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Utilization of Geothermal Energy and Emissions for Production of Renewable Methanol

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ABSTRACT

The purpose of the paper is to review the operation and economics of the first CO_2 to renewable methanol industrial scale plant, utilizing geothermal energy and non-condensable gases. Key success factors for the project include innovative technology and a resource pooling partnership between Carbon Recycling International ehf, and HS Orka hf.

1. INTRODUCTION

Iceland has one of the highest numbers of cars per capita in the world, approximately 227,321 for a population of approximately 315,000 people [1]. The level of pollution from transportation and industrialization is a public concern and a limit to growth. Consequently, Iceland is investigating ways to reduce carbon dioxide emissions, in order to minimize petroleum dependency and improve balance of trade.

Iceland has a high concentration of volcanoes and geothermal energy is readily available [2, 3]. This renewable energy source lends itself to the production of two feed stocks, hydrogen and carbon dioxide which can be used for the production of fuel.

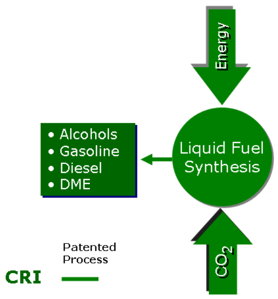

Figure 1: CO2 to Liquid Fuels Diagram

Carbon Recycling International (CRI) and HS Orka (HS) cooperate in demonstrating the use of geothermal energy and capture carbon dioxide to produce Renewable Methanol (RM). RM can be upgraded to dimethylether or gasoline using available standard conversion technology.

The processing of carbon dioxide from emissions of geothermal power plants and the electrolyzing of water provide necessary carbon sources and hydrogen gas to produce clean fuel. Carbon dioxide is the main component in the non condensable gas, a by-product gas of geothermal power production [4, 5].

Carbon Recycling International plans to construct and operate an Industrial Scale Plant (ISP) in 2010 which will produce 2.1 million liters per annum of RM and be co-located with the Svartsengi geothermal Combined Heat and Power (CHP) generation plant.

2. COOPERATION BETWEEN HS AND CRI

HS Orka hf harnesses the geothermal energy at Svartsengi, and in other areas in the Reykjanes peninsula. The company has a history of innovation and covers the complete value cycle of geothermal energy utilization. It includes power plant engineering and construction, plant operations, and electrical distribution in this area. The company is a service provider of electricity, heat, and hot water for residential and industrial utilizes, well centers and theme parks.

CRI was founded to pursue the proposition of producing an alcohol-based fuel, renewable methanol, from renewable resources. Currently, methanol is produced from fossil fuels, either natural gas or coal. CRI would be the first company to produce renewable methanol in large quantities using only carbon dioxide, water and electricity as inputs.

The main purpose of ISP at Svartsengi is twofold: 1) to mitigate the environmental impact of the geothermal gas stream from the power plant and 2) to convert the geothermal gas stream to a valuable product from the power plant. The concept fits in the philosophy of Resource Park (RP) by HS which promotes total utilization of geothermal energy to enable development of derivative applications in harmony with the local environment. It is achieved through successful use of heat waste for the Blue Lagoon, skin therapy and treatment, fish farming, beyond the traditional production of electricity, heat, and water. The recycling of carbon dioxide for near zero emission power generation and clean fuel manufacturing is an integral development of the RP geothermal strategy. HS will secure land and provide water, power, steam and labor in support of CRI for permitting, engineering, construction and operation of ISP. CRI will undertake the engineering, permitting, construction and operation of ISP. HS recovers its investment through participation in the sales of methanol from the operation of ISP.

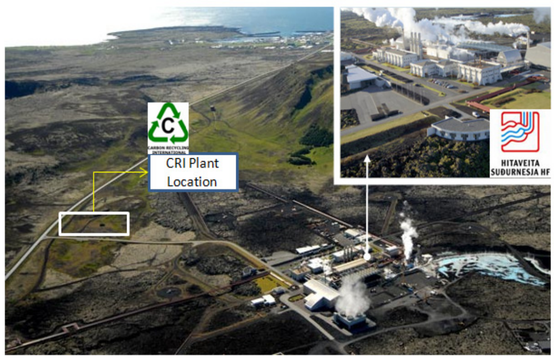

Figure 2: Geothermal Power plant of HS Orka hf in Svartsengi, Iceland and Location of ISP plant.

3. CO_2 TO LIQUID FUEL PROCESS

CRI has proven the viability of the technology on a laboratory scale at its facility in Reykjavik, Iceland. Figure 3 below shows a block flow diagram of the ISP process. The demonstration plant proposed will generate methanol from the consumption of electrical energy supplied on peak or off peak and the use of CO_2 rich Non-Condensable Gas (NCG) feed from a geothermal steam plant.

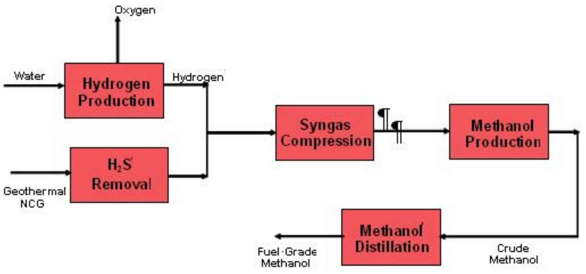

Figure 3: Block Flow Diagram of ISP Process.

The process shown in Figure 3 uses carbon dioxide which is the primary component of an effluent stream of NCG discharged from the geothermal power plant as a raw material for the methanol production. The electrical power produced from the geothermal power is used for the electrolysis of water to produce hydrogen which is also used as a raw material. Hydrogen sulfide is contained in the NCG effluent and must be removed prior to use in the methanol conversion reactor to ensure longevity of the downstream catalyst's lifetime. The purification of the carbon dioxide is achieved through an amine scrubbing system which will discharge the H_2S removed from NCG. Following this purification step, the carbon dioxide is combined with the hydrogen and compressed from atmospheric pressure to the pressure required in the methanol conversion loop. After the raw syngas is compressed it is passed through heat exchanger for pre-heating and then sent to a reactor where it is partially converted to methanol. The partially converted syngas is then cooled and sent to a gas liquid separator where the gas from the separator must be recompressed and recycled back to the methanol converter in order to improve the overall conversion of the process. The liquid from the separator contains crude methanol which can be further processed for fuel grade methanol or to other fuels such as dimethylether or gasoline.

4. ENTITY OBJECTIVES

The engineering, design, construction and operation of the liquid fuels plant ISP at Svartsengi will address the following technical areas to transform the concept into a commercially viable entity:

- Effective separation of carbon dioxide from the composition of emission associated with the geothermal site
- Integration of the liquid fuels plant with the working geothermal power operation
- Production of renewable methanol at the targeted fuel specification
- Reliable supply of renewable methanol to the existing blending terminal

The success of carbon dioxide recycling implementation requires the seamless blending of affordable renewable methanol in gasoline or biodiesel supply line. It is necessary to address carbon recycling by optimizing the complete value chain (Figure 4).

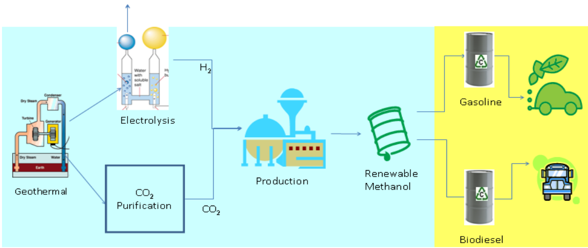

Figure 4: Value Chain of CRI process

5. ISP OPERATING PARAMETERS

ISP will remove 2,500 tonnes of carbon dioxide per annum from the emission at Svartsengi power generation plan. It will apply 2.5 megawatts of clean electricity to produce 2 million liters of fuel grade renewable methanol (RM) per annum. The plant foot print is 50 by 50 meters. The construction will be one year. ISP will be on line in the second quarter of 2010. The schedule of Engineering, Procurement, and Construction (EPC) is depicted in Table 1.

	2009				2010			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Feedstock Purchase Agreement Fuel Off take Agreement								
Environmental Permit								
Land Provision								
Operational Permit Detail Design								
EPC								
Commissioning & Testing								
Full Scale Production								

Table 1: Engineering, Procurement and Construction of ISP.

6. USE OF RENEWABLE METHANOL

The clean production and burning characteristics of renewable methanol is a critical attribute in developing alternative fuel which must meet not only the criteria of affordability and availability but also low carbon and renewability. Figure 5 depicts the concept of carbon recycling by CRI needs less energy, emits less carbon dioxide and drives for the same distance [6].

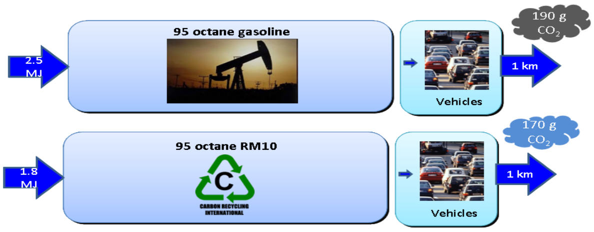

Figure 5: Well to wheels. Analysis of Renewable Methanol

CRI's renewable methanol (RM) can enter the existing transportation fuel pipeline in various path ways:

a. Renewable Methanol blending to Gasoline in low volumes (RM10) [7]

RM can be a substitute component for fuel to develop substantially similar renewable gasoline by blending it in to gasoline up to 10% by volume. RM10 requires no change in the car, minimal changes are required in distribution infrastructure, and no loss in mileage.

b. Alternative renewable fuel [7]

RM 85 (up to 85% Methanol and remaining Gasoline) can fuel Flexible Fuel Vehicles (FFVs) which uses methanol or gasoline in the same tank through the use of an alcohol fuel sensor that measures the methanol content of the fuel going to the engine and adjusts the fuel flow rate and spark advance accordingly. Relatively few changes are needed to turn a vehicle into an FFV with incremental costs $50 - $150.

c. RM – Ethanol blends in Gasoline

Low volume bio ethanol blends are used in European Union (up to 5% by volume). Renewable Methanol can co-exist with ethanol, with methanol-ethanol blends in gasoline [8].

d. RM for Biodiesel production

Around 12% by weight of Methanol is used as input for the production of bio diesel. Bio diesel is mixed with fuel diesel up to 20% by volume.

e. RM for fuel cells

On board reformer fuel cell uses methanol as a hydrogen carrier. It extracts the hydrogen from the methanol and passes to the base hydrogen fuel cell. Direct Methanol Fuel cell does not require any conversion of methanol to hydrogen [9, 10].

7. CONCLUSION

The potential geothermal energy in Iceland, alone, is in excess of 20 TWh per annum [3]. The world average emission from a geothermal plant is 122 g per kWh [4]. The continuing increase in geothermal energy will vent a large amount of carbon dioxide into the atmosphere. The application of the CRI process is a sensible approach to harness emission free geothermal energy and to produce renewable fuel.

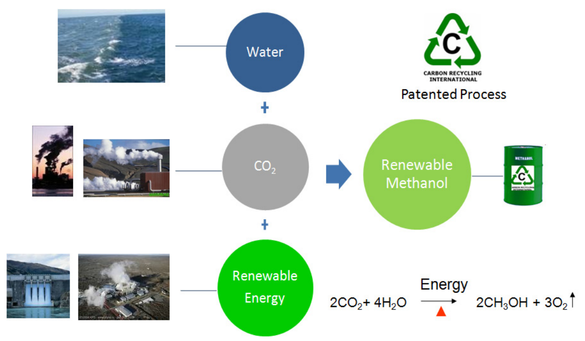

Figure 6: Interrelations between CRI, geothermal power utilities and fuel retailers.

The CRI concept is competitive if the source of energy is renewable, abundant and the price of oil is more than 50 USD per barrel. However, a successful commercialization of the technology requires favorable renewable transportation fuel and carbon regulations from the government. It also requires the participation and approval of the gasoline retailers and automobile makers to enable the introduction of renewable methanol into the gasoline pipeline.

A coordinated public private partnership between CRI, HS, the municipality of Grindavik and the central government Iceland has been the cornerstone for the deployment of the technology.

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