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Title "LIFE CYCLE ANALYSIS OF THE PRODUCTION OF FT-FUELS - 4 DIFFERENT SCENARIOS"

Author (s) **Blinge, Magnus** (1) ; **Rehnlund, Björn** (2); **Larsen, Ulrik Lundorf, Peter; Ivarsson, Anders; Schramm, Jesper** (3)

E mail bjorn.rehlund@atrax.se, ul@meh.dtn.dk, js@mek.dtn.dk

Affiliation (1) Chalmers University of Technology, Sweden
(2) Atrax Energi AB, Sweden
(3) Technical University of Denmark

Country Sweden; Denmark

Abstract This paper deals with aspects concerning the life cycle aspects regarding Fischer-Tropsch (FT) fuels. Four different scenarios are being analysed based on Life Cycle Assessment (LCA) -figures.

The results etc presented below emanates from a project undertaken by the International Energy Agency's (IEA) Implementing Agreement on Advanced Motor Fuels (IEA/AMF). The project has been carried out as an IEA/AMF annex, number XXXI, with financial support from the USA, Finland and Denmark. [...] The IEA/AMF project has also included emission tests on road vehicles fuelled by FT-Gasoline. These tests have been performed by The Technical University of Denmark and will be presented in another presentation at the ISAF XVI, "Emissions from Road Vehicles Fuelled by Fischer-Tropsch Based Diesel and Gasoline", by Jesper Schramm, DTU, Denmark .

Keywords Fischer-Tropsch (FT) fuels; Life cycle analyses

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Blinge, Magnus
Chalmers University of Technology, Sweden

Rehnlund, Björn
Atrax Energi AB, Sweden

Larsen, Ulrik
Lundorf, Peter
Ivarsson, Anders
Schramm, Jesper
Technical University of Denmark

Abstract
This paper deals with aspects concerning the life cycle aspects regarding Fischer-Tropsch (FT) fuels. Four different scenarios are being analysed based on Life Cycle Assessment (LCA) -figures.
The results etc presented below emanates from a project undertaken by the International Energy Agency's (IEA) Implementing Agreement on Advanced Motor Fuels (IEA/AMF). The project has been carried out as an IEA/AMF annex, number XXXI, with financial support from the USA, Finland and Denmark.
Some important results from the scenario studies based on the evaluated LCA data are:

- Production and use of GTL fuel has the potential of contributing about the same or slightly less greenhouse gas to the atmosphere than production and use of conventional diesel.
- Production and use of CTL emits more than twice as much greenhouse gases compared to traditional fuels.
- Production and use of BTL reduces the emissions of greenhouse gases by 60-90 %.
- To substitute 15 % of the EU 15 countries fuel consumption would an area of 310 000 km² be cultivated with Salix. This corresponds to an area of the size of Poland. It would also require 122 FT-plants of 1,6 GW.
- Theoretically, it is possible supply the worlds need for energy with biomass. However, planning the production, the localization of plants, building the infrastructure, this will take time and requires heavy long-term investments.
- The demand for Natural gas is increasing and there is no way for the US to meet an increased demand from supplying the vehicle fleet with F-T fuels from domestic reserves. With the political situation in the Middle East and in Venezuela, it doesn't seem likely that this solution will ease the US problems with reducing their oil dependences.

The IEA/AMF project has also included emission tests on road vehicles fuelled by FT-Gasoline. These tests have been performed by The Technical University of Denmark and will be presented in another presentation at the ISAF XVI, "Emissions from Road Vehicles Fuelled by Fischer-Tropsch Based Diesel and Gasoline", by Jesper Schramm, DTU, Denmark

Keywords: Fischer-Tropsch (FT) fuels; Life cycle analyses.

Background

There is a growing demand for new alternative motor fuels to replace conventional fossil fuels and to improve tailpipe emissions. Today ethanol and bio diesel seems to be the most interesting alternatives introduced on the market. However, most experts are of the opinion that the production of so-called synthetic fuels probably will be the next generation of alternative fuels replacing gasoline and diesel oil.

The Fischer-Tropsch technique (FT- Technique) is a way to make synthetic fuels but also many other products such as waxes, alcohols and gases. The technique was discovered by two German coal-researchers, Hans Tropsch and Franz Fischer in 1923, but was first implemented on a larger scale during World War 2. The FT-technique proved to be useful fuelling the German war-machine during the oil embargo.

FT-Technique was also implemented again during the oil embargo of the South African Apartheid regime and as a consequence mainly Sasol Oil has further developed the method to this date. Many international oil companies today have adopted the technique and are working to improve the process. Among those are Shell, BP, Statoil, Chevron and Texaco, but the principal producers of FT fuels today are Shell and the two South African oil companies PetroSA and Sasol Oil. The process is, at this point in time, in South Africa, mostly being used to produce gasoline, but the diesel fuel share of the total production are continuously growing.

Though the process was originally used as a substitution for traditional oil refining, the process could also use oil as feedstock in order to make cleaner fuels.

FT fuels can be alternative motor fuels of brilliant quality and can be produced from as different feedstocks as coal, natural gas, biomass and even municipal waste. The technology is as such a GTL (Gas to Liquids), CTL (Coal to Liquids) or BTL (Biomass to Liquids) technology – depending on the feedstock.

Literature Review and information collection

The scope of the LCA study was to look for a feasible set of LCA data on production of Fischer-Tropsch fuels, from a global perspective and a large-scale basis, based on existing reports and to use them for qualified prediction of the FT-fuels impact on climate and environment compared to gasoline and diesel oil and furthermore to use them in scenario studies.

In order to get an overview of the papers and articles concerning production, distribution and use of FT-Fuels a literature review was carried out. Several Internet search engines were applied in an extensive search for any kind of publication concerning relevant data.

Besides the literature study several companies, organisations and Universities has been contacted and to some extent visited such as Sasol, South Africa, VTT Energy, Finland, Nykomb Synergetics, Sweden, ETC Sweden, and Chemrec Sweden.

LCA studies

In environmental calculations for vehicles using alternative fuels, the production method of the fuel itself is very important. Different production methods can give big differences in emissions, particularly of CO_2.

Over the years, more than 800 life cycle analyses (LCA: s) have been performed on fuels (Quirrin et al, 2004). The choice of system boundaries and allocation method, time perspectives, and geographical conditions are some of the factors that are of crucial importance for the result of an LCA for fuels. This has been established in a number of reports (Blinge M, 1998), (Jonasson & Sandén, 2004), (Quirin et al., 2004).

The following five different life cycle analyses (LCA) of Fischer-Tropsch diesel are found relevant to compare and used when extracting LCA data:

1. *Gas to Liquids Life Cycle Assessment. Synthesis Report. Prepared for: ConocoPhillips, Sasol Chevron, Shell International Gas. Prepared by: Five Winds International. August 2004.*
2. *GM Well-to-wheel analysis of energy use and greenhouse gas emissions of advanced fuel/vehicle systems – a European study. L-B-Systemtechnich GmbH for GM, ExxonMobil, Shell, BP and TotalFinaElf. 27 September 2002.*
3. *Well-to-wheels analysis of future automotive fuels and power trains in the European context. European Commission Directorate-General Joint Research Centre: Concawe, European Council for Automotive R&D. Version 1B January 2004*

4. *Life-cycle Emissions Analysis of Alternative Fuels for Heavy Vehicles; CSIRO, Australia, 2000*

5. *Vergleichende Ökobilanz von SunDiesel (Choen-Verfahren) und konventionellem Dieselkraftstoff*, PE-Europe GmbH, Leinfelden-Echterdingen, Germany, 2005

Scenario Studies

Theoretically, it is possible to supply the world's need for energy with biomass. The sun is very generous with energy, but a full-scale biomass based energy system will imply dramatic changes in the supply chain. Planning the production, the localization of plants, building the infrastructure, this will take time and requires long-term investments. If this shall be done in a smooth way must the planning start before the technology is fully developed. Otherwise the shift to a fossil free economy will be even further delayed.

The problem is primarily economical. The biomass-based energy cannot compete with the fossil energy as long as the external costs on society are not internalized.

But it is also a logistic problem. The available land suitable for bio energy production is not situated close to the users. The enormous amounts of biomass needed to substitute all fossil fuels used in the world will probably have large impacts on other parts of the economy besides the energy and transport sectors, such as the prices on food, paper and wood industry and on suitable land.

There is also a substantial need for investments in production plants and infrastructure for the new energy system.

In order to do a first attempt to make the consequences visible of what a biomass based Fischer-Tropsch production process will have on the logistic- and transportation systems for a selected number of representative countries, four scenarios is drawn in this study.

- Finland, with forest residues as feedstock for biomass based F-T Fuel
- Polen, with energy forest as feedstock for biomass based F-T Fuel
- Denmark, with energy forest as feedstock for biomass based F-T Fuel
- USA, with Natural Gas as feedstock for fossil F-T Fuel

The scenario calculations are based on the following principle steps:

1. Assessment of realistic size and efficiency of the plants
2. Biomass potential in respective country
3. Energy efficiency and realistic usable land area in respective country
4. Transport distance
5. Amount of fuel that can be substituted
6. Results in terms of number of vehicles and transport work

The scenario studies are furthermore based on a syngas reactor with fluidized bed and an IGT reactor. The plant capacity used for the calculations are 80 ton dry mass/hour and an energy content of 1,5 GJ/ton dry mass which gives an outcome of 167 MWh FT-fuel and 15 MWh electricity. This implies an efficiency of 50 %, where 46 % is FT-Fuel and 4 % is electricity.

Results

Some results from the scenario studies based on the evaluated LCA data are:

- Production and use of GTL fuel has the potential of contributing about the same or slightly less greenhouse gas to the atmosphere than production and use of conventional diesel.
- Production and use of CTL emits more than twice as much greenhouse gases compared to traditional fuels.

- Production and use of BTL reduces the emissions of greenhouse gases by 60-90 %.
- The use of FT Fuels reduces emissions of smog inducing matters with about 90%.
- The reduction of emissions affecting acidification and metrification is about 5-40 % when using Fischer-Tropsch fuels.
- To substitute 15 % of the EU 15 countries fuel consumption would an area of 310 000 km² be cultivated with Salix. This corresponds to an area of the size of Poland.
- It would also require 122 FT-plants of 1,6 GW.

  If we widen the perspective and think about the rest of Europe we can only imagine the problems of finding enough space at the coastline to support the European total fuel consumption. It will not only be a logistic problem, but also a land use problem.

- It is not likely that the production prize of biomass based F-T will ever be competitive with coal or natural gas based F-T unless there will be some kind of global regulation introduced on emissions of fossil CO2.
- According to information from Sasol it is possible to produce FT-fuels with coal as feedstock to a market competitive price as soon as the crude oil price is higher than 30 to 40 USD per barrel.
- The demand for Natural gas is increasing and there is no way for the US to meet an increased demand from supplying the vehicle fleet with F-T fuels from domestic reserves. With the political situation in the Middle East and in Venezuela, it doesn't seem likely that this solution will ease the US problems with reducing their oil dependences.

Acknowledgements.

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Atrax Energi AB has been appointed as operating agent for annex XXXI.

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