Thermal Desorption Technology Group

WEB: **http://www.terrenum.net/cleancoal** General Manager: **Edward Someus**

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3R CARBON CAPTURE AND STORAGE "CCS"

The global warming is the observed increase in the average temperature of the Earth's atmosphere and oceans in recent decades for which phenomena the increased level of the green house gases are identified to be responsible as major factor. From this increasing global average temperature a variety of resulting effects predicted, - namely, rising sea levels, altered patterns of agriculture, increased extreme weather events, and the expansion of the range of tropical diseases.

There are alternative scientific discussions if the ongoing climate change is a result of the accelerating, rapid and massiv human activity impacts on our environment or a natural phenomena or the mix of both. However, the scientific evidence is now overwhelming: climate change is a serious global threat, and it demands an urgent global response. We must absolutely clearly recognize, that the negative environmental impacts of the global human activities on air, water, soil and the extensive exploitation of the natural resources are so massive, so complex and so rapid, that already significant environmental degradation made, for which natural recovery is not possible anymore. The human time frames, years and decades, are milliseconds only in a natural evolution process, resulting that not even chance is given to natural recovery process,- that has been known from the Earth's geological history. There is an high risk for irrevocable environmental degradation and that risk the humankind can not afford to take. Therefore, urgent, massive, complex and global action plan need to be worked out for reduction of the environmental impacts.

It is very important to urgently make a global and massive human promoted environmental recovery for which the most important tool is the introduction of new and closed loop zero emission technologies to substitute or at least upgrade conventional technical solutions. The new added value technologies open new technical and economical ways, such as:

- ✔ **SUSTAINABLE ENVIRONMENTAL PROTECTION:** providing ZERO EMISSION performance, e.g. all and any output streams are recycled, reduced and reused, while it is preventing pollution, protecting environment and preserving natural resources.

- ✔ **DEVELOPING NEW ECONOMICAL DRIVERS:** the new, efficient and ADDED VALUE TECHNOLOGIES means new and attractive investments for market demanded projects and new jobs through the whole economical chain.

- ✔ **SUPPORTING SUSTAINABLE SOCIAL STRUCTURES:** society and social developments are certainly conditioned to the access to clean water, clean air and clean agricultural land to produce clean and healthy food.

In this context the 3R technology offers new alternative solutions for clean energy production. The 3R anthracite clean coal technology provides revolutionary solution for climate impact prevention, protection and preservation by the combination of the advanced Anthracite Clean Coal technology and as a output results safety improvement of the optimized GHG storage conditions with zero emission seepage. The input 3R CO_2 for CCS geological structure injection is clean, low in volume and high in concentration, all in order to optimize the "once for all" stabilized chemical fixation of the CO_2 to the mineral matrix. The 3R techniques is in the streamline of the international community efforts (including the European Union as main supported of the Kyoto Protocol, North America, Australia and other countries) to make progressive steps to decrease the negative effects of the global climate change in the early decades of the 21st century.

GHG introduction

Carbon dioxide capture and storage is now included in most OECD countries' energy policies and R&D programmes as a potential contributor to carbon dioxide mitigation strategies. Techno-economic studies have generally concluded that in any widespread deployment capture is the most expensive element of the chain. This is called post combustion capture. A number of ways of achieving high levels of carbon capture have been identified, with the proviso that some systems are more likely to be matched to some power production methods.

The overwhelming majority of fossil fuel fired power plants produce a low pressure, low CO_2 concentration flue gas in which the GHG's are mixed with HAP's.

Post-combustion capture of CO_2 by solvents such as methanolamine is commercially available now from well-known licensors.

However, such processes were not originally designed for application to large fossil fuel fired power stations.

About 40% of the world's power generation is based on the use of pulverised coal which, if linked to solvent-based CO_2 capture, would present the solvent system with a range of contaminants. To use such solvents in an oxidising environment requires additives to reduce degradation. Therefore new alternatives need to be identified. The Greenhouse Gas Protocol Initiative aims at harmonizing GHG accounting and reporting standards internationally to ensure that different trading schemes and other climate related initiatives adopt consistent approaches to GHG accounting.

The development of these standards and corresponding tools has become increasingly relevant since the ratification of Kyoto and the development of national, and other relevant GHG emissions trading schemes both within and outside of the Kyoto framework.

The 3R Anthracite Clean Coal technology positive impacts on the GHG climate programs

The 3R Anthracite Clean Coal technology opens new technical and economical solutions for climate policy that recognizes the need to take near-term (urgent) corrective actions, while maintaining economic growth that will improve the world's standard of living.

Combating climate change and minimising its potential consequences is one of the key 3R objective. The 3R pretreatment technology application results effective climate impact prevention, protection and preservation by recycling, reduction and reuse technological option towards total and technically & economically efficient GHG management.

For all added value material treatments, especially for contaminated and waste type materials, the selective handling, preventive pretreatment, minimized volume and fully controlled process streams are critically important. In order to efficiently handle the total GHG management, therefore, such climate program must be started rather in the pre-treatment phase than after the "end of the pipe".

The technical expectations to limit output emission contamination have been significantly enforced by laws during the past two decades, which resulted a necessity of technology concept change. Traditional "end of the pipe" offgas treatment technologies have reached its ultimate technical and economical opportunities, therefore preventive solution need to be applied. Long term sustainable coal energetic utilization processing can be made environmentally friendly as of advanced norms and standards beyond 2010, subject to that preventive recycling, reduction and reuse added-value treatment technology concepts are applied.

The following advanced technical solutions offered by the 3R technology, all in order to support the CO_2 emission capture and safe storage programs in a sustainable way:

SOLID FUEL PRETREATMENT - ENERGY PRODUCTION-PHASE:

- ✔ **PHASE SEPARATION PROVIDES OTIMIZED BURNING = RESULTING LESS CO_2 GENERATION**: The reductive thermal desorption decomposition process provides separation of HAP's form Anthracite Clean Coal solid fuel stream in low process-gas volume, providing efficient and optimized burn off both the pyrolysis gas-vapors and clean coal, resulting total GHG emissions reduction in total.

- ✔ **LESS OFFGAS VOLUME WITH INCREASED CO_2 CONCENTRATION:** The **CO_2 concentration** from the main unit is higher, but less in total volume.

- ✔ **CLEAN OFFGASES AVOIDING MIXTURE OF HAP's and GHG's**: The GHG output from the main unit carried by **cleansed offgases**, so hazardous air pollutants will not be part of the CO_2 CCS operations, resulting better risk management.

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✉ H-1222 Budapest, Szechenyi 59. Hungary Tel.: (36-20) 201 7557 Tel./Fax: (36-1) 424 0224
E-mail: edward@terrenum.net - WEB: http://www.terrenum.net

INTEGRATED CCS PHASE: the output gases form the pre-treatment energy production phase have optimal characteristics, such as **cleansed gas performance, concentrated CO_2 and low in total volume, which elements are efficiently integrated supporting the safe carbon capture and storage solutions.**

During the past years advanced GHG storage techniques have also been developed, including but not limited for techniques such as:

1. **Carbon capture and storage** in sub-sea offshore and mainland geological structures (unminable coal beds, depleted oil and gas reserves, deep saline aquifers) from land based sources

2. **Improved Oil Recovery**

3. **Oxycombustion** for CO_2 capture

4. **Aqueous Mineral Carbonation** - Conversion of gaseous CO_2 to solid carbonate (US DOE Mineral Carbonation Study Group)

5. **Other innovative CCS solutions are underway to be studied and developed, such as:**

   - The reductive recycling and reformation of excess atmospheric carbon dioxide to methanol and through it to useful fuels and hydrocarbons is under study. This approach supports the methanol economy, including new cost efficient options for energy storage, efficient fuels and synthetic hydrocarbons.

   - Microbiological conversion of CO_2 into methane within geologic reservoirs by naturally occurring bacteria ("methanogens") is also under study, in order to introducing bacterial consortia into geologic sequestration sites to harness their natural methanogenic ability to convert injected GHGs to producible new natural gas resources.

However, concerns rised against GHG storage techniques, including the possibility of seepage, e.g. the physical release of the subsurface injected CO_2.

In fact, no surface seepage reported from the CCS demonstration projects so far, but the number of the CCS demonstration projects are still few, therefore more experience needed. Some scientist modelled 5000 years before seepage could theoretically first accour, while other models indicating dissolvation of the CO_2 after 3000 years and other models shorter time frames. This means in industrial reality, that under any circumstances the CCS practice operational safety measures must be improved, so the seepage risk is decreased.

As CCS zero emission seepage scientific models are theoretical, but the potential risk for early seepage is still a risk, therefore **it is outmost important that the input CO_2** for injection **into the CCS geological structures is rather clean, low in volume and high in concentration, all in order to SAFETY IMPROVE THE OPTIMIZED GHG STORAGE CONDITIONS, while promoting the "once for all" stabilized fixation** (incl. chemical adsorption and absorption, thermogenic conversion and mineral carbonation processes) **of the CO_2, to the geological structure matrix. In this context the 3R technology offers significant safety improvements for the GHG-CCS conditions.**

The mineralogical trapping of the CO_2 is depending on the petrological and geochemical variations of the rocks, where the mineralogical trapping might be limited by an inhomogeneous HAP mix composition of the injected GHG gas, and lack of calcium and magnesium.

Therefore, **the combination of the 3R Anthracite Clean Coal and Carbon Capture and Storage technologies opens new perspectives for safer, better and less costly carbon capture and storage into geological structures, than know solutions today.**

The 3R clean CO_2 injection is not containing other pollutants or waste elements, therefore the disposal into subsea and mainland geological bed has the highest application potential with lowest risk, while it is providing and economical solution for the present climate liability for long term, where the "long term" is seen from geological timing perspective. CCS in sub-sea offshore and onshore geological structures are technically feasible and using established technologies. Optimal sites geological structures need to be identified, evaluated, monitored and environmental risk assessment executed.

Legislative considerations for combination of 3R and CCS.

CCS is progressing towards acceptance by international law, developments to cover national onshore CCS strategies are underway, however the public awareness is still limited.

The marine protection law established in 1992 is to prevent dumping of waste into offshore sea and set global standardization against marine pollution. Dumping of waste into onshore main land is restricted same as well. In this context the main legal issue is if the CO_2 is whether classified as an "industrial waste" or not.

However, **off gases from conventional plants containing HAP's contaminants** (even if below permitted limits) **in combination with GHG's, which makes it rather "industrial waste" type.**

From environmental technological point of view there are two important criterion (among several others), such as

- **MONOLITHIC HOMOGENITY, inject clean and of monolithic type GHG**

substance for input disposal (instead of high risk profile HAP mixture with of variating chemical compositions of different substances and byproducts, that may possibly course uncontrolled and variating chemical reactions under geological subsurface conditions, where the geological matrix is also variating naturally.)

- **PRODUCE AS LOW GHG VOLUMES** as it is possible, where the lower volume of 3R GHG production is obviously advantageous from industrial production, transport, injection, storage and economical viability point of view.

The ocean acidification and other environmental / ecological effects are of serious concerns, therefore, the applied CCS technology must be of low and affordable risk performance for long term in geological time frame terms. Therefore, professionals must do everything to optimize the storage conditions by **selecting monolithic and cleansed CO_2 qualities for injection.**

As CCS is accepted as mitigation option under Kyoto Protocol, the 3R CCS safety improvements will certainly fit into this policy. CCS demonstration activities already announced in Australia (Stanwell Corp and Kalide project), i the USA (Future-Gen), in Canada (Saskatchewan Power) and in Europe (HypoGen Dynamis).

The 3R removes barriers for implementation os ZERO EMISSION programs in the Clean Coal energy production industrial sector

The 3R removes barriers for safe CCS implementation

- ✔ The injected clean CO_2 is better fixed and chemically bounded into the geological layers than an conventional "waste type" HAP mixture of gas composition, so it decreases the risk of seep back and subsurface gas release seepage phenomena, e.g. **SAFETY IMPROVE THE OPTIMIZED GHG STORAGE CONDITIONS.**

- ✔ Generating overall lower input volumes of CO_2, with higher concentration.

- ✔ Removing international legal CCS barriers for disposal of waste materials into sea and land subsurface and demonstrating higher safety and technical viability by **using monolithic and cleansed CO_2 qualities gas streams.**

- ✔ **The incremental coal utilization 3R technology provides less cost of electricity while sustainable carbon capture and storage made, when all costs included.**

- ✔ **The 3R CCS is seen as part of the portfolio to mitigation options towards zero emission, such as improvements on the energy efficiency, total HAP control, fuel switching, fuel flexibility, secure fuel supply and energy production cost decrease.**

- ✔ **The 3R CCS ZERO EMISSION SOLUTION opens new ways for increased production of environmentally friendly clean energy, providing technical and economical added value, while creating new jobs and stabilized economy.**

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TERMINOLOGIES:

GLOBAL WARMING is the observed increase in the average temperature of the Earth's atmosphere and oceans in recent decades. The Earth's average near-surface atmospheric temperature rose 0.6 ± 0.2 °Celsius (1.1 ± 0.4 °Fahrenheit) in the 20th century. The prevailing scientific opinion on climate change is that "most of the warming observed over the last 50 years is attributable to human activities". The increased amounts of carbon dioxide (CO_2) and other greenhouse gases (GHGs) are the primary causes of the human-induced component of warming. They are released by the burning of fossil fuels, land clearing and agriculture, etc. and lead to an increase in the greenhouse effect. The first speculation that a greenhouse effect might occur was by the Swedish chemist Svante Arrhenius in 1897, although it did not become a topic of popular debate until some 90 years later. The measure of the response to increased GHGs, and other anthropogenic and natural climate forcing, is climate sensitivity. This sensitivity is usually expressed in terms of the temperature response expected from a doubling of CO2 in the atmosphere. The current literature estimates sensitivity in the range 1.5–4.5 °C (2.7–8.1 °F). Models referenced by the Intergovernmental Panel on Climate Change (IPCC) project that global temperatures might increase between 1.4 and 5.8 °C (2.5 to 10.5 °F) between 1990 and 2100. The uncertainty in this range results from both the difficulty of estimating the volume of future greenhouse gas emissions and uncertainty about climate sensitivity. An increase in global temperatures can in turn cause other changes, including a rising sea level and changes in the amount and pattern of precipitation. These changes may increase the frequency and intensity of extreme weather events, such as floods, droughts, heat waves, hurricanes, and tornados. Other consequences include higher or lower agricultural yields, glacial retreat, reduced summer stream flows, species extinctions and increases in the ranges of disease vectors. Warming is expected to affect the number and magnitude of these events; however, it is difficult to connect particular events to global warming. Although most studies focus on the period up to 2100, warming (and sea level rise due to thermal expansion) is expected to continue past then, since CO_2 has an estimated atmospheric lifetime of 50 to 200 years. Only a small minority of climate scientists discount the role that humanity's actions have played in recent warming. However, the uncertainty is more significant regarding how much climate change should be expected in the future, and there is a hotly contested political and public debate over what, if anything, should be done to reduce or reverse future warming, and how to deal with the predicted consequences.

MITIGATION OF GLOBAL WARMING involves taking actions aimed at reducing the extent or likelihood of global warming. This is in contrast to Adaptation to global warming which involves taking action to take advantage of the positive effects of global warming while preventing or minimizing the negative effects.

ADAPTATION TO GLOBAL WARMING covers all actions aimed at reducing the negative effects of global warming. This in contrast to mitigation of global warming which involves actions meant to avoid or delay the occurrence of climate change due to global warming.

THE PREDICTED EFFECTS OF GLOBAL WARMING for the environment and for human life are numerous and varied. The main effect is an increasing global average temperature. From this flow a variety of resulting effects, namely, rising sea levels, altered patterns of agriculture, increased extreme weather events, and the expansion of the range of tropical diseases. In some cases, the effects may already be occurring, although it is generally difficult to attribute specific natural phenomena to long-term global warming.

LINKS:

- Stanford University Collection of recent news articles on CO_2 capture and storage. **http://pangea.stanford.edu/~mhesse/NewsLinks.html**
- Intergovernmental Panel on Climate Change IPCC Special Report on Carbon Dioxide Capture and Storage. **http://www.ipcc.ch/activity/srccs/index.htm**
- DOE Fossil Energy Department of Energy programs in carbon dioxide capture and storage. **http://www.fossil.energy.gov/programs/sequestration/index.html**
- CO2 Capture and Geologic Storage National Energy and Technology Laboratory summary of worldwide projects. **http://www.netl.doe.gov/technologies/carbon_seq/core_rd/storage.html**
- Stern Review on the Economics of Climate Change (Sir Nicholas Stern, Head of the Government Economics Service and Adviser to the Government on the economics of climate change and development, report presentation to the Prime Minister and the Chancellor of the Exchequer on the Economics of Climate Change) **http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm**

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