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Coal in the twenty-fist century; Meeting Sustainable Development Goals and Managing Investor Expectations

Note by the Secretariat

I. Introduction

1. Key terms:

(a) This document uses the term "coal-as-fuel" to distinguish it as a single product. Coal producers offer it to the electric power and industrial sectors. The term "coal-as-fuel" differentiates it from a more diversified mix of uses of coal, where use of coal-as-fuel is excluded;

(b) The term "multi-resource platform" is used as a category. It includes uses of coal as raw material input for downstream products. For example, as precursors for advanced and critical materials, or as a land, previously used for mining, which may offer attractive renewable energy opportunities or other sources of value;

(c) Renewable energy is, for this document, a category including solar, wind, green hydrogen, and geothermal resources, used to produce electricity and/or heat. Any organic or engineered resources not emitting greenhouse gases (GHGs), e.g., microalgae, are included in this category;

(d) The term "Coal Mining Enterprise" (CME) is used as a category definition. It includes coal mining companies (small to large), either public (government-owned) or private (investor-owned). CMEs may be involved directly or indirectly along a general supply chain. A general coal supply chain begins with coal extraction that may have been preceded with years of exploration and mine design work. It ends with delivery to users of coal-as-fuel, or downstream derived products;

(e) The term "coal transitions" is a rubric that covers coal phaseouts, as well as initiatives that revise, repurpose, or reinvent the use and investment values of coal lands and assets.

2. The United Nations Economic Commission for Europe (ECE) is pursuing energy sector decarbonization, applying the principles of carbon neutrality and transition justice.

3. There is a longstanding goal to phaseout the use of coal-as-fuel. Significant progress has occurred, especially over the last 15 years. However, the ongoing war in Ukraine has disrupted natural gas supplies to the European Union (EU). It has caused some of its member States to return to coal-as-fuel for electricity and industrial production. While for other reasons, India, China and other nations in Asia in recent years are also increasing its use for energy generation.

4. These circumstances are anomalies against a longstanding downward trend in the use of coal-as-fuel. Nevertheless, key questions are provoked by seeming trend reversals. For example, will present circumstances reinstate coal as a critical energy resource for decades to come? If the present circumstance is a temporary disruption in a longstanding trend how long will this disruption persist? Can established national phaseout policies and practices remain effective, or are such policies and practices sufficiently tarnished that new models may be necessary, if coal phaseout progress is to continue?

5. Innovations supporting phaseouts of coal-as-fuel can create new value using coal assets as non-carbon-emitting resources. Doing so may preserve global coal industry investor value and create new sources of value, which can support the aims of transition justice for local coal communities, regions, and nations.

II. Scope and purpose

6. The goal of this document is to enhance the dialogue on non-zero-sum coal phaseouts. A dialogue that enables continued, if not accelerated, phaseouts of coal-as-fuel, which simultaneously achieve indelible transition justice, as well.

7. Valid transition justice must include all relevant stakeholders. Preserving and creating new wealth for all of them is foundational. Coal transition justice for impacted coal communities and economic regions requires, among other things, supporting coal mining enterprise (CME) transformations in business models. This applies to all enterprise scales — from local to global entities.

III. Actors involved

8. The Secretariat provided guidance and assistance in developing this document. Mr. David Jermain, a Senior Fellow of the Boston University (BU) Institute for Global Sustainability, Mr. Raymond Pilcher, Chair of the Group of Experts on Coal Mine Methane and Just Transition (CMMJT), Dr. Z. Justin Ren, an Associate Professor of the Questrom School of Business of Boston University, Mr. Eugene J. Berardi, a graduate of the MBA program of the Questrom School, are primary authors of this document. Additionally, the Director of IGS, Professor Benjamin Sovacool provided perspective and guidance to BU actors contributing to this work.

IV. Methodology

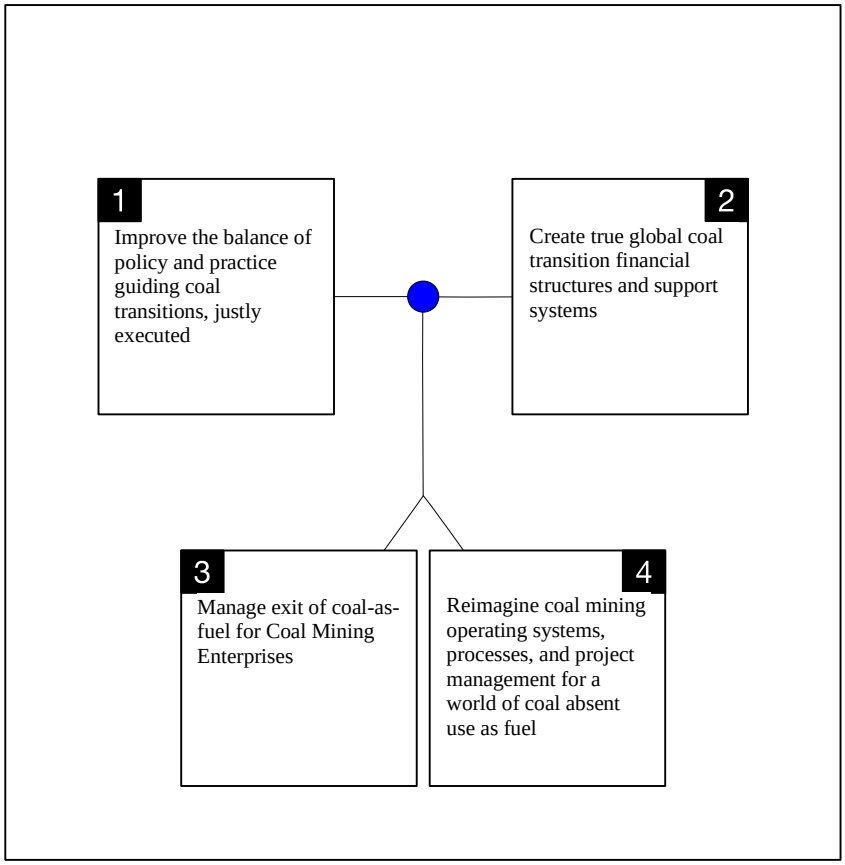
9. The case presented in this document is based on extensive review of deep and diverse academic, commercial, and trade literatures. Key actors involved have meaningful lived experience in the coal industry, spanning four decades. Lived experience and literature reviews were informed by the ongoing work of the CMMJT, the SED, and a new Taskforce on Just Transitions (TJT) operating within the CMMJT. The deep experiences of CMMJT members and participants over many years contributed to this document.

V. Innovative coal phaseout pathways

A. General framework

10. Four interdependent strands, managed together, open new pathways for coal phaseouts and transition justice to continue at a meaningful pace. Figure I depicts these four strands. Discussion follows.

Figure I
Four Intertwined Strands of Just Coal Transitions



11. The first strand focuses on improving the balance of policy and practice in coal transitions. Policy must be more actionable. Practice is only as effective as the policy framework in which it is executed.

12. The second strand concerns creating true global coal transition financial structures and support systems. New institutions are needed to pool resources and diversify risks. Thereby, all stakeholders in coal transitions can achieve meaningful desired outcomes.

13. The third strand aims to enable CMEs to exit coal-as-fuel with minimal-to-no losses in enterprise values. Supporting development of a multi-resource platform business model offers a potential net positive substitute for selling coal-as-fuel. The platform design focuses on multiple revenue streams to offset for lost value from exiting coal-as-fuel.

14. The fourth strand focuses on modifying core coal mining operations planning systems, processes, and project management. Revisions in core planning modalities are key to maximizing potential value at mine sites.

15. Each of these strands is discussed below. Thereupon, managing them as an integrated approach is discussed.

B. First strand: improved integration of policy and practice

16. The practice of coal transitions is becoming more challenging as progress is made. Effective results are difficult to validate. Successes and failures across cases tend to be inefficiently shared, if shared at all.

17. Creating tools that enhance learning from actual cases can improve the alignment of policy (intention) and the practice (effectiveness of execution) of coal transitions, justly achieved. Here are examples of learning from coal transition cases:

(a) Incentives and financial engineering are important determinants of successful coal phaseout execution. Incentives must support coal community transitions, e.g., preserving jobs or creating new jobs of equal or greater value. What is often overlooked, however, is the importance of providing incentives to CMEs that reward coal phaseouts, e.g., stranded asset cost recovery, or reinvestment benefits for shifting coal lands into other uses, such as renewable energy production;

(b) Intermediaries help facilitate productive interactions and exchanges amongst impacted stakeholders in coal phaseout cases. Skilled intermediaries anticipate issues and help resolve conflicts. They help find solutions that benefit parties impacted by issues or other sources of conflict. They serve to ensure appropriate transparency within and amongst stakeholder groups. All too often, the role of intermediaries as core supporting actors is overlooked;

(c) Culture matters more than politics. It shapes how individuals and groups interpret both words and behaviours of stakeholders. Misunderstanding culture increases the likelihood of overlooking critical sensitivities. Often this undermines trust in processes involved in executing a transition that is just;

(d) Build and keep updated maps of key factors involved in a coal phaseout. Understand how relationships and the stakes involved in phaseouts influence perceptions and behaviours. Do so before designing specific transition plans;

(e) Focus on miners and plant workers. They are key bellwethers of how coal phaseouts and related transitions are proceeding. They are primary recipients of coal phaseout impacts, both positive and negative. Keep the ratio of benefits and costs front and centre as a specific coal phaseout occurs. Doing so improves the likelihood of outcomes that are just for all.

18. For a more comprehensive discussion of integrating policy and practice in coal phaseouts and transitions see the following article in The Electricity Journal — “Coal in the 21st Century: Integrating Policy and Practice.”[1]

C. Second strand: coal transition financial structures

19. The UN 2030 Agenda for Sustainable Development has seventeen sustainable development goals (SDGs). The sum of the goals is about improving environments and communities. And for communities, goals focus on improving living and working conditions. SDG 7 concerns provisioning clean and affordable energy and technology.

20. Phasing out of coal-as-fuel is a global endeavour, promoted and facilitated, in part, by the United Nations. The UN has deep experience in processes and tools that help enable SDG realization.

21. The challenge of coal phaseouts at scale may exceed the capacity of the UN. Its value as an orchestrator may not be suited for organizing the financial instruments needed to achieve complete transitions, justly executed.

[1] David O. Jermain, Z. Justin Ren, Scott B. Foster, Raymond C. Pilcher, Eugene J. Berardi, “Coal in the 21st Century: Integrating Policy and Practice,” The Electricity Journal, Volume 35, Issue 10, December 2022; available at https://doi.org/10.1016/j.tej.2022.107220

22. The UN can facilitate the formation of financial institutions tailored to ensuring coal transition justice. It's reach and depth stem, in part, from the structuring of regional entities like ECE. Old models for financing infrastructure may be the source of global innovations needed to achieve new modes of financing coal transitions. Regional entities may be an ideal initial scale for crafting, testing, and proving the value of new modes of financing.

23. Trust structures, while long established, have not been used at scale to facilitate coal transitions. They can provide sources of funding and governance systems, which can shape coal transition processes and desired outcomes. Trust structures can be equally effective if used to electrify communities with little or no access to electricity — another UN priority.

24. A Trust providing a globalized "social security" solution can strengthen coal transitions. A Trust[2] that speeds the deployment of electricity to areas with little or no access uses an early 20th century model. Electric utilities came into existence using a "virtuous circle" transaction through which investment in communities and their economic development grew electricity sales. A virtuous circle approach to coal transitions binds together CMEs and coal communities in efforts to create new value beneficial to both.

25. Trust structures offer pragmatic ways to help decarbonize the world. That is, they may be applicable in other economic sectors.

26. For a more comprehensive outline of how Trust structures can drive global coal phaseouts and clean electrification phase-ins see the following article in The Electricity Journal — "Trusting clean energy: novel perspectives on transition pathways for coal phaseouts and clean electrification phase-ins."[3]

D. Third strand: managing investor priorities

27. Coal phaseouts are about closing coal mines and facilities that use coal-as-fuel. Often, the financial consequences of such closures for investors are underemphasized. The same is true when it comes to impacted coal communities.

28. Investors in coal have multiple choices. One choice is to, hold onto coal assets and bet that longstanding boom/bust cyclicality is worth it. This may involve passive postures that focus on maximizing cash flows; or it may involve active resistance to block phaseout efforts by governments and various advocacy organizations; or redeploy to other investments with better risk/reward profiles. Against this optionality, coal communities often have little or no choices for adapting to cases of coal phaseouts.

29. However, coal can be a key contributor to achieving clean energy and economy futures without continuing as a fuel resource. A shift in perspective involves seeing CMEs having long-term value as a multiple resource platform. New value comes from repurposing and leveraging mining lands, recovering, and refining minor and trace elements from coal, and creating new revenue from harvesting hydrogen and carbon materials from coalbed methane, raw coal, coal tailings, and fly ash residues.

30. Not all "platform options" offer equally compelling values. Minor and trace elements may, in the near-term, have trace values. However, a forward look at economic and political factors may find trace values becoming substantial values. Accordingly, making the shift to a platform model for coal in the 21st century can enhance CME value. Also, it supports clean energy and circular economy systems while eliminating coal combustion as a GHG pariah.

31. There is a question that is generally missing from the dialogue about coal in the 21st century. Is coal being undervalued by ignoring non-fuel revenue values? Would alternate non-fuel revenue sources be lost if the phaseout of coal-as-fuel results in closed mining

[2] "Trust" written here beginning with an uppercase letter is a formal term used to reference this particular form of financial structure. A lowercase "t" trust could be interpreted as meaning "you can trust this structure."

[3] David O. Jermain, Raymond C. Pilcher, "Trusting clean energy: novel perspectives on transition pathways for coal phaseouts and clean electrification phase-ins," The Electricity Journal, Volume 36, Issue 7, August-September 2023, available at https://doi.org/10.1016/j.tej.2023.107318

operations? Are investors and local communities losing the future value of land and resources if coal transitions stop at mine closures?

32. There are three non-fuel factor structures with significant value potential for coal assets, investors, and local communities (if developed):

(a) Leveraging mining lands to develop renewable resources. Harvesting water for agricultural uses, using deep shaft mines for carbon sequestration, energy storage, and production of microalgae;

(b) Microalgae production captures CO2 and promotes soil amelioration. Also, it organically remediates toxic mine waste. It creates several distinct benefits for CMEs, local communities, and decarbonization efforts — including but not limited to new revenue for CMEs, jobs and new industry for local communities, and possibly carbon credits of one kind or another for CMEs;

(c) Refining extracted coal to produce specific products that are non-fuel and of higher value than coal sold for fuel. Examples include, but are not limited to, purified carbon powder, activated carbon, minor and trace elements — e.g., rare earth elements (REEs), cobalt, and lithium, and advanced materials such as carbon nanotubes (CNTs) and graphene. Minor and trace elements are small markets with significant upside potential. They support critical infrastructures — e.g., batteries for energy storage, steel substitution or performance enhancements, road and building materials. Also, improving computing, data storage, air and spacecraft, and more;

(d) Harvesting other valuable commodities from coalbed methane (CBM) such as hydrogen, CNTs, polymers, starches, ammonia for fertilizer, and graphene production, which may be done onsite;

(e) These three factors create new revenue streams for CMEs and new jobs and economic vitality for coal mining communities. Multi-resource uses of coal deposits and mining infrastructure aids governments in aggressive support of coal industry transformations, through which coal transition justice can be achieved. Perhaps ironically so, coal in the 21st century can be, and should be, a critical success factor in achieving clean energy and economy futures.

33. CMEs have four unique advantages in the transformation from selling coal-as-fuel to producing a diverse mix of "refined coal" products:

(a) In-place infrastructure that can be used to add processing circuits at lower cost than greenfield initiatives;

(b) Established and capable workforce that can continue to leverage existing mining capacities and learn new techniques and tools for producing refined coal products;

(c) Supportive coal mining communities that provide employee stability and a local socio-cultural milieu that supports workers and CMEs;

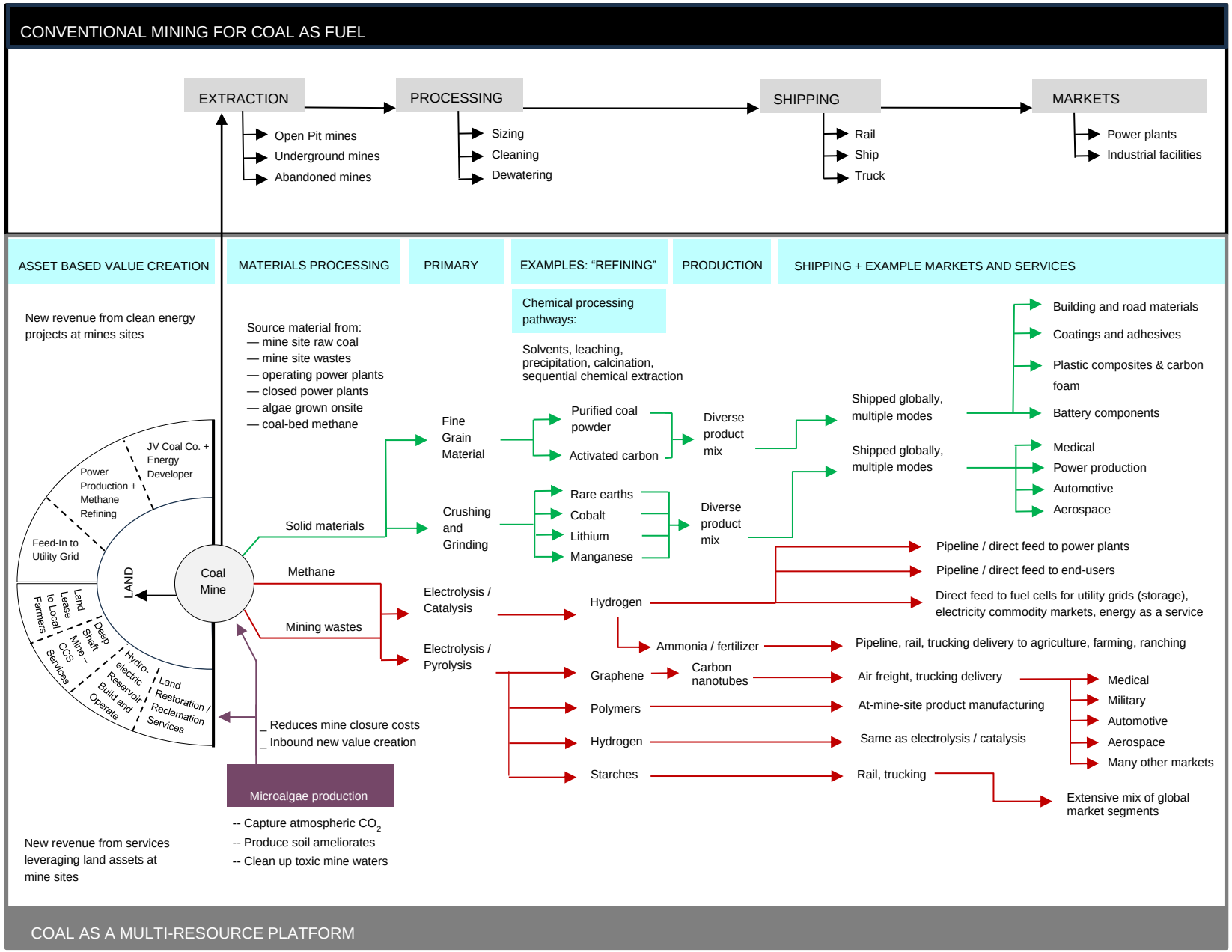
(d) The above three advantages combine to make a significant and unique first mover advantage.

34. These unique advantages position CMEs for developing emerging new markets based on "refined coal products." CMEs have time, patience, and discipline necessary to evolve with new markets. Onsite pilot projects, test beds, beta products, and test markets are key tools for methodically developing multiple new opportunities. Through such pathways, CMEs and investors can optimize risks and returns.

35. In turn, the phaseout of coal-as-fuel can be systematically planned. It can provide a stable, albeit declining "safety net" for the financial migration into coal as a multi-resource platform. If for no other reason, a global Trust structure mitigating impacts on workers and coal communities is a meaningful endeavour.

36. A visual depiction of the above discussion is presented below in Figure II below.

Figure II:
Design for Transforming Coal as Fuel into Coal as a Multi-Resource Platform



E. The Fourth strand: modify operational planning

37. Coal can contribute to clean energy and economy futures when phased out as a fuel. Nevertheless, achieving it requires a shift in perspective and in practices. CMEs must discover other long-term value in their assets, as discussed.

38. Such a shift involves adjusting core operational planning methods and practices used by CMEs. Coal mine planning adjustments must integrate new value streams into conventional mining activities, including:

(a) Leveraging mining land for non-mining purposes, by designing the mine and using the land surface while in operation that does not foreclose on alternate future uses of land resources;

(b) Harvesting minor and trace elements from coal. These elements have been shown to be present in minable quantities at some mining locales and at power plants that use coal from these locales.[4] Exploration and ongoing drilling activities at active mines should include additional laboratory testing to evaluate the potential;

(c) Creating new revenue streams from harvesting hydrogen and carbon materials from coal and collocated methane resources;

(d) Doing the same with coal waste residues. These wastes may also contain extractable quantities of trace metals and other critical raw materials but are likely unknown due to lack of sampling and analytical testing for elements other than those mandated by environmental regulations.

39. Mine operations planning adjustments include:

(a) Changing drilling and mine sampling plans programs to include additional elements in analytical testing programs;

(b) Integrating additional process circuits into raw coal processing plants to separate and recover additional high value products;

(c) Adding new production activities post-processing. For example, ones that create potentially significant new value streams, such as, hydrogen production, production of graphene and other carbon nanomaterials, and adding renewable energy production to mining lands;

[4] For a general overview see: Barbara J. Arnold, "A review of element partitioning in coal preparation," *International Journal of Coal Geology*, Volume 274, 1 June 2023, available at https://doi.org/10.1016/j.coal.2023.104296. For specific examples of elements in coal seams see: Avijit Das, et al., "Geochemical variations of major, trace, rare earth elements in some Gondwana and Eocene coals of India with a comparison of their germanium, lithium, and mercury content," *Geochemistry*, Volume 83, Issue 2, May 2023, available at https://doi.org/10.1016/j.chemer.2023.125960; Businesswire, "Major Deposits of Magnetic Rare Earth Elements Discovered at Ramaco Resources Mine in Wyoming," May 03, 2023, available at: https://www.businesswire.com/news/home/20230503005966/en/Major-Deposits-of-Magnetic-Rare-Earth-Elements-Discovered-at-Ramaco-Resources-Mine-in-Wyoming; D.A. Bagdonas, etal., "Rare earth element resource evaluation of coal byproducts: A case study from the Powder River Basin, Wyoming, *Renewable and Sustainable Energy Reviews*,158 (2022), https://doi.org/10.1016/j.rser.2022.112148; Denis Talan, Quingquing Huang, "A review study of rare Earth, Cobalt, Lithium, and Manganese in Coal-based sources and process development for their recovery," *Minerals Engineering*, 189 (2020); https://doi.org/10.1016/j.mineng.2022.107897;The following paper explores the potential for extraction of rare earth elements from acid mine drainage: Yan Wang, et al., "Speciation of rare earth elements in acid mine drainage precipitates by sequential extraction", *Minerals Engineering*, Volume 168, 2021,106827,ISSN 0892-6875, https://doi.org/10.1016/j.mineng.2021.106827. The following paper examines the potential to extract rare earth elements from fly ash: Ronghong Lin, et al., "Application of sequential extraction and hydrothermal treatment for characterization and enrichment of rare earth elements from coal fly ash", *Fuel*, Volume 232, 2018, Pages 124-133, ISSN 0016-2361, https://doi.org/10.1016/j.fuel.2018.05.141.

(d) Creating new value streams and offset for losses from coal phaseouts. It summarily benefits coal mine enterprises, associated investors, and local coal mining communities.

40. Absent such operations planning adjustments, progressive initiatives to create new value may be foreclosed before even beta level process testing is given a green light.

F. Binding together four strands to change the role of coal and its future

41. Four distinct strands must be braided together to maximize potential value. Value that can positively benefit investors, CMEs, and coal mining communities. Value accretion is enabled through innovations that change core mining operations planning:

(a) Operational decision-making functioning within a comprehensive context of multi-resource value potential and actual operations executed within a whole-mine lifecycle process;

(b) Revising exploration campaigns, mine planning and operations contextualized using a map of key influencing factors (continuously updated) to prioritize platform operations. For example, the mix of materials extracted from coal processing may be periodically changed based on market prices of specific resources, e.g., lithium, cobalt, pure carbon, and so on. Other factors necessitating change include the complexity of mining coal to extract high value minor and trace materials. Concentrations can vary within coal seams and surrounding strata. It requires greater precision when maximizing value driven extraction practices;

(c) Managing coal phaseout transition execution and CME transformation based on value creation in multi-resource market development;

(d) Leveraging Trust structures to facilitate and hedge transit from coal-as-fuel to multi-resource platform. While it transacts at the specific mine level, it is enabled when Trust structures operating at the global level support coal transition justice for all relevant stakeholders;

(e) Designing coal transitions and coal enterprise transformations provides context and roadmap for future activities that preserve value and reduce risks. Actual execution happens through managing people, processes, technologies, and information.

VI. Conclusions and recommendations

42. The successful phaseout of coal-as-fuel must occur within the frame of clean energy systems substituting for coal — worldwide. However, coal's value can reach far beyond clean energy systems to contribute to the transformation of carbon-emitting economies into clean economies, in part born of using advanced carbon materials.

43. The long-term value of coal, therefore, warrants intentional policy that defines its comprehensive value and limits, then phases out its role as a fuel source, worldwide.

44. Policies must provide incentives and rewards for CMEs that phaseout coal-as-fuel operations. Such policies must limit losses of value to investors and enhance the value of coal mining communities while coal-as-fuel phaseouts occur. The diversity of transition circumstances globally limits this document's recommendations to a general framework. Specific application must be shaped to fit local, regional, and national circumstances.

45. Use Trust structures as a supra-delivery and facilitation mechanism at global scale. These structures can provide support services and reduce the obligations on CMEs as they transform from coal-as-fuel provider to multi-resource platform business models.

46. Create a competition that provides cash prizes for a mine re-design that will transform an operating coal mine into a multipurpose platform where extraction of coal for advanced carbon products and other collocated resources are recovered as a part of an integrated business model, which focuses on providing products and materials needed for a greener 21st century. The initial prize could be nominal, e.g., $100,000 and awarded to a university or

company that is not directly involved in mining coal; however, a second award could be significantly larger and given to a mining company that successfully implements a pilot project that proves the concept is viable for a specific mining region.

47. Pursuing the approach framed in this document is, thus far, an unrealized potential for coal's future as a non-fuel resource. Developing this path forward will contribute to lessening the economic, social, and cultural shocks of transitions phasing out coal-as-fuel. Valid and indelible coal transition justice can be enhanced by realizing the potential of coal as a multipurpose resource for both coal communities and CMEs. This approach can facilitate changes in ways that are less dramatic for all involved parties.

48. ECE has an important and unique role to play:

(a) Orchestrate continued engagement on matters of coal transitions. It provides a necessary and unique forum for considering policy, practice, financial engineering, and operations planning innovations;

(b) Assume responsibility for establishing Trust structures as a key to success. It relieves all stakeholders of the complications associated with trying to establish a meaningful global innovation. One that supports all stakeholders during coal transitions, ensuring that transitions are just;

(c) Facilitate the migration of Trust structures (and any other instruments supporting transitions and transformations) from incubation to independent operating entities. It is an essential step. Achieving it will require a focused effort on establishing Trust governing boards. Also, helping boards with selecting a Trustee to manage operations and develop the Trust;

(d) Play an ongoing role as monitor to ensure transparent, fair, and impartial management for the benefit of coal-related stakeholders.

VII. Next Steps for the Secretariat

49. Engage ECE member States and stakeholders to build a transparent and collaborative process for proceeding. That is, identify one or more opportunities to prove the concept, e.g., pilot project(s), demonstration(s), living laboratory for continuous improvement learning regarding how to modify coal mine operations planning and develop multi-resource platforms at the individual mine level.

50. Engage with at least one (preferably more than one) CME as a cooperating enterprise. Mining enterprises have knowledge that is critical to ensuring that proof of concept efforts is realistic, and outcomes are both fair and valid.

51. Decide a go-forward plan with a focus on Trust structures, ensuring engagement of various influential constituencies.

52. Undertake fundraising efforts to gather sufficient resources to initiate and start implementing the solutions proposed in this paper.

53. Use a proof-of-concept approach to test validity. Refine the approach if proof of concept is validated. Thereupon, build a comprehensive implementation plan.

54. Go forward with active prosecution of coal phaseouts in the context of transition justice for all relevant stakeholders based on a transformation of coal to a multi-resource platform supporting clean energy and economies.