Coal Mine Gas Utilization with Gas Engines - Case Study Sasyadko Mine, Ukraine

Gerhard Pirker
GE Energy
Jenbacher gas engines

Methane to Markets Partnership Exposition
Coal Sector, Session 2, 10:30

October 30-31, 2007
China World Center, Beijing

GE imagination at work
The Coal Mine Gas business for GE Energy
GE Energy is a worldwide leading supplier of reliable and efficient products/services for the energy industry

<table>
<thead>
<tr>
<th>Turbines, gas engines, control equipment, generators, software and other for</th>
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<tbody>
<tr>
<td>Coal</td>
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<td>Oil</td>
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<td>Nuclear energy</td>
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<td>Wind/ Solar energy</td>
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<td>Natural Gas</td>
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<td>Renewables</td>
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John Krenicki, Jr.
President and Chief Executive Officer, Energy

- Financial Results 2006:
  - Revenues 19.1 billion US$,
  - Net Earnings: 3.0 billion US$
Overview GE Energy Jenbacher gas engines

- World wide **1,500 employees** (1,200 in HQ Jenbach, Austria)
- **0.25-3MW** Gas Engines, Generator Sets, Co-/Trigeneration, Container Solutions
- **Total** installed base: > **8,000 engines**, > **7,000 MWel**
- Total **CMG base** installed up to know: **169 units**, output **360MWel**
GE-Jenbacher is a leading supplier for PG and CHP plants fueled by CMG

Split of installed CMG gas engines by country in % MWel

- **Ukraine**: 20%
- **Germany**: 21%
- **China**: 4%
- **Poland**: 1%
- **Australia**: 38%
- **United Kingdom**: 16%
- **Ukraine**: 20%

**Total = 360 MWel**

- **Thoresby Colliery, United Kingdom**: 2 x JGC 420 GS S.L3 MWel
- **Fenne, Germany**: 14 x JMS 620 GS S.LC, 40 MWel, 41 MWth
- **Teralba, Australia**: 8 x JGS 320, 8 MWel, 5 MWth
Project overview Sasyadko
Sasyadko - A milestone in CMG utilization

- Large scale Coal Mine Methane CHP plant nearby Donezk, Ukraine

- Awarded "World's best Power Plant" and "Project-of-the-Year"*

- Total capacity 73MW delivered with 12/24 engines in operation since May 2006 ("phase I")

- Mitigating emissions at an amount equivalent to 2.6 to 2.9 million tons of CO2 annually

- Considerable contribution to Ukraine's CH₄ emission reduction/ approved one of Ukraine's first projects in international emissions trading in accordance with the Kyoto Protocol

* see announcements in Diesel & Gas magazine Jan/Feb issue 2006 respectively PEI magazine, renewable category 2006
Technical project data Sasyadko

Thermal output >>
- heating the mine
- replacing existing boilers
- surplus heat supplied to Donezk district heating system

Electrical energy >>
- used on-site
- including pumps & ventilation system
- critical for mine safety

Gas consisting of 25% methane (fluctuations) LEANOX® system rapidly reacting to unpredictable changes in methane concentration and gas quality

System handles extremely low pressure of 100 mbar >> gas does not have to be compressed

Special features >>
- cooling system
- silencer
- heat recovery unit
- compact V-shaped engine design lowers foundation size requirements
Some more pictures and plant location
Lessons learned from Sasyadko -
The CMG power generation business today
The coal mine gas business has changed

- Mine operations equipped with a modern degasification system
- Projects have been initiated by supported feed-in tariffs or other public subsidies
- Mine safety and emission reduction only co-drivers

>> main task = optimizing electrical and thermal efficiency from good quality CMG
- focusing at the engine supply

- Degasification system less powerful >> lower and more fluctuating methane concentration
- Mine operations in remote areas
- Projects are initiated by emission reduction credit trading following the Kyoto protocol mechanisms (CDM & JI)
- Mine safety and emission reduction are the main drivers

>> main task = ensuring availability and durability of engines despite more critical gas
- service coverage
- plant engineering know-how
Typical challenges using CMG with gas engines

- **low CH4-range**
- air content ($O_2$)
- quick CH$_4$-fluctuations
- gas contaminations
- **gas humidity**
- gas pressure fluctuations

>> all depending on mine type and degasification system

- extensive gas analysis
- gas pretreatment know-how
- efficient engine layout for large LHV range
- appropriate engine control system to ensure stable energy output (DIA.NE® + LEANOX®)
The GE-Jenbacher Solution

GE Jenbacher's aim is to contribute to safety and ensure profitability and emission reduction to mine operations

- GE-Jenbacher know-how from 20 years experience ensure reliability, efficiency and flexibility in CMG utilization for PG
- GE-Jenbacher's selected subcontractors care for an appropriate gas supply and pretreatment and thus contribute to work safety
- GE-Jenbacher sales & service team and distributors support project owners along the project lifetime
- GE-Jenbacher gas engines allow
  - Availability/ durability down to low calorific values + high gas humidity
  - Low life cycle costs through specific Customer Service Agreement
and are permanently further tuned to this specific application
Thank you very much for your attention!
**GE-Jenbacher LEANOX® + DIA.NE®**

*LEANOX® system levels out fluctuations in methane content and keeps NOx emissions below the critical values*

*DIA.NE® enables smooth and automatic engine start and operation despite gas fluctuations and other issues*

>> Chinese version soon available
NG versus CMG air/fuel ratio

Natural Gas Operation

- **Air**: 20% O₂, 75% N₂, 5% CH₄
- **NG**: 100% CH₄

CMG Operation

- **Air**: 20% O₂, 75% N₂, 5% CH₄
- **CMG**: 15% O₂, 55% N₂, 30% CH₄

With CMG the engine has to take in much higher volumes through the fuel inlet.

ratio

19/1 m³ₙ

ratio

5.5/1 m³ₙ
DIA.NE® + LEANOX ® optimum solution

The GE-Jenbacher DIA.NE® + LEANOX ® engine control system is an optimum solution to handle the CMG-specific air/fuel ratio as well as methane fluctuations and provides a stable energy output.
Specially adapted engines for CMG power generation

- gas pretreatment
  (filter, condensate drainage, preheating, drying...)
- layout for large LHV range
  (turbo charger tuning, gas train, gas mixer, peripheral system...)
- high dynamic of power- and combustion control
  (emission control)
CMG Applications with Type 6 engines

• 3MW >> lowest specific investment
• Longtime experience with CMG plants in Germany, UK, Australia and Ukraine
• Efficiency, reliability and durability proofed by >1.650 installed engines
• Not just a converted diesel unit but a designed gas engine
Customer requirement I - Increase Work Safety

Gas explosions in coal mines cause severe accidents

>> Increased pressure on production output targets and lower coal prices resulted in critical safety conditions in many mining operations.

- Additional gas drainages decrease the danger of gas explosions.
- A CMG utilization project demands an appropriate degasification system, which consequently increases work security.
- Increase in safety leads to an increase in productivity - the initial investment is not too high and can be shared with project partners.
- Controlled gas utilization gives a clear picture of future methane quality and resources and thus enables professional project planning.
- All these measures have a positive impact on workers' working attitude and improve the image of the mining sector in general.
Customer requirement II - Increase Profitability

Mining sector faces tough business conditions

COST REDUCTION OPPORTUNITIES

• autonomous on-site power supply for pumps, ventilation and other
• replacing boilers and other local heating facilities
• committing to security standards, that had to be established anyway

ADDITIONAL REVENUES THROUGH ...

• selling emission reduction credits at a current rate of around US$ 55,-/MWh
• feed-in tariffs, that are possibly further supported by government
• receiving tax credits for safety measures
• selling thermal energy to local heating system
Customer requirement III - Emission Reduction

Coal Mine Gas is dominantly contributing to the GHG effect

- CH$_4$ is 21 times more harming to the environment than CO$_2$, thus reduction has a high leverage on mitigating the GHG effect
- That's why governments and international stakeholders are paying much attention to this issue and CER credits will probably increase further
- Several professional Carbon Credit Advisors and Carbon Developers came into existence, that support project owners
- Despite those favorable facts relatively few CMG reduction projects have been announced and some are conducted at a poor level
- Achieving emission reductions not only provides additional revenues (see profitability) but improves the image of the mine and strengthens the mining sector position within a country's energy portfolio
Coal Gas to Energy Solutions

M2M Conference, Beijing 31st October 2007

“Concept to Creation”
Overview of Presentation

- Introduction
- Clarke Energy & GE Jenbacher Background
- Technical and Commercial Challenges
- Design and Delivery Approach
- Operation and Maintenance – Life Cycle
- Case Examples
Introduction - Concept
Introduction - Creation
Clarke Energy background

- Established in the UK as a specialised engine service company in 1989, operating now in 7 countries
- GE Energy Jenbacher’s largest independent distributor
- Clarke Energy has installed capacity of over 1,500MW of GE Energy Jenbacher products worldwide, equating to 6% of the worldwide power generation market share.
- Total service solutions provider in Supply, Design, Install and Operate
- Over 900MW under Operation and Maintenance contracts
Clarke Energy highlights

- Sole distributor for GE Energy Jenbacher engines
- Designs and builds complete power stations
- Extensive design and project team experience
- The major product and service provider in Coal Seam / Coal Mine applications in Australia, UK and regions where CE operate
- Most experienced suppliers and operators in CSM/CMM generation
- In Coal Gas - Over 235 MW on 17 sites in Australia and the UK.
Technical and Commercial Challenges

- Fuel Gas supply and availability
- Quality of gas - conditioning
- Connection and Export availability - NSP
- Economics – PPA, CapX / OpeX, Timeline, GSA
- Regulatory consents – AGA, NEEMCO etc
- Approvals – Timeline and Development consent
Key Technical Challenges

- Gas pretreatment (filter, condensate drainage, preheating, drying...)
- Layout for large LHV range (turbo charger tuning, gas train, gas mixer, peripheral system...)
- High dynamic of power - and combustion control (emission control)
- Modular design for augmentation or reduction in gas reserves
Gas Conditioning / Cooling CSM/ CMM

Examples
Design & Delivery - ‘Fast Track’ approach and performance
Design & Delivery - ‘Fast Track’ approach and performance
Design & Delivery - ‘Fast Track’ approach and modular design
Clarke Energy Australia – Coal Mine Installations – Oaky Creek

- Full turnkey installation
- 13MWe power output
- 12 x JGS 320 engines (expanding to 20)
- Coal Mine & Coal Seam Methane
- Long term O & M contract
- Commissioned June 2006
Clarke Energy Australia – Coal Mine Installations – Moranbah North

- Full turnkey installation
- 45 MWe installed capacity
- 15 x JGS 620 engines
- Coal mine / seam methane
- Commissioning Aug / Sept 2008
Clarke Energy Australia – Coal Mine Installations – Glennies Creek

- Full turnkey installation
- 11MWe installed capacity
- 10 x JGS 320 engines
- Coal mine / seam methane
- Commissioning Sept / Oct 2007
Clarke Energy Australia – Coal Mine Installations - Teralba

- Full turnkey installation
- 8MWe power output
- 8 x JGC320 engines
- Closed / Abandoned Mine
- Commissioned June 2004
- Long term O & M contract
Clarke Energy Australia – Coal Seam Installations
– Daandine, Qld

- Full turnkey installation
- 33MWe installed power
- 11 x JGS 620 engines
- Coal seam methane
- Long term O & M contract
- Commissioned Feb 2007
Operation & Maintenance – Life Cycle

- Planned and unplanned Maintenance
- Accurate / reliable data
- Certainty of costs / performance
Advantages of Proven Experience and Product

- Certainty of Cost and Time
  - Administration and Tender call period
  - Proven Specification and Design completed

- Certainty of Delivery
  - Proven build model
  - Proven approvals
  - Continuous improvement gains

- Certainty of Early Generation
  - Shortest engine delivery in the market today

- Competitive Design and Delivery
## The Benefits of the Clarke Energy / GE Jenbacher Partnership

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<th>GE ENERGY JENBACHER</th>
<th>CLARKE ENERGY</th>
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<tr>
<td>Equipment design</td>
<td>Proven Design and integration of BoP</td>
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<tr>
<td>Equipment development</td>
<td>Project &amp; Construction Management</td>
</tr>
<tr>
<td>Equipment manufacture</td>
<td>Commissioning</td>
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<tr>
<td>Parts manufacture</td>
<td>Service &amp; Maintenance</td>
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<tr>
<td>“Product Quality Focused”</td>
<td>Parts Stockholding</td>
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<tr>
<td></td>
<td>“Customer / Project Quality Focused”</td>
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Clarke Energy & GE Energy Jenbacher

“The Perfect Partnership” for coal mine applications

Contact www.clarke-energy.com