

Success Stories of Advanced Biofuels for Transport

ALL-GAS: ALGAE BIOFUEL FOR VEHICLES

Year of plant start-up:	2014
Location:	Spain, Andalucia, Chiclana de la Frontera (Cadiz)
Technology:	Microalgae biofuel production for vehicles based on wastewater nutrients and biomethane upgrading to CNG
Plant capacity:	2 Ha of algae cultures and biofuel production above 26,000 kg CH ₄ /year (enough to run 35 vehicles x 15 000 km/yr)
Operational experience achieved:	Above 35,000h (non-stop operation since 2014 on various scales)
Total Capital Expenditure:	ca. 4 M€
Principal feedstocks:	Nutrients contained in wastewater which are transformed in microalgae biomass
Feedstock Capacity	2000 m ³ / d of wastewater that transform to between 100 to 140 ton biomass per hectare and year, or a total of 250 t/yr on the 2 ha.
Products/markets:	<p>Main product:</p> <p>Compressed biomethane for fleet vehicles (> 90 % CH₄, meeting Automotive fuel specifications (EN 16723 – Part 2) .</p> <p>Co-products:</p> <ol style="list-style-type: none">1. Residual biomass after anaerobic digestion rich in aminoacids, nitrogen and phosphorus (biofertilizer)2. Reuse water (meeting standards of COMMISSION DIRECTIVE 98/15/EC of 27 February 1998 amending Council Directive 91/271/EEC with respect to N + P)
Technology Readiness Level (TRL):	TRL 9 – actual system proven in operational environment

DESCRIPTION

Thanks to EU Support since 2011, the FP7 All-gas project represents a true revolution in the circular economy, establishing a new paradigm by producing algae biofuel from wastewater with a positive energy balance, fuelling up to 20 vehicles per ha, and allowing sustainable water reuse as a by-product.

The project was born with the objective of demonstrating, on an industrial scale, the production of algae biofuel for vehicles. In addition, it uses urban wastewater as a source of nutrients for the culture and presents a circular economy model in which algae treat the wastewater without external energy supply, through photosynthesis.

In December 2017, the industrial plant in Chiclana (Spain) was inaugurated by EU Commissioner for Energy, Miguel Arias Cañete. An algae culture area of more than 2 hectares came into service making this plant the world's largest facility for the generation of biofuels from microalgae.

Currently, the project is capable of moving up to 40 cars with the biofuel obtained, with the effluents of 10,000 inhabitants (2000 m³/d). Compared with ordinary biofuels, such as bioethanol from sugar or biodiesel from palm-oil, All-gas produces 4 times more energy per hectare, generating at the same time reuse water - without the need to use agricultural land or fertile soil, freshwater or artificial fertilizer.

This technology allows to convert the wastewater from any small or medium-sized town with enough available land (1 football field for 5000 people) and sunlight into a sustainable biofuel. At the same time, the electrical energy needed to clean wastewater with conventional technology is saved.



Fleet vehicles and algae ponds of the FP 7 All-gas project in Chiclana (Cadiz)

Stakeholders involved:	<p>EU Commission – DG ENER</p> <p>Chiclana Municipality and its Environmental Management Company, Chiclana Natural</p> <p>FCC Aqualia as the local operator or Wastewater Treatment</p> <p>Permitting Agencies (National Coastal Management Administration, Fisheries, Water and Environmental Depts. Of the Andalusia Regional Government)</p> <p>Universities of Cadiz and Almeria as supporting Research and Scientific Community</p>
Financing Support:	<p>EU FP 7 grant, co-financing by FCC Aqualia and Chiclana Natural as well as the consortium partners (BDI Bioenergy/AU, Fraunhofer-Umsicht/DE, Hygear/NL and University of Southampton/UK).</p>
Contribution to Sustainable Development Goals:	<p>GHG emission reduction (SDG13): Wastewater energy requirement is reduced 5-fold in comparison to conventional methods (from 0,5 kWh el/m³ to < 0,1 kWh/m³)</p> <p>Sustainable consumption and production patterns (SDG 12): Third generation biofuels can be produced onsite from waste.</p> <p>Reliable, sustainable and modern energy for all (SDG7): biomethane (EN 16723 – Part 2) for fleet vehicles can be produced with recycled nutrients contained in the wastewater, without need for freshwater, arable land or artificial fertilizers.</p> <p>Ensure availability and sustainable management of water and sanitation for all (SDG6): a new paradigm of wastewater treatment is developed, where a positive energy balance is achieved - biofuel is produced and electricity needs are minimal.</p>
Contribution to GHG emission reduction in transports:	<p>To achieve serious reductions in GHG emissions over the coming decades involves a combination of three broad changes:</p> <ol style="list-style-type: none">1. Transforming the economy from running on carbon-dioxide-emitting fossil fuels to rely on renewable fuels;2. Achieving substantial improvements in energy efficiency;3. Implementing the large-scale capture and storage of carbon dioxide emissions. <p>This project addresses all three of these targets:</p> <ol style="list-style-type: none">1. Producing biofuels from algae, based on renewable, non-fossil CO₂ and sunlight2. Harvesting resources such as wastewater and agricultural residues as nutrients and for energy generation to achieve a self-sufficient biofuel production system

3. The net balance of CO₂ generated in this project is positive, as it is based almost entirely on renewable sources.

The aim of the project is not only the production of quality biofuel from algae but also taking in account a sustainability approach: biofuel feedstock is grown with environmentally safe and biodiversity-friendly practices, sequestering carbon from the biomass to give a positive carbon balance of the overall system.

This project fulfils the main European policy goals:

1. Reducing greenhouse gas emissions
2. Boosting the decarbonisation of transport fuels
3. Diversifying fuel supply sources and developing long term replacements for fossil oil
4. Diversifying income and employment in rural areas

Employment:

During lifespan of the project more than 10 direct jobs were created among researchers and engineers in process development. In addition, during the construction and implementation of the infrastructure, around 15 to 20 indirect jobs were created among builders and suppliers.

In the long run through replication, the municipalities that implement the new solution will employ personnel in a new activity of biofuel production and distribution

Replicability and scale-up potential:

Replicability of FP project is very high since it needs mainly wastewater and non-arable land for its application. The land requirements of the process (kg CH₄/ha year) will depend on the climatological conditions, in the Mediterranean region an algae harvest around 100 t / ha is possible, yielding up to 15 000 kg CH₄/yr.

Success factors:

1. Need for wastewater treatment: extension, upgrading or replacement of existing facilities - or waste nutrients from manure and animal farming
2. Available Land
3. Fleet of municipal cars to be converted to CNG, or easy access to gas network with L quality.

Constraints:

1. Climatic conditions affect the performance of the process
2. Land availability and nutrient supply (wastewater, manure)
3. Permits related to the operation of CNG facilities



Schematic Performance of Algae biofuel production

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More information: <http://www.all-gas.eu/en/>
<https://www.youtube.com/watch?v=4ZSjeXjoO88>
<https://www.youtube.com/watch?v=9a5p4crkxq4>