IEAGHG Information Paper; 2013-IP19: Electrochemically Mediated Amine Regeneration (EMAR)

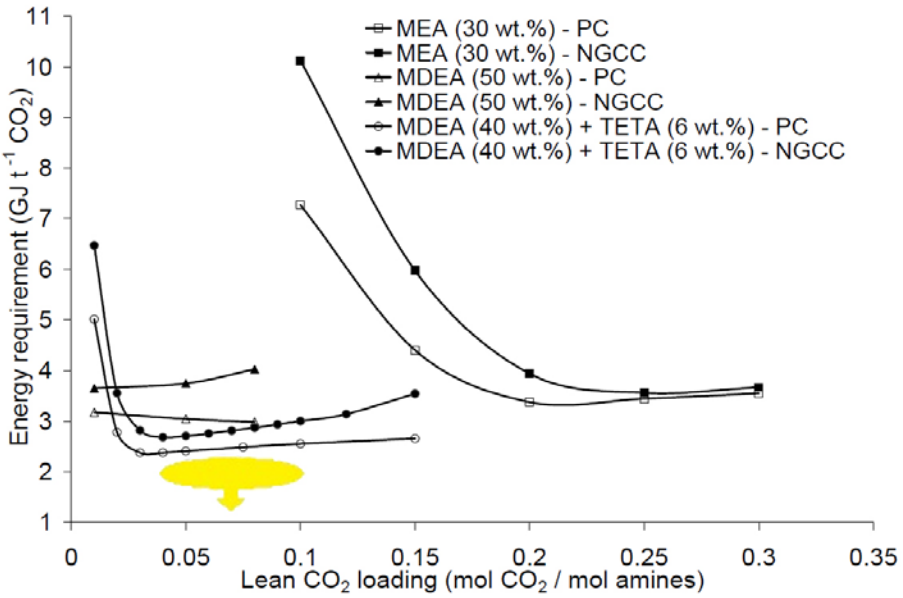
Background:- *Post-combustion carbon dioxide capture using electrochemically mediated amine regeneration* – M.C. Stern, F Simeon, H Herzog and A Hatton, MIT, **Energy and Environmental Science**. 6th June 2013.

A recent paper from MIT introduces a new concept for incorporation into post combustion CO_2 capture schemes. Instead of using large amounts of low pressure steam for heating a reboiler in the solvent regeneration section of a conventional amine scrubbing plant, it uses electricity in a novel electrochemical process to strip CO_2 from the CO_2-laden amine solvent stream. Potential cost savings are indicated.

Before considering applications of this possible technology breakthrough, this note first considers the energy penalty implications of consuming the high grade energy resource of electricity instead of the low grade energy resource of low pressure steam.

The paper describes a bench scale demonstration that has achieved a system electrical energy requirement of 26 kWh per kg.mole of CO_2 separated, which was operated over a 5 hour experimental proof-of-concept period. The solvent used was ethylenediamine (EDA) and the process achieved a low residual CO_2 loading in the recycled lean amine solution. Modelling suggests opportunity for substantial improvements in the process performance. Model runs at higher temperatures and pressures indicate that energy requirements of 3 kWh per kg.mole CO_2 are possible.

A study by Amman (2009) used Aspen Plus to investigate the energy (LP steam) demands of amine CO_2 capture systems from coal (PC) and natural gas (NGCC) flue gases. A graphical form of those results is reproduced here, superimposed with the electrical energy consumption of the proof-of concept performance and potential of the EMAR process shown in yellow.



This indication of relative performance shows that EMAR potentially uses significantly less energy than a traditional steam reboiler for an MEA system. However, the EMAR process uses high grade energy in the form of electricity.

If a power station has low pressure (0.5 MPa) steam available then it can be used in a low pressure turbine to generate electricity with an energy conversion efficiency of about 23%. For example, at 3.5 GJ/tonne of CO_2 reboiler duty, the use of that LP steam would sacrifice about 10 kWh/kg.mole of CO_2. This suggests that the experimental EMAR process would require a 2-3 fold improvement in performance over the proof-of–concept laboratory result to become a direct competitor with an LP steam reboiler on the basis of electrical energy penalty. Such an improvement in the performance of EMAR is potentially possible.

Notwithstanding energy penalty considerations, there could be other benefits of the EMAR process in reducing the intrusion of CCS into the operation of a host power station.

- In the case of a combined heat and power (CHP) installation, where low-grade heat from the power station is used efficiently to provide district heating facilities, there may be insufficient LP steam available to provide the energy for CCS. In such a situation the use of EMAR could potentially resolve the energy supply problem;
- In the case of retrofitting CCS to an existing power station, integration and load following may be facilitated by the use of EMAR for solvent regeneration;
- The EMAR process has potential to be operated at elevated pressure. Initial modelling assessments show that operation at pressure could significantly improve performance. There would also be energy advantages as regards compression of the CO_2 product.
- The stripping of CO_2 from the amine solvent is more complete in the EMAR process than in conventional steam stripping. This would enable a lower solvent recirculation rate to be used which and would reduce the size and cost of the absorber column.
- The EMAR concept potentially widens the scope for the application of CCS beyond power stations to situations where low pressure steam utilities are unavailable.

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Reference:-Amman (2009) CO2 Capture from Power Stations Running with Natural Gas (NGCC) and Pulverized Coal (PC): Assessment of a New Chemical Solvent Based on Aqueous Solutions of N-MethylDiEthanolAmine + TriEthylene TetrAmine. **GHGT-9.** M.C Amman & C. Bouallou.