.2009	12:59:50	23.8	243.9	223.9	-21.4	-10.5	10.33
17.8.2009	12:59:55	21.7	301.1	281.1	-18.6	11.2	10.33
17.8.2009	13:00:00	27.4	239.8	219.8	-23.7	-13.8	10.33

17.8.2009	13:00:05	20.1	244.7	224.7	-18.2	-8.6	10.33
17.8.2009	13:00:10	24.2	230.9	210.9	-18.8	-15.2	10.33
17.8.2009	13:00:15	19.8	276.1	256.1	-19.6	2.1	10.33
17.8.2009	13:00:20	23.9	259	239	-23.4	-4.5	10.33
17.8.2009	13:00:25	27.6	243.9	223.9	-24.8	-12.1	10.33
17.8.2009	13:00:30	29.6	260	240	-29.2	-5.1	10.33
17.8.2009	13:00:35	32.1	237.4	217.4	-27	-17.3	10.33
17.8.2009	13:00:40	18.7	255.3	235.3	-18.1	-4.7	10.33
17.8.2009	13:00:45	33.9	255.1	235.1	-32.8	-8.7	10.33
17.8.2009	13:00:50	26	255.4	235.4	-25.2	-6.6	10.33
17.8.2009	13:00:55	32.6	234	214	-26.4	-19.1	10.33
17.8.2009	13:01:00	27.1	243	223	-24.1	-12.3	10.33
17.8.2009	13:01:05	24.8	274.7	254.7	-24.7	2	10.33
17.8.2009	13:01:10	24.1	241.3	221.3	-21.1	-11.6	10.33
17.8.2009	13:01:15	27.2	249.4	229.4	-25.4	-9.6	10.33
17.8.2009	13:01:20	27.2	284.6	264.6	-26.3	6.9	10.33
17.8.2009	13:01:25	23.3	272.3	252.3	-23.3	1	10.33
17.8.2009	13:01:30	22.4	247.7	227.7	-20.7	-8.5	10.33
17.8.2009	13:01:35	24.7	274.7	254.7	-24.6	2	10.33
17.8.2009	13:01:40	29.4	238.9	218.9	-25.2	-15.2	10.33
17.8.2009	13:01:45	23.2	276.1	256.1	-23	2.5	10.33
17.8.2009	13:01:50	24.6	264	244	-24.4	-2.6	10.33
17.8.2009	13:01:55	28.4	244.3	224.3	-25.6	-12.3	10.33
17.8.2009	13:02:00	27.1	276.1	256.1	-27	2.9	10.33
17.8.2009	13:02:05	29.4	245.3	225.3	-26.7	-12.3	10.33
17.8.2009	13:02:10	18	244.4	224.4	-16.2	-7.8	10.33
17.8.2009	13:02:15	25.9	257.6	237.6	-25.3	-5.6	10.33
17.8.2009	13:02:20	25	235.3	215.3	-20.5	-14.2	10.33
17.8.2009	13:02:25	24.6	264.5	244.5	-24.5	-2.4	10.33
17.8.2009	13:02:30	25	203.4	183.4	-9.9	-22.9	10.33
17.8.2009	13:02:35	27.3	253.3	233.3	-26.1	-7.8	10.33
17.8.2009	13:02:40	23.6	241.2	221.2	-20.7	-11.4	10.33
17.8.2009	13:02:45	16.3	246.6	226.6	-15	-6.5	10.33
17.8.2009	13:02:50	25.8	230.2	210.2	-19.8	-16.5	10.33
17.8.2009	13:02:55	20.6	244.1	224.1	-18.5	-9	10.33
17.8.2009	13:03:00	28.9	226.6	206.6	-21	-19.9	10.33
17.8.2009	13:03:05	21.4	251.7	231.7	-20.3	-6.7	10.33
17.8.2009	13:03:10	29.8	235.8	215.8	-24.7	-16.8	10.33
17.8.2009	13:03:15	26	244	224	-23.3	-11.4	10.33
17.8.2009	13:03:20	24.7	247.2	227.2	-22.8	-9.6	10.33
17.8.2009	13:03:25	30.1	243.5	223.5	-26.9	-13.4	10.33
17.8.2009	13:03:30	30.8	245.7	225.7	-28.1	-12.7	10.33
17.8.2009	13:03:35	28.1	248.6	228.6	-26.2	-10.2	10.33

17.8.2009	13:03:40	34.1	259	239	-33.5	-6.5	10.33
17.8.2009	13:03:45	28.2	255.9	235.9	-27.3	-6.9	10.33
17.8.2009	13:03:50	31.3	246	226	-28.6	-12.8	10.33
17.8.2009	13:03:55	33.3	246.9	226.9	-30.7	-13.1	10.33

High tide: Flatey - 17:37

Þorskafjörður data from measuring equipment

		hraði cm/sek	stefna	leiðrétt -20°	a/v	n/s	hiti
18.8.2009	18:31:50	48	310.7	290.7	-36.4	31.3	12.2
18.8.2009	18:31:55	34.8	299.4	279.4	-30.3	17.1	12.21
18.8.2009	18:32:00	37.8	206.8	186.8	-17.1	-33.8	12.22
18.8.2009	18:32:05	39.9	193.5	173.5	-9.3	-38.8	12.21
18.8.2009	18:32:10	50.1	171	151	7.8	-49.5	12.2
18.8.2009	18:32:15	57	205.4	185.4	-24.4	-51.5	12.2
18.8.2009	18:32:20	38.5	228.2	208.2	-28.7	-25.6	12.2
18.8.2009	18:32:25	42.2	292	272	-39.2	15.8	12.21
18.8.2009	18:32:30	46.4	323.8	303.8	-27.4	37.4	12.21
18.8.2009	18:32:35	57.7	331.2	311.2	-27.8	50.6	12.21
18.8.2009	18:32:40	51.5	330	310	-25.8	44.6	12.21
18.8.2009	18:32:45	42	319.4	299.4	-27.3	31.9	12.21
18.8.2009	18:32:50	28.3	250.5	230.5	-26.7	-9.5	12.21
18.8.2009	18:32:55	46.6	187	167	-5.7	-46.3	12.21
18.8.2009	18:33:00	56.8	178.4	158.4	1.6	-56.7	12.21
18.8.2009	18:33:05	50.7	214.5	194.5	-28.7	-41.8	12.21
18.8.2009	18:33:10	44.8	201.9	181.9	-16.7	-41.5	12.22
18.8.2009	18:33:15	45.8	211.8	191.8	-24.1	-38.9	12.22
18.8.2009	18:33:20	34.5	238.7	218.7	-29.5	-17.9	12.22
18.8.2009	18:33:25	35.9	308.2	288.2	-28.2	22.2	12.22
18.8.2009	18:33:30	39.1	306.5	286.5	-31.4	23.2	12.22
18.8.2009	18:33:35	41.6	311.7	291.7	-31.1	27.7	12.22
18.8.2009	18:33:40	39.1	315	295	-27.6	27.6	12.23
18.8.2009	18:33:45	37.9	249.1	229.1	-35.4	-13.5	12.22
18.8.2009	18:33:50	43.4	193.7	173.7	-10.3	-42.2	12.23
18.8.2009	18:33:55	46.4	212.4	192.4	-24.9	-39.1	12.23
18.8.2009	18:34:00	48.5	212.9	192.9	-26.3	-40.7	12.22
18.8.2009	18:34:05	47.3	209.8	189.8	-23.5	-41	12.22
18.8.2009	18:34:10	40.4	273	253	-40.4	2.1	12.22
18.8.2009	18:34:15	49.9	318.1	298.1	-33.3	37.1	12.22
18.8.2009	18:34:20	53.4	343.3	323.3	-15.4	51.1	12.21

18.8.2009	18:34:25	55	313.8	293.8	-39.7	38.1	12.22
18.8.2009	18:34:30	42	287.1	267.1	-40.1	12.3	12.22
18.8.2009	18:34:35	32	238.7	218.7	-27.3	-16.6	12.22
18.8.2009	18:34:40	41.8	204	184	-17	-38.2	12.23
18.8.2009	18:34:45	53.1	191.8	171.8	-10.8	-51.9	12.23
18.8.2009	18:34:50	47.2	190.8	170.8	-8.9	-46.4	12.23
18.8.2009	18:34:55	49.6	197.6	177.6	-15	-47.3	12.22
18.8.2009	18:35:00	38.9	238.5	218.5	-33.2	-20.3	12.22
18.8.2009	18:35:05	33.9	294.7	274.7	-30.8	14.1	12.22
18.8.2009	18:35:10	40.8	318.3	298.3	-27.1	30.5	12.21
18.8.2009	18:35:15	47	316.6	296.6	-32.2	34.1	12.22
18.8.2009	18:35:20	43.2	342.1	322.1	-13.3	41.2	12.22
18.8.2009	18:35:25	49	259.8	239.8	-48.2	-8.6	12.23
18.8.2009	18:35:30	33.3	242.8	222.8	-29.6	-15.2	12.22
18.8.2009	18:35:35	50.7	182	162	-1.8	-50.7	12.23
18.8.2009	18:35:40	47.8	190.5	170.5	-8.7	-47	12.23
18.8.2009	18:35:45	43.7	197.8	177.8	-13.3	-41.6	12.23
18.8.2009	18:35:50	44.5	231.6	211.6	-34.8	-27.6	12.23
18.8.2009	18:35:55	41.4	289.5	269.5	-39	13.8	12.23
18.8.2009	18:36:00	45.9	290.8	270.8	-42.9	16.3	12.24
18.8.2009	18:36:05	53.1	310.6	290.6	-40.3	34.6	12.24
18.8.2009	18:36:10	49.9	314.6	294.6	-35.5	35	12.23
18.8.2009	18:36:15	43.9	293.7	273.7	-40.2	17.6	12.24
18.8.2009	18:36:20	42	231.9	211.9	-33.1	-25.9	12.24
18.8.2009	18:36:25	59.3	201.4	181.4	-21.6	-55.2	12.24
18.8.2009	18:36:30	57.7	195.1	175.1	-15.1	-55.7	12.23
18.8.2009	18:36:35	55.7	206	186	-24.4	-50	12.23
18.8.2009	18:36:40	55.5	227.4	207.4	-40.8	-37.6	12.23
18.8.2009	18:36:45	40	231.2	211.2	-31.2	-25	12.23
18.8.2009	18:36:50	40.8	268.9	248.9	-40.8	-0.8	12.22
18.8.2009	18:36:55	36.7	304.3	284.3	-30.3	20.7	12.22
18.8.2009	18:37:00	39.8	316.1	296.1	-27.6	28.7	12.22
18.8.2009	18:37:05	36.8	267.1	247.1	-36.8	-1.9	12.23
18.8.2009	18:37:10	37.6	249	229	-35.1	-13.4	12.23
18.8.2009	18:37:15	29.3	257.9	237.9	-28.7	-6.2	12.23
18.8.2009	18:37:20	35.1	269	249	-35.1	-0.6	12.22
18.8.2009	18:37:25	41.3	290.9	270.9	-38.6	14.7	12.23
18.8.2009	18:37:30	46.3	267	247	-46.3	-2.4	12.24
18.8.2009	18:37:35	40	304.6	284.6	-33	22.7	12.24
18.8.2009	18:37:40	35.3	268.6	248.6	-35.3	-0.9	12.23
18.8.2009	18:37:45	45.2	234	214	-36.5	-26.6	12.23
18.8.2009	18:37:50	40.6	213.8	193.8	-22.6	-33.7	12.23
18.8.2009	18:37:55	47.4	222.1	202.1	-31.8	-35.2	12.24

18.8.2009	18:38:00	42.2	215	195	-24.2	-34.6	12.23
18.8.2009	18:38:05	28.7	235.6	215.6	-23.7	-16.2	12.23
18.8.2009	18:38:10	43.3	271.2	251.2	-43.3	0.9	12.23
18.8.2009	18:38:15	40.4	302.8	282.8	-33.9	21.9	12.22
18.8.2009	18:38:20	44.2	301.9	281.9	-37.5	23.3	12.22
18.8.2009	18:38:25	48.6	301.7	281.7	-41.4	25.5	12.24
18.8.2009	18:38:30	48.6	274.2	254.2	-48.5	3.5	12.24
18.8.2009	18:38:35	47.8	273.7	253.7	-47.7	3.1	12.23
18.8.2009	18:38:40	34.4	277	257	-34.2	4.2	12.24
18.8.2009	18:38:45	34.3	232.5	212.5	-27.2	-20.9	12.22
18.8.2009	18:38:50	46.6	269.3	249.3	-46.6	-0.6	12.23
18.8.2009	18:38:55	42.3	228.9	208.9	-31.9	-27.8	12.24
18.8.2009	18:39:00	47.8	186.2	166.2	-5.1	-47.5	12.24
18.8.2009	18:39:05	45.3	252.6	232.6	-43.2	-13.6	12.23
18.8.2009	18:39:10	49.3	258.3	238.3	-48.3	-10	12.23
18.8.2009	18:39:15	36.3	278.5	258.5	-35.9	5.4	12.23
18.8.2009	18:39:20	51.2	270.8	250.8	-51.2	0.7	12.24
18.8.2009	18:39:25	37.9	294.7	274.7	-34.5	15.9	12.23
18.8.2009	18:39:30	43.6	288.1	268.1	-41.4	13.5	12.24
18.8.2009	18:39:35	40.2	287.5	267.5	-38.4	12.1	12.23
18.8.2009	18:39:40	40.2	266.3	246.3	-40.1	-2.6	12.23
18.8.2009	18:39:45	50	312.3	292.3	-37	33.7	12.24
18.8.2009	18:39:50	45.2	271.3	251.3	-45.2	1	12.24
18.8.2009	18:39:55	43.7	272.1	252.1	-43.6	1.6	12.24
18.8.2009	18:40:00	42.1	239.6	219.6	-36.3	-21.3	12.24
18.8.2009	18:40:05	43.3	231.2	211.2	-33.7	-27.1	12.23
18.8.2009	18:40:10	62.3	206.8	186.8	-28.1	-55.6	12.23
18.8.2009	18:40:15	58.4	210.5	190.5	-29.7	-50.3	12.25
18.8.2009	18:40:20	48	219.3	199.3	-30.4	-37.1	12.24
18.8.2009	18:40:25	51.3	298.6	278.6	-45	24.6	12.25
18.8.2009	18:40:30	52.9	288.4	268.4	-50.2	16.7	12.26
18.8.2009	18:40:35	54.3	309.2	289.2	-42.1	34.3	12.26
18.8.2009	18:40:40	61.3	303.5	283.5	-51.1	33.8	12.27
18.8.2009	18:40:45	34.4	247.4	227.4	-31.8	-13.2	12.26
18.8.2009	18:40:50	46.2	212.1	192.1	-24.5	-39.2	12.24
18.8.2009	18:40:55	46.6	247.3	227.3	-43	-18	12.23
18.8.2009	18:41:00	44.7	255.2	235.2	-43.2	-11.4	12.3
18.8.2009	18:41:05	35.9	266.7	246.7	-35.8	-2.1	12.24
18.8.2009	18:41:10	38.7	293.2	273.2	-35.6	15.2	12.22
18.8.2009	18:41:15	41.3	248.9	228.9	-38.6	-14.9	12.29
18.8.2009	18:41:20	33.1	248.8	228.8	-30.9	-12	12.3
18.8.2009	18:41:25	48.8	238.1	218.1	-41.4	-25.8	12.27
18.8.2009	18:41:30	51.2	246	226	-46.8	-20.8	12.3

18.8.2009	18:41:35	42.6	243.7	223.7	-38.2	-18.8	12.27
18.8.2009	18:41:40	43.4	268.5	248.5	-43.4	-1.1	12.29
18.8.2009	18:41:45	43.5	262.7	242.7	-43.2	-5.5	12.28
18.8.2009	18:41:50	39.2	277.2	257.2	-38.9	4.9	12.31
18.8.2009	18:41:55	35.1	283.4	263.4	-34.1	8.1	12.29
18.8.2009	18:42:00	45.2	259.2	239.2	-44.4	-8.5	12.28
18.8.2009	18:42:05	45.7	265.8	245.8	-45.5	-3.3	12.3
18.8.2009	18:42:10	43.8	244.2	224.2	-39.5	-19.1	12.31
18.8.2009	18:42:15	42.6	246	226	-38.9	-17.3	12.31
18.8.2009	18:42:20	36.9	276.5	256.5	-36.7	4.2	12.28
18.8.2009	18:42:25	36.2	292	272	-33.6	13.6	12.23
18.8.2009	18:42:30	44	265.3	245.3	-43.9	-3.6	12.28
18.8.2009	18:42:35	41.4	261.6	241.6	-41	-6	12.31
18.8.2009	18:42:40	50.7	227.9	207.9	-37.6	-34	12.29
18.8.2009	18:42:45	50.3	244.5	224.5	-45.4	-21.7	12.28
18.8.2009	18:42:50	56.7	191.6	171.6	-11.4	-55.5	12.26
18.8.2009	18:42:55	71.5	209.1	189.1	-34.8	-62.4	12.31
18.8.2009	18:43:00	59	197.8	177.8	-18	-56.2	12.32
18.8.2009	18:43:05	53	287.3	267.3	-50.6	15.8	12.33
18.8.2009	18:43:10	60.5	285.7	265.7	-58.2	16.4	12.33
18.8.2009	18:43:15	49.9	268.2	248.2	-49.9	-1.6	12.33
18.8.2009	18:43:20	42.9	291.2	271.2	-40	15.5	12.31
18.8.2009	18:43:25	39.9	221.3	201.3	-26.4	-30	12.31
18.8.2009	18:43:30	32.8	253.1	233.1	-31.4	-9.5	12.3
18.8.2009	18:43:35	43.7	229.7	209.7	-33.3	-28.3	12.3
18.8.2009	18:43:40	44.7	226.4	206.4	-32.4	-30.8	12.32
18.8.2009	18:43:45	43.8	226.4	206.4	-31.7	-30.2	12.33
18.8.2009	18:43:50	47.4	250.8	230.8	-44.8	-15.6	12.33
18.8.2009	18:43:55	48.6	296.1	276.1	-43.6	21.3	12.31
18.8.2009	18:44:00	52.9	292.7	272.7	-48.8	20.4	12.32
18.8.2009	18:44:05	47.1	289.7	269.7	-44.4	15.9	12.33
18.8.2009	18:44:10	43.1	249.6	229.6	-40.4	-15	12.31
18.8.2009	18:44:15	49.7	223.3	203.3	-34	-36.2	12.3
18.8.2009	18:44:20	53.8	209.3	189.3	-26.4	-46.9	12.31
18.8.2009	18:44:25	61	204.6	184.6	-25.4	-55.5	12.33
18.8.2009	18:44:30	53.1	205.6	185.6	-22.9	-47.9	12.35
18.8.2009	18:44:35	45	249.2	229.2	-42.1	-16	12.35
18.8.2009	18:44:40	53.6	306.1	286.1	-43.3	31.6	12.32
18.8.2009	18:44:45	57.7	301.6	281.6	-49.2	30.2	12.32
18.8.2009	18:44:50	45.4	280.5	260.5	-44.6	8.2	12.32
18.8.2009	18:44:55	45.8	273.1	253.1	-45.8	2.5	12.34
18.8.2009	18:45:00	52.4	235.9	215.9	-43.4	-29.4	12.36
18.8.2009	18:45:05	45.3	222.2	202.2	-30.4	-33.6	12.36

18.8.2009	18:45:10	54	214.1	194.1	-30.3	-44.7	12.35
18.8.2009	18:45:15	51.8	220	200	-33.3	-39.7	12.34
18.8.2009	18:45:20	52.5	282	262	-51.3	10.9	12.34
18.8.2009	18:45:25	49.1	270.7	250.7	-49.1	0.6	12.35
18.8.2009	18:45:30	52.2	311.1	291.1	-39.4	34.3	12.34
18.8.2009	18:45:35	52.4	309.3	289.3	-40.5	33.2	12.33
18.8.2009	18:45:40	46.6	276.3	256.3	-46.4	5.1	12.33
18.8.2009	18:45:45	50	248.9	228.9	-46.7	-18	12.34
18.8.2009	18:45:50	40.4	222.2	202.2	-27.1	-29.9	12.33
18.8.2009	18:45:55	54	217.5	197.5	-32.9	-42.9	12.33
18.8.2009	18:46:00	54.5	229.8	209.8	-41.6	-35.2	12.33
18.8.2009	18:46:05	54.2	230.1	210.1	-41.6	-34.8	12.34
18.8.2009	18:46:10	54.3	282.6	262.6	-53	11.8	12.35
18.8.2009	18:46:15	53.8	268.4	248.4	-53.8	-1.5	12.34
18.8.2009	18:46:20	51.8	289.5	269.5	-48.8	17.3	12.33
18.8.2009	18:46:25	49.9	306.1	286.1	-40.4	29.4	12.33
18.8.2009	18:46:30	52.8	273.6	253.6	-52.7	3.3	12.33
18.8.2009	18:46:35	36	255.1	235.1	-34.8	-9.2	12.34
18.8.2009	18:46:40	58.2	206.3	186.3	-25.8	-52.2	12.35
18.8.2009	18:46:45	47.7	214.2	194.2	-26.8	-39.4	12.33
18.8.2009	18:46:50	50	235.2	215.2	-41.1	-28.5	12.33
18.8.2009	18:46:55	53.1	239.2	219.2	-45.6	-27.2	12.35
18.8.2009	18:47:00	55.3	284.4	264.4	-53.6	13.8	12.36
18.8.2009	18:47:05	49.2	317	297	-33.6	36	12.36
18.8.2009	18:47:10	50.1	269.2	249.2	-50.1	-0.7	12.34
18.8.2009	18:47:15	46	262.9	242.9	-45.6	-5.7	12.35
18.8.2009	18:47:20	47.9	237.6	217.6	-40.5	-25.6	12.33
18.8.2009	18:47:25	40.5	226.4	206.4	-29.4	-28	12.33
18.8.2009	18:47:30	56.7	223.5	203.5	-39.1	-41.1	12.33
18.8.2009	18:47:35	56.6	231.8	211.8	-44.5	-35	12.35
18.8.2009	18:47:40	61.5	232.3	212.3	-48.7	-37.6	12.37
18.8.2009	18:47:45	56.4	272.2	252.2	-56.4	2.2	12.37
18.8.2009	18:47:50	61.3	289.3	269.3	-57.8	20.3	12.36
18.8.2009	18:47:55	54.4	325.2	305.2	-31.1	44.6	12.35
18.8.2009	18:48:00	45.4	288.9	268.9	-43	14.7	12.34
18.8.2009	18:48:05	49.6	235.8	215.8	-41	-27.9	12.35
18.8.2009	18:48:10	62.4	197.7	177.7	-19	-59.5	12.35
18.8.2009	18:48:15	71.2	201.1	181.1	-25.7	-66.4	12.36
18.8.2009	18:48:20	52.9	217.9	197.9	-32.5	-41.8	12.37
18.8.2009	18:48:25	60.2	251.9	231.9	-57.2	-18.7	12.37
18.8.2009	18:48:30	50.9	247	227	-46.9	-19.9	12.37
18.8.2009	18:48:35	55.2	253.4	233.4	-52.9	-15.8	12.37
18.8.2009	18:48:40	51.4	304.1	284.1	-42.6	28.9	12.37

18.8.2009	18:48:45	53.5	301.2	281.2	-45.8	27.8	12.38
18.8.2009	18:48:50	53.6	284	264	-52	13	12.36
18.8.2009	18:48:55	59.3	231.8	211.8	-46.6	-36.7	12.37
18.8.2009	18:49:00	63.4	205.3	185.3	-27.1	-57.4	12.38
18.8.2009	18:49:05	70.8	220	200	-45.5	-54.3	12.36
18.8.2009	18:49:10	55.7	222.8	202.8	-37.8	-40.9	12.37
18.8.2009	18:49:15	65.8	263.9	243.9	-65.4	-6.9	12.36
18.8.2009	18:49:20	55.1	311.2	291.2	-41.4	36.3	12.36
18.8.2009	18:49:25	59.8	318.7	298.7	-39.4	44.9	12.35
18.8.2009	18:49:30	61.1	284.4	264.4	-59.2	15.2	12.38
18.8.2009	18:49:35	46.1	297.2	277.2	-41	21.1	12.38
18.8.2009	18:49:40	43	256.1	236.1	-41.8	-10.3	12.35
18.8.2009	18:49:45	44.7	228.1	208.1	-33.3	-29.9	12.34
18.8.2009	18:49:50	45.4	242.9	222.9	-40.4	-20.7	12.34
18.8.2009	18:49:55	60.4	230.7	210.7	-46.8	-38.2	12.33
18.8.2009	18:50:00	48.8	213.1	193.1	-26.7	-40.9	12.33
18.8.2009	18:50:05	58	266.1	246.1	-57.8	-3.9	12.33
18.8.2009	18:50:10	50.3	284.8	264.8	-48.7	12.9	12.32
18.8.2009	18:50:15	44.9	309.4	289.4	-34.7	28.5	12.3
18.8.2009	18:50:20	46.6	287	267	-44.6	13.6	12.33
18.8.2009	18:50:25	46	320.9	300.9	-29.1	35.7	12.33
18.8.2009	18:50:30	44.6	214.1	194.1	-25	-37	12.32
18.8.2009	18:50:35	57.5	225.9	205.9	-41.3	-40	12.31
18.8.2009	18:50:40	66.5	189.7	169.7	-11.2	-65.6	12.34
18.8.2009	18:50:45	70.4	234.5	214.5	-57.3	-40.9	12.33
18.8.2009	18:50:50	57.8	230.8	210.8	-44.8	-36.5	12.33
18.8.2009	18:50:55	48.9	222.8	202.8	-33.3	-35.9	12.33
18.8.2009	18:51:00	49.2	270.5	250.5	-49.2	0.4	12.32
18.8.2009	18:51:05	43.9	282	262	-42.9	9.2	12.32
18.8.2009	18:51:10	47.6	276.6	256.6	-47.3	5.4	12.35
18.8.2009	18:51:15	44.6	272.4	252.4	-44.5	1.9	12.33
18.8.2009	18:51:20	48.1	274.1	254.1	-47.9	3.4	12.33
18.8.2009	18:51:25	53.4	210.2	190.2	-26.8	-46.1	12.33
18.8.2009	18:51:30	60.1	229.2	209.2	-45.5	-39.3	12.33
18.8.2009	18:51:35	56.8	215	195	-32.6	-46.5	12.33
18.8.2009	18:51:40	51.5	261.6	241.6	-50.9	-7.5	12.34
18.8.2009	18:51:45	46.5	279.9	259.9	-45.8	8	12.33
18.8.2009	18:51:50	52.8	274.8	254.8	-52.6	4.4	12.34
18.8.2009	18:51:55	50.4	282.3	262.3	-49.2	10.7	12.33
18.8.2009	18:52:00	50	245.2	225.2	-45.3	-21	12.34
18.8.2009	18:52:05	63.1	212	192	-33.5	-53.5	12.33
18.8.2009	18:52:10	62.3	208.1	188.1	-29.4	-54.9	12.35
18.8.2009	18:52:15	60.1	206	186	-26.3	-54.1	12.34

18.8.2009	18:52:20	58.7	249	229	-54.8	-21	12.34
18.8.2009	18:52:25	51.5	278.3	258.3	-50.9	7.4	12.33
18.8.2009	18:52:30	53.6	293.7	273.7	-49.1	21.5	12.33
18.8.2009	18:52:35	54.5	290.8	270.8	-50.9	19.3	12.37
18.8.2009	18:52:40	53.1	292.6	272.6	-49	20.4	12.37
18.8.2009	18:52:45	47.5	251.6	231.6	-45.1	-15	12.36
18.8.2009	18:52:50	49.5	283.1	263.1	-48.2	11.2	12.35
18.8.2009	18:52:55	41.1	255.1	235.1	-39.7	-10.6	12.35
18.8.2009	18:53:00	50.1	227.2	207.2	-36.7	-34.1	12.34
18.8.2009	18:53:05	59.6	198.3	178.3	-18.7	-56.6	12.34
18.8.2009	18:53:10	61.7	207.8	187.8	-28.8	-54.6	12.36
18.8.2009	18:53:15	66.4	214.2	194.2	-37.3	-54.9	12.35
18.8.2009	18:53:20	63.5	229.2	209.2	-48.1	-41.5	12.36
18.8.2009	18:53:25	62.6	256.2	236.2	-60.8	-15	12.36
18.8.2009	18:53:30	58.4	251.7	231.7	-55.5	-18.4	12.35
18.8.2009	18:53:35	52.5	293.6	273.6	-48.2	21	12.35
18.8.2009	18:53:40	55.8	319.3	299.3	-36.4	42.4	12.38
18.8.2009	18:53:45	49.5	265.4	245.4	-49.3	-4	12.36
18.8.2009	18:53:50	50	254.1	234.1	-48.1	-13.7	12.36
18.8.2009	18:53:55	52.6	266.2	246.2	-52.5	-3.5	12.35
18.8.2009	18:54:00	55.6	232.4	212.4	-44	-33.9	12.35
18.8.2009	18:54:05	56.7	203.3	183.3	-22.4	-52.1	12.35
18.8.2009	18:54:10	66.4	214.8	194.8	-37.9	-54.6	12.36
18.8.2009	18:54:15	59.8	209.5	189.5	-29.4	-52.1	12.35
18.8.2009	18:54:20	57.2	277.4	257.4	-56.7	7.4	12.36
18.8.2009	18:54:25	58.2	285.1	265.1	-56.2	15.2	12.37
18.8.2009	18:54:30	52.9	291.6	271.6	-49.2	19.5	12.37
18.8.2009	18:54:35	51.1	275.6	255.6	-50.9	5	12.37
18.8.2009	18:54:40	52.9	265.3	245.3	-52.7	-4.4	12.37
18.8.2009	18:54:45	53.4	268.5	248.5	-53.4	-1.4	12.35
18.8.2009	18:54:50	52.2	247.7	227.7	-48.3	-19.8	12.35
18.8.2009	18:54:55	52.3	276.5	256.5	-52	5.9	12.36
18.8.2009	18:55:00	51.6	235.5	215.5	-42.5	-29.2	12.36
18.8.2009	18:55:05	63	279.3	259.3	-62.1	10.1	12.36
18.8.2009	18:55:10	56.9	258.7	238.7	-55.8	-11.1	12.36
18.8.2009	18:55:15	60.5	298.2	278.2	-53.4	28.6	12.36
18.8.2009	18:55:20	54.5	247.6	227.6	-50.4	-20.7	12.36
18.8.2009	18:55:25	50.4	273	253	-50.3	2.6	12.38
18.8.2009	18:55:30	50.9	241.4	221.4	-44.7	-24.4	12.37
18.8.2009	18:55:35	52.5	263.2	243.2	-52.1	-6.2	12.36
18.8.2009	18:55:40	53.1	245.6	225.6	-48.3	-21.9	12.35
18.8.2009	18:55:45	53.9	223.3	203.3	-37	-39.2	12.35
18.8.2009	18:55:50	56.5	242	222	-49.9	-26.5	12.36

18.8.2009	18:55:55	52.1	246.2	226.2	-47.7	-21	12.35
18.8.2009	18:56:00	52.4	256.8	236.8	-51	-12	12.37
18.8.2009	18:56:05	53.5	230.4	210.4	-41.3	-34.1	12.36
18.8.2009	18:56:10	47.9	235.5	215.5	-39.5	-27.1	12.34
18.8.2009	18:56:15	49.5	277.6	257.6	-49.1	6.6	12.3
18.8.2009	18:56:20	54.1	247.7	227.7	-50	-20.5	12.34
18.8.2009	18:56:25	53.1	235.7	215.7	-43.9	-29.9	12.32
18.8.2009	18:56:30	47.1	234.1	214.1	-38.1	-27.6	12.37
18.8.2009	18:56:35	53.9	227	207	-39.4	-36.8	12.35
18.8.2009	18:56:40	55.5	270.1	250.1	-55.5	0.1	12.34
18.8.2009	18:56:45	47.9	288	268	-45.5	14.8	12.34
18.8.2009	18:56:50	52.6	270.9	250.9	-52.6	0.8	12.34
18.8.2009	18:56:55	53.5	247.8	227.8	-49.5	-20.2	12.31
18.8.2009	18:57:00	44.2	252.2	232.2	-42.1	-13.5	12.34
18.8.2009	18:57:05	47.5	246.1	226.1	-43.4	-19.3	12.33
18.8.2009	18:57:10	47.2	260.4	240.4	-46.5	-7.9	12.32
18.8.2009	18:57:15	40.9	225	205	-28.9	-28.9	12.35
18.8.2009	18:57:20	54.6	226.9	206.9	-39.9	-37.3	12.35
18.8.2009	18:57:25	54	257.6	237.6	-52.7	-11.6	12.35
18.8.2009	18:57:30	47.9	252.7	232.7	-45.8	-14.2	12.36
18.8.2009	18:57:35	50.6	207.4	187.4	-23.3	-44.9	12.35
18.8.2009	18:57:40	56	261.3	241.3	-55.3	-8.5	12.36
18.8.2009	18:57:45	55.1	256.6	236.6	-53.6	-12.8	12.34
18.8.2009	18:57:50	57.6	239.1	219.1	-49.4	-29.6	12.35
18.8.2009	18:57:55	55.6	241.4	221.4	-48.8	-26.7	12.35
18.8.2009	18:58:00	54.5	275.7	255.7	-54.2	5.4	12.36
18.8.2009	18:58:05	51.2	241.2	221.2	-44.9	-24.7	12.34
18.8.2009	18:58:10	47.2	232.1	212.1	-37.2	-29	12.36
18.8.2009	18:58:15	51.4	238.3	218.3	-43.8	-27	12.35
18.8.2009	18:58:20	59.5	237	217	-49.9	-32.4	12.35
18.8.2009	18:58:25	58.1	254.1	234.1	-55.9	-15.9	12.33
18.8.2009	18:58:30	53.3	261	241	-52.6	-8.3	12.31
18.8.2009	18:58:35	46.4	255.4	235.4	-44.9	-11.7	12.32
18.8.2009	18:58:40	56.1	270.6	250.6	-56.1	0.6	12.32
18.8.2009	18:58:45	54.1	248.8	228.8	-50.4	-19.6	12.33
18.8.2009	18:58:50	48.4	213.1	193.1	-26.4	-40.5	12.33
18.8.2009	18:58:55	53.5	237.8	217.8	-45.3	-28.5	12.33
18.8.2009	18:59:00	53	262	242	-52.5	-7.3	12.32
18.8.2009	18:59:05	52.4	259.4	239.4	-51.5	-9.6	12.33
18.8.2009	18:59:10	52.7	254.1	234.1	-50.6	-14.4	12.33
18.8.2009	18:59:15	52.4	239.4	219.4	-45.1	-26.7	12.36
18.8.2009	18:59:20	49.5	274.4	254.4	-49.3	3.8	12.36
18.8.2009	18:59:25	53.3	243	223	-47.5	-24.2	12.35

18.8.2009	18:59:30	59.4	270.7	250.7	-59.4	0.7	12.35
18.8.2009	18:59:35	46.5	248.8	228.8	-43.3	-16.8	12.37
18.8.2009	18:59:40	56.5	231.3	211.3	-44.1	-35.3	12.36
18.8.2009	18:59:45	54.7	237.8	217.8	-46.2	-29.1	12.34
18.8.2009	18:59:50	50.6	220.1	200.1	-32.6	-38.7	12.34
18.8.2009	18:59:55	55.4	213.1	193.1	-30.2	-46.4	12.35
18.8.2009	19:00:00	57.3	227.5	207.5	-42.3	-38.7	12.35
18.8.2009	19:00:05	58.7	256.7	236.7	-57.1	-13.5	12.38
18.8.2009	19:00:10	54.4	296.7	276.7	-48.6	24.4	12.35
18.8.2009	19:00:15	50.6	263.4	243.4	-50.3	-5.8	12.35
18.8.2009	19:00:20	48.5	251.2	231.2	-45.9	-15.7	12.3
18.8.2009	19:00:25	61	217.1	197.1	-36.8	-48.6	12.33
18.8.2009	19:00:30	57.4	206.7	186.7	-25.8	-51.3	12.34
18.8.2009	19:00:35	67.7	206.4	186.4	-30.1	-60.6	12.34
18.8.2009	19:00:40	65.5	220.6	200.6	-42.6	-49.7	12.38
18.8.2009	19:00:45	63.5	247.3	227.3	-58.5	-24.5	12.37
18.8.2009	19:00:50	57.3	306.1	286.1	-46.3	33.8	12.35
18.8.2009	19:00:55	64.8	298.1	278.1	-57.2	30.5	12.35
18.8.2009	19:01:00	59	274.8	254.8	-58.8	4.9	12.36
18.8.2009	19:01:05	60.2	257.7	237.7	-58.8	-12.8	12.35
18.8.2009	19:01:10	48.6	238.4	218.4	-41.4	-25.5	12.36
18.8.2009	19:01:15	55.4	226.4	206.4	-40.1	-38.2	12.34
18.8.2009	19:01:20	53.5	218	198	-32.9	-42.2	12.33
18.8.2009	19:01:25	67.8	208.7	188.7	-32.5	-59.5	12.32
18.8.2009	19:01:30	61.3	217.6	197.6	-37.4	-48.6	12.35
18.8.2009	19:01:35	81	287.1	267.1	-77.4	23.8	12.34
18.8.2009	19:01:40	59.3	269.7	249.7	-59.3	-0.3	12.32
18.8.2009	19:01:45	41	267	247	-41	-2.1	12.34
18.8.2009	19:01:50	61.1	249.3	229.3	-57.2	-21.6	12.34
18.8.2009	19:01:55	56.2	259.1	239.1	-55.2	-10.7	12.36
18.8.2009	19:02:00	53.4	241.5	221.5	-47	-25.5	12.37
18.8.2009	19:02:05	60.4	233.1	213.1	-48.3	-36.2	12.36
18.8.2009	19:02:10	58.8	235.1	215.1	-48.2	-33.6	12.35
18.8.2009	19:02:15	51.9	250.5	230.5	-48.9	-17.3	12.35
18.8.2009	19:02:20	55.1	258.3	238.3	-53.9	-11.1	12.35
18.8.2009	19:02:25	50.3	300.3	280.3	-43.4	25.4	12.37
18.8.2009	19:02:30	55.6	231.6	211.6	-43.6	-34.5	12.35
18.8.2009	19:02:35	53.1	217.7	197.7	-32.5	-42	12.34
18.8.2009	19:02:40	59.2	245.7	225.7	-53.9	-24.4	12.38
18.8.2009	19:02:45	64.5	220.1	200.1	-41.5	-49.3	12.3
18.8.2009	19:02:50	62.3	251.2	231.2	-58.9	-20.1	12.36
18.8.2009	19:02:55	61	261.8	241.8	-60.4	-8.7	12.39
18.8.2009	19:03:00	56.2	272.5	252.5	-56.2	2.5	12.38

18.8.2009	19:03:05	61.3	294.5	274.5	-55.8	25.4	12.37
18.8.2009	19:03:10	56.2	259.6	239.6	-55.2	-10.2	12.37
18.8.2009	19:03:15	57.8	240.2	220.2	-50.2	-28.7	12.36
18.8.2009	19:03:20	57.6	246.2	226.2	-52.7	-23.2	12.35
18.8.2009	19:03:25	64.8	239.5	219.5	-55.9	-32.9	12.34
18.8.2009	19:03:30	54.5	254.7	234.7	-52.6	-14.4	12.34
18.8.2009	19:03:35	60.8	256.3	236.3	-59.1	-14.4	12.36
18.8.2009	19:03:40	58.5	245.4	225.4	-53.2	-24.3	12.37
18.8.2009	19:03:45	62.8	284.8	264.8	-60.7	16	12.36
18.8.2009	19:03:50	52.8	265.3	245.3	-52.6	-4.4	12.34
18.8.2009	19:03:55	54.2	259.2	239.2	-53.2	-10.2	12.34
18.8.2009	19:04:00	54.6	227.7	207.7	-40.4	-36.7	12.36
18.8.2009	19:04:05	54.7	252	232	-52	-16.9	12.34
18.8.2009	19:04:10	55.4	252.5	232.5	-52.8	-16.7	12.32
18.8.2009	19:04:15	57.2	235.9	215.9	-47.4	-32.1	12.37
18.8.2009	19:04:20	62.7	241.2	221.2	-55	-30.2	12.37
18.8.2009	19:04:25	62.4	267.9	247.9	-62.4	-2.3	12.37
18.8.2009	19:04:30	62.3	258.4	238.4	-61	-12.5	12.35
18.8.2009	19:04:35	57.1	237.8	217.8	-48.3	-30.4	12.37
18.8.2009	19:04:40	57	279.2	259.2	-56.3	9.1	12.37
18.8.2009	19:04:45	60	261.4	241.4	-59.3	-9	12.37
18.8.2009	19:04:50	60.2	275	255	-60	5.3	12.37
18.8.2009	19:04:55	54.1	259.7	239.7	-53.3	-9.7	12.35
18.8.2009	19:05:00	54.2	252.5	232.5	-51.7	-16.3	12.36
18.8.2009	19:05:05	52.2	263	243	-51.8	-6.3	12.35
18.8.2009	19:05:10	55.4	262.5	242.5	-54.9	-7.2	12.34
18.8.2009	19:05:15	54.8	258.9	238.9	-53.8	-10.5	12.34
18.8.2009	19:05:20	55.2	231.8	211.8	-43.4	-34.2	12.36
18.8.2009	19:05:25	58.8	243.1	223.1	-52.5	-26.6	12.33
18.8.2009	19:05:30	60.5	253.9	233.9	-58.1	-16.8	12.35
18.8.2009	19:05:35	55.1	216.7	196.7	-32.9	-44.2	12.36
18.8.2009	19:05:40	61.9	239.8	219.8	-53.5	-31.1	12.37
18.8.2009	19:05:45	65.2	228.2	208.2	-48.6	-43.4	12.38
18.8.2009	19:05:50	61.8	240.6	220.6	-53.8	-30.4	12.37
18.8.2009	19:05:55	55.3	281	261	-54.3	10.5	12.37
18.8.2009	19:06:00	57.1	283.3	263.3	-55.5	13.1	12.37
18.8.2009	19:06:05	55.5	244.8	224.8	-50.2	-23.6	12.37
18.8.2009	19:06:10	57.8	273.9	253.9	-57.6	3.9	12.38
18.8.2009	19:06:15	54.9	270.8	250.8	-54.9	0.8	12.36
18.8.2009	19:06:20	60.7	262.7	242.7	-60.2	-7.7	12.37
18.8.2009	19:06:25	62.4	250.8	230.8	-59	-20.5	12.39
18.8.2009	19:06:30	58.8	237	217	-49.3	-32	12.39
18.8.2009	19:06:35	58.3	221.9	201.9	-38.9	-43.4	12.37

18.8.2009	19:06:40	58.5	238.4	218.4	-49.9	-30.6	12.37
18.8.2009	19:06:45	60.8	255.2	235.2	-58.8	-15.6	12.37
18.8.2009	19:06:50	58.8	259.8	239.8	-57.9	-10.4	12.38
18.8.2009	19:06:55	55.9	250.8	230.8	-52.8	-18.4	12.38
18.8.2009	19:07:00	54.6	257.4	237.4	-53.3	-11.9	12.37
18.8.2009	19:07:05	58.4	257.7	237.7	-57.1	-12.4	12.38
18.8.2009	19:07:10	61.8	230.5	210.5	-47.7	-39.3	12.39
18.8.2009	19:07:15	57.8	219.6	199.6	-36.9	-44.5	12.37
18.8.2009	19:07:20	59.8	281.3	261.3	-58.6	11.7	12.38
18.8.2009	19:07:25	56.2	265.3	245.3	-56	-4.6	12.36
18.8.2009	19:07:30	53.8	257.6	237.6	-52.5	-11.5	12.35
18.8.2009	19:07:35	59.9	262.9	242.9	-59.4	-7.4	12.37
18.8.2009	19:07:40	58.2	240.5	220.5	-50.7	-28.7	12.36
18.8.2009	19:07:45	58.6	277.2	257.2	-58.2	7.3	12.38
18.8.2009	19:07:50	61.4	255.9	235.9	-59.6	-15	12.36
18.8.2009	19:07:55	60.3	262.3	242.3	-59.8	-8.1	12.33
18.8.2009	19:08:00	54	248.7	228.7	-50.3	-19.6	12.36
18.8.2009	19:08:05	61.3	239.1	219.1	-52.6	-31.5	12.39
18.8.2009	19:08:10	62.7	225.9	205.9	-45	-43.6	12.36
18.8.2009	19:08:15	60.4	282.3	262.3	-59	12.9	12.39
18.8.2009	19:08:20	65.9	282.1	262.1	-64.4	13.8	12.41
18.8.2009	19:08:25	70	273.7	253.7	-69.9	4.5	12.39
18.8.2009	19:08:30	61.5	260.8	240.8	-60.7	-9.9	12.39
18.8.2009	19:08:35	61	251.1	231.1	-57.7	-19.7	12.41
18.8.2009	19:08:40	55.1	259.5	239.5	-54.1	-10	12.4
18.8.2009	19:08:45	56	225.2	205.2	-39.8	-39.4	12.38
18.8.2009	19:08:50	75.7	211.1	191.1	-39.1	-64.8	12.38
18.8.2009	19:08:55	74.6	211.9	191.9	-39.4	-63.3	12.39
18.8.2009	19:09:00	67.8	223.3	203.3	-46.5	-49.4	12.4
18.8.2009	19:09:05	70	243.9	223.9	-62.9	-30.9	12.41
18.8.2009	19:09:10	66.1	248.5	228.5	-61.5	-24.2	12.38
18.8.2009	19:09:15	68.6	256.8	236.8	-66.8	-15.7	12.42
18.8.2009	19:09:20	64	272.7	252.7	-63.9	3.1	12.42
18.8.2009	19:09:25	66.3	290.7	270.7	-62.1	23.4	12.39
18.8.2009	19:09:30	60.2	293.7	273.7	-55.1	24.1	12.39
18.8.2009	19:09:35	59.2	274.7	254.7	-59	4.9	12.38
18.8.2009	19:09:40	58.7	232.2	212.2	-46.4	-36	12.38
18.8.2009	19:09:45	54.1	229.1	209.1	-40.9	-35.4	12.38
18.8.2009	19:09:50	62.7	217.1	197.1	-37.8	-50	12.38
18.8.2009	19:09:55	59.7	264.2	244.2	-59.4	-6	12.38
18.8.2009	19:10:00	60.8	259.4	239.4	-59.8	-11.2	12.39
18.8.2009	19:10:05	61.9	246.1	226.1	-56.6	-25.1	12.38
18.8.2009	19:10:10	59.8	225.4	205.4	-42.6	-42	12.39

18.8.2009	19:10:15	60.8	257.4	237.4	-59.4	-13.3	12.39
18.8.2009	19:10:20	58.8	267.1	247.1	-58.7	-2.9	12.38
18.8.2009	19:10:25	54.6	248.3	228.3	-50.8	-20.2	12.38
18.8.2009	19:10:30	61.7	260.9	240.9	-61	-9.7	12.4
18.8.2009	19:10:35	64.6	249.2	229.2	-60.4	-23	12.39
18.8.2009	19:10:40	67	237.1	217.1	-56.3	-36.4	12.41
18.8.2009	19:10:45	57.5	247.8	227.8	-53.3	-21.7	12.41
18.8.2009	19:10:50	62.4	245.8	225.8	-56.9	-25.6	12.4
18.8.2009	19:10:55	62.9	256.8	236.8	-61.2	-14.4	12.4
18.8.2009	19:11:00	64.3	272	252	-64.2	2.2	12.4
18.8.2009	19:11:05	56	244.5	224.5	-50.6	-24.1	12.39
18.8.2009	19:11:10	61.5	270.3	250.3	-61.5	0.3	12.41
18.8.2009	19:11:15	65	239.1	219.1	-55.7	-33.4	12.42
18.8.2009	19:11:20	59	247.2	227.2	-54.4	-22.9	12.41
18.8.2009	19:11:25	65.7	255.7	235.7	-63.7	-16.2	12.42
18.8.2009	19:11:30	61.8	264.4	244.4	-61.5	-6	12.41
18.8.2009	19:11:35	64.1	255.1	235.1	-62	-16.5	12.39
18.8.2009	19:11:40	59.4	262.9	242.9	-59	-7.3	12.4
18.8.2009	19:11:45	61.4	251.1	231.1	-58.1	-19.9	12.41
18.8.2009	19:11:50	63.1	264.3	244.3	-62.8	-6.2	12.42
18.8.2009	19:11:55	60.3	242.3	222.3	-53.4	-28	12.42
18.8.2009	19:12:00	63.7	227.7	207.7	-47.1	-42.9	12.42
18.8.2009	19:12:05	59.2	227.3	207.3	-43.5	-40.1	12.43
18.8.2009	19:12:10	61.5	222.3	202.3	-41.4	-45.5	12.43
18.8.2009	19:12:15	68.7	194.4	174.4	-17.1	-66.6	12.42
18.8.2009	19:12:20	82.3	225.3	205.3	-58.5	-57.9	12.43
18.8.2009	19:12:25	73.7	209.6	189.6	-36.4	-64	12.41
18.8.2009	19:12:30	77.5	238.4	218.4	-66	-40.6	12.42
18.8.2009	19:12:35	67.9	227.3	207.3	-49.9	-46	12.44
18.8.2009	19:12:40	66.7	260.1	240.1	-65.7	-11.5	12.43
18.8.2009	19:12:45	65.4	257.7	237.7	-63.9	-13.9	12.41
18.8.2009	19:12:50	61.2	267.2	247.2	-61.1	-3	12.42
18.8.2009	19:12:55	60.2	255.3	235.3	-58.2	-15.2	12.41
18.8.2009	19:13:00	61.9	251.7	231.7	-58.8	-19.4	12.42
18.8.2009	19:13:05	64.1	271.7	251.7	-64.1	1.9	12.43
18.8.2009	19:13:10	63.8	262.6	242.6	-63.3	-8.2	12.42
18.8.2009	19:13:15	66	262.9	242.9	-65.5	-8.1	12.43
18.8.2009	19:13:20	61.4	280.7	260.7	-60.4	11.4	12.43
18.8.2009	19:13:25	67.9	274.5	254.5	-67.7	5.4	12.43
18.8.2009	19:13:30	67.7	273.2	253.2	-67.6	3.8	12.43
18.8.2009	19:13:35	66.1	256.3	236.3	-64.2	-15.7	12.41
18.8.2009	19:13:40	63.2	252.3	232.3	-60.2	-19.2	12.42
18.8.2009	19:13:45	57.4	253.7	233.7	-55.1	-16.1	12.41

18.8.2009	19:13:50	64.7	234.2	214.2	-52.5	-37.8	12.42
18.8.2009	19:13:55	70.6	237.5	217.5	-59.5	-38	12.42
18.8.2009	19:14:00	56.9	250.3	230.3	-53.6	-19.2	12.42
18.8.2009	19:14:05	71.7	247.6	227.6	-66.3	-27.3	12.42
18.8.2009	19:14:10	56.6	255.7	235.7	-54.8	-14	12.42
18.8.2009	19:14:15	55.9	234.5	214.5	-45.5	-32.5	12.42
18.8.2009	19:14:20	62	256.1	236.1	-60.2	-14.9	12.42
18.8.2009	19:14:25	61.2	253.3	233.3	-58.6	-17.6	12.41
18.8.2009	19:14:30	69.4	225.5	205.5	-49.5	-48.6	12.42
18.8.2009	19:14:35	66.5	251.7	231.7	-63.2	-20.9	12.44
18.8.2009	19:14:40	64.5	237	217	-54.1	-35.1	12.41
18.8.2009	19:14:45	69.2	258.9	238.9	-67.9	-13.4	12.43
18.8.2009	19:14:50	67.5	263.2	243.2	-67	-8	12.45
18.8.2009	19:14:55	65	244	224	-58.4	-28.5	12.43
18.8.2009	19:15:00	60.2	261.2	241.2	-59.5	-9.2	12.43
18.8.2009	19:15:05	68.8	259.7	239.7	-67.7	-12.3	12.43
18.8.2009	19:15:10	59.7	279.6	259.6	-58.9	10	12.45
18.8.2009	19:15:15	74.5	277.1	257.1	-74	9.2	12.44
18.8.2009	19:15:20	72.8	279.8	259.8	-71.7	12.3	12.43
18.8.2009	19:15:25	68.1	276.1	256.1	-67.7	7.2	12.43
18.8.2009	19:15:30	76.1	270.9	250.9	-76.1	1.2	12.44
18.8.2009	19:15:35	63.5	273.9	253.9	-63.3	4.3	12.44
18.8.2009	19:15:40	63.1	239.3	219.3	-54.3	-32.2	12.43
18.8.2009	19:15:45	61.8	218.4	198.4	-38.3	-48.4	12.43
18.8.2009	19:15:50	71.4	212.8	192.8	-38.6	-60	12.45
18.8.2009	19:15:55	65.5	238.3	218.3	-55.7	-34.4	12.44
18.8.2009	19:16:00	67.5	262.2	242.2	-66.9	-9.1	12.42
18.8.2009	19:16:05	61	277.9	257.9	-60.4	8.4	12.42
18.8.2009	19:16:10	62.2	272.7	252.7	-62.2	3	12.43
18.8.2009	19:16:15	60.3	264.9	244.9	-60	-5.4	12.44
18.8.2009	19:16:20	59.9	236.5	216.5	-49.9	-33	12.43
18.8.2009	19:16:25	58.8	220.8	200.8	-38.4	-44.5	12.46
18.8.2009	19:16:30	67.9	212.7	192.7	-36.7	-57.1	12.43
18.8.2009	19:16:35	75.2	219.3	199.3	-47.7	-58.1	12.43
18.8.2009	19:16:40	70.6	233.3	213.3	-56.6	-42.2	12.44
18.8.2009	19:16:45	68	262.5	242.5	-67.5	-8.8	12.43
18.8.2009	19:16:50	67.9	278.5	258.5	-67.2	10.1	12.42
18.8.2009	19:16:55	62.1	257.8	237.8	-60.7	-13.1	12.43
18.8.2009	19:17:00	56.1	276.6	256.6	-55.7	6.4	12.43
18.8.2009	19:17:05	62.6	295.2	275.2	-56.6	26.7	12.44
18.8.2009	19:17:10	58.2	241.1	221.1	-51	-28.1	12.45
18.8.2009	19:17:15	63.7	235.3	215.3	-52.4	-36.2	12.46
18.8.2009	19:17:20	58.4	260.1	240.1	-57.6	-10	12.44

18.8.2009	19:17:25	70	244.5	224.5	-63.1	-30.1	12.45
18.8.2009	19:17:30	67.7	260	240	-66.7	-11.8	12.45
18.8.2009	19:17:35	66	271.3	251.3	-66	1.6	12.45
18.8.2009	19:17:40	63.3	270.2	250.2	-63.3	0.2	12.44
18.8.2009	19:17:45	65.9	253.6	233.6	-63.2	-18.6	12.45
18.8.2009	19:17:50	62.4	222.9	202.9	-42.4	-45.7	12.45
18.8.2009	19:17:55	68.7	230.7	210.7	-53.2	-43.5	12.44
18.8.2009	19:18:00	70.6	226.4	206.4	-51.1	-48.7	12.45
18.8.2009	19:18:05	74.8	259	239	-73.4	-14.3	12.47
18.8.2009	19:18:10	75.5	252.2	232.2	-71.9	-23.1	12.46
18.8.2009	19:18:15	72.5	271.1	251.1	-72.5	1.4	12.47
18.8.2009	19:18:20	69.7	266.5	246.5	-69.6	-4.2	12.47
18.8.2009	19:18:25	68.7	282.6	262.6	-67	15	12.45
18.8.2009	19:18:30	62	258.1	238.1	-60.7	-12.8	12.46
18.8.2009	19:18:35	66.1	247	227	-60.9	-25.8	12.47
18.8.2009	19:18:40	69	258.2	238.2	-67.6	-14.2	12.45
18.8.2009	19:18:45	75.2	246.6	226.6	-69	-29.9	12.47
18.8.2009	19:18:50	70.1	270.3	250.3	-70.1	0.3	12.47
18.8.2009	19:18:55	55.4	257.8	237.8	-54.1	-11.7	12.47
18.8.2009	19:19:00	56.2	245.5	225.5	-51.1	-23.3	12.45
18.8.2009	19:19:05	65.6	250.2	230.2	-61.7	-22.2	12.45
18.8.2009	19:19:10	65.9	225.4	205.4	-47	-46.3	12.46
18.8.2009	19:19:15	72.1	231.2	211.2	-56.2	-45.2	12.46
18.8.2009	19:19:20	68.8	252.4	232.4	-65.6	-20.8	12.46
18.8.2009	19:19:25	73.3	256.7	236.7	-71.3	-16.8	12.45
18.8.2009	19:19:30	60.5	268.2	248.2	-60.5	-1.9	12.45
18.8.2009	19:19:35	66.3	257.5	237.5	-64.7	-14.3	12.45
18.8.2009	19:19:40	67.2	230.1	210.1	-51.6	-43.1	12.45
18.8.2009	19:19:45	68.2	282.4	262.4	-66.6	14.6	12.46
18.8.2009	19:19:50	72.9	263	243	-72.3	-8.9	12.47
18.8.2009	19:19:55	58.7	253.4	233.4	-56.2	-16.7	12.46
18.8.2009	19:20:00	69	234.4	214.4	-56.1	-40.2	12.45
18.8.2009	19:20:05	67.2	226.7	206.7	-48.9	-46.1	12.46
18.8.2009	19:20:10	66.7	242	222	-58.9	-31.3	12.46
18.8.2009	19:20:15	71.9	232.8	212.8	-57.3	-43.5	12.47
18.8.2009	19:20:20	76.8	251.5	231.5	-72.8	-24.4	12.46
18.8.2009	19:20:25	71.8	269.6	249.6	-71.8	-0.5	12.47
18.8.2009	19:20:30	67.5	278.8	258.8	-66.7	10.3	12.46
18.8.2009	19:20:35	65.1	253.5	233.5	-62.4	-18.5	12.48
18.8.2009	19:20:40	68.1	234.7	214.7	-55.6	-39.3	12.47
18.8.2009	19:20:45	73.8	231.1	211.1	-57.5	-46.3	12.47
18.8.2009	19:20:50	71.7	233.6	213.6	-57.7	-42.6	12.48
18.8.2009	19:20:55	80	245.7	225.7	-73	-32.9	12.47

18.8.2009	19:21:00	65.8	266.1	246.1	-65.7	-4.5	12.47
18.8.2009	19:21:05	71.2	256.4	236.4	-69.2	-16.8	12.46
18.8.2009	19:21:10	66.9	256.1	236.1	-64.9	-16.1	12.46
18.8.2009	19:21:15	71.8	258.7	238.7	-70.4	-14	12.47
18.8.2009	19:21:20	63.2	264.7	244.7	-62.9	-5.8	12.46
18.8.2009	19:21:25	60.2	265.1	245.1	-60	-5.1	12.46
18.8.2009	19:21:30	66.3	251.1	231.1	-62.7	-21.5	12.46
18.8.2009	19:21:35	57.2	232.2	212.2	-45.2	-35	12.46
18.8.2009	19:21:40	69.2	245.1	225.1	-62.8	-29.2	12.46
18.8.2009	19:21:45	73.2	230.3	210.3	-56.3	-46.8	12.46
18.8.2009	19:21:50	70.7	240.9	220.9	-61.8	-34.4	12.47
18.8.2009	19:21:55	67.5	264.8	244.8	-67.2	-6.1	12.47
18.8.2009	19:22:00	70.8	272.6	252.6	-70.8	3.2	12.47
18.8.2009	19:22:05	69.5	267.5	247.5	-69.4	-3	12.47
18.8.2009	19:22:10	74.1	256.7	236.7	-72.1	-17.1	12.48
18.8.2009	19:22:15	67	256.8	236.8	-65.2	-15.3	12.48
18.8.2009	19:22:20	73.1	264.9	244.9	-72.8	-6.5	12.48
18.8.2009	19:22:25	74.1	257.2	237.2	-72.2	-16.4	12.48
18.8.2009	19:22:30	65.8	241.9	221.9	-58	-31	12.47
18.8.2009	19:22:35	68.4	247.6	227.6	-63.2	-26.1	12.47
18.8.2009	19:22:40	64.3	234.1	214.1	-52.1	-37.7	12.47
18.8.2009	19:22:45	69.5	256.9	236.9	-67.7	-15.7	12.47
18.8.2009	19:22:50	75.6	247.8	227.8	-70	-28.6	12.46
18.8.2009	19:22:55	65.6	226.8	206.8	-47.8	-44.9	12.47
18.8.2009	19:23:00	70.5	243.5	223.5	-63.1	-31.5	12.48
18.8.2009	19:23:05	67.3	256.2	236.2	-65.4	-16.1	12.48
18.8.2009	19:23:10	75	230.4	210.4	-57.8	-47.8	12.48
18.8.2009	19:23:15	67.2	250.2	230.2	-63.3	-22.8	12.47
18.8.2009	19:23:20	75.4	237.4	217.4	-63.5	-40.6	12.48
18.8.2009	19:23:25	67	255.7	235.7	-64.9	-16.6	12.47
18.8.2009	19:23:30	71	278.8	258.8	-70.2	10.8	12.48
18.8.2009	19:23:35	73	261.7	241.7	-72.2	-10.6	12.49
18.8.2009	19:23:40	78.4	273.8	253.8	-78.2	5.2	12.48
18.8.2009	19:23:45	69.8	284.7	264.7	-67.5	17.8	12.47
18.8.2009	19:23:50	74.5	270.7	250.7	-74.5	0.9	12.48
18.8.2009	19:23:55	69.4	251.5	231.5	-65.8	-22	12.48
18.8.2009	19:24:00	70.7	247.8	227.8	-65.5	-26.7	12.48
18.8.2009	19:24:05	65.4	242.1	222.1	-57.8	-30.6	12.47
18.8.2009	19:24:10	66.3	235.5	215.5	-54.6	-37.6	12.47
18.8.2009	19:24:15	67.5	270.2	250.2	-67.5	0.2	12.48
18.8.2009	19:24:20	77.8	272.8	252.8	-77.8	3.8	12.48
18.8.2009	19:24:25	77	288.5	268.5	-73	24.4	12.48
18.8.2009	19:24:30	73.8	241.3	221.3	-64.7	-35.4	12.48

18.8.2009	19:24:35	69.7	238.6	218.6	-59.5	-36.3	12.48
18.8.2009	19:24:40	68.4	227.8	207.8	-50.7	-46	12.49
18.8.2009	19:24:45	73.4	236.5	216.5	-61.2	-40.5	12.49
18.8.2009	19:24:50	65	233.9	213.9	-52.5	-38.3	12.48
18.8.2009	19:24:55	70.5	232.5	212.5	-56	-42.9	12.48
18.8.2009	19:25:00	70	246.9	226.9	-64.4	-27.5	12.48
18.8.2009	19:25:05	68	245.4	225.4	-61.8	-28.3	12.49
18.8.2009	19:25:10	72.1	255.1	235.1	-69.6	-18.5	12.49
18.8.2009	19:25:15	71.8	276	256	-71.4	7.6	12.48
18.8.2009	19:25:20	68.1	274.2	254.2	-67.9	5	12.48
18.8.2009	19:25:25	57.6	274	254	-57.5	4	12.48
18.8.2009	19:25:30	51.8	243.2	223.2	-46.3	-23.4	12.48
18.8.2009	19:25:35	56.1	237.2	217.2	-47.1	-30.4	12.48
18.8.2009	19:25:40	63.9	232.7	212.7	-50.8	-38.8	12.49
18.8.2009	19:25:45	63.5	243.6	223.6	-56.9	-28.3	12.48
18.8.2009	19:25:50	65.1	267.4	247.4	-65.1	-3	12.48
18.8.2009	19:25:55	78.2	257.3	237.3	-76.3	-17.2	12.48
18.8.2009	19:26:00	66.8	273.8	253.8	-66.7	4.5	12.48
18.8.2009	19:26:05	70.5	267.8	247.8	-70.5	-2.7	12.48
18.8.2009	19:26:10	61.9	243	223	-55.2	-28.1	12.48
18.8.2009	19:26:15	69.2	233.8	213.8	-55.8	-40.8	12.49
18.8.2009	19:26:20	69.7	258	238	-68.1	-14.5	12.48
18.8.2009	19:26:25	70	236.3	216.3	-58.2	-38.8	12.49
18.8.2009	19:26:30	75.4	227.8	207.8	-55.8	-50.7	12.48
18.8.2009	19:26:35	65.9	267.2	247.2	-65.8	-3.2	12.48
18.8.2009	19:26:40	66.3	272.8	252.8	-66.3	3.2	12.48
18.8.2009	19:26:45	67.5	261.4	241.4	-66.7	-10.1	12.48
18.8.2009	19:26:50	61.2	265.5	245.5	-61	-4.8	12.48
18.8.2009	19:26:55	64.1	249.6	229.6	-60.1	-22.3	12.48
18.8.2009	19:27:00	68.9	272.9	252.9	-68.8	3.4	12.48
18.8.2009	19:27:05	61.8	263.7	243.7	-61.5	-6.7	12.49
18.8.2009	19:27:10	56.5	255.2	235.2	-54.6	-14.4	12.48
18.8.2009	19:27:15	65.8	241.6	221.6	-57.9	-31.3	12.48
18.8.2009	19:27:20	70.9	235.3	215.3	-58.3	-40.3	12.48
18.8.2009	19:27:25	73.3	233.8	213.8	-59.2	-43.3	12.48
18.8.2009	19:27:30	77.9	258	238	-76.2	-16.2	12.48
18.8.2009	19:27:35	77.3	292.6	272.6	-71.4	29.7	12.48
18.8.2009	19:27:40	71.7	262.2	242.2	-71	-9.8	12.48
18.8.2009	19:27:45	74	277.1	257.1	-73.5	9.1	12.48
18.8.2009	19:27:50	67.6	241.9	221.9	-59.6	-31.9	12.48
18.8.2009	19:27:55	76.7	265.3	245.3	-76.4	-6.3	12.48
18.8.2009	19:28:00	73.5	263	243	-73	-9	12.48
18.8.2009	19:28:05	67.9	258.3	238.3	-66.5	-13.7	12.49

18.8.2009	19:28:10	63.8	261.8	241.8	-63.1	-9.1	12.49
18.8.2009	19:28:15	64.8	237.2	217.2	-54.5	-35.1	12.49
18.8.2009	19:28:20	75.4	224	204	-52.4	-54.2	12.49
18.8.2009	19:28:25	68.4	256.3	236.3	-66.4	-16.2	12.49
18.8.2009	19:28:30	73	245.9	225.9	-66.6	-29.8	12.48
18.8.2009	19:28:35	69.4	246.8	226.8	-63.8	-27.3	12.48
18.8.2009	19:28:40	77.3	244.4	224.4	-69.7	-33.4	12.48
18.8.2009	19:28:45	76.1	252.5	232.5	-72.6	-22.8	12.48
18.8.2009	19:28:50	61.3	253.6	233.6	-58.8	-17.3	12.49
18.8.2009	19:28:55	66.6	264.4	244.4	-66.3	-6.5	12.49
18.8.2009	19:29:00	64	233.6	213.6	-51.5	-38	12.49
18.8.2009	19:29:05	77.6	242.5	222.5	-68.8	-35.8	12.48
18.8.2009	19:29:10	80.4	237.5	217.5	-67.8	-43.2	12.49
18.8.2009	19:29:15	76.6	237.5	217.5	-64.6	-41.1	12.49
18.8.2009	19:29:20	74.5	250.3	230.3	-70.1	-25.1	12.49
18.8.2009	19:29:25	65.8	274	254	-65.6	4.6	12.49
18.8.2009	19:29:30	65.6	267.8	247.8	-65.5	-2.5	12.48
18.8.2009	19:29:35	73	270.9	250.9	-73	1.1	12.48
18.8.2009	19:29:40	69.7	257.1	237.1	-68	-15.6	12.48
18.8.2009	19:29:45	56.9	293.1	273.1	-52.4	22.3	12.49
18.8.2009	19:29:50	69.6	257	237	-67.8	-15.7	12.49
18.8.2009	19:29:55	63	271.1	251.1	-63	1.2	12.49
18.8.2009	19:30:00	64.5	282.5	262.5	-62.9	13.9	12.48
18.8.2009	19:30:05	66.4	259.6	239.6	-65.3	-11.9	12.48
18.8.2009	19:30:10	59.2	294.2	274.2	-54	24.3	12.49
18.8.2009	19:30:15	64.2	283.5	263.5	-62.4	15	12.49
18.8.2009	19:30:20	63.6	244.8	224.8	-57.6	-27.1	12.49
18.8.2009	19:30:25	69.7	251.4	231.4	-66.1	-22.3	12.48
18.8.2009	19:30:30	70.4	260.4	240.4	-69.4	-11.8	12.48
18.8.2009	19:30:35	65.8	232	212	-51.9	-40.5	12.48
18.8.2009	19:30:40	74.6	238.9	218.9	-63.8	-38.6	12.49
18.8.2009	19:30:45	73.9	233.8	213.8	-59.6	-43.6	12.49
18.8.2009	19:30:50	70.3	269.1	249.1	-70.3	-1.1	12.49
18.8.2009	19:30:55	79.5	268.7	248.7	-79.5	-1.8	12.49
18.8.2009	19:31:00	71.1	248.7	228.7	-66.3	-25.9	12.49
18.8.2009	19:31:05	75.4	277.8	257.8	-74.7	10.3	12.48
18.8.2009	19:31:10	76.2	266.6	246.6	-76	-4.6	12.48
18.8.2009	19:31:15	68.4	234.1	214.1	-55.4	-40.1	12.48
18.8.2009	19:31:20	67.9	256.9	236.9	-66.1	-15.4	12.48
18.8.2009	19:31:25	78	234.1	214.1	-63.2	-45.7	12.49
18.8.2009	19:31:30	76	235.7	215.7	-62.8	-42.9	12.49
18.8.2009	19:31:35	71.2	260.9	240.9	-70.3	-11.2	12.49
18.8.2009	19:31:40	72.1	246.5	226.5	-66.1	-28.7	12.49

18.8.2009	19:31:45	67.8	268.7	248.7	-67.7	-1.5	12.49
18.8.2009	19:31:50	72.5	266.8	246.8	-72.4	-4	12.49
18.8.2009	19:31:55	75.9	272.4	252.4	-75.8	3.2	12.49
18.8.2009	19:32:00	72.9	270.6	250.6	-72.9	0.7	12.49
18.8.2009	19:32:05	75.7	237.6	217.6	-63.9	-40.5	12.49
18.8.2009	19:32:10	72.7	234.1	214.1	-58.9	-42.6	12.48
18.8.2009	19:32:15	72.4	242.7	222.7	-64.3	-33.2	12.48
18.8.2009	19:32:20	77.9	230.3	210.3	-59.9	-49.7	12.49
18.8.2009	19:32:25	65.8	253.6	233.6	-63.1	-18.5	12.49
18.8.2009	19:32:30	70.6	254.5	234.5	-68	-18.9	12.49
18.8.2009	19:32:35	79	236.8	216.8	-66.1	-43.2	12.49
18.8.2009	19:32:40	78.2	260.8	240.8	-77.2	-12.6	12.49
18.8.2009	19:32:45	73.3	245.6	225.6	-66.8	-30.3	12.49
18.8.2009	19:32:50	71.1	245.6	225.6	-64.8	-29.3	12.49
18.8.2009	19:32:55	73	276.9	256.9	-72.5	8.7	12.49
18.8.2009	19:33:00	75.3	266	246	-75.1	-5.3	12.49
18.8.2009	19:33:05	73	251	231	-69.1	-23.8	12.49
18.8.2009	19:33:10	76.2	282.3	262.3	-74.5	16.2	12.48
18.8.2009	19:33:15	77	268.4	248.4	-76.9	-2.2	12.49
18.8.2009	19:33:20	75.3	253.6	233.6	-72.2	-21.2	12.48
18.8.2009	19:33:25	72.7	258.3	238.3	-71.2	-14.8	12.48
18.8.2009	19:33:30	71.1	243.3	223.3	-63.6	-31.9	12.48
18.8.2009	19:33:35	71.2	251.4	231.4	-67.5	-22.7	12.48
18.8.2009	19:33:40	75.2	269.2	249.2	-75.2	-1.1	12.49
18.8.2009	19:33:45	73.8	254.7	234.7	-71.2	-19.4	12.48
18.8.2009	19:33:50	71.4	229.9	209.9	-54.7	-46	12.49
18.8.2009	19:33:55	68.2	238.2	218.2	-57.9	-35.9	12.49
18.8.2009	19:34:00	69.4	244.6	224.6	-62.7	-29.8	12.49
18.8.2009	19:34:05	73.2	228	208	-54.4	-48.9	12.49
18.8.2009	19:34:10	73.3	256.8	236.8	-71.4	-16.7	12.49
18.8.2009	19:34:15	77.9	269.8	249.8	-77.9	-0.3	12.49
18.8.2009	19:34:20	79.7	260.8	240.8	-78.7	-12.7	12.49
18.8.2009	19:34:25	70	249.5	229.5	-65.6	-24.5	12.49
18.8.2009	19:34:30	75.2	267.3	247.3	-75.1	-3.6	12.48
18.8.2009	19:34:35	73.5	266.9	246.9	-73.4	-4	12.48
18.8.2009	19:34:40	75.2	262.3	242.3	-74.5	-10.1	12.48
18.8.2009	19:34:45	59.7	250.5	230.5	-56.3	-19.9	12.48
18.8.2009	19:34:50	72.6	229.4	209.4	-55.1	-47.2	12.48
18.8.2009	19:34:55	68.7	251.8	231.8	-65.2	-21.4	12.48
18.8.2009	19:35:00	70.9	244.7	224.7	-64.2	-30.3	12.48
18.8.2009	19:35:05	71.2	248.5	228.5	-66.2	-26.1	12.49
18.8.2009	19:35:10	73.3	245.6	225.6	-66.7	-30.3	12.49
18.8.2009	19:35:15	64.7	265.6	245.6	-64.6	-5	12.48

18.8.2009	19:35:20	58	262	242	-57.4	-8	12.49
18.8.2009	19:35:25	61.1	247.7	227.7	-56.5	-23.2	12.48
18.8.2009	19:35:30	63.5	227.5	207.5	-46.8	-42.9	12.49
18.8.2009	19:35:35	58.8	246.7	226.7	-54	-23.3	12.49
18.8.2009	19:35:40	68.2	250.7	230.7	-64.4	-22.5	12.49
18.8.2009	19:35:45	70	279	259	-69.1	10.9	12.49
18.8.2009	19:35:50	74.8	244.7	224.7	-67.7	-32	12.49
18.8.2009	19:35:55	69.5	250.4	230.4	-65.5	-23.3	12.48
18.8.2009	19:36:00	74	257	237	-72.1	-16.6	12.48
18.8.2009	19:36:05	70.3	261.5	241.5	-69.5	-10.4	12.49
18.8.2009	19:36:10	73.8	244.1	224.1	-66.4	-32.3	12.49
18.8.2009	19:36:15	69.1	237.4	217.4	-58.2	-37.3	12.48
18.8.2009	19:36:20	77.4	230	210	-59.3	-49.8	12.49
18.8.2009	19:36:25	76	241.5	221.5	-66.8	-36.3	12.49
18.8.2009	19:36:30	64.4	260.9	240.9	-63.6	-10.2	12.49
18.8.2009	19:36:35	72	258	238	-70.5	-14.9	12.49
18.8.2009	19:36:40	76.3	254.1	234.1	-73.3	-20.9	12.48
18.8.2009	19:36:45	65.6	262.2	242.2	-65	-8.9	12.48
18.8.2009	19:36:50	74.6	251.5	231.5	-70.8	-23.7	12.49
18.8.2009	19:36:55	66.6	237.5	217.5	-56.1	-35.8	12.49
18.8.2009	19:37:00	73.6	261.7	241.7	-72.8	-10.6	12.48
18.8.2009	19:37:05	65.8	228.3	208.3	-49.2	-43.8	12.48
18.8.2009	19:37:10	72.8	258.9	238.9	-71.5	-14	12.48
18.8.2009	19:37:15	69.7	272.7	252.7	-69.6	3.3	12.48
18.8.2009	19:37:20	74.4	268.1	248.1	-74.3	-2.5	12.48
18.8.2009	19:37:25	78.3	257.9	237.9	-76.5	-16.4	12.48
18.8.2009	19:37:30	70.1	252	232	-66.7	-21.7	12.48
18.8.2009	19:37:35	73.1	246.4	226.4	-66.9	-29.3	12.48
18.8.2009	19:37:40	75.6	233.9	213.9	-61	-44.6	12.48
18.8.2009	19:37:45	74.8	231.3	211.3	-58.3	-46.8	12.49
18.8.2009	19:37:50	76.2	252.5	232.5	-72.7	-22.9	12.49
18.8.2009	19:37:55	73.2	267.2	247.2	-73.1	-3.6	12.48
18.8.2009	19:38:00	66.6	264.7	244.7	-66.3	-6.2	12.48

av cm/sek	58.94755
stdv	10.97713
m/sek	0.589475
av míla/klst	1.147087

Data from Langeyjarsund

		hraði	stefna	Leiðrétt - 20°	a/v	n/s	hiti
18.8.2009	20:19:00	47	180.1	160.1	-0.1	-47	11.69
18.8.2009	20:19:05	46.7	188.8	168.8	-7.2	-46.2	11.69
18.8.2009	20:19:10	40.9	172.3	152.3	5.5	-40.5	11.69
18.8.2009	20:19:15	31.5	193.2	173.2	-7.2	-30.7	11.7
18.8.2009	20:19:20	24.5	205.8	185.8	-10.7	-22	11.7
18.8.2009	20:19:25	22.5	250	230	-21.1	-7.7	11.69
18.8.2009	20:19:30	30.8	315.1	295.1	-21.7	21.9	11.69
18.8.2009	20:19:35	45.6	353.5	333.5	-5.1	45.3	11.7
18.8.2009	20:19:40	58.9	346.2	326.2	-14	57.2	11.7
18.8.2009	20:19:45	55.7	2.3	-17.7	2.2	55.7	11.69
18.8.2009	20:19:50	55.3	356.6	336.6	-3.2	55.2	11.69
18.8.2009	20:19:55	49.2	352.1	332.1	-6.8	48.8	11.7
18.8.2009	20:20:00	44.4	359.9	339.9	-0.1	44.4	11.69
18.8.2009	20:20:05	38.9	348.8	328.8	-7.6	38.1	11.68
18.8.2009	20:20:10	26.8	325.6	305.6	-15.1	22.1	11.69
18.8.2009	20:20:15	17.2	299.4	279.4	-14.9	8.4	11.7
18.8.2009	20:20:20	14.4	239.7	219.7	-12.4	-7.3	11.7
18.8.2009	20:20:25	29.5	188.7	168.7	-4.4	-29.2	11.69
18.8.2009	20:20:30	35.8	173.4	153.4	4.1	-35.5	11.69
18.8.2009	20:20:35	37.2	167	147	8.3	-36.2	11.69
18.8.2009	20:20:40	44	172.1	152.1	6.1	-43.6	11.69
18.8.2009	20:20:45	39	172.7	152.7	5	-38.6	11.7
18.8.2009	20:20:50	35.4	179.1	159.1	0.5	-35.4	11.69
18.8.2009	20:20:55	28.7	176.9	156.9	1.5	-28.6	11.69
18.8.2009	20:21:00	30.9	192.7	172.7	-6.8	-30.2	11.69
18.8.2009	20:21:05	24.8	201.3	181.3	-9	-23.1	11.7
18.8.2009	20:21:10	19.5	250.3	230.3	-18.4	-6.6	11.7
18.8.2009	20:21:15	17.6	296.9	276.9	-15.7	7.9	11.69
18.8.2009	20:21:20	22.2	337.5	317.5	-8.5	20.5	11.69
18.8.2009	20:21:25	25.9	337.1	317.1	-10.1	23.8	11.69
18.8.2009	20:21:30	37.5	0.5	-19.5	0.3	37.5	11.7
18.8.2009	20:21:35	42.5	354.7	334.7	-3.9	42.3	11.7
18.8.2009	20:21:40	38.3	0.9	-19.1	0.6	38.3	11.7
18.8.2009	20:21:45	34.4	357.5	337.5	-1.5	34.4	11.71
18.8.2009	20:21:50	31.5	320.3	300.3	-20.1	24.2	11.69
18.8.2009	20:21:55	21.1	298.7	278.7	-18.5	10.1	11.7
18.8.2009	20:22:00	26.9	214.1	194.1	-15.1	-22.3	11.71
18.8.2009	20:22:05	42.4	180.3	160.3	-0.2	-42.4	11.72

18.8.2009	20:22:10	47.8	177.2	157.2	2.4	-47.7	11.7
18.8.2009	20:22:15	61	164.9	144.9	15.9	-58.9	11.7
18.8.2009	20:22:20	62.9	174.3	154.3	6.3	-62.6	11.7
18.8.2009	20:22:25	66.1	177.6	157.6	2.7	-66.1	11.69
18.8.2009	20:22:30	54.8	179.4	159.4	0.6	-54.8	11.69
18.8.2009	20:22:35	45.4	188.2	168.2	-6.5	-45	11.69
18.8.2009	20:22:40	25.4	202.3	182.3	-9.6	-23.5	11.7
18.8.2009	20:22:45	18.5	254.3	234.3	-17.8	-5	11.69
18.8.2009	20:22:50	25.5	325.7	305.7	-14.4	21.1	11.7
18.8.2009	20:22:55	43.7	330.9	310.9	-21.2	38.2	11.69
18.8.2009	20:23:00	49.1	342.4	322.4	-14.9	46.8	11.69
18.8.2009	20:23:05	56.2	359.5	339.5	-0.5	56.2	11.69
18.8.2009	20:23:10	56.5	354.7	334.7	-5.2	56.2	11.69
18.8.2009	20:23:15	47.3	349.8	329.8	-8.4	46.6	11.69
18.8.2009	20:23:20	37.6	353.1	333.1	-4.5	37.3	11.7
18.8.2009	20:23:25	33.8	346.9	326.9	-7.7	33	11.69
18.8.2009	20:23:30	17.6	261.6	241.6	-17.4	-2.6	11.72
18.8.2009	20:23:35	27.6	195.4	175.4	-7.3	-26.6	11.7
18.8.2009	20:23:40	44.7	175.3	155.3	3.7	-44.6	11.69
18.8.2009	20:23:45	49.3	172.5	152.5	6.4	-48.9	11.69
18.8.2009	20:23:50	50	166.5	146.5	11.7	-48.6	11.69
18.8.2009	20:23:55	47.5	180.7	160.7	-0.6	-47.5	11.69
18.8.2009	20:24:00	38.7	181	161	-0.7	-38.7	11.69
18.8.2009	20:24:05	38	188.6	168.6	-5.7	-37.6	11.69
18.8.2009	20:24:10	30.6	182.9	162.9	-1.5	-30.6	11.69
18.8.2009	20:24:15	28.5	224.1	204.1	-19.8	-20.5	11.69
18.8.2009	20:24:20	18.8	279.7	259.7	-18.6	3.2	11.69
18.8.2009	20:24:25	23	325	305	-13.2	18.8	11.69
18.8.2009	20:24:30	36.6	351.4	331.4	-5.5	36.2	11.69
18.8.2009	20:24:35	45.3	353.4	333.4	-5.2	45	11.69
18.8.2009	20:24:40	42	358.9	338.9	-0.8	42	11.69
18.8.2009	20:24:45	43.6	350.5	330.5	-7.2	43.1	11.69
18.8.2009	20:24:50	37	4.6	-15.4	3	36.8	11.69
18.8.2009	20:24:55	32.2	358.8	338.8	-0.7	32.2	11.69
18.8.2009	20:25:00	18.5	308.6	288.6	-14.5	11.6	11.69
18.8.2009	20:25:05	42.5	190.1	170.1	-7.5	-41.8	11.7
18.8.2009	20:25:10	56.8	178.4	158.4	1.6	-56.8	11.69
18.8.2009	20:25:15	56.4	177.3	157.3	2.6	-56.4	11.69
18.8.2009	20:25:20	54	179.7	159.7	0.3	-54	11.69
18.8.2009	20:25:25	54.3	173.3	153.3	6.3	-53.9	11.69
18.8.2009	20:25:30	45.5	183.7	163.7	-2.9	-45.4	11.69
18.8.2009	20:25:35	41	185.2	165.2	-3.7	-40.8	11.69
18.8.2009	20:25:40	29.6	198.4	178.4	-9.3	-28.1	11.7

18.8.2009	20:25:45	18.6	238.6	218.6	-15.9	-9.7	11.7
18.8.2009	20:25:50	22.6	310.4	290.4	-17.2	14.6	11.7
18.8.2009	20:25:55	32.5	348.5	328.5	-6.5	31.8	11.7
18.8.2009	20:26:00	50.8	351.2	331.2	-7.8	50.2	11.69
18.8.2009	20:26:05	55.3	355.5	335.5	-4.3	55.1	11.69
18.8.2009	20:26:10	55.1	352.4	332.4	-7.3	54.6	11.69
18.8.2009	20:26:15	51.6	356.4	336.4	-3.3	51.5	11.69
18.8.2009	20:26:20	40.6	344.8	324.8	-10.7	39.2	11.69
18.8.2009	20:26:25	31	327	307	-16.9	26	11.69
18.8.2009	20:26:30	26.9	212.8	192.8	-14.6	-22.6	11.69
18.8.2009	20:26:35	48.8	182.8	162.8	-2.4	-48.7	11.69
18.8.2009	20:26:40	58.4	173.9	153.9	6.2	-58.1	11.69
18.8.2009	20:26:45	65.7	166	146	15.9	-63.8	11.69
18.8.2009	20:26:50	58.9	179.7	159.7	0.3	-58.9	11.69
18.8.2009	20:26:55	42.2	185	165	-3.7	-42	11.69
18.8.2009	20:27:00	34.6	193.4	173.4	-8	-33.7	11.7
18.8.2009	20:27:05	30.4	195.9	175.9	-8.3	-29.3	11.7
18.8.2009	20:27:10	21.4	266.1	246.1	-21.4	-1.4	11.7
18.8.2009	20:27:15	27.4	323	303	-16.5	21.9	11.7
18.8.2009	20:27:20	40.3	354.9	334.9	-3.6	40.1	11.7
18.8.2009	20:27:25	52.1	348.4	328.4	-10.4	51	11.69
18.8.2009	20:27:30	56.7	353.3	333.3	-6.6	56.3	11.69
18.8.2009	20:27:35	59.5	356.4	336.4	-3.8	59.4	11.69
18.8.2009	20:27:40	49.7	345	325	-12.9	48	11.69
18.8.2009	20:27:45	38.3	356.6	336.6	-2.3	38.2	11.69
18.8.2009	20:27:50	33.8	339.2	319.2	-12	31.6	11.7
18.8.2009	20:27:55	19.6	309.7	289.7	-15.1	12.5	11.69
18.8.2009	20:28:00	16	277.7	257.7	-15.9	2.1	11.7
18.8.2009	20:28:05	25.6	188	168	-3.6	-25.3	11.73
18.8.2009	20:28:10	28.6	182.1	162.1	-1.1	-28.5	11.71
18.8.2009	20:28:15	38.4	175.7	155.7	2.9	-38.3	11.72
18.8.2009	20:28:20	46.4	167.5	147.5	10	-45.3	11.73
18.8.2009	20:28:25	48.4	180.6	160.6	-0.5	-48.4	11.72
18.8.2009	20:28:30	42.6	175.3	155.3	3.5	-42.5	11.69
18.8.2009	20:28:35	32.2	178	158	1.1	-32.2	11.69
18.8.2009	20:28:40	30.5	182.7	162.7	-1.4	-30.4	11.69
18.8.2009	20:28:45	22.8	211.8	191.8	-12	-19.4	11.69
18.8.2009	20:28:50	20.9	279.8	259.8	-20.6	3.5	11.68
18.8.2009	20:28:55	26.5	321.3	301.3	-16.6	20.7	11.68
18.8.2009	20:29:00	39	338.2	318.2	-14.5	36.2	11.68
18.8.2009	20:29:05	47	341.1	321.1	-15.2	44.4	11.69
18.8.2009	20:29:10	50.7	352.6	332.6	-6.5	50.2	11.68
18.8.2009	20:29:15	42.8	4.2	-15.8	3.2	42.7	11.68

18.8.2009	20:29:20	44.8	356.8	336.8	-2.5	44.7	11.7
18.8.2009	20:29:25	42.9	349.3	329.3	-7.9	42.2	11.71
18.8.2009	20:29:30	34.7	324.5	304.5	-20.1	28.2	11.76
18.8.2009	20:29:35	23.9	305.5	285.5	-19.5	13.9	11.78
18.8.2009	20:29:40	15.7	253.8	233.8	-15.1	-4.4	11.77
18.8.2009	20:29:45	24.6	197.1	177.1	-7.3	-23.6	11.75
18.8.2009	20:29:50	36.1	160.2	140.2	12.2	-33.9	11.75
18.8.2009	20:29:55	42.9	169	149	8.2	-42.1	11.74
18.8.2009	20:30:00	44.1	171.9	151.9	6.2	-43.7	11.71
18.8.2009	20:30:05	50.5	175.2	155.2	4.2	-50.3	11.71
18.8.2009	20:30:10	39.3	182.2	162.2	-1.5	-39.3	11.72
18.8.2009	20:30:15	35.7	186.9	166.9	-4.3	-35.4	11.69
18.8.2009	20:30:20	31.7	189.3	169.3	-5.1	-31.3	11.69
18.8.2009	20:30:25	25.2	200.2	180.2	-8.7	-23.7	11.69
18.8.2009	20:30:30	21.9	259.2	239.2	-21.5	-4.1	11.69
18.8.2009	20:30:35	20.4	301.6	281.6	-17.3	10.7	11.69
18.8.2009	20:30:40	28.4	336	316	-11.5	25.9	11.69
18.8.2009	20:30:45	33.9	350.3	330.3	-5.7	33.4	11.68
18.8.2009	20:30:50	41.4	351.1	331.1	-6.4	40.9	11.68
18.8.2009	20:30:55	38.9	347.2	327.2	-8.6	37.9	11.69
18.8.2009	20:31:00	38.4	340.3	320.3	-13	36.1	11.69
18.8.2009	20:31:05	31.7	342.5	322.5	-9.5	30.2	11.69
18.8.2009	20:31:10	32.9	5.3	-14.7	3	32.7	11.7
18.8.2009	20:31:15	24.6	321.1	301.1	-15.4	19.1	11.72
18.8.2009	20:31:20	28.6	208.1	188.1	-13.5	-25.3	11.75
18.8.2009	20:31:25	40.5	184.4	164.4	-3.1	-40.4	11.76
18.8.2009	20:31:30	38.2	181.6	161.6	-1	-38.2	11.71
18.8.2009	20:31:35	57.2	171.9	151.9	8.1	-56.7	11.71
18.8.2009	20:31:40	64.1	168.4	148.4	12.9	-62.8	11.69
18.8.2009	20:31:45	61.8	170.3	150.3	10.5	-60.9	11.68
18.8.2009	20:31:50	57.7	178	158	2	-57.7	11.69
18.8.2009	20:31:55	39.8	185	165	-3.5	-39.7	11.69
18.8.2009	20:32:00	29.1	189.5	169.5	-4.8	-28.7	11.69

E Samples of calculations that STEM carries out.

Mean Flow ms^{-1}	Max Flow ms^{-1}	Mean Hyd Pow kWm^{-2}	Max Hyd Pow kWm^{-2}	Mean Dev Pow kW	Max Dev Pow kW	Device Output $MWha^{-1}$
0.83	1.78	0.44	2.91	32.99	216	289

HOME PARK

	Count hrs	Time days	M_2 ms^{-1}	S_2 ms^{-1}	M_4 ms^{-1}	K_2 ms^{-1}	K_1 ms^{-1}	O_1 ms^{-1}	Total ms^{-1}	Total ms^{-1} Rectified	u less Th ms^{-1}	Power kWm^{-2}	Power kW	Power max at installed kW	Power max at installed MW
amplitude			1.28	0.26	0.00	0.26	0.00	0.00							
period			12.4206	12.0000	6.0000	11.9670	23.930	25.820							
	0	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0.00
	1	1	0.62	0.13	0.00	0.13	0.00	0.00	0.87	0.87	0.00	0.00	0.00	0	0.00
	2	1	1.08	0.22	0.00	0.22	0.00	0.00	1.52	1.52	1.52	1.81	134.41	134	0.13
	3	1	1.27	0.26	0.00	0.25	0.00	0.00	1.78	1.78	1.78	2.91	215.77	216	0.22
	4	1	1.15	0.22	0.00	0.22	0.00	0.00	1.59	1.59	1.59	2.05	152.25	152	0.15
	5	1	0.73	0.13	0.00	0.13	0.00	0.00	0.99	0.99	0.00	0.00	0.00	0	0.00
	6	1	0.14	0.00	0.00	0.00	0.00	0.00	0.13	0.13	0.00	0.00	0.00	0	0.00
	7	1	-0.50	-0.13	0.00	-0.13	0.00	0.00	-0.75	0.75	0.00	0.00	0.00	0	0.00
	8	1	-1.00	-0.22	0.00	-0.22	0.00	0.00	-1.45	1.45	1.45	1.55	115.08	115	0.12
	9	1	-1.26	-0.26	0.00	-0.25	0.00	0.00	-1.77	1.77	1.77	2.84	210.58	211	0.21
	10	1	-1.20	-0.22	0.00	-0.22	0.00	0.00	-1.64	1.64	1.64	2.26	167.58	168	0.17
	11	1	-0.84	-0.13	0.00	-0.12	0.00	0.00	-1.09	1.09	1.09	0.67	49.40	49	0.05
	12	1	-0.27	0.00	0.00	0.00	0.00	0.00	-0.26	0.26	0.00	0.00	0.00	0	0.00
	13	1	0.37	0.13	0.00	0.13	0.00	0.00	0.63	0.63	0.00	0.00	0.00	0	0.00
	14	1	0.91	0.22	0.00	0.22	0.00	0.00	1.36	1.36	1.36	1.28	95.28	95	0.10
	15	1	1.23	0.26	0.00	0.25	0.00	0.00	1.74	1.74	1.74	2.70	200.50	201	0.20
	16	1	1.24	0.22	0.00	0.22	0.00	0.00	1.68	1.68	1.68	2.42	179.52	180	0.18
	17	1	0.94	0.13	0.00	0.12	0.00	0.00	1.19	1.19	1.19	0.86	63.50	63	0.06
	18	1	0.40	0.00	0.00	-0.01	0.00	0.00	0.39	0.39	0.00	0.00	0.00	0	0.00
	19	1	-0.24	-0.13	0.00	-0.13	0.00	0.00	-0.50	0.50	0.00	0.00	0.00	0	0.00
	20	1	-0.81	-0.22	0.00	-0.22	0.00	0.00	-1.26	1.26	1.26	1.02	76.01	76	0.08
	21	1	-1.19	-0.26	0.00	-0.25	0.00	0.00	-1.70	1.70	1.70	2.51	186.14	186	0.19
	22	1	-1.26	-0.22	0.00	-0.22	0.00	0.00	-1.70	1.70	1.70	2.52	187.34	187	0.19
	23	1	-1.02	-0.13	0.00	-0.12	0.00	0.00	-1.27	1.27	1.27	1.05	78.08	78	0.08
	24	2	-0.53	0.00	0.00	0.01	0.00	0.00	-0.52	0.52	0.00	0.00	0.00	0	0.00
	25	2	0.10	0.13	0.00	0.14	0.00	0.00	0.37	0.37	0.00	0.00	0.00	0	0.00
	26	2	0.71	0.22	0.00	0.23	0.00	0.00	1.15	1.15	1.15	0.78	58.12	58	0.06

....

4370	190	-1.10	0.22	0.00	0.22	0.00	0.00	-0.65	0.65	0.00	0.00	0.00	0	0.00
4371	191	-0.65	0.26	0.00	0.25	0.00	0.00	-0.14	0.14	0.00	0.00	0.00	0	0.00
4372	191	-0.03	0.22	0.00	0.22	0.00	0.00	0.40	0.40	0.00	0.00	0.00	0	0.00
4373	191	0.59	0.13	0.00	0.12	0.00	0.00	0.84	0.84	0.00	0.00	0.00	0	0.00
4374	191	1.06	0.00	0.00	-0.01	0.00	0.00	1.05	1.05	1.05	0.60	44.66	45	0.04
4375	191	1.27	-0.13	0.00	-0.13	0.00	0.00	1.01	1.01	1.01	0.53	39.05	39	0.04
4376	191	1.16	-0.22	0.00	-0.23	0.00	0.00	0.71	0.71	0.00	0.00	0.00	0	0.00
4377	191	0.76	-0.26	0.00	-0.25	0.00	0.00	0.25	0.25	0.00	0.00	0.00	0	0.00
4378	191	0.17	-0.22	0.00	-0.22	0.00	0.00	-0.27	0.27	0.00	0.00	0.00	0	0.00
4379	191	-0.47	-0.13	0.00	-0.12	0.00	0.00	-0.71	0.71	0.00	0.00	0.00	0	0.00
4380	191	-0.98	0.00	0.00	0.01	0.00	0.00	-0.97	0.97	0.00	0.00	0.00	0	0.00
4381	191	-1.25	0.13	0.00	0.14	0.00	0.00	-0.99	0.99	0.00	0.00	0.00	0	0.00
4382	191	-1.21	0.22	0.00	0.23	0.00	0.00	-0.76	0.76	0.00	0.00	0.00	0	0.00
4383	191	-0.86	0.26	0.00	0.25	0.00	0.00	-0.35	0.35	0.00	0.00	0.00	0	0.00
4384	191	-0.30	0.22	0.00	0.21	0.00	0.00	0.13	0.13	0.00	0.00	0.00	0	0.00
4385	191	0.34	0.13	0.00	0.12	0.00	0.00	0.58	0.58	0.00	0.00	0.00	0	0.00
4386	191	0.89	0.00	0.00	-0.01	0.00	0.00	0.88	0.88	0.00	0.00	0.00	0	0.00

F Questionnaire

Questionnaire concerning the harnessing of tidal energy

Question 1

Gender: Female 3, Male 17

Age (20-30) (30-40)2 (40-50)**7** (50-60)**2** (60-70)**7**

Question 2

Who are you?

Local resident	8
Policy maker	
Local farmer/ landowner	7
Government official	1
Representative of NGO	1
Other	4

Comments:

Question 3

Would you attend a stakeholder meeting to discuss tidal power plant in your area?

Yes	17
No	1

Comments :

Question 4

Do you understand what the project will do, what it will look like and what the impact of the project will be?

Yes 18

No 0

Comments:

Question 5

Do you agree with building tidal power plants in the Westfjords?

Yes 15

No 1

Don't know 2

Comments

Question 6

Do you think the project will have a positive or negative impact on you?

Positive 13

Negative 1

Don't know 2

Comments

Question 7

Do you think the project will have economic benefits?

Yes 13

No 0

Don't know 3

Local economic benefits of jobs during construction 10

Local economic benefits of jobs during operation 11

Other local economic benefits 0

Question 8

Do you think the project will have negative impact on the environment?

Yes 6

No 6

Don't know 5

If yes, in what way? Check all applicable (More than one answer allowed)

Pollution from the construction and siting of the turbines	3
Sight spoiling, negative impacts to the aesthetic enjoyment of the ocean	1
Impact on commercial and recreational fishing	1
Impact on water recreation usages	0
Impact on water based tourism usages in the area	1
Impact on local property values	0
Impact on seaweed harvesting	5
Impact on wildlife	4
Impact on birds	1

Comments :

Question 9

Do you think that government rules and regulations guarantee good, safe and clean construction and operation?

Yes 6

No 2

Don't know 8

Comments :

Question 10

Do you think there will be conflict concerning this project?

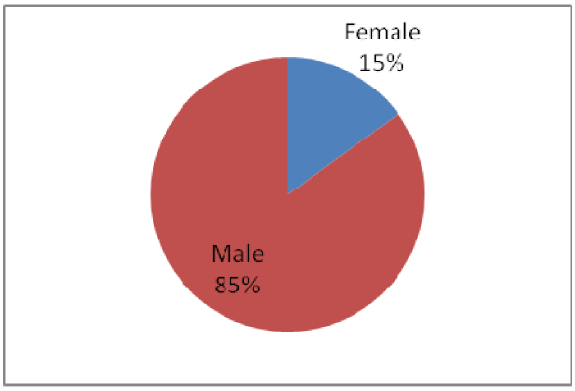
Yes 11

No 2

Don't know 4

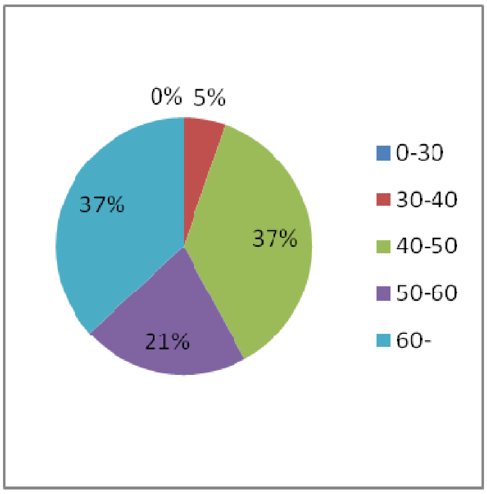
Questionnaire concerning the harnessing of tidal energy

Female	3
Male	17



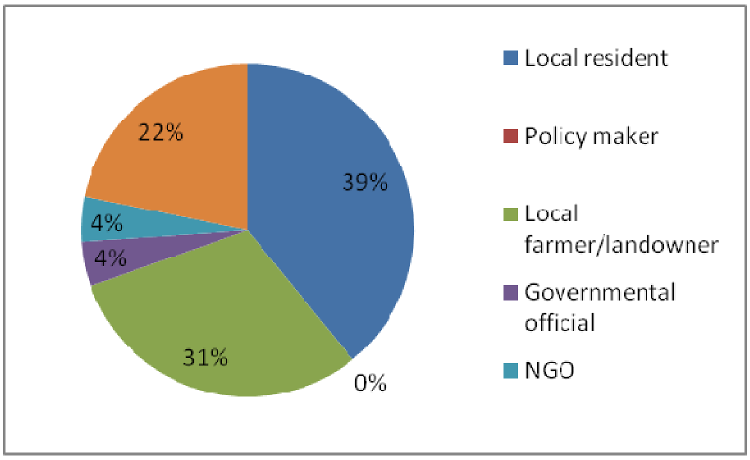
Q1
Age

0-30	0
30-40	1
40-50	7
50-60	4
60-85	7



Q2
Who are you?

Local resident	9
Policy maker	0
Local farmer/landowner	7
Governmental official	1
NGO	1
Other	5

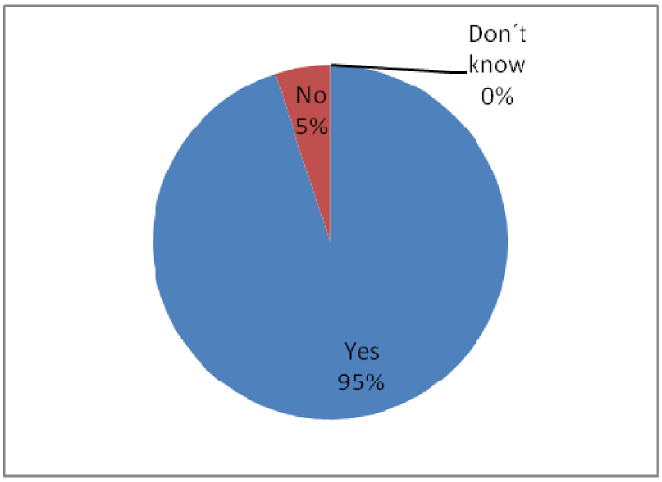


Comments:

Q3

Would you attend a stakeholder meeting to discuss tidal power plant in your area?

Yes	19
No	1
Don´t know	0



Q4

Do you understand what the project will do, what it will look like and what the impact of the project will be?

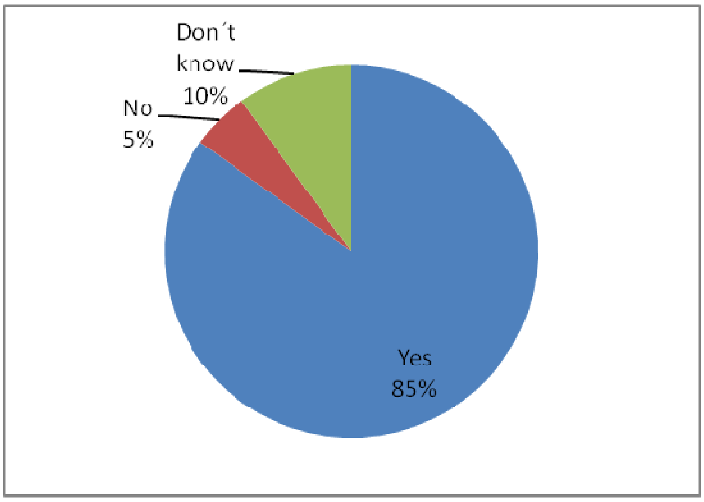
Yes	20
No	0

Q 5

Do you agree with building tidal power plants in Þorskafjörður?

Yes	17
No	1
Don´t know	2

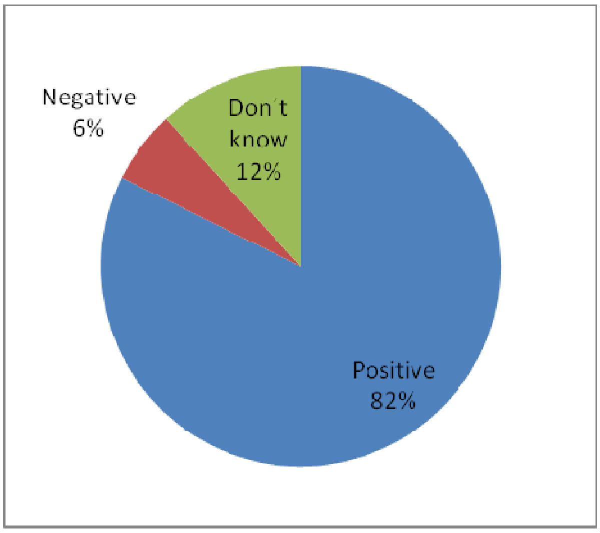
Comments: Positive. Need more information.



Q6

Do you think the project will have a positive or negative impact on you?

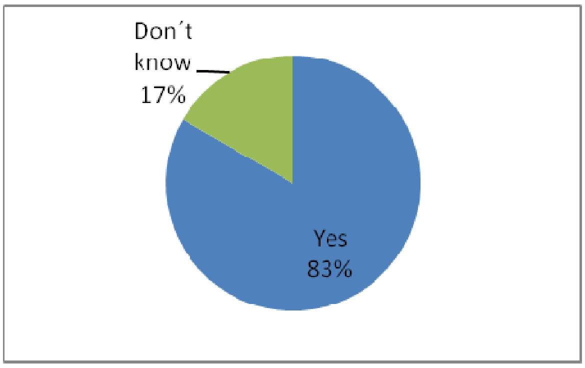
Positive	14
Negative	1
Don´t know	2



Q 7

Do you think the project will have economic benefits?

Yes	15	
No		0
Don´t know	3	



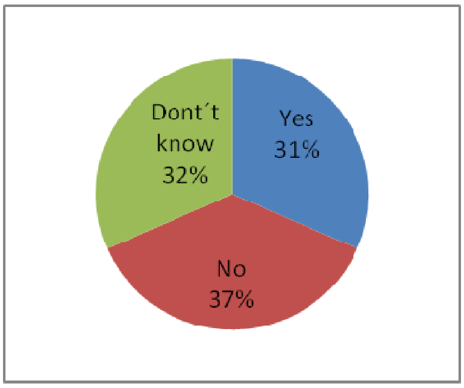
Local economic benefits of jobs during construction	10
Local economic benefits of jobs during operation	11
Other local economic benefits	0

Comments:

Q 8

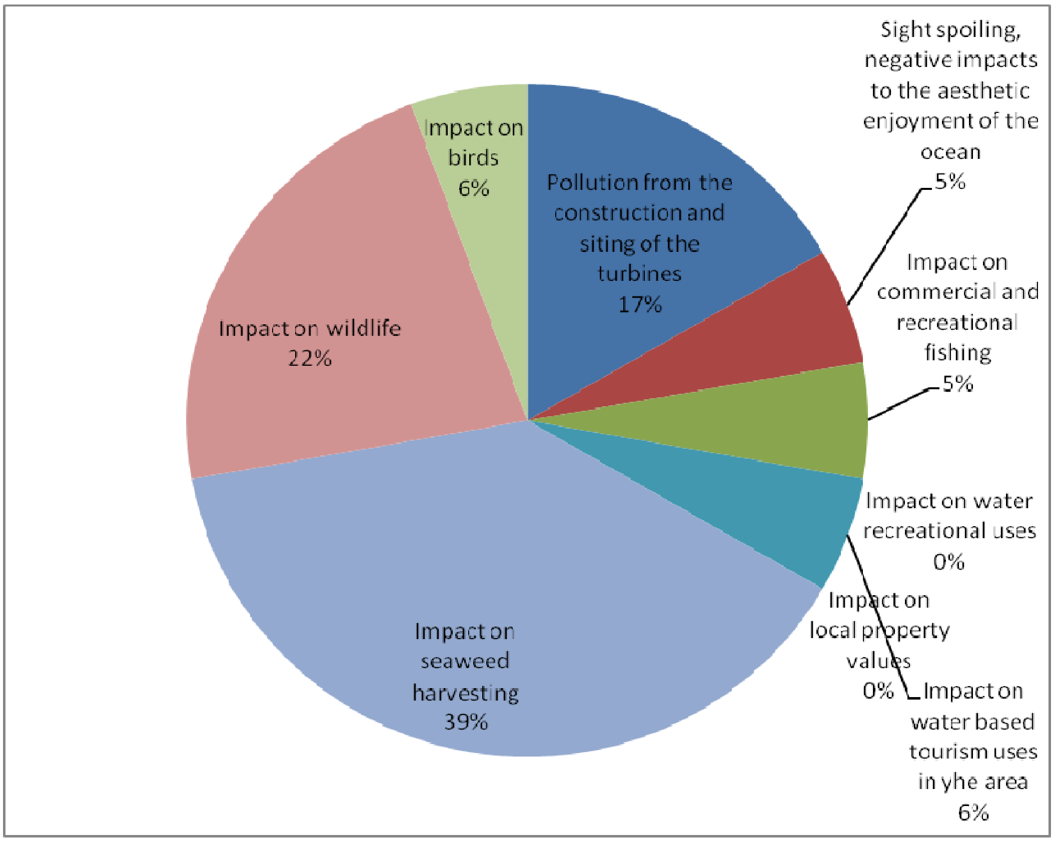
Do you think the project will have negative impact on the environment?

Yes	6
No	7
Dont´t know	6



If yes, in what way? Check all applicable (More than one answer allowed)

Pollution from the construction and siting of the turbines	3
Sight spoiling, negative impacts to the aesthetic enjoyment of the ocean	1
Impact on commercial and recreational fishing	1
Impact on water recreational uses	0
Impact on water based tourism uses in yhe area	1
Impact on local property values	0
Impact on seaweed harvesting	7
Impact on wildlife	4
Impact on birds	1



Q 10

Do you think there will be conflict concerning this project?

Yes	11
No	4
Don´t know	4

Comments: Environmental issues. Between local inhabitants. Environmentalists.