INTERNATIONAL ENERGY AGENCY
COAL INDUSTRY ADVISORY BOARD

CIAB

38th PLENARY MEETING

DISCUSSION REPORT

IEA Coal Industry Advisory Board Plenary Meeting
Ministère des Affaires Étrangères Centre de Conférences
27 rue de la Convention, Paris
21/22 November 2016

CIAB PLENARY DISCUSSION SESSIONS

Held on Monday, November 21st and Tuesday November 22nd, 2016

The *Coal Industry Advisory Board* (CIAB) is a group of high level executives from coal-related enterprises, established by the International Energy Agency Governing Board in July 1979 to provide advice to the IEA from an industry perspective on matters relating to coal. The CIAB Plenary meeting is held annually and is one of the mechanisms in which CIAB Members provide information and advice to the IEA on relevant energy and coal-related topics. The meeting includes a series of discussion sessions with presentations from external and member speakers on topics of relevance to a wider audience. This report covers the three discussion sessions discussed at the CIAB's 38th Plenary meeting.

"Discussion Session 1: The Current Trajectory"
Chaired by Benjamin Sporton, Chief Executive of the World Coal Association

- **The Two Degree Scenario and the Implications for Coal**
  Laszlo Varro, Chief Economist at the IEA
- **Current state of play of coal power (HELE) deployment and CCS progress**
  Dr. Andrew Minchener, General Manager of the IEA Clean Coal Centre
- **Technology Developments – What is readily available? Perspectives from an Equipment Supplier**
  Michael Donohue, Chief Marketing Officer, Power Services, GE Power
- **Technologies for Clean & Efficient Utilization of Coal in China**
  Dr. Ling Wen, President and Chief Executive Officer of Shenhua Group

Discussion

"Discussion session 2: Delivering Coal Related NDCs"
Chaired by Greg Evans, Executive Director Coal and Chief Executive of the COAL21 Fund

- **Coal Based Power Generation in India: Present Situation and Future Plans for HELE Deployment**
  Girish Sethi, Senior Director Industrial Energy Efficiency Division, The Energy and Resources Institute
- **ASEAN Nationally Determined Contributions (NDCs)**
  Dr. Atit Tippichai, Manager of Policy Research and Analytics Programme at the ASEAN Centre for Energy
- **Considering environmental and social risks financing HELE deployment**
  Mr. Mark Eadie, Acting Head, Environmental and Social Risk Management, Standard Chartered Bank

Discussion

"Discussion Session 3: Achieving material CO_2 emission reductions from coal"
Chaired by Peter Freyberg, Head of Coal Assets Glencore

- **Cost of CCS and its value to the Electricity System**
  Dr Keith Burnard, Project Manager at the IEA Greenhouse Gas Programme)
- **Southern Company view of Advanced Coal technology (Kemper County)**
  Kerry Bowers, President and CEO and Southern Generation Technologies, LLC
- **CIAB Recommendations for Incentives and Policies to Deploy CCS**
  Ken Humphreys, FutureGen Alliance

Discussion

Introduction

The aim of the discussion sessions is to engage the IEA Secretariat, CIAB Members including consumers (particularly the electricity industry), producers and infrastructure/transportation providers, and invited guests, in a debate on major issues affecting the coal industry and its role in effectively mitigating greenhouse gas emissions today and in the future. The three sessions started by defining the path for clean coal in the Paris Agreement targets. The second session took a look at how the building blocks of the agreement or country level Nationally Determined Contributions (NDC) can be used to deliver country targets in coal growth regions as well as a discussion of the financing challenges. The final session highlights what is needed for CCS to be deployed addressing technological, policy and financial aspects to reach the carbon abatement targets by 2040. While CCS technology is proven, global leaders in government and in industry will need to implement a series of recommendations to provide policies and incentives to foster and create a pathway for large scale capture projects and storage to be implemented within nations dependant on coal.

DISCUSSION SESSION 1: The Current Trajectory

Chaired by Benjamin Sporton, Chief Executive of the World Coal Association

Mr Sporton opened the session noting that many in the world have the belief that coal will vanish from the energy world in the short-run. The role of coal has taken on a new trajectory but will remain a critical fuel source for many countries for the next generation providing a source of electricity and energy security. The first presentation will look at the role clean coal must play in a climate solution over the next forty years to reach abatement targets as outlined in the IEA World Energy Outlook. The next presentations will look initially at the current state of play for clean coal technologies first globally, then from an equipment supplier perspective and finally in a deep dive into the use of clean coal in China the world's largest coal consumer. In a carbon-constrained world, he emphasised the important role high-efficiency, low-emissions (HELE) coal-fired technologies play as a means to mitigate not only carbon but all greenhouse gas (GHG) emissions, in power generation and as the only solution for many large industries. The Speakers in this session will define the role of coal in the 2°C going forward, discuss the status and costs of clean coal technology around the globe, and provide perspectives on the state and challenges HELE and CCS technology from a major equipment supplier and a utility in China.

The Two Degree Scenario and the Implications for Coal

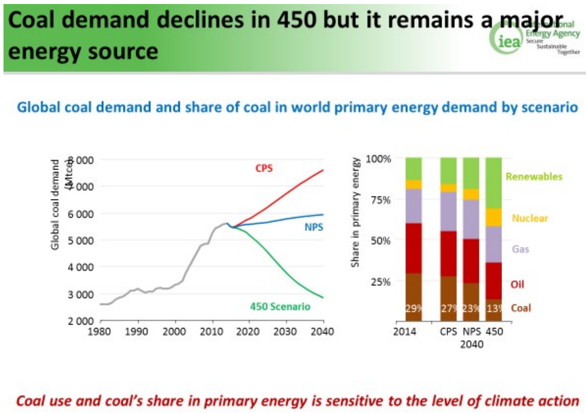
Laszlo Varro, Chief Economist at the IEA

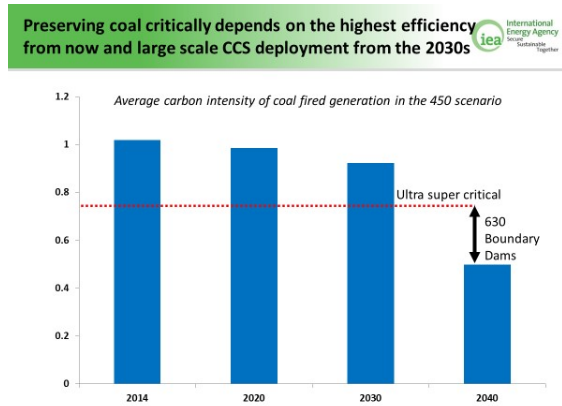
Mr Varro started his speech with a reference to the Paris Climate Agreement. He shared his surprise about the extended public perception that the mission is already accomplished when the hardest is to be done. He gave the analogy that the world is at base camp and faces a significant climb ahead to reach the climate summit.

He pointed out that the IEA World Energy Outlook forecasts that regions like Southeast Asia and India will remain energy hungry with power demand driving economic growth. Even with the implementation of energy efficiency policy measures, power demand is expected to rise over the period except in the 450 ppm or 2-degree scenario (2°C). The electrification of the global vehicle fleet will likely increase demand even further through 2030. This creates the challenge of how an energy system can undergo a transformation securing adequate investment, meets electricity demand while reducing carbon intensity by 2040. Country level solutions will vary with some paths decentralised relying on renewables, and others like India relying on a centralised solution with large energy plants and decentralised energy sources.

He reported that coal remains a major energy source in all IEA WEO scenarios which forecast a decline in global in the 2°C, an increase in the current policies (CPS) and stagnation in the new policy scenario (NPS).

He said that an energy system reliant on 100% renewable sources is unlikely, despite improvements in the integration of this energy into the grid, due to the unanswered questions an energy system faces with high renewable shares when greater flexibility is needed to balance out supply and demand. These can potentially be covered by "dispatchable" plants, smart grids, energy storage or trading.





He pointed out that the costs for renewable energy sources had fallen significantly in the past decade and now offer the cheapest source of low-carbon energy. This came as the result of a low cost of capital and the existence of clear financial policies citing the level of growth in countries like Germany and the USA. Over the same period investment in CCS has been limited leading to a delay in the commercial project pipeline in deployment with most institutional investors not seeing a viable financial model for clean coal technology. In addition to the establishment of clear financial policies in support of clean coal projects, project management performance and guarantees need to be established to improve industrial confidence for new projects

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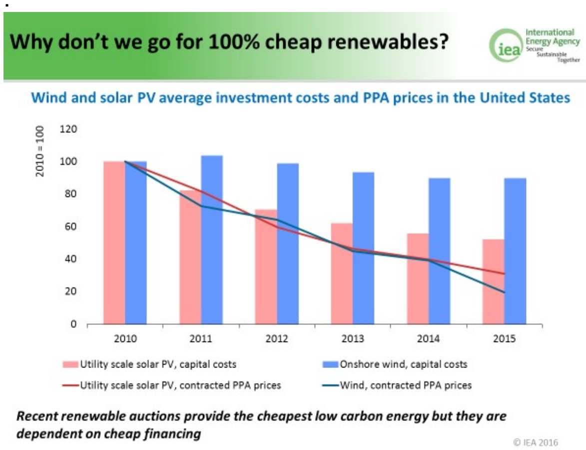


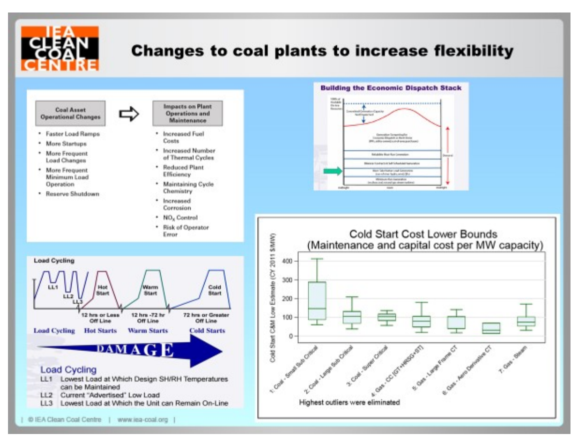
A successful decarbonization strategy will rely on clear climate policy, cheap renewable sources and the deployment of clean coal technology. The path for coal will be determined by the degree of climate action, but for coal to remain in the energy mix, it needs to operate at the highest efficiency now and be ready for large scale CCS deployment from the 2030s.

Current state of play of coal power (HELE) deployment and CCS progress

Dr. Andrew Minchener, General Manager of the IEA Clean Coal Centre

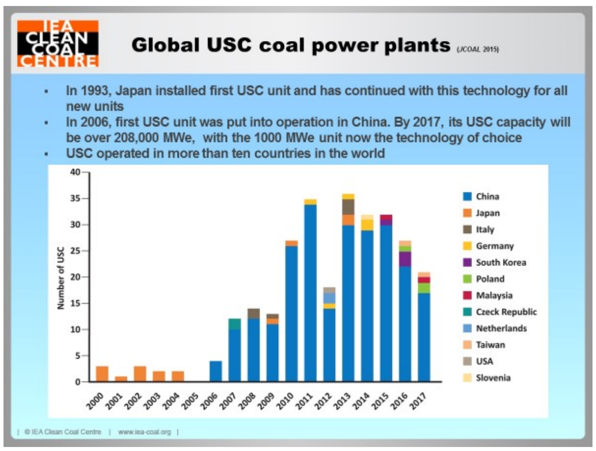
Dr Minchener started by provided an overview of the IEA Clean Coal Centre (IEA CCC). The IEA CCC is an international organisation, endorsed by the IEA, to provide independent, objective information on how to use coal more efficiently, effectively, and cleanly, to minimise its environmental impact, while providing cost effective energy. The IEA CCC produces comprehensive assessment reports on all aspects of clean coal technology but also building up knowledge exchange and the implementation of capacity building activities in developing countries and industrialising nations.

He started by examining the status of High-Efficiency Low Emissions (HELE) Coal Technologies-current and providing an outlook for the future. HELE clean coal technologies are a key step towards near zero emissions from coal which reduces GHG, other pollutants, and fuel consumption while providing a bridge to CCS technologies.

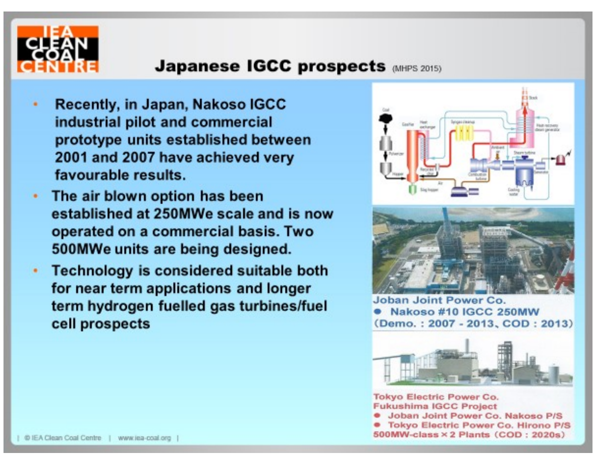


Dr Minchener acknowledged that often fundamentals of coal-fired power generation appear stagnant, but in reality, significant improvements are ongoing to improve efficiency, reduce emissions, and increase flexibility.

The capacity of ultra-supercritical plants (USC) total 208 GW in operation and under construction and offer the best technology available to the market which can match a gas-fired plant on conventional emission standards. China is home to the most advanced USC fleet. The existing best-in-class technology unit can reach a 49% net efficiency and is being tested. In the future, he expects that efficiencies of 50%+ are possible with the creation of materials and components that can reach temperatures of 700 degrees Celsius. He said that a demonstration of this technology would be tested in Japan in the next decade.



The second improvement under development is a gasification-based system, where syngas is produced with a constant stream of CO_2. The most successful projects to date are in Japan, where they have two prototypes and have a 250 MW scale unit that is now commercially operating. The costs are not yet readily available, but there is potential from a CCS standpoint.



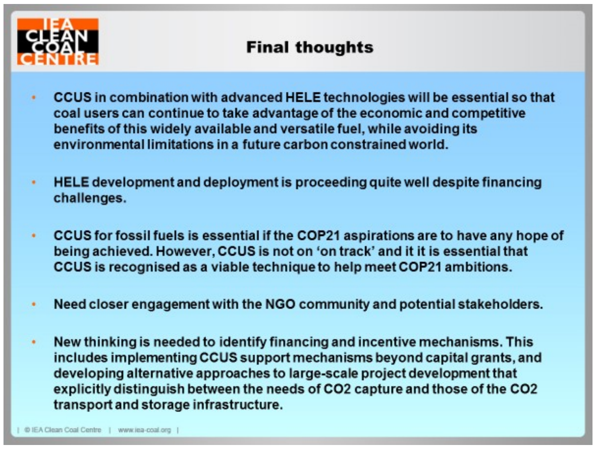
He believes the largest challenge for future HELE and USC projects is the availability of financing mechanisms in the private and public sector, but also for developing nations.

In the second part of his presentation, ***Dr Minchener*** examined the current path for CCS/CCUS development, deployment and future challenges. The positive news for the power sector is the success of the first large-scale plant, Boundary Dam 3 unit, which began test operations in October 2014 and has collected 1.15 mn t of CO2 to date. Early in 2017, two additional power projects (Kemper County Energy Facility with 524 MWe in Mississippi and Petra Nova Carbon Capture Project with 240 MWe in Texas) are expected to launch full-scale commercial operations in the United States and capture up to 4.4 mtpa. The troubling point remains the lack of next generation projects in the global pipeline, particularly in non-OECD countries, where a higher priority may be on energy security and economic growth.

He asserted that the reason for the delay in the deployment of CCS projects might be rooted in the perception that CCS is a less attractive investment due to the high upfront project costs. To solve this, CCS needs to be placed on a level playing field with other low carbon energy sources, or it will face difficulties to compete in the deployment phase over the next decade. He noted that CCUS deployment offers industrial players financial advantages over CCS, but the number of demonstration projects remains limited on a global basis. To foster deployment, perceptions would need to change where CO_2 isn't only seen as a problem, but also as a means to enhance the performance of a plant as done in the planning of the U.S. Department of Energy (DoE). An example on the technological front is the use of an oxyfuel turbine with syngas/natural gas using supercritical CO_2 as the working fluid.

Dr Minchener invited CIAB members to attend the upcoming Clean Coal Technologies workshop which will be held on May 8th-12th, 2017 in Caligari, Italy.

In closing, he provided the following summary of the current market for clean coal technology development across the globe.



Technology Developments – What is readily available? Perspectives from an Equipment Supplier

Michael Donohue, Chief Marketing Officer, Power Services, GE Power

Mr Donohoe reminded the forum of the state of the global electricity market where today 2 bn people in the world have insufficient or unreliable power and more than 1 bn lack access to electricity completely. General Electric (GE) is committed to delivering affordable, reliable, and sustainable power, but that this will require a diverse energy mix that includes steam power to meet rising global demand. GE is an equipment supplier for 30% of steam turbine capacity and 30% of boilers globally and over a century of experience.

He said that global trends are transforming the power industry that creates challenges (slower GDP growth, resource and financing constraints) as well as a wealth of opportunities (emerging market growth, global clean energy and data capabilities). To meet customer requests, GE Power is accelerating the development of technology and product offerings to raise efficiency and lower emissions focusing on technology advancements, digital capabilities and environmental controls. He illustrated an example of the benefits achieved via a performance optimisation done for a 1000 MW steam plant in China which achieved a 1.5% increase in efficiency, a 5% reduction in unplanned maintenance, and 3% drop in CO_2 emissions.

He demonstrated the potential of using new technology to respond to the increasingly tighter environmental standards where 99% of SO_x, more than 95% of NO_x and 99.9% of particulates can be removed. Environmental controls are currently able to lower emissions by 70% more than the world's most stringent emission standards.

He closed by saying that customers, the global energy sector and environment all would win with an equation that improved efficiency and lowering emissions creating better economics for all.

Technologies for Clean & Efficient Utilization of Coal in China

Dr Ling Wen, President and Chief Executive Officer of Shenhua Group

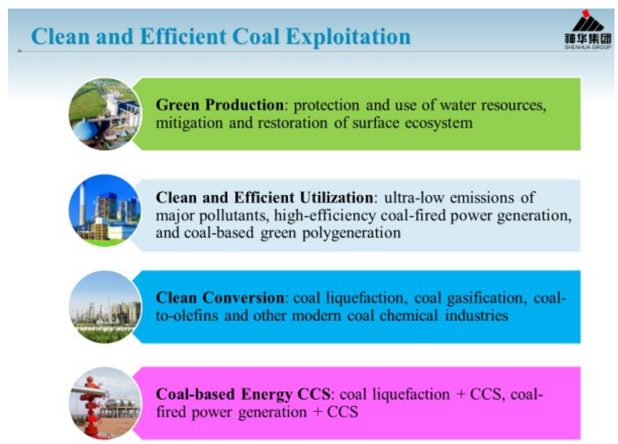
Dr Wen provided an overview of the energy structure in China, the world's largest energy user consuming 23% or a total of 4.3 bn TCE of global energy. In 2015, coal consumption was almost 4 bn t and fuelled 64% of primary energy consumption and contributing 5% of GDP.

The country is a world leader for renewable energy sources relying on hydropower production (providing 8.5% of primary energy) wind and PV solar (providing 1.3% of primary energy). These will continue to grow in the future along with nuclear capacity. The country lacks indigenous gas and oil sources, so coal will remain a bedrock for the countries socio-economic development and provides the most affordable and reliable energy source in the country. He said coal is the support behind China’s fast growth contributing 70% of electricity, 86% energy for iron and steel and 79% for construction materials.

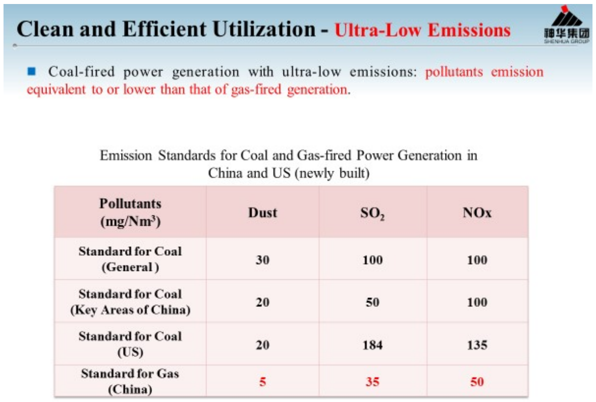
He said that from 2001, coal fuelled the “golden decade” for Chinas power industry but now faces challenges of weaker demand and excess capacity in slower market conditions. There is 1 bn tonnes of excess capacity in the coal industry, and utilisation of coal units has dropped from almost 5,300 hours in 2011 to under 4,000 hours in 2016. Also, there are greater environmental constraints to reduce carbon emissions, air pollution and stop damage to ground water and surface ecosystem during the mining process and reduce air pollution. He remarked that large plants of the modern, efficient fleet are not the main contributors, but the high level of coal consumption at the household level or from small boilers. China has proposed that carbon emissions will peak by 2030.

He said that China is on a path to transition to green energy which will rely on five concepts which are innovative, coordinated, green, open and shared.

For the coal industry, this transition will use innovation to promote clean and efficient coal use and other supply-side reforms. He outlined the measures that were underway that would promote greener mining production, the cleaner and efficient use of coal in the power sectors, cleaner conversion in industrial processes like liquefaction and promotion of CCS.



In the utility sector, China has implemented ultra-low emissions standards for all new coal-fired plants that would reduce pollutant levels (Dust, SO_2 and No_x) to at or below that of gas-fired plants. The State Council has mandated that all coal units achieve ultra-low standards by 2020. He reported that the majority of Shenhua‘s installed capacity is comprised of 75 ultra-low emission coal units (with 39.76 GW of installed capacity). In 2014, Shenhua commissioned China's first ultra-low emission coal unit the Zhoushan power plant which has emissions of 2.46 mg/Nm^3 for dust, 2.76 mg/Nm^3 for SO_2, and 19.8 mg/Nm^3 for NO_x or lower than Chinese gas plants.

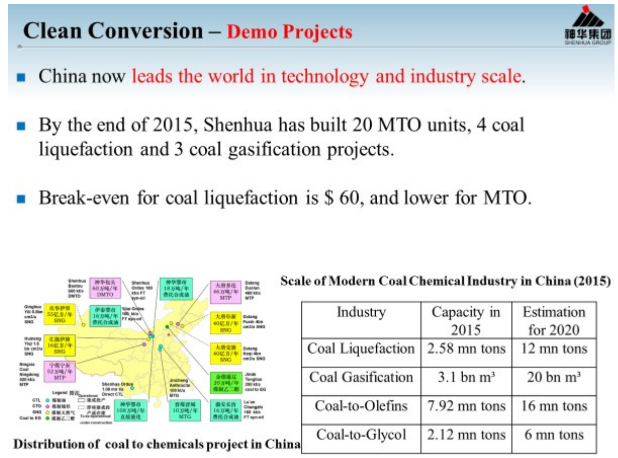


Pollutants (mg/Nm^3)	Dust	SO_2	NOx
Standard for Coal (General)	30	100	100
Standard for Coal (Key Areas of China)	20	50	100
Standard for Coal (US)	20	184	135
Standard for Gas (China)	5	35	50

He reported that utilising advanced HELE technologies has raised net efficiency by +2.8% to 46.2% in the last decade lowering emissions and coal consumption.

Shenhua strongly supports technological innovation for clean coal use through R&D and pilot projects. It continues work on high efficiency circulating fluidized bed (CFB) technology to optimise low CV coal qualities efficiently. The company is operating the largest CFB unit in the world and is working on 660 MW USC CFB technology with a target gross efficiency of 42%. The firm is also working on innovating coal-based poly generation so that renewable energies can be used to supplement coal-fired power.

In China, coal is also used in liquefaction and gasification processes to create oil and chemical products like natural gas, methanol, olefins and other petrochemical products. Shenhua completed the world's first direct coal liquefaction demonstration project (DCL) with 1 Mtpa capacity and a conversion efficiency of 58%. They also expect to start operations at the end of 2016 of the largest indirect liquefaction project at Ningxia come with a capacity of 4 Mtpa.



Industry	Capacity in 2015	Estimation for 2020
Coal Liquefaction	2.58 mn tons	12 mn tons
Coal Gasification	3.1 bn m³	20 bn m³
Coal-to-Olefins	7.92 mn tons	16 mn tons
Coal-to-Glycol	2.12 mn tons	6 mn tons

In 2015, the Asian Development Bank (ADB) and the National Development Reform Commission (NDRC) put together a roadmap in China for the development of CCS with the goal to reduce emissions by 10 Mtpa by 2030 and reaching commercial deployment by 2040. Shenhua is committed to CCS as seen with the construction of a 100,000 tpa demonstration plant including storage in a saline aquifer. The company has a series of demonstration projects underway exploring all three capture technologies as well as a 100,000 tpa whole process demonstration that combines post-combustion & geological storage that is scheduled to start operations in 2017.

China's CCUS Roadmap Jointly Released by NDRC and ADB (2015.11 Paris)

Dr Wen sees the next generation of Chinese innovation projects looking at several different paths. One trend is the production of coal-to-hydrogen with CCS together to realise near-zero CO2 emissions. There is also work underway in integrated gasification fuel cells (IGFC) with distributed power generation technologies; Shenhua has two demonstration projects planned. The company is also looking at coal-based smart poly generation to integrate coal-based energy with non-fossil fuels. They believe this technology offers a lower cost potential than IGCC.

He concluded by reaffirming that coal will continue to be China's main source of energy for the near future, but that coal will become cleaner and more efficient. The country and firms like Shenhua are leading the work in technologies for clean coal and CO2 mitigation, and he believes innovation is vital to achieve the needed breakthroughs for coal-based energy to be sustained.

Mr Sporton thanked each Speaker and opened up the session for questions.

Discussion

Mr Seamus French inquired whether government policies were in place in China to support the technological breakthroughs that are underway particularly for CCS. ***Dr Wen*** replied that government policies provide a clear direction and momentum for business leaders to implement changes needed.

Mr Mathias Hartung asked for a description of what a "decarbonized world" could look like in theory and practice. ***Dr Varro*** answered that for the global energy system it would mean almost zero carbon emissions that translate into a lack of a carbon budget in the 2oC for unabated coal use. The reason is that in nature there are many naturally occurring emissions sources like rice fields. The IEA is in favour of a carbon neutral system.

Mr Sporton raised a question about the size of the carbon budget designated to gas as a fuel for generation. ***Dr Varro*** said that there is a substantial capacity for gas that is needed to meet reserve requirements particularly in the 2oC. The use would be primarily from OGCT plants with a load factor primarily in peak hours with a price above $1,000/MWh.

Mr Julian Beere asked about how project financing is being offered for coal projects in the current market. ***Mr Donohue*** commented that projects for plant upgrades with a positive carbon mitigation balance received higher priority. In China, he noted that projects tend to be well funded and implementation quicker than in many other countries. He advised that it would be beneficial to demonstrate the success of projects under construction in countries like India and China to boost investor confidence. The other solution is to engage with international agencies like the IEA to help promote private/public partnerships to create innovative solutions.

Dr Hans-Wilhelm Schiffer questioned why the IEA and other NGO organisations did not strongly support policy parity equally across all low carbon technologies. The IEA policy statements show that renewable technologies are flourishing yet that this alone cannot reach carbon neutrality. The fact is that the world will also rely on CCS to meet carbon mitigation targets and steps must be taken to encourage deployment.

Mr Mick Buffier inquired about the amount of analysis underway to estimate the additional costs for adequate storage and transmission as renewable penetration increases in the 2oC. Currently, the country's leading this transition and offering the most flexibility are: U.S., Germany and Spain, but there are many theoretical and operational issues to remaining to solve for a renewables penetration of >85% in the grid.

Mr Andrea Clavarino was impressed by the steps China has taken to reduce emission in the generation sector. He asked whether there was also a strategy imposed by the state to reduce coal use in private households. ***Dr Wen*** said that there is still work underway to improve efficiency in the mining sector and it is more difficult with the imbalance in the market. The utility sector is working diligently to improve plant efficiency by constructing units with larger boilers. Still, there more work ahead to reduce the 66% of emissions in other sectors, but this is difficult since there is often a lack of access to another fuel source in many small villages and towns. He said that despite the market conditions, the largest challenge for the coal industry is how to reduce CO_2 emissions. He encouraged the IEA and the CIAB to provide a platform to share best practise and knowledge sharing to help the entire industry solve this problem jointly.

Mr Sporton closed the discussion thanking all Speakers for the insightful presentations that show the significant role that coal plays in the world today and its place in the 2oC world of the future. He said that CCS is real, but HELE technologies will be needed to first bridge that gap. Chinese HELE technology development remains at the forefront for clean coal. Still, CCS is facing larger challenges that must be addressed for CCS to progress and deploy at the scale needed.

DISCUSSION SESSION 2

Delivering Coal Related NDCs

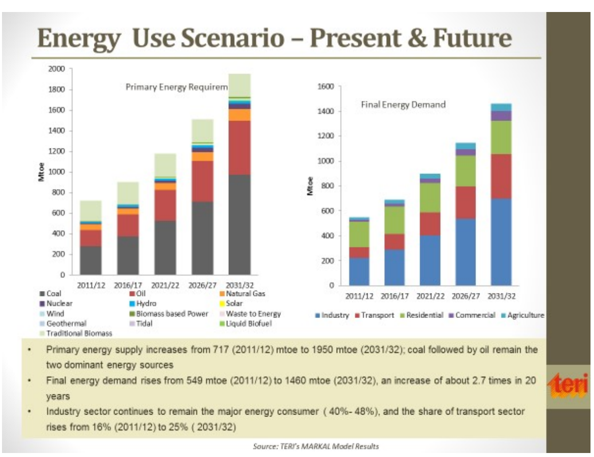
Chaired by Greg Evans, Executive Director Coal and Chief Executive of the COAL21 Fund

Mr Evans opened the second session which will take a deeper dive into the NDC of countries dependent on coal for energy security. The session will also look at how the coal industry will be able to deliver carbon reductions in the Paris Agreement via the building blocks the NDC submitted by each country to the UNFCCC Secretariat. Countries are allowed to submit an updated NDC every five years to represent their growing ambitions to cut emissions. Today's sessions include three presentations, two looking at developments in coal-fired growth regions of India and Southeast Asia and then insights from the finance sector.

Coal Based Power Generation in India: Present Situation and Future Plans for HELE Deployment

Girish Sethi, Senior Director Industrial Energy Efficiency Division, The Energy and Resources Institute)

Mr. Sethi opened by introducing The Energy and Resources Institute (TERI), a non-profit support independent think tank advising on issues of environment, energy and sustainable development. TERI has over 1,000 employees and a separate university (TERI University) that provides masters and doctoral courses focussing on environmental and sustainable development related subjects. TERI creates their own projections for energy use out to 2031/32 and provided the back-end work for the INDC scenarios used by the Indian Government.



He said that in India primary energy demand is expected to rise from 717 in 2011/12 to 1,950 Mtoe by 2031/32. Coal and then oil will remain the dominant fuel sources. The industry sector remains the largest energy consumer, but demand in the transport sector grows strongly. End consumer demand will increase fuelled by electrification in the rural sector, increasing demand of electricity in urban areas (primarily being attributed to air-conditioning) and steady population growth.

He said that in India primary energy demand is expected to rise from 717 in 2011/12 to 1,950 Mtoe by 2031/32. Coal and then oil will remain the dominant fuel sources. The industry sector remains the largest energy consumer, but demand in the transport sector grows strongly. End consumer demand will increase fuelled by electrification in the rural sector and the strong population growth.

He provided an overview of the Indian INDC, which commits to:

- reduce emissions intensity of GDP by 33-35% by 2030 from 2005 levels
- achieve about 40% cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030
- create an additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent through additional forest and tree cover by 2030.

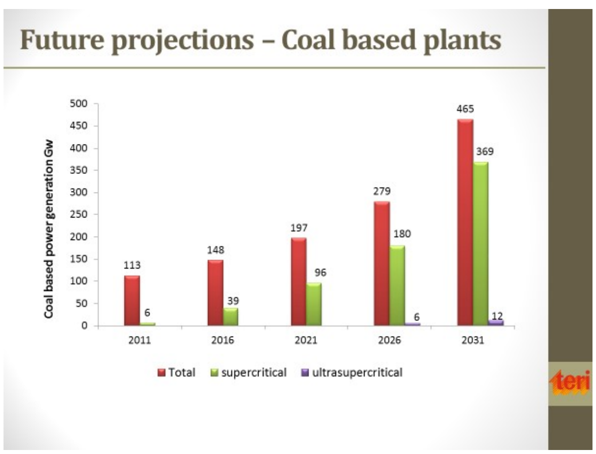
This will be done in the power sector by introducing new, more efficient and cleaner technologies for thermal generation while promoting renewable energy and increasing the share of alternative fuels in the overall fuel mix. There is also a major program underway in India to coordinate and improve energy efficiency across all sectors in the country. Initiatives include: setting energy efficiency targets for the top 7-8 industry sectors and setting minimum energy standards and labels for all major appliances

Mr. Sethi explained the drivers and challenges being faced in the Indian power market in terms of trying to meet strong demand growth for the existing base, averaging 7.65% in the last decade, and to still provide electrical services to the 300 mn people lacking access.

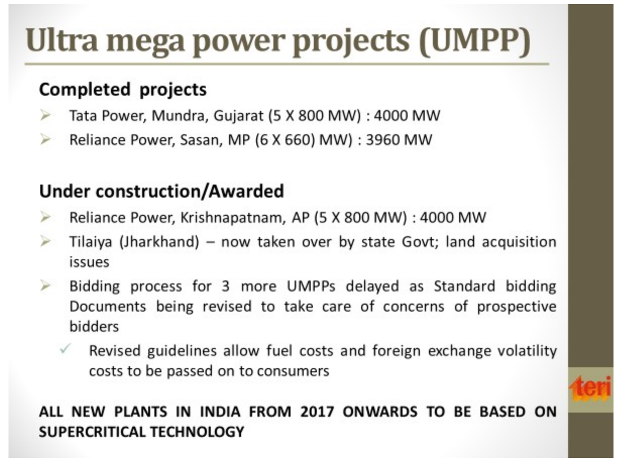
He said that thermal power provides almost 70% of total generation with coal being the primary fuel source in this mix. In the last decade, there was a major shift from government to the private sector who now owns 42% of generation capacity. Although the deficits are decreasing, the country still faces a power crunch with an overall deficit of 2.1% and in peak hours 3.2% with supplies unable to match demand. The Government of India is working towards ensuring continuous electricity supply to all but faces multiple challenges. There is also a huge volatility in demand, also seasonal with a growing middle class. This increases the need for flexibility that must be addressed by distribution and transmission companies. Despite the gap, load factors for many coal-fired plants are now near 50%. At the same time, there are also views that there exists a significant latent demand.

He added that another challenge is to provide access to clean cooking facilities. The new government in India has laid emphasis on providing LPG to rural households and piped natural gas to cities to provide clean cooking facilities.

He expects that coal will remain the largest fuel source for the generation sector providing over 50% of power generation in 2031. He said that new coal-fired capacity will move to super critical plants and the retirement of the older subcritical plants as the power gap closes. This can often mean the construction of a newer SCP and closing a subcritical unit at the same location. By 2031, the first USC plants are also expected.



He reported on the slow progress of the coal based Ultra Mega Power Projects (UMPP) planned in the last decade. Each project was proposed with installed generation of 4,000 MW per site (5x 800 MW) and utilizing supercritical technology. Till date, only 2 projects have been constructed. Most proposals are stalled due to various factors like delays in land acquisition and policy changes regarding bidding documents, state level law and permits, and coal linkage agreements assuring supply commitments. He said that all new plants awarded from 2017 onwards will be based on supercritical technology.



He summarized the state of the Indian coal market. While India has proven reserves of 126 bn tonnes, the domestic production is currently at 570 mn tonnes sourced mostly from open cast mines. Indian coal quality is high ash and there are large variations in calorific value. Indigenous coal production is not able to keep up with demand due to mining constraints, infrastructure bottlenecks and environmental regulations and large quantities of coal (approx. 220 mn tonnes) are currently being imported from Indonesia, South Africa and Australia. Depending upon the progress of the Indian renewable energy program, the coal imports will vary and can increase further.

However, it is believed that coal will retain its predominant position in the Indian power generation mix in installed capacity and in generation in the coming years. Clean coal technologies will be the focus of future power projects, India is first implementing supercritical steam cycle technology with higher steam parameters that could lift efficiency rates by +2-3% and reduce fuel consumption and costs. Large coal-fired stations between 800 – 1000 MW will be required to handle Indian domestic coal, but further cooperation is needed with international manufacturers. This reinforces the earlier presentation from ***Dr. Minchener*** that a political commitment to invest in supercritical technology is needed. As for CCS in India, there isn't currently discussion or support for projects due to the immediate challenges faced in the energy market.

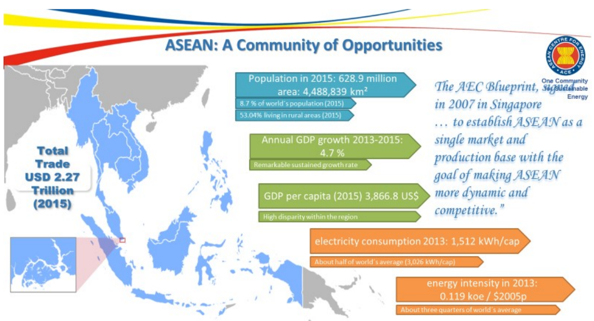
ASEAN Nationally Determined Contributions (NDCs)

Dr Atit Tippichai, Manager of Policy Research and Analytics Programme at the ASEAN Centre for Energy

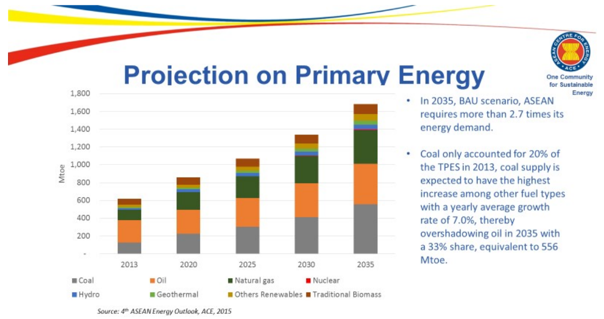
Dr Tippichai introduced the ASEAN Centre for Energy (ACE) as an independent ASEAN intergovernmental agency with headquarters in

Jakarta, Indonesia, that represents the ten member countries interests in the energy sector. The Centre serves as a catalyst supporting economic growth and the integration of the ASEAN region by facilitating joint and multilateral collaborations for energy activities. It serves three critical roles: acts as an energy think tank acts as a catalyst to unify and strengthen energy cooperation in the energy sector and serves as an energy data centre and knowledge hub.

He continued by providing an outlook of the energy market in Southeast Asia out to 2035 which offers a “community of opportunities” but in reality, poses a difficult task due to the diverse economic conditions across the region. The Big Five players of Thailand, Philippines, Myanmar, Indonesia and Malaysia make up over 90% of demand in the region and ACE expects higher growth than that reported by the IEA.



ACE forecasts that final energy consumption will more than double between 2013 and 2030 driven by strong demand from industry and transportation: primary energy will grow by 270% between 2013 to 2035. In 2013, coal provided 20% of primary energy in the region. Over the forecast period, coal is expected to grow 7% annually, faster than other fuels, to reach a 33% share by 2035. In the power sector, coal and gas are the main sources of fuel for power generation. To match growing demand, generation is expected to increase by 5.9% annually and the installed capacity base to grow by 5.6% each year in the business as usual (BAU) scenario. The next update of the ASEAN energy situation will be done in 2017.



In the second half of his presentation, ***Dr Tippichai*** summarised the ASEAN Plan of Action for Energy Cooperation (APEC) between member countries that are set to guide policy for the period between 2016 and 2025. The goal is to enhance "energy connectivity and market integration in ASEAN to achieve energy security, accessibility, affordability and sustainability for all". The first phase through 2020 concentrates on achieving milestones in six areas.

ASEAN PLAN OF ACTION FOR ENERGY COOPERATION 2016-2025: PHASE I: 2016-2020

1. ASEAN Power Grid	To initiate multilateral electricity trade in at least one sub-region by 2018.
2. Trans-ASEAN Gas Pipeline	To enhance connectivity for energy security and accessibility via pipelines and regasification terminals.
3. Coal & Clean Coal Technology	To enhance the image of coal through promotion of clean coal technologies (CCT).
4. Energy Efficiency & Conservation	To reduce energy intensity by 20% in 2020 based on 2005 level.
5. Renewable Energy	Aspirational target to increase the component of RE to 23% by 2025 in ASEAN Energy Mix.
6. Regional Energy Policy and Planning	To better profile the energy sector internationally.
6. Civilian Nuclear Energy	To build capabilities in policy, technology and regulatory aspects of nuclear energy.

One Community for Sustainable Energy 18

He reported that as of November, six ASEAN member states had signed and ratified the Paris agreement. He provided a summary of the (I)NDCs submitted by each country and said that the current pledges at the regional and global level are still inadequate and deeper cuts to emissions will be needed to reach the carbon mitigation goals. In the ASEAN region, emission levels are still increasing in all countries with the exception of Singapore. In the tables that he provided (below) is an overview of the INDC targets and mitigation measures planned to limit CO_2 emissions. In the region, none of the NDCs submitted addresses the long-term deployment of CCS, but they often include measures targeting energy savings, energy intensity, emission levels, emission intensity or share of renewable power in the energy mix.

(I)NDCs of ASEAN Member States

	INDC Target	Target Year	Reference Year	Mitigation Measures
Brunei Darussalam	63% (energy saving)	2035	2035 (BAU)	- Electricity tariff reform - Energy standard & labelling - Energy management policy - Final incentives, awareness raising, etc.
	45% (energy intensity)	2035	2005	
	10% RE share (power)	2035		- Increasing the use of solar power - Utilising waste to energy resources
Cambodia	27%	2030	2030 (BAU)	- Renewable (solar, hydro, biomass and biogas) - Promoting mass public transport - Energy efficiency for building and more efficient cooking stoves, etc.
Indonesia	29% to 41%	2030	2030 (BAU)	- Effective land use and spatial planning - Energy conservation - Promotion of clean and renewable energy sources, etc.
Lao PDR	30% RE share	2025		- Increase the use of small scale power, solar energy, biomass, biogas, wind, etc.
	10% biofuel share	2025		- Use of bioethanol and biodiesel - Promotion of public transport
Malaysia	35% to 45% (emission intensity)	2030	2005	- Introduction of feed-in-tariff - Financing RE investment - Pursuing green growth

(I)NDCs of ASEAN Member States

	INDC Target	Target Year	Reference Year	Mitigation Measures
Myanmar	20% (electricity saving) 30% RE share (power)	2030	2030 (BAU)	- National Energy Plan (2014) - National Energy Efficiency and Conservation Policy, Strategy and Roadmap for Myanmar (2015) - Long-term Energy Master Plan (2016)
Philippines	70%	2030	2030 (BAU)	- Sustainable low-emission development - Financing resources, technology development and transfer, and capacity building
Singapore	36% (emission intensity)	2030	2005	- National Climate Change Strategy 2012 - Sustainable Singapore Blueprint 2015
Thailand	20% to 25%	2030	2030 (BAU)	- Alternative Energy Plan - Energy Efficiency Plan - Power Development Plan (More efficient power plants and renewable sources) - Thailand Smart Grid Development Master Plan - Sustainable Transport master plan
	30% (energy intensity)	2036	2010	
	30% RE share	2036		
Viet Nam	8% to 25%	2030	2030 (BAU)	- Efficient and effective use of energy in production - Energy saving and renewable energy in residential - Develop public passenger transport - Establish standards on fuel consumption - Chang energy structure towards low emission energy sources, etc.
	30% (emission intensity)	2030	2010	

He reiterated that the ASEAN will be a region driving global future energy demand and acknowledged that this will still rely heavily on fossil-based energy far into the future. He also said that while there are policy directives (like the APAEC), the region still needs to adopt a long-term decarbonization strategy. The submitted (I)NDCs are inadequate to meet carbon mitigation targets on a global scale, and more ambitious goals will be needed. These targets must address the power generation and transport sectors that are interlinked. A strategy should also include technological innovation that can improve efficiency and provide reliable, clean energy sources.

Considering environmental and social risks financing HELE deployment

Mr Mark Eadie, Acting Head, Environmental and Social Risk Management, Standard Chartered Bank

Mr Eadie spoke about the changing scope of corporate social responsibility for companies and the finance sector as the market becomes more intertwined and complex. He sees that risk assessment has expanded beyond just managing financial risk but has extended to reputation which includes evaluating and limiting a client's environmental and social risk. There are two questions that companies consider carefully when setting up a corporate risk strategy.

1) Reputation: Where are you?
2) Brand: Where do you want to be?

He listed the sources of reputational risk and questions need to be considered both for the mid- and long-term:

1) Clients, Products & Transaction: describes the business we choose to do and who we deal with)
2) Operational Failure: assesses the design and control of our internal processes (i.e. data)
3) Priority Themes and Stakeholder Management: deals with internal and external thematic issues like environmental climate

He said that the Standard Chartered Bank is working carefully with clients on how best to evaluate environmental and social risks within their portfolio. Their approach includes providing position statements which guide their approach to financial services for clients who operate in sensitive business sectors (like mining and metals). In the past, Standard Bank has produced 20 position statements for 17 specific industries that are to be used by clients, media, NGOs, funds and other interested parties. Recent statements address topics like: climate change and energy financing, fossil fuel power generation and human rights.

Presently he said that there is scrutiny of the bank's investment decisions when evaluating energy projects, but that it would not be pragmatic to refuse the financing of all coal projects. He noted that on a global scale there are banks, largely from developing nations, that evaluate these projects in regions like Africa and Asia. Standard Chartered criteria are that it will not fund new standalone non-captive coal mines or projects with an emissions threshold criteria of 830 g/kWh or above, but the bank will consider projects at a lower threshold. The bank's criteria are similar to the standards adopted by other private lenders across the international banking sector.

In evaluating a borrower's risk profile, he provided an overview of the key components reviewed and how this information is collected and regularly updated. Assessments are also done at a client and transaction level and on an ad-hoc level for specific issues. The evaluation process goes beyond legal compliance, budget and management as well as review of sustainability of resources, people and the underlying business plan on a long-term basis. The role of his team is to make certain that companies are assessing their environmental risks adequately, adopting sustainable mitigation measures, and actively engaging with communities.

Mr Evans thanked the Speakers for their insights and opened up the session for questions.

Discussion

Mr Yoshihiko Sakanashi said that the financial houses should evaluate the specific locations and operations of power plants at the local level since this can be quite different between locations. ***Mr Eadie*** answered that all banks are impacted by the decisions at COP21 and need to consider market trends in evaluating climate risk. Their Financial Stability Board (FSB) is reviewing climate-related disclosures, and a report should be released shortly. In the market, there is a growing concern about stranded assets in the energy sector. He noted that Standard Bank is working with a University to develop a toolbox with assessment criteria that identifies the risks and opportunities at the asset level for case-by-case evaluations with transparency.

Mr Sporton asked the Speakers on their experience with banks in supporting the implementation of INDCs at the country level including the 22 nations using HELE as a carbon mitigation strategy. ***Mr Sethi*** answered that he has seen ongoing challenges for coal-fired plants due to land access challenges and wondered if this was also the case for solar projects. ***Mr Eaide*** said that for difficult decisions regarding environment and social risk factors, decisions are escalated to a senior committee for review. The report that is forwarded to the committee includes a statement with information on the country INDC. Currently, this is just information, and there is not a systematic way to quantify the risks. ***Mr Sethi*** believes that for many solar projects this is not yet a critical issue with many sites developed on unpopulated and unproductive land, but this is a risk for future projects as optimal land becomes scarcer.

Mr Kellow asked if Mr Eadie could provide further information on central bank regulations and retail perspectives in the sector and the financing of non-mining activities. ***Mr Eadie*** referenced an example from the Appalachian mining community in 2007 and believes that the mining sector and utilities need to work on the communication and work at the local level. He believes that communication would improve by engaging with pragmatic NGOs and the general public and providing a clear message on how this impacts daily life in the region.

Mr Beere said he noticed that in the presentations on the ASEAN region and India, the plan to use CCS technology was not noted and this could be a sign that the push for clean coal technologies is not being heard by policymakers. In Mr Donohue's presentation, GE is working to offer customers partnering and financing. He asked whether the financing used the standard of adopting "the best technology available" and under what terms. In the palm oil industry, companies are working to find a financing mechanism to achieve a positive result at the end of the supply chain, but they may lose financing of upstream projects. He believes that a better solution is found when industry works together to find a solution that optimises results along the complete chain of supplies. An example is to minimise overall carbon footprints from the source to end user.

Mr Evans closed the session by noting that even though CCS technology is proven, there is still delays in delivering the technology. In developing countries, the highest priorities are still in providing economic opportunities to citizens and improving living standards. While financing of coal projects is increasingly difficult, the speakers today showed that alternative options could exist directly with the equipment supplier or with existing banking institutions.

DISCUSSION SESSION 3
Achieving material CO_2 emission reductions from coal

Mr Peter Freyberg, Head of Coal Assets Glencore

Mr Freyberg opened the session stressing the important role of coal for many economies to fuel energy security and economic growth now and in the decades to come, but that this also includes the obligation to do so responsibly. The World Coal Association, CIAB and his firm, Glencore, as representatives of the coal industry, recognise that there needs to be a change in the narrative and the industry needs to work together to be part of the solution and achieve material reductions in CO_2.

Citing IEA analysis, he noted that 12% of total cumulative reductions in emissions should be solved using CCS technology to achieve the targets in the 2oC. It is estimated that the total costs to the global economy would be +138% more when CCS is not a viable part of the carbon abatement solution. As empirical studies find, without CCS it will be almost impossible to reach the targets in the Paris Agreement or to hold the "increase in the global average temperature to well below 2 °C above pre-industrial levels".

He said industry and governments together have proven that CCS is a feasible technology on a commercial scale that is already storing 27 mn tonnes of CO_2 emissions annually. According to the Global CCS Institute Annual report, between 2007 and 2016, global policy support for the energy market totalled approx. $800 bn, while the total amount spent for CCS deployment was around 2% or $20 bn. He stressed the importance of strong policy, which is lacking, drive strong action and provides a signal to industry when making investment decisions. He warned that an optimal solution would not be found if industry and government try to pick a technological winner citing the European wind market as an example. There are no national boundaries for CO_2 emissions, and the basket of solutions for the globe, region and nation must encompass all alternatives.

He reiterated that private firms like Glencore couldn't achieve this alone, but it will need partnerships between private and public entities to act and support project development, like FutureGen and Callide, to meet the goals of the Paris Agreement.

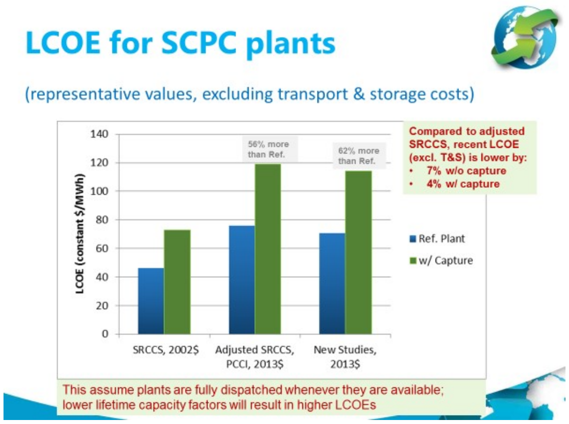
Cost of CCS and its value to the Electricity System
Dr. Keith Burnard, Project Manager at the IEA Greenhouse Gas Programme

Dr. Keith Burnard opened with an overview of the IEA Greenhouse Gas R&D Programme, which has been part of the IEA Energy Technology Network (ETN) since 1991 and has 32 members from 18 countries along with OPEC and the European Union. CIAB is also a Member and on the Executive Committee. He instructed that the purpose of the organization is technically based and not to define or advocate policy. The mission is to provide members and policy makers with a source of independent technical input. While their activities address all greenhouse gases (GHG), a main focus is to review the technical aspects, ongoing R&D and costs of CCS across the value chain from capture to storage and monitoring. He thanked the CIAB Associates for their ongoing support and input during the peer review process for technical papers.

He then turned to the development of CCS costs over the last decade based on the paper, "The cost of CO2 capture and storage", by Rubin, Davison and Herzog (RDH) that was published in the International Journal of Greenhouse Gas Control (IJGGC). A successful webinar on the topic, entitled "CCS cost trends and outlook", with two of the authors, was arranged by the IEA GHG Programme and took place on 27 October 2016 (https://www.youtube.com/channel/UCThjpzmbJU89kF7OqqQW9lw).

The initial Carbon Dioxide Capture and Storage special report (SRCCS) was completed by the Intergovernmental Panel on Climate Change (IPCC) in December 2005 and updated regularly to provide a comprehensive look at CCS as a climate change mitigation option. ***Dr. Burnard*** shared findings from the RDH paper which reviewed sixteen recent CCS cost studies covering all technologies from the U.S. and Europe for new power plants and adjusted all costs to a constant 2013 USD level for comparison purposes.

The RDH research paper found that the costs for post combustion CCS projects increased compared to the SRCCS initial assessments (conducted in 2003) for supercritical pulverized coal (SCPC) power plants. The cost increases were more notable when CO2 capture was included. A comparison of the levelized cost of electricity (LCOE), without transport and storage costs, shows that the cost increases over original estimates is more moderate at +7% without capture and +4% with capture cost estimates. Still the total capital cost of capture systems since SRCCS increased significantly by +52% on average over the period for the project for post-combustion SCPC projects ceteris paribus.



He pointed out that the results can often vary depending on the key assumptions used in an analysis such as basic power plant design (i.e. size of plant, plant efficiency, CO2 capture rates, etc.) making comparisons difficult. Still, some assumptions affecting CCS costs have changed such as the average power plant sizes without CCS (growing +10-25%), higher capacity load factors, and lower fixed charge factors over the time period. Additionally, the potential to use CO2-EOR as a supporting business case has increased in addition to capital and fuel costs since the original study period.

A comparison of three options shows that LCOE estimates are roughly unchanged but natural gas post-combustion projects represent the lowest cost option, but that these costs have increased over the past decade. The cost for SCPC post-combustion have remained steady and fall significantly if credits for EOR are utilized.

Total plant LCOE (2013 $/MWh)

(for CO_2 capture, transport and geological storage)

Case	NGCC post-combustion capture	**SCPC post-combustion capture**	IGCC pre-combustion capture
Without EOR			
SRCCS (adjusted)	56 – 110	**94 - 163**	92 – 150
Recent Studies	63 – 122	**95 - 150**	112 – 148
With EOR credits			
SRCCS (adjusted)	48 – 100	**76 – 139**	77 – 128
Recent Studies	48 – 112	**61 – 121**	83 – 123

LCOE ranges are roughly unchanged (particularly for SCPC, while some increases for NGCC and IGCC)

Mitigation costs (2013 $/t$CO_2$ avoided)

(for CO_2 capture, transport and geological storage)

Case	NGCC post-combustion capture*	**SCPC post-combustion capture***	IGCC pre-combustion capture*
Without EOR			
SRCCS (adjusted)	64 – 136	**45 - 114**	(Not available)
Recent Studies	59 – 143	**46 - 99**	53 - 137
With EOR credits			
SRCCS (adjusted)	38 – 107	**17 – 77**	(Not available)
Recent Studies	10 – 112	**(5) – 58**	3 – 102

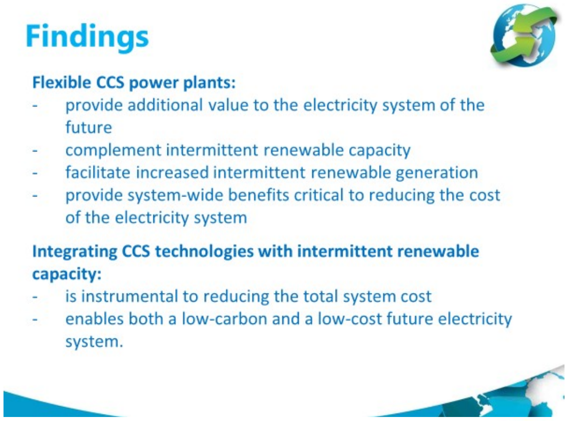
* Reference plant for all cases is a SCPC plant with no CCS

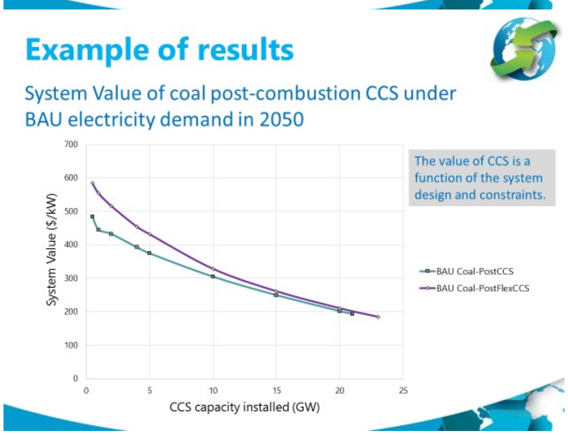
Mitigation costs also are roughly unchanged (some decreases for NGCC and SCPC)

The study found that there is potential for substantial cost reductions as measured by electricity cost ($/MWh) and mitigation costs ($/t CO2 avoided) that can be achieved from sustained R&D, implementing lessons learned from earlier projects, and with the creation of strong policy drivers for the next generation of CCS plants. The factors currently contributing to the higher costs of projects are rooted in: capital costs, commodity costs for construction (i.e. steel), stagnant design mechanisms and capture rates, and higher capacity factors yet lower utilization.

Still the high cost of CCS remains a barrier to the deployment path, and it is important to also look at the additional value provided by CCS technology before making final conclusions. ***Dr. Burnard*** said the IEA GHG worked with the Imperial College of London on a research project entitled "Valuing flexibility in CCS Power Plants," (MacDowell, Heuberger et al) to estimate the value that CCS delivers via flexibility as measured by system value and the reduction in total system costs. The paper conducted an initial study based on the European electricity system where the autonomous fuel decision is a function of resources, political context, and public acceptability which creates a trilemma. In the analysis, the researchers reviewed the value of electricity as measured through the value of lost load (VoLL) in the UK as a surrogate for the reliability of investments. In general, as electricity dependency rises the value of volatile generation patterns and VoLL also increased. The system value of power technology was defined as the reduction in total system costs from the deployment of CCS technology. CCS capacity offers an energy system flexibility to connect and balance power supplies and demand via ramping. In addition, flexible CCS power plants provide intermittent power for renewable capacity and lower costs for the entire electric grid system.

He pointed out that despite modelling constraints that ignore storage, the project collaborators strongly believe that these constraints are moderate compared to the improved quantitative results. He said that integrating CCS technologies with intermittent renewable capacity and offering flexible CCS power plants will be instrumental to reduce the total system costs that enable both the creation of a low-carbon and low-cost energy system for the next generation.





He closed with trends from the whole system perspective, CCS technology costs remain high, but the benefits of flexible CCS on total cost and the carbon intensity from power generation remain indisputable. Still, without carefully designed policies and incentives from local politicians, the move forward will be limited.

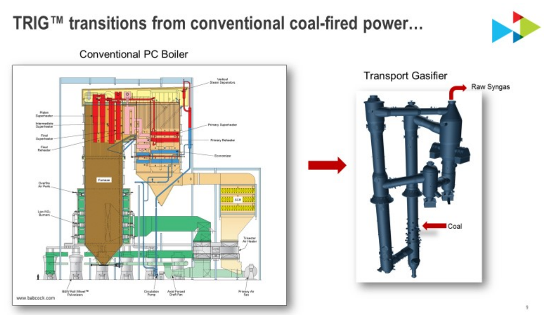
Southern Company view of Advanced Coal Technology (Kemper County)

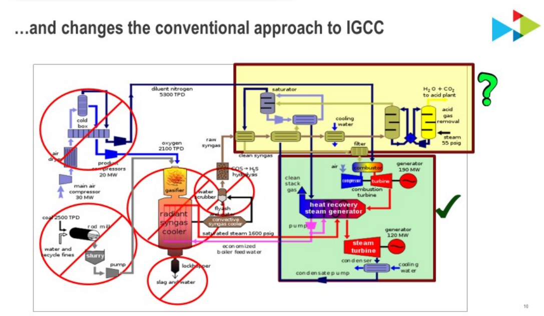
Kerry Bowers, President and CEO and Southern Generation Technologies, LLC

Mr Kerry Bowers opened his presentation with an overview of the Southern Company, the parent company of Mississippi Power, who is constructing the Kemper Energy Facility a critical first generation CCUS project that will be launching full operations shortly. Southern Company is a vertically integrated utility, made up of 11 electric and gas utilities and operating in 18 states. On the power side, they own 44 GW of installed capacity with a diverse generating portfolio. Southern is pursuing a "full portfolio" energy strategy further diversifying its portfolio and has built 14 GW of new natural gas units in the past ten years, 4,000 MW of renewable energy in the past six years, and is in the process of building two new nuclear plants. They are committed to advancing 21st century coal technology as illustrated in the construction of the Kemper County Energy Facility which is the largest scale IGCC plant in the world that includes ***CCUS and will capture 3.4 mnta of CO2.***.

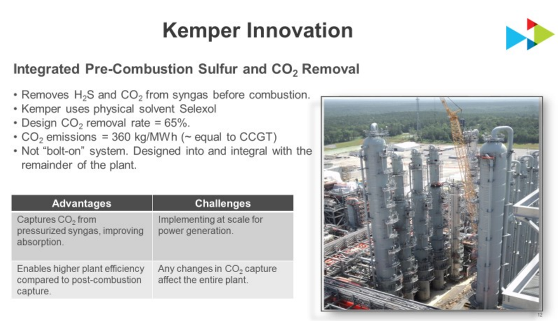
He explained that the Kemper site and IGCC technology offered many advantages for construction including the inland location, proximity to a stable economical fuel source (mine-mouth operation), economic benefits for the local state economy, and the environmental benefits and perspectives for this advanced technology. The availability of the TRIG technology enabled Kemper to keep lignite in Mississippi Power's fuel mix, which would have not been possible without the IGCC + CCUS project.

The company sees a bright future for the proprietary TRIG technology due to the abundance of low-rank coal reserves around the world, especially in regions with strong projected electricity demand growth. The technology was first developed for use with low-rank coals with a high moisture and ash content, like lignite, and moves from using a conventional PC boiler to a transport gasifier to produce syngas. TRIG technology was first developed in a joint R&D effort with the Department of Energy, Southern Company and KBR at the -Power Systems Development Facility to create a low-rank coal gasification process. This is now home to the U.S National Carbon Capture Center (http://nationalcarboncapturecenter.com)



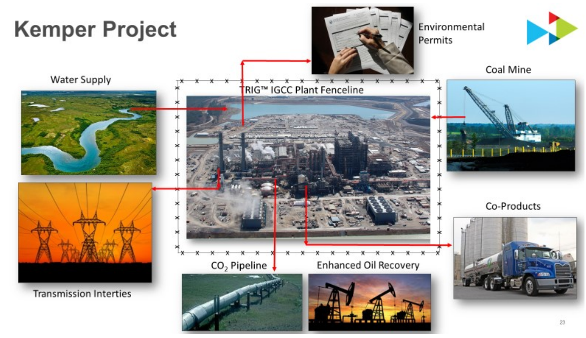


The innovations at Kemper extend also to the coal feeding system, fly ash separation and removal as well as the integrated pre-combustion process for sulphur and CO2 removal.

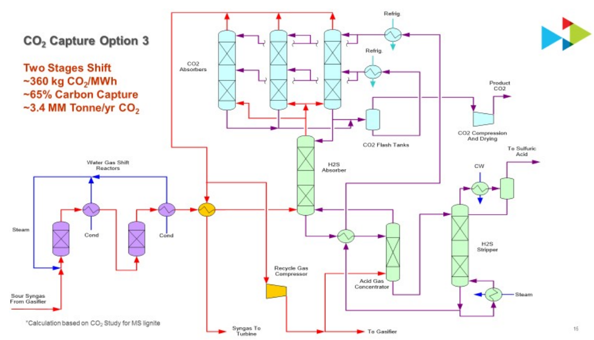


He provided a status report noting that the Kemper power block has been operational since 2014 and the gasification systems are also operational with the first syngas produced in July 2016. As of November, CO2 has been captured at the unit, but has not yet been delivered into the pipeline. The next task is to bring both units online simultaneously and this is expected in the near future.

The Kemper project is far larger than solely the TRIG with CCUS plant. The entire project is not just a first-of-a-kind IGCC plant combining carbon storage, but also includes a coal mine, water supply, and CO2 pipeline with enhanced oil recovery in addition to the equipment within the plant fence line.



Regarding CO2 capture, multiple CO2 capture designs were considered. A two-stage water gas shift option was chosen which limits resulting emissions to 360 kg CO2/MWh or the footprint of a CCGT plant by capturing 65% of CO2 emissions and producing up to 3.4 mtpa. The Kemper project is a poly-generation plant and produces more than electricity. When fully operational, Kemper is expected to also produce 127,000 mt of sulphuric acid and 17,000 mt of ammonia annually which can be sold to chemical companies along with CO2 for enhanced oil recovery.



The CO2 capture levels achievable by the TRIG technology as deployed at Kemper are at or below the 550 kg/MWh level established by some European investment banks, which can enable project finance options for future projects.

He closed noting the crucial lessons learned over the course of the Kemper project and hoped these would benefit the next generation of projects. Foremost, a change in the industry mindset is needed that embraces new technologies like Kemper, so a viable path forward for new coal is seen by policy makers and the public. It is crucial to have firm policy and permit requirements for emissions established early in a project timeline. The energy industry needs to see power plants such as Kemper equipped with carbon capture as poly-generation plants that co-produce electricity and other products, like CO2, which should be identified as a product and not a waste for disposal. He noted that skilled personnel comprised of a complementary mix engineering disciplines will be needed for further plants combining IGCC and CCUS. He closed by inviting all CIAB Members and the IEA Secretariat to visit the Kemper project onsite to see technology in action and a glimpse at what 21st century coal will look like.

An International Commitment to CCS: Policies and Incentives to Enable a Low-Carbon Energy Future

Mr Ken Humphreys, FutureGen Alliance

The key focus of the CIAB work programme was to submit a set of policy recommendations, both policy and financial, to the IEA that would help address the challenges faced by clean coal projects and to accelerate the deployment path for commercial-scale CCS throughout the globe to achieve the "Paris Goals". A copy of the submission can be found on the website at: https://www.iea.org/ciab/papers/CIAB_Report_CCSReport.pdf

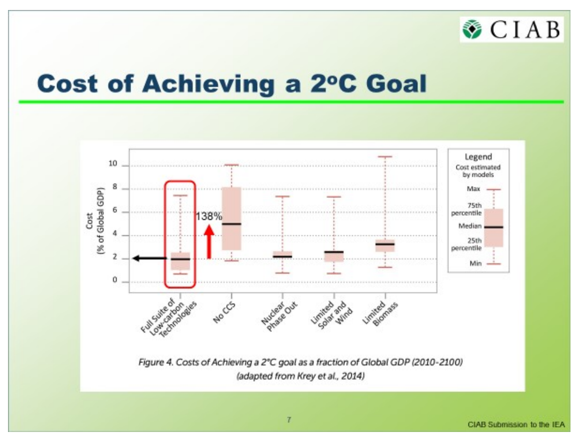
Mr Humphreys, who co-chaired the CIAB Working Group, said the first challenge undertaken was to evaluate the potential of CCS in fulfilling the goals of the Paris Agreement for climate change. The Paris agreement contains two goals:

- "Holding the increase in global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels…"
- "…balance sinks and sources post-2050…"

The 2°C goal which seeks to stabilise CO_2 concentrations in the atmosphere at ~450 ppm. The IEA estimates the need for at least 215 GW of CCS-enabled HELE plants by 2030 to maintain the trajectory. To achieve the far more aggressive target of "well below 2°C", carbon emissions would be required to peak well before 2035 and reach net-zero post-2050. Empirical research shows that this is likely unachievable without CCS and the timescale for action is quick with new power plants locking in carbon emissions for the next forty years. He pointed out that discussion often centres around the use of CCS in power generation, but it will need to be applied across diverse industrial, chemical and bioenergy applications to achieve this low carbon path. CCS is the only technology where root components are available for many industries to achieve the necessary net negative long-term emissions.

He said that the Paris Goals are not likely to be achieved without an international commitment to CCS and that this commitment does not exist today. International commitment would need to take shape via well-designed government policies that incentivize deployment and create an orderly transition for the energy system. The collaboration with industry to design these policies would foster an environment where banks are willing to finance CCS projects, industry can drive a wave of new projects, and create a climate for innovation and development. Additionally, the creation of more projects drives down the costs and commercial risks for investments.

In a simple example, ***Mr Humphreys*** outlined the estimated economic cost of achieving the 2°C target regarding global GDP. In the assessment, based on the recent IPCC's 5th Assessment which evaluates the cost of policies to limit global temperatures. This report used input from independent modelling teams from around the world on a mixture of CO_2 mitigation solutions and estimated that the average cost of achieving the 2°C scenario using all low-carbon technologies with CCS is the equivalent of ~2% total GDP annually or approx. $1.5 trillion dollars per year based on the last years global GDP. The estimated cost to achieve this target without CCS rises by +138% or to nearly 5% of global GDP. This equates to $3.5 trillion dollars which is roughly equivalent to the entire 2015 U.S. federal budget. The Paris agreement is based on a target of "well below 2°C" which would drive costs even higher and make the contribution needed from CCS even greater.



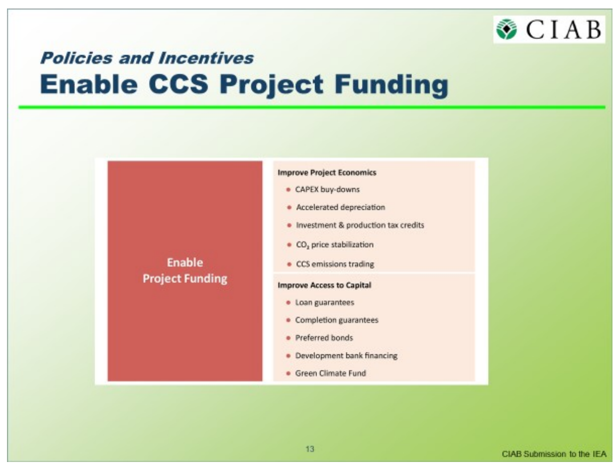
The positive news he reported is that industry and government have proven the feasibility of clean coal technology. There are over 670 coal-fired HELE plants in operation around the globe, another fifteen large-scale CCS plants in operation capable of storing 27 mntpa of CO_2 and another seven projects under construction. Still, the first-generation technology remains expensive and is still not always commercially available, but the second- and third-generation technology will reduce the costs and risks. Well-designed policies will be needed to systematically address the deployment challenges CCS faces around the globe. These challenges surround financing, transport and storage issues, as well as stakeholder challenges.

He outlined four categories of policies and incentives that would create an environment where industry can bring CCS deployment forward, incentivize commercial investment, spur competition and innovation, and reduce costs and commercial risks. These CIAB recommendations are based on project experience from experts across the energy industry. The actual basket of policies and incentives for a specific country or region will vary depending on market conditions, geographical location and government.

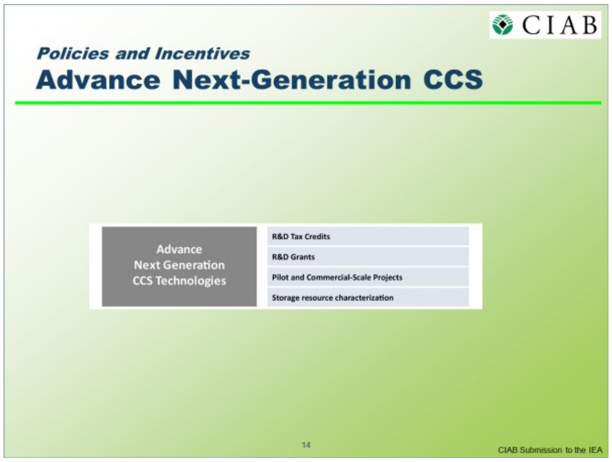
The first set is to stimulate CCS market uptake which could, for example, be achieved by providing or facilitating power purchase mechanisms or providing policy parity in portfolio standards and NDCs for all low carbon technologies.

The second group are mechanisms to provide support to project development, which could be achieved through many means. This could be providing development grants for projects with no cost-sharing during construction or by streamlining the permitting process. A key area that would assist with project timelines is the pre-qualifying and permitting of storage resources and the coordination of CO_2 transport infrastructure in a hub structure for multiple projects.

The third category is to improve basic project economics and provide access to capital customized to the individual needs of the area or project. This can be as simple as offering investment and production tax credits, providing loan guarantees, or access to low interest financing sources. A key issue for many nations dependent on coal is the establishment of financing through development banks and/or green climate funds offering parity for all low technologies.



The final category is meant to advance the next-generation CCS technologies and can be reached by offering tax credits and grants for further R&D and comprehensive storage resource characterization.



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Also, he noted the importance of intra-governmental coordination at the onset of projects that can cut across these categories in regions. An example is the work being done in Japan to find alternative storage sites.

He wrapped up his speech by encouraging all Members and Associates to advocate for CCS within their networks by presenting a positive narrative on the benefits and necessity of CCS as a climate change solution. An international commitment, from government and industry, will be needed to put in the necessary policies and to set up the channels to deploy CCS at the scales demanded in the Paris Agreement.

In closing, he extended his appreciation to the fourteen members of the working group for their input, contributions and intensive feedback as well as those external authors who contributed to the case studies.

Discussion

Mr Freyberg thanked Mr Humphreys for his work and has a great appreciation for the explanation of what the cost of a carbon mitigation plan could be both with and without CCS. He sees the need to build up this positive narrative when approaching government and opened the floor to questions.

Mr Buffier asked Mr Lipponen about why he felt the 2008 G8 commitment to have 20 CCS projects by 2020 had waned and what would be needed to return to that commitment level. He answered that there is no single answer. First, there needs to be greater collaboration between players and second CCS needs to a focus on the COP agreements, in work with the UNFCCC, and by governments embedding CCS in their NDCs. The heavy hitting governments like US, China, and Australia should be more willing to combine experience and to share their knowledge via international collaboration. More collaboration is needed and it needs to be more vocal and consistent. He said that the IEA can do this when they hold their meetings with the policy makers.

Mr Richard Reavey commended Ms Fisher, Mr Humphreys and Ms Rademacher for "herding this collaboration" to deliver a great piece of work. He said the next critical step is to turn this into an action plan for the 2017 work program.

Mr David Bryson said that this action needs to be made tangible, even if the answer is intangible. He asked the forum, "What are we doing with these governments?" He said the CIAB needs to be clear as a group of what actions it will take via the IEA. Even if it is the only conversation, there needs to be consistent communication planned to make certain this is picked up and acted on.

Mr Hartung reflected on Dr Birol's strategy to widen the approach of the IEA and increase collaboration in industry and energy security. He said it is imperative to create an awareness with politicians to move this forward and that this work needs to be undertaken in conjunction with other associations and industrial partners to get the message out beyond the coal industry. He said it is a fact that public sentiment currently does not want CCS as a solution to meet the goals of the Paris Agreement.

Mr Lipponen remarked that one of the lessons is that currently there is no downside publicized for not doing CCS or backlash for politicians that have abandoned CCS projects or funding. He said a potential partner to move CCS forward would be to work with selected members of the NGO community. He asked Mr Bower whether there were key lessons learned in the utilisation of TRIG technology and changing regulator CO_2 targets.

Mr Bowers answered that there needs to be regulatory certainty before a plant design basis is completed to minimise political risk and cost overruns. He pointed out that there is no clear definition for "capture-ready" often cited in legislation. This depends on the type of technology utilised and capture ready activities needs to be defined and designed before construction.

Mr Humphreys asked how an international commitment should be defined and whether it incorporates cooperation or would include a governing organization. ***Mr Lipponen*** does not envision a signed document, but he instead drew a parallel to the renewables market where leading countries made a commitment to put policies in place, supported by legislation, which created a stable environment for investment. In the U.S., the average tenure at the Department of Energy is 18-24 months, but the project planning phase is often six to ten years. A stable policy environment is needed successfully launch project financing even with a change in government. He said that if you establish the momentum, other countries would fall in and choose to join the effort.

Mr Janakaraj said that strong advocacy from the industry is needed especially with the volatile political cycles in countries around the world. He feels the next step is more engagement with NGOs and a focus on bringing the public on board with clear messaging. He asked whether CCS technology is being marketed and is available for others to implement on a global scale.

Dr Ling Wen thanked Mr Bowers for the excellent presentation on this pivotal project. He asked how diverse the fuel basket could be using the TRIG technology and for more information on profitability. ***Mr Bowers*** answered that it was developed for low-rank sub-bituminous coal basket, but new technology would be available shortly for all fuels including bituminous coal. He said the cost of all first-of-a-kind plants is always high and the Kemper project has been very transparent with the ongoing project costs and overruns. He saw Kemper as “CCS gift to the world” and is optimistic that future projects would be built at a lower cost.

Mr Freyberg thanked all of the speakers, Mr Burnard for sharing facts on CCS costs and benefits, Mr Bower for sharing lessons learned from the Kemper project, and Mr Humphreys for leading and presenting the CIAB policy recommendations for CCS. The high level of interest of CIAB Members is reflected in the number of questions and interest shown in developing an advocacy plan together.

Mr French remarked on the renewed sense of purpose and positive energy in the air after the third Discussion Session. He hopes this continues while discussing the upcoming work program.

Annex – Plenary Meeting Participants

CIAB Members

Mr	David	Bryson	Chief Operation Officer - Asset Operations, Uniper	DEU
Mr	Andrea	Clavarino	Chairman, Assocarboni and Chief Executive Officer, Coeclerici Logistics	ITA
Mr	Ted	Doheny	President and Chief Executive Officer, Joy Global Mining, Inc.	USA
Mr	Seamus	French	Executive Chairman, Anglo American Coal	GBR
Mr	Peter	Freyberg	Head of Coal Assets, Glencore	AUS
Mr	Thava	Govender	Group Executive: Transmission & Sustainability, Eskom Holdings Ltd.	ZAF
Mr	Robert	Gentile	President and Chief Executive Officer, Leonardo Technologies Inc.	USA
Mr	Mathias	Hartung	Member of the Executive Board, RWE Power AG	DEU
Mr	Ken	Humphreys	Chief Executive Officer, FutureGen Alliance Inc.	USA
Mr	Jeyakuma	Janakaraj	Chief Executive Officer, Adani Mining	AUS
Mr	Glenn	Kellow	President and Chief Executive Officer, Peabody Energy Co. Inc.	USA
Mr	Colin	Marshall	President and Chief Executive Officer, Cloud Peak Energy Resources LLC	USA
Mr	Yoshihiko	Sakanashi	Senior Counselor, J-POWER	JPN
Mr	Benjamin	Sporton	Chief Executive, World Coal Association	GBR
Mr	Angel	Vivar	Director of Energy Resources and Environment, UNESA	ESP
Mr	Fernando L	Zancan	President, Brazilian Coal Association	BRA

CIAB Associates

Mr	Julian	Beere	Head of Business Development and Strategy, Thermal Coal, Anglo American Operations Ltd.	GBR
Mr	Mick	Buffier	Group Executive, Coal Assets, Glencore	AUS
Mr	Graham	Chapman	Advisor to the CEO - International Development, SUEK (Siberian Coal Energy Company)	RUS
Ms.	Gina	Downes	Corporate Consultant: Environmental Economics, Climate Change and Sustainable Development Department, Group Sustainability, Eskom	ZAF
Mr	Mücella	Ersoy	Chief Engineer, Project Planning Dept., Turkish Coal Enterprises	TUR
Ms.	Nikki	Fisher	Coal Stewardship and Carbon Footprint Manager, Anglo Operations Limited	ZAF
Mr	Rajesh	Gupta	Head of Finance and Company Secretary, Adani Mining	AUS
Mr	Frank	Huschka	Head, Fuel & By-Products, Operational Support, Global Unit Next Generation, Uniper	DEU
Mr	David	Lawson	Vice President, Coal, Norfolk Southern Corporation	USA
Mr	Roland	Lübke	Economic Affairs, German Coal Association (GVSt)	DEU
Mr	Liam	McHugh	Policy Advisor, World Coal Association	GBR
Mr	Itaru	Nakamura	Executive Managing Officer, J-POWER	JPN
Mr	Richard	Reavey	Vice President Public Affairs, Cloud Peak Energy Resources LLC	USA

Mr	David	Ruddell	Vice President, Strategy and Development, Coal, BHP Billiton	AUS
Mr	Shintaro	Sawa	Director, Energy Business Dept., J-POWER	JPN
Dr	Hans-Wilhelm	Schiffer	Advisor to the RWE Executive Board	DEU
Mr	J. Gordon	Stephens	Washington Representative for Joy Global Inc., P&H Mining Equipment and Joy Mining Machinery	USA

CIAB Speakers & Guests:

Mr	Markus	Becker	GE Power	CHE
Mr	Kerry	Bowers	President and CEO and Southern Generation Technologies, LLC	USA
Dr	Keith	Burnard	Project Manager, IEA Greenhouse Gas Programme	GBR
Mr	Michael	Donohue	Chief Marketing Officer, Power Services, GE Power	CHE
Mr	Mark	Eadie	Acting Head, Environmental and Social Risk Management, Standard Chartered Bank	GBR
Mr	Roger	Emslie	Director EMEARC Primary Fuels Fundamentals, Wood Mackenzie	ZAR
Mr	Greg	Evans	Executive Director Coal and Chief Executive of the COAL21 Fund	AUS
Dr	Andrew	Minchener	General Manager of the IEA Clean Coal Centre	GBR
Mr	Serge	Perineau	CTX	FRA
Mr	Brian	Ricketts	Secretary General, EURACOAL	BEL
Mr	Girish	Sethi	Senior Director Industrial Energy Efficiency Division, The Energy and Resources Institute	IND
Dr	Atit	Tippichai	Manager of Policy Research and Analytics Programme at the ASEAN Centre for Energy	IDN
Mr	Jiang	Wen	Shenhua Research Institute	CHN
Dr	Ling	Wen	President and Chief Executive Officer of Shenhua Group	CHN
Mr	Yunhi	Zhang	Shenhua Group	CHN

IEA & Staff:

Dr	Fatih	Birol	Executive Director, IEA	INT
Mr	Eren	Cam	Gas, Coal and Power Markets Division, IEA	INT
Mr	Carlos	Fernández Alvarez	Senior Energy Analyst (Coal), Gas, Coal and Power Markets, IEA	INT
Mr	Juho	Lipponen	Head of the Carbon Capture and Storage Unit	INT
Mr	Raimund	Malischek	Gas, Coal and Power Markets Division, IEA	INT
Ms.	Samantha	McCulloch	Energy Analyst (CCS), IEA	INT
Mr	Kamel	Naceur	Director for Sustainable Energy Policy and Technology, IEA	INT
Ms.	Maggi	Rademacher	Executive Co-ordinator, CIAB	INT
Mr	Keisuke	Sadamori	Director, Energy Markets and Security, IEA	INT
Mr	Tristan	Stanley	Energy Analyst (CCS), IEA	INT
Mr	Kevin	Tu	Gas, Coal and Power Markets Division, IEA	INT
Dr	Johannes	Trüby	Gas, Coal and Power Markets Division, IEA	INT
Mr	László	Varró	Chief Economist, IEA	INT

Coal Industry Advisory Board

For more information about the IEA Coal Industry Advisory Board, please refer to www.iea.org/ciab, or contact Carlos Fernández Alvarez at the IEA (Carlos.Fernández@iea.org) or Maggi Rademacher, CIAB Executive Coordinator (coordinator@ciab.international).

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