

IEA GREENHOUSE GAS  
R&D PROGRAMME

# Co-production of Hydrogen & Elec

with



Foster Wheeler Italiana has undertaken a study for the International Energy Agency's Greenhouse Gas R&D Programme (IEA GHG) on the co-production of hydrogen and electricity, with CO<sub>2</sub> capture.

*"CO<sub>2</sub> capture and storage is expected to make a major contribution to future energy systems with low greenhouse gas emissions. The expertise provided by Foster Wheeler has been a key factor in helping IEA GHG to demonstrate the merits of CO<sub>2</sub> capture in various energy technologies."*

John Davison  
Manager, IEA GHG

This programme is a major international research collaboration that assesses technologies capable of achieving deep reductions in greenhouse gas emissions.

This is the third study project that Foster Wheeler Italiana has undertaken for this programme: the previous ones being the "Gasification Power Generation Study" (2003) and "CO<sub>2</sub> capture in low-rank coal power plants" (2005).

Hydrogen may become widely used in future as a low-CO<sub>2</sub> energy carrier for vehicles and distributed heat and power generation using fuel cells. This latest study is focused on different integrated gasification combined cycle (IGCC) plant configurations burning high-rank coal with CO<sub>2</sub> capture and H<sub>2</sub> production.

*"The long-term goal for the 'hydrogen economy' is generally recognised to be production of hydrogen from sustainable renewable energy sources, but in the near term the cheapest way to produce hydrogen with low CO<sub>2</sub> emissions is expected to be by use of fossil fuels with CO<sub>2</sub> capture and storage."*

Silvio Arienti  
Process Director, Power Division, Foster Wheeler Italiana

Electricity  
CO<sub>2</sub> capture



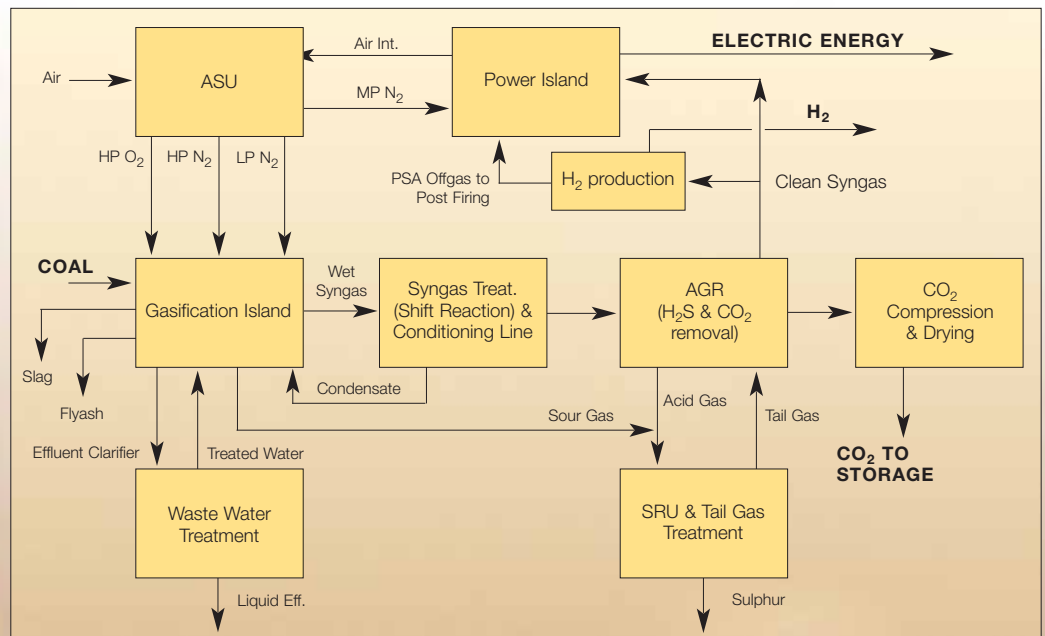
The primary purpose of this coal-fired IGCC study is to assess the potential advantages of flexible co-production of hydrogen and electricity from fossil fuel with CO<sub>2</sub> capture.

The study is based on the hydrogen and electricity demands of the Netherlands and of the USA, in a potential future scenario where the standard fossil fuel systems are replaced as much as possible by hydrogen systems. These two countries have been chosen because they represent two significantly different consumption scenarios.

In order to constantly match the hydrogen demand variations over time with different plant configurations and to keep the number of required plants as low as possible, hydrogen storage is considered. As part of the study, we have also analysed geological underground storage, which we believe provides the best solution to deal with the very large volumes of hydrogen which need to be stored for extended periods.

We reviewed and compared three available gasification technologies and two available solvents for acid gas removal from the syngas. After the selection of the technologies, we developed five different production schemes:

- A Production of electricity only, without CO<sub>2</sub> capture – this is the reference case
- B Production of electricity only, with CO<sub>2</sub> capture
- C Production of hydrogen and sufficient electricity for internal plant consumption, with CO<sub>2</sub> capture
- D Co-production of hydrogen and electric energy at a fixed specific ratio and with CO<sub>2</sub> capture; the ratio corresponds to the future H<sub>2</sub>/electric energy consumption ratio evaluated for the Netherlands
- E Co-production of hydrogen and electric energy at a flexible ratio and with CO<sub>2</sub> capture



Block flow diagram.

## Electricity costs

The cost of generating electricity in a base-load IGCC plant with CO<sub>2</sub> capture is estimated to be 0.072 €/kWh and the cost of avoiding CO<sub>2</sub> emissions is 31.3 €/tonne. The flexible plant can vary the hydrogen to electricity net output ratio between 1.3:1 and 3.1:1, while continuing to operate the coal gasifiers at full load.

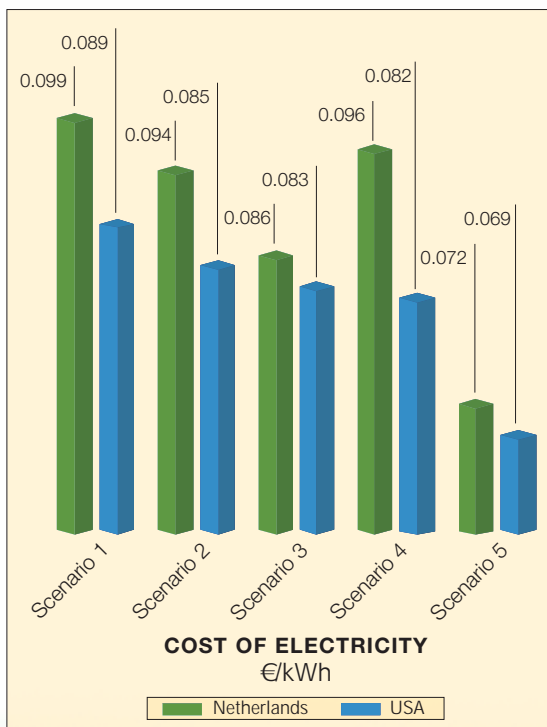
## Five co-production scenarios

Finally, five co-production scenarios, obtained as combinations of different types of production plants and different hydrogen storage volumes, have been evaluated and compared to find the most promising combination of plants and storage able to satisfy the energy consumption in the two different countries.

The five scenarios are:

- 1 Electricity-only and H<sub>2</sub> only production plants, without H<sub>2</sub> storage
- 2 Non-flexible co-production plants, without H<sub>2</sub> storage
- 3 Non-flexible co-production plants, with H<sub>2</sub> storage
- 4 Flexible co-production plants, without H<sub>2</sub> storage
- 5 Flexible co-production plants, with H<sub>2</sub> storage

Flexible plants with hydrogen storage are the lowest-cost option in both countries. Flexible plants without storage are advantageous in the USA because the peak demands for hydrogen and electricity would be at different times of the year. That is not so in the Netherlands, where the peak demands for hydrogen and electricity would both be in winter.



The capital cost of the underground storage, depending on the geological configuration of the area, greatly varies between 1 €/kg and 40 €/kg. The sensitivity analysis carried out in the study shows that hydrogen storage has advantages up to a storage cost of 35 €/kg.

A paper on this study was presented at the IChemE 8th European Gasification Conference in September 2007 in Antwerp.

### FW infobase

A copy of the full paper is available on our website [www.fwc.com/publications/tech\\_papers/index.cfm](http://www.fwc.com/publications/tech_papers/index.cfm) under "Carbon Capture & Storage"

You can also find out more about the earlier IEA GHG studies at [www.fosterwheeler.it](http://www.fosterwheeler.it)