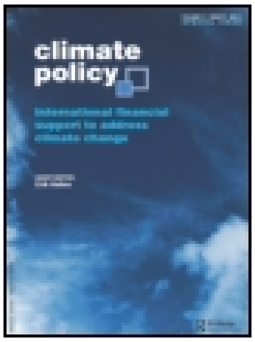

Climate Policy

ISSN: 1469-3062 (Print) 1752-7457 (Online) Journal homepage: http://www.tandfonline.com/loi/tcpo20

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To cite this article: Pao-Yu Oei & Roman Mendelevitch (2018): Prospects for steam coal exporters in the era of climate policies: a case study of Colombia, Climate Policy, DOI: 10.1080/14693062.2018.1449094

To link to this article: https://doi.org/10.1080/14693062.2018.1449094

CLIMATE POLICY, 2018
https://doi.org/10.1080/14693062.2018.1449094

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SYNTHESIS ARTICLE

Prospects for steam coal exporters in the era of climate policies: a case study of Colombia

Pao-Yu Oei[a,b] and Roman Mendelevitch [b,c]

[a]Workgroup for Economic and Infrastructure Policy (WIP), TU Berlin, Berlin, Germany; [b]German Institute for Economic Research (DIW Berlin), Berlin, Germany; [c]Humboldt-Universität zu Berlin, Berlin, Germany

ABSTRACT
Continued global action on climate change has major consequences for fossil fuel markets, especially for coal as the most carbon-intensive fuel. This article summarizes current market developments in the most important coal-producing and coal-consuming countries, resulting in a critical qualitative assessment of prospects for future coal exports. Colombia, as the world's fourth largest exporter, is strongly affected by these global trends, with more than 90% of its production being exported. Market analysis finds Colombia in a strong competitive position, owing to its low production costs and high coal quality. Nevertheless, market trends and enhanced climate policies suggest a gloomy outlook for future exports. Increasing competition on the Atlantic as well as Pacific market will keep coal prices low and continue pressure on mining companies. Increasing numbers of filed bankruptcies and lay-offs might be just the beginning of a carbon bubble devaluing fossil fuel investments and leaving them stranded. Colombia largely supplies European and Mediterranean consumers but also delivers some quantities to the US Gulf Coast, and to Central and South America. Future coal demand in most of these countries will continue to decline in the next decades. Newly constructed power plants in emerging economies (India, China) are unlikely to compensate for this downturn owing to increasing domestic supply and decreasing demand. Therefore, maintaining or even increasing mining volumes in Colombia should be re-evaluated, taking into account new economic realities as well as local externalities. Ignoring these risks could lead to additional stranded investments, aggravating the local resource curse and hampering sustainable economic development.

Key policy insights

- The climate policies of most of Colombia's traditional trade partners target steam coal as the more emission-intensive fossil fuel, with many countries implementing or considering a coal phase-out.
- Coal exporters should re-evaluate their operations and new investments taking into account this new policy environment.
- To prevent a race to the bottom among coal producers that would favour weak regulation, climate policy makers should also consider the local social and external costs of coal mining, including on health and the local environment.

ARTICLE HISTORY
Received 3 October 2017
Accepted 2 March 2018

KEYWORDS
Case study; climate policy; Colombia; decarbonization; energy policy; Steam coal market

CONTACT Roman Mendelevitch roman.mendelevitch@hu-berlin.de German Institute for Economic Research (DIW Berlin), Mohrenstrasse 58, 10117 Berlin, Germany, Humboldt-Universität zu Berlin, Unter den Linden 6, 10099 Berlin, Germany

Supplemental data for this article can be accessed at https://doi.org/10.1080/14693062.2018.1449094.

1. Introduction

The sustainable development goals (SDGs) adopted at the United Nations Sustainable Development Summit in September 2015 include tackling climate change as a key target (UN, 2015a). A few months later, international climate policy achieved global consensus on the urgent need to combat anthropogenic climate change at the 21st Conference of the Parties (COP21) in Paris (UN, 2015b) with the adoption of the Paris Agreement. Under the Paris Agreement, all countries are expected to take on nationally determined contributions (NDCs) to address climate change and help limit global temperature rise to 'well below' 2°C. Over 170 countries have now ratified the Paris Agreement and confirmed their NDCs, including Colombia (Allesandro De Pinto, Loboguerrero, Londono, Sanabria, & Castano, 2017). Estimates of fossil fuels that have to remain in the ground to achieve the 2°C target foresee the heaviest burden falling on coal (Meinshausen et al., 2009). Some 82% to 88% of current coal reserves are considered 'unburnable', compared to 33–35% of oil and 49–52% of gas reserves (McGlade & Ekins, 2015). It is not only scientists (e.g. Johnson et al., 2015) and nongovernmental organizations (e.g. Jones & Gutmann, 2015) that see the need to phase-out coal if climate change mitigation is taken seriously, but also policy makers, and actions are being taken worldwide: COP23 in 2017 demonstrated increasing momentum to phase-out coal in some economies (including Canada, Denmark, Italy, Netherlands and UK through the newly formed Global Alliance to Phase Out Coal, Powering Past Coal, 2017). However, further concrete policies are needed to bring about a global coal phase out (Piggot, Erickson, Lazarus, & Asselt, 2017). In this regard, other policies that are not primarily motivated by climate change mitigation are contributing to a reduction in coal consumption: China, for example, has introduced a moratorium on new coal power plants and mines owing to, among other things, an overheated market (The State Council of the People's Republic of China, 2016) and India is observing a much slower increase in coal demand than expected due in part to local pollution concerns (NewClimate Institute, Climate Analytics, and Ecofys, 2017).

Despite some sceptics who claim that the world cannot do without coal (Umbach, 2015; van der Zwaan, 2005), the industry is starting to feel that its prospects are fading. This global trend is unlikely to be reversed despite the change of government in the US.[1] Caught between the shale gas boom and decreasing costs of renewables, by 2016 numerous US coal producers (including Peabody Energy Cooperation, Arch Coal Inc. and Alpha Natural Resources, listed first, second and fourth in the top four US coal mining companies) had filed for bankruptcy (EIA, 2016; Mooney & Mufson, 2016; Sussams & Grant, 2015, 18), and 271 mines in the US were idle or closed in 2013 (EIA, 2015c). Steam coal production in the US declined by around 28% between 2005 and 2015 (IEA/OECD, 2016a, III.279). A large share of producers in Queensland, one of Australia's two main coal regions, were producing at a loss in 2014 (McCracken, 2015). Coal companies worldwide are struck by low prices, but are also challenged by the divestment movement, with big financial institutions increasingly recognizing the danger of climate change (Piggot et al., 2017; Steckel, Edenhofer, & Jakob, 2015). Financial institutions are starting to acknowledge the potential carbon investment bubble, whereby current fossil assets are likely to become stranded as more stringent climate policies are put in place (Leaton, Ranger, Ward, Sussams, & Brown, 2013). Therefore, they are starting to refuse to provide further finance for fossil fuel projects (Arabella Advisors, 2015). Observing this massive failure of classical business models, Fulton, Spedding, Schuwerk, and Sussams (2015) suggest an alternative paradigm of evaluating and managing company risk, taking into account nonlinear and structural changes in both fossil fuel markets and finance.

Against this background, this article analyses the situation of Colombia, as the world's fourth largest exporter of steam coal, to assess the imminent question of how coal exporting countries will be affected by the decline of the coal industry, and more specifically, whether they will all be hit alike by the downturn. A wide range of studies already exists that focus on various environmental and social dimensions of the coal mining industry in Colombia (e.g. see CAN, 2016b; Chomsky & Striffler, 2014; CINEP/PPP, 2014; Hawkins, 2014; Moor & van de Sandt, 2014; Schücking, 2013). By contrast, this article focuses on business and economic considerations and aspects of climate policy, leaving other issues concerning (a continuation of) coal extraction in Colombia aside. In so doing, the article summarizes current market developments in the most important coal producing and consuming countries. The resulting qualitative assessment of potential winners and losers from the current developments critically examines prospects for future coal exports and for Colombian coal exports in particular. Exporting countries, such as Colombia, risk not only losing high shares of their state income, but also to be left with mono-industrialized regions, whose opportunities for transitioning towards alternative and more sustainable industry sectors are low. In addition, especially in the case of sudden divestment strategies or bankruptcy of coal firms, insufficient provisions for recultivation and restauration of mining territory can result in additional costs for the Colombian state and its people. The Colombian case is therefore at risk of becoming another example of the 'resource curse' (Ansari, 2016; Betz, Partridge, Farren, & Lobao, 2015; Corden & Neary, 1982; Krugman, 1987; Sachs & Warner, 1999; Steckel et al., 2015; van der Ploeg, 2011).

2. Colombia in the international steam coal market

2.1. The international steam coal market

Since 2007, steam coal[2] consumption in the Organisation for Economic Co-operation and Development (OECD) has decreased by 19.4%, owing to general trends of decarbonization and lower energy consumption. However, over that same period consumption has continued to grow dramatically in non-OECD countries – by 10 times the volume of the OECD decrease (IEA/OECD, 2016a). This rapid growth in demand has triggered significant investment in supply capacities and transport infrastructure (IEA/OECD, 2014b, 186). However, since 2015, demand growth has started to decline slowly. Both total steam coal production and consumption peaked in 2013 and have significantly declined since.

Since the 1980s, China has been the world's largest consumer of steam coal (Morse & He, 2015). India has been the world's third largest steam coal consumer since 1995, but since 2005 has almost doubled its consumption to become the world's second largest in 2014 (on a tonnage basis) – narrowly overtaking the US, whose consumption has decreased by around 20% over the past decade (IEA/OECD, 2016a). Other large consumers of steam coal over the past two decades are South Africa, Japan and the Russian Federation, while in the 1970s and 1980s, Poland, the United Kingdom and Germany were also in the mix (Thurber & Morse, 2015). Table 1 lists the main steam coal producers and consumers in 2015. In the last decades, China and India have been the driving forces behind increasing global coal consumption. But in the recent years, coal has also increasingly been used to fuel economic growth in other countries, especially in South-East Asia but also in Turkey (Steckel et al., 2015) where energy systems are increasingly focused on coal.

The world's largest consumers of steam coal are also its largest producers. Since the mid-1980s, China has produced the largest volumes of steam coal, followed by the US. India has been the world's third-largest producer of steam coal since the 1990s, having overtaken South Africa. Along with Australia and the Russian Federation, these countries account for over 90% of world steam coal production – with China alone accounting for 52% of the total. Similar to consumption trends, Poland, the United Kingdom and Germany were historically large producers of steam coal, but by the 1990s had lost any significant market share. Colombia is currently the ninth largest producer of steam coal (84 Mt in 2014, 86 Mt in 2015) (IEA/OECD, 2016a) Traditionally, Colombia exports more than 90% of these volumes, as electricity generation relies heavily on hydropower, and requires only small amounts of coal for domestic consumption (USGS, 2015).

Figure 1 depicts major importers, exporters and trade flows of steam coal in 2014 and 2015. Worldwide, the total quantity of internationally traded steam coal in 2014 represented 17% of total demand, with the majority being seaborne trade (IEA/OECD, 2016a). The total volume traded has increased at an average annual rate of 6%

Table 1. Major steam coal producers and consumers in 2015 (in Mt).

Major producers in 2015	Major consumers in 2015
China (2920 Mt)	China (3090 Mt)
United States (691 Mt)	India (764 Mt)
India (594 Mt)	United States (630 Mt)
Indonesia (467 Mt)	⋮
⋮	Japan (140 Mt), South Korea (100 Mt)
	⋮
Colombia (86 Mt)	Germany (47 Mt), UK (33 Mt)
World production 5810 Mt (6060 Mt, in 2013)	World consumption 5830 Mt (6100 Mt, in 2013)

Source: IEA/OECD (2016a).

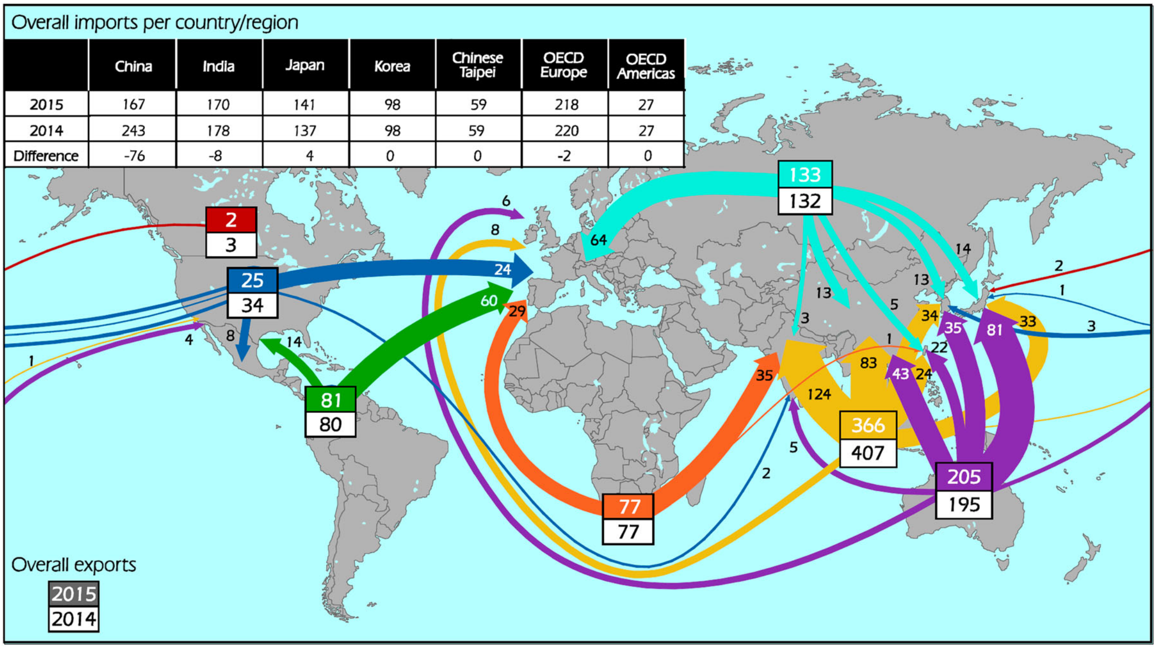

Figure 1. Major exporter, importers and trade flows of steam coal in 2014 and 2015. Source: IEA/OECD (2016c) © OECD/IEA 2016 Medium-Term Coal Market Report, IEA Publishing. License: www.iea.org/t&c

between 1990 and 2014, and the proportion of seaborne trade increased at an average annual rate of 2% over the same period. Since the late 2000s, China, and subsequently India, are the world's largest importers. Indonesia, Australia and the Russian Federation are the world's largest exporters of steam coal, followed by Colombia and South Africa. Owing to their geographical location, South Africa, as well as Russia, are 'swing suppliers', which export to both the Pacific and Atlantic regions according to market dynamics. Colombia is currently the fourth largest steam coal exporter with 78.8 Mt in 2014. Its production and export volumes evolve concurrently and have almost tripled since 2000. It has therefore become the largest supplier on the Atlantic market and supplies mainly Europe as well as some quantities to the US in the Gulf Coast, and to Central and South America.

2.2. Cost structure and price formation

The capital costs of coal production – for prospecting and exploration and the development of mines and associated infrastructure – constitute a relatively small proportion of overall costs (IEA/OECD, 2014a, 53). Variable costs are the more significant component, including the costs of labour, materials, transport, taxes and royalties. These costs vary, especially based on the distance to market but also depending on the type of mining operation, mining conditions, local labour market and productivity (IEA/OECD, 2014c, 56; Ritschel & Schiffer, 2007). The extraction costs for coal are indirectly influenced by the oil price through the fuel costs for the machinery.

Steam coal prices are fundamentally based on the free on board (FOB) costs,[3] freight rates and the currency exchange rate. Steam coal is graded according to its quality characteristics, such as energy-, ash- and sulphur content, and prices will vary accordingly (Li, 2010). The world steam coal market was traditionally divided into a Pacific market and an Atlantic market, with prices differing owing to geographical separation and other market conditions (Li, 2010). However, with increasing trade between the regions, the traditional divide has been blurred and prices are now more closely linked (Thurber & Morse, 2015). At present, world steam coal prices are low owing to slowing demand growth, as discussed above, and an over-supplied market (IEA/OECD, 2014b, 186) but also owing to low oil prices, which are relevant because of the fuel supply required for mining machinery and freight ships. Historically, coal was traded under long-term contracts, and its commoditization has only occurred in the past two decades. According to Li (2010, 526–27), the evolution of a liquid commodity market for steam coal reflects the prevailing market conditions, where there is less concern about supply security, and more concern about sourcing low-priced fuel in increasingly competitive energy markets.

Although understanding the development of steam coal markets is key to assessing the effects of climate policies, quantitative analysis of the market is sparse (cf. Haftendorn & Holz, 2010; Paulus & Trüby, 2011). Various studies focus on the coal sector in a particular country but do not consider the international dimension (see e.g. Paulus & Trüby, 2011; Rioux, Galkin, Murphy, & Pierru, 2015, with a focus on China). Two strands of literature on international coal markets exist, with one focusing on the analysis of market structure (cf. Haftendorn, 2012; Haftendorn & Holz, 2010; Trüby & Paulus, 2012), and the other analysing the effects of various climate policies on the international steam coal markets (c.f. Bertram et al., 2015; Blondeel & Van de Graaf, 2016; Culver & Hong, 2016; Haftendorn, Kemfert, & Holz, 2012; Johnson et al., 2015; Mendelevitch, 2018; Richter, Mendelevitch, & Jotzo, 2018; von Hirschhausen et al., 2011). This article draws from these quantitative analyses to evaluate prospects for the international steam coal market in the era of climate policies in line with the Paris Agreement. A special focus is hereby put on Colombia, being the fourth largest steam coal exporter in the world.

2.3. Relative performance of Colombian coal compared to other competitors

Steam coal is not a homogenous good. Rather, different suppliers provide different coal types with varying moisture, energy-, sulphur- and ash content. Different coal qualities can be blended to achieve a particular composite of these key parameters. This becomes necessary because power plants are optimized to a particular type of coal and deviations can reduce plant efficiency. Moreover, it increases maintenance requirements and material wear (e.g. an increase in moisture content reduces plant efficiency as it reduces the useable energy (IEA CIAB, 2010, 18)). For a given energy content, the CO_2 intensity of a fuel increases with higher shares of volatile matters, i.e. inherent ash (IEA CIAB, 2010, 49). Higher sulphur content requires higher flue gas temperatures to avoid the acid dew point and thereby also reduces plant efficiency (IEA CIAB, 2010, 54). In addition to increasing maintenance intensity for removing ash discharge from the furnace bottom, higher ash content also comes with a reduction of total efficiency because the removal of ash from the flue gas removes a portion of useable energy (IEA CIAB, 2010, 54).

The quality of coal is also reflected in prices, where coal with high energy content, low moisture, sulphur and ash content is most desirable, and therefore also best priced. Data on energy content of coal from different destinations are shown in Table 2. According to Energy Watch Group (2007), the decline in coal quality in recent years is not only attributable to a shift towards lower rank coals, such as sub-bituminous coals, but also to a quality decline within each class. In Colombia, coal quality is rather high (USGS, 2006), while especially in Indonesia and South Africa, the deposits for high-quality coal are very limited. Given current trends, coal quality supplied by these suppliers is likely to decline in terms of its energy content.[4] On an energy basis, Colombian steam coal has a price advantage owing to its high quality and low production costs in open cast mining operations.

Table 2. Energy, ash and sulphur content of coal by production region (in kcal/kg and GJ/t).

Region	Calorific value in kcal/kg	Energy content in GJ/t	Sulphur content in %	Ash content in %	Comments
US Appalachia[12]	6949	29.075	1.9	11–13	
China Shanxi, Shaanxi, Inner Mongolia[13]	6597	27.600	1	23	
Australia Queensland[14]	6500	27.196	N.A.	12–20	
Australia New South Wales[12]	6300	26.359			
Colombia[15]	6375	26.673	<0.1	<5	
South Africa[16]	5500	23.013	0.6–0.7	<15	Requires washing to get export quality
Indonesia[17]	5450	22.803	<1	5–7	
India West[12]	5209	21.793	N.A.	25–45	Ash content before washing
US Powder River Basin[10]	4781	20.004	0.6–0.7	8–10	

Source: Adapted from Holz, Haftendorn, Mendelevitch, and von Hirschhausen (2016) and extended by various sources.

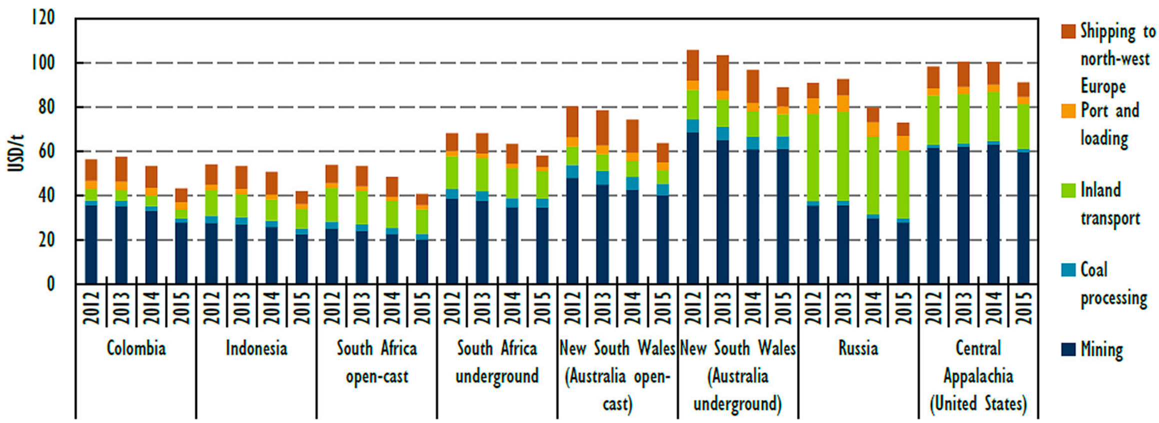

Figure 2. Indicative steam coal supply costs to North West Europe by supply chain component and by country, 2012–15, excluding taxes and royalties (in USD/t). Source: OECD/IEA (2016c) © OECD/IEA 2016 Medium-Term Coal Market Report, IEA Publishing. Licence: www.iea.org/t&c

There are three consequences for the competitiveness of Colombian coal that follow from the considerations above:

(i) The degree to which a particular supplier of steam coal can be substituted depends on the specifics of the power plant and on the coal it is designed for.
(ii) Colombian high-quality coal is compatible with modern high-efficiency power plants. Coal from Indonesia and South Africa on average is of lower quality and would need further preparation and beneficiation before it could substitute for Colombian coal in high-efficiency supercritical and ultra-supercritical boilers.
(iii) Vice versa, coal-fired power plants in India and South-East Asia are designed for low-quality coal and cannot easily switch to other suppliers offering high-quality coal, such as from Colombia (IEA/OECD, 2015a, 440).

Figure 2 illustrates the total costs of mining, coal processing, inland transport and port handling for the main steam coal exporters. The figure illustrates the relative competitiveness of Colombian coal on the European market. Inland transportation infrastructure is another key cost component which governs relative competitiveness. While in Colombia and Indonesia coal deposits are located close to, or right at, the shore, steam coal from South Africa and, in particular, Russia, requires long rail haulage which increases its respective FOB costs. A third decisive component is the distance to market for the respective coal producer. Colombia, together with the US and South Africa has a favourable position to supply the European market. Indonesia and Australia benefit from their proximity to markets in China, Korea and Japan, and the South-East Asian countries. Table 3 depicts indicative average freight rates as estimated by Holz, Haftendorn, Mendelevitch, and von Hirschhausen (2015) for 2010. Two factors will heavily influence future freight rates: Firstly, fuel costs are a major cost component and therefore future freight rates will depend on future fuel prices, especially oil prices; and secondly, dry bulk shipping is subject to general trends of international trade such as investment cycles and inter- and

Table 3. Estimated freight rates for selected routes in the year 2010 (in USD/t).

	To			
From	Rotterdam (Netherlands)	Guangzhou (China)	Yokohama (Japan)	Chennai (India)
Colombia – Puerto Bolivar	15.44	18.50	17.55	19.41
Australia – New South Wales	20.33	15.25	15.38	16.55
South Africa – Richards Bay	16.94	16.42	17.28	15.09
US West – Portland, OR	18.08	15.72	15.23	17.97
Indonesia – Banjarmasin	19.84	13.76	14.46	13.60

Source: Own calculation based on cost parameters estimated by Holz et al. (2015).

intra-market competition. With currently very low oil prices (see Figure S.1 in the supplementary material) and a cool down in global economic growth, freight rates for coal have substantially decreased. As a result, rates for coal from Colombia – Puerto Bolivar delivered to, for example, Rotterdam were halved from around 15 USD/t from 2010 to 2013 to 8 USD/t in August 2015 (Platts, 2015) (see Table 3 and Figure 2). Lower transport costs for coal increase competition in between the Atlantic and the Pacific coal market. This increases the risk for additional stranded investments in coal capacity as it is unclear which market players will stay solvent in case of shrinking global coal demand. This is particularly true for the Colombian coal sector, which is entirely dependent on its coal exports to other countries.

2.4. Coal mining activities in Colombia

Colombia increased its export volumes steadily from 14Mt of coal in 1990 to 82Mt in 2012. Becoming the fourth largest exporter of steam coal, its export figures stayed relatively constant until 2015 (IEA/OECD, 2016a). In 2016 with a share of 14%, steam coal is Colombia's second most important export good, behind crude petroleum accounting for 26% of overall Colombian exports. Most coal exports are bound for the US and the European Union, with which Colombia signed free trade agreements in May 2012 and August 2013, respectively. These large export volumes, however, make Colombia vulnerable to changes in global resource demand and prices. A reduction of international steam coal prices in the last years have resulted in a strong decrease in Colombiás coal rents[5] from an all-time high of 2.3% of gross domestic product (GDP) in 2008 to 0.5 in 2015 (World Bank, 2016). Regional economic indicators furthermore highlight that coal mining is still a very dominant economic driver, for example contributing 42% of the GDP in the region of Cesar and 52% in La Guajira (Bayona, 2016), with little existing economic alternatives for most affected regions. In addition, royalties from coal exports are currently being used to finance the ongoing peace process (Presidencia de la República de Colombia, 2017). The interrelations between the coal industry and politics are also highlighted by Strambo, Espinosa, Velasco, and Atteridge (2018).

The Colombian oil and gas sectors are dominated by state-owned companies, whereas the coal sector is dominated by three international firms: Cerrejón, owned by a consortium of BHP Billiton, Anglo American and Glencore; US-based Drummond; and Prodeco, a Glencore subsidiary. The continuous reduction of profit margins in coal mines puts increasing pressure on a weakened industry sector. This might in some cases result in bankruptcies (e.g. in the US, EIA, 2016; Mooney & Mufson, 2016; Sussams & Grant, 2015). In other cases, companies will redirect their investment to other sectors or concentrate coal production in some countries only. Coal production in Colombia, and in particular in the Cesar region, is associated with numerous negative environmental impacts. Cardoso (2015) categorized different types of socio-economic liabilities surrounding coal mining aside from climate change, ranging from local impacts on air (gas emission and coal dust), soil (mining waste), water (quality loss) and public health (increase in mortality and morbidity), as well as national level impacts owing to coal transport (from noise and air pollution).

Currently, around 30,000 people are directly employed by the three biggest coal companies in Colombia (FES, 2014). The estimates regarding Colombian steam coal reserves vary significantly in the literature. Reserves are estimated at 5 Gt to 6.4 Gt (Bright, 2011; EIA, 2015b), which is less than 2% of global reserves. The exact figure is, however, of minor importance. The speed of the coal phase-out may not be driven by the remaining coal reserves, as coal is no scarce resource, neither in Colombia nor on a global level. As this article argues, the main driver for the coal phase-out will rather be shrinking global demand owing to climate and environmental policies, as well as direct competition from cheaper and cleaner energy sources. As the majority of coal resources is expected to remain in the ground, unnecessary investment should be redirected to avoid stranded assets.

2.5. Colombia's steam coal infrastructure and exports

In Colombia, much of the infrastructure for transport to, and at, the export terminals is undergoing expansion or has recently been expanded despite the described negative outlook for coal. Usually, coal from mines in La Guajira and Cesar is transported by rail; whereas coal from smaller mines in other parts of the country is shipped on the road (Bright, 2011) (see Figure 3). The widening of the Panama Canal in 2016 is expected to increase the competitiveness of Colombian steam coal exports also on the Pacific market, as it allows vessels

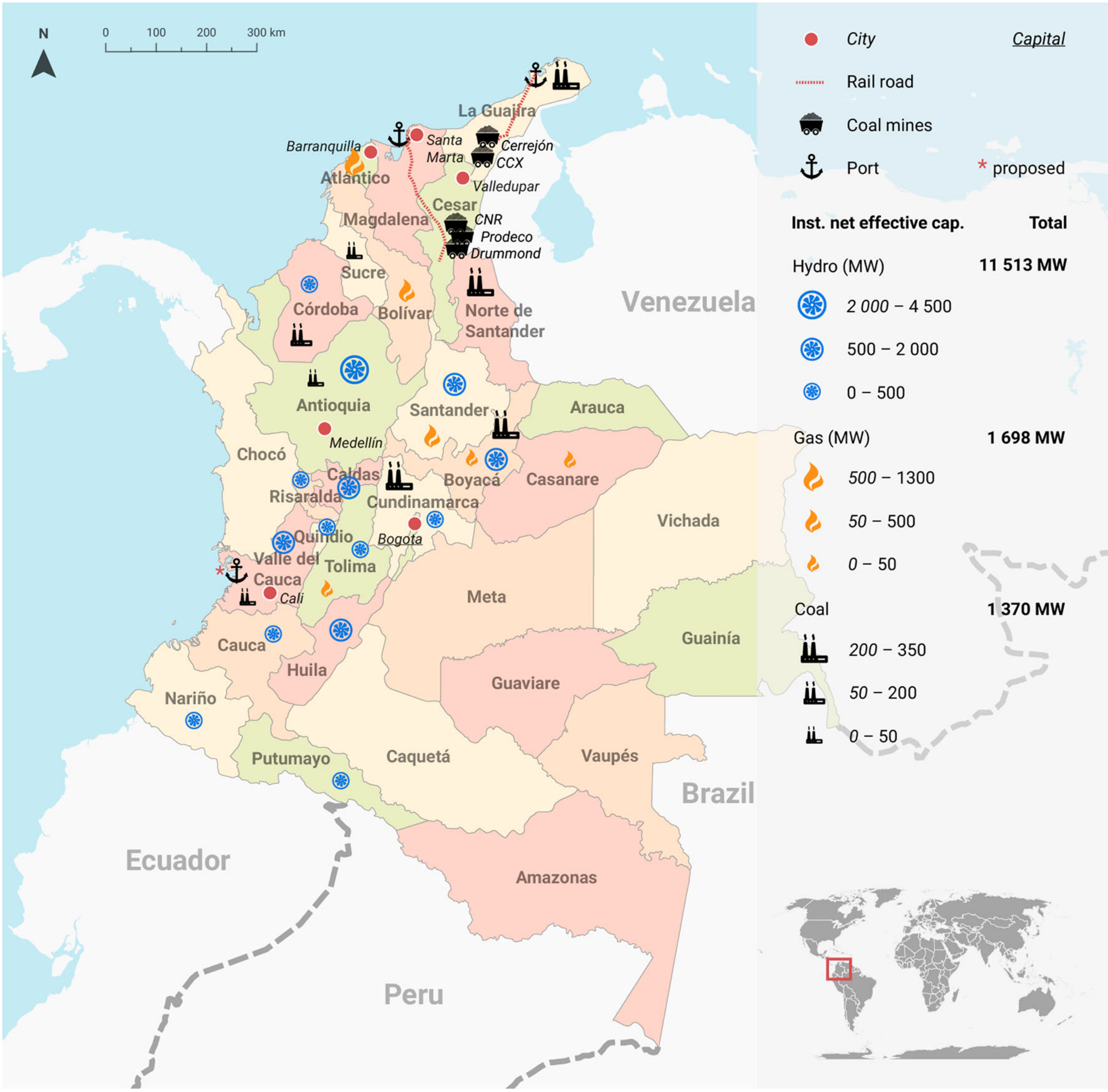

Figure 3. Coal mines, power generation units, and existing and proposed coal infrastructure in Colombia. Source: Own illustration based on UPME (2014) and USGS (2006).

to avoid travelling around South America. This prospect triggered the construction of the 'Puerto Brisa' in Dibulla, La Guajira. Owing to its favourable location close to the Panama Canal, this 30 Mt/a terminal can be used for exports intended for China and South-East Asia (Buendia & Gagan, 2012; Puerto Brisa, 2015). Furthermore, there are ongoing contract talks for the expansion of 'Puerto Buenaventura' on the Pacific coast and a connecting railroad with Chinese investors initially announced for 2011. However, critics, strongly doubt economic feasibility and security aspects, and therefore do not expect this project ever to happen (ERGO, 2011).

To determine trade partners that are particularly relevant for the future development of Colombian steam coal exports, export data from 2000 to 2014 is depicted in Table 4.[6] From 2000 to 2015, exports to most countries increased significantly. Currently, most exports go to Europe, particularly to the Netherlands, Germany, the UK and to a smaller extent to multiple other countries. The single European market, with its main harbours in Amsterdam, Rotterdam, and Antwerp (ARA) as well as several transition points, however, causes distortions in the statistics complicating the matching of origin and final destinations of steam coal. Furthermore, the

Table 4. Main export destinations of Colombian steam coal and share of coal-fired generation in the electricity mix from 1970 to 2015.

		2000	2010	2013	2014	2015p
Chile	Exports [Mt]	0.0	3.4	5.9	6.1	6.7
	electricity share [%]	21	28	41		35
Germany	Exports [Mt]	0.9	7.6	10.0	7.4	9.8
	electricity share [%]	53	42	45		44
Israel	Exports [Mt]	0.8	3.6	5.2	7.2	5.8
	electricity share [%]	69	58	54		45
The Netherlands	Exports [Mt]	6.8	10.4	8.5	14.9	17.5
	electricity share [%]	23	20	21		37
Turkey	Exports [Mt]	0.0	2.7	7.7	9.3	11.4
	electricity share [%]	30	25	25		28
United Kingdom	Exports [Mt]	5.0	5.4	9.8	9.3	4.1
	electricity share [%]	32	28	36		23
United States	Exports [Mt]	6.4	13.0	6.0	7.0	7.7
	electricity share [%]	52	45	39		34

Source: For Figures on export destinations: VDKI (VDKI, 2016, 48) for Germany and IEA/OECD (2016a, III.62) for other countries. For the latter, figures for 2015 are derived from provisional data based on submissions received in early 2016; for figures on share in generation mix: IEA/OECD (2015b) and IEA/OECD (2016b).[18]

US, Israel and Turkey are major importers of Colombian coal, which can be reached by the Atlantic Ocean. Another import partner in Latin America is Chile. The aforementioned countries are considered to be of utmost importance for the future economics of Colombian steam coal exports. Owing to described global coal market trends in the last years it is unclear how the previously growing Colombian coal exports will evolve. The following section therefore analyses energy policies in current export destinations as well as potential future export partners in Asia focussing on prospects for future steam coal demand.

3. Trends influencing the future demand for Colombia's steam coal

3.1. The international perspective

The Paris Agreement and the international consensus on reducing GHG emissions directly imply a rapid reduction of coal consumption for the near term. The NDCs of most countries, however, do not yet include specific targets related to coal consumption or production. Moreover, the United Nations Environment Programme (UNEP) Gap report highlights that current NDCs are only sufficient to provide one third of the needed emission reductions to reach the 2°C target (UNEP, 2017). This discrepancy is also present in institutional projections of future coal demand.[7] Figure 4 shows projections from a range of institutions, energy companies, and scientific articles. It is important to note that, although the forecasts are provided by a seemingly heterogeneous group, some common motives can be identified. BP, ExxonMobil and Statoil are all oil and gas companies that have an inherent incentive to prolong the unconstrained use of fossil fuels, and will be negatively affected if stringent climate policies are enforced. Consequently, the reports and scenarios differ in their assessment of current and future reductions of levelized costs of electricity from renewables. In particular, they diverge in judging in how far technological progress has resulted in economic drivers that are increasing the speed of the global energy transition. Especially estimates for photovoltaics and wind, which also profit from improved and cheaper battery technology, vary in the examined studies.[8] The International Energy Agency (IEA) and Energy Information Administration (EIA), in particular, are both considered to constantly lag behind with their assessment of the potential of renewable energy sources, and therefore to favour projections that do not foresee any structural changes in the energy systems, and hence fossil fuel demand (Gilbert & Sovacool, 2016; Metayer, Breyer, & Fell, 2015). This is to be contrasted with the projections provided by McGlade and Ekins (M&E, 2015), which take the 2°C CO_2 budget and the respective allocation for the energy sector as given.

While some of the institutions provide several scenarios describing different futures, they also need to be treated with care. For example, in the case of IPCC SSP1 W2.6, IEA WEO SDS, M&E, and IPCC AR5 450 NoCCS projections, all claim to be consistent with a 2°C target. Still there is a divergence of 25 EJ to 70 EJ. The main reason for the disagreement is the crucial role that carbon capture, transport, and storage (CCTS) play in the

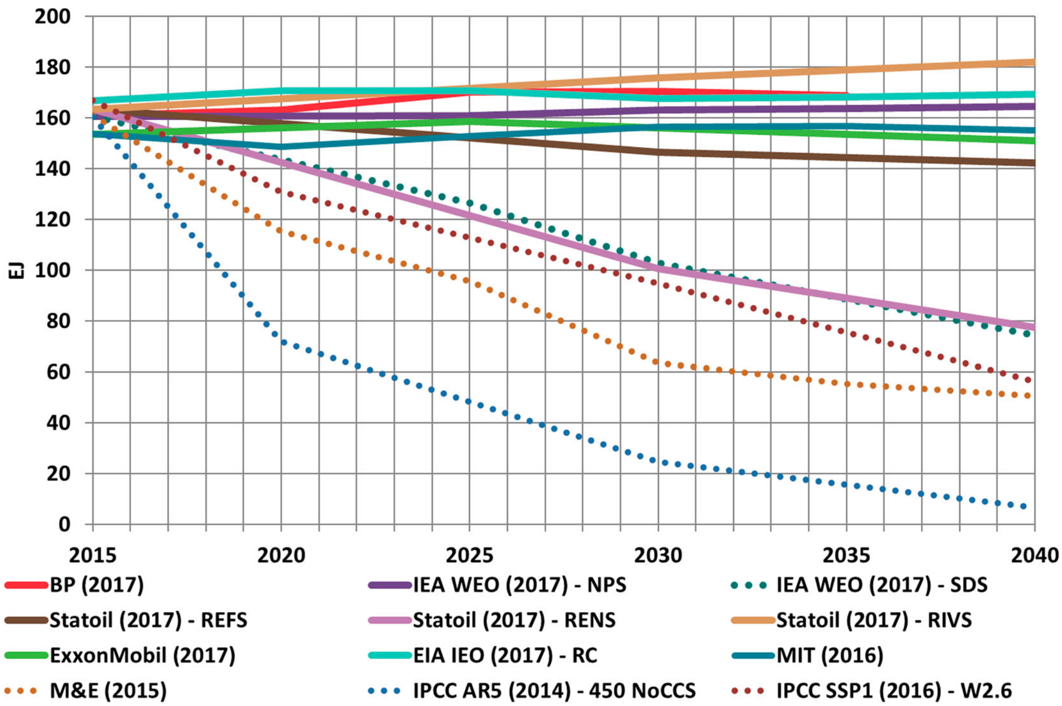

Figure 4. Projected coal demand until 2040 from various studies (in EJ).[11] Source: Own illustration based on BP (2017), EIA (2017), ExxonMobil (2017), IEA/OECD (2017), McGlade and Ekins (2015), MIT (2016), and Statoil (2017), Kriegler et al. (2014) and van Vuuren et al. (2017).

respective future energy system. While the IEA World Energy Outlook (WEO) Sustainable Development Scenario (SDS) assumes that more than 50% of installed coal-fired power generation capacity is equipped with CCTS (19% for the Intergovernmental Panel on Climate Change (IPCC) SSP1 W2.6 scenario), M&E and IPCC AR5 – 450 NoCCS estimate coal consumption patterns that would result in the absence of this technology. For CCTS, however, there is growing consensus that the chances for the technology to reach maturity before 2030 are very low (Downie & Drahos, 2017; EC, 2016; Oei & Mendelevitch, 2016; Oei, Herold, & Mendelevitch, 2014; von Hirschhausen, Herold, & Oei, 2012). Therefore, the M&E scenario is the only one that projects a coal demand pattern that is robustly in line with the 2°C target. Sticking to decarbonization targets therefore implies the rapid decline of coal in primary energy use from a current level of 160 EJ to 60 EJ by 2030. IPCC AR5 450 NoCCS projects an even more drastic coal phase-out that takes into account the relative burden of the energy sector to other GHG emitting sectors in a 2100 horizon perspective. These scenarios imply a rapid phase-out of much of the existing coal-fired generation fleet. If there is still an international coal market at all, it will be characterized by strong competition between many potential suppliers and very low shrinking demand.

3.2. Overview of coal consumption trends in current Colombian import partners

Given the ambiguity about the global trend in coal consumption described in the previous section, this section takes a more detailed look into trends in those countries that currently import Colombian coal. This provides the context for Colombian export infrastructure and potential new investments described in Section 2.5, which have to match with expectations about future imports from Colombia, otherwise they run the risk of becoming stranded. The remainder of the following two sections is a summary from detailed country case studies which can be found in the supplementary material to this article.

As noted above, the traditional importers of Colombian steam coal are located in Europe, US and to a lesser extent in Latin America. European countries share the common emissions trading system (EU-ETS), which requires reduction of CO_2 emissions from the power sector (EC, 2003; Fallmann et al., 2016). However, they vary in their energy mixes as well as their national energy policies which gives different emphasis on matters of climate policy or other aspects such as energy security. As a consequence, different strategies for reducing CO_2 emissions in the electricity sector either lead to support for renewable energy sources, nuclear capacities or CCTS technology. Table 4 shows the share of coal-fired generation in the electricity mix of the examined countries from 1970 to 2015 (IEA/OECD, 2016b).

Future coal demand in Europe and its neighbouring states has three parallel storylines that more or less follow an East–West divide:

- The Western European countries, having served as major importers of Colombian coal, have embarked on a coal phase-out path in the medium-term. Seven smaller countries in the EU are already coal-free: Belgium, Cyprus, Luxemburg, Malta and the Baltic countries. France and Sweden are planning to phase-out by 2022. The UK and Italy have announced the phase-out of coal by 2025, and the same is true for Denmark and Austria (CAN, 2016c; Jacobsen, 2014; Rudd, 2015). The Netherlands, Portugal and Finland have announced 2030 as their phase-out date (CAN, 2017).
- Germany's less advanced coal phase-out is currently being discussed for the 2040s. Other Western European countries (like Denmark, Spain, etc.) are also embarking on similar pathways with declining coal demand in the medium term (Agora Energiewende and Sandbag, 2017). As a consequence, Colombiás exports to Europe and also the role of the Netherlands as European hub for coal imports, is likely to decline and is examined thoroughly in the supplementary material to this article.
- The second storyline concerns some Eastern European states (most notably Poland, Czech Republic and some countries in the Balkans). These countries, apparently in contradiction with all climate change mitigation goals, are continuing to pursue a course of supporting coal-fired electricity and heat with the aim of supporting their domestic coal production (Frantál, 2016; Korski, Tobór–Osadnik, & Wyganowska, 2016; Manowska, Osadnik, & Wyganowska, 2017). As a consequence, coal mining companies, facing economic pressure owing to plummeting global coal prices, are being given state subsidies or are being renationalized (CAN, 2016a; Widera, Kasztelewicz, & Ptak, 2016). This limits the possibility for Colombian imports to enter these markets. Large domestic coal and lignite reserves imply a need for additional research on the future role of coal in these countries (Jonek Kowalska, 2015).
- Moving further to the east, investors in Turkey are planning to construct several new coal-fired power plants which might serve as potential new customers for Colombian coal exports. Another country that has increased its coal demand in recent years is Israel. Colombian coal, however, will have to compete with local suppliers in these countries as well as with shipments from the US, South Africa and Russia, and therefore needs closer evaluation in the supplementary material to this article.

Traditionally, the US has been both a coal exporter in times of high coal prices and strong demand from the European economies, and a coal importer in times of low coal prices but prolonged domestic demand. With the 'shale gas revolution' and increasing shares of renewables, this situation has changed fundamentally. There is high pressure on the domestic coal production sector and prices have fallen by up to 50% from 2010 to 2015 (Sussams & Grant, 2015, 16–17). Even if the era of cheap gas were to end in the near term, until the change in administration, environmental regulation in place had prescribed a coal phase-out (EPA, 2017a, 2017b, 2016a, 2016b). With the current rescinding of the Clean Power Plan framework (The White House, 2017a) the future of US domestic coal consumption is uncertain. If the Clean Power Plan is to be permanently suspended this could cushion the rapid decline of the US coal industry. Still, this leaves no space for future coal exports from Colombia to the US. On the contrary, the US might become a competitor on the Pacific market in the unlikely event that the current opposition of the US. West Coast states against constructing coal export terminals for Powder River coal from Wyoming breaks down (Western Interstate Energy Board, 2012). Even with US President Trump's roll-back of environmental regulation and promises to revitalize the US: coal industry, his clear 'America first' agenda will not allow increasing imports from Colombia.

With respect to trade partners in South America, Chile and Brazil benefit from their vast renewable potential and aim to increase their share of renewable energy supply. Owing to security of supply considerations, especially in times of drought, however, Chile had plans to maintain its coal-fired generation base (Ministerio de Energía, 2012) but announced in February 2018 that the country will not build new coal plants without carbon capture and begin talks to replace existing capacity with cleaner sources. Brazil still plans to construct new thermal plants in the southern states (Ventura, 2014). Domestic coal resources are not sufficient for these needs and, in the case of Brazil, are also of too low quality. Both countries will therefore continue to rely on coal imports. Colombia will most likely play an important role for these exports but could face increasing competition from US suppliers. Also, in Brazil, the majority of planned new fossil investment is directed towards natural gas, including liquefied natural gas (LNG) terminals.

3.3. Perspective on possible new export partners

The following section provides an analysis of regions with a potential increase in coal demand which therefore might be potential future export partners for Colombia. A special emphasis is put on the two biggest coal consumers, China and India, as well as Japan – being the only G7 member still considering the construction of several new coal-fired power plants. More detailed country case studies can be found in the supplementary material to this article.

If there will be any new market opportunities for Colombian steam coal, they will be mostly located in the Pacific region, where the two largest importers of steam coal - China and India – are located. At the same time, several factors speak against major exports of Colombian steam coal to the Pacific market. Currently it is dominated by Indonesia and - to a lesser extent – Australia, which can supply coal to China at lower costs than Colombia. However, with newly introduced and enforced quality standards on imported coal,[9] Colombian coal gains advantage against low-quality Indonesian coal (cf. Table 2). But demand for imported coal in China is likely to decrease rather than increase owing to ease in inland coal transport, and its 'coal-by-wire' programme.[10] Most importantly, a forecast decline in coal demand leaves little space for large-scale exports to China.

India is likely to decide the future of international steam coal markets. With its strong increase in projected energy demand, the future Indian fuel mix will be at the core of steam coal demand. If ambitious plans to expand renewable-based generation fail, the demand is likely to be met by additional coal-fired generation. But even then, it is unclear whether Colombia could get a role in supplying India's coal needs. Currently more than 85% of the new coal-fired generation fleet use sub-critical technology tailored for low energy and high ash content Indian coal. Similar coal types can be found in South Africa and Indonesia. If regulation to equip new-build power plants with supercritical technology becomes effective, then these might be more suitable for Colombian and Australian coal and open up new market opportunities.

Most power plants in South-East Asia, however, are designed for low-quality supply from Indonesia which can deliver coal at low cost owing to short distances and easy maritime access. This makes it very difficult for Colombian coal to enter these markets. Japan, and to a lesser extent also South Korea, on the other hand, are planning to construct new high-efficiency coal power plants. These plants are suited for burning coal of high quality from Australia, but might also use Colombian coal in the future. Consequently, the first shipments of ~0.6 Mt from Colombia arrived in the Pacific market in June 2016. These shipments up to now only constitute a minor share of South Koreàs imports, which mostly depend on Australia (~5 Mt/month) and Indonesia (~2–3 Mt/month) but still caused coal prices to drop to a 10-year low (Gloystein, 2016). This indicates that Colombiás entrance into the Pacific steam coal market might result in a continuous drop of coal prices and therefore affect the profitability of many actors. A drop of coal prices, however, might also incentivize the interest of other countries in coal usage, e.g. in the Middle East and North Africa (MENA) region (Corbeau, Shabaneh, & Six, 2016; Griffiths, 2017) as well as in southern Africa (Jacob, 2017; Power et al., 2016). This risk of the green paradox (Sinn, 2008) signals the need for a consistent global climate policy scheme in addition to the ongoing regional and national actions.

4. Conclusion

Continued global action for combatting climate change is having major consequences for fossil fuel producing countries, especially with respect to coal as the most carbon-intensive fuel. Given that CCTS technology is unlikely to prolong the usage of coal power plants, sticking to decarbonization targets implies a phase-out of all coal power plants in the next decades. Moreover, future coal demand in most European countries and in the US is declining, and will most likely continue to do so in the next decades. Reasons for this are increasing shares of renewable energy sources, stricter national environmental standards as well as alternative cheap gas supply in the US case. Various countries have already phased-out coal power plants or are currently discussing phase-out corridors for the next decades. Other potential consuming countries, such as Poland but also China and India, are likely to use subsidies and measures of renationalization to protect domestic companies from foreign imports. The consequence for coal exporters such as Colombia is stronger competition on the Atlantic as well as Pacific markets in an environment of low coal prices.

Starting a transition towards alternative industries in coal extracting regions is of the utmost importance, irrespective of projected final mine closure dates. The Colombian coal sector is, similar to that in many other countries, dominated by a small number of international private companies. These companies put their entire focus on coal extraction in Colombia but will drop any investment once this business becomes unprofitable. Exporting countries, such as Colombia, are thereby at risk not only of losing high shares of their state income, but also of being left with mono-industrialized regions that will face real difficulties in moving towards alternative, more sustainable industry sectors, if they start doing so too late. Continuing or even increasing mining volumes in coal exporting countries like Colombia should therefore be evaluated more closely from an economic perspective taking new market realities and trends, as well as local externalities, into account. Ignoring the risks could lead to additional stranded investments in mining and coal transportation facilities, providing another example for how the resource curse can slow down the economic development of regions.

In a high-competition and high-risk environment, mining operations will face increasing pressure, leading to a ramp up of mine closures, indicating the bursting of the carbon bubble. Devalued (stranded) carbon investments in many coal extracting countries will be the consequence. An increasing number of pension and insurance funds have consequently started to divest their portfolios into more sustainable sectors (Arabella Advisors, 2016). The remaining international firms are likely to concentrate their businesses on those mines with the lowest costs and the best coal quality. With their business model focusing on maximizing short-term profits, they will act to increase government support for their operations and to minimize their accountability for negative local impacts. The latter include local environmental and health costs as well as labour costs owing to less stringent safety regulations in some countries. As a result, those countries with the weakest governance and the lowest regulatory, environmental and safety standards might remain as the cheapest coal exporters. International climate policy making should take into consideration the need to prevent a 'race to the bottom' (i.e. a competition on lowering standards between coal exporters) when designing policy instruments.

Notes

1. Until the inauguration of President Trump in 2016, the US, under the Obama Administration, was also pursuing a clear Climate Action Plan (The White House, 2013) and had begun to enact the Clean Power Plan (CCP) (EIA, 2015a). However, using executive orders, Trump has repealed most of Obama's climate policies (The White House, 2017a). Moreover, he has decided to opt-out from the Paris agreement (The White House, 2017b) and against all trends, has committed himself to revitalize the US coal sector.
2. Coal is not a homogeneous commodity but is commonly categorized as steam coal, metallurgical or coking coal and lignite, based on its material properties and end-use. Steam coal is the set of coal types that are typically combusted to produce steam. Metallurgical coal is bituminous coal which is used to produce coke for use in the iron and steel industry. Lignite is a low-quality brown coal which is also typically used to produce steam.
3. FOB costs include all cost incurred from the point of production to loading the coal on a ship ready for shipment.
4. See SACRM (2011, 2013) for South Africa, and Cornot-Gandolphe (2017) for Indonesia on coal quality and reserves.
5. Coal rents are calculated by the World Bank as international coal prices minus total costs of production.
6. Figures for Germany, however, were inconsistent from 2010 onwards and were therefore derived from statistics by VDKI (2016).
7. Including steam coal, metallurgical coal and lignite. One should note that future consumption of steam coal and lignite vs. metallurgical coal might develop very differently, due to use of the latter for steel production, where few substitutes are available, compared to the power sector. Consequently, steam coal demand has to decline even more rapidly in deep decarbonization scenarios (von Hirschhausen et al., 2012). Yet, the reported figures do not allow disentangling the development in all cases. For example, in the IEA WEO (2017) the ratio of coal in power generation vs. total primary coal demand stays constant at around 60% between 2015 and 2040 in the New Policies Scenario (NPS) (on an energy content basis), while in the Sustainable Development Scenario (SDS) the ratio drops to 33%.

8. These trends can also be seen in recent studies that show global energy system models for 2050 based on 100% renewable energy sources (Breyer et al., 2017; Löffler et al., 2017; Jacobson et al., 2017).
9. E.g. in China, c,f, CKIC. 2017. "The Analysis of Unqualified Coal during China's Coal Import in 2016." CKIC. May 26, 2017. http://www.ckic.net/news/special-topic/the-analysis-of-unqualified-coal-during-chinas-coal-import-in-2016.html. Access 07.12.2017, 14:55.
10. The Chinese government set out a programme to integrate coal producers and power generators to establish 'coal-power bases', which enable the transport of 'coal-by-wire', i.e. via the electricity grid instead of railroads (Rui, Morse, & He, 2015).
11. The underlying models provide estimates in 5- to 10-year steps. Therefore, the line between these steps are only for illustrative purposes. IEA WEO (2017) – CPS refers to the IEA World Energy Outlook's Current Policy Scenario (IEA/OECD, 2017), NPS stands for New Policies Scenario, and SDS is the Sustainable Development Scenario; Statoil – REFS refers to the Statoil World Energy Perspectives Reform Scenario(Statoil, 2017), RENS to the Renewables Scenario, and RIVS to the Rivalry Scenario; EIA EIO – RC refers to the EIA Energy International Outlook's Reference Case (EIA, 2017), M&E refers to the extraction path for coal calculated to be consistent with a 2°C target by McGlade and Ekins (2015), excluding the option of CCTS; IPCC AR5 (2014) refers to scenarios reviewed in the Fifth Assessment Report (AR5) of Working Group III of the Intergovernmental Panel on Climate Change (IPCC), here results of the MESSAGEV.4-AMPERE2-450-NoCCS-OPT run are presented (Kriegler et al., 2014); lastly, IPCC (2016) SSP1 W2.6 refers to Shared Socioeconomic Pathways (SSPs) and related Integrated Assessment scenarios, here results of the MESSAGE-GLOBIOM-SSP1-26 are presented (van Vuuren et al., 2017).
12. See ESPA (2012) for details on energy content, ash and sulphur in the US.
13. See Cornot-Gandolphe (2014) for ash and sulphur content.
14. See IEEFA for details on ash content in Australia and comparison to India.
15. See Tewalt et al. (2010) for calorific value, ash and sulphur content.
16. See Burton and Winkler (2014) for the energy content and SACRM (2011) ash and sulphur content.
17. See Cornot-Gandolphe (2017) for ash and sulphur content.
18. The IEA only includes data for Israel from 1990 onwards for the share of coal in the electricity sector.

Acknowledgements

We thank Andrea Cardoso, Kristina Dietz, Karin Gabbert, Ferdinand Muggenthaler, Laura Rodriguez, and Sebastian Rötters for helpful insights, critiques, and comments regarding the particularities of the Colombian coal market. Additional thanks go to Jan Ilsemann, Bobby Xiong, Hanna Brauers, Franziska Holz and Christian von Hirschhausen for their discussions on our work. Moreover, we would like to thank three anonymous reviewers. The usual disclaimer applies.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

Funding was provided by the German Federal Ministry for Education and Research (Bundesministerium für Bildung und Forschung, BMBF) in the 'CoalExit' project [01LN1704A].

ORCID

Roman Mendelevitch http://orcid.org/0000-0001-5054-109X

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