KAPSARC Energy Workshop Series

Has Coal Come to a Fork in the Road?

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About KAPSARC

The King Abdullah Petroleum Studies and Research Center (KAPSARC) is an independent, non-profit research institution dedicated to researching energy economics, policy, technology, and the environment across all types of energy. KAPSARC's mandate is to advance the understanding of energy challenges and opportunities facing the world today and tomorrow, through unbiased, independent, and high-caliber research for the benefit of society. KAPSARC is located in Riyadh, Saudi Arabia.

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Key Points

Coal's future depends on politics and technology. The world currently seems divided between the OECD members—attempting to phase coal out of their energy mix—and much of the rest of the world that is torn between access to cheap energy and its environmental impacts. This leaves governments faced with convincing their citizens to pay for climate change policy before securing access to their basic needs. Regardless of which view prevails:

- Even the externalities of renewable energy development, such as intermittency, reliability and system efficiency impacts, will not be sufficient to prevent coal becoming commercially uncompetitive, particularly if a global climate deal is achieved that imposes carbon pricing.
- China may cease to be a major importer of coal. It is planning to reduce coal's share in its energy mix and may even reduce coal demand in absolute terms.
- India may pick up the slack resulting from any reduced global coal market role for China. However, India's ambitious plans to boost domestic production could stymie such hopes.
- For now, coal is winning the 'battle for Asia' against natural gas, based on its affordability, but its future depends on successful, widespread adoption of carbon capture and storage (CCS).

Coal is clearly approaching a fork in the road and it will not be long before we have a clearer view of which turning it will take.

Executive Summary

Fuel mix forecasts tend to fall into one of two categories. One says that coal, and fossil fuels more generally, will enjoy growing demand and supply based on their expected economic competitiveness. The alternative sees fossil fuels, and coal in particular, as falling victim to policies designed to transition to a low carbon economy. Which of these two potential outcomes takes place appears to depend on the extent to which the developing economies that rely on coal for their growth can bear the additional costs of alternatives.

History shows that the future can differ widely from expectations. Only 15 years ago it was common to assume that coal was a declining energy source—a relic of 20th century industrialization. In fact, it has grown more quickly than any other source of energy and, by some estimates, may exceed even oil as the largest component of the global energy mix. Whatever the future holds, it will likely be different than the one imagined. One of the most pressing questions on the minds of policymakers is therefore: *what should the future be for coal?*

Coal faces an almost certain future of declining demand in the West, contrasted by a very likely increase in consumption in Asia and the rest of the developing world. In particular, China and India have become the central focus of future discussion as, together, they consume over 60 percent of the coal produced in the world. Efficiency improvements in power generation and technology pathways to lowering the environmental impact of coal use do not come without challenges. But success in either of these two dimensions may not produce enough abatement to reverse coal's negative impacts.

An agreement on climate change at the UN Climate Change Summit (COP21) meeting in Paris would have an enormous potential impact on coal demand provided it incorporates approaches to implementation that ensure compliance. Even then, any significant decline in coal demand would lead to appreciably lower prices than are seen today and could create more headroom to invest in measures that abate the environmental impacts of coal use. The future could see more coal than its detractors intend and less than its promoters hope. However, the long lead times,

installed capital stock and relatively low cost of coal as an energy source will ensure that it continues to be an important part of the global energy mix during any reasonable planning horizon.

Background to the Workshop

In March 2015, KAPSARC and the Clingendael International Energy Program convened the second workshop in a series on coal. The event was held at the Huys Clingendael in The Hague, Netherlands.

Over two dozen international experts on coal production, sales, logistics, and modeling gathered to share their insights on the theme topic 'Does coal have a future?', with specific emphasis on answering some of the most critical questions facing the coal industry:

- Will coal continue to enjoy growing demand and supply based on its expected economic competitiveness or will it fall victim to policies designed to transition to a low carbon economy?
- Is peak coal demand in China a real possibility? If so, when, how and at what level will it peak?
- Will India become the new China in terms of international coal demand?
- Are renewables ready to displace coal or can CCS make a difference?
- Can changes in the efficiency of its use change coal demand patterns?
- Will the COP21 meeting provide the catalyst for a decline in coal demand?

The Role of Coal in Economic Development

Despite being challenged by policies designed to reduce energy demand, limit CO_2 emissions and grow the share of renewables, global coal consumption has grown faster than any other fuel over the last 25 years. During the same period, the share of fossil fuels in the primary energy mix has remained constant at 82 percent, which means that the coal intensity of the global economy has increased as populations and economies have grown. In addition, most of the major current energy projections seem to contain coal as a major component of the primary energy mix for at least the next two decades. It appears that policies designed to curb CO_2-intensive fuel demand have underestimated the resilience of coal.

While OECD policymakers appear to feel increasingly dissatisfied about having coal in the mix, nobody disputes that energy is essential to societal wellbeing. For many developing economies, coal is a form of starter energy—a step up from biomass—and essential to progressing industrial development. Electricity would certainly help improve the lives of those 1.3 billion people who do not have access to it and for many countries coal is the cheapest and most easily accessed primary energy option. KAPSARC's own research on the strong growth of coal in the last decade concluded that a key lesson to be drawn from the period 2000-2007 is that: "Governments of emerging economies will not easily turn their backs on a source of energy that is affordable and reliable to drive economic growth. The relative costs of energy are as important to them as social, political and environmental considerations in shaping the global energy mix." [KAPSARC, 2015]

However, public acceptance is shifting, and social media is changing the way pressure is exerted on policymakers. The popular success of the documentary *Under the Dome* may serve as an indication that the future of coal will be shaped by societal pressure, forcing tougher policies on coal. The dominant position of coal in the global energy mix could be challenged as public understanding of the long-term impacts of fuel choices and policies grows. Certainly it demonstrates that local pollution—that can be seen and

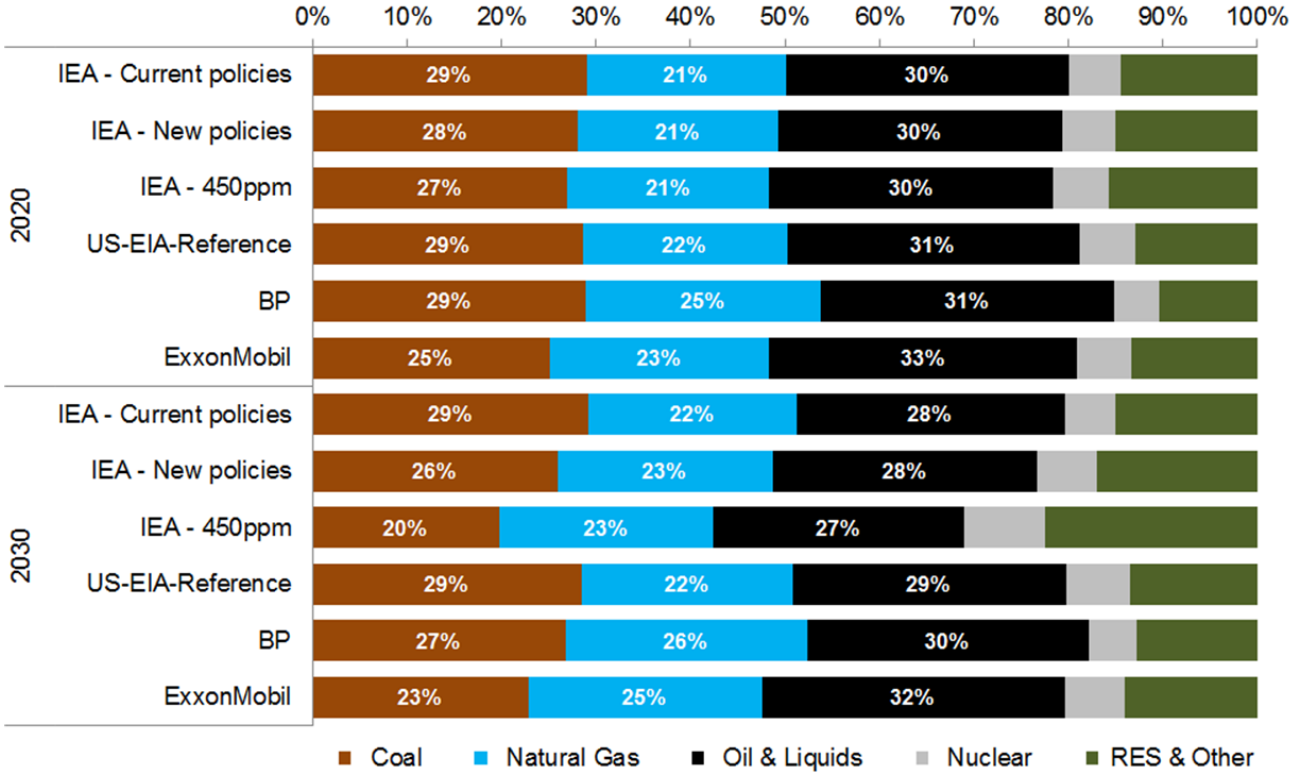


Figure 1 – Summary of Six Different Fuel Mix Scenarios to 2030
Source: NERA analysis from IEA (WEO 2014), EIA (IEO 2013), BP (2014 Outlook to 2035), ExxonMobil (2015 Outlook for Energy)

smelled—is a far more powerful determinant of public acceptance than global climate change.

Egypt, on the other hand, provides an example of public pressure to gain access to cheap energy. The country has experienced power blackouts every summer for a number of years, as a result of insufficient gas supplies, rapid population growth and budget deficits exacerbated by electricity subsidies. As a result, the government has decided to lift its ban on coal imports and to include coal in its planned electricity mix. The cement industry, particularly impacted by regular gas supply outages, has also benefited from the ability to import coal at a time when cement is in high demand. Infrastructure development and access to electricity are the most pressing priorities for Egypt.

Coal Survival Strategies in a Downturn

Seaborne coal trade volumes and prices are a proxy for the overall condition of the global coal industry. A review of events over the last 25 years of the global coal trade can illustrate how the industry has steered through tough times and how it is likely to respond in the coming years.

During the decade of the 90s, before the acceleration of economic growth in China and India, the global thermal coal market remained subdued as a consequence of relentless competition from new low-cost coal exporting countries. Demand growth was not enough to keep up with the glut in supply, putting prices continuously under pressure. The effects of coal-on-coal competition rather than

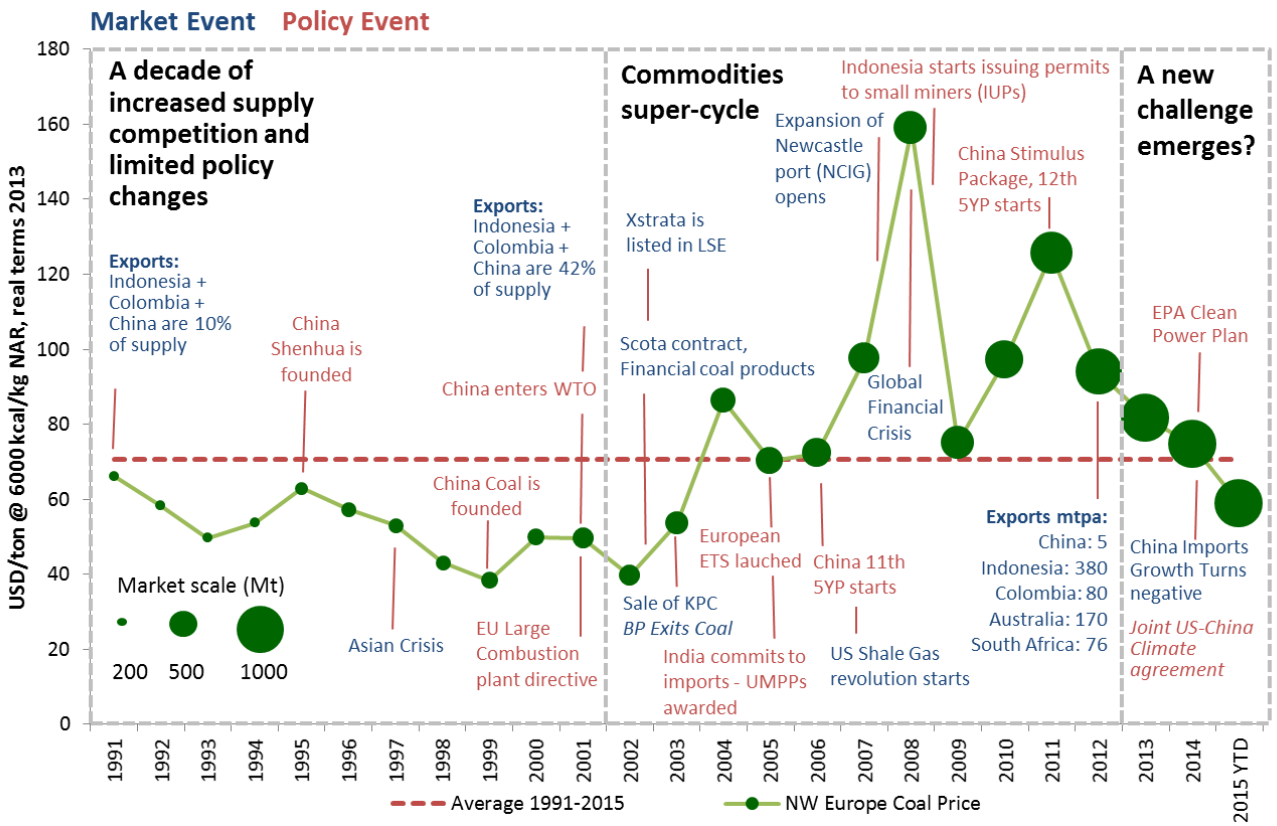


Figure 2 – Prices and Volumes in the Seaborne Coal Market During 1991-2015
Source: KAPSARC Analysis

policy changes defined market dynamics during this period. Climate change and decarbonization of the economy were not yet issues in the minds of policymakers.

After 2001, a global acceleration in seaborne demand in countries including China, India, Southeast Asia and even the U.S., resulted in a period of booming coal prices. This period gave a much needed respite to producers from the previous decade of price weakness and even encouraged coal companies to invest in new capacity. Nonetheless, policy and market pressures started building against coal, with the European Union launching the first large Emissions Trading Scheme (ETS) in 2005 as well as the Large Combustion Plant Directive; China deploying significant efforts to improve energy productivity; and the U.S. undergoing what has become known as the 'shale-gas revolution'. None of these policies or events, however, appeared to have an impact in the decade of the 2000s.

The decline in Chinese coal consumption and imports in 2014, together with the ongoing contraction of the domestic U.S. market, seems to signal a change in the trend for coal demand and the start of a new down-cycle for the industry. This has prompted coal producers to compete for survival by increasing efficiency and lowering capital expenditure in existing operations. Scheduled greenfield projects, including the Galilee and Surat basins in Australia, will likely be postponed and potentially cancelled entirely as investors become increasingly wary that these assets might become stranded. The industry is beginning to respond on the basis that this down-cycle might not be followed by an up-cycle—peak coal demand could be in sight.

What Does Xi Jinping's 'New Normal' Mean for Coal in China?

Given that China produces and consumes approximately half of the coal in the world, it is fair to say that the future of coal depends to a large extent on China. It is, therefore, important to understand whether the implication of Xi Jinping's 'New Normal' is that coal demand will peak in China and, if so, when that peak will occur. To answer this question requires an understanding of the transformation of three major drivers:

- the changing structure of the economy;
- the resulting industry restructuring;
- Chinese energy and environmental policies; and
- structure of the Chinese Economy.

Structure of the Chinese Economy

The level of coal consumption in China in the long run will be largely determined by the relative participation of the industry and services sectors in the economy. The 'New Normal' is a reference to the transition that other countries have gone through as they moved from emerging industrial economies to developed heterogeneous economies. The accepted implication for China is that the services industry should gradually become a key element of the national economy, resulting in a decline in energy intensity and a potential reduction in coal demand.

However, the relative position of industry within the Chinese economy seems to have stronger roots than in other countries. The reduction of industrial participation in GDP seems to be taking place at a

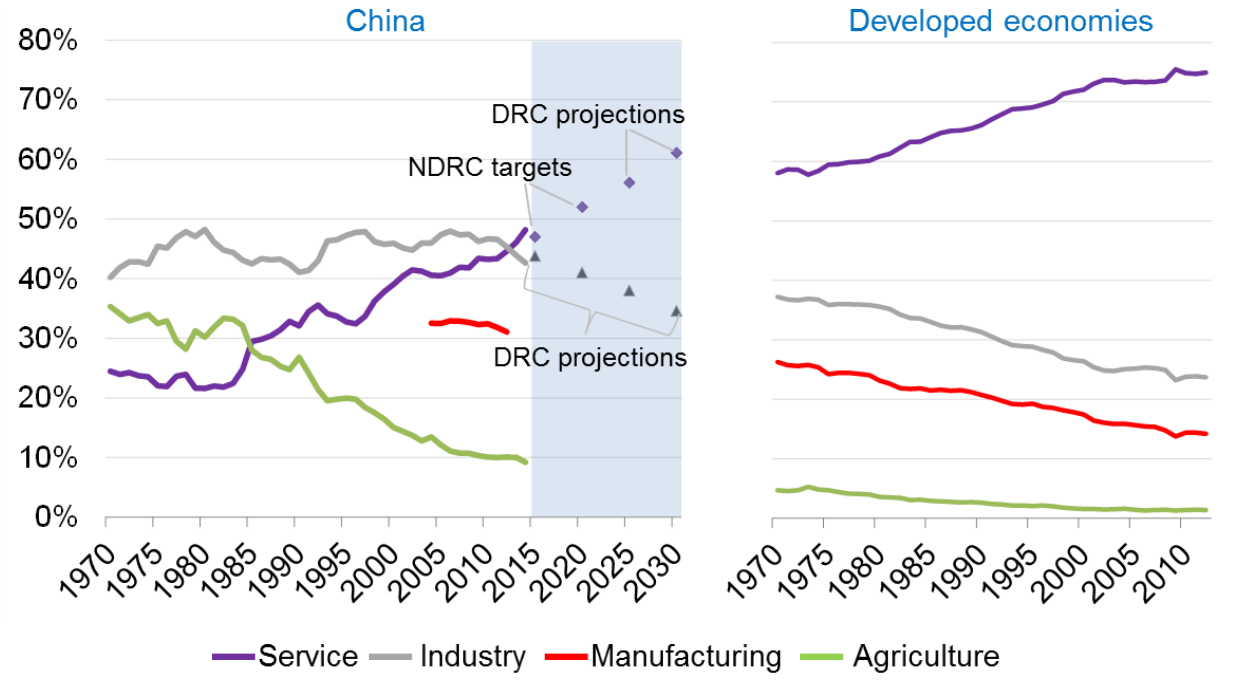


Figure 3 – Transition of the Economic Model of China vs. Other Economies
Sources: EIA, UNCTADstat, China National Bureau of Statistics (NBS) National Development and Reform Commission (NDRC, September 2014). Development Research Center of State Council (DRC, 2013)

slower pace than would be expected compared with the path followed by others. Though it is clear that the government is targeting 60 percent of GDP from services by 2030, this is still well below the typical level for other developed economies, which is closer to 75 percent.

Industry Restructuring: Emphasis on 'Lighter'

In the last 30 years, manufacturing has consumed approximately 70 percent of primary energy in China. However, industry has started shifting away from heavy manufacturing, with cement, pig iron and steel production growing by just 2 percent in 2014, compared with over 20 percent per annum in the early 2000s. This change of industrial focus has begun to reduce the proportion of energy used in manufacturing in China, which has fallen slightly to below 68 percent. This is one of the main reasons that, according to the latest official figures, demand for coal in China declined by 3 percent in 2014, the first reduction since the Asian crisis of 1998.

Energy and Environmental Policies: Approaching the Problem from all Angles

Efficiency increases in the industrial and electricity sectors have played an important role in attaining the target of reducing energy intensity by 16 percent during the 12th five-year plan. Power plant efficiency, for instance, has improved from 30 percent in 2000 to 38 percent in 2013, reducing coal demand by 500 MMmt in 2013 alone, if all other factors remained the same.

Other initiatives for improving efficiency and increasing the quality of demand include, 1) the banning of small, coal-fired boilers, of which China had up to 270,000 units in the late 2000s; 2) the migration towards higher use of electricity rather than direct burning of coal in industry, which makes it easy to substitute coal by renewables; and 3) the banning of the construction of new subcritical coal-fired power plants since 2010.

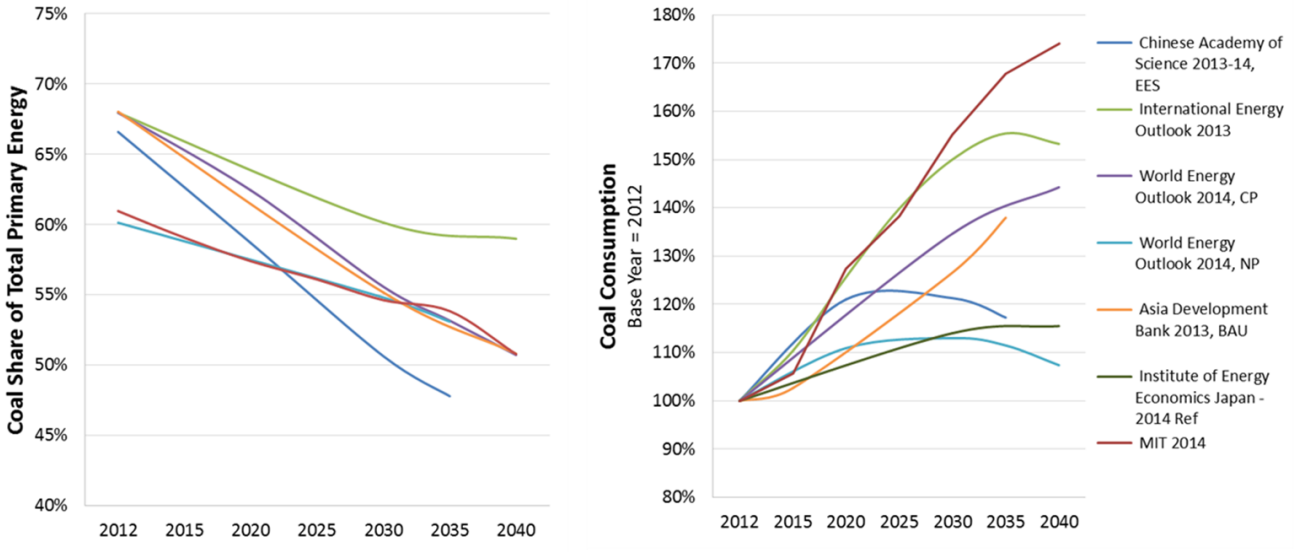


Figure 4 – Transition of the Economic Model of China vs. Other Economies

Sources: EIA. Notes: Projections are extracted from or estimated based on the following outlooks: World Energy China Outlook 2013-2014 by Chinese Academy of Social Sciences; IEO2013_ref; WEO2014 Current and New Policy Scenarios; Asian Development Outlook 2014 by Asian Development Bank; IEEJ2014_ref; MIT2014

Largely as a result of these three external drivers, the participation of coal in the energy mix has started to decline. In spite of some differences regarding historical data and differences in the definition of primary energy, most forecasts predict that by 2040 the proportion of coal in the energy mix will have moved from the current 60-65 percent to 45-60 percent. Consensus regarding peak coal demand in China, however, is harder to come by, with the timing of the predicted peak ranging from anywhere between 2020 and post-2040 and its magnitude from 12 percent to over 70 percent above 2012 levels or 4,000 to 6,120 MMmt of raw coal.

This highlights the wide range of possible outcomes for China and the fact that even small differences in economic structure result in substantial changes for the domestic and international industries. China could equally resume its appetite for imports or become a net exporter, as it was in the 1990s. For the international coal industry, the difference between these two positions could define whether producers and supply chains survive or disappear.

India's Coal Growth: Dependent on Repairing a Broken System?

India is endowed with the fifth largest coal reserves globally and it is the third largest coal producer and consumer. The country, however, has a chronic history of power shortages and its per capita electricity consumption is one-third of the world's average, at just 940 kWh per person per year. In comparison, China and the United States consume 4,000 kWh and 14,0000 kWh per capita, respectively.

Approximately 700 GW of electricity generation capacity will be needed in India by 2030 and, even allowing for the success of current efforts to increase the share of renewables and gas, most scenarios have something in common: coal-fired generation capacity will, at least, double over the next 15 years.

Challenges in the Indian Electricity Sector

Power distribution losses in India are high by global standards, amounting to 40 percent on average, with commercial losses accounting for approximately

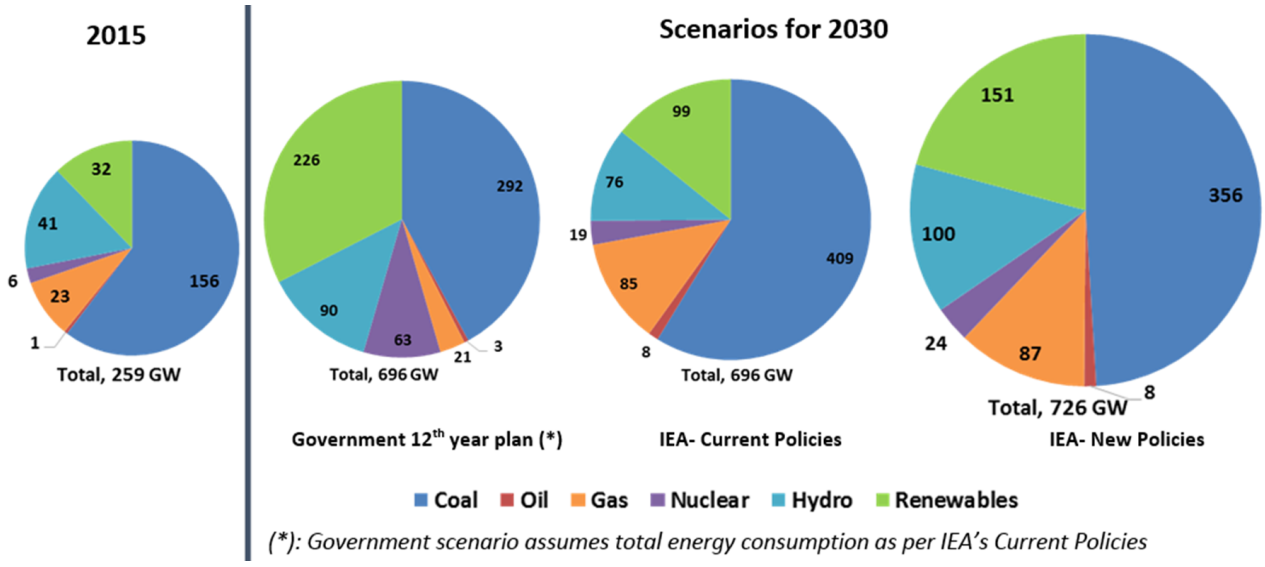


Figure 5 – Projections for Electricity Capacity Mix in India
Source: KAPSARC Analysis, IEA, Ministry of Power in India

three-quarters of this total. Distribution companies often struggle to recover the cost of electricity, and have no other choice but to limit power supply during certain times of day in the face of out of control demand and theft. The lack of reliability of the electricity system has led businesses and wealthier households to generate electricity for their own use from small diesel generators, of which the country currently has 90 GW, though these are not included in the official capacity numbers. Electricity from these sets, however, does not come cheap, with a levelized generation cost of approximately $250/MWh. Generators provide an unsustainable patch fix, rather than a solution in a system plagued with inefficiencies that need to be addressed by the government.

This situation has led to a discussion of whether distributed options for power in India could make a difference. Coal is the cheapest alternative but it is mainly suitable to centralized systems, which rely on functional distribution and retailing of electricity. Currently, demonstrations of the mini and micro-grid concept are taking place across India, with financing from NGOs, private companies and government incentives. Despite the government support for the concept, the issue remains that the cost of each one of these grids is too high for villagers to afford without large subsidies. Mini and micro-grid developments might be suitable for rural areas, but not for industrial development. Progress in distributed systems cannot preclude efforts to fix the centralized electricity system.

More Domestic Coal Production is Urgently Needed

The increasing reliance of India on energy imports is an issue at the top of the agenda in Indian politics. If actions are not taken, India's dependence on imported energy will increase from 30 percent in 2012 to nearly 70 percent by 2030. Nevertheless, shortages of domestic coal supply have led to a sharp increase in coal imports, which have grown from 24 to 176 MMmt in the period 2005-2014 (22 percent CAGR). India is now the second largest thermal coal importer in the world, and could soon overtake China.

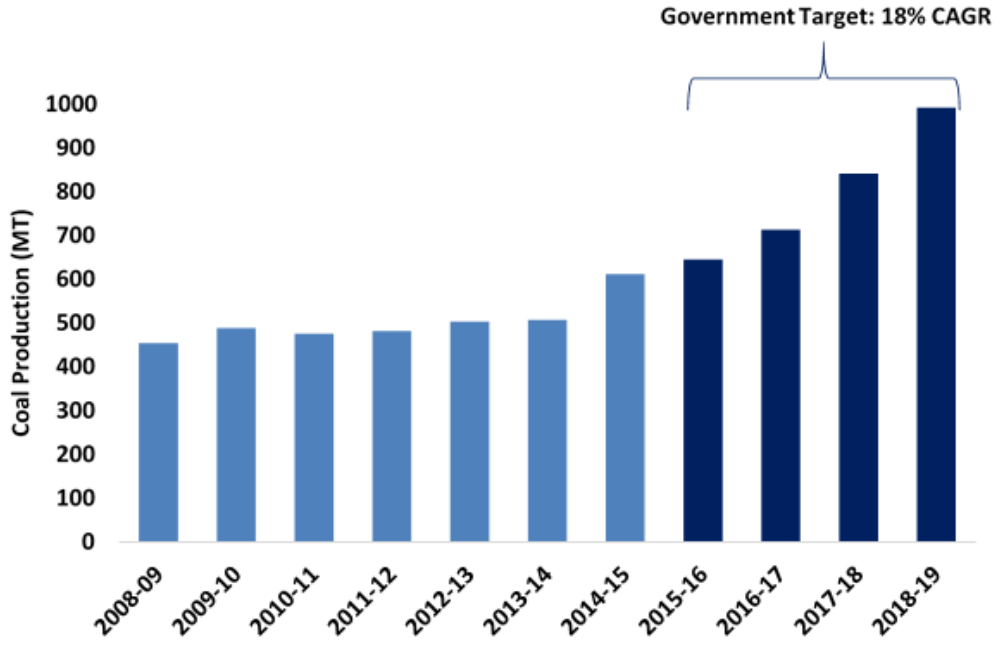


Figure 6 – Indian Government's Domestic Coal Production Growth Plan
Source: KAPSARC Analysis, Indian central government coal production announcements

Consequently, one of the most pressing factors in improving local energy supply is to increase domestic coal production. The Modi administration has requested the state-owned coal producers to double production from just over 500 MMmt, to one bmt by 2019. In the longer term, another 500 MMmt could come from 207 coal blocks that the government has started re-auctioning to private companies after the transparency of the previous process was called into question. Additionally, the government has called for foreign companies to participate in a liberalized coal mining sector—historically, a sector largely controlled by the government.

India could become the second largest coal producer in the world if its plans materialize, but that would require successful reform of the sector. The level of growth required by the government plan would by far exceed the historical growth rates the Indian coal industry has achieved. Additionally, clearing the land needed for the expansion of coal mines could cause significant social distress in poor regions such as Chhattisgarh, West Bengal and Jharkhand. Thousands of people would need to be displaced from their farming areas to give way to mining and forests would need to be stripped.

Another challenge for domestic growth is logistics, as railways are the backbone of the Indian economy. Currently, coal competes with other commodities and, more importantly, passengers for priority on bottlenecked lines. Hence, the government has requested expansion of three critical railway lines at Jharkhand, Odisha and Chhattisgarh. This will also be needed to help increase output by 60 MMmt/yr by 2017-18, ramping up to 200 MMmt/yr by 2021-22.

The Future of Coal in India

India has been one of the countries with the most robust growth in coal demand in the last decade and, despite the current challenges to growing its domestic industry, it is likely to keep coal as the top fuel in its energy mix. India will play a major role in balancing the seaborne market in the coming decade and could become the biggest coal importer in the world in the near future. Nevertheless, big questions remain as the country struggles to fix its electricity system and attempts to improve its domestic coal supply system.

Can Technology Change the Global Future for Coal?

Regional differences in generating fleet composition, development and penetration of new technologies all highlight the challenges in changing the future global electricity mix. Under current economic and political pressures, governments of many OECD countries have started a move away from coal, albeit in different ways. Displacing coal in developing economies has proven a more difficult proposition, especially in India and Southeast Asia.

Renewables are leading the way in Europe, where customers and taxpayers appear more prepared to accept the high cost of decarbonization. This transition, however, has not been without issues and utilities have suffered the consequences of high system integration costs. There have also been unforeseen developments, such as the displacement of natural gas by lignite in the German electricity mix and the successive collapses of prices under the European ETS.

Gas abundance in the U.S. has meant that lowering coal demand has not imposed the same price as for Europeans. However, local economies have suffered as a result of the loss of jobs in the mining industry, which is more labor intensive than gas production.

The dynamics are different in developing Asian economies, where gas and renewables are only affordable alternatives in some small niche markets. Orders for new coal-fired power plants suggest that

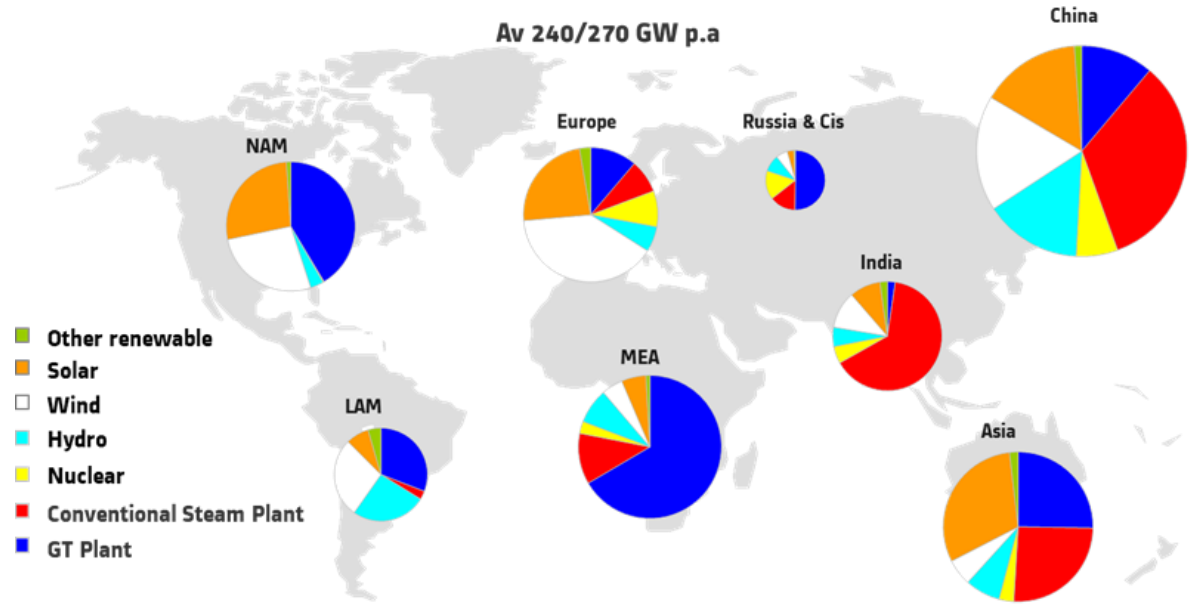


Figure 7 – Global Power Capacity Installations: 2015-2020
Source: ALSTOM MACA 2014

coal will remain a dominant component of the mix for years to come in Southeast Asia, India and China. Economic development and societal welfare would be compromised if these regions cannot access affordable forms of energy.

Three areas of development are of particular importance for the future of coal:

- efficiency, both in end-user demand for heat and power, but especially in coal-fired power generation;
- carbon capture and storage (CCS); and
- development of cost competitive alternative sources of energy (e.g. renewables).

Technological developments in the first two would allow coal to respond to changing policy and retain a share in the energy mix, while the development of substitutes would potentially displace coal.

The Role of Energy Efficiency

Approximately 70 percent of the current global power plant fleet uses low efficiency, subcritical boilers. There is also a large gap in coal use efficiency between developed and developing countries, which needs to be overcome in order to make coal a cleaner alternative. For example, coal-fired power plant efficiency ranges from 41 percent in Japan to as low as 24-26 percent in India. This stark contrast is due to the ability to afford better boiler technologies, as well as varying coal quality in different countries.

For many years, Japan has had the incentive to find ways to use coal efficiently, due to the low availability of local resources. Most coal-fired power stations in Japan are supercritical or ultra-supercritical and use high quality bituminous coal as fuel, which has resulted in efficiency near the current

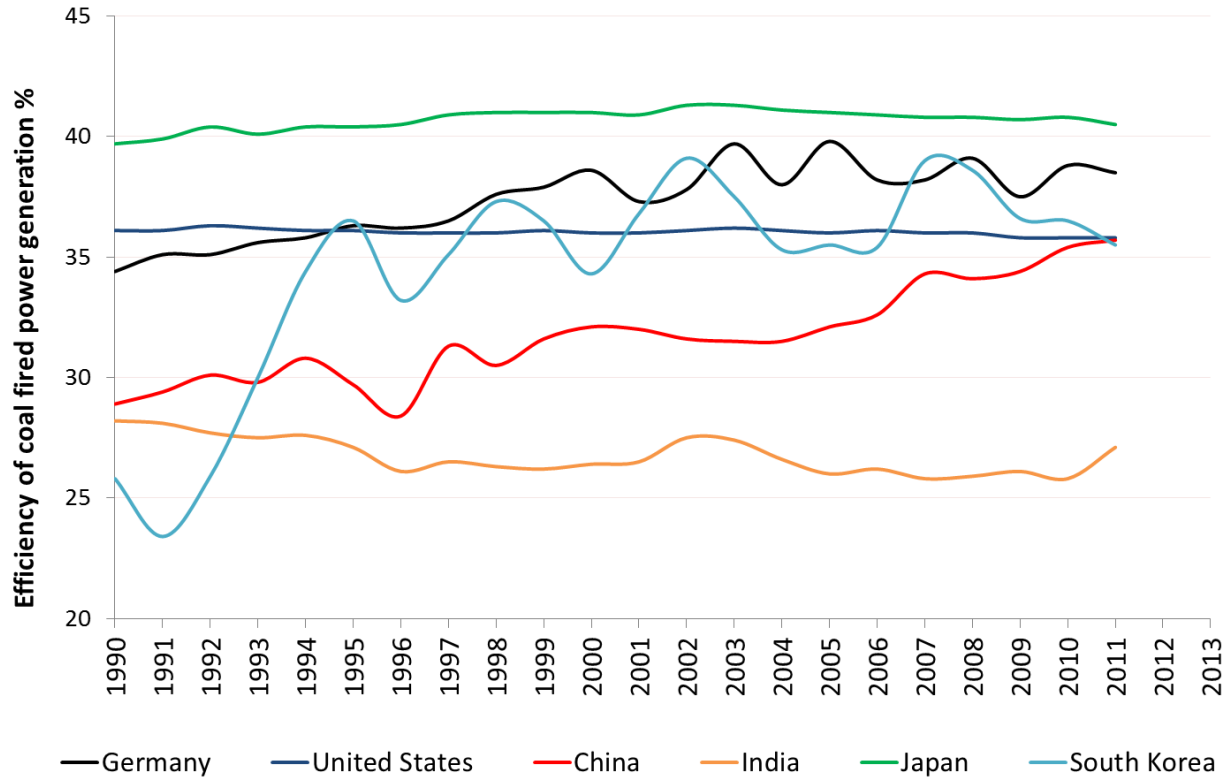


Figure 8 – Coal-fired Power Plant Efficiency for Main Coal Consuming Countries
Source: KAPSARC Analysis, based on ECOFYS–International comparison of fossil power efficiency and CO_2 intensity (2014).

highest technical limit. On the other hand, India holds large coal reserves and production costs are relatively low. This has resulted in widespread use of subcritical boilers, which are cheaper to build and maintain, but much less efficient. Additionally, the low quality of Indian coal, which often contains ash in excess of 40 percent, provides a further challenge to attaining high power plant efficiency.

By making use of available coal technologies, India would benefit greatly from a transition towards higher coal efficiency, such as the one China and Korea have implemented. Power output from coal in India, for example, could be increased by over 50 percent without higher coal consumption if efficiency were improved to the Japanese standard. This, however, cannot be achieved without policy, finance, implementation and enforcement that both set a clear direction for efficiency standards and provide incentive for investments in efficiency. Aging coal boilers are not easily retired while they still produce a marginal income for owners.

Furthermore, a comparison of efficiency in India and the U.S. suggests that, even though coal-fired plants there also use subcritical boilers, the average efficiency attained is much higher than in India. The reason for this difference can be explained by higher fuel quality, but also by more efficient operational practices in the U.S., according to USAID South Asia Energy.

CCS: Necessary, but Failing to Capture Sufficient Support

According to the IEA, CCS should be the third largest source of CO_2 emissions reductions out of the total required to achieve a 2-degree warming scenario by 2050. However, CCS projects currently cannot be justified on purely economic grounds and

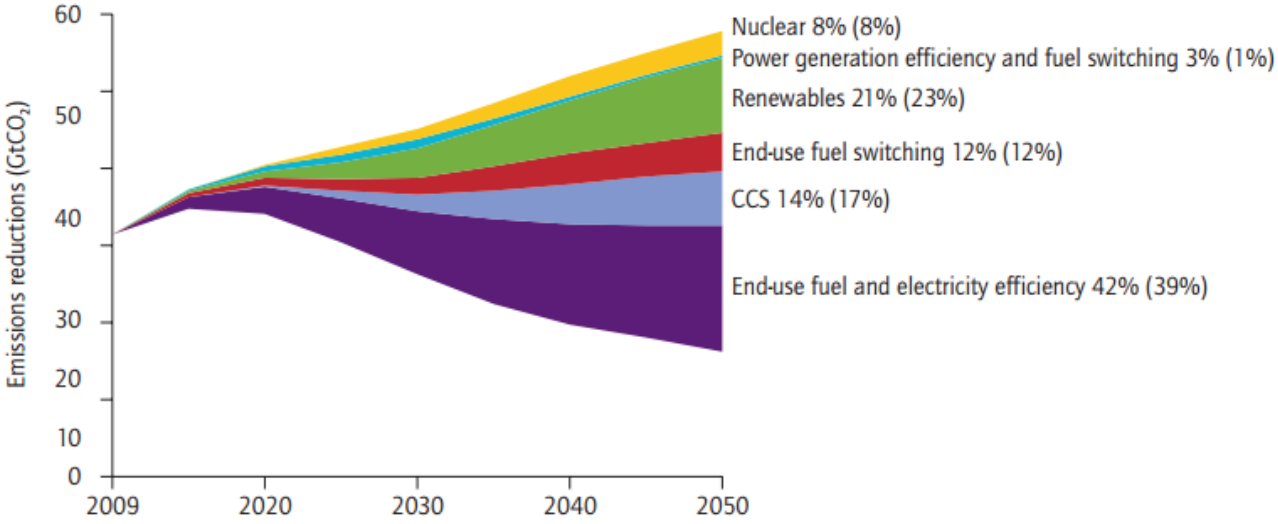
need the support of governments through carbon prices at sufficiently high levels, or other incentive mechanisms. In addition, public support for the technology has not yet been gained because of safety concerns that might be dispelled through full-scale demonstrations. This has resulted in a lag in the number of projects needed to achieve deployment of the technology by 2020 or even 2030.

Another challenge is that the potential of CCS is predicated on the availability of storage space. Carbon would ideally be captured close to a suitable storage reservoir to avoid prohibitive costs of long-distance CO_2 transportation. Hence there is a need for proper matching of regions with demand for power and storage availability. Currently certainty regarding storage potential varies by region, with developed countries tending to have better quality data. This is more serious in countries such as India, for example, where reliable data is not yet available.

Power Generation: Can Alternatives Compete with Coal?

Despite the improvement in the economics of renewable alternatives over the past five years, coal, nuclear and hydro power remain the cheapest options for electricity generation in most developing countries. Wind and solar power are cost-competitive when accounting for externalities, such as air pollution and its impact on human health, but many governments do not place as much weight on these factors as on lifting people out of poverty. Pollution and health become bigger concerns as populations become wealthier.

According to IRENA's REMap 2030 [2], China would need a nationwide carbon price of about $50/mt to raise the cost of coal-fired generation enough to make distributed solar PV cost-competitive. Prices in the range of $25-30/mt of CO_2 would ensure that



Note: Numbers in brackets are shares in 2050. For example, 14% is the share of CCS in cumulative emission reductions through 2050, and 17% is the share of CCS in emission reductions in 2050, compared with the 6DS.

Figure 9 – Potential Contribution of CCS to CO_2 Reductions by 2050
Source: IEA, 2012c

wind and solar PV could compete with coal at utility scale. Such high carbon price scenarios, however, would not guarantee the end of coal as falling coal demand would probably result in more competitive coal prices.

On the other hand, the externalities of renewables also need to be considered, as the intermittency they introduce into the grid needs to be offset by installing backup capacity. This capacity is often not considered when calculating the cost of renewable generation and has become an issue in Europe, where fossil fuels have to be dispatched to compensate for drops in renewable availability. The problem is exacerbated when using, for example, high efficiency ultra supercritical coal-fired power plants to cycle along with renewables, which results in a deterioration of the performance of these power plants, which were originally designed to run base-load. In reality, all generation options should consider the likelihood that they will increasingly see time of use and demand driven market prices in the future and all should be ready to respond to more variable market signals. Coal plants may gain new profitability in markets offering premia for spinning reserve and power quality products as well as locational factors.

Can Paris COP21 Change Coal's Future?

Eight years passed between the signing of the Kyoto Protocol and its final ratification. Even then, major setbacks involving some of the main actors in the process occurred at the point of final ratification. China, the U.S., Canada, Australia and Russia, among others, either did not agree to binding emissions reductions targets, or failed to set new targets after 2012.

Hopes of a global climate agreement currently rest on the upcoming UN Climate Change Conference (COP21) that will be held in December 2015 in

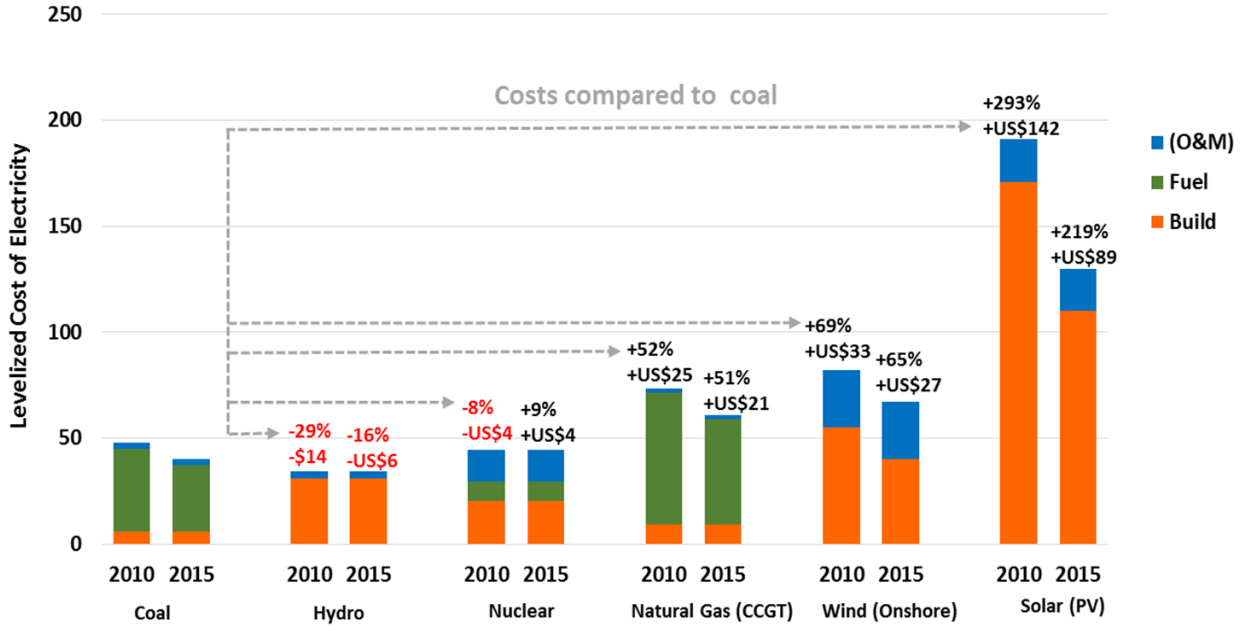


Figure 10 – Comparison of the Levelized Cost of Electricity for Alternatives in Coastal China
Source: KAPSARC Analysis

Paris. The main goal is, for the first time in over 20 years of UN negotiations, to achieve a binding and universal agreement on climate change, from all the nations of the world. This goal is challenging enough, but it looks closer given the U.S.-China joint climate agreement that was signed in September 2014. However, even if a global agreement is reached, another five years could pass before its full ratification.

In the meantime, different regions have—or have not—moved to address the issue through the implementation of local or regional Emissions Trading Schemes (ETS) or carbon taxes. Importantly, China successfully carried out its pilot ETS program in seven cities, all areas of heavy air pollution. Though it is not clear in what form the program could be implemented nationwide, the trials indicate the direction in which China is moving to address the issue, and that the price of carbon should become a consideration for power generation and coal in China.

India, on the other hand, being at an earlier stage of industrialization, remains a challenge to achieving a global agreement. Having seen all other major economies, including China, develop without carbon restrictions, India is reluctant to be the first nation to develop at the same time as paying for the consequences of climate change.

The likely implication for coal seems to be that Paris could be the beginning of a global position on climate change, though it is not likely to result in major impact to the coal market before the next decade.

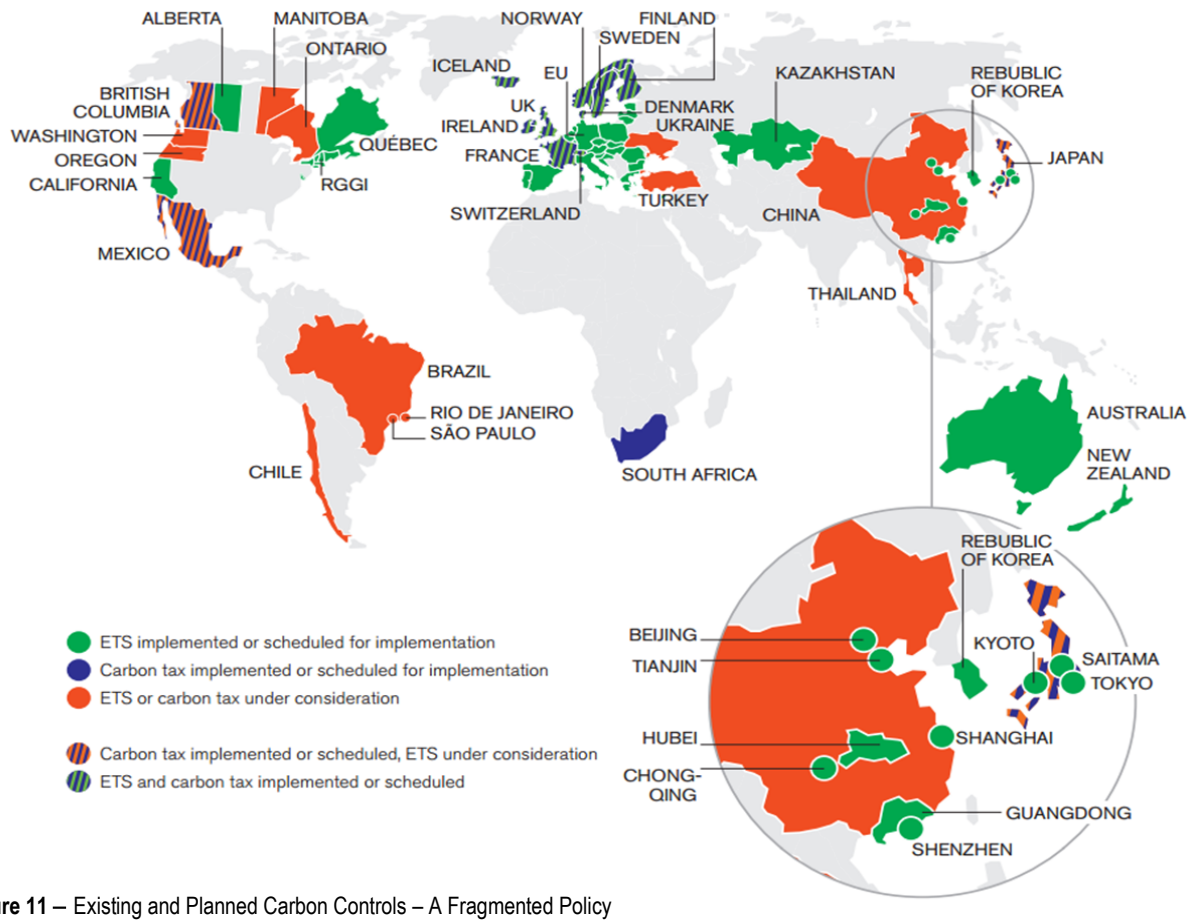


Figure 11 – Existing and Planned Carbon Controls – A Fragmented Policy
Source: World Bank

Workshop Conclusions

Coal's future depends on politics and technology, with the world appearing to be divided between East and West:

- North America and Europe are attempting to phase coal out of their energy mix and will, over the coming decade, continue to find more mechanisms for reducing carbon emissions. Accounting for the externalities of coal has become increasingly prevalent in these markets.
- Asia, Africa and potentially the Middle East, on the other hand, may be torn by the potential for their economies to ride the industrialization curve by gaining access to cheap electricity. This puts pressure on governments that are faced with convincing their citizens to pay for climate change policy before they secure access to their basic needs.

Efficiency improvements in the power, cement and steel sectors can make a significant difference to the path to lower carbon emissions per kWh. China is now the leading exporter and developer of coal-fired power stations and will have a key role to play.

As alternative energy technologies become available which can produce affordable energy, coal's future will depend on demonstrating successful CCS and, ultimately, its widespread adoption. Cost-effective retrofitting of coal-fired plants will be needed if the large amount of recently built infrastructure is not to become stranded.

Renewables have started to take market share from fossil fuels as their economics have become more competitive. However, in order to assess the real cost of renewables compared with fossil fuel alternatives, their own externalities - including intermittency, reliability, and connection costs - need to be considered.

Finally, a global agreement on climate change that imposes a cost of carbon, either directly or indirectly, would mean that burning coal is likely to become more expensive. Coal producers will have to compete harder to retain a share in the energy mix.

Coal is clearly approaching a fork in the road and it will not be long before we have a clearer view of which turning it will take.

References

[1] Atallah, T., Blazquez, J., "How coal fueled global growth and slowed energy productivity gains in the early 21st century." KAPSARC Discussion Paper (2015).

[2] Renewable Energy Prospects: China, IRENA, November 2014

Notes

About the workshop

In collaboration with KAPSARC, Clingendael International Energy Programme (CIEP) hosted a workshop in The Hague in March 2015. It was conducted under the rule of capturing the discussion on a non-attribution basis. Forty international and local experts participated, as follows

Afifi Afifi – Managing Director, ProTrade Company

Shahad Al-Arenan – Research Analyst, KAPSARC

Samer Al-Ashgar – President, KAPSARC

Ziyad Al-Fawzan – Research Analyst, KAPSARC

Nader Al-Kathiri – Senior Research Analyst, KAPSARC

Yazeed Al-Rashed – Senior Research Analyst, KAPSARC

Paul Baruya – Coal Market Analyst, IEA Clean Coal Centre

Mauricio Bermudez-Neubauer – Associate Director, NERA Economic Consulting

Amulya Charan – Independent Advisor

Sylvie Cornot-Gandolphe – SCG Consulting/Research Fellow, Oxford Institute for Energy Studies (OIES) and IFRI

Carol Cormack – Collaboration, KAPSARC

Jacques de Jong – Senior Fellow, Clingendael International Energy Program

Hugo du Mez – Advisor Business Intelligence, Port of Rotterdam

Tilak Doshi – Senior Research Fellow, KAPSARC

Rodrigo Echeverri – Research Fellow, KAPSARC

Carlos Fernandez Alvarez – Senior Coal Analyst, International Energy Agency (IEA)

Fabio Gabrieli – Director, Dry Bulk Analysis and Strategy, Mercuria Energy Trading S.A.

Jorn Higgen – Head of Market Analysis Solutions & Support, E.ON Global Commodities SE

David Hobbs – Head of Research, KAPSARC

Franziska Holz – Research Associate, DIW Berlin

Nicholas Howarth – Research Fellow, KAPSARC

Ayaka Jones – General Engineer, Energy Information Administration (EIA)

Bob Kamandanu – President, Indonesian Coal Mining Association (APBI-ICMA)

Angelina La Rose – Natural Gas Markets Analysis Team Leader, EIA (Energy Information Administration)

Jim Lennon – Managing Director, Red Door Research Ltd.

Stefan Ljubisavljevic – Commodities Analyst, Macquarie Securities

Marwan Masri – President Emeritus, Canadian Energy Research Institute (CERI)

Roman Mendelevitch – Research Associate, Technical University of Berlin

Jane Nakano – Senior Fellow, Energy and National Security Program, Center for Strategic & International Studies (CSIS)

Philippe Paelinck – VP Portfolio & Strategic Positioning, Alstom Power

Ke-Xi Pan – Professor, Fudan University

Bert Pothoven – Business Analyst and Insurance Manger, EMO bv

Brian Ricketts – Secretary-General, EURACOAL aisbi

Jitendra RoyChoudhury – Associate Consultant, HDR Salva

Hamad Al-Sayari – Former Governor, Saudi Arabian Monetary Agency (SAMA)

Rodolfo Shimatu – Senior Analyst - Coal, SUEK AG

Sammy Six – Research Associate, Clingendael International Energy Program

Coby van der Linde – Director, Clingendael International Energy Program

Tomasz Wróblewicz – Principal Master Planner, Gas and Energy Master Planning, Shell Global Solutions International B.V

Hanxiong Zhu – Post-doctoral researcher, School of Social Development and Public Policy, Fudan University

About the team

Kankana Dubey is a Research Associate working on energy productivity in China and GCC countries. She holds an MSc degree in energy management from the University of Stirling.

Berenice Garcia-Tellez is a Senior Research Analyst examining coal markets, and researching the energy-water nexus. She has a MS degree from KAUST.

Rodrigo Echeverri is a Research Fellow analyzing coal markets. He has worked at Adaro Energy in Indonesia and Cerrejon Coal in Colombia and Europe.

Nicholas Howarth is a Research Fellow specializing in technological change, energy and the environment, working on energy productivity in China and GCC countries. He holds a DPhil in applied economics from the University of Oxford.