# Best Practices in CMM Project Development

## Workshop on Promoting Coal Mine Methane (CMM) for Energy, Safety and the Environment: Legislation and Project Development in Kazakhstan

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Astana, Kazakhstan

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# Presentation Outline

- What is good safety practice?
- Review of methane drainage systems
- Integrating coal mine methane (CMM) capture and utilization
- CMM utilization
- Ventilation air methane (VAM) utilization
- Best practices case study
- Conclusions
- Discussion

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# What is Good Safety Practice?

**Avoid explosive gas mixture**

- Rapidly dilute explosive mixtures to safe concentrations
- Maximize methane drainage to minimize high gas concentrations in mine airways

**Why employ best practice**

- Mine safety
- Asset protection
- Coal Production
- Energy Recovery
- Environmental Protection

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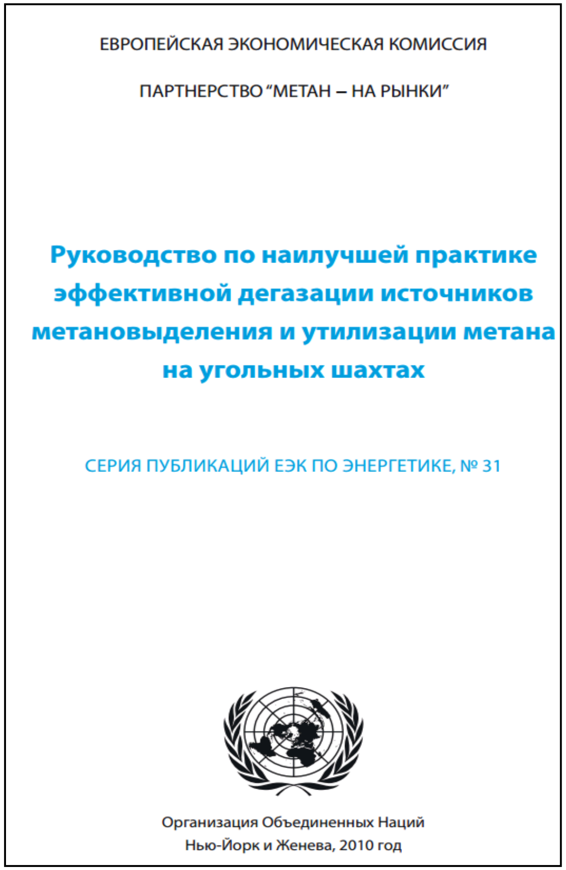
# UNECE Best Practice Guidance on Effective Drainage and Use In Coal Mines

- High level principals-based guidance
- Target audience - government and corporate decision-makers
- Adopted by the UNECE in 2010
- Recommended for worldwide application by UN Economic and Social Counsel (ECOSOC) in 2011
- Supports development of safer and more effective practices
- Includes real world case studies
- Available in 7 languages including Russian
- Currently revising and 2nd edition expected to be released in 2016.
- Complements existing legal and regulatory frameworks


ЕВРОПЕЙСКАЯ ЭКОНОМИЧЕСКАЯ КОМИССИЯ

ПАРТНЕРСТВО "МЕТАН – НА РЫНКИ"

**Руководство по наилучшей практике эффективной дегазации источников метановыделения и утилизации метана на угольных шахтах**

СЕРИЯ ПУБЛИКАЦИЙ ЕЭК ПО ЭНЕРГЕТИКЕ, № 31

Организация Объединенных Наций
Нью-Йорк и Женева, 2010 год

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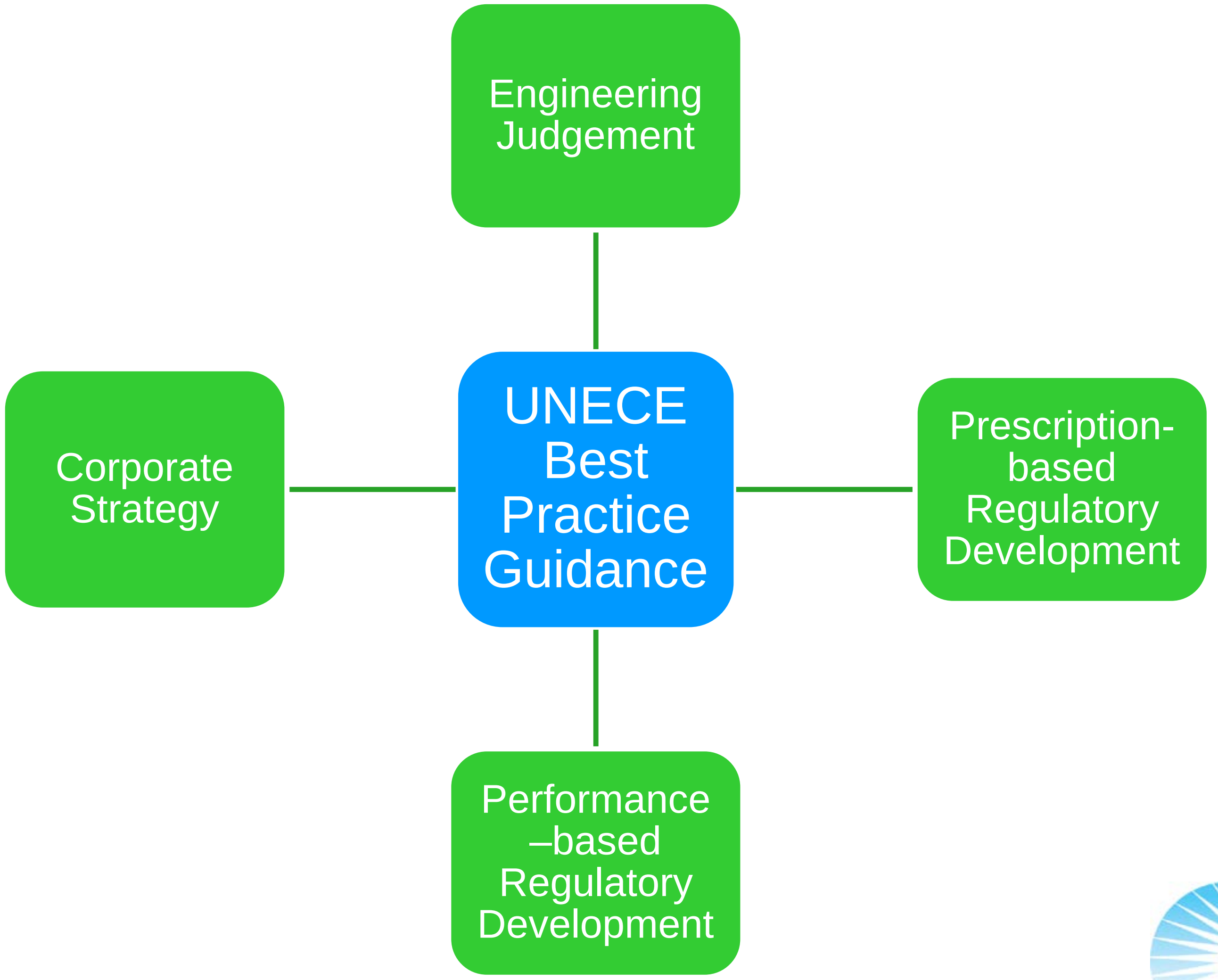
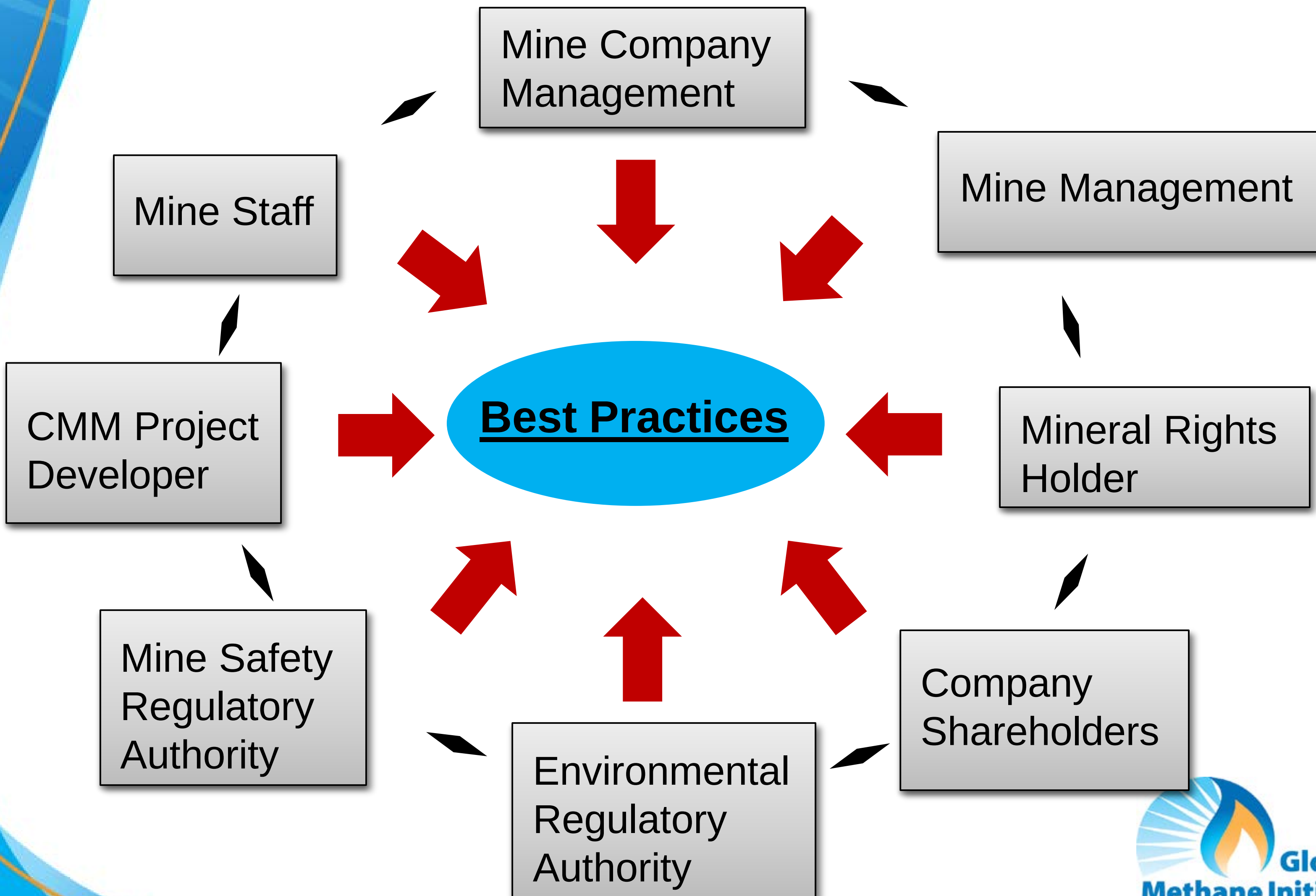
# Flexible Nature of Guidance



# Stakeholders Critical to Achieve Best Practice



# Key Tenets for Best Practices

Prediction of underground gas release

Efficient mine ventilation

Effective gas drainage

Optimal use of drained gas (CMM) and ventilation air methane (VAM) for near-zero emission coal mining

Management and staff education and training

Reinvestment in mine and gas operations

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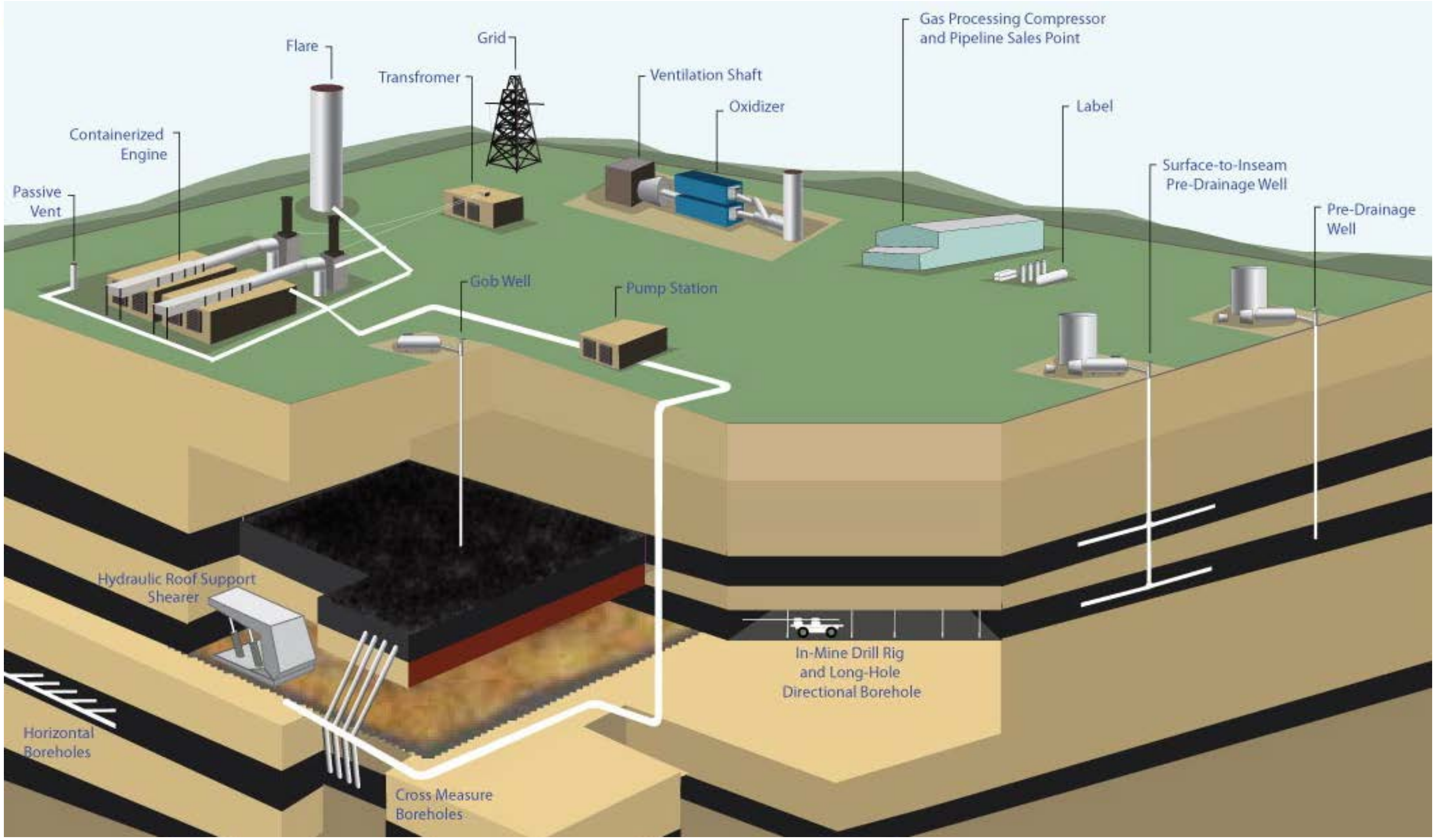
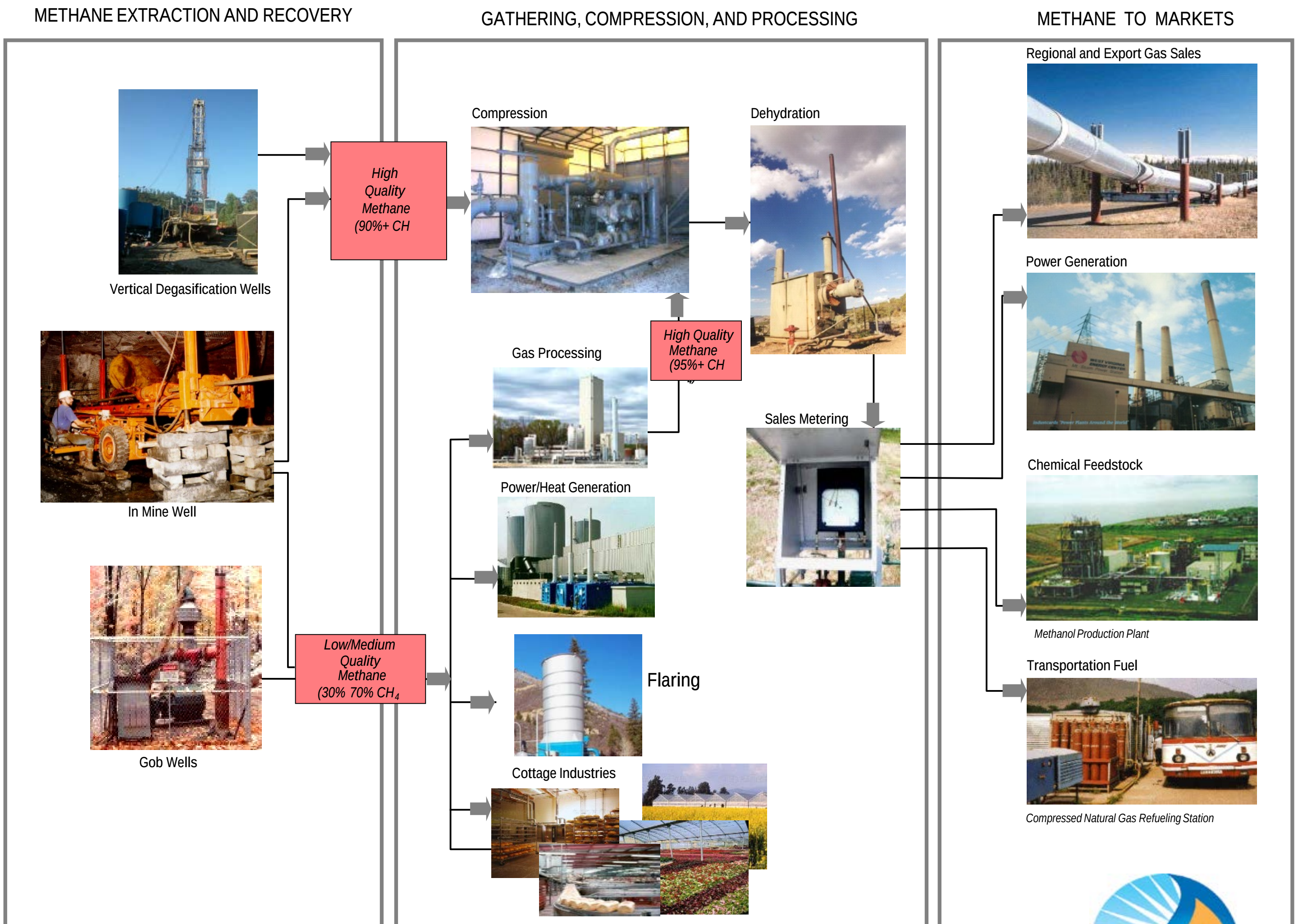
# Methane Drainage Techniques

| Technique | Advantages | Disadvantages |
|---|---|---|
| **Conventional Vertical Unstimulated Pre-Drainage** | • Simple<br>• Does not interfere with mining operation | • Perform poorly in low permeability |
| **Surface Vertical Hydraulic Fracture Pre-Drainage** | • Multi-seam completions<br>• High recovery efficiency of 40-70% | • Limited effectiveness in complex geology<br>• Large footprint |
| **Surface Directionally Drilled Pre-Drainage** | • High recovery efficiency, up to 90%<br>• Smaller footprint than vertical wells<br>• No hydraulic fracturing | • Expensive<br>• Can be difficult to steer in complex geology |
| **In-Mine Short Hole** | • Simple – use non-steerable rotary drills<br>• Relatively inexpensive | • Requires access to galleries<br>• Drainage efficiency is limited by very short drainage period |
| **In-Mine Long-Hole Directionally Drilled Borehole** | • Up to 1 year in advance of mining<br>• Up to 50% recovery efficiencies | • Requires access to galleries<br>• Lower drainage efficiency than surface pre-drainage |
| **Drainage Galleries** | • Lower cost and widely used<br>• Does not require boreholes | • Inflexible to change during mining<br>• Can be inefficient |
| **Cross Measure Boreholes** | • Practicable for deep coal seems<br>• Effective in low permeability | • High capture efficiencies difficult to sustain |
| **Surface Gob Vent Boreholes** | • Very effective for shallower coal seams<br>• Lower drilling cost than pre-drainage | • CH4 concentration declines rapidly<br>• Challenging in mountainous terrain |

# Integrated CMM Capture and Utilization at an Operating Mine



# Coal Mine Methane (CMM) Value Chain

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# Methane Drainage Use and Destruction Technology Options

| Technology | Comments |
|---|---|
| **Natural Gas Pipeline Sales** | • Requires consistently high gas quality to meet pipeline specifications. |
| **Power Generation** | • Small IC engines (500kW-3 MW) are most common because they can handle lower CH4 concentrations down to 25% CH4<br>• Containerized modular construction allows for cost effective operation. Most popular use outside the US. |
| **Vehicle Fuel – CNG/LNG** | • LNG/CNG can be used for mine vehicles or external markets<br>• Requires very pure CH4 stream - expensive options |
| **Boiler Fuel** | • Not technologically complex and can use mine gas with 30% CH4 concentration.<br>• Very common use – usually involves conversion of a coal-fired boiler |
| **Direct Heating** | • Use in industrial burners or industrial flares<br>• Primary use is mine shaft heating in winter or in manufacturing |
| **Flaring** | • Used for stranded gas with no market, as an interim GHG destruction option, or to destroy excess GHGs in an integrated CMM project. |
| **Other uses** | • CMM has been used in methanol production, glass making, steel manufacturing, desalination plants, green houses, and coal drying. |

# Methane Drainage Key Points

- Technologies to use or destroy CMM are the same as those that use natural gas.
- End use is determined by many factors:
  - Gas quality ($CH_4$ %)
  - Gas quantity (4.2 $m^3$/min $CH_4$ = 1 MW)
  - Access to markets
  - Infrastructure
  - Financial position
  - Staff capacity
  - Mining company priorities
  - Government policy priorities

# Methane Drainage Key Points

- Projects often include a portfolio of technologies to maximize gas use.
- When deciding what technology to use:
  - Power, flaring, boilers, and vacuum pumps require minimal gas treatment
  - LNG, CNG, and pipeline sales require expensive gas treatment
- In order to implement a successful methane drainage project:
  - Improve gas availability (gas quantity and quality) and maintain $CH_4$ concentrations above the explosive range
  - Size plant properly- 80% of average gas flow
  - Flare gas when not used rather than venting
  - Regular maintenance and overhaul are required to keep the plant operating

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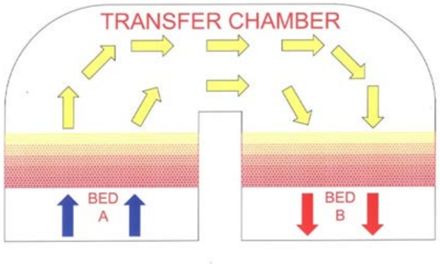
# Ventilation Air Methane (VAM) Abatement Technology




- Regenerative Thermal Oxidizer (RTO) technology has become standard through successful demonstration in Australia, China, and U.S.
- Currently 2 VAM projects operating in U.S., 1 in Australia, with 1 in under development in China

- **Other technologies are in development and close to commercialization**
  - Regenerative Catalytic Oxidation
  - Lean-burn turbines
  - Monolithic reactors
  - Rotary kilns

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# Commercial VAM Projects

**Marshall County Mine, West Virginia, USA**

- Mine formerly owned by CONSOL and project began under CONSOL
- Mine purchased by Murray Energy in December 2013
- VAM project financed and developed by Sindicatum Sustainable Resources
- 3 2-can RTOs from Durr
- Capacity = 160,000 cfm
- Emission reductions = 197,411 tCO2e

**Gaohe Mine, Shanxi Province, China**

- Owned by Shanxi LuAn Group
- In development
- 12 RTOs + steam turbine
- Will rely solely on power sales revenue
- Full capacity will be 700,000 cfm and utilize RTOs
- Using drained gas to enrich VAM to 1% $CH_4$

**VAM RTO Manufacturers**

- MEGTEC
- Biothermica
- Durr
- HEL-East Ltd
- Gulf Coast Environmental
- Shendong (China)

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# VAM Best Practices

- VAM projects are a significant investment – requires careful planning before development and considerable oversight after operations begin.
- Understand the methane resource, mine plan, and mine ventilation plan including gas drainage.
- Design should be based on air flow and CH4% data obtained from regular sampling and analysis or preferably continuous emissions monitoring systems.
- Most projects will be destruction-only. Success is almost entirely dependent on carbon markets
- Some potential for power generation with consistent flow and high VAM concentration (0.90% $CH_4$ or greater).

***VAM abatement is essential for near-zero emissions coal mining!***

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# Case Study: Duerping Coal Mine, China

- Owned by Xishan Coal & Electricity Co Ltd, a subsidiary of Shanxi Coking Coal Ltd (Jiaomei Group)
- Xishan Coal Field near Taiyuan City
- 1,600m above sea level
- Metallurgical coal mine
- Production capacity = 5 Mtpa
- 700 Mt reserves
- 50 year life
- Relative emissions = 17.7 m3/t (567 ft3/st)
- CH4 emissions increasing as mine goes deeper and production increases
- Drainage system before project
  - in place prior to project development
  - Prior CH4 concentrations: 25-30%
  - Drainage efficiency = 15%
- No CMM utilization prior to the CMM utilization project


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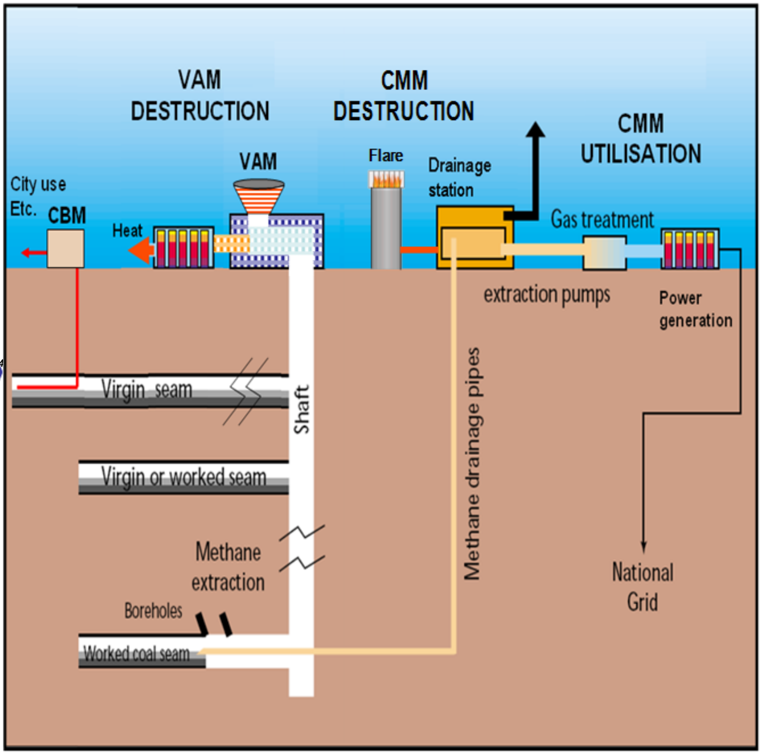
# Near Zero Emission Mining for the Duerping Mine CMM Project:

- Maximise gas drainage capture
- Optimise utilisation of the drained coal mine methane (CMM)
- Thermal destruction of surplus CMM
- Destruction of the methane in the ventilation air (VAM)
- Exploit waste heat




**A holistic approach to mine safety, energy production & environmental protection**

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# Approach for the Duerping Mine CMM Project*: Steps 1 and 2

## Step 1: Determine Gas Availability

- Confirmed gas content data, structure of the coal matrix and permeability of the coals
- Modeled CH4 liberation rates

## Step 2: Improve Gas Quality & Quantity

- Enhanced methane purity
  - Improved borehole sealing (2-stage)
  - Regulated Suction
- Raised gas capture
  - Increase orifice - plate size in the choke
  - Improved borehole design and pattern
  - Controlled extraction from sealed areas

*Acknowledgment to Sindicatum Sustainable Resources and Xishan Coal & Electricity Co.

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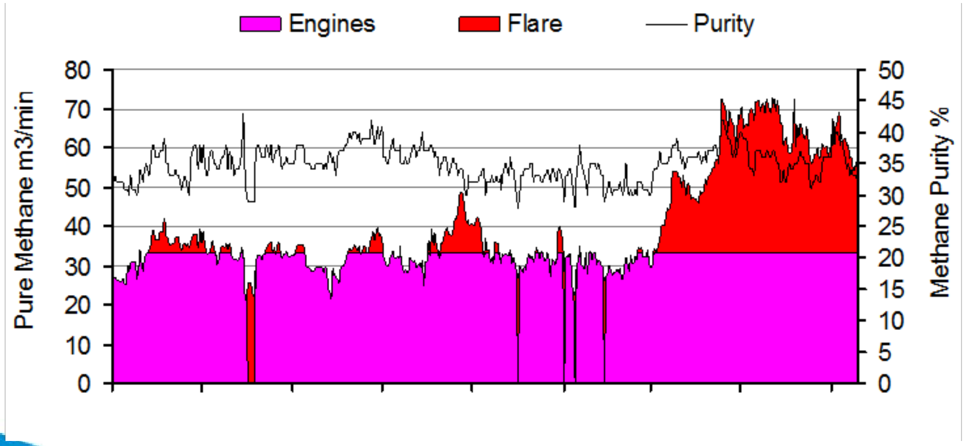
# Step 3: CMM Utilization System Design

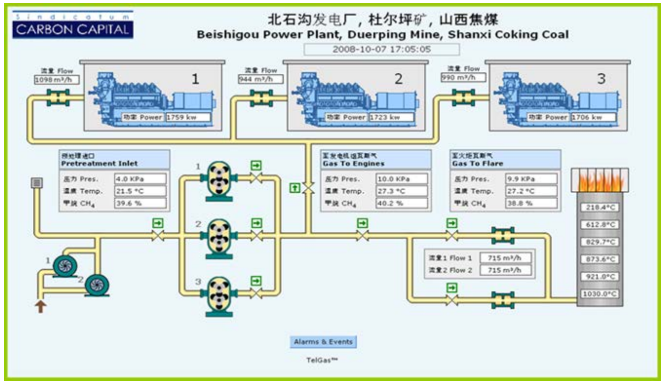
- CMM power plant includes:
  - Power generation - 12 MW
  - 5000 $m^3$ per hour enclosed flare
  - Closed loop oil-based heat recovery system
  - Passive vent
  - Minimal gas processing: dewater with knock-out pot and chiller and use 2-stage dust control
- Employed a conservative approach for power plant design
  - Sized project at 80% of the average $CH_4$ flow
  - Assume 80-85% availability for gas engines
- Focus first on utilization of gas drainage
- VAM destruction was secondary objective



# Step 4: CMM Plant Operation

- After start-up, implemented best practices to maintain plant operations
  - Training for mine and SSR staff
  - Team to worked with the mine staff to maintain gas availability.
  - Telemetry to monitor operations remotely.
  - Regular walk-throughs and scheduled maintenance including
- Operational monitoring
  - Constant observation to ensure project is operating as planned
  - Alarms and notice system alert staff to problems

Duerping Phases 1&2

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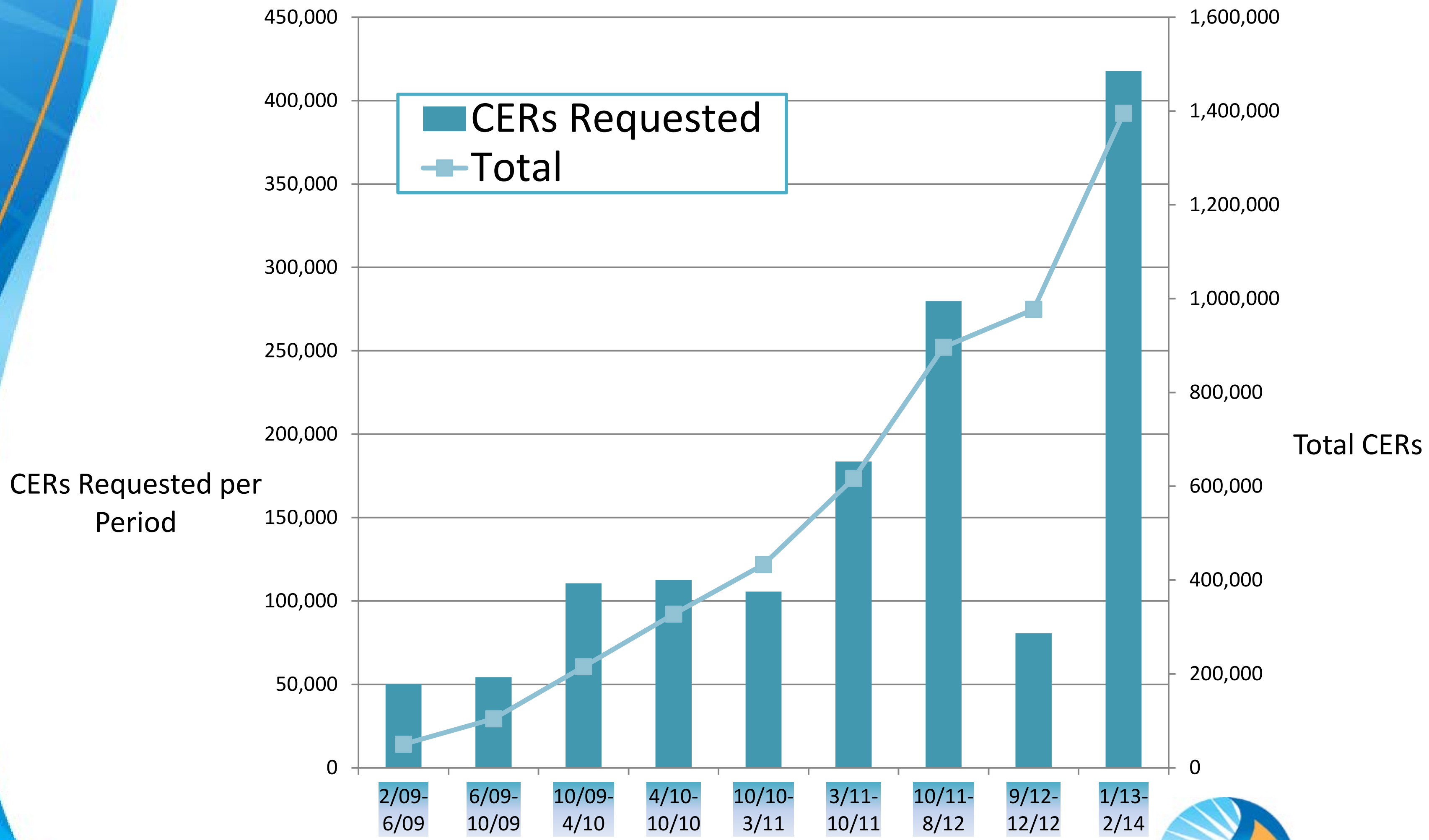
# Power Plant & Flare Performance

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# Step 5: VAM Plant

- Preparation
  - Installed continuous emissions monitoring system for 3 years recording $CH_4$% data every 15 minutes
  - Regular air flow data at the fan provided by mine staff
- Contracted with manufacturer in 2011
  - One 35 $m^3$/sec RTO
  - One 20 $m^3$/sec RCO
  - Plant is destruction only
- Project registered as CDM project in November 2011
- Construction in 2012/2013
- Plant is currently idled due to low CDM prices

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# Conclusions

- Every project is unique – tailor each project to the operations, mine gas characteristics, regulatory framework, and market conditions
- Be open to employing a portfolio of methane capture and use technologies to achieve near-zero emissions mining
- Project success will be enhanced by
  - Excellent communication among stakeholders
  - Thorough preparation and planning
  - Conservative approach – it is easier and more cost-effective to scale up than scale down.
- But be prepared to still face range of issues throughout project development, construction and operation
  - Gas quality and quantity
  - Mechanical issues
  - Changes in mine operations
  - Changes in market conditions

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