Chemical Cluster in Helguvík

How is the utilization of the products and by-products?

Extract from a final thesis for B.Sc. degree

Keilir Institute of Technology and University of Iceland, School of Engineering and Natural Sciences

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Chemical Cluster in Helguvík

Albert Þórir Sigurðsson

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Advisor(s)
Dr. Andri Ottesen
Egill Þórir Einarsson

Keilir Institute of Technology
University of Iceland
School of Engineering and Natural Sciences
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Abstract

A chemical cluster is an assembly of plants whose processes share interdependent inputs and outputs in order to reduce cost and waste.

The goal of this project is to take a look at seven manufacture processes (aluminum, biodiesel, glycol, methanol, municipal waste, silicon metal and sodium chlorate). How well they work together and how they share their inputs and outputs. Equations from chemistry are used to calculate how much amount of chemicals is needed for each manufacture.

The conclusions show that all of the manufactures work well together. In some cases enough material is left for other process to make their own plant in the chemical cluster. And also this is in the opposite direction, more material is needed for some of the manufactures.

Útdráttur

Efnavinnslu þyrpingar eru þekktar víðsvegar um heim en þær nýta afurðir hver frá öðrum og auka því nýtni á afurðum sem annað hvort eru fluttar langar vegalendir og seldar eða fargað. Það dregur einnig úr kostnaði.

Tilgangurinn með þessu verkefni er að skoða hvernig sjö framleiðsluferli (ál, bíódísel, glýkol, metanól, brennslu á heimilisúrangi, kísilmálm og natríum klórat) vinna saman í efnavinnslu þyrpingu og hvernig þau deila afurðunum og auka afurðunum á milli sín. Notaðar eru jöfnur úr efnafræði til að reikna hversu mikið magn af afurðum þarf fyrir hvert framleiðsluferli fyrir sig.

Niðurstöður leiða það í ljós að framleiðsluferlin vinna öll saman eins og búist var við. En í sumum tilfellum er til nægilega mikið magn til að bæta við öðrum framleiðslum. Það aftur á móti er það sama hægt að segja með að sum staðar þarf að finna aðra framleiðsluferla til að framleiða efnin sem vantar eða framleiða afurðirnar beint

1 Introduction

1.1 Background

A chemical cluster is an assembly of plants whose processes share interdependent inputs and outputs in order to reduce cost and waste. In other words, the by-products of some processes can be used as feedstock for other processes. The success of chemical cluster depends upon the ability of the participants to effectively exchange their by-products. When the by-products from one process can be used as raw material for another process costs can be reduced and pollution minimized.

Michael Porter is one the person that have defined cluster optimally. Clusters can be defined as a geographical cluster of companies and institutions in a particular field that have common interests at stake. In cooperation like clusters, it involves getting different party such as government, government agencies, manufactures, suppliers, service providers, distributors, researchers, educational institutions, financial institution, organizations and other parties that strengthen the cluster with its participation. This will force the parties in the clusters to cooperate together and combine the understanding, skills, insight and techniques in different areas. At the same time it is important that within the cluster is effective competition so the companies are constantly trying to do better and increase their productivity. Clusters do often lead to innovation for new techniques and technology [1].

Various types of clusters do exist, it all depends on what field is looked at, in this case it is the chemical field. Chemical clusters are known everywhere in the world and many large-scale clusters does exist, such as the Port of Rotterdam in Netherland, Antwerp Port in Belgium, Rheinhessen-Pfalz in Deutschland and in Houston in United States of America, along with many other clusters all over the world [2].

1.2 Feasibility of cluster formation in Iceland

Even though Iceland is not a large country, there is always space to build clusters. Few things have to be taken into account that material needs to be shipped back and forth to the chemical cluster, because many products cannot be sold in large quantity in Iceland. So Helguvík is an ideal place for that, with a harbor, airport and close to inhabited area. There is no chemical cluster in Iceland, but HS Orka a privately owned energy company in Iceland have build a resource park around both of their geothermal power plants at Svartsengi and Reykjanes. Svartsengi produces 150MW in thermal energy and 75MW in electrical energy, CRI uses the CO_2 for production of methanol, the Blue lagoon spa uses the drain from the power plant, they also create a lot of cosmetics, there is a clinic for people with psoriasis, biotechnology center and few other things. The Reykjanes geothermal power plant produces 100MW in electrical energy, a fish farming is using the drain from the power plant, holistic fish processing and few other things are located there. So Iceland have used by-products before and they can do it in many other productions [1].

In the last couple of years, many studies have been done in Iceland for cluster. Examples for these studies are the Icelandic Ocean Cluster, the Icelandic Geothermal Cluster, Cluster in Tourism and Health Cluster in Iceland.

1.3 Helguvík harbor

Helguvík, the future site of Century Aluminum, aluminum plant, is located at the Reykjanes peninsula 4km away from Keflavík. The airport is 4km away from Helguvík while Reykjavík capital is less than hour away. The United States Air Force used the harbor located at Helguvík to transport fuel for their air fleet [3]. Helguvík has access to power from Landsnet, harbor, pollution protection and large steel storage tanks. The harbor is 200m long with a depth of 15m, allowing ships of up to 200m in length and 45,000 tones of displacement to dock safely [4]. The large steel storage tanks could be used for the storage of feedstock and products from the chemical industry. There is an ample supply of water for the chemical cluster operation at Helguvík. Since the site is located on the shoreline, ocean water is virtually limitless. Fresh water, process water and hot water are also available in large quantities for industrial applications. The air is quite cool in Iceland, which allows for reliable air cooling—cutting down on operating cost. However the only thing missing at the harbor is heavy lifting industrial equipment, which can be installed later on. Helguvík is a particularly suitable location for a chemical park [5].

1.4 Goal of this project

Dr. Andri Ottesen one of the advisors of this project, has been working for more than a year on making a chemical cluster in Helguvík. Carbon Recycling International and Reykjanesbær have now signed a memorandum to make a chemical cluster in Helguvík. But a great deal of work and research needs to be completed in order to be able to build the chemical cluster.

To achieve the goal for this project, information about the manufacture are collected from books, also evaluation reports that the companies have handed into the Icelandic National Planning Agency for environmental assessment. And at last short interview were made with the people from the companies that are connected to the chemical cluster.

The goal of this project is to see if the following processes are able to share their input and output, and to come up with other solutions that could be used instead or added to the chemical cluster.

3 Synergistic effect

This chapter will show the synergistic effect between the companies. How they share their inputs and outputs. All the companies share the common of electricity and water, a table will show how much of electricity and water will be required. A simple figure of the chemical cluster will also be included in this chapter.

3.1 Electricity and water

Table 3-1 contains information for water and electricity usage. This shows that around 627 MW is needed for the chemical cluster. Probably few more MW is needed in the production of biodiesel and methanol production. The water usage is around 740.869 tons, but in some cases the water usage could be lower, for example if enough of hydrogen is produced. The glycol and methanol production uses less water for creating hydrogen. The municipal waste incinerator early operation is only 7200 hours each years so that is had in mind for the electricity calculations and the water usage will be calculated with that in mind they are producing steam for other companies, the water usage is only for the boiler, there is naturally used more water in the production.

Table 3-1 Is showing the water and electricity usage for each process

Process	Water	Electricity
Aluminum	283.824 tons	422 MW (3700 GWh)
Biodiesel	171.926 tons	0,3 MW (2,65 GWh)
Glycol	123.742 tons	22,8 MW (200 GWh)
Renewable methanol	89.021 tons	30 MW (268,2 GWh)
Municipal waste	36.000 tons	0,3 MW (2.160 GWh)
Silicon metal	6356 tons	136MW (1200 GWh)
Sodium Chlorate	30.000 tons	41,5 MW (363,540 GWh)
Total	**740.869 tons**	**625,9 MW (5736,55 GWh)**

3.2 Carbon dioxide exchange

In table 3-2 carbon dioxide usages for the chemical cluster is shown, a lot of carbon dioxide is available for usage, although methanol have to use very pure source of carbon dioxide for their manufacture. Carbon dioxide from the silicon production can clean it with their steam. For the aluminum smelter produces 365.000 tons of carbon dioxide each year and the carbon dioxide coming from the smelter is not clean enough to be used directly into fuel production.

Table 3-2 Contains information for the carbon dioxide exchange

Chemicals	Producers			Consumer	Balance
	Sodium Chlorate	**Aluminum**	**Glycols**	**Methanol**	
Produced/consumed	360.000	365.000	860	54.402	671.458

The formula for calculating efficiency of carbon dioxide is:

$$efficiency = \frac{users}{producers}$$

$$efficiency = \frac{54402}{725860} = 0,075 = 7,5\%$$

A lot of amount of carbon dioxide is not used and in conclusion it will be discussed further how it can be used.

3.3 Hydrogen exchange

For the hydrogen exchange, the results are shown in table 3-3. The sodium chlorate plant does not produce enough hydrogen for both the glycol and methanol processes. The sodium chlorate plant needs to produce at least 220.000 tons of sodium chlorate to take cover of all the hydrogen sharing.

Table 3-3 Has information about the hydrogen exchange

Chemicals	Producer	Consumer		Balance
	Sodium chlorate	**Methanol**	**Glycols**	
Produced/consumed	3.300	9.891	2.280	-125.481

3.4 Glycerol exchange

As shown in table 3-4, Lífdísill produces glycerol as a by-product. The main feedstock for AGC is glycol. Lífdísill would have to have a huge factory producing 900.000 tons each year of biodiesel if they are suppose to make enough glycerol for AGC.

Table 3-4 Shows information about the glycerol exchange

Chemicals	Producers	Consumer	Balance
	Biodiesel	Glycols	
Produced/consumed	6.519	132.000	-125.481

3.5 Methanol exchange

Carbon Recycling International is the only company producing pure methanol, and Lífdísill is the only company-using methanol for their manufacture. As shown in table 3-5 Carbon Recycling International produces enough methanol for biodiesel. The production of the renewable methanol is their main product, so this is only devised to meet the requirements of the biodiesel production.

Table 3-5 In this table, methanol exchange is shown

Chemicals	Producers	Consumer	Balance
	Methanol	Biodiesel	
Produced/consumed	39.565	6.802	32.763

The formula for calculating efficiency of methanol is:

$$efficiency = \frac{users}{producers}$$

$$efficiency = \frac{6802}{39565} = 0{,}1719 = 17{,}2\%$$

3.6 Steam exchange

Silicon United Iceland and Kalka produces both steam, as a by-product and Lífdísill and AGC are consumers of it. Table 3-6 shows information for how much each user is producing, how much each consumer is using and how much amount is needed. The table also shows that not enough steam is produced for the biodiesel and glycols manufacture.

Table 3-6 Has information about the steam exchange

Chemicals	Producers		Consumer		Balance
	Silicon metal	**Waste**	**Biodiesel**	**Glycols**	
Produced/consumed	334.282	36.000	14.960	498.000	-142.678

3.7 Overview for the synergistic effects

For the overview of the synergistic effect, table 3-7 shows the overall information that have been shown above. It has the main chemicals exchange with how much amount in tons is produced, how much is consumed. It show how much is used and what is left and also it shows the efficiency.

Table 3-4 Shows the overall synergistic effects

Chemical	Produced	Consumed	Balance	Efficiency
Carbon dioxide	725.000	55262	54402	7.5%
Hydrogen	3.300	12.171	-8.871	100%
Glycerol	6.519	132.000	-125.481	100%
Methanol	39.565	6.802	32.763	17.2%
Steam	370.282	512960	-142.678	100%

3.8 Flow chart of the chemical cluster

In figure 3-1 it shows a flow chart of the chemical cluster, how the feedstock is used, what products and by-products are used in other companies.

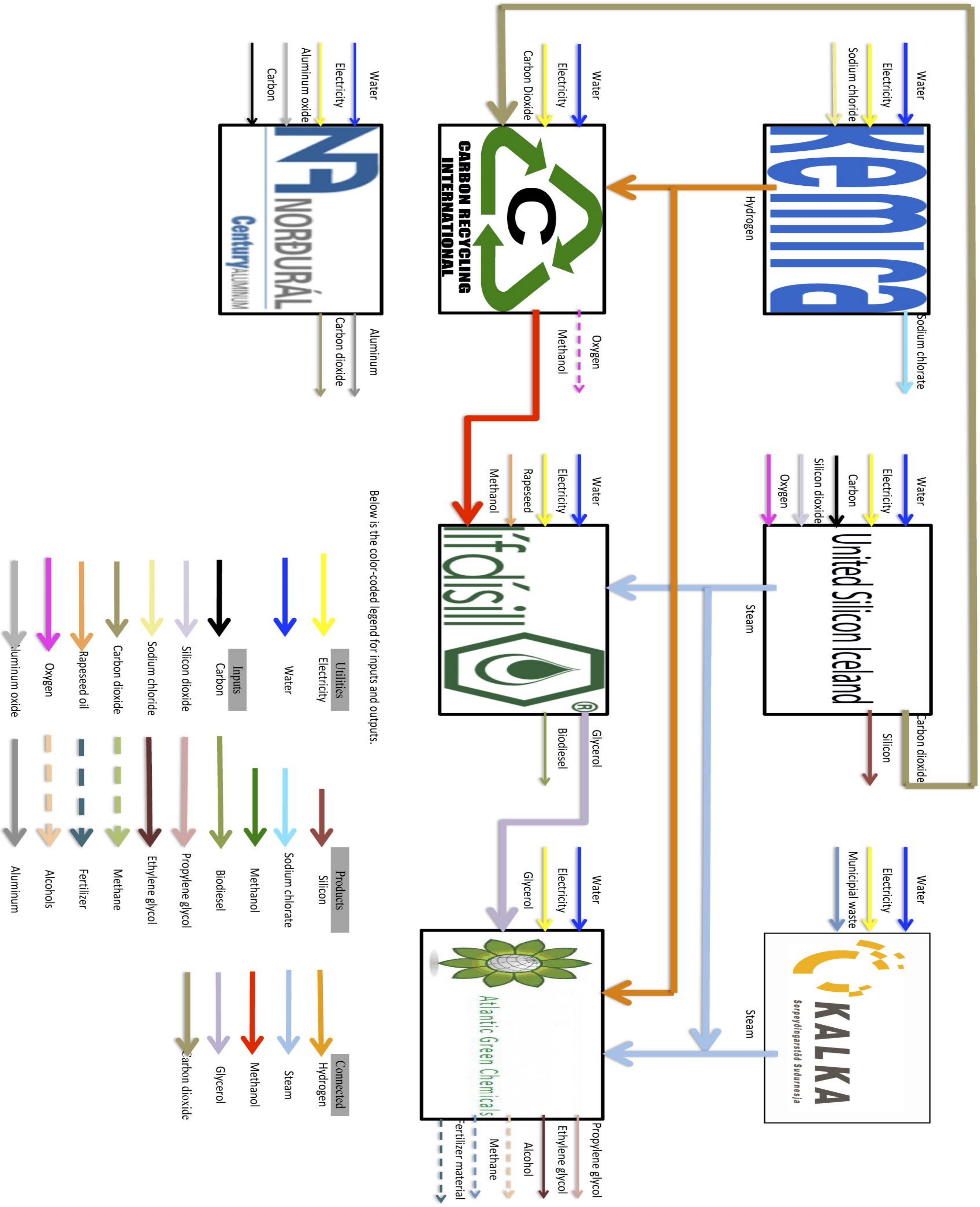

Figure 3-1 Shows the overall process for the chemical cluster

4 Discussions

The conclusion for the chemical cluster are very postive, they shows what was expected that all of the manufacture processes works well together. All of the proccesses are using each other products or by-products for their manufacture. A lot of extra material is available for other companies that could be added into the cluster, that is one of the most surprising from the conclusions. Even though a lot of extra material is available, few of the manufactures biodiesel, glycol and methanol need more material to meet their requirements for their manufacture. This results show that chemical cluster is a very good idea. Although few things need to be sorted out before next step is made for the cluster. Better steam calculations are need in the manufacture of the municipal waste and also from the silicon metal. If it is not enough steam a solution must be found to cover the steam usage. Also not enough hydrogen is produced for the methanol and the glycol processes so it would either need another hydrogen producer or having the same hydrogen plant producing for both of the process instead of having two hydrogen plants up and running.

The aluminum manufacture is not sharing any products with other manufactures. If the carbon dioxide is suppposted to be used, the flour needs to be purified from it. Wet cleaning could be used to purify the carbon dioxide. Then it is possible to use carbon dioxide for algae farms, greenhouse production. The heat from the smelter could also be used for this production. The greenhouse could include the cultivation of flowers or vegetables. The algae could be used in the cosmetics industry or for the biodiesel manufacture. Carbon dioxide could also been used for making shield gas for MIG/MAG welding, or used in the oil industry if Iceland decides to drill after oil. For the MIG/MAG welding the carbon dioxide is mixed with argon. Carbon dioxide is pumped into the oil wells. Mineral carbonation plant could also be interesting. Using the carbon dioxide from the aluminum smelting mixing minerals and re-use it in constructions.Alur scrap is a company up and running in Helguvík, they could quite easy integrate their plant into the chemical park. They recycle waste aluminum and slag, and could use the oxygen from the methanol and glycol manufacture. It could also be able to use the aluminum to make aluminum cable on-site in the chemical cluster.

If Lífdísill is not ready for making a plant at Helguvík, other biodiesel manufacture could come into their place. For example Atlantic biodiesel could step in. Atlantic biodiesel have a pilot plant up and running in Blönduós using animal fat from the slaughterhouse to make biodiesel. If algae culture might rise in the chemical cluster, the algae could be used to produce biodiesel. Animal fat or fish oil from the fishing industry that is around Helguvík could also be a choice.

Atlantic Green Chemicals, have to find a way to produce steam if the silicon company cannot fulfill their steam requirements. The glycol is used as antifreeze both for cars and airplanes. They produce methane that could be used as fuel for cars. The alcohol mixture would be used as additive for fuel. Biodiesel is not producing enough glycerol for them, which was known in advance. If ammonium nitrate is produced with neutralization method, steam is produced as by-product. For every ton of ammonium nitrate produced 1 ton of steam is produced.

Carbon Recycling International is producing enough of methanol for the biodiesel plant. The methanol is used as a burning fuel that can blend with gasoline. The hydrogen production for both the methanol and the glycol production is not enough so a solution is needed for that. It could be either having one hydrogen plant for both of the processes or adding another manufacture that produces hydrogen as a by-product. Chlor alkali process produces hydrogen as a by-product. They are producing oxygen as a by-product that could be used for Alur scrap production as mentioned above. Also the silicon production could use oxygen for their process. And it has high enough quality to sell their oxygen to fish farms, medical institutions or waste gasification.

Kalka steam production needs further research. They need to calculate how much steam could be produced from their manufacture for the glycol plant and the biodiesel plant. The heat from Kalka could also be an interesting source to take a look at. Kalka is also playing a vital part in the chemical cluster, they can dispose chemicals that are dangerous and also all waste from other productions.

The silicon metal is one of the most important manufacture in the chemical cluster, producing a large amount of steam for the glycol plant. The silicon dioxide will be sold into the cement production, so this will open opportunities for an Icelandic company to make cement. The silicon slag will be sold for production of ferrosilicon and siliconmanganese. The silicon dioxide could also be used for medical grade plastic or for the cosmetic industry. One of the most interesting part of the silicon production, if the silicon is cleaned to 99.99% pure silicon, it would be possible to make solar cells.

Sodium chlorate is producing hydrogen as their by-product for the methanol and glycol plants. It will not be enough hydrogen for their processes. The sodium chlorate is used in bleaching paper.

The chemical cluster uses a lot of electricity and water. Around 630MW are used only for these seven processes so more electricity is needed. A research needs to been done to calculate how much electricity is needed and where it should come from.

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