Annað veldi ltd

Skuli Johannsson skuli@veldi.is

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Export of Icelandic geothermal hot water for district heating in the Faroe Islands

Introduction

In 1975 a preliminary study was performed on possibilities of exporting hot geothermal water from Iceland to Gothenburg in Sweden. The hot water would primarily be used for residential heating but additionally the 30°C lukewarm water, after leaving the district heating network, could be used for swimming halls, amusement parks, pavement heating, greenhouses etc. The idea was to export 10-30 million tons of hot geothermal water yearly using 250.000 tons oil tank ships. The study was conducted jointly by Reykjavik Energy and a Swedish company named Wilong.

In the following study we assume, without any loss of generality, that Thorshavn in the Faroe Islands is the port of delivery.

Table 1 show statistics for Reykjavik and Faroe Islands and also for Copenhagen for comparison purposes.

Table 1. Statistics of Reykjavik, Faroe Islands and Copenhagen

Item	Unit	Reykja-vik	Thors-havn	Copen-hagen
No of inhabitants		210.000	60.000	1.100.000
Hot water use pr inhab as % of Reykjavik		100%	80%	60%
Total Market for hot water (heat+potable)	M.tons/year	85,0	19,4	267,1
Specific hot water usage	tons/year/inhab	405	324	243
Specific hot water energy usage	MWh/year/inhab	27,7	22,1	16,6

Tank ships are assumed to transport the hot water from Iceland across the Atlantic to the Faroe Islands. As a first phase, we will base our calculations on one 50.000 tons ship carrying 2,4 Mtons/year. As seen in table 6, the transport capacity is then 2,4 million tons/year in 48 round trips. This will cover ca 12,5% of the total market for hot water in the Faroe Islands.

Feasibility analysis in table 6 reveales a nice 14% in yearly pre-tax profit.

Fuel Consumption

According to table 2 rough calculations for a 50.000 tons tanker reveal that ca 15% of the energy in the hot water cargo, according to utilization of the water from 90°C down to 30°C, equals energy in the quantity of oil needed for the ship to sail from Reykjavik to the Faroe Islands and back.

Total yearly fuel usage of 2.400 tons/year amounts to 0,10 l/sec. The fuel could be a conventional diesel oil or DME DiMethyl Ether. Reykjavik Energy recently joined

Table 2. Fuel Consumption

Fuel Consumption of one vessel		
Price of fuel	550	USD/ton
Consumption	10	Tons/day
Price per journey	27.500	USD/journey
Yearly fuel price	1.320.000	USD
Total fuel 1 ship	2.400	tons/year
Hot water capacity	2.400.000	tons/year
Heat capacity	164.000	MWh/year
Heat of combustion	40.000	kJ/kg
Total combustion heat	24.000	MWh/year
	15%	of Heat Capacity

forces with Mitsubishi Heavy Industries Ltd on cooperation in studies of DME production from gas associated with geo-thermal power generation. We assume temporarily the same purchase price for DME as for diesel.

Price of Energy

Table 3 shows structure of the tariff system in Reykjavik and Copenhagen and the prices used in feasibility study in table 6. The price in Faroe Islands is estimated based on similar information from Copenhagen (Flemming Andersen Teknisk direktør VEKS). The table reveals the price difference between Reykjavik on one hand and Copenhagen/Faroe Island on the other hand.

Table 3 Energy Prices

Energy Prices (Energy part of tariff system) USD/MWh			
Item	Reykja-vik	Thors-havn	Copen-hagen
Price of hot water	**7,50**	**59,00**	**50,00**
Price of Energy	8,38		66,65
Energy Tax	0,16		12,86
CO2-Tax	0		1,75
SO2-Tax	0		0,08
VAT	0,60		20,34
Total	9,14	119,82	101,68

Tank ships

There are two ways to estimate transportation costs, buying or renting. In the following we assume buying but it should be noted that probably a more practical way to operate is by renting.

The largest tank ships to-day are 500.000 tons. Tankers are often sold second-hand. Some representative prices for year 2005 include:

- $ 43 M for a 40.000 DWT tanker
- $ 61 M for a 80–95.000 DWT
- $ 73 M for a 130–150.000 DWT
- $116 M for a 250–280.000 DWT

Table 4. Cost Model for Transport Vessel

Cost Model for transport vessel			
Item	**Value**	**Unit**	**Ref.**
Size	50.000	tons	
Price	50.000.000	USD	
Ec.lifetime	25	years	
Int.rate	5,0%		
Annuity	3.547.623	USD/year	
Crew	500.000	USD/year	1,0%
Operation	350.000	USD/year	0,7%
Fuel	1.320.000	USD/year	2,6%
Harbour dues	305.290	USD/year	
Maint	550.000	USD/year	1,1%
Insurance	400.000	USD/year	0,8%
Sum	6.972.913	USD/year	
Unit price	2,91	USD/ton	

Assuming $50 M for a 50.000 tons tank ship leads to a transport price of 2,91 USD/ton according to assumptions made in table 5. Until further notice, we assume that the tank ships for transportation of geothermal hot water have been properly insulated. The ships would sail from Reykjavik to the Faroe Islands fully loaded and without cargo from the Faroe Islands back to Reykjavik.

Land tanks

The land tank structures have not yet been designed but we assume without further notice that the tanks will be built in similar way as was assumed in the former mentioned study from 1975, see figure 1. Some technical issues regarding the tank structure are explained in table 5.

Table 5. Some technical issues in Reykjavik

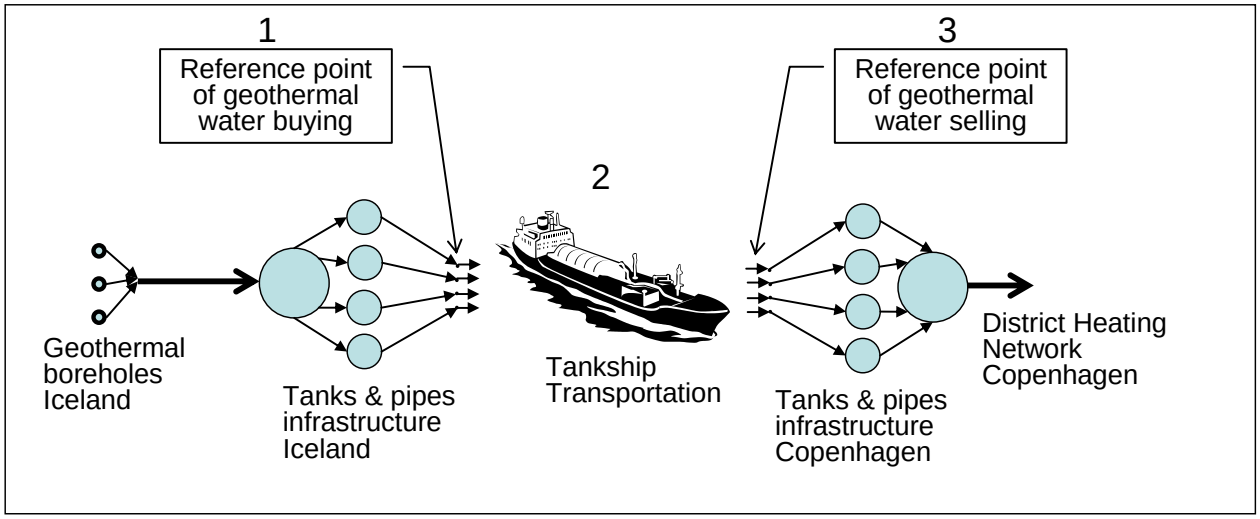
	Technical issues at provider in Rvk	Unit	Value
1	Steady inflow of hot water to land tanks	l/sec	100
2	Flow during loading	l/sec	1.160
3	Nozzles during loading and unloading	nozzles	4
4	Flow in each nozzle	l/sec	290
5	Height of tanks	m	18
6	Diameter of main tank	m	60
7	Diameter of service tanks	m	20
8	Number of service tanks		4
9	Capacity of main tank	m3	50.868
10	Capacity of each service tank	m3	5.652
11	Total tank capacity	m3	73.476

Some assumptions and feasibility

In figure 1 we show the reference points for calculation of feasibility.

1. The geothermal hot water provider in Iceland would deliver the water FOB thereby assuming the provider would finance and install all necessary infrastructure in Iceland.
2. We assume a contract with a shipping company which would provide required shipping capacity with sufficiently insulated tanks to ensure a temperature drop of < 1,5°C during ocean transportation.
3. The geothermal hot water buyer in Thorshavn would receive the water into its water tanks system, delivering the geothermal water onwards to the district heating network.

Figure 1 Reference points for business transaction



Feasibility of this setup is shown in table 6, reveling a yearly profit of 1.373.000 USD/year or 14% of revenue of 9.976.000 USD/year.

Table 6. Feasibility Analysis (pre-tax)

Item	Unit	Value	Comments
Tankships	ship	1	
Transport capacity of each tankship	tons/journey	50.000	
Tankships utilization		67%	
Round trips	days/journey	5	
Number of Round Trips	journeys/year	48	
Hot water – total quantity	M.tons/year	2,4	
Hot water – Thorshavn Tour temperature	°C	90	
Hot water – Thavn Retour temperature	°C	30	
Hot water – Temp Difference utilization	°C	60	
Energy for district heating	MWh/tons	0,068	
Total Energy in hot water	MWh/year	164.000	
FOB hot water energy price Rvk	USD/MWh	7,50	
FOB total hot water price	M.USD/year	**1,230**	
Unit price of transportation	USD/ton	2,91	
Total price of transportation	M.USD/year	**6,973**	
CIF hot water energy price Thorshavn	USD/MWh	59,00	
CIF total hot water price Thorshavn	M.USD/year	**9,676**	
Staff and office	M.USD/year	**0,100**	
Net result	M.USD/year	**1,373**	
Net specific profit		14%	

Auxiliary sources of income

Following sources of income could contribute to better feasibility of the project:

- Cost benefit of pollution free energy production (carbon credit, tax benefits etc.)
- Lukewarm water, with 30°C retour temperature, for swimming halls and amusement parks etc.
- Pavement heating.
- Greenhouse heating.
- Use the tank ship for cold water transport in the summertime when demand for hot water for district heating is at minimum.

Timeline

Using economic lifetime of 25 years we would assume contracts of same period of time with

- Hot water provider in Iceland,
- Sea transport company and
- District heating company as the hot water buyer in the Faroe Islands.

Ocean route

Figure 2 explains the ocean route.

Figure 2. Ocean Route from Reykjavik to Thorshavn in the Faroe Islands