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Strategies to Reduce GHG Emissions from Coal Mines: A Review of Australian Perspective

M2M Expo, 3-5th March 2010, New Delhi

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Strategies to Reduce GHG Emissions from Coal Mines

Presentation outline

- Introduction : Over view of International and Australian GHG emissions and legislation
- Impact of carbon charge on economics of coal mining
- Options for GHG reduction from UG Coal mines
- Alternatives for optimal decision making for reduced GHG emissions
- Ideal Future GHG friendly mine scenario

Strategies to Reduce GHG Emissions from Coal Mines

Introduction

- International GHG emissions ~ 41,000 Mt CO_2-e (IPCC – data)
- Australian GHG emissions
  - ~544 Mt CO_2-e (Since one year till June 2009)
    - Energy Sector ~ 415 Mt CO_2-e
      - Fuel combustion ~ 376 Mt CO_2-e
      - Fugitive emissions~ 39 Mt CO_2-e

      (Australian– National GHG Inventory 2009)
  - Only 1.4% of the world GHG emissions
  - Increased from 483 Mt CO_2-e since 1999
  - Decreased by 1.4% from previous year
- Coal mining fugitive emissions 26.8 Mt CO2-e (2007)

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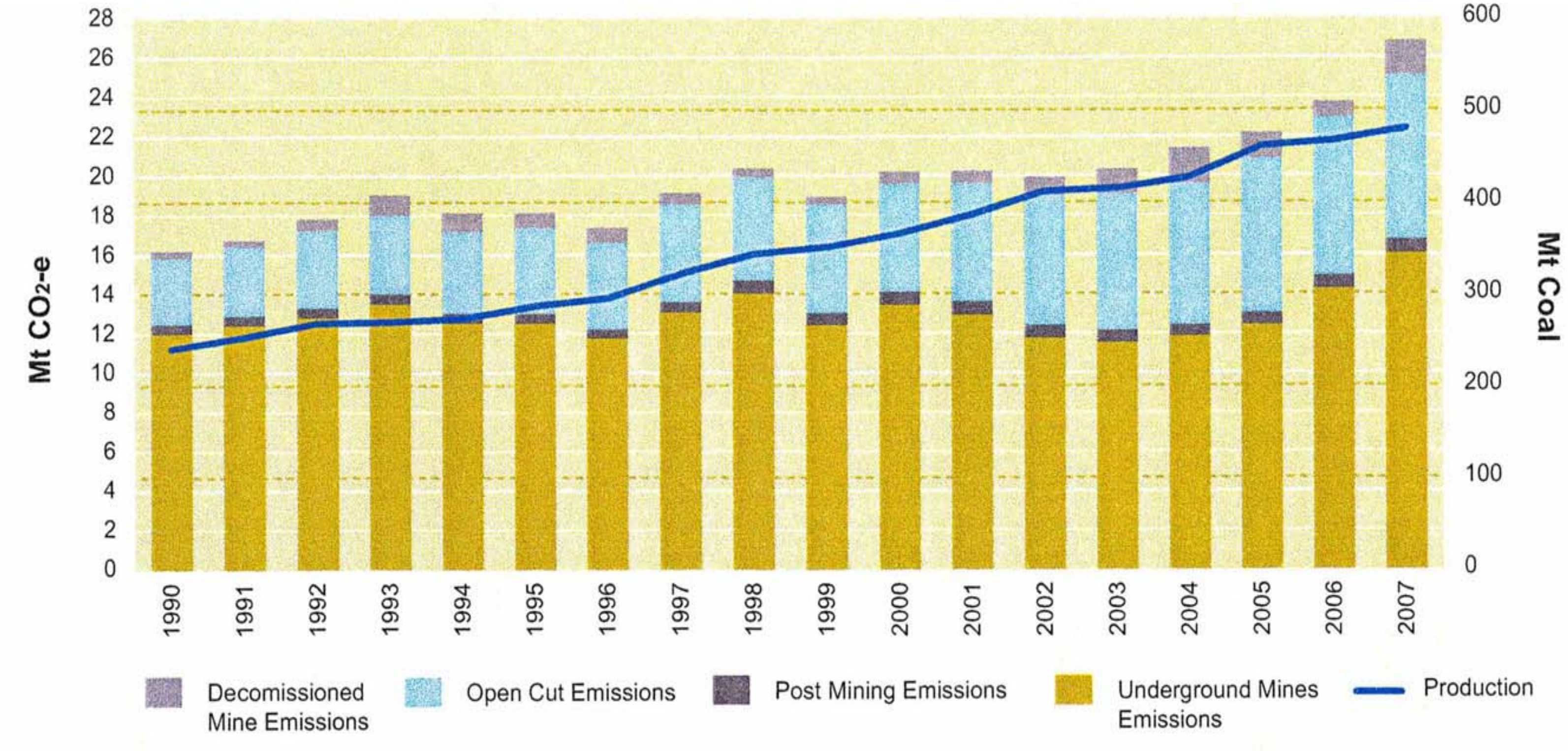
Fugitive GHG Emissions from Australian coal mines

(Australian National GHG Inventory, 2009)



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Introduction (Cont.2)

- **Australian Climate change Legislation**
  - *National Greenhouse and Energy Reporting Act 2007* (The NGER Act) for the reporting of greenhouse gas emissions.
  - All Coal mines to report the GHG emissions under the act
  - Methods of emission estimation
    - For Open Cut mines: emission factors (in CO_2-e Tonnes)
      - Mines in NSW: 0.045* Annual Coal production
      - Mines in QLD: 0.017* Annual coal production
    - For Underground mines: Direct measurement

(Uses method 4 as per the IPCC guide lines)

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Proposed Carbon Pollution Reduction Scheme (CPRS)

- Basically a cap and trade scheme.
- Applicable to facilities with GHG emissions > 25,000 t/year of CO2-e; all Coal mines in Australia are covered.
- Fugitive GHG emissions from coal mines will be capped and annual permits required for GHG emissions from coal mining operations.
- Free permits to Emission intensive trade exposed (EITE) Industries. Coal mining Industry excluded from EITE assistance
- Scheme incorporated Coal Mining Abatement fund ($250 Million) and Coal Mining transitional Assistance fund for ($ 500 Million) in 5 years.
- Final scheme yet to be approved after modifications and political consensus.

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Impact of carbon charge on Coal mining in Australia

- CO_2-e and methane (CH_4) flow rates
  - 1 m3/s CH_4 ~ 0.45 Mt/y CO_2-e   (10 Mt CO_2-e ~ 22 m3/s)
  - CPRS scope at 25,000 t/y CO_2-e ~ equivalent to ~ 56 l/s CH_4
- CH_4 emissions and carbon charge
  - At A$25/t CO_2-e, 1 m3/s (1,000 l/s) emissions ~ $11 M/y charge
- Power generation and Flares
  - 1.0 m3/s CH_4 ~ 12.5 MW capacity (@ 80 l/s = 1 MW)
- Coal Industry sponsored study by ACIL Tasman estimated ~ $14 Billion carbon charge over next 10 years. and future emissions)
- Urgent need to review the strategies to reduce GHG emissions from UG Coal mines

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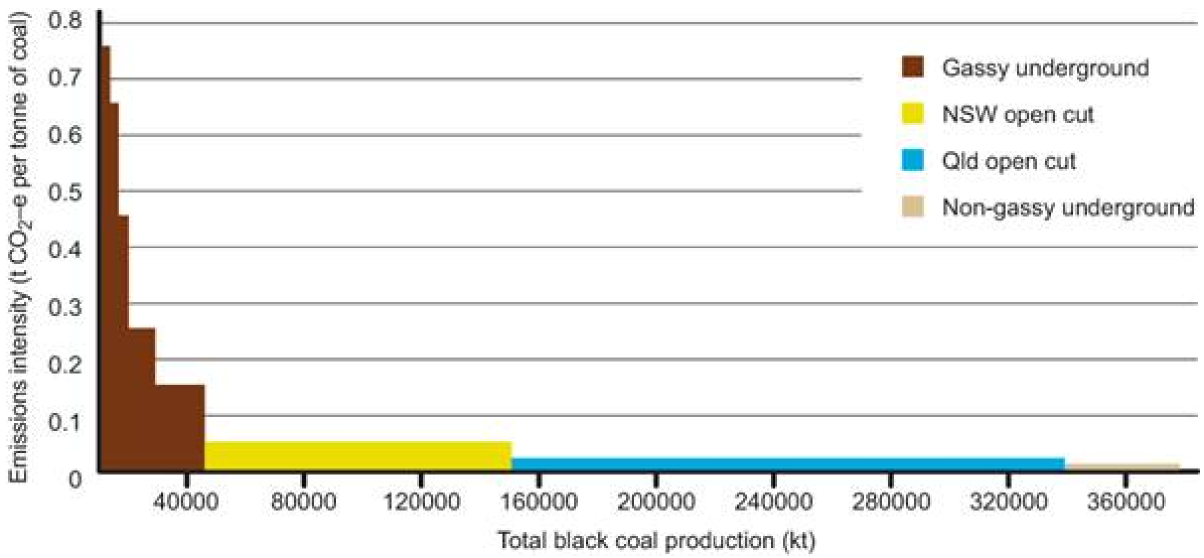
Coal mine fugitive emissions intensity- by National Greenhouse Accounts



From the above figure, for example:

- Gassy underground mine producing 5 Mt with intensity of 0.3 – total emissions around 1.5 Mt of CO_2-e, which equates to $38 M/yr (at permit cost of @$25/t)

- NSW open cut mine producing 5 Mt with intensity of 0.045 – total emissions around 0.225 Mt of CO2-e, which equates to $5.6 M/yr (at permit cost of @$25/t)

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Options for GHG reduction from UG Coal mines

- UG fugitive emissions ~ 16 to 17 Mt CO_2-e
  - Total VAM around 30 m^3/s CH_4 (13 to 14 Mt CO_2-e)
  - Total drained gas ~ 20 m3/s CH4
    - Drained gas ~ around 40% of total (20 m3/s out of total 50 m3/s)
    - 75% of drained gas used for Power generation and in Flares
- The Intensity of GHG emissions from UG mines varies from 0.1 to 0.7 CO2-e/Tonne of coal production
- GHG reduction Options
  - VAM emissions mitigation and capture/management
  - Maximising Pre drainage and capture
  - Post drainage options

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VAM emissions capture and Management

- 80-85% of the UG mine GHG emissions are from VAM.
- VAM Issues
  - Low % of CH_4 – a challenge for utilisation and mitigation
  - Mitigation not techno economically feasible with < 0.3% of CH_4
  - Power generation possible with >0.8% of CH_4
- Options: Bring the VAM to a feasible % to mitigate or utilise
  - Modifying the mine ventilation layouts and mitigating the part vent system with high % of CH_4
  - Bleeder Ventilation in LW panels and goaf areas
  - Gas drainage from adjoining goaf areas into VAM stream

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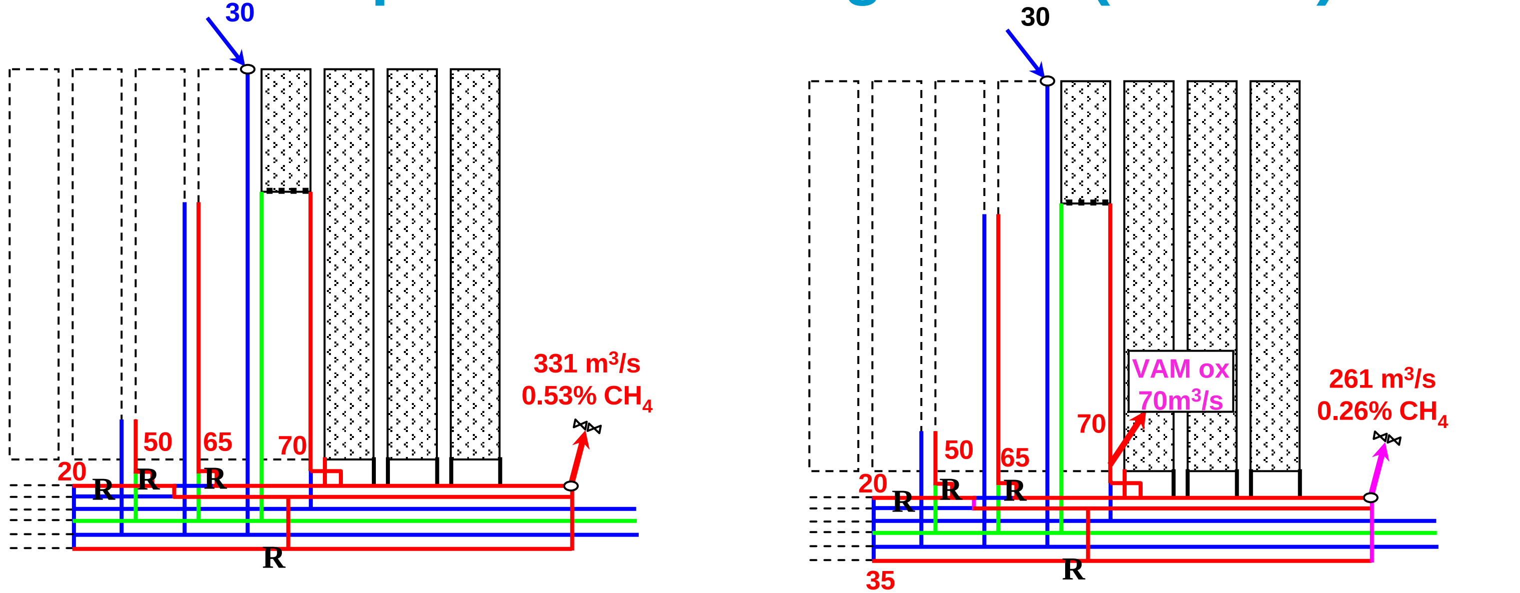
VAM emissions capture and Management (cont. 2)



Targeting LW return/bleeder for VAM mitigation optimisation

- **LW airflow is about 30% of mine ventilation, but have 70% of the VAM gas.**
- **Total VAM (330 m^3/s~ 0.8 Mt CO_2-e@ 0.53% CH_4) mitigation – may or may not be feasible**
- **Mitigation of only 70 m^3/s with high CH_4 (~ 1.5%) LW return air**
  - Reduces total VAM emissions by half
  - May be a cost-effective option

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Gas drainage and Gas Capture maximisation

- Present Gas drained ~ 20 m3/s of CH_4
  - 10-12 m3/s pre-drainage done on safety issues
  - 8-11 m3/s of Goaf drainage for gas control in LW goaf
- Gas drainage done by
  - SIS and UGIS holes using MRD technology in working seams for Pre drainage
  - Surface to goaf and UG cross measure holes for Goaf drainage
- About 12 to 14 mines do gas drainage of either forms mostly for gas control and out burst control during normal mining operations.
- Most of the drainage is carried out only in the working coal seam.

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Options for Improved gas drainage (maximise capture)

1. Introduce pre-drainage to capture gas in mines which otherwise have no safety issues on gas management
2. Advanced SIS holes for drainage of gas from coal seams and strata above the working seam years ahead of actual mining.
3. Extensive CBM operations ahead of mining where ever feasible
4. Improve gas drainage efficiency using hydro fraccing techniques
5. Advanced gas capture techniques like two heading circuit with twin intakes and dedicated gas drainage road way in the base rock of the coal seam.

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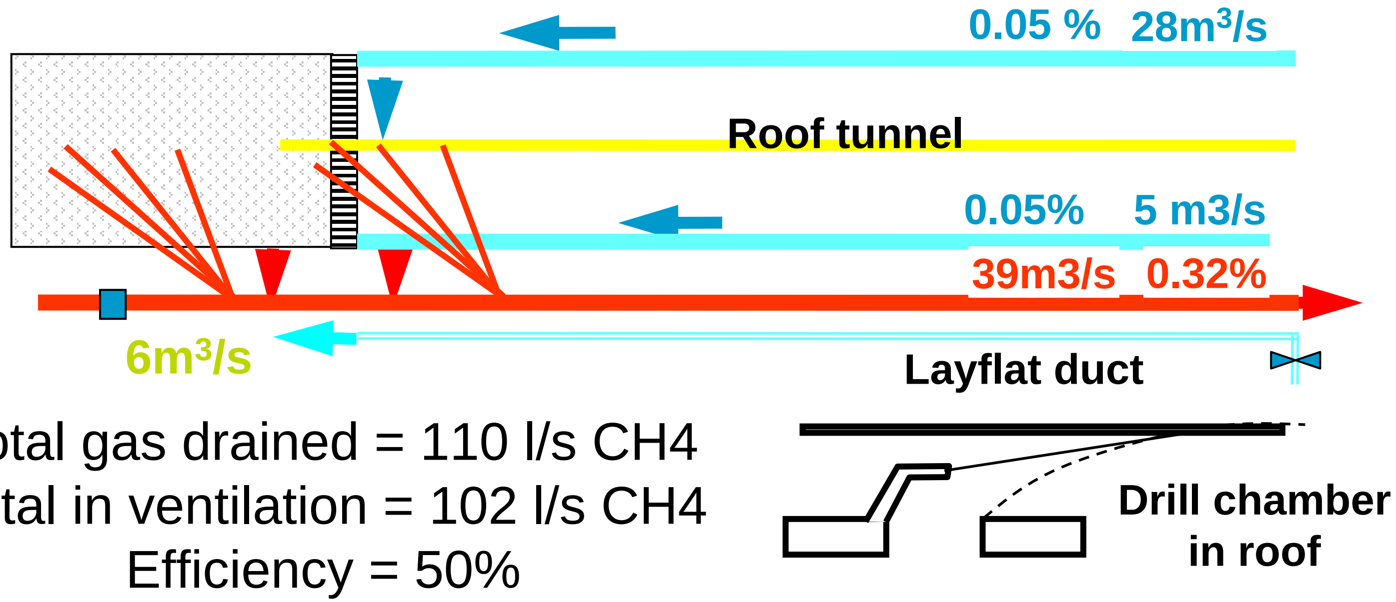
Gas capture – UG goaf drainage in China & UK



- Two heading circuit with twin intakes
- Gas drainage focus on near face active zone (in front and close behind)
- Note: Capture efficiency of 50% achieved even at low flow rates
- Purity is an issue – some times < 30% CH_4

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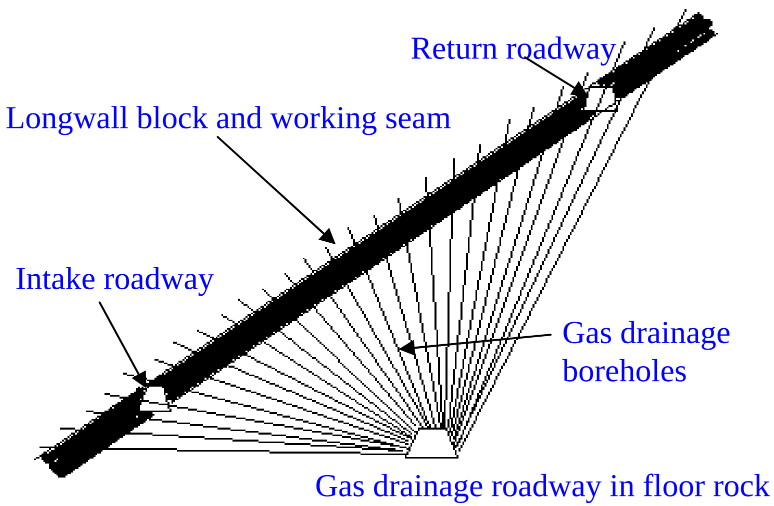
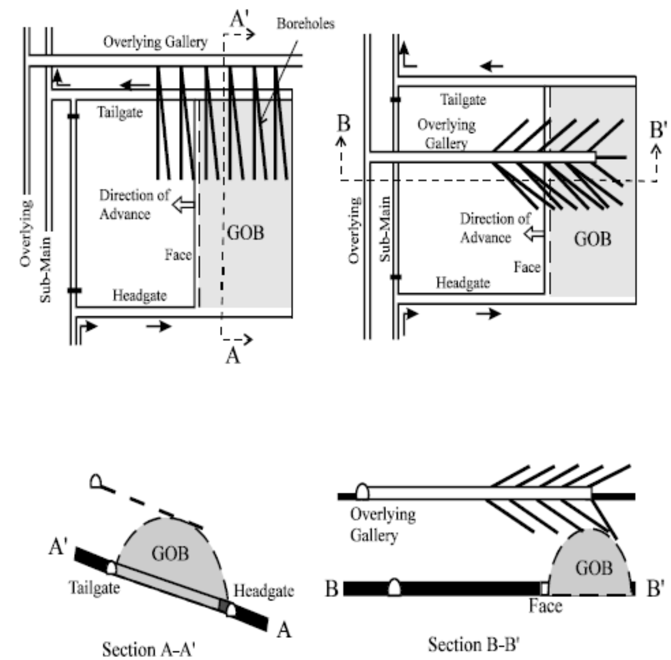
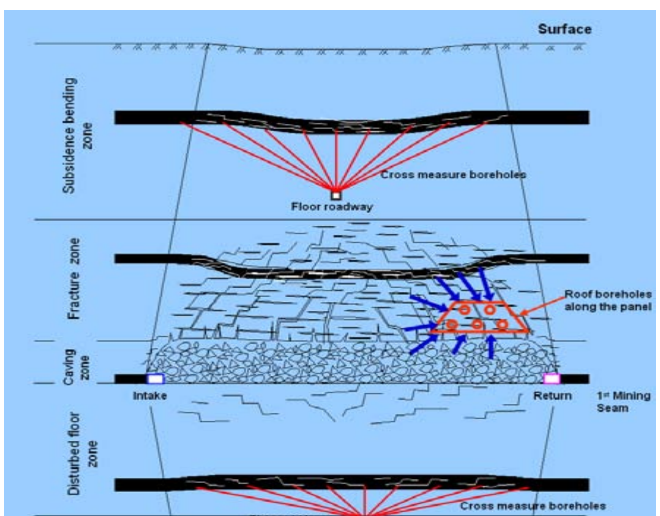
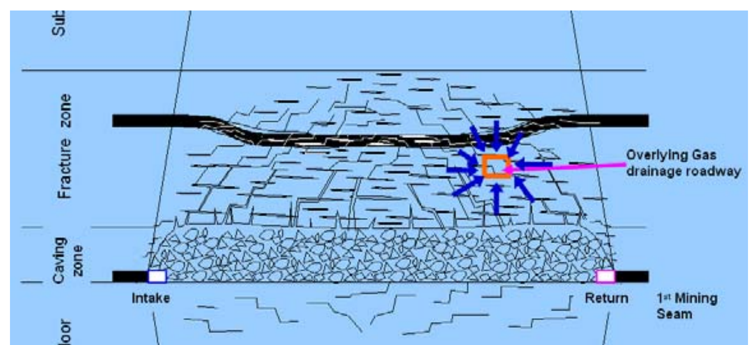
Gas capture – Unconventional Hole Patterns









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Post Drainage options

- Goaf gas drainage to be increased from 40% to 80%
- Implement Goaf gas drainage strategies from both surface and underground.
- Deep Goaf gas drainage strategies to be implemented.
- Design changes in mine ventilation to maximise gas capture from goaf.
- Post drainage gas capture also reduces the decommissioned mine emissions which are likely to be measured and charged in the near future.

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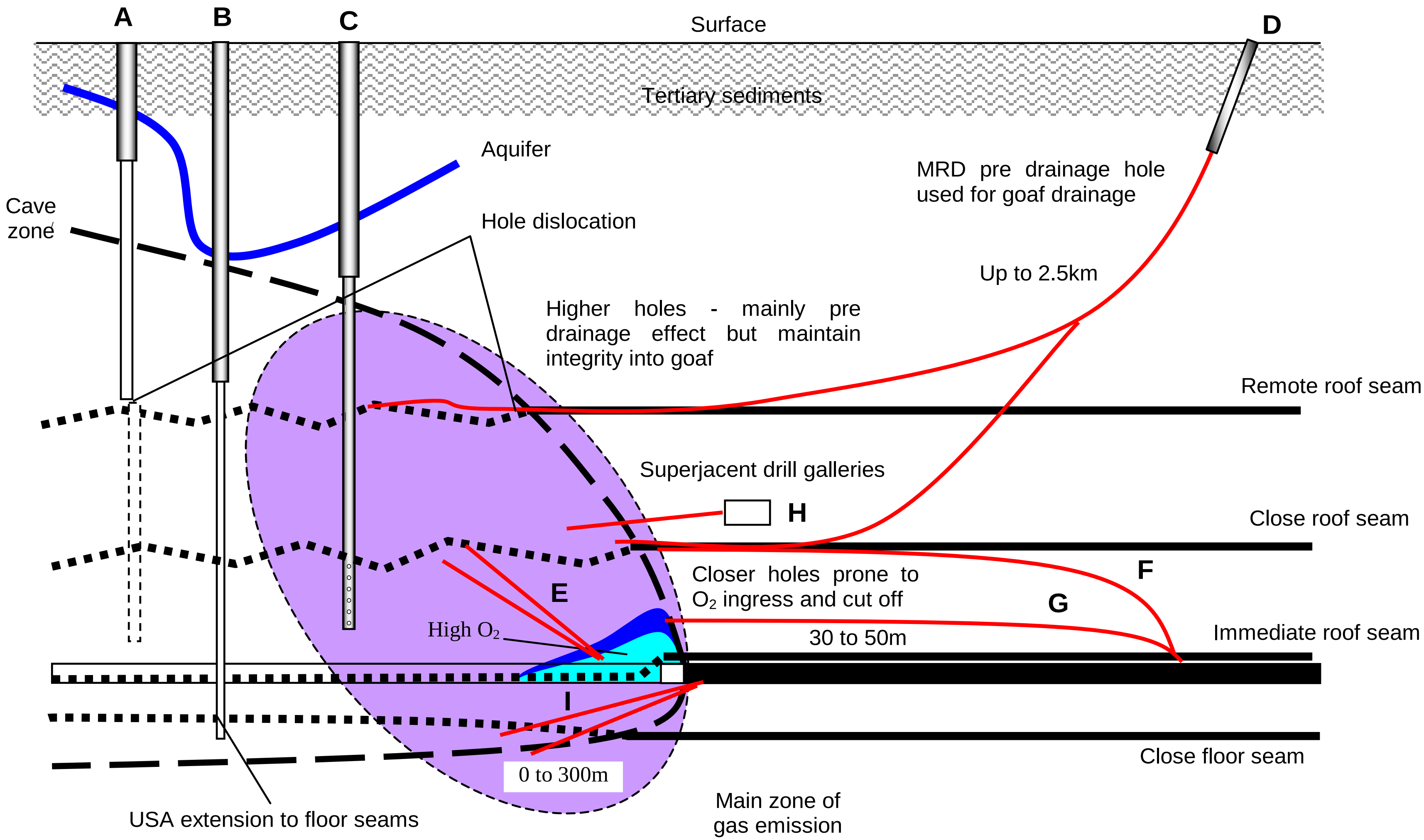
Gas capture – Alternative Post Drainage Strategies



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Decision making criteria

- Doing nothing - costs $ M/year
- Operational and economical rational for decisions
- Availability of Technical solutions with respect to carbon charge
- Whether to introduce pre-drainage
  - Where mines are in compliance using ventilation alone
  - In upper seams and strata
- Additional gas drainage/ increasing the intensity
- Optimum balance between pre-drainage, post drainage, VAM mitigation – at current and future production rates

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Decision Making Criteria–Potential Strategies

- Mines could be classified as
  - Very low gas emission mines (GRS < 30 m3/m2, WS gas < 3 m3/t)
  - Low gas emission mines (30 < GRS < 50 m3/m2, 3 < WS < 5 m3/t)
  - Medium gas emission mines (50 < GRS < 80 m3/m2, WS < 7 m3/t)
  - High gas emission mines (80 < GRS < 110 m3/m2, WS > outburst)
  - Very high gas emission mines (GRS > 110 m3/m2, WS > outburst)
- Strategies could be a combination of the following
  - Pre drainage with or without simulation in working seams and seams above
  - VAM mitigation with or without split ventilation
  - Goaf drainage of active and sealed areas
  - Additional gas capture

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GHG friendly mine – Ideal scenario

- All sources of gas emissions are accounted for monitored utilised or mitigated (VAM).
- Mine design/layout/vent/schedule – allows max gas capture and minimise VAM component
- Gas drainage – not just for gas control, but for gas capture
- Introducing pre-drainage in all feasible coal seams 3 to 10 years ahead (or CBM ahead of mining) and also when not otherwise required.
- Introducing alternative strategies to increase gas capture.
- Goaf gas capture – even at low flow rates with low CH4 and introduce active/sealed/deep goaf drainage when not required.

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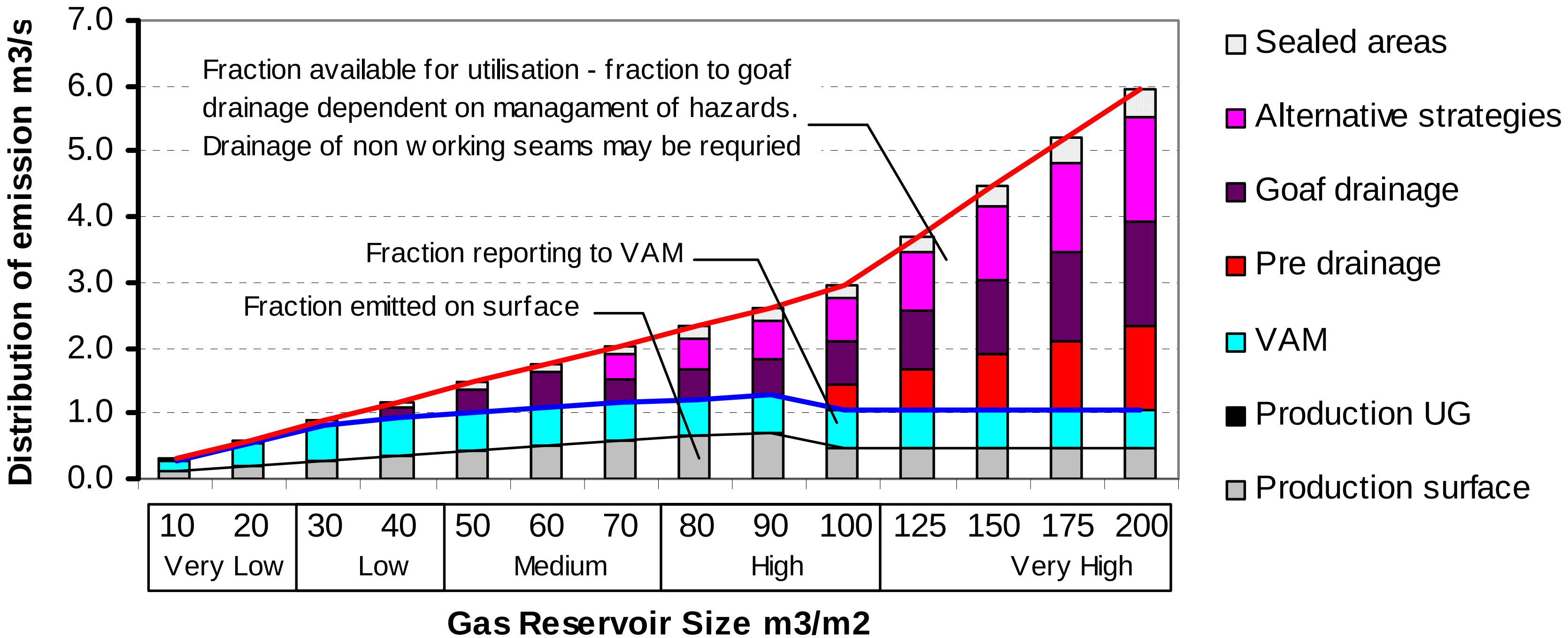
GHG friendly mine – Ideal scenario (cont. 2)



LW gas emissions in m³/s at 3.0Mtpy coal production

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Challenges

- Possible increase in gas emissions with coal production.
- Mines getting deeper – more gas (and may be less permeability)
- Goaf gas drainage – surface restrictions (Environ. issues)
- Multiple seam mining – goaf drainage complications
- Thick seam extractions – LTCC – may be more VAM or post mining emissions – unless entire thick seam is pre-drained
- Sponcom issues may restrict goaf drainage
- Remote mines and less CMM demand in Australia – issue for gas capture maximisation
- Safety issues – to capture CH4 at less than 30%

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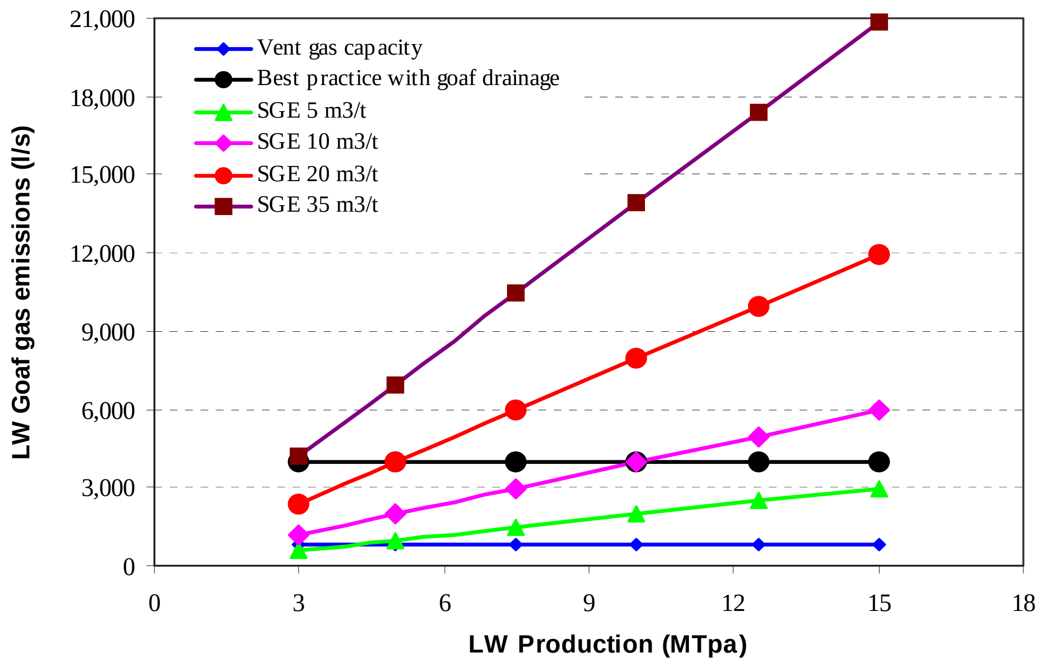
Strategies to Reduce GHG Emissions from Coal Mines

Challenges

- Possible increase in gas emissions with coal production



- Current CMM capture (both pre-drainage & goaf drainage) from all coal mines (around 12 to 14 mines) ~ 20 m^3/s = 20,000 l/s only

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Future requirements

- Accurate gas reservoir characterisation with the effect of mining on gas in upper seams.
- Accurate measurement of air quantities in exhaust shafts and actual fugitive emissions.
- ‘Gas Capture Maximisation’ technologies and strategies
  - Hydrofracturing to improve pre-drainage efficiency
  - Enhancement of pre-drainage through inert gas injection
  - Mine design/vent changes – for increased gas capture
  - Gas capture in low to medium gassy mines.
- Strategies to significantly improve goaf gas drainage
- VAM mitigation technologies development
- Ventilation design changes and split vent systems for optimum/economical VAM mitigation and reduce VAM component of total mine CMM.
- Determination of retained gas content-important for OC mines and post mining GHG estimations.

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Conclusions

- Impact on coal mines is large
- VAM mitigation – both technical and economical issues
- Current gas drainage practice – for Outburst control and LW panel gas control only (at minimum required levels)
- Increasing gas drainage to reduce total VAM emissions
- Need to introduce “Gas Capture Maximisation”, through
  - Increased intensity/innovative gas drainage strategies, and
  - Development of alternative technologies and optimum strategies
- A fundamental shift in the approach to reduce coal mining fugitive emissions is required

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Thank you