PROJECT REPORT
17 - 03

Rannsóknastofnun fiskiðnaðarins

MAY 2003

ORKUSPAR
An Energy Effiency Improvement Simulator (SUMMARY OF THE Final Report)

Eva Yngvadóttir (editor)

Skýrsluágrip Rannsóknastofnunar fiskiðnaðarins
Icelandic Fisheries Laboratories Report Summary

Titill / Title	**ORKUSPAR-The Energy Efficiency Improvement Simulator/ORKUSPAR - Orkuhermir**		
Höfundar / Authors	*Eva Yngvadóttir(editor), Otto Andersen, Sigurjón Arason, Georg Saros, Baldur Jónasson, Jens Arnljótsson, Árni Ragnarsson*		
Skýrsla Rf /IFL report	17-03	*Útgáfudagur / Date:*	May 2003
Verknr. / project no.	1508		
Styrktaraðilar / funding:	*Commission of the European Communities; SAVE II, IFL,TÍ;OS,EVI,SVE,WNRI,Grandi,Skipatækni,Fiskeriverket*		

Ágrip á íslensku:

Þessi skýrsla inniheldur samantekt úr lokaskýrslu (Verkefnaskýrsla Rf 16-03) í fjölþjóðlegu verkefni sem nefnist "ORKUSPAR-hermir til að bæta orkunýtingu."

Verkefnið hófst í April 2001 og því lauk í Mars 2003.

Markmið verkefnisisns er að þróa hermi til að bæta orkunýtingu í fiskiðnaði bæði til lands og sjávar og við sjóflutninga.

Afrakstur verkefnisins er ORKUSPAR-orkuhermir, sem skipta má í þrjá hluta:

1. ORKUSPAR-Orkuhermir fyrir fiskiskip
2. ORKUSPAR-Orkureiknir fyrir flutningaskip
3. ORKUSPAR-Orkureiknir fyrir bolfiskvinnslu

Hægt er að nálgast þessi forrit í gegnum veraldarvefinn án endurgjalds http://www.rf.is/verkefni/Orkuspar/

ORKUSPAR er hugbúnaður sem hægt að nota til að endurbæta orkunotkun og minnka magn gróðurhúsalofttegunda frá fiskiskipum, flutningaskipum og bolfiskvinnslu. Hugbúnaðurinn reiknar út heildar orkunotkun, orkunotkun miðað við mismunandi aðgerðir og um leið sýnir hvernig hægt er að minnka notkunina.
ORKUSPAR er sérstaklega ætlaður stjórnendum fiskvinnslu og útgerðarfyrirtækja, skipahönnuðum, sjóflutningsfyrirtækjum, rannsóknastofnunum í fiskiðnaði, tækniskólum og háskólum.
ORKUSPAR er mikilvægt tæki til að benda á hvar í ferlinum hægt er að spara orku og um leið minnka kostnað og draga úr umhverfisáhrifum skipa og fiskvinnslu í Evrópu.

Þáttakendur í verkefninu eru frá:
Íslandi: Rannsóknastofnun fiskiðnaðarins, Tækniháskóli Íslands. Orkustofnun, Grandi hf og Skipatækni ehf.
Svíþjóð: Energivision EB, Swedish Energy* og Fiskeriverket
Noregi: Vestlandsforskning

* Hættu í verkefninu 2002

Lykilorð á íslensku: *Orka,sparnaður,hermir,sjávarútvegur,flutningaskip*

Skýrsluágrip Rannsóknastofnunar fiskiðnaðarins
Icelandic Fisheries Laboratories Report Summary

Summary in English:

This is a summary of a final report (IFL Report 16-03) in the SAVE-project "ORKUSPAR-The energy efficiency improvement simulator". It consists of an overview of the results of the project, from the start April 1, 2001 until its conclusion on March 31, 2003.

The objective of this project is to develop an energy efficiency improvement simulator, called ORKUSPAR, specifically aimed at the fishing industry, both sea- and land based, and ocean freight shipping.

The outcome of the project is **ORKUSPAR - The Energy Efficiency Improvement Simulator**, which is divided into three parts.

1. ORKUSPAR- Energy Efficiency Simulator for fishing vessels.
2. ORKUSPAR- Energy Efficiency Calculator for cargo ships
3. ORKUSPAR- Energy Efficiency Calculator for freezing fish processing industry.

The programs can be accessed through the Internet free of charge http://www.rf.is/verkefni/Orkuspar/

ORKUSPAR-Energy Efficiency Improvement Simulator is a computer program, which enables the user to optimise the energy usage and decrease environmental impact from greenhouse gas emission in shipping, deep-sea fishing vessels and fish processing industry. It calculates the overall fuel consumption, shows the fuel consumption at different levels of usage and, consequently, how it can possibly be reduced.
ORKUSPAR is to be used by owners, managers, designers and operators of the relevant facilities (fish processing- and freezing plants, ocean trawlers, container and other shipping) to demonstrate the impact of the operating mode on the fuel consumption. ORKUSPAR is to be used in schools to make the students aware of the oil consumption since they will be the most important end users in the future.
ORKUSPAR is a valuable tool for identification of actions for decreased fuel consumption. In addition could it give economical benefits by saving money and reduce the environmental impacts in the shipping and fishing industry throughout Europe.

The participants in the project are as follows:
Iceland: Icelandic Fisheries Laboratories, The Technical University of Iceland, The National Energy Authority in Iceland, Grandi hf, Skipatækni LTd.
Sweden: Energivision Stockholm, Swedish Eneregy*, National Board of Fisheries in Sweden
Norway: Western Norway Research Institute

**Left the project 2002*

English keywords: *Energy, economy, simulator, fishing industry, freight shipping,*

ORKUSPAR
The Energy Efficiency Improvement Simulator

European Commission Project no: SAVE 4.1031/Z/00-029

OBJECTIVE

To develop an Energy Efficiency Improvement Simulator ORKUSPAR specially aimed at ocean freight shipping and the fishing industry, both sea and land based

Target end-users

Sea Fishing Trade Association
Shipdesigners
Fishing and fish processing companies
Fisheries Research Institutions
Shipping companies
Colleges and Universities

Orkuspar Simulator

Input data

- **Specifications**
- **Real data for energy usage**
- **Energy prices**
- **Energy expenditure for different uses**

Output data

- **Assessment of potential efficiency improvement measures**
- **Analyze energy efficiency for target end-users**
- **Potential savings in cost and energy**
- **Environmental benefits**
- **Actual energy expenditure compared with standard or average values**

"ORKUSPAR - The Energy Efficiency Improvement Simulator" is the name of a project, funded by the Commission of the EC´s Directorate-General for energy and transport. The project is coordinated by the Icelandic Fisheries Laboratories.
It began in 2001 and will end in 2003.

For more information http://www.rf.is/verkefni/Orkuspar/index.htm
Contact: Eva Yngvadóttir, Icelandic Fisheries Laboratories, Skúlagata 4, P.O.Box 1405, 121 Reykjavík, Iceland. eva@rf.is

Summary from the European Commission SAVE project 4.1031/Z/00-029: "ORKUSPAR-The Energy Efficiency Improvement Simulator"

This project "ORKUSPAR-The Energy Efficiency Improvement Simulator" was carried out with financing from SAVE-program in the European Commission Directorate-General for Energy and Transport. The project started April 1, 2001 and finished March 31, 2003.

Objective

The objective of the project is to develop an energy efficiency improvement simulator, called ORKUSPAR, specifically aimed at the fishing industry, both sea- and land based, and ocean freight shipping.

The purpose of the ORKUSPAR simulator is to design a tool for the assessment and monitoring of envisaged energy efficiency measures. It quantifies attainable energy efficiency improvements for owners, management, designers and operators of the relevant facilities (process plants, ocean trawlers and freight shipping), energy use and environmental pathways in shipping and deep-sea fishing vessels (fish processing trawlers). The software simulates economic and other benefits gained by diverse measures, and it is, e.g. intended to:

- Decrease fossil fuel consumption
- Improve energy efficiency of processing systems
- Improve automatic control and monitoring of systems
- Decrease pollutant emissions

The primary aim is to decrease harmful gaseous emissions to the atmosphere in accordance with the goals put forward in the Agenda 21 action plan and the subsequent Kyoto declaration.

Description of the work

One ship, Þerney RE 101 a freezer stern-trawler with a fish meal plant, was used as a model of the fishing ship in the simulator's prototype. Since there are many similar functions for fishing vessels and cargo ships, a simplification could be made, by handling cargo ships as trawlers, but without the fishing gears. Land based fish industry is a much simpler system than a fishing vessel. A freezing fish processing plant was used as a model for the land based fishing industry.

The work in the project was divided into the following main phases:1) Data collection, 2) Data sorting and analysis, 3) Development of simulators, 4) Trials and modifications, 5) Dissemination and 6) Project management.

Achievements

In this project a computer program called ORKUSPAR-The Energy Efficiency Improvement Simulator was developed. This simulator is to be used by owners, managers, designers and operators of the relevant facilities (fish processing- and freezing plants, ocean trawlers, container and other shipping) to demonstrate the impact of operating mode on the fuel consumption. ORKUSPAR is to be used in schools to make the students aware of the oil consumption, since they will be the most important end users in the future.

ORKUSPAR - The Energy Efficiency Improvement Simulator is divided into three parts.

1. ORKUSPAR -Energy Efficiency Simulator for fishing vessels.
2. ORKUSPAR- Energy Efficiency Calculator for cargo ships
3. ORKUSPAR- Energy Efficiency Calculator for freezing fish processing industry.

The programs can be accessed through the Internet free of charge
http://www.rf.is/verkefni/Orkuspar/

Conclusion

ORKUSPAR is an instrument, which can be used, for calculating the oil consumption and identify specific actions to reduce it. It can be used to raise awareness about these matters and to show the impact of the oil consumption at different levels, i.e. from the fleet administration to the captains. Not many administrators are currently aware of how their decisions effect the oil consumption. ORKUSPAR can be used in schools to increase student's' knowledge of oil consumption issues. Ship designers can use ORKUSPAR to increase the energy efficiency of ships.

ORKUSPAR is a valuable tool for identification of actions for decreased fuel consumption. In addition, it could give economical benefits by saving money and reduce the environmental impacts in the cargo and fishing industry throughout Europe.

Future actions

In the future, the aim is to make ORKUSPAR more "intelligent," focus on optimization and different actions, e.g. the process of trawling. This part of the fishing trip accounts for up to 70 % of the total oil consumption when bottom trawl fishing gear are used.

Final Report from European Commission SAVE project 4.1031/Z/00-029:

"ORKUSPAR-The energy efficiency improvement simulator"

By

Eva Yngvadóttir (editor)[1], Otto Andersen[2], Sigurjón Arason[1],
Baldur Jónasson [4,6], Jens Arnljóttson [4], Árni Ragnarsson[5], Georg Saros[3]

[1] Icelandic Fisheries Laboratories, Iceland

[2] Western Norway Research Institute, Norway

[3] Energivision Stockholm AB, Sweden

[4] Technical University of Iceland

[5] The National Energy Authority, Iceland

[6] Skipatækni Ltd, Iceland

Preface

This is a final report in the SAVE-project "ORKUSPAR-The energy efficiency improvement simulator". It consists of an overview of the work and results of the project, from the start April 1, 2001 until its conclusion on March 31, 2003.

The main objective of the project was to develop an energy efficiency improvement simulator, called ORKUSPAR, specifically aimed at the fishing industry, both sea- and land based, and ocean freight shipping.

This report is a joint effort from the participants in the project:

Eva Yngvadóttir (IFL) editor, Sigurjón Árnason (IFL), Otto Andersen (WNRI), Baldur Jónasson (TUI, Skipatækni Ltd), Jens Arnljótsson (TUI), Árni Ragnarsson (OS) and Georg Saros (EVI).

Reykjavík, May 2003

Eva Yngvadóttir

Coordinator

Appendix 1

- Diagram of the operation-energy calculation of ORKUSPAR-Energy Efficiency Simulator for fishing vessels.
- Description of the specifications of the vessel, fishing gear and fishing trip
- Description of the input data requirements and the output data produced.

Appendix 2

- Samples of input tables and results from the ORKUSPAR-Energy Efficiency Simulator for fishing vessels.
- User manual for ORKUSPAR-Energy Efficiency Simulator for fishing vessels.

Appendix 3

- Flow diagram of a freezing processing fish filleting plant.
- Printout from the ORKUSPAR-Energy Efficiency Calculator for freezing fish processing industry.

Appendix 4

- The Energy Efficiency Simulator, Phase 4 Trials and modification. Final Thesis in Mechanical Engineering at The Technical University of Iceland 2002 by Árni Eyfjörð Ragnarsson

1. Introduction

This is a final report in the SAVE-project "ORKUSPAR-The energy efficiency improvement simulator". It consists of an overview of the results of the project, from the start April 1, 2001 until its conclusion on March 31, 2003.

During this period, three project meetings with all participants were held, in Reykjavík and Stockholm. Reports from these meetings have been submitted to the Commission (1) (2) (3). An interim report was submitted to the Commission in September 2002 when 70 % of the work had been finished (4). There, a thorough description was made regarding the progress and achievements of the project over the first 18 months of the project. At the meeting in Stockholm, Mr. Pedro Ballesteros, the project's contact person in the Commission made a technical visit to the project.

Currently, the end-users especially targeted for the ORKUSPAR simulator are: Fishing vessel owners, shipbuilders, fish processing plant manufacturers and designers, individual fishing and fish processing companies, fisheries research institutions, shipping companies, technical colleges, universities, etc. in the European Union and the associated states.

2. Objective

The objective of the project is to develop an energy efficiency improvement simulator, called ORKUSPAR, specifically aimed at the fishing industry, both sea- and land based, and ocean freight shipping.

The purpose of the ORKUSPAR simulator is to design a tool for the assessment and monitoring of envisaged energy efficiency measures. It quantifies attainable energy efficiency improvements for owners, management, designers and operators of the relevant facilities (process plants, ocean trawlers and freight shipping), energy use and environmental pathways in shipping and deep-sea fishing vessels (fish processing trawlers). The software simulates economic and other benefits gained by diverse measures, and it is, e.g. intended to:

- Decrease fossil fuel consumption
- Improve energy efficiency of processing systems
- Improve automatic control and monitoring of systems
- Decrease pollutant emissions

The primary aim is to decrease harmful gaseous emissions to the atmosphere in accordance with the goals put forward in the Agenda 21 action plan and the subsequent Kyoto declaration.

3. Description of the work

The work was divided into the following main phases to be carried out by the various participants in the project over two years.

Phase	Description
1	Data collection (Responsible partners: 1, participating partners:1,2,3,4,5,6,7)
2	Data sorting and analysis (Responsible partners: 2, participating partners:1,2,5,6,7)
3	Simulator development (Responsible partner: 5, participating partners: 1,2,5,6,7)
4	Trials and modifications (Responsible partner: 1, participating partners: 1,2,4,5,6,7)
5	Dissemination, follow-up: (Responsible partner: 1, participating partners: 1,2,4,5,6,7)
6	Project management: (Responsible partner: 1, participating partners: 1,2,4,5,6)

Partners (all contractors)

1. Icelandic Fisheries Laboratories (IFL), Reykjavik, Iceland
2. Technical University of Iceland (TUI), Reykjavík, Iceland*
3. Swedish Energy (SVE), Stockholm, Sweden**
4. The National Energy Authority (OS), Reykjavik Iceland
5. Energivision Stockholm AB (EVI), Stockholm, Sweden
6. Western Norway Research Institute (WNRI), Sogndal, Norway
7. End-Users group ***
    - Skipatækni Ltd, Reykjavik, Iceland
    - National Board of Fisheries (Fiskeriverket), Sweden
    - Grandi hf, Reykjavik, Iceland

* The Icelandic College of Engineering and Technology, (TÍ) changed to The Technical University of Iceland (TUI), July 1st 2002.

**Swedish Energy participated during the first 40% of the project but could then not continue any longer in the project and Energyvision took over their role. These changes were reported to the Commission, which approved them. These changes had no adverse effect on the quality of the project or its outcome.

*** Notice that according to the contract there are 7 participants. In the application the 7th participant is defined to be the end-users group that is represented by three companies:

Skipatækni Ltd, Grandi hf and Fiskeriverket. The only name, however, appearing in the contract is Skipatækni Ltd. This fact was pointed out in a letter to the Commission dated March 27, 2001.

The persons who were involved in developing and performing the main work tasks in the project were:

IFL: Eva Yngvadóttir (coordinator), Helga R. Eyjólfsdóttir, Sigurjón Arason

Subcontractor; V.E.R. Skiparáðgjöf, Emil Ragnarsson (phase 1,2,3,4)

TÍ: Baldur Jónasson, Jens Arnljótsson, Paul Jóhannsson, Árni Eyfjörð Ragnarsson

Subcontractor; V.E.R. Skiparáðgjöf, Emil Ragnarsson (phase 1,2,3,4)

SVE: Krister Carlsson

OS: Árni Ragnarsson, Einar Tjörvi Elíasson

EVI: Georg Saros, Jonas Klittermark, Roger Olofsson

WNRI: Otto Andersen

4. Results and discussion

In this project a computer program called ORKUSPAR-The Energy Efficiency Improvement Simulator was developed. This simulator is to be used by owners, managers, designers and operators of the relevant facilities (fish processing- and freezing plants, ocean trawlers, container and other shipping) to demonstrate the impact of operating mode on the fuel consumption. ORKUSPAR is to be used in schools to make the students aware of the oil consumption, since they will be the most important end users in the future.

ORKUSPAR-The Energy Efficiency Improvement Simulator is divided into three parts.

1. ORKUSPAR-Energy Efficiency Simulator for fishing vessels.
2. ORKUSPAR-Energy Efficiency Calculator for cargo ships
3. ORKUSPAR-Energy Efficiency Calculator for freezing fish processing industry.

The programs can be accessed through the Internet free of charge
http://www.rf.is/verkefni/Orkuspar/

One ship, Þerney RE 101 a freezer stern-trawler with a fish meal plant, was used as a model of the fishing ship in the simulator's prototype. As the project work developed, it became clear that the main emphasis would be on the fishing trawlers. Since there are many similar functions for fishing vessels and cargo ships, a simplification could be made, by handling cargo ships as trawlers, but without the fishing gears. Land based fish industry is a much simpler system than a fishing vessel. A freezing fish processing plant was used as a model for the land based fishing industry. This kind of a process line is one of the most common land based fish industries in Western Europe.

This chapter gives an overview of the work during the different phases of the project.

4.1 Phase 1 - Data collection.

All necessary input data for the simulator were collected for Þerney RE 101. Data were collected for different trips and stored in the database. Data have also been gathered for three different ships and is ready to be tested further. Questionnaires were sent out to transportation companies in order to collect data for cargo ships. Due to poor responses, data were obtained from a survey on the Internet and is available for testing in the calculator for the cargo ships. Data from machineries and data from a freezing fish processing plant was used to test the land based calculator.

4.2 Phase 2 - Data sorting and analysis

All collected data was assessed, collated, sorted and interpreted. The relevant data and that of prescribed quality were included in the Simulator's databank.

4.3 Phase 3 - Development of simulators

As was expected, most of the time and effort in the project were spent during phase 3, the development of simulator and calculators. The specification for the vessels included the input values for the model, the database values that the user of the simulator could select from, and the mathematical formulas in the model. Also, much effort was made in specifying and developing the end-user interface and instructions on how the results were to be presented in tables and diagrams and finally the limitations of the model. The specifications for the fishing vessel were modified to also work for cargo ships and applied in the calculator for cargo ships. A freezing fish processing plant was used as a model for the land-based fishing industry calculator. The land based calculator for freezing fish processing plant can be used as a guideline for the processing deck on board fishing vessels.

4.3.1 ORKUSPAR-Energy Efficiency Simulator for fishing vessels

One fishing ship, Þerney RE 101 (2203), was used as a model for the simulator. The input and output data were based on real measurements of this ship. The simulator has been tested for 20-120 meters fishing vessels, using otter board as fishing gear.

In appendix 1 is shown a diagram of the operation-energy calculation for the simulator. Furthermore, a description is given of the specifications of the fishing vessel, fishing gear and fishing trip, as well as the input data requirements and the output data produced.

A single fishing trip consists of many different and constantly changing operations and variables, which makes it very difficult to simulate a whole fishing trip, from harbour to harbour. In this version of the simulator, the fishing trip was simplified to make the simulation work better. The simulator is capable of simulating one type of fishing gear for one fishing

trip, one fishing water depth and one fish species. During a typical fishing trip, however, 1-4 types of fishing gears are used, 1-2 fish or more species are caught and the fishing gears are operated at different water depth. In chapter 4.4, the results of making this simplification are discussed and evaluated. The single most important factor in the simulator, as far as fuel consumption is concerned, is the fishing gear, which is responsible for more than 70% of the fuel consumption of the fishing vessel when fishing with bottom trawl. Relative energy use for different operation in processing trawler during fishing with bottom trawl can be seen in figure 1.

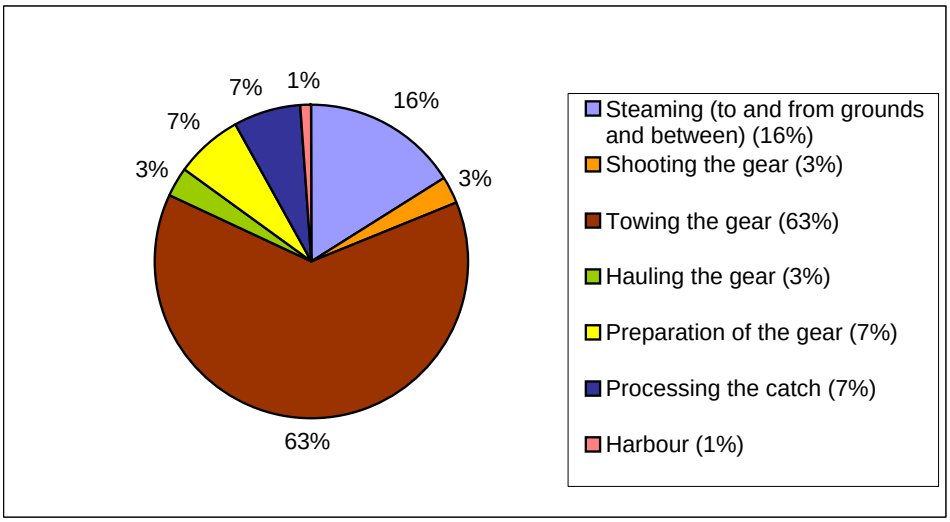

Figure 1. Relative energy use for different operation in processing trawler during fishing with bottom trawl

A graphical picture of the ORKUSPAR-Energy Efficiency Simulator for fishing vessels is shown in figure 2.

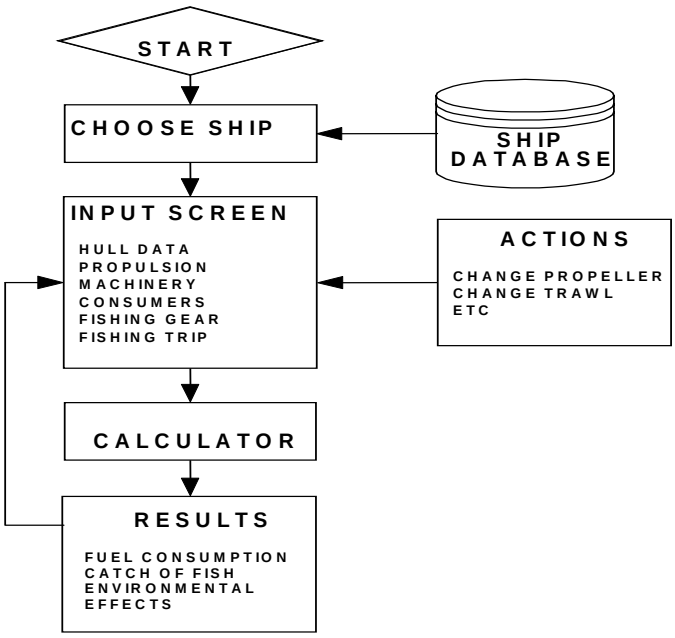

Figure 2. A graphical picture of the ORKUSPAR -Energy Efficiency Simulator for fishing vessels

A database will contain different kinds of predefined ships. The user of the simulator can choose a ship from a list to simulate or define a new ship and store it in his/her personal databank.

Different data of the ship can be seen on the input screen. The data is divided into different sectors, hull data, propulsion and so on. The user can change the predefined values of the different data. The user can also choose among different actions, for instance changing the fishing gear, change of propellers and so on.

The interface of the computer program is web-based. The user has to go through a login function to start the program.

ORKUSPAR is built on the new Microsoft.NET framework with ASP.NET. All the programming codes are written using C# (C sharp). ORKUSPAR has mainly three parts: 1. Input 2. Calculations 3. Output. This is also reflected in the development of the project where ORKUSPAR constitutes a solution containing the three projects Input, Output, and Calculations, which are later built separately. The solution also contains a web project area with the necessary .aspx files, pictures etc.

The ORKUSPAR solution also uses databases, mainly for two purposes. Firstly, all the input parameters, value ranges, menu systems, users etc., are kept in a database to support the running of the ORKUSPAR program. This also makes it easier to update ORKUSPAR when all the relevant information is stored in a database. Secondly, a database with all the vessels, fishing gear and fishing trips that users have saved is stored in order for them to be put into the program later. The database is built upon the Microsoft SQL Server.

Some examples of input tables and results from the simulator can be shown in the appendix 2.

4.3.2 ORKUSPAR-Energy Efficiency Calculator for cargo ships

The consortium agreed that the specifications for the fishing ship would be used as a base for cargo ships as well, where the cargo ship would be handled as fishing vessels, but without the fishing gears. This is a simplification in order to reduce the complexity of the simulator. Treating the cargo ships as fishing vessels without the fishing gear implies that the energy use for winches is not included in the simulator. Some cargo ships have winches for the loading/unloading, and some have not. It is however assumed that the contribution of the winches in terms of the overall energy usage aboard the cargo ships is relatively low, compared to the situation aboard fishing vessels.

For the purpose of improving the functionality of the simulator some limitations for the cargo ship application was made. The largest ship categories (e.g. oil tankers) were excluded. Despite this limitation, the ships responsible for transporting about half of the total gross tonnage made by Norwegian ships are still included. The calculator is then applicable for combination-ships, bulk carriers, freezing-ships, supply-ships, and other dry cargo ships.

Data obtained from a survey on the Internet was made available for testing in the calculator for the cargo ships. The calculator, ORKUSPAR-Energy Efficiency Calculator for cargo ships will

be developed further and tested. It will be ready to be used later this year and will then be available on the Internet.

4.3.3 ORKUSPAR-Energy Efficiency Calculator for freezing fish processing industry

A freezing fish processing plant was used as a model for the land based fish industry. This system is not as complicated to specify compared with specifying a fishing vessel. This type of process can be described as follows at sea: gutting, bleeding, washing and cooling, the fish is put on ice and kept in a chilled storage both at sea and on shore to preserve the quality of the raw material. In the filleting, freezing plant, the processing flow is following: deicing, grading, washing, heading, filleting, skinning, trimming, grading, packing, freezing, packing, storage and exported. The fillets are graded for size and packed according to specifications before being quick frozen. Most energy usage is during the freezing process. The choice of freezing methods has large influence on the total energy use. A sample of relative energy use for different operation in a filleting, freezing plant is shown in figure 3.

The function of the land based model is based on different input sectors, such as processing, capacity, freezing, storage and so on. The user can change the predefined values for the different data. The user can also choose among different actions, for instance changing the fish species and size, yield, capacity, production time (actual), freezing method, storage temperature etc.

A database contains information about different processing lines for each product and fish species. The user of the simulator can choose a fish species, size and processing line from a list to simulate, or he can define processes and store it in his databank.

A calculator, ORKUSPAR-Energy Efficiency Calculator for freezing fish processing industry, (a simple simulator) was made for the main energy usage for a freezing fish processing plant. In appendix 3 is shown a flow diagram of freezing fish processing plant and a printout from the ORKUSPAR-Energy Efficiency Calculator for freezing fish processing industry.

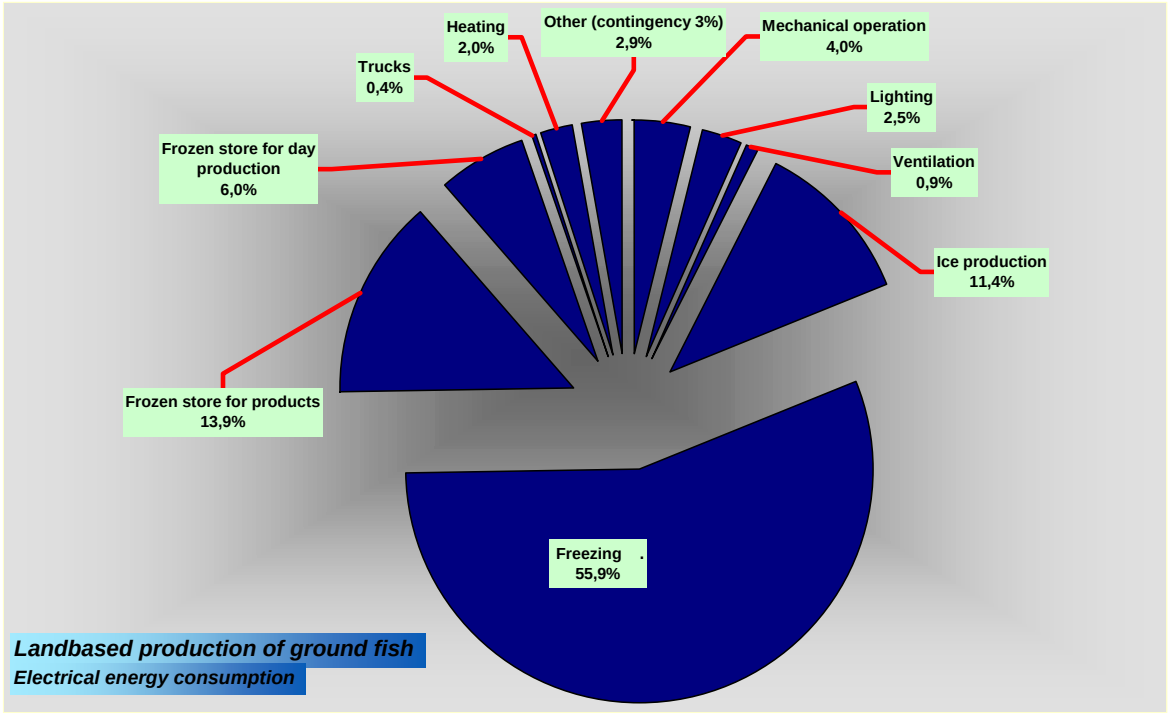

Figure 3. Relative energy use for different operation in a filleting, freezing plant.

4.4 Phase 4 - Trials and modifications

The ORKUSPAR -Energy Efficiency Simulator for fishing vessels was tested under real-life conditions for 20-120 meters fishing ships, using otter boards as fishing gear. The main emphasis of this phase was on testing the formulas and to come up with suggestions for modifications. This work was done in co-operation with end-users and described in a report (5), which is also enclosed as appendix 4.

The aim of this test phase was to identify and correct errors in the calculations, and to evaluate the deviations between the output of the simulators and the real output data. A very thorough search for errors in the formulas was carried out to ensure that the simulator was correctly calculating the output values This led to some modifications which improved the simulator. This work also constituted a final thesis in mechanical engineering, made at The Technical University of Iceland. This describes the test and modifications phase and the outcome of it (appendix 4).

After evaluating the deviation, both for the input and output data, it was clear that there are only a few parameters that really affect the output deviations. Basically, there are three parameters, which are the main reason for the deviation of the fuel consumption, as calculated by the simulator and the real fuel consumption. They are: The fishing vessel (the main engine and vessel resistance), the fishing gear (trawl resistance) and the fishing trip (weather and ocean conditions and catch rate).

The fishing vessel deviations

The specific fuel consumption of the main engine is supplied by the engine manufacturer, where the engine has been tested under the best available conditions. However, as the engine starts to operate under real-life conditions, dirt gradually accumulates in the engine and the engine systems. This increases the fuel consumption as the engine ages. It is to be expected that actual specific fuel consumption can be up to 4% higher than given in the engine test plan.

The resistance of the vessel increases as dirt, like scab and seaweed, accumulates on the keel. This leads to an increase in the fuel consumption. How fast this increase occurs, depends on various factors, e.g. the type of the paint used, how frequently the vessel is used, the shape of the hull and the sailing speed. The simulator has taken this increase in resistance into account up to a certain point, but it can be expected that the real resistance can be ±5% different than the calculated one.

The fishing gear deviations

The trawl net resistance increases as the trawl wears. This increase is expected to be up to 10%. The net resistance is the dominating part of the resistance. The trawl net represents 60-70% of the fishing gear resistance and 50 – 60% of the resistance to overcome trawling when the total

vessel resistance is taken into consideration. Figure 4 shows the fishing gear resistance and figure 5 shows the total resistance of the vessel to overcome trawling.

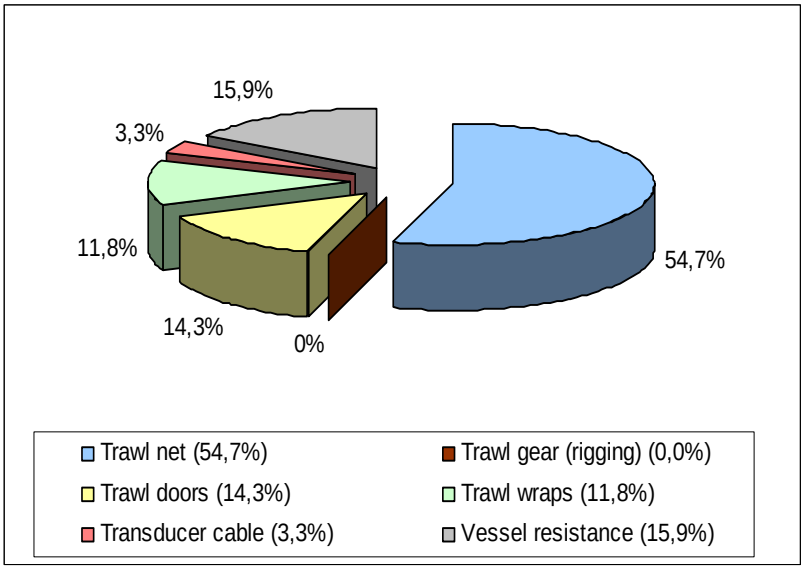

Figure 4. Total resistance to overcome trawling

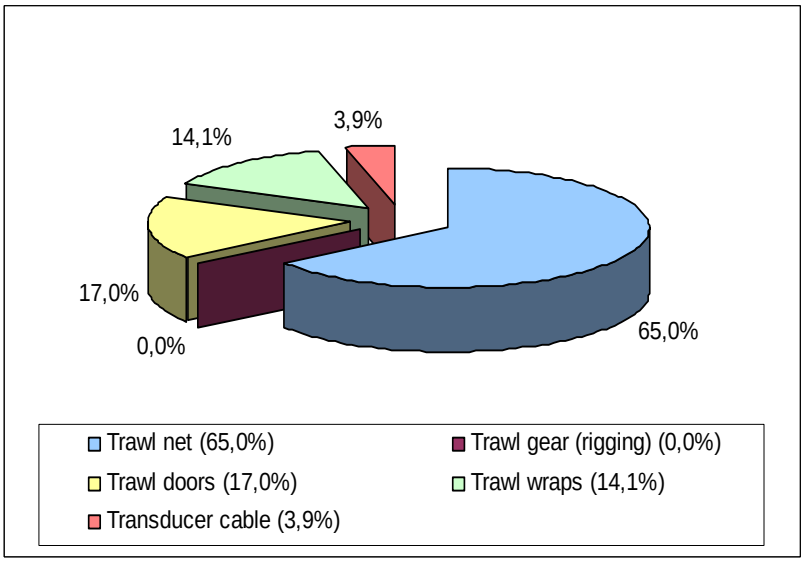

Figure 5. Fishing gear resistance

The fishing trip deviation

Since the weather is a constantly changing factor, it is difficult to simulate in advance the appropriate weather conditions. The simulated weather conditions are expected to be ± 40% from the actual weather conditions.

The catch rate affects the weight of the ship, along with other parameters, thus increasing the fuel consumption. The actual catch rate is estimated to be ± 15% from the actual one.

The total deviation

There are other factors that can affect the accuracy of the simulator. One of them is the human factor. That is e.g. a human error in typing the input data and wrong estimates of values. This, along with other input deviations, is estimated to be ± 2%. Table 1 shows the estimated deviations of the input data and of the calculated total fuel consumption.

Table 1. Estimated deviations of the input data and of the calculated total fuel consumption.

	Deviations in input	Deviations in total fuel consumption	
	+/- %	Min	Max
The fishing vessel			
Main engine	+4% and -0%	-0%	+4%
Vessel resistance	+/- 8%	-2%	+2%
The fishing gear			
Trawl resistance	+10% and -0%	-0%	+5%
The fishing trip			
Weather and sea state	+/- 40%	-5%	+5%
Catch rate	+/- 15%	-2,5%	+2,5%
Other causes			
Human factor, and more	+/- 2%	-2%	+2%
ORKUSPAR expected deviation		**-5%**	**+10%**

The deviations in the fuel consumption are estimated to be between -5% to +10%. This deviation could be controlled and reduced to ± 4% by adding correction coefficients for the fishing gear resistance and the weather conditions, to the future versions of the ORKUSPAR simulator.

Data were obtained from a survey on the Internet and is available for testing in the calculator for the cargo ships. It will be ready to use on the Internet later this year.

The land-based model for a freezing fish processing plant was tested with data obtained under real-life conditions.

4.5 Phase 5 - Dissemination

The project has been introduced and disseminated at various events, such as seminars, exhibitions, in magazines, newsletters and brochures available on the Internet during the whole project period.
A website is located at the IFL´s server (http://www.rf.is/verkefni/Orkuspar/index.htm). Here one can find information about the objectives of the project, the partners in the project and where the ORKUSPAR project has been introduced. There is also an access to the ORKUSPAR simulator itself on this website.

Information about ORKUSPAR has e.g. already been disseminated in the following manner:

Date and place	Dissemination activity
WNRI, Norway Throughout the project period	An Internet presentation on the Western Norway Research Institute presentation page: http://www.vestforsk.no/English/
Reykjavik, Iceland October 2001	Introduced in a lecture at the Energy Conference in Iceland
Reykjavik, Iceland December 2001	An article in the Icelandic magazine Ægir (11th issue, December 2001)
Reykjavik, Iceland March 2002	Lecture at a workshop for Life Cycle Assessment in Seafood, sponsored by NARP
Reykjavik, Iceland September 2002	A poster and a handout at The Icelandic Fisheries Exhibition 2002
Alaska, USA October 2002	A handout at the 2nd International By-product Conference
Reykjavik, Iceland November 2002	A poster in connection with a conference on the introduction on the EU 6th. RTD Framework Programme
Roskilde, Denmark November 2002	In a lecture and a handout at a LCA workshop, sponsored by NARP
Reykjavik, Iceland March 2003	In a lecture at a Technology and Fisheries conference
Reykjavík, Iceland March 2003	Introduced in an article in the Icelandic magazine Verktækni (3rd issue, March 2003)

Seminars were held where interested parties were invited and the usability of the ORKUSPAR - The Energy Efficiency Simulator was introduced. Brochures have been mailed to possible end users. ORKUSPAR is available free of charge on the Internet http://www.rf.is/verkefni/Orkuspar

4.6 Phase 6 - Project management

The coordinator has been in good contact with the partners. The partners have submitted quarterly reports on the status of their work. These reports have given the coordinator a good overview of the status of the project.

The project proceeded well after a slightly modified schedule. More time was spent on phase 3 - simulator development, than had been anticipated at the beginning of the project. This constituted the work with the specification and development of the computer program.

Table 2 represents the actual work in hours.

Table 2. Actual work (hours)

Proposer	IFL	TUI	SVE	OS	EVI	WNRI	Skipatækni	Grandi	Fiskeriverket	Total
Hours	1458	505	60	152	2324	432	170	177	96	5374

5. Energy usage in the future

In the publication "World Energy Outlook 2002," the IEA (International Energy Agency) presents projections of the world's energy supply to the year 2030. The projections are derived from a referenced scenario based on a set of assumptions about macroeconomic conditions, population growth, energy prices, government policies and technological development.

According to this projection, world enery use is expected to increase by 1.7% per year from 2000 to 2030, reaching an annual level of 15.3 billion tonnes of oil equivalents in 2030. The increase will be equal to two-thirds of current total demand. Fossil fuels will remain the primary sources of energy, meeting more than 90% of the increase in demand. Global oil demand will rise about 1.6% per year. Almost three-quarters of the increase in demand will come from the transport sector. Oil will remain the fuel of choice in road, sea and air transportation. According to the IEA study, the transport demand, almost entirely for oil, will grow most rapidly of all end-use sectors, at 2.1% per annum. It will overtake the industry in the 2020s as the largest final-use sector. Oil resources are ample, but new reserves will have to be identified in order to meet rising oil demand to 2030.

Global energy-related emissions of carbon dioxide are projected to increase by 1.8% per year from 2000 to 2030, reaching 38 billion tonnes in 2030. This is 70% more than today. By 2010, energy-related carbon dioxide emissions will be 36% higher than in 1990. Power genaration

and transport will account for about three-quarters of the increase in greenhouse gas emissions. This illustrates the challenge that most industrialised countries face in meeting their emission reduction commitments under the Kyoto Protocol.

Prices are important drivers of energy demand. International crude oil prices have flucuated a lot during the past decades. In the IEA study it is assumed that the price will be $21 per barrel over the period 2002-2010 (in year 2000 dollars). That price is roughly equal to the average for 1986-2001. The oil prices are assumed to rise linearly after 2010, reaching $25 in 2020 and $29 in 2030. This reflects gradual changes in expected marginal production costs and supply patterns.

In view of the IEA energy projections described above, it is obvious that various measures to reduce oil consumption are and will be of great importance. The ORKUSPAR simulator can contribute to this in the fishing idustry and ocean freight shipping as an excellent tool to investigate and implement improvements with regard to energy efficiency.

6. Conclusions

The project "ORKUSPAR-The energy efficiency improvement simulator" proceeded well according to a slightly modified schedule. The outcome of the project is ORKUSPAR - The Energy Efficiency Simulator which is divided into three parts:

1. ORKUSPAR-Energy Efficiency Simulator for fishing vessels.
2. ORKUSPAR-Energy Efficiency Calculator for cargo ships.
3. ORKUSPAR-Energy Efficiency Calculator for freezing fish processing industry.

The main emphasis was on making a good simulator for a fishing vessel, which calculates the output values with reasonably good accuracy. The simulator has been tested for 20-120 meters fishing vessels, using otter board as fishing gear. A calculator for the land based fishing industry has been developed and tested and a calculator for cargo ships, is currently being developed and tested and will be available on the Internet later this year.

ORKUSPAR is an instrument, which can be used, for calculating the oil consumption and identify specific actions to reduce it. It can be used to raise awareness about these matters and to show the impact of the oil consumption at different levels, i.e. from the fleet administration to the captains. Not many administrators are currently aware how their decisions effect the oil consumption. ORKUSPAR can be used in schools to increase the student’s knowledge of oil consumption issues. The students will be the most important end users in the future. Ship designers can use ORKUSPAR to increase the energy efficiency of ships.

In the future, the aim is to make ORKUSPAR more "intelligent," focus on optimization and different actions, e.g. the process of trawling. This part of the fishing trip accounts for up to 70 % of the total oil consumption when fishing with bottom trawl.

ORKUSPAR is a valuable tool for identification of actions for decreased energy consumption. In addition could it give economical benefits by saving money and reduce the environmental impacts in the cargo and fishing industry throughout Europe. ORKUSPAR is available free of charge on the Internet http://www.rf.is/verkefni/Orkuspar/

7. References

1) Yngvadóttir, E., Eyjólfsdóttir, H., 2001. ORKUSPAR - An energy efficiency improvement simulator. Project report IFL 11-01.

2) Yngvadóttir, E., Eyjólfsdóttir, H., Arason, S., 2002. ORKUSPAR - An energy efficiency improvement simulator (2nd report). Project report IFL 05-02.

3) Yngvadóttir, E., 2003. ORKUSPAR - An energy efficiency improvement simulator (3rd report). Project report IFL 02-03.

4) Yngvadótti, E. (editor), Andersen, O., Arason, S., Saros, G., Jónasson, B., Arnljótsson, J., Ragnarsson, Á., Eyjólfsdóttir, H., 2002. ORKUSPAR - An energy efficiency improvement simulator, Interim Progress report. Project report IFL 16-02.

5) Ragnarsson, Á.E., 2002. The Energy Efficiency Simulator, Phase 4 Trials and modification. Final Thesis in Mechanical Engineering at The Technical University of Iceland 2002.