G.I. Dynamics
Coal Mine Methane Utilization Technologies
Agenda

- Introduction
- CMM Market Overview & Influencing Parameters
- CMM Drainage & Extraction
- Coal Mine Methane Processing
- Project Reference(s) & Case Study
- Concluding
Introducing G.I. Dynamics

G.I. Dynamics is a company with hands-on industrial experience, operating together with specialists and niche business partners in order to **improve the performance and develop the sustainability** for our clients’ business.

Global Network

- G.I. Dynamics Offices
- Business Partners
- Support Network

G.I. Dynamics is backed up by an extended network of highly experienced senior executives, associated in the **Institute for Independent Business**.

19 October 2011
Introduction

- **Understanding and experience of oil & gas business** and complete supply chain, economic and operational drivers of the industry, business partners and opportunities.

- **Aligning and Bridging industries** between the different market sectors, and generating business opportunities to improve the overall business performance.

- **Core business focused on sustainability and environment** therefore our technologies are selected and our business orientation is in areas like unconventional gasses and carbon capture.

- **Providing proven and applied world-class gas processing/treatment technologies** to the oil & gas industry.
  - Cryogenic Nitech™ NRU (Nitrogen Rejection)
  - Helium Recovery
  - Ultra High CO2 Extraction and Sequestration
  - Liquefaction plants

- **Perform projects from licensing up to LumpSumTurnKey** based on above mentioned technologies, and operational support.

- **Supporting our clients** with a full committed team from cradle to grave to ensure an added value and the necessary innovation to the project at the right time.
CMM Market Overview

Market Overview & Influencing Parameters:

- **Mine**
  - drainage
  - ventilation layout
  - mine safety
  - coal production
  - geology

- **Gas sources**
  - catalytic oxidation
  - thermal oxidation
  - flares
  - boiler
  - IC engines

- **Main utilisation technologies**
  - VAM quantity
  - VAM quality
  - CMM quantity
  - CMM quality

- **Market**
  - carbon market
  - heat market
  - power market
  - gas market

- **Other influences (outside mine)**
  - national & local policy
  - local energy demand
  - infrastructure

G.I. Dynamics’ scope:
- gas processing
- pipeline injection/ LNG

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G.I. Dynamics provides together with BCCK:
Coal Mine Methane Utilization Technologies for Methane Purification towards Pipeline/LNG
CMM Drainage & Extraction

Process of Coal Mine Methane Utilization

- CMM extraction planning
- CMM Extraction and Recovery
- CMM purification and compression
- Pipeline injection or LNG transportation

Market Gas (High Quality)

Carbon Credits
## CMM Drainage & Extraction

### What is there?
- Low CMM concentrations
- Low CMM recovery rates
- Explosion risk
- Coal production limited by CH\(_4\) concentrations of ventilation air
- High mixture flow in drainage system due to high air content
- High costs for CMM processing

### What has to be done?
- Improvement of:
  - Drilling scheme
  - Drilling technology
  - Borehole sealing
  - Underpressure
  - Borehole management
  - Pipeline network
  - Dewatering systems
  - Gas management

### What is the benefit?
- High CMM concentrations
- High CMM recovery rates
- Improved mine safety
- Higher coal production feasible
- Lower mixture flow to be transported by drainage system
- Lower costs for CMM processing (e.g. Nitech™)

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Improvement of gas drainage

A minimum investment in improving the drainage and extraction of the CMM has a major impact on the investment costs of the CMM purification.

### Actual state

<table>
<thead>
<tr>
<th>Gas pump no./Drainage system no.</th>
<th>Mixture flow</th>
<th>CH$_4$ conc.</th>
<th>CO$_2$ conc.</th>
<th>O$_2$ conc.</th>
<th>N$_2$ conc.</th>
<th>CH$_4$ flow</th>
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<tr>
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<td>[m$^3$/min]</td>
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</table>

### Improved state

<table>
<thead>
<tr>
<th>Gas pump no./Drainage system no.</th>
<th>Improvememt reasonable</th>
<th>CH$_4$ conc. medium term target</th>
<th>CO$_2$ conc.</th>
<th>O$_2$ conc.</th>
<th>N$_2$ conc.</th>
<th>Mixture flow after improvement</th>
<th>Improvemennt</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>[m$^3$/min]</td>
<td>[%]</td>
<td>[%]</td>
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<td>20</td>
</tr>
<tr>
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</table>

Investment savings

- Costs for improvement of gas drainage system: ~150-200K euro
- Savings for gas purification unit: ~500–2000K Euro
Create Synergy between Mine Operator and Project Developer

Mine Operator

- Ventilation and gas drainage are mainly carried out for mine safety
- CMM and VAM are usually seen as waste products of coal mining only
- Coal mining is core business, not gas production or utilization
- Value of CH$_4$ is considerable lower compared to value of produced coal

Project Developer

- Investment in gas utilization project
- Revenues from gas utilization and/or CO$_2$ credits are basic
- Stable CH$_4$ quantities and qualities
Coal Mine Methane Processing

Process of Coal Mine Methane Utilization

- CMM extraction planning
- CMM Extraction and Recovery
- CMM purification and compression
- Pipeline injection or LNG transportation

Market Gas (High Quality)

Carbon Credits
G.I. Dynamics provides together with BCCK:
Coal Mine Methane Utilization Technologies for Methane Purification towards Pipeline/LNG

Coal Mine Methane Gas Treating Configuration
The Cryogenic Nitech™ NRU Technology;

- **Nitrogen Rejection Units (NRU) selectively removes nitrogen from a gas stream.**
  - In practice, cryogenic plants have the highest methane recovery rate (approximately 99%) of any of the nitrogen rejection technologies.
  - The units have become standard practice for large-scale projects.

- **Key figures;**
  - Nitech™ is the preferred choice NRU process in the USA. Almost all new NRU systems are built with the Nitech™ process;
  - More than 21 Nitech™ NRU systems have been installed
  - There are currently 3 Nitech™ NRU systems under construction
  - The first overseas Nitech™ will be built in Poland;
  - The Nitech™ NRU technology can be up to 15% less expensive on both OPEX and CAPEX in comparison to other cryogenic technologies.

- **Major technical advantages;**
  - Typically only three major components;
  - No cryogenic rotating equipment required;
  - High methane recovery in excess of 99%;
  - A less complex, more reliable and lower cost design.
* Excluding any usage of the extra heat available from the oxygen system. We can do several things (make heat for mine, make steam, or make steam and power).
Coal Mine Methane Processing

Example data: CMM-to-Natural Gas

<table>
<thead>
<tr>
<th>Drainage station no.</th>
<th>Mixture flow [m³/min]</th>
<th>CH₄ conc. [%]</th>
<th>G.I. Dynamics’ scope of delivery*</th>
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</thead>
<tbody>
<tr>
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<td></td>
<td></td>
<td>Old CMM-to-NG</td>
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<tr>
<td>1</td>
<td>155</td>
<td>45,0</td>
<td>€ 12.375.000</td>
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<tr>
<td>2</td>
<td>800</td>
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<td>€ 21.037.500</td>
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Example data: CMM-to-LNG

<table>
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<tr>
<th>Drainage station no.</th>
<th>Improvement reasonable</th>
<th>Target [%]</th>
<th>G.I. Dynamics’ scope of delivery*</th>
</tr>
</thead>
<tbody>
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<td></td>
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<td></td>
<td>Old CMM-to-LNG</td>
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<tr>
<td>1</td>
<td>yes</td>
<td>60,0</td>
<td>€ 16.545.000</td>
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<tr>
<td>2</td>
<td>yes</td>
<td>50,0</td>
<td>€ 28.125.000</td>
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</table>

Note. G.I. Dynamics scope of Delivery: License, engineering, equipment and interconnecting piping systems
Waynesburg, Pennsylvania - Highlights

- **Plant in co-ownership** via Greene Energy, LLC.
- To date, we **continue to provide engineering and optimization services** for the plant.

Black Warrior Methane, Alabama – Highlights

- Ahead of mining operations, BWM sells approximately 500 million m³ per year of coal bed methane gas. **The addition of the Nitech™ NRU increased gas sales by 10%-15%**.
- The capture of this methane will allow producers to bank the carbon credits earned from capturing this methane and to trade the corresponding carbon credits with other businesses.

Illinois Methane NRU, Illinois – Highlights

- The Illinois Methane facility was placed on an **abandoned coal mine (AMM)** whereby active mining has been ceased for several years.

**Experience**

The Nitech™ process is already in operation across the country with coal mine methane enrichment facilities in:

- **PA, USA**
  - 120 million m³ annual
  - 10% - 25% N₂

- **Alabama, USA**
  - 120 million m³ annual
  - 15% – 30% N₂

- **Illinois, USA**
  - 120 million m³ annual
  - 15% – 30% N₂

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**Our scope may vary from technology provider towards turn key project contractor up to co-ownership.**
Case study of a Coal mine

- Coal production: 4 million T/A
- Vented CH$_4$: 150 m$^3$/min
- Drained CH$_4$: 75 m$^3$/min

- Value of coal: ~500 million $ / A
- Value of total emitted CH$_4$ (Carbon Credits): ~20-30 million $ / A
- Value of natural gas from drained gas after purification: ~15 million $ / A

Nevertheless significant additional revenues from CH$_4$ utilisation!
Concluding

Benefits of Efficient Gas Drainage

- Main benefits for effective and correct drainage system will address the inherit risks associated with coal mines. By having an effective utilization process for the drained CMM, an additional revenue can be created. Main benefits for effective capture and utilization of CMM;
  - **Safe working environment** — decreases the risk of fire/explosion
  - **Environmental friendly** — methane, a dangerous greenhouse gas, is captured instead of vented to the atmosphere
  - **Cost-effective fuel source** — captured, processed gas can power mining equipment

Benefits of Gas Purification for Pipeline/LNG

- Utilizing to the Nitech™ NRU technology, you can;
  - **Stop venting** coal mine methane to the atmosphere,
  - **Capture that waste gas** and
  - **Create a sellable methane** product or liquid natural gas (LNG).

coal mining and methane mining now go hand-in-hand!
G.I. Dynamics’ Gas Processing Group;
Provides proven and applied world-class gas processing / treatment technologies up to LS turnkey facilities to the oil & gas industry and align interested players/parties in the market. Our experience and capabilities cover gas processing activities in the area of;

- Conventional low-BTU Gas
- Shale Gas
- Tight Gas
- Coal Seam Gas / Coal Mine Methane
- Enhanced Oil Recovery

Some of the unique technologies we supply;
- Cryogenic Nitech™ NRU (Nitrogen Rejection)
- Nitech™ Xpan
- Ultra High CO2 Removal

Scope of supply:
- Feasibility study
- Technology plus extended basic engineering package
- LS Turn key plant or
- Proprietary equipment and start up assistance
- Co-ownership/operations
Concluding

Summary

- We provide world-class technology for the CMM processing & utilization
- We cooperate with relevant business partners, able to cover the latest developments in;
  - CMM Drainage & Extraction
  - CMM Utilization to up high quality Natural Gas or LNG
- Successful with global players
- Supporting client to develop project and operating support
- Supporting in the business finance
Thank you.

Contact Us
For more information about the technology and applications, don’t hesitate to contact our business associates. We would be glad to help you in achieving sustainable business!

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