ECRN Initiative

for a

"European research initiative – coal as an alternative chemical raw material for basic chemicals and fine chemicals to supplement the development of energetic use"

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1. Starting position

The discussion about the future use of coal (black coal and brown coal) in Europe is to date primarily held from the perspective of power generation on the basis of combustion plants and thermal recovery.

Many European countries have large coal deposits and the 27 member states currently cover around 30 % of their power requirements with coal power plants."Given the increased climate protection requirements to be expected within the EU, the advantages which coal shows with regard to economic efficiency and security of supply shall not suffice in the long run in order to ensure it a fixed position in the mixture of energy sources.“[1]

Conventional energy recovery, however, is only one possibility for the future use of coal. The material management processes of the chemical industry shall also require a carbon source in the future which in regions with a limited biomass potential - such as Europe - is only feasible with fossil fuels for large technical productions. Coal chemistry offers an unique possibility for Europe to extract this carbonate from the native coal deposits and to thus overcome its unilateral dependence on oil and gas imports.

At the same time, the coal chemistry is paving the way into the chemical storage of renewable energies which are being generated in a way that is decreasingly able to cope with requirements despite increasing expansion. Via hydrogen and oxygen which originate from over production of the renewable energy sources, the synthetic gas production processes and hydrogenation processes of coal chemistry become more ecological and effective.

[1] Cf. the study "Future Role of Coal in Europe (FRC)" which can be obtained from: http://www.prognos.com/fileadmin/pdf/publikationsdatenbank/et_ZukunftKohle_0709.pdf)

By means of this position paper, the European Chemical Regions Network shall make a concrete contribution to the debate on the further use of coal and to the designing of the European Union's future research, energy and raw materials policy.

2. The non-energetic use of coal in Europe

In addition to power generation, coal offers a high, additional added value potential and can contribute to the decrease in the chemical industry's dependency on crude oil in European countries. The large coal deposits in Europe ensure an increased security of supply, proximity to the producers with the associated reduction of delivery distances and greater independence from the currently dominating crude oil suppliers.

Coal is a complex mixture of various chemical associations. The non-energetic use of the raw material coal includes the comprehensive use of the existing associations through the combination of low temperature and high temperature conversions. In the case of low temperature conversion which is carried out at temperatures of up to around 500°C (extraction, pyrolysis, catalytic controlled scission of coal), existing associations are separated and modified into chemical products or also fuels. Only after no originally usable parts are available, the remaining associations are broken up and thermally decomposed into the base products of carbon monoxide, hydrogen or methane (synthetic gas production). In turn, these serve the chemical industry as a stepping stone to manufacturing other complex associations and, using the combined processes of brown coal drying and pyrolysis, the manufacturing of chemical raw materials and raw materials for metallurgy.

To effectively exploit the resources in the coal, it is necessary to push forward the research and development of new process technologies and plant technologies for the extraction and recovery of raw materials which has been neglected in the oil age. The coal chemistry in Europe has a significant backlog demand which can only be caught up on through collective efforts between the European partners. Due to the great appeal of the non-energetic use of coal also in other regions around the world such as China, India, Australia, USA, Canada, South America and South Africa, there is also the chance of marketing the technological progress made globally. For this purpose, important technological breakthroughs are necessary over the next few years.

3. The future energetic use of coal

The present energetic use of coal is primarily in the combustion of coal in large power plants. Such large power plants are, however, not very flexible in the case of varying energy requirements (in the case of the increasing development of the renewable energy sources, there will also be an extremely varying "remaining power requirement" due to their volatility which must be covered by fossil fuels). Furthermore, in this way, no local supply which enables the cogeneration of heat and power can take place. According to a new proposal by the EU commission, this is already prescribed for new or modernised plants with a nominal power which is greater than 20 MW in the future.

Here a gasification of the coal can provide the necessary gaseous fuels (synthetic gas, IGCC process) for a local power supply from local raw materials. In this way, highly efficient and flexible gas and stem turbine power plants are possible with combined heat and power generation.

The use of carbonic gaseous fuels, however, also paves the way for the chemical storage of renewable energy sources which is becoming increasingly necessary given the increasing development of these energy sources. In this way, hydrogen which has been obtained via electrolysis from excess power from renewable sources can be transformed with synthetic gas. As a result, a chemical energy carrier with a high percentage of hydrogen is obtained (methane or other hydrocarbons) and thus achieves a reduction of the fossil carbonate in the overall energy content. On the other hand, the hydrogen can also be used to convert CO_2 into methane, which makes the use of CO_2 possible in substantial quantities. In the process, an energy supply based on the carbonate cycle also seems possible in perspective.

In this way, a future energetic use of the coal in the form of gasification may at first enable local and flexible power plant concepts based on local coal. Simultaneously, depending on the development of the renewable energy sources, the percentage of fossil carbonate may be reduced. The (re-)conversion into electricity of hydrogen transformed into methane from renewable energy sources can thereby take place in the same gas and turbine power plants.

Thus coal gasification offers access to the storage of renewable energy sources in the form of a conventional chemical energy carrier with a high storage capacity and wide social acceptance.

4. Development prospects for chemical sites in Europe

The non-energetic use of coal can offer long-term development prospects to many chemical sites and coal processing centres in Europe given the decreasing global oil reserves and political instabilities of the producing countries. This applies in particular to chemical sites in Germany, Poland, the Czech Republic, Romania and other countries in the European Union.

Coal represents the most voluminous and longest available highly concentrated carbonate source for the European Union and a number of other countries. These base products obtained from coal can easily be fed into the existing value added chains. The investment outlay can thus be reduced and the entry barrier lowered for coal chemistry.

Particularly in Germany but also at other European sites, there is the opportunity to integrate the non-energetic use of coal into the structures in chemical parks which have emerged over the last 15 years whose spatial proximity to the deposits represents a significant advantage for the site. Via intelligent networking, significant amounts of energy can be saved and thus limit the production of CO_2 to a minimum. In addition, existing quantities of CO_2 can be non-energetically incorporated into the products, something which is already being implemented. The coal chemistry has the crucial advantage that via the process selection and the process implementation, the level of integration of the carbonate into the end product can be controlled. The manufacturing of chemical base products is thus more energy efficient, cheaper and less harmful for the environment. In contrast to the combustion with subsequent storage (CCS), the avoidance of CO_2 is significantly more effective. Apart from this, the effective CO_2 separation from existing conversion processes (power plants, steel industry) combined with the use of CO_2 as a carbonate carrier plays an important role.

Incidental CO_2 is cleaned in the course of the treatment of the produced synthetic gas in a process-related way. It is thus immediately available for further use (integration in products, energy storage through CO_2 methanisation using regenerative hydrogen and during the coal hydrogenation etc.).

In order to achieve these goals, the following prerequisites must be fulfilled:

- Efficient reactivation of the still available knowledge about non-energetic coal use
- Improved understanding about the material composition of the coal
- Targeted research and development in subareas of coal chemistry
- Setting up of plant complexes for the industrial demonstration and further development of technologies
- Creation of the political and social framework conditions for the acceptance and approval of such technologies and processes
- Consideration of the geostrategical and politico-economic aspects, of regional added value and of the extensive CO_2 balance (fair benchmarking) in the integration of coal chemistry into CO_2 emission trading

5. Development perspectives of the European (brown) coal industry

From the present point of view, the supplies of (brown) coal deposits known in Europe will last several hundred years, correspondingly longer if energetic use is reduced. Thus coal remains an important part of raw material supply, particularly against the background of future non-energetic utilisation.

However, an assured raw material supply directly depends on a sustainable raw material assurance policy; deposits must not only be available, but also must be available commercially. In this process, the following aspects play a key role:

- Is there a socio-political consensus in order to break down deposits in the future; or how can this consensus be reached?
- Deposits must be sustainably protected against rival uses (e.g. infrastructural measures, (environmentally) protected areas)

Furthermore, in the course of the non-energetic utilisation of coal, significantly higher demands are also placed on coal as a raw material. The provision of raw material which is tailored to suit the needs of the chemical industry is necessary (provision of various types of coal with defined quality parameters), given the condition of increasingly more complex depositing conditions. The realisation of these requirements requires highly selective extraction from the solid coal seams based on a new and integrated deposit management. In the process, it should be clarified to what extent the remaining coal seams may have a practical use as a carbon carrier for non-energetic or energetic use.

6. Technological challenges for research and innovation in Europe

In the future, process technologies and plants shall be needed worldwide which make alternative hydrocarbon sources useful to the chemical industry. In the process, complete solutions which consider the characteristics of the coal from exploration to processing, shall play a particular role with regard to efficiency and economic viability.

The focal points of coal research are product based low temperature conversion processes which are adapted to the respective coal, as well as robust, high-performance and residue-free operable high temperature conversions for the remaining residue which is to some extent difficult to use. Particular attention is given to the non-energetic and energetic optimisation of the process chain and the input of hydrogen generated without CO_2. In the process, the aim is, as previously described above, to extract the structures and material combinations present in the coal in a CO_2 free way and to store renewable energies through the addition of hydrogen and the recycling of CO_2 through methanisation.

Provided that the coal is made catalytically accessible for energy efficiency reasons just like earth oil, the resulting product streams can in particular be effectively integrated into the existing processing steps in chemical sites. The basis for this is the provision of types of coal which are tailored to the demands of the chemical industry. The long-term availability of sustainable, economically priced coal is essential for the economic viability of the downstream refining process.

The following technological challenges can be derived from these framework conditions:

- Low temperature conversion processes which are low in CO_2 emissions that can be flexibly adapted according to the coal type specific, macro and microscopic and molecular structural characteristics and are based on comprehensive material and process understanding
  - Reactive extraction with reactive sorbents
  - Innovative extraction processes with supercritical fluids such as H_2O and CO_2, involving separated CO_2 as a reactive extraction agent
  - Catalytically controlled scission of coals
  - Extraction of resources using solvents transferring hydrogen
  - Extraction of base and fine chemicals from coal similar to the extraction of chemicals from biomass
- Structure determination and use of unknown organic substances in coal and biomasses for new products
- Use of more cost effective, selectively efficient catalysers
- Process chain optimised and low in CO_2 emission gasification or hydrogenating gasification of the residue of the low temperature conversion
- Optimised input of CO_2 neutral created hydrogen
- Energetic recycling of CO_2 (released from power plant processes) through methanisation with hydrogen from renewable energies. The hydrocarbons created in this way represent a chemical repository for renewable energies
- Integrated processes for the use of renewable energies for coal refining processes and gas-to-liquid processes
- Non-energetic and ecological use of brown coal for the creation of cokes and coke dust which are rich in carbonate
- Process chain optimisation with regard to product added value and a decrease in CO_2 emissions
- Development of new sensors for material recognition
- Development and construction of a new generation of flexible mining machines for highly selective mining
- Methodical further development of depositary management (exploration, modelling, planning)

Key research areas include:

- Identification and quantification of the substances in the coal
- Development and method based proof of the process-oriented coal molecular description and the modelling of the reaction mechanism based on this
- Development of low temperature conversion processes which are dependent on coal type and low in CO_2 emissions, and in particular of suitable catalysers and reactive extraction agents for this purpose

- Development of process chain optimised processes for gasification / hydrogenating gasification
- Stationary and dynamic process chain simulation
- CO_2 neutral creation of hydrogen from excess renewable energies in flexible load conditions
- Catalytic conversion of the CO_2 with hydrogen under the constraint of available and robust catalysers
- Development of flexible power plant concepts
- Processes of the use of renewable energies for coal refinement
- Development of processes for coal drying and pyrolysis

In addition to the technological challenges, the potentials of industrial use should also be developed. Today's plant and process technology is, however, only developed partly and for few special cases. In the area of a concerted process chain for non-energetic use, there are no modern findings. For this reason, targeted collective research is necessary in order to develop the non-energetic use of coal in a systematic way.

7. Proposal for a European research initiative for the non-energetic use of coal to supplement the development of its energetic use

The potential of the coal chemistry can only be tapped in Europe if a coherent and concerted strategy by the stakeholders involved is pursued on a regional, national and European level for this purpose.

The current discussion about a strategic framework of the future research and innovative policy of the European Union called "Horizon2020“[2] may make a significant contribution here by

- linking together the initiatives of the European Union, the member states and the European regions
- linking together in a practical way existing instruments, such as the Research Fund for Coal and Steel[3], the research framework programme (or its successor "Horizon2020“) and the deployment of the structural fund at a European level
- undertaking EU wide efforts for cooperation research in this area.

The energy carrier coal and its non-energetic use may make a significant contribution to achieving the European policy goals, particularly in the areas of security of energy supply, air quality control, reduction of greenhouse gas emissions and industrial competitiveness.

In a political environment which stimulates research, development and deployment, they can become both attractive and competitive and enable the market forces to increasingly accentuate these essential advantages for the public over time.

A targeted **ten year research, development and demonstration programme** is required, in order to fill the technical gaps for commercialisation. This includes:

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[2] http://ec.europa.eu/research/csfri/pdf/com_2011_0048_csf_green_paper_de.pdf

[3] The Research Fund for Coal and Steel – originating from the European Coal and Steel Community (ECSC) – is an independent, supplementary programme to the framework research programme. All aspects of coal and steel research are covered thematically, from production to application up to the use or the conversion of resources. In the process, the programme contributes to improving the use of coal as a clean energy carrier and reducing CO_2 emissions from the use of coal or from steel production. Annually, 60 million Euros are allocated in subsidies.

- The development and qualification of conversion process which can be implemented in the short and medium term for non-energetic use of the coal while adhering to previously decided energy political scenarios
- CO_2 emission free coal chemistry which can be achieved in the long term through the generation and input of hydrogen which is generated free of CO_2 emissions.

The key challenges are:

- Fundamental new process combinations for the maximum possible non-energetic use of the chemical carbonate inventory including selective catalysed processes
- Demonstration on a pilot and large industrial scale
- Development of new fields of implementation of non-energetic use along the value added chain
- Development of a socio-political requirement profile (acceptance) for future European coal mining as a part of ensuring sustainable raw material supply.

The public investments (such as a Joint Technology Initiative - JTI between the member states and regions) together with the activities of the private sector should mean that an efficient application of non-energetic coal use should follow by 2020.

The next step in filling the holes between research and development on the one hand and commercialisation on the other is the creation of large scale demonstration projects. These include:

- A limited number of a significant size, with the focus on industrial use in Europe
- Selected chemical parks as pilot regions for the non-energetic use of coal on an industrial scale, taking into account their spatial proximity to the available, chemically relevant coal deposits in Europe.

Furthermore, a survey of the chemically relevant coals in Europe and their potential for non-energetic use on an industrial scale is of great importance.

The CO_2 neutral generation of hydrogen from renewable energies and the conversion of CO_2 with hydrogen into methane and hydrocarbons is currently being researched. The integration of coal refining and the development of pyrolytic processes are immediately planned as research projects.

The political framework and the financial planning for crucial and long-term public contributions and incentives are also indispensable.

8. Outlook

The European Chemical Regions Network will now promote this subject at a European level in discussions with representatives of the European institutions and other organisations.

The ECRN would like to see the European Research Initiative incorporated into the organisation of the next European framework programme "Horizon 2020“ and is interested for comments and further ideas for the initiative.

A follow up report to this initiative will be published later in 2012. Any comments can be sent until February 29th 2012 to the following e-mail address: office@ecrn.net.

Further information about the network's activities can also be obtained from the website: www.ecrn.net.

The European Chemical Regions Network (ECRN) is an association with 21 member regions from 10 European countries (Belgium, Czech Republic, Estonia, France, Germany, Italy, Poland, Spain, the Netherlands, and the UK). The aim of the ECRN is to improve the competitiveness of chemical regions, facilitate sharing of experiences and collaboration between regions, and to represent the common interests of the chemical regions in Europe. For further information, please visit the ECRN website (www.ecrn.net) or contact the Director of the ECRN Secretariat, Dr. Hanny Nover, +32 27410947, e-mail: office@ecrn.net.