SUMMARY OF THE PROJECT

Recycling of carbon dioxide (CO2) into liquid hydrocarbon fuels

Development and series production of industrial plants for production of synthetic liquid hydrocarbon fuels by means of plasma chemical low temperature hydrogenation of the gas-vapor mixture in the presence of small amount of accelerants using the atmospheric carbon dioxide as a raw material.

Project partners:
Java Trade GmbH is a trade and investment company. The company invests in research and development projects in Central and Eastern Europe for commercialization of innovative technologies in the areas of materials technology and renewable energy in Austria and the EU. The company operates also in project business (management of infrastructure projects in Slovenia, Romania, Bulgaria). The company has its headquarters in Vienna and offices in Maribor (Slovenia), Zurich (Switzerland) and Kiev (Ukraine).

The project is being developed together with Ukrainian researchers and patent applicants (patent applications EP2551329A2 and US2013030234A1) Mr. Viktor Astafiev, Mr. Sergii Iakovliev, Mr. Alexander Kozlov, Mr. Sergii Lytvynenko. The lead developer is Mr. Viktor Astafiev, Institute of Geophysics of the Academy of Sciences of Ukraine (http://www.igph.kiev.ua/index.html Palladin av 32, Kiev, Ukraine, 03680), he owns over 30 ukrainian, russian and international patents. Noteworthy are the lectures and publications of Mr. Viktor Astafiev "Effect of material split in non-uniform gravitational field" (Publications Collection of the Academy of Sciences of Ukraine (ASU) № 11 1980, № 6 1982, № 10, 1983), "Plasma-assisted generation of electric energy" (ASU Publications Collection № 7 2000), "High-efficiency fuel on the basis of plasma gas" (ASU Publications Collection № 1 2002). Austrian Research and Technology Partner: Güssing Energy Technologies GmbH, Research Institute for Renewable Energy, Wiener Straße 49, A-7540 Güssing http://www.get.ac.at/ and BioEnergy2020+ GmbH, Wiener Straße 49, 7540 Güssing http://www.bioenergy2020.eu/.

Background
The various concepts of CO2 capture and storage (CCS: Carbon Capture and Storage) and material use of CO2 (CCR: Carbon Capture and Reuse) propose different methods for recycling of CO2 into hydrocarbon fuels. The existing industrial hydrocarbon synthesis technologies utilizing water and atmospheric air are based upon creating conditions for water decomposition into hydrogen H2, oxygen O2, and extraction of carbon dioxide from ambient air. The core problem in the production of liquid hydrocarbons using carbon dioxide CO2 as a raw material is currently a high production cost of produced fuels due to the cost- and energy-intensive electrolysis processes for the production of hydrogen for its subsequent conversion into synthesis gas, so that more energy will be consumed, than can be produced by the energetic use of obtained hydrocarbons.

The most known industrially applicable technologies for obtaining synthetic liquid hydrocarbons with the binding of atmospheric CO2 are multistage and include following basic stapes: electricity generation from low carbon power generation sources such as wind power and solar power, CO2 capture, extraction of hydrogen gas (H2) using the electric energy from sources with substantially lower amounts of carbon dioxide emissions, transformation of hydrogen gas into synthesis gas - a carbon monoxide-hydrogen mixture and then converting the mixture of carbon monoxide and hydrogen into liquid hydrocarbons (mostly methanol production in the Fischer-Tropsch process).

In accordance with the present process, the synthesis of hydrocarbons is performed in a quasi-continuous process by means of plasma chemical low temperature hydrogenation of the gas-vapor mixture. The technology is directed to synthesis of hydrocarbons without intermediate stage of production of H_2, O_2, CO_2, $CO+H_2$, CH_4 and other substances usually used for the synthesis of hydrocarbons. The synthesis is carried out without high energy consuming for water electrolysis for obtaining the hydrogen gas and with low energy consumption, whereby this method differs from the other methods for the synthesis of hydrocarbon fuels. To produce the competitive synthetic fuel is needed 0.7 to 0.9 kW / h electricity, depending on the density of the fuel.

Description of technology and research results

The technology is a method of direct synthesis of gaseous, gaseous-watery and liquid hydrocarbons on a module apparatus. The method comprises use of water and atmospheric (ambient) air, which are consumed during the synthesis process, as well as the use of hydrocarbons as an initial fill, which are maintained unconsumed through the technological cycle of the synthesis process. The method and the device are fixed in the European and U.S. Patent Applications EP2551329A2 and US2013030234A1. The developed and operated experimental apparatus produce a hydrocarbon suspension similar to oil with a density of 790-800 kg/m3 and its derivatives having the density of 730-760 kg/m3 (gasoline, diesel oil, etc.).

The apparatus consists of a hydrocarbon synthesis chamber, a sump tank to collect hydrocarbon condensation obtained in the process of synthesis, and a bubbling chamber. All chambers as well as the sump tank are interconnected by means of pipes. The synthesis chamber is equipped with devices to supply water, and the bumbling chamber is equipped with device to supply atmospheric air into the chamber. The process of hydrocarbon synthesis takes place in the synthesis chamber, where the initial hydrocarbon fill has been placed. The hydrocarbons fill is heated up and brought to melted condition in the synthesis chamber, and then under very specific temperature, finely pulverized water is spray-injected through a nozzle into the synthesis chamber, and onto the boiling surface of the hydrocarbon fill. As a result of water injections into the synthesis chamber where small amounts of initial hydrocarbon fill has been placed, and as a result of both the heating of the hydrocarbon fill and water injection, a steam-gaseous mixture forms. Then, due to colliding interaction of the finely pulverized water with the boiling surface of the hydrocarbon fill, the steam-gaseous mixture becomes ionized in the EDL. This in turn induces the commencement of adiabatic, plasma-chemical and exothermal reactions of synthesis, which produce a wide spectrum of synthesis gases: CO, H2, O2, CO2, C1 - C4, all in their metastable state. The gases then immediately react herewith and form synthesis-condensation of light hydrocarbons, ethers, carboxylic acids, spirits, etc. In order to maintain the balance of gases in the module apparatus a portion of both ether water and final product is returned to the synthesis chamber.

At today's stage, some operating regimes of the plant and a comprehensible demonstration procedures are fixed experimentally and can be demonstrated on the already constructed and operated experimental device in a fundamental conformance with process described in the attached patent application. The performance of the existing unit is 1 L of fuel per hour. The currently produced sulphur-free gasoline has the following values: density 745.1 kg/m3 at 200C, octane number 74-98, aromatic hydrocarbons to 0.4%, without lead, water, ethanol, benzene and methanol content.

Benefits & Applications

The technology offers a possibility for an efficient utilizing of atmospheric CO2 and CO2-emissions from various sources, such as power plants, biogas plants, and converting them to liquid hydrocarbons. By recent experiments, the reduction of the reaction temperature was reached at about 85-900C, whereby the power consumption for the production of a synthetic fuel can be reduced to about 0.5 kW / h. In addition to the economic benefits due to the use of water (technical industrial water or treated wastewater) and atmospheric CO_2 as reaction raw materials and due to the low energy reaction process for synthesis of high value chemicals, this industrial application contributes significantly to the binding of CO_2 - carbon dioxide and helps to avoide climate changes reducing greenhouse gas emissions.

The modular design will allow the production of plants with different capacities depending on the customer requirements. The use of CO_2 as a raw material, containing in the exhaust gases of power plants and the stored CO_2 from carbon capture and storage projects can increase the efficiency of the process. Producing of 3 tons of fuels by means of this innovative technology is binding about 2 tons of atmospheric CO_2. After process modification the method also enables the recovery of the atmospheric nitrogen for producing nitrogen-based fuels and materials.

Business strategy and marketing of the technology

The addressing the most interesting market for automotive fuels would delay the commercial use of the technology due to unpredictable marketing costs and expenses. For this reason, along with the handling this market we aim the technology for use in the context of industrial manufacturing processes.

In contrast to North America with a high gasoline consumption, the industrial and agricultural sector in Europe use almost exclusively systems and equipment with diesel or gas as fuel. A larger effort therefore should be set to the optimization and adjustment of operating regimes to produce diesel and chemical components for the plastics industry. This is also the reason for large cost amounts for R&D efforts in connection with the realization of the prototype.

Annexes:

1. Stages of the project
2. Preliminary cost and revenue planning
3. Basic financial planning for production of equipment and fuels
4. Basic financial planning for clients – purchaser of equipment for fuel production
5. Patent application
6. Premisses and organisation study by the Styrian Business Promotion Agency, SFG for the present project.
7. Letters of intent with fuel purchaser
8. Letters of support from the Styrian Business Promotion Agency, SFG and ABA-Invest, the Austrian national investment promotion company

Annex 1: Project Stages

Stage 1: Duration: about 3 months
Cost: EUR 50.000, -
Preparatory work and concept development for the implementation of the project including researches and analysis of the technology transfer potential are performed in collaboration with the Güssing Energy Technologies GmbH, Research Institute for Renewable Energy, Wiener Strasse 49, A-7540 Güssinghttp://www.get.ac.at/ and BioEnergy 2020 + GmbH, Wiener Strasse 49, 7540 Güssing http://www.bioenergy2020.eu/. Together with Güssing Energy Technologies GmbH, Research Institute for Renewable Energy we are applying for an R&D fundung by the Austrian Research Promotion Agency (FFG), the national funding agency for industrial research and development in Austria. At this stage are further Letters of of intent and preliminary agreements with customers and partners, as well as reworking of the business plan to be provided. The definition of the business model of a company or consortium that will take over the marketing of the technology (production and distribution of plants for the production of hydrocarbons; manufacture of machinery and plant operation with sales of produced hydrocarbon fuels; sale of licenses to plant production). The evaluation of production costs for a complete system including the necessary post-processing of produced hydrocarbons for the purposes of plastics industry and logistics and updating of the business plan are carrying out.

Stage 2: Duration: about 3 months
Cost: EUR 650.000, -
Construction of an demonstration and experimental production unit with the capacity to 50 L liquid hydrocarbons per hour. This demonstration unit will be used for the experimental determination of various operating regimes for the production of the respective fuels and to fix the production costs. There are all data of material conversion processes to be acquired and calculated, a complete energy balance of the process is to be determined. Thiis second stage shall overlap in time with the stage 3 (prototype construction), there will be used the same premises and equipment. The preliminary contracts with customers on this stage are to be concluded.

Stage 3: Duration: 14 months
Cost: EUR 28.000.000, -
The design and construction of a prototype with the performance of 20 to 100 L / hour. Certification of the facility and the fuels and chemicals produced thereby. Conclusion of contracts with customers and partners.

Prototype: from the present state of development appears the production of an industrial plant with the capacity of 50 to 100 L / hour of high-quality sulfur-free gasoline of RON 95 to RON 100 most economical. This is due to the fact that the production of light hydrocarbons according to the method carried out at lower temperatures (up to 90^0C) and with lower power consumption, than the production of heavier hydrocarbons as diesel or fuel oil.

The components of the prototype are made either according to specification by third parties or purchased from third parties. Personal: up to 10 persons (electrical engineer, engineer for thermal systems engineer for automation systems, boiler technician 1-3, 1-2, electricians, two laboratory technicians). Total staff hours: 7000-8500.

Premises and laboratory equipment
The area of the laboratory (Engineering Center) for the construction of the prototype (demonstration plant) should be approximately 300 m2. The rooms are to be equipped with ventilation system, including appropriate filtration (potential dangerous emissions: ethers), water supply, electricity connection (U = 220V and 380V three-phase) requirements for petrochemical laboratories. Laboratory equipment: air compressor, compressed air tank

(pressure 220 to 250 atmospheres for water injection system), electronic scales, spectrograph, Hydrometer Set, petrochemical and chemical glassware and tool kits, eg Siemens), portable laboratory gas burner, safety and preservatives, solvents and cleaning agents (industrial quality).

Stage 4:

Preparing and start of the production
Cost: EUR 250 million, -
The planning, construction and launch the plant for a series production of industrial equipment for production of synthetic liquid hydrocarbon fuels.

Annex 2: Preliminary cost and revenue planning

Manufacturing of equipment for the production of gasoline and gasoline production:

Basic data for manufacturing of equipment:
Based on the required materials, capital goods, R&D and personnel expenses, the production cost for one equipment unit/system (two modules per 50L/hour) with the overall performance of 100L/hour will be EUR 357,500 -. This value is to be verified on the stages 3-4. Totally 900 equipment units/systems are to be build. The production costs are always calculated in the previous month. Among the production costs EUR 130,000- are accepted as external costs per unit. With this, the cost of sales, logistics, various installation services, commissions and a small safety buffer are taken into account. Therefore, there is a revenue of EUR€ 162,500, - per unit calculated.

Basic data for fuel production by manufacturer of equipment and clients - purchaser of equipment for fuel production:
For optimal use of the system is a continuous operation (7x24) required. We assume that a system consisting of 20 modules per 50L/hour shall ensure the best return on investment. In this scale, both the personnel costs as well as the necessary facilities are ideal to use. The personnel costs (2.5 to 3 persons during the operating time) are with approximately € 51,000 for total 13 employees (shift operation) calculated.

With a production capacity of 1000 liters per hour and daily production capacity of 23,000 liters results an annual production of about 8 million liters. Personnel costs can be calculated in such a system with 8 € cents per liter. The share of the required infrastructure costs in 1 liter is about 10 € cents. Investments including the operational infrastructure for a so-dimensioned system are calculated by € 7 million. Therefore with a targeted payback period of 4 years is a capital allowance with € 20 cents per liter for basic facilities and 4 € cents for equipment calculated. The energy and water costs per liter assumed 11 € cents. For the financing of the investment costs with an financing interest rate of 6% is a share of 5 € cents per liter and calculated. The cost per liter of produced fuel at a so-sized apparatus will be 50-51 € cents per liter. The selling price is 55-59 € cents per liter.