PREUSSE, A. and KRAEMER, J. Exploration and extraction of mine gas in Germany—New significant energy source and contribution for safety and climate protection. *Application of Computers and Operations Research in the Minerals Industries,* South African Institute of Mining and Metallurgy, 2003.

Exploration and extraction of mine gas in Germany—New significant energy source and contribution for safety and climate protection

A. PREUSSE and J. KRAEMER
Institute of Mine Surveying, Mine Subsidence Engineering and Geophysics in Mining, Aachen University, Aachen, Germany

In the federal state of North Rhine Westphalia (Germany) small and medium sized companies are beginning to extract the related gas via old shafts or boreholes and to use it as a source for the production of electricity and heat. More than 100 applications for the separate mining right on mine gas had already been filed by beginning of 2002, since mine gas is treated as a mineral resource under the Federal Mining Law. Meanwhile more than 40 mine gas concessions have been granted and first projects are being developed with encouraging results so far.

To enhance the applied techniques and their efficiency Aachen University has formed a research team in this discipline.

Scope and goals of this research activities are being presented in this paper.

Keywords: extraction mine gas, Renewable Energy Act, Ruhr District.

Introduction

The utilization of the so-called alternative or renewable energy sources has made enormous progress in recent years. Since April 2000, when the 'Renewable Energy Act'[1] became effective in Germany, also the subject of methane gas has acquired special importance in Germany, particularly in North Rhine Westphalia. Whereas methane gas was previously only a by-product of hard coal extraction, it has meanwhile become an independent energy source. Numerous projects for utilization of methane gas as an energy source have been established in the Ruhr district[2]. Initial problems were solved, the technical feasibility proved and the legal framework conditions created.

Definition

During coalification, i.e. the bio- and geochemical alteration of organic matter within geological periods, hydrocarbons are generated which in part remain in the coal but predominantly (up to 95%) are bound to the coal matrix, forming a gas reservoir. Similarities and differences to conventional gas reservoirs are depicted in Figure 1[3].

The gas consists mainly of methane (up to 95%). Three different types of mine gas can be distinguished according to the applied extraction method—before, during or after mining activities.

- *Coal Bed Methane* (CBM)—From the early to the mid-'80s, special methods for the extraction of adsorptively bound methane gas in virgin hard coal deposits were developed. The goal was to form a possibility for optimally exhausting a hitherto largely unused energy potential. These techniques—vertical or deviated surface wells into gassy coal seams with stimulated desorption predominantly applying the method of hydraulic fracturing (Figure 2)—are very successful in the North American coal deposits. Up to 7000 wells with an annual production of more than 30 billion m^3 are reported.
  Trying to apply these methods in the European coal deposits in the '90s of the last century unfortunately failed due to different geological and technical reasons.
- *Coal Seam Methane* (CSM)—CSM describes the extraction and utilization of mine gas in active coal mines for supply with electricity and heat. The gas is obtained parallel to the process of hard coal extraction. 25% to 60% methane contents are common for CSM.
- *Coal Mine Methane* (CMM)—CMM defines the extraction from abandoned coal mines via old shafts or by means of surface wells. Typical methane contents in CMM-projects are in the order of 60–80%. Predominantly the extracted gas is converted to electricity. Local power plants of about 1.35 MW per unit are installed on the site (Figure 3).

Projects in the Ruhr District and supporting measures by the State initiative

In the recent two years an enormous boom in mine gas–also called firedamp—extraction is taking place in defunct mines of the Ruhr region.

Since the passage of the Renewable Energy Law, motivation is high and profitability is guaranteed by the corresponding legal framework. Electricity generated by mine gas sells for up to 8 cents per kilowatt hour.

Three factors make firedamp extraction interesting. First, its utilization as an innovative energy source. Second, environmental protection through the reduction of harmful methane emissions. Once all currently planned projects have been realized, North Rhine Westphalia can achieve an annual reduction of approximately 3.6 million tons equivalents of the harmful greenhouse gas carbon dioxide.

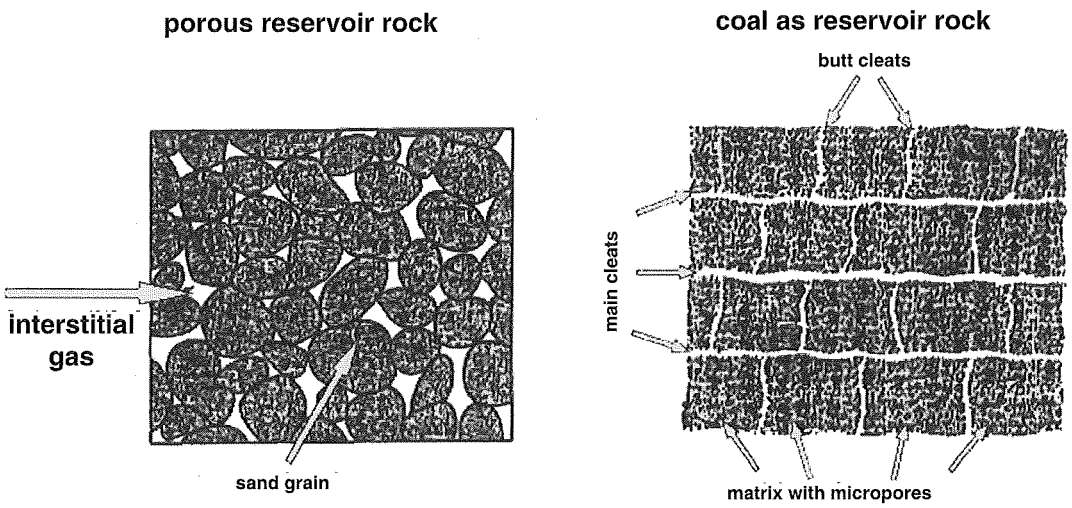

Figure 1. Conventional gas reservoir and coal methane seam reservoir

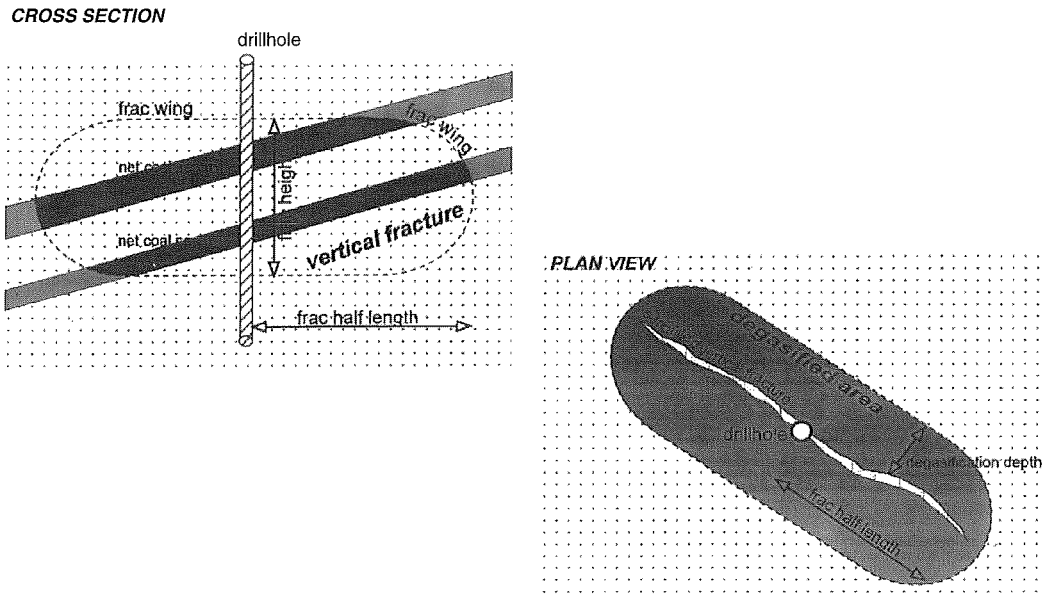

Figure 2. Hydraulic fracturing

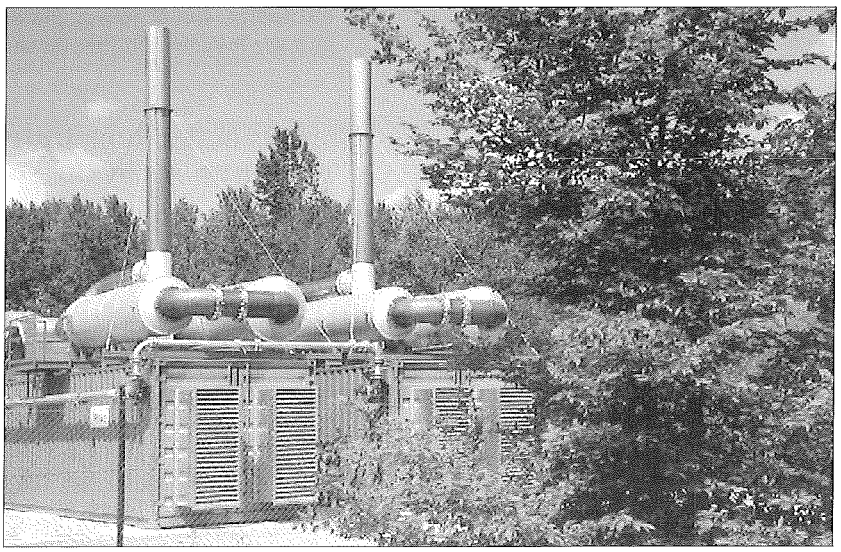

Figure 3. Mine gas power plant unit

And third, the utilization of firedamp provides a greater level of safety, since gas that seeps uncontrolled through surface cracks in the ground represents a latent source of hazard to the public.

Two major players in North Rhine Westphalia started utilizing mine gas on the base of exploration and production licenses for mine gas (separate from coal mining rights) some two to three years ago.

Some 40 production licenses were granted so far. Figure 4[4] shows the geographical position in the Ruhr District. An annual production of mine gas equivalent to 70 MW will be achieved by the end of 2002.

Besides firedamp extraction at existing shafts in defunct as well as in active mines, the exploitation of new gas reserves by means of targeted drilling into abandoned mines also presents promising opportunities (Figure 5).

In the federal state of North Rhine Westphalia the rapid development in mine gas production has been driven by the 'Mine Gas Initiative NRW'. Founded in 2001, this initiative -consisting of partners from relevant industries, authorities and technical universities—has three major goals:

- State of the art and development of efficient technologies in mine gas extraction
- Creating a positive framework
- Accomplishing and improving chances of export.

In the future firedamp energy production technology from North Rhine Westphalia could prove to be a top export.

Eastern Europe countries such as Poland, the Czech Republic and Ukraine have already expressed their interest.

Research and development

The promising economic developments on the methane sector are faced by many unsettled questions. Therefore an intensive scientific treatment of this problems is urgently needed[5].

A research and development project currently realized at the Institute for Mine Surveying (IfM) of the Aachen University deals with the gas emissions from shut-down mines. In co-operation with partners from the fields of government, economics and research, degasification processes are seized and examined scientifically, based on an exemplary, recently shut-down mine. The measuring data concerning the output of mine gas are computer-aided prepared and further processed. Due to the fact that the mine layout creates the access to the actual gas deposit, the surveying data of the mine are edited and a three-dimensional, computer-aided model of the mine layout is constructed (Figure 6).

In this way, possible sources and flow paths of methane can be seized and described in detail. On this basis of data, a computer-aided simulation of gas flow from a shut-down mine is to be accomplished, describing gas emission from former mining operation areas through the underground roadway system to the shafts. The migration of gas through the overlaying rock will be simulated as well. The main goal is to present a three-dimensional simulation of methane distribution and gas flow in the area of the defunct mine, based on data collected during the active phase of mining as well as data from recent measurements. The potential of the defunct mine as a methane deposit can be valued, providing important information for possible investors. It also supports the government by supplying data on possibly dangerous, uncontrolled methane emission from the mine to the surface. After the successful completition of research, this simulation can be transferred to other mines by schematizing and generalizing the described degasification and distribution processes.

This research work in general serves the purpose of supplying scientifically founded answers for unsettled facts. A well-founded statement about the duration and the total quantity of the methane emission is of great interest. Furthermore, the spheres of influence of the gas exhaustion and therefore the associated borders of the legal permission fields will be part of the research. Also the optimization of target drillings into the mine layout for the purpose of gas production can be performed by those means. Beyond that, the possibility is given for the improvement of possible measures during the shut-down of mines, to ensure a better exhaustion of mine gas. Further unsolved questions refer to the differing methane concentrations at the individual shafts, as well as the origin of the other deviating components contained in the emitting gas.

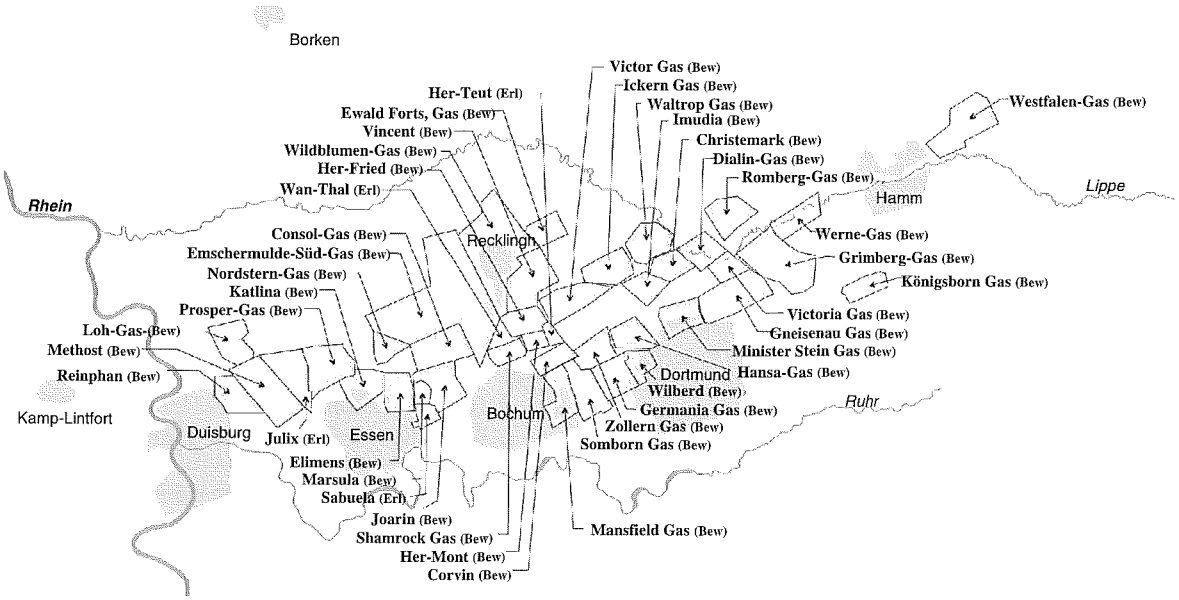

Figure 4. Mine gas exploration and production licences Ruhr district

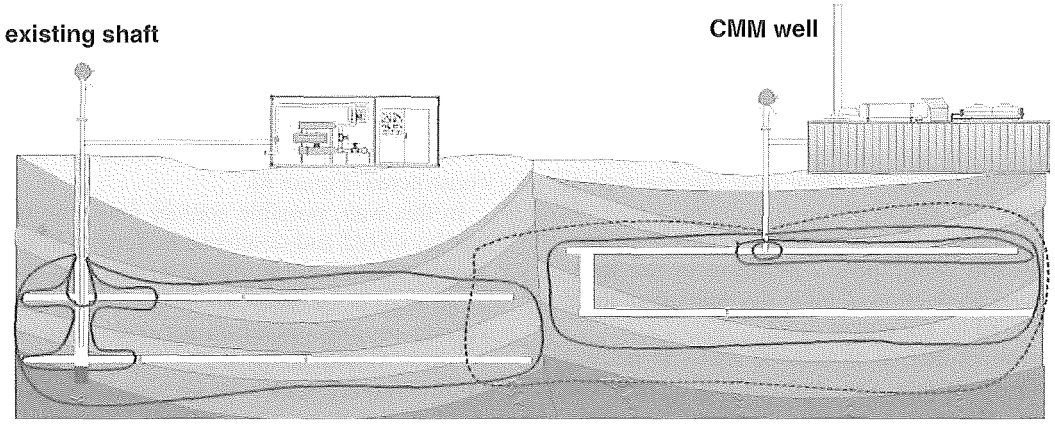

Figure 5. Mine gas utilization from abandoned mines via old shafts or surface wells

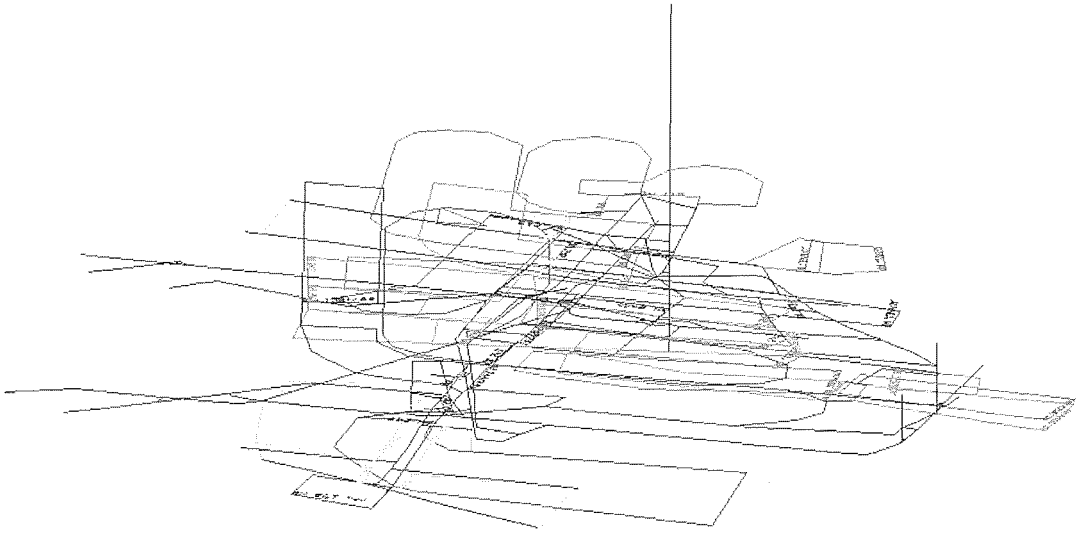

Figure 6. Computer-aided representation of a mine layout

Additionally, basic research in form of gas-flow-simulation is carried out in Germany, concerning gas migration through the overlaying strata to ensure safety for the inhabitants of former mining areas. In this way a combination of all research efforts can possibly lead to increased safety above ground.

Conclusions

In abandoned coal mines as well as in active coal mines, large quantities of mine gas are stored. Mine gas—also called firedamp—is related to the energy source natural gas and consists of up to 90% of methane. In the federal state of North Rhine Westphalia (Germany) small- and medium-sized companies are beginning to extract the related gas via old shafts or boreholes and to use it as a source for the production of electricity and heat. More than 100 applications for the separate mining right on mine gas had already been filed by beginning of 2002, since mine gas is treated as a mineral resource under the Federal Mining Law. Meanwhile more than 40 mine gas concessions have been granted and first projects are being developed with encouraging results so far.

To enhance the applied techniques and their efficiency Aachen University has formed a research team in this discipline.

Scope and goals of these research activities have been detailed in this paper.

References

1. Gesetz für den Vorrang Erneuerbarer Energien (Erneuerbare-Energien-Gesetz–EEG), 2000.
2. BORCHERS, S. Grubengas—ein Energieträger in NRW. *Landesinitiative Zukunftsenergien NRW*, Essen, 2002.
3. PREUßE, A. Grubengas—vom Nebenprodukt zum eigenständigen Energieträger. *Konventionelle und regenerative Energien im Wettbewerb: Geothermie, Grubengas, Kraft-Wärme-Kopplung 1. Essener Energiekolloquium*, Essen, Haus der Technik, 23/24 April 2002.
4. WEIß, E.-G. Schaffung positiver Rahmenbedingungen für geplante Standorte von Grubengasanlagen. *Sitzung der Unterarbeitsgruppe Genehmigungen der Arbeitsgruppe Grubengas, Landesinitiative Zukunftsenergien NRW*, Essen, 21 February 2002.
5. KRÄMER, J., PREUßE, A., SCHROTT, B. GRUBENGAS—Energieträger aus stillgelegten Bergwerken. *Wissenschaftliche Schriftenreihe im Markscheidewesen*, vol. 20, pp. 257–266, 2001.