

## The ZEG-technology (ZEG<sup>®</sup>)

*- Superior technology for high efficient energy production -*



The ZEG-technology (ZEG<sup>®</sup>) is a hybrid technology for co-production of electric power and hydrogen from hydrocarbon fuels, with integrated CO<sub>2</sub>-capture.

ZEG<sup>®</sup> provides the power concept with highest energy efficiency from hydrocarbon fuels, in the range of 70 to more than 80% depending on the plant size. ZEG<sup>®</sup> is the only concept with the potential to produce electric power and hydrogen with integrated CO<sub>2</sub>-capture at lower cost than existing state-of-the-art technologies. In addition there are no emissions from a ZEG Power plant, neither CO<sub>2</sub>, NO<sub>x</sub>, particles nor aerosols. The technology also shows great flexibility with respect to fuel; all hydrocarbons can be used: natural gas, biogas, gasified coal, tar or oil. In addition, the relative amount of electric power and hydrogen (and heat) can be adjusted according to market demand and customer need.

The technology development started as a cooperation between Institute for Energy Technology (IFE) and Christian Michelsen Research AS (CMR Prototech). ZEG Power AS is established to realise the great potential of ZEG<sup>®</sup> for sustainable energy production. The main objective is to design, build and verify the patented ZEG<sup>®</sup> for commercial power plants of increasing size and complexity. At Risavika Gas Centre ZEG<sup>®</sup> is tested with positive results in a laboratory scale verification unit with a production capacity of 1kW electricity and 1kW hydrogen, with integrated CO<sub>2</sub> capture. At present a 50kW scale plant is commissioned, ready for test operation at the same time as pre-engineering of a 400kW plant has started.

ZEG<sup>®</sup> is a module based platform technology for several applications. On a short to medium term the goal is flexible distributed small to medium scale ZEG<sup>®</sup> plants for integrated processes that requires power and where hydrogen are needed in further industrial processes or for sale directly to the customers. Some applications:

- Transportation, logistics, hydrogen refuelling stations
- Bio refinery purposes; methanol production, upgrading of bio-oil
- Greenhouses, district heating
- Metallurgical industry

## The BioZEG-concept

For distributed plants the use of local, cheap biomass resources as fuel is of special interest. Here ZEG<sup>®</sup> allows a cost effective standalone green production of hydrogen and electric power. The produced hydrogen and electric power can be used directly for transportation purposes; for electrical battery or hydrogen powered vehicles.

Production of hydrogen from biomass will reduce the CO<sub>2</sub>-emissions; at the same time as green hydrogen for transportation becomes an early market introduction for ZEG Power. Furthermore, on-site production of hydrogen will reduce the need for energy consuming transport of hydrogen to the refuelling station.

CO<sub>2</sub> from biomass is considered climate neutral, however in BioZEG CO<sub>2</sub> is captured as an integrated part of the process. This will give a positive climate contribution if the CO<sub>2</sub> is sequestered, used locally or stored.

## Highlights in 2013

The 50 kW **BioZEG** plant at the Hynor Lillestrøm hydrogen refuelling station ([www.hynor-lillestrom.no](http://www.hynor-lillestrom.no)) was commissioned late 2013. The main goal of the plant operation is to demonstrate 70% total efficiency by close thermal integration of the two **ZEG**<sup>®</sup> core technologies; electric power production by a 20 kW<sub>el</sub> SOFC (Solid Oxide Fuel Cell) module and hydrogen production by a 30 kW<sub>H<sub>2</sub></sub> SER (Sorption Enhanced Reforming) reactor system. The project is supported by Innovation Norway and Statoil. A comprehensive test campaign is planned for the plant. Long-term operation and process optimisation will form the basis for development of commercial, small-scale standalone **BioZEG** -plants

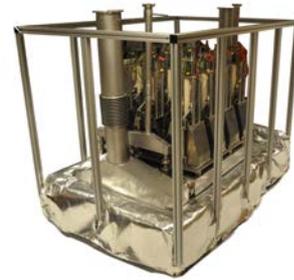
The German research institute ZSW ([www.zsw-bw.de](http://www.zsw-bw.de)) finalised a third party assessment of the **ZEG**-technology and up-scaling from 50 kW to **ZEG**<sub>400</sub>, a 400 kW unit. No clear showstoppers were identified and the concept and its potential was confirmed. Recommended areas for development are given focus in the ongoing projects and in planned, future work.



Integrated 50kW **BioZEG** plant



30kW<sub>H<sub>2</sub></sub> SER reactor system, by IFE



SOFC Module (20kW<sub>el</sub>) by Prototech Stacks from PLANSEE / Fraunhofer IKTS

### Input:

- Biomethane

### Output:

- Hydrogen (30 kW<sub>H<sub>2</sub></sub>)
- Electricity (20 kW<sub>el</sub>)
- CO<sub>2</sub>

The pre-engineering of **ZEG**<sub>400</sub>, has started. A 400 kW plant will be the “proof of concept” in industrial scale. Main objectives are efficiency optimisation and operation for improved lifetime. The project is supported by CLIMIT Demo (Gassnova).

Patent is granted on technology application, mainly related to production of heavy oil with integrated CO<sub>2</sub>-capture for enhanced heavy oil recovery and cost-efficient integrated solutions based on biomass resources. Two new patent applications are filed, both focused on the use of **ZEG**<sup>®</sup> in post-combustion applications.

The overall business objective is to sell and deliver small scale plants as well as concepts and detailed design of **ZEG**<sup>®</sup> plants for different applications. Establishment and verification of benchmarks on production cost for end products (e.g. grid parity for electricity or levelised cost for hydrogen production) and identification of applications where **ZEG**<sup>®</sup> is particularly suitable are prioritised activities. Focus will be on small to medium scale standalone **BioZEG** -plants for integrated industrial applications and customers that require both hydrogen and electricity production

**ZEG Power** is in a very exiting expansion phase, seeking investors and strategic partners to bring the technology to the market. **ZEG Power** has secured substantial public funding for the technology development, but to secure progress industrial and financial partners are invited to participate either with direct project support or as an investor in **ZEG Power AS**.

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