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Energy consumption in Norwegian sea food industry

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TECHNICAL REPORT

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This report is deliverable D 3.3.2 in the CREATIV project.

This report aims to collect the data available on the energy consumption in the sea food industry, and show the potential for increased energy efficiency. Main focus will be on cooling and freezing processes.

The data are collected from an Enova report on potential for increased energy efficiency in the food industry[1], two COWI reports[2, 3] on possibilities for reduction of energy consumption in pelagic and hatchery-produced fish industry respectively and two SINTEF reports [4, 5] on energy usage in clip fish and hatchery-produced fish industry. Some new data is also collected from the SSB database.

The data available shows that there are large potentials for reduction in energy consumption in the sea food industry, and especially the pelagic and hatchery produced fish industry. For the white and red fish industry, there are indications of large reduction potentials, but more data is needed to describe the problem areas and propose solutions.

KEYWORDS

SELECTED BY AUTHOR(S)		
	Sea food	
	Energy	

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1 INTRODUCTION

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According to the Enova report[1], the sea food industry (including hatchery fish production) represents 28 % for the energy consumption in the food production industry (see Figure 1).

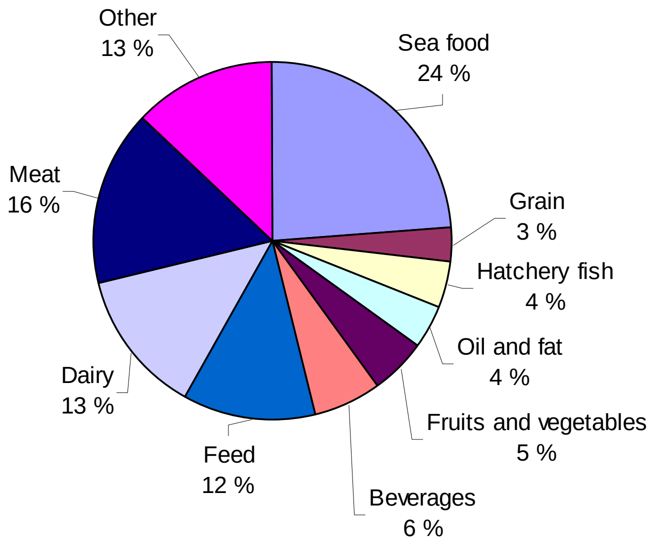

Figure 1: Distribution of energy consumption in food production industry[1]

2 OVERVIEW OF ENERGY USAGE IN SEA FOOD INDUSTRY

The sea food industry can be divided into many sub categories, such as pelagic, clipfish, white fish and red fish. This overview includes the energy usage in the industry that process and conserve fish after it is caught. Therefore hatchery-produced fish for stocking is not included in this overview (see Chapter 5 for information on the hatchery-produced fish industry). Figure 2 shows the total purchased energy in the sea food industry. According to Enova [1], production of fish meal represents 75 % of the thermal energy consumption (oil and gas).

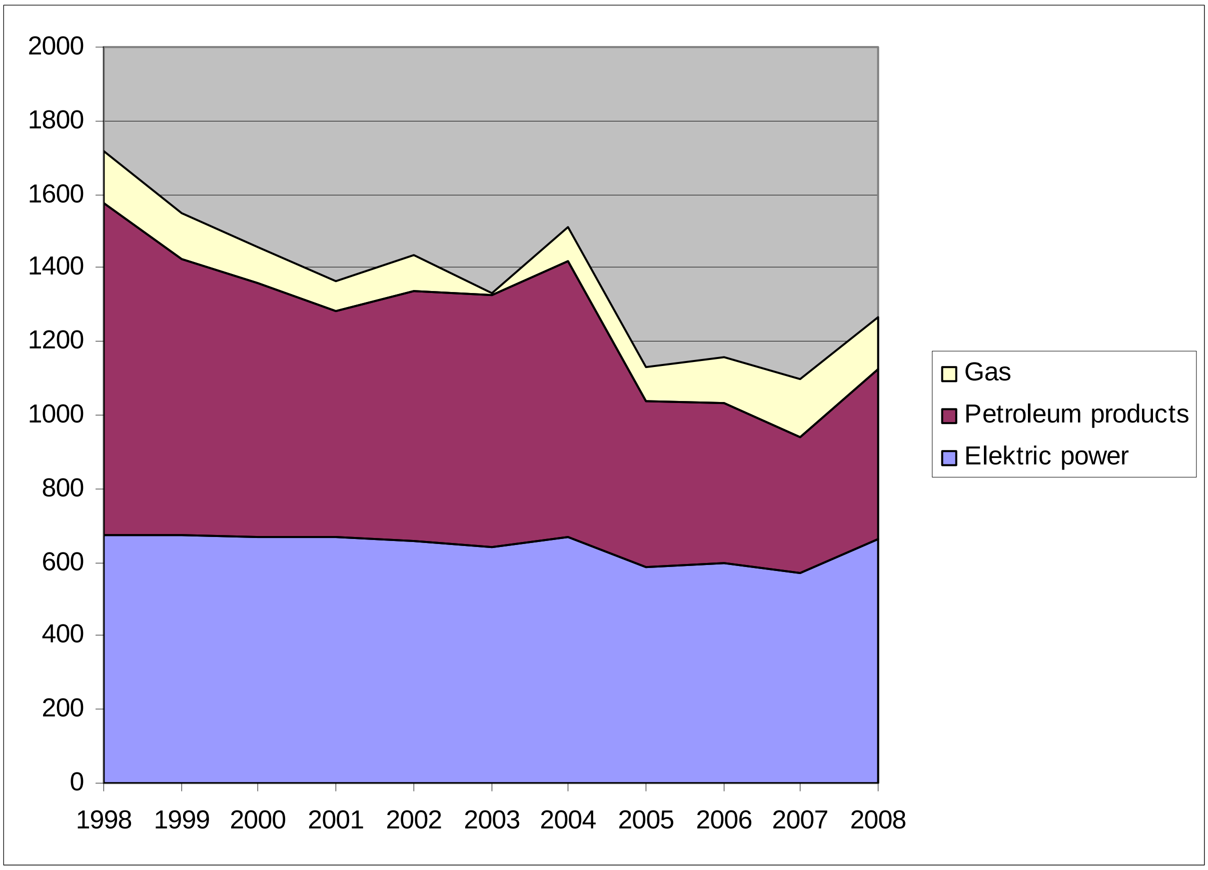

Figure 2: Purchased energy in sea food industry [6].

In 2004 and 2008 Enova listed the specific energy consumption of some subcategories in the Sea food industry (Table 1). The numbers are based on data from the members of the Enova industry network (12 % of the companies in sea food industry are members of this network [1]), and show the difference between the average specific energy usage and the lowest. One can see that within all sectors (except shellfish, where no data were found for 2008) both the average and the lowest specific energy consumption were reduced significantly. However, the big difference between the average and the lowest consumption in 2008 indicate a large potential for further reduction in energy usage.

Table 1: Specific energy consumption [7, 8]

	Specific Energy consumption (kWh/ton)					
	2004		2008		Reduction	
Category	**Average**	**Lowest**	**Average**	**Lowest**	**Average**	**Lowest**
White fish	732	273	696	237	0,05	0,13
Farmed fish	13.443	6.538	10.821	4.684	0,20	0,28
Pelagic	253	194	195	118	0,23	0,39
Shellfish	1.003	909	N/A	N/A	N/A	N/A
Abattoir	149	104	112	76	0,25	0,27

3 ESTIMATION OF ENERGY REDUCTION POTENTIAL

To get an estimate of the production of the different sub categories, data has been extracted from the exports statistic for 2008 from the Norwegian Seafood Export Council (NSEC). The data is given in very detailed categories and is therefore summarized in higher-order categories. Only the subcategories with higher export value than 60.000 kNOK is counted for in the summarization. However, as seen in Table 2, this includes 93 % of the total amount of exported sea food. The red fish industry is a farmed fish industry and belongs to that category in Table 1. Only caught (not farmed) cod is included in the white fish category.

If one assumes that the rest of the exported fish is distributed similar to that in Table 2, these four categories will represent 93 % of all exported sea food products (on weight basis).

Table 2: Distribution of exported fish with export value above 60.000 kNOK [9]

Category	Treatment	Amount [ton]	Value [kNOK]
Red fish	Fresh	592.461	16.505.425
	Frozen	98.087	2.929.279
White fish	Fresh	33.524	971.128
	Frozen	129.612	2.529.739
Pelagic	Fresh	82.327	396.888
	Frozen	858.696	5.925.801
Clip fish	Dried	82.258	5.700.764
SUM		**1.876.965**	**34.959.024**
% total		0,81	0,89
Other		284.046	2.035.230
SUM		**2.161.011**	**36.994.254**
% total		0,93	0,95

For estimation of the energy needed in an effective production line, calculations done during the project “Fremtidens ENØK bedrift i fiskeriindustrien” are used [4, 10].

These calculations only include the cooling duty needed for processes such as freezing, storage and production of ice. In addition, other processes and daily operation of the installation consumes some energy. However, the COWI report [2] state that in an average pelagic installation, freezing and storage represents 80 – 85 % of the total energy consumption. In other categories, the amount energy used on other processes is somewhat higher. Enovas general distribution of energy demand in the fish processing industry is shown in Figure 3. Farmed fish specific processes are not included in this overview.

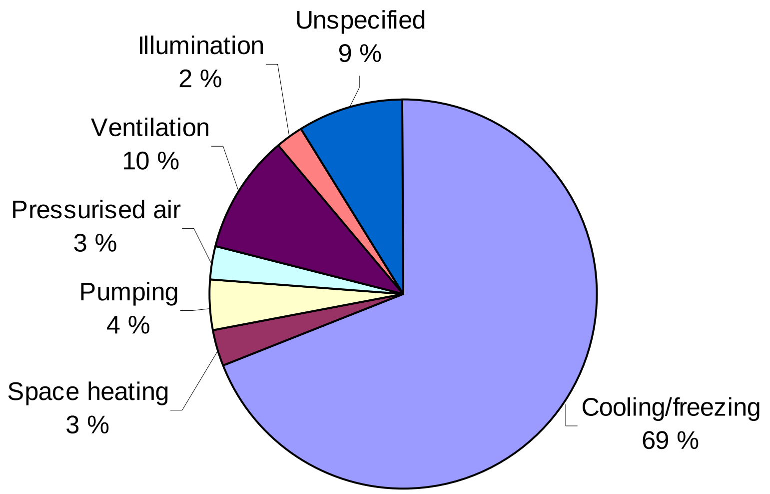

Figure 3: General distribution of energy demand at fish processing plants [1]

3.1 Freezing

Magnussen and Nordtvedt [10] estimates the energy consumption to be about 109 kWh/kg for continuous freezing of cod. This is when the installation is used to its full capacity. The energy usage would be a bit higher, since this is not always the case. However, since this report is meant to show the minimum energy consumption, this number is used. In addition the cooling duty will vary with different species. Therefore the energy consumption for freezing of the different categories are corrected based on the enthalpy difference during freezing for each product. Figure 4 shows the specific and absolute energy consumption for frozen fish products. For the absolute values, the numbers listed in Table 2 are used, while the adjusted absolute values should represent all exported fish.

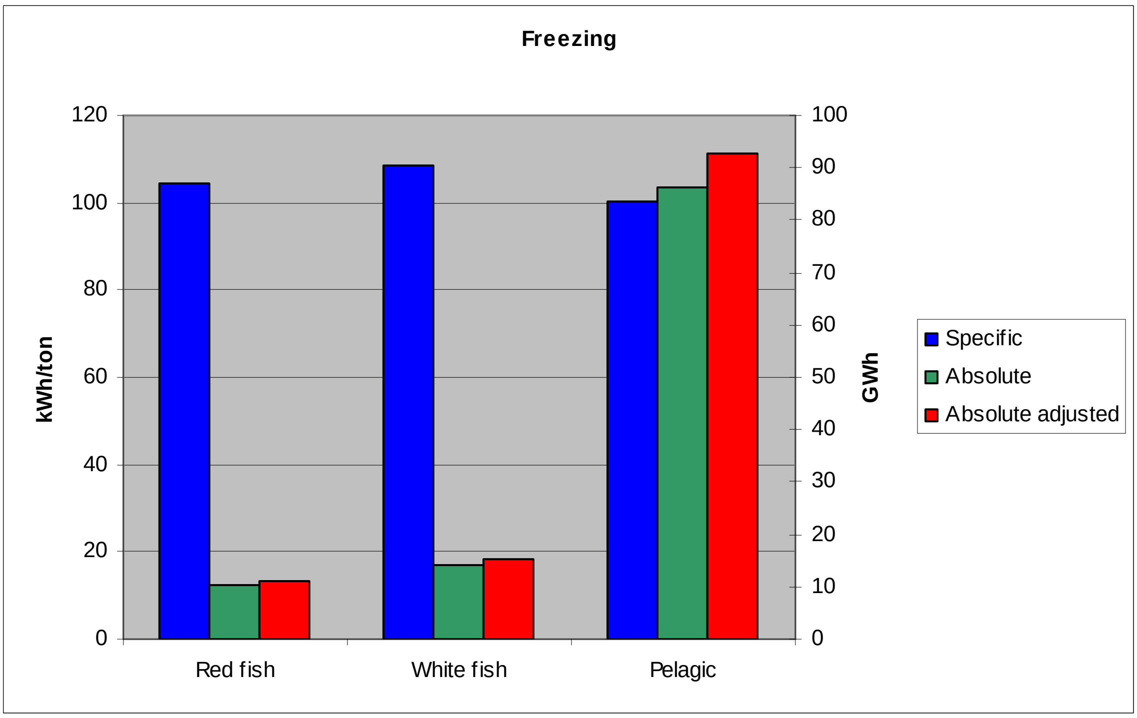

Figure 4: Energy consumption for freezing

3.2 Storage

Magnussen and Nordtvedt state that at reasonably good storage room should have a yearly energy consumption of 60 W/m^3 for frozen storage (-25 °C) and 9 W/m^3 for chilled (0 °C). With assuming a storage density at 400 kg/m^3 and average storage time of 1 month for frozen storage and 200 kg/m^3 and 3 days for fresh storage, one can calculate an estimated energy consumption pr ton fish. The results are shown in Figure 5.

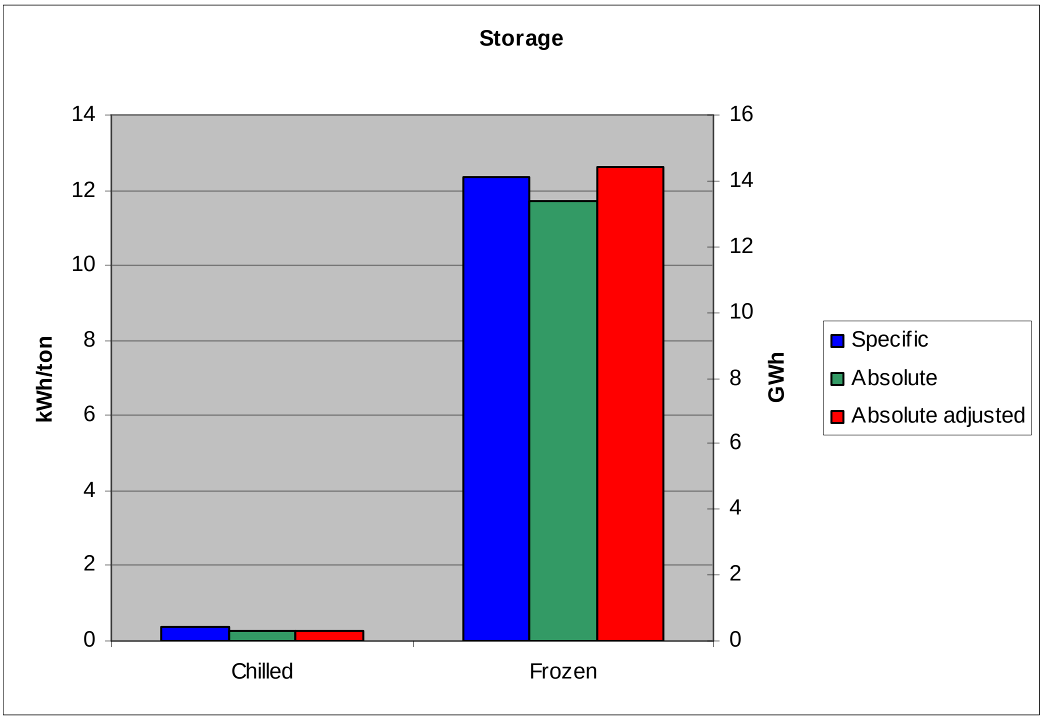

Figure 5: Energy consumption for storage

3.3 Ice production

Fresh products are packed together with ice, to keep the temperature constant at 0 °C. The production of ice has a great impact on the total energy consumption. For calculation of the energy need it is assumed that the packed fish is shipped with 30 % ice. The specific cooling duty for ice production is assumed to be 439 kJ/kg ice. The energy consumption is shown in Figure 6

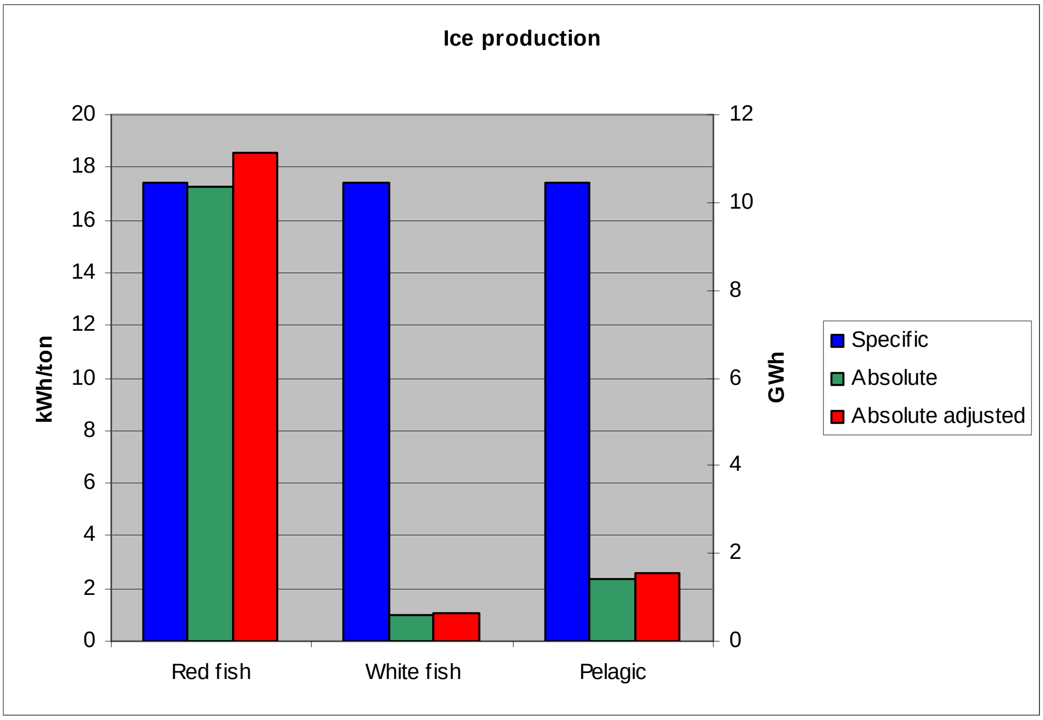

Figure 6: Energy consumption for ice production

3.4 Drying

The drying process for clip fish is relatively energy intensive. Magnussen and Nordtvedt [4] found that a SMER value of 1,7 should be reachable for a high efficiency heat pump drier. This would yield an energy consumption of 130 kWh/ton for drying from an initial water content of 55 % to an exit water content of 45 %. The total energy consumption is shown in Figure 7.

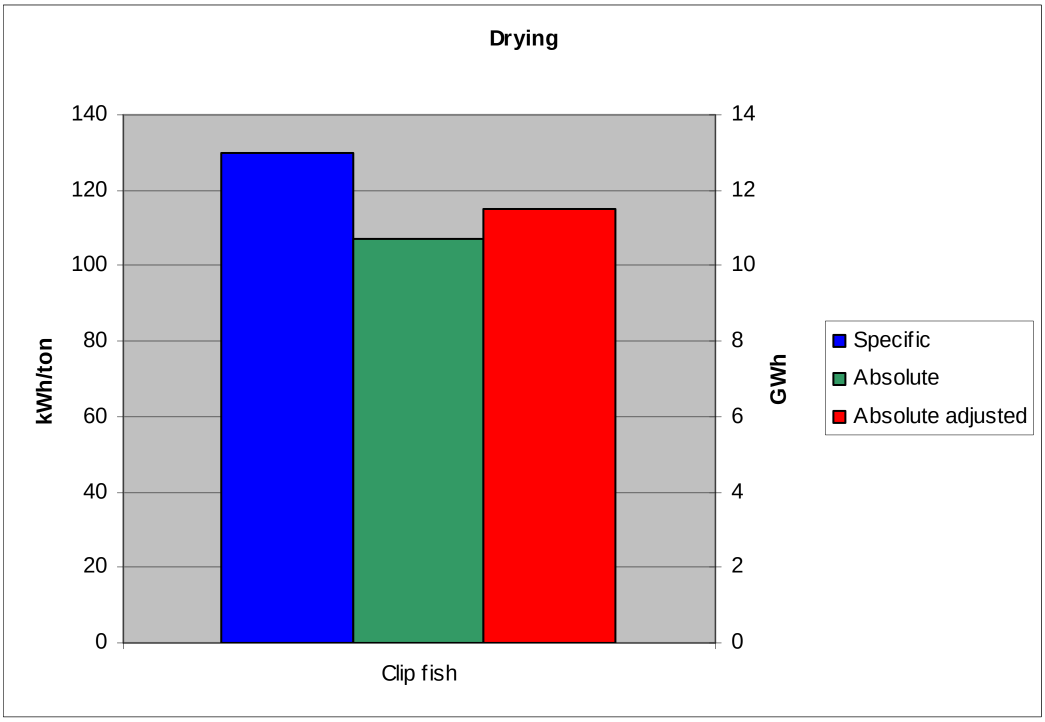

Figure 7: Energy consumption for drying

3.5 Total

The total energy consumption of the processes described above is shown in Figure 8.

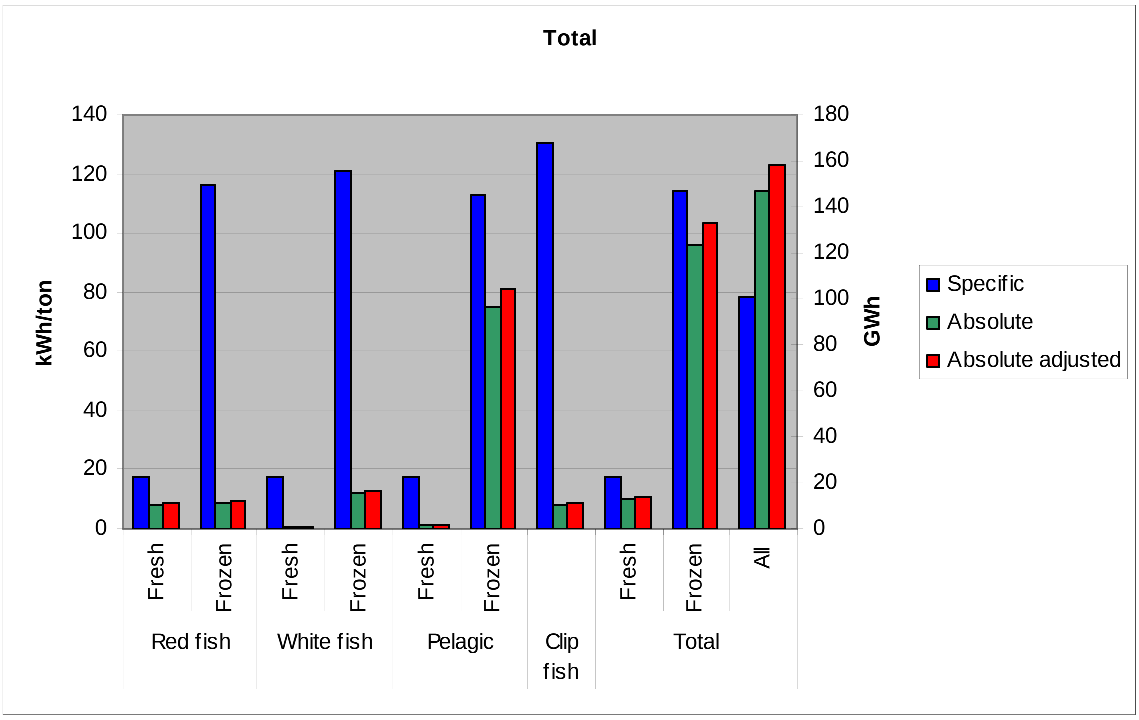

Figure 8: Total energy consumption

If one compares the calculated total energy consumption with the data from SSB Figure 2, there is a big difference. This illustrates that there are a lot of energy intensive activities in addition to the cooling processes. In addition, high energy demanding industries such as fish meal and fish oil production are not included in the calculations.
However, the figure tells us that of the treated categories, the pelagic industry has the highest potential for reduction in absolute energy consumption within the cooling processes. This is of course because they by far, deliver the highest amount of frozen products (see Table 2).

In Table 1, shows that that the pelagic industry has the lowest specific energy consumption of the three treated categories, while in Figure 8 the specific energy consumption is relatively similar. This is because in the pelagic industry freezing and storage is the main energy demanding processes, while in the white and red fish industry several other processes consume energy (especially in the farmed fish industry).

4 MEASURES FOR LOWER ENERGY CONSUMPTION

Enova[1] has porposed several possible measures for reduced energy consumption:

- Reduce the need for cooling power by using more efficient doors and lightning and reduce the amount of packaging.
- Frequency control of compressors and optimum operation of cooling machines.
- Outdoor temperature compensation of cooling machines.
- Higher heat transfer surface in heat exchangers
- Replace old equipment with new high efficient systems
- Fan control in freezing tunnels.
- Exploit the possibility of free cooling at cold days
- Separate system/compressor for RSW installation
- Reuse of hot water for washing.
- Heat recovery
- Speed control of electric motors
- Reduce need for hot water by installation of specialised equipment
- Optimisation of cleaning facility to reduce the need of energy for pumps, fans, compressors etc.
- Production of biogas from waste.

In addition, the report proposes several general measures for the whole food industry. In total they state an energy saving potential in the sea food industry of 250 GWh (151 GWh of electricity).

5 THE HATCHERY-PRODUCED FISH INDUSTRY

Hatchery-produced fish plants include production of edible fish, shellfish, spawn/alevin and hatchery-produced fish. There are about 220 production plants in operation in Norway [1]. According to Enova, the total energy consumption in this industry sector was 166 GWh in 2005 and about the same in 2003. A typical distribution of the energy usage at a plant without oxygen production is shown in Figure 9. According to COWI [3], 15 654 ton of biomass was produced in 2003 and they estimate a total energy consumption of 183 GWh. This is somewhat higher than the Enova number, but this is partially because COWI has included purchased oxygen as an energy factor. If the COWI numbers are used as basis, the specific energy consumption is 11 691 kWh/ton biomass.

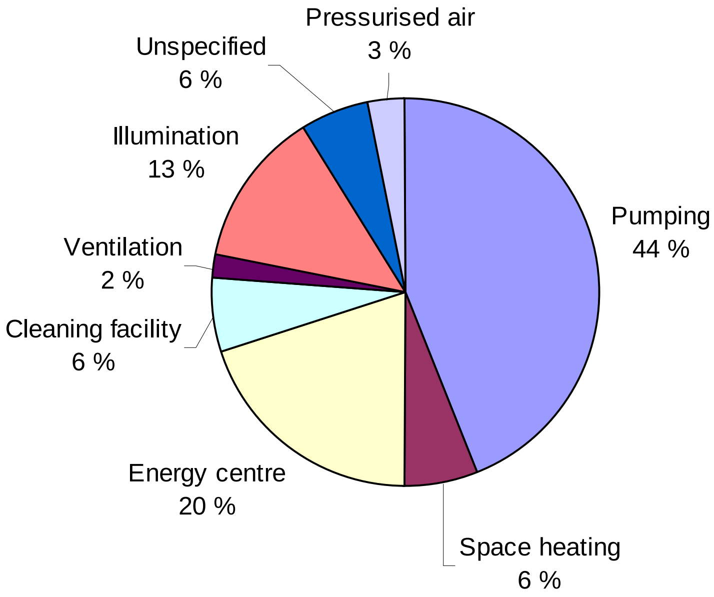

Figure 9: General distribution of energy demand hatchery-produced fish plant[1]

5.1 Energy reduction potential

COWI [3] has compared the energy consumption in different processes and categories at 10 different plants. With this basis they have found the most efficient processes and composed an ideal plant, to find the minimum specific energy consumption and calculate the possible energy reduction potential. The results are summarised in Table 3. One should be aware that the nature based boundary conditions have a great impact on the energy consumption at a plant. This means that a large portion of the existing plant does not have the potential to reduce their energy consumption down to the level of the ideal plant.

Table 3: Theoretical potential for energy savings in the hatchery-produced fish industry[3].

Produced biomass in 2003	15 654	ton
Energy consumption in 2003	183	GWh
Average specific energy consumption in 2003	11 236	kWh/ton
Theoretical potential specific energy consumption	3651	kWh/ton
Theoretical energy consumption	57	GWh
Reduction in energy consumption for the industry	126	GWh
Relative reduction in energy consumption for the industry	69	%

5.2 Measures for energy reduction

Magnussen and Nordtvedt [5] mentions three main factors for reducing the energy consumption at hatchery-produced fish plants:

1. Use of sea water: Sea water from deep below the surface have a higher temperature than fresh water during winter, and the lower freezing point (-2,2 °C) is a good measure against freeze out in the evaporator
2. Recirculation of water: Reduces the need for water heating
3. Energy from oxygen generators: Waste heat can be used for heating purposes.

6 CONCLUSIONS

The data available shows that there are large potentials for reduction in energy consumption in the sea food industry, and especially the pelagic and hatchery produced fish industry. For the white and red fish industry, there are indications of large reduction potentials, but more data is needed to describe the problem areas and propose solutions.

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