European University Institute

ROBERT SCHUMAN CENTRE FOR ADVANCED STUDIES

Issue 2021/06
February 2021

POLICY BRIEF

FSR ENERGY
Florence School of Regulation

Methane Emissions From the Coal Sector During Coal Phase-Out

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Highlights

- Methane emissions from coal mining activities remain an important issue in decreasing GHG emissions.
- There is much uncertainty about methane emission quantification from the coal sector, particularly from abandoned mines.
- A robust MRV standard for methane emissions from the energy sector should also cover emissions from the coal sector.
- The capture and utilization of coal mine methane (CMM) and abandoned mine methane (AMM) offers substantial environmental and social benefits and should be promoted using the Just Transition Mechanism.

1. Introduction

In 2019, the EU produced 373 Mt and imported roughly 175 Mt of coal[1]. The majority of Member States (MSs) have already committed to a coal phase out – Greece (by 2028), Spain (by 2030), Germany (by 2038). Recently, the Polish government and trade union representatives reached an agreement to phase out coal mining by 2049. A coal phase out is also under consideration in the Czech Republic and Slovakia[2].

However, there are two important challenges for a coal phase out. First, when we talk about the transition away from coal, we usually imply thermal or steam coal used for electricity generation. The consumption of coking coal used in the steel and iron industry is expected to remain stable in the EU, at least until low or zero-carbon steelmaking technologies mature. The EU included coking coal on its list of critical raw materials[3]. Second, abandoned coalmines continue to leak methane after their closure, often for decades.

Globally, coal mining and handling accounts for 11% of methane emissions from anthropogenic sources[4]. In the EU, the coal sector accounts for 0.7% of total GHG emissions, but it is the second most important source of fugitive emissions in the energy sector and is responsible for 35% of emissions[5]. However, those emissions may be significantly underestimated. The data analytics company Kayrros revealed that, observed from space, the only methane hotspots over the EU are the coal regions of Central and Eastern Europe.

This Policy Brief addresses the following questions: What is the level of uncertainty around methane estimates from coal mining? How can we create incentives for coalmines to reduce methane emissions, while the share of coal in the EU energy mix continues to decrease? What could be the role for the Just Transition Mechanism and the Initiative for Coal Regions in Transition?

This Policy Brief is structured as follows: Section 2 looks at the GHG inventories and the key drivers of uncertainty; Section 3 focuses on particular challenges related to methane capture and utilization as well as available policy incentives; Section 4 concludes with a list of policy recommendations linking the existing EU initiatives with new ones.

2. Methane Emissions From Coal Mining: the Key Drivers of Uncertainty

Coal mining is one of the main sources of man-made methane emissions, accounting for some 33% of total fossil-fuel related emissions (42 Mt)[6]. Coal mining emissions constitute half of methane emissions from oil and natural gas (80 Mt). But there is a much greater uncertainty range for many countries: 29-61 Mt compared to 68-92 Mt range for oil and

1. IEA, Coal 2020. Analysis and forecast to 2025. Paris, 2020. Please note that IEA data on coal imports are available for Europe only, the figures concerning coal production are disaggregated between Europe and the EU.

2. Sikow-Magny, C.: 'Current outlook of the Coal Regions in Transition Initiative' presented at Just Transition Platform Meeting – Coal Regions in Transition Virtual Week, 16-19/11/2020.

3. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability. COM/2020/474 final, Brussels, 3.9.2020.

4. Saunois, M. et al.: The Global Methane Budget 2000–2017, Earth Syst. Sci. Data, 12, 1561–1623, https://doi.org/10.5194/essd-12-1561-2020, 2020.

5. Annual European Union greenhouse gas inventory 1990–2018 and inventory report 2020. Submission to the UNFCCC Secretariat, 27 May 2020, p. 73 and 352.

6. Saunois, M. et al., op. cit., p. 1572. Average over 2008-2017.

natural gas. As a result, "coal mining is the main source explaining the differences between [GHG] inventories globally"[7].

In the European Union, methane emissions from coal mining and handling accounted for 6% of total EU methane emissions in 2018[8]. Between 1990 and 2018, those emissions dropped by 70%, due to the decline in coal mining activities. This trend continues, as methane emissions decreased by 7% between 2017-2018, mostly due to reductions in Germany, the Czech Republic, Poland and Romania. Those four countries account for 90% of CH4 from the coal sector.

The above-mentioned data show that coal mining remains a considerable source of methane emissions, even in a macro region exiting from coal, like the EU. However, the point of concern is the high uncertainty range of the available estimates for methane emissions from this source. There are two main factors, which drive uncertainty: the heterogeneity of emission sources and the lack of robust emission estimates based on the direct measurements of emissions, instead of emission factors.

2.1 Heterogeneity of Emission Sources

Coal mine methane (CMM) – produced during the coal formation (coalification) and locked in coal seams – is released during mining activities[9]. When the coal seam is fractured, methane escapes into the mine works and eventually into the atmosphere. The amount of methane released during mining depends on many factors, but the most important are: coal rank (brown coal emits more than hard coal); coal seam depth (deeper coal seams are gassier than shallow seams); and the mining method (underground mining leads to higher emissions than surface mining)[10]. Yet, the emissions arise at various stages: exploration, mining, post-mining (handling, processing, coal transport), and also from abandoned or decommissioned mines[11].

Therefore, we can usefully distinguish three main sources of methane emissions: active underground mines; active surface mines; and abandoned mines[12]. In the case of underground mines, most emissions are released into the atmosphere through ventilation and degasification systems. These practices allow for the removal of methane and thus the protection of the miners in terms both of general health and workplace safety. Ventilation enables a constant flow of air into mine workings and the dilution and removal of harmful gases such as methane. Degasification requires bore holes to be drilled from the surface or horizontally into the coal seam or surrounding strata: it can be carried out before, during or after mining. Due to lower gas content, smaller quantities

7. Ibid.

8. Annual EU GHG inventory, op. cit., p. 372.

9. We can distinguish coal mine methane (CMM) released alongside coal mining activities and abandoned mine methane (AMM) released after coal production ceases and the mine is decommissioned or abandoned.

10. IPCC (2002) Background Papers IPCC Expert Meetings on Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. CH4 Emissions: Coal Mining and Handling, pp.129-144.

11. 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Chapter 4: Fugitive emissions.

12. Please note that the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories includes 'Exploration' among the key sources, yet the Tier 1 emission factors to estimate emissions from this source have not yet been developed due to a lack of scientific evidence.

of methane are released by active surface mines, e.g. from newly exposed coal faces and surfaces[13].

The emissions released from ventilation and degasification systems are usually measured with the use of handheld methane detectors and flowmeters at the base of the ventilation air shaft in the mine. There are also continuous monitoring devices that warn when there are high methane concentrations[14]. In the last few years, unmanned aerial vehicles (e.g. drones), aircraft and satellite imagery have been used more frequently in the coal sector, for both underground and surface mines. They have various applications. Above all they are used for monitoring and inspection (e.g. coal fires monitoring, stockpile management). But they can also be used to detect and quantify methane emissions, not least from abandoned mines, which will be an increasingly significant source of emissions[15].

Once mining ceases, coal mines are usually sealed and abandoned. Following an initial decline, abandoned mine methane (AMM) is released at a near-steady rate for decades[16]. The seals slow the initial rate of emissions, but do not prevent methane emissions over time. If a mine is flooded, methane leakage stops within fewer than ten years. Due to ownership issues, measurement problems (e.g. access, the extent of mine flooding…), the creation of an AMM inventory has proved very challenging.

Kholod et al. (2020) estimated the AMM to be roughly one fifth of coal mine methane emissions (22 bcm compared to 103 bcm of CMM)[17]. The study predicts that by 2100 methane emissions from abandoned mines will increase two times faster than from active underground mines and its share in total methane from coal mining will increase from 17% in 2010 to 27% in 2100.

This findings could be particularly relevant in an EU context. The EU mining industry is subject to the Environmental Liability Directive based on the "polluter pays" principle. The Directive has been in force since 2004 and was progressively implemented in all MSs. "In the past, under less stringent regulations, mines were often abandoned without being adequately reclaimed"[18].

2.2 National GHG Inventories – Methodological Issues

The IPCC guidelines suggest two general approaches to estimating methane emissions from coal mining[19]. The first (the Tier 1 and the Tier 2 methods) builds upon activity data (usually coal production) and

13. Karacan, C. & Ruiz, Felicia & Cotè, Michael & Phipps, Sally. (2011). Coal mine methane: A review of capture and utilization practices with benefits to mining safety and to greenhouse gas reduction. International Journal of Coal Geology - INT J COAL GEOL. 86. 121-156. 10.1016/j.coal.2011.02.009.

14. National Academies of Sciences, Engineering, and Medicine 2018. Improving Characterization of Anthropogenic Methane Emissions in the United States. Washington, DC: The National Academies Press. P. 110.

15. Ren, H. et al., A review of UAV monitoring in mining areas: current status and future perspectives. Int J Coal Sci Technol 6, 320–333 (2019). Fiehn, A. et al. Estimating CH4, CO2and CO emissions from coal mining and industrial activities in the Upper Silesian Coal Basin using an aircraft-based mass balance approach. Atmos. Chem. Phys., 20, 12675–12695, 2020. Varon, D. J. et al., Quantifying Time-Averaged Methane Emissions from Individual Coal Mine Vents with GHGSat-D Satellite Observations. Environmental Science & Technology 2020 54 (16), 10246-10253.

16. Kholod, N. et al., Global methane emissions from coal mining to continue growing even with declining coal production. Journal of Cleaner Production. Volume 256, 20 May 2020, 120489.

17. Ibid., p. 9.

18. Alves Dias, P. et al., EU coal regions: opportunities and challenges ahead, Publications Office of the European Union, Luxembourg, 2018, p.94.

19. 2019 Refinement to the 2006 IPCC Guidelines, op. cit.

Method	Source	Uncertainty	References
Tier 1	Mining emissions	Factor of 2 greater or smaller	Expert judgment (GPG, 2000)
	Post-mining emissions	Factor of 3 greater or smaller	Expert judgment (GPG, 2000)
Tier 2	Mining emissions	± 50-75%	Expert judgment (GPG, 2000)
	Post-mining emissions	± 50	Expert judgment (GPG, 2000)
Tier 3	Drainage gas – spot measurements of CH4	±2%	Expert judgment (GPG, 2000)
	Drainage gas – degasification flows	±5%	Expert judgment (GPG, 2000)
	Ventilation gas – continuous or daily measurements	±5%	Expert judgment (GPG, 2000)
	Ventilation gas – spot measurements every 2 weeks	±10%	Mutmansky and Wang, 2000
	Ventilation gas – spot measurements every 3 months	±30%	Mutmansky and Wang, 2000

Estimates of uncertainty for underground mining for Tier 1 and Tier 2 (emission factors) and Tier 3 approaches. Source: IPCC (2019).

emission factors. The second approach, the Tier 3 method, requires mine-specific measurements (e.g. from ventilation and degasification systems in the case of underground mines) to develop national estimates. Unlike T1, T2 involves the use of country- or basin-specific emission factors.

Since the uncertainty with activity data is rather low, the point of concern is the uncertainty of emission factors. Methane emission sources are highly heterogenous and there may be significant differences between coal basins and coal beds, as well as between individual coal beds[20]. Therefore, the global or regional emission factors may prove inaccurate when applied to individual mines. Moreover, the accuracy of the T3 approach may also depend on the frequency of measurements and measurement accuracy: calibration, operator experience etc.

The IPCC guidelines invite countries with higher emissions from coal mining to use a more stringent methodological approach. We have looked at the approaches used by MSs and gathered in the EU GHG Inventory. The first thing we noted were the substantial but unexplained differences between the information provided in Annex III and the Table 3.113 in the EU GHG Inventory[21]. Looking at a more-detailed Annex III – for underground mines – Poland and Germany (responsible for, respectively, 62% and 6% of emissions to this source) use, in the case of Poland, a Tier 3 method and, in the case of Germany, a combination of Tier 3 and Tier 2 methods[22]; the Czech Republic uses Tier 2; and Romania Tier 1. In the case of surface mines, both the Czech Republic and Poland, responsible, note, for over 50% of EU emissions from this category,

20. Strąpoć, D. et al., Methane-Producing Microbial Community in a Coal Bed of the Illinois Basin. Applied and Environmental Microbiology Apr 2008, 74 (8) 2424-2432; DOI: 10.1128/AEM.02341-07.

21. Annex III to EU GHG Inventory. Table 3.113 on p. 354 of the main document.

22. According to Annex III, Germany uses T3 method to calculate emissions from hard coal and T2 method to calculate emissions from open-pit lignite mining. Please note that Poland uses T1 methods to estimate emissions from underground post-mining activities.

use the T1 method. The use T1 or T2 methods to estimate emissions from abandoned mines prevails. As a result, EU emissions from the coal sector may be significantly underestimated. Despite highly inaccurate estimates, the experience of some MSs shows that the capture and utilization of CMM and AMM is possible, if challenging.

3. Challenges for Methane Emissions From Coal Mining and Current Initiatives

Over the last few years, methane emissions have been one of the key facets of the debate on the benefits of coal-to-gas switching in power generation. At first sight, it may seem that coal sector emissions are relatively easy to abate, as the sources of emissions are much more concentrated. Yet, the coal industry is less active in addressing methane emissions compared with the oil and gas industry. There is no industry-led initiatives resembling the CEO-led Oil and Gas Climate Initiative (OGCI) or GIE/Marcogaz.

The World Coal Association did not react to the EU Methane Strategy, while the EUROCOAL issued a short and, at times, contradictory press release[23]. It should be noted that in response to the recent round of public consultations, EUROCOAL reiterated its willingness to work towards the creation of robust MRV standards (no mention of OGMP 2.0), a Tier 3 reporting framework and the establishment of an International Methane Emissions Observatory (IMEO)[24].

The low awareness of the environmental impact of emitted methane could be explained by the fact that methane is primarily viewed as a safety issue. Moreover, the current coal emission estimates are subject to a high uncertainty range, with, as we explained in Section 2, persistent and significant gaps in the research on abandoned mine methane and high-emitting (or super-emitters) sources[25]. Additionally, the deployment of emerging technologies to capture and utilize CMM is rather low.

The low deployment of new technologies has to do with the fact that the economics of methane capture and use in the coal sector is less convincing than in the oil and gas sector. Although it is technically possible to mitigate CMM emissions from active underground mines by implementing methane drainage systems, combined with recovery and use projects, the quality of the recovered gas may limit methane utilization options[26].

Only high-quality gas (95% of methane or greater) may be injected into natural gas pipelines. Medium quality gas (> 30% methane) can be used for electricity generation (either on-site or sold to the utilities); as a fuel for onsite plants (e.g. coal drying plants) and boilers; and district heating or as a feedstock (e.g. in nearby chemical plant). According to Karacan et al. (2011) power derived from ventilation air methane (VAM) is not commercially

23. Press release: EURACOAL comments on the Commission communication on an EU strategy to reduce methane emissions. Brussels, 14/10/2020. Neither of the organisations took part in the public consultations organized by the European Commission prior to the publication of the strategy.

24. EUROCOAL response to Inception Impact Assessment on a proposal for a legislative act to reduce methane emissions in the oil, gas and coal sectors. Brussels, 26/01/2021.

25. Ember found out, using data reported to the UNFCCC, that some of the Polish mines emit significantly more methane than the 23% national average. Ember, Poland's Second Bełchatów. Methane leaking from Poland's coalmines needs more urgent action. P. 6

26. Karacan et al., op. cit., p. 146.

ASPECTS	COAL SECTOR	GAS & OIL SECTOR
Is methane emissions reduction considered as a priority by the industry?	NO	YES
Major sources of uncertainties in data collection and reporting	• EFs and gas contents not accurate on mine scale • Relatively high uncertainties for abandoned underground mines and surface mines • Underground mine ventilation: lack of simultaneous measurements on the surface • Super-emitters • Completeness (emissions exploration, mining waste disposal)	• EFs not accurate • Super-emitters • Completeness (e.g. intermittent sources) • Confidential business information
Is methane capture and use economic?	Yes, but to a very limited degree. Highly dependent on the quality (purity) of recovered gas + natural gas/electricity prices.	Yes, around one third of emissions can be abated at no net cost or at low cost. Highly dependent on natural gas prices.
Other barriers to methane mitigation	Lack of awareness and knowledge of available technological solutions, ownership issues, market uncertainties due to climate change policies and public opposition, taxes and royalties	Lack of awareness and knowledge, competition for human resources and capital, regulatory, structural
Policy and regulatory instruments	• Clear Ownership rules • Policy incentives (e.g. feed-in-tariff and priority dispatch for electricity produced from captured CMM/AMM under German EEG) • Sharing knowledge and best practices: e.g. The International Centres of Excellence on Coal Mine Methane (ICE-CMM) in Katowice (Poland) and Shanxi Province (China).	• Prescriptive requirements • Performance-based or outcome-based requirements • Economic instruments • Information-based requirements

Authors' own elaboration based on: JRC (2015) Environmental and Sustainability Assessment of Current and Prospective Status of Coal Mine Methane Production and Use in the European Union; EPA (2019) Status of CMM Ownership and Policy Incentives in Key Countries: Considerations for Decision Makers; EPA (2019) Legal and Regulatory Status of Abandoned Mine Methane in Selected Countries: Considerations for Decision Makers; the 2019 Refinement to the 2006 IPCC Guidelines; IEA (2020) Regulatory Roadmap and Toolkit, National Academies of Sciences, Engineering, and Medicine (2018) Improving Characterization of Anthropogenic Methane Emissions in the United States.

feasible without additional incentives[27]. They also point out that, ideally, all utilization projects should be equipped with a flare in case of equipment malfunction, temporal shut-down, or during early mine development.

Moreover, there are particular legal constraints related to AMM ownership rights and gas production licensing process, which are not always straightforward. The table below summarizes the comparison of coal and gas/oil sectors in relation to methane emissions.

With all these differences in mind, there is no evidence that the coal sector requires a different approach in establishing a robust measurement, reporting and verification (MRV) framework. Moreover, EUROCOAL considers a lack of the EU-wide rules on MRV as an "omission", which should be addressed. The OGMP 2.0 reporting framework might serve as a good basis for this.

Robust methane MRV followed by CMM/AMM recovery and use may bring substantial benefits to coal regions: enhanced mine safety thanks to decreases in in-mine methane concentration; job creation and the development of transferrable skills useful in other methane-emitting sectors (hand-held methane detectors or drone operation); environmental benefits; conservation of a local source of energy; and should electricity be produced from captured gas, higher grid stability, which will be more and more important with the rising share of variable renewable energy.

4. Policy Recommendations

Phasing out coal from the energy sector must not mean less attention towards methane emissions from coalmining. Emissions leaked during the transition period and the abandoned mine methane need to be tackled. Support from the Just Transition Mechanism is justified. Due to high levels of uncertainty, as well as economic and regulatory barriers, methane recovery and use is more complex. The "polluter pays" principle is not, on its own, enough here.

The EU MRV system, using the OGMP 2.0 reporting framework as a basis, should fully apply to the coal sector, including active and abandoned mines. Voluntary programs for coalmines with individual methane capture and utilization targets would be helpful. Coalmines with higher methane capture and use rate might become eligible for additional funding via the Just Transition Fund.

The capture and use of methane from both active and abandoned coalmines ought to be promoted. It will require: local force training and reskilling; additional funding for the closure and remediation of coal mine sites; facilitated access to natural gas and power markets for recovered gas; exchange of best practices; and support for research activities.

More effort is needed to share best practices and to support research activities. To this end, the Coal Methane Partnership should be established. The Partnership should promote methane reduction both in the EU and globally, currently one of the priorities of EU climate and energy diplomacy[28]. The EU's experience with a just transition, coalmine phase-out, and methane emission reduction could be promoted in other countries facing similar challenges.

27. Ibid.

28. Council conclusions on Climate and Energy Diplomacy -Delivering on the external dimension of the European Green Deal. Brussels, 25/01/2021.

QM-AX-21-006-EN-N

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With the support of the
Erasmus+ Programme
of the European Union

doi:10.2870/551463
ISBN:978-92-9084-961-2
ISSN:2467-4540