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PERSPECTIVES ON COLOMBIAN COAL EXPORTS ON THE INTERNATIONAL STEAM COAL MARKET UNTIL 2030

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EXECUTIVE SUMMARY

Continued global action for combating climate change has major consequences for fossil fuel producing countries and especially with respect to coal reserves as most carbon-intensive fuel. Depending on various scenarios, 70–90 % of coal, 30–60 % of gas and 30–60 % of oil reserves of the world must not be burned to meet the internationally-agreed climate target of avoiding more than a 2° C rise in global average temperature. The carbon capture, transport, and storage technology will not be an option to prolong the usage of coal power plants. Sticking to decarbonization targets therefore implies a phase-out of all coal power plants in the next decades. Prolonged investments in fossil assets make-up the so-called carbon bubble which might burst once stringent climate policies are enforced. The consequence would be stranded investments in carbon-intensive infrastructure by both countries and companies with big fossil reserves. This is going to affect also Colombia that is estimated to have around 5 Gt of probable coal reserves.

Colombia is currently the 4th largest steam coal exporter in the world (79.0 Mt in 2013, and 78.8 Mt in 2014). It largely supplies European and Mediterranean consumers but also delivers some quantities to the U.S. at the Golf Coast, and to Central and South America. Since 2005, however, steam coal consumption in the OECD has decreased by around 12 %. Future coal demand in most European countries and in the USA will most likely continue declining in the next decades. Reasons for this are increasing shares of renewable energy sources, stricter national environmental standards as well as for the case of the U.S. alternative cheap gas supply. On a global level coal power plant capacities of more than 165 GW have been retired since 2010 or are announced for closure. With 100 GW, the majority of this share is located in the U.S., but also EU hard coal consumption was halved since 1990.

Future coal demand in the EU has two parallel storylines which more or less follow an east-west divide: Most western European countries 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, as well as the Baltic countries Estonia, Latvia and Lithuania. Portugal is planning to phase-out in 2020, followed by Finland in the 2020s. The UK, Denmark and Austria have announced to phase-out coal until 2025. Germany's less advanced coal phase-out is currently being discussed for the 2040s. Other Western and Southern European countries (France, Spain, Italy etc.) are also embarking on a similar pathway with declining coal demand in the medium term. As a consequence the role of the Netherlands as the European hub for coal imports is also likely to decline. On the other hand, against all efforts of climate change mitigation some Eastern European states (most notably Poland, and Czech Republic) pursue a course of supporting coal-fired electricity generation by backing up their domestic coal industry. This reduces the possibility for additional imports from ColombiaTurkey and Israel, on the other hand, are planning to construct several new coal fired power plants. Colombian coal, however, will have to compete with local suppliers as well as with shipments from the USA, South Africa, and Russia.

Traditionally, the USA was 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 with increasing shares of renewables this situation has changed fundamentally. There is high pressure on the domestic production sector and prices have fallen by up to 50 % from 2010 to 2015. Even if the era of cheap gas would end in the near term, environmental regulation in place prescribes a coal phase-out. This gloomy outlook for the U.S. coal sector leaves no space for future coal exports from Colombia to the USA. On the contrary, the USA might become a competitor on the Pacific market in the unlikely

event that the current opposition of the U.S. West Coast states against constructing coal export terminals for Powder River coal from Wyoming brakes down.
Brazil will continue to rely mainly on renewable energy sources for its power generation and on Liquefied natural gas imports for thermal power generation rather than strongly increasing the share of coal. Chile benefits from vast renewable potential and aims at increasing its share of renewable energy supply. Due to security of supply considerations, however, Chile also plans to maintain its coal-fired generation base. Although also developing domestic resources, it will therefore, continue relying on coal exports. Colombia will most likely play an important role as exporter, but could face increasing competition from US suppliers. The same is true for future supplies to Mexico.

The world steam coal market was traditionally divided into a Pacific market and an Atlantic market, with prices differing due to geographical separation and other market conditions. Colombia, together with the USA and South Africa has a favorable 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. However, with increasing trade between the regions, the traditional divide has blurred and prices are now more closely linked. At present, world steam coal prices are weak due to slowing demand growth and an over-supplied market but also due to low oil prices which factors in via required fuel supply to mining machinery and freight ships. As demonstrated in this analysis, if there will be any new market opportunities for Colombian steam coal, they will be mostly located in the Pacific region.

The recent widening of the Panama Canal is expected to increase the competitiveness of Colombian steam coal exports on the Pacific market, as it allows vessels to avoid travelling around South America. The degree, to which a particular supplier of steam coal can be substituted, however, depends on the specifics of the power plant and of the coal it is designed for. 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 needs future preparation and beneficiation before it could substitute Colombian coal in high efficiency supercritical boilers. 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.

Currently the Pacific market is dominated by Indonesia and – to a smaller extent – Australia which can supply coal at lower costs than Colombia. Several factors speak against China becoming a large importer of Colombian steam coal as a forecasted decline in coal demand leaves little room for large-scale exports. With new quality standards on imported coal Colombian coal gains advantage against low quality Indonesian coal, though. On the other hand, demand for imported coal in China is likely to decrease due to ease in inland coal transport, and its "coal-by-wire" program. Also in other South-East Asian countries power plants are designed for low quality supply from Indonesia which can deliver coal at low cost due to short distances and easy maritime access. This makes it very difficult for Colombian coal to enter these markets.

India is likely to decide the future of international steam coal markets due to its strong increase in projected energy demand. But even then, it is unclear whether Colombia could get a role in supplying India's coal needs. Currently more that 85 % of the young 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 but not in Colombia. Japan and South Korea are planning to construct new coal power plants suited for burning coal of high quality from Australia but might also use Colombian coal. News spread when first shipments of ~0.6 Mt from Colombia were announced to arrive in South Korea in June 2016. These shipments only constitute a minor share of Korea`s 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-years low.

This study examines possible future trends of the international steam coal market with a focus on export potentials for Colombia. The study puts an emphasis on business and economic considerations taking into account future aspects of climate policy. The findings show that major shares of former export quantities are about to vanish in the next years. Possible newly constructed power plants are unlikely to compensate for this decline. Increasing competition on the Atlantic as well as Pacific coal market will keep coal prices low and consequently also revenues of the mining companies. The increasing number of filed bankruptcies and lay-offs, including three out of the top five US coal mining companies in 2015, might just be the beginning of a carbon bubble devaluating stranded carbon investments. An increasing number of pension and insurance funds consequently started to divest from fossil fuels and reorienting their portfolios towards more sustainable sectors. Continuing or even increasing mining volumes in Colombia should therefore be evaluated more closely from an economic perspective. Ignoring the described risks could lead to additional stranded investments in mining facilities, being another example for how the resource course slows down the economic growth of Colombia and in particular of the regions La Guajira and Cesar.

DETAILED CONTENTS

LIST OF ABBREVIATIONS

bcm	Billion cubic meter
CCS	Carbon capture and storage
CCTS	Carbon capture, transport, and storage
CCU	Carbon capture and utilization
CO_2	Carbon dioxide
CO_2-EOR	CO_2-Enhanced Oil Recovery
EC	European Commission
EJ	Exajoules
FOB	Free on broad, costs include all cost incurred from the point of production to loading the coal on a ship ready for shipment.
GJ	Gigajoules
Gt	Giga tons
HELE	high efficiency and low emissions
IEA	International Energy Agency
INDC	intended nationally determined contribution
Mt	Mega tons
t	Ton
OECD	Organization for Economic Co-operation and Development
WEO	World Energy Outlook

1 INTRODUCTION

The sustainable development goals (SDG) adopted at the United Nations Sustainable Development Summit in September 2015 include tackling climate change as one of its key targets (UN 2015a). This goal was confirmed by the Paris Agreement aiming at limiting global temperature rise well below 2° C and to drive efforts to increase the target even further to 1.5° C (UN 2015b). The need for combating global warming is by now widely accepted across governments (Leader of the G7 2015; World Summit of the Regions 2014), international institutions (World Bank Group 2015; IPCC 2014), civil society organizations and religious groups (e.g. Roman Catholic Church: Pope Franziskus 2015). The Intergovernmental Panel on Climate Change (IPCC) calculated a remaining budget of 870–1,240 billion t CO_2 from 2011 through 2050 to have a more than 50 % chance of achieving the 2° C target (IPCC 2014).

A major challenge in tackling global warming is the reduction of GHG emissions. Burning fossil fuels is the biggest source behind rising global GHG emissions (see Box 1). Thus the majority of global fossil fuel reserves, equivalent to 11,000 $GtCO^2$, must not be burned (Meinshausen et al. 2009). Studies by McGlade and Ekins (2015) and by Bauer et al. (2013b) estimate that, depending on various scenarios, 70–90 % of coal, 30–60 % of gas and 30–60 % of oil reserves of the world must not be burned to meet the internationally-agreed climate target of avoiding more than a 2° C temperature increase. Therefore, effective policies to curb fossil fuel and, in particular, coal consumption are needed as quickly as possible. The projections of McGlade and Ekins (2015) result in a maximum budget of 90 EJ of coal annually between 2010 and 2050 in order to achieve the 2° C target. The constant, ongoing, exploration for new fossil resources, despite the awareness of climate change, has led to reserves (11,000 $GtCO_2$) that exceed the allowed budget (870–1,240 $GtCO_2$) by a factor of 10. This so-called carbon bubble might burst once stringent climate policies force giving up already discovered reserves. The consequence would be stranded investments in carbon-intensive infrastructure by both countries and companies with big fossil reserves. Many state-owned companies and pension funds would suffer since they have invested in resource businesses. The global divestment campaign including the carbon tracker initiative is encouraging investors to redirect their investments from carbon intensive industries into more sustainable sectors. An increasing number of pension and insurance funds, including the Norwegian Government Pension Fund Global as well as the Axa and Allianz insurance companies, have already altered their investment strategies for a combination of economic and moral reasons. (Leaton 2011; Marshall 2013; HSBC 2012; Leaton et al. 2014)

Continued global action combatting climate change therefore is having major consequences for countries with fossil fuels and especially with respect to coal reserves as most carbon-intensive fuel. This is going to affect also Colombia that is estimated to have around 2.4 billion barrels of crude oil reserves, 161 bcm natural gas reserves, 62 bcm of Coalbed methane, and 5.041 Gt of probable coal reserves (EIA 2015a). More than 90% of Colombia's extracted coal is currently being exported, contributing a major share to its overall GDP. Shrinking coal consumption from its main export partners in the USA and Europe as well as plummeted coal prices, will have an influence on Colombia`s economy. This study therefore examines possible future trends of the international steam coal market with a focus on export potentials for Colombia. The study focuses on business and economic considerations and aspects of climate policy, leaving other issues of (a continuation of) coal extraction in Colombia aside. There, however, exists a wide range of studies that put different foci on environmental and health aspects (CINEP 2012; CINEP/PPP 2016; CENSAT 2015; Fierro Morales 2014; Greenpeace 2008) as well as social, human rights and work conditions (Moor and van de Sandt 2014; Ganswindt, Rötters, and Schücking 2013; CAN 2016a; Romero Epiayú and Barón Romero 2013; Hawkins 2014; Chomsky and Striffler 2014; Roa 2013; Coronado Delgado et al. 2014; CINEP/PPP 2014; Roa Avendano et al. 2012) or the financial institutions behind the mining companies (Schücking 2013). The findings of those studies focusing hereby on Colombia can partly also be transferred to other developing or emerging countries that rely on fossil fuel extraction such as Indonesia or South Africa.

The remainder of the study is structured as follows: This introduction is followed by a section describing the international steam coal market before focusing on the status quo of the Colombian steam coal sector in the third section. Section four examines key current and potential future destinations of Colombian coal exports providing insights on current coal demand and trend for the future. Section five elaborates on different technical and political trends that could influence future global coal consumption before drawing final conclusions in section six.

Box 1: Negative external effects of coal combustion

Combustion of fossil fuels (coal, gas, and oil) entails a long list of negative external effects, including emissions of carbon dioxide (CO_2), nitrogen oxides (NO_x), sulfur dioxide (SO_2), mercury, dust, small particulates matter, and noise (EC 2003). Burning coal results in the highest external costs of between 80 and 100 €/MWh, according to a study for the European Commission (EC) by Ecofys (2014). This is twice the average European electricity wholesale price (Agora Energiewende 2014). Moreover, extracting resources leads to indirect pollution, to large-scale devastation, and forces the relocation of thousands of people. International resource companies, on the other hand, reap large profits and sometimes even receive state subsidies ("polluter profits") (Richards and Boom 2015). The Organization for Economic Co-operation and Development (OECD 2015) published a study that improves the understanding of the range and magnitude of fossil fuel subsidies in different countries. They counted almost 800 individual policies that support the production or consumption of fossil fuels in OECD countries and six large partner economies (Brazil, the People's Republic of China, India, Indonesia, the Russian Federation, and South Africa) with an overall value of US$160-200 billion annually over the 2010–14 period. A global study by the International Monetary Fund (IMF 2015) find an overall figure of 6.5% of global GDP, including direct subsidies as well as indirect ones, which includes when countries set energy taxes below levels that fully reflect the environmental damage associated with energy consumption.

2 INTRODUCTION TO THE INTERNATIONAL STEAM COAL MARKET

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[1]. Around 70 % of steam coal is used to produce electricity and heat, and the remainder mostly for other industrial heat-consuming activities (IEA 2015c, III.68). Following the International Energy Agency (IEA), steam coal includes anthracite, other bituminous coal and sub-bituminous coal, with an energy content ranging from 20 GJ/t to as much as 30 GJ/t (IEA 2015c, I.25).
Steam coal is mined at either surface or underground mines, mainly depending on the depth of the coal seam (Speight 2012). The raw coal is processed through crushing, screening and beneficiation/washing operations to meet customer specifications. To transport the coal to port or market, rail is most common, but river barges are also used (as well as other modes of transport over short distances). Where necessary along the supply chain, coal is stored in open air stockpiles or enclosed silos.

2.1 The international steam coal market and the role of Colombia

Large-scale demand for steam coal originated in the eighteenth and nineteenth centuries, where its use in powering steam engines was central to the Industrial Revolution and subsequent economic growth in Europe and the United States (Fernihough and O'Rourke 2014; Chandler 1972). By the start of the twentieth century coal had become the dominant source of energy worldwide, though during the early to mid-twentieth century it lost shares to oil and gas (Smil 2000). The oil crises of the 1970s triggered the revival of the steam coal market, as countries which had previously imported large quantities of oil for power generation sought to bolster their energy security by diversifying their power supply (IEA 1997, 25). Coal was an attractive substitute for oil due to its wide abundance and low cost (Thurber and Morse 2015, 12–13). From 1980 to 2000, steam coal consumption grew steadily in most OECD and non-OECD regions alike (with Europe being an exception), and from 2000 to 2005 there was a large spike in steam coal consumption in non-OECD countries (China and the rest of the Asia-Pacific region in particular) (IEA 2014d).
Since 2005, steam coal consumption in the OECD has decreased by around 12 % (IEA 2015c), due to general trends of decarbonization and lower energy consumption (IEA 2014e, 172). 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 2015c). This rapid growth in demand triggered significant investment in supply capacity and transport infrastructure (IEA 2014e, 186). However, since 2015 demand growth has slowed.

Table 1: Major steam coal producers and consumers in 2014 (in Mt).

Major producers in 2014	Major consumers in 2014
China (3,200 Mt)	China (3,280 Mt)
United States (770 Mt)	India (760 Mt)
India (560 Mt)	United States (750 Mt)
Indonesia (470 Mt)	⋮
⋮	Japan (137 Mt), South Korea (100 Mt)
	⋮
Colombia (84 Mt)	Germany (46 Mt), UK (42 Mt)
World production 6,150 Mt	**World consumption 6,090 Mt**

Source: IEA (2015c).

Since the 1980s, China has been the world's largest consumer of steam coal. India was 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 steam coal consumer in 2014 (on a tonnage basis) – narrowly overtaking the USA, whose con-

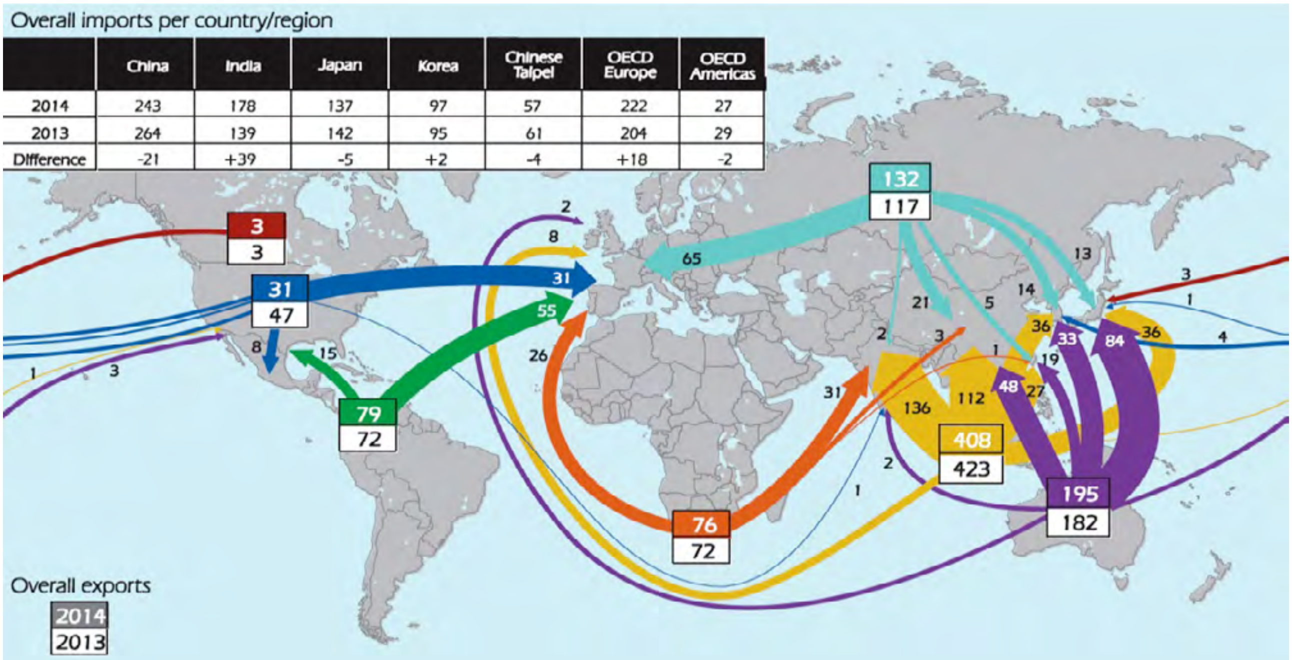
1 Metallurgical coal is bituminous coal which is used to produce coke for use in the iron and steel industry. Lignite is a low-quality brown coal which is also used to produce steam.

sumption has decreased by around 20 % over the past decade. 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. In more recent years, analysis by Steckel et al. (2015) shows that it is not only China and India which are driving a renaissance of coal; rather, it is gaining dominance in numerous countries around the world (especially in South-East Asia but also in Turkey) to fuel their economic growth. (IEA 2015c)

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 USA. 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 the 9th largest producer of steam coal (84.5 Mt in 2013, 81.3 Mt in 2014). (IEA 2015c)

Figure 1 depicts major importers, exporters and trade flows of steam coal in 2013 and 2014. Worldwide, the total quantity of internationally traded steam coal in 2014 represented 17 % of total demand, with the majority being seaborne trade. The total volume traded has increased at an average annual rate of 6 % 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. Due 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 (IEA/OECD 2014, 50). Colombia is currently the 5th largest coal exporter (80.2 Mt in 2013, 80.3 Mt in 2014), and the 4th largest steam coal exporter, 79.0 Mt in 2013, and 78.8 Mt in 2014). It is the largest supplier on the Atlantic market but also supplies some quantities to the US at the Golf Coast, and to Central and South America. (IEA 2015c)

Figure 1: Major exporter, importers and trade flows of steam coal in 2013 and 2014.


Overall imports per country/region

	China	India	Japan	Korea	Chinese Taipei	OECD Europe	OECD Americas
2014	243	178	137	97	57	222	27
2013	264	139	142	95	61	204	29
Difference	-21	+39	-5	+2	-4	+18	-2

Source: OECD/IEA (2015) © IEA/OECD 2015 Medium-Term Coal Market Report, IEA Publishing. License: www.iea.org/t&c

Box 2: Tracking the origin of steam coal supply

The issue of "blood coal", where coal companies were accused of having financed and collaborated with paramilitary organizations has been raised by many NGOs (SOMO 2013; Moor and van de Sandt 2014). But despite the foundation of the industry-level Bettercoal initiative (Bettercoal 2016) the coal supply chain remains vastly untransparent. (e.g. see Kern 2015; Schröder 2015). This means that even experts having access to customs and shipping information have difficulties determining the origin of coal supply (SOMO 2014).

2.2 Cost structure and price formation

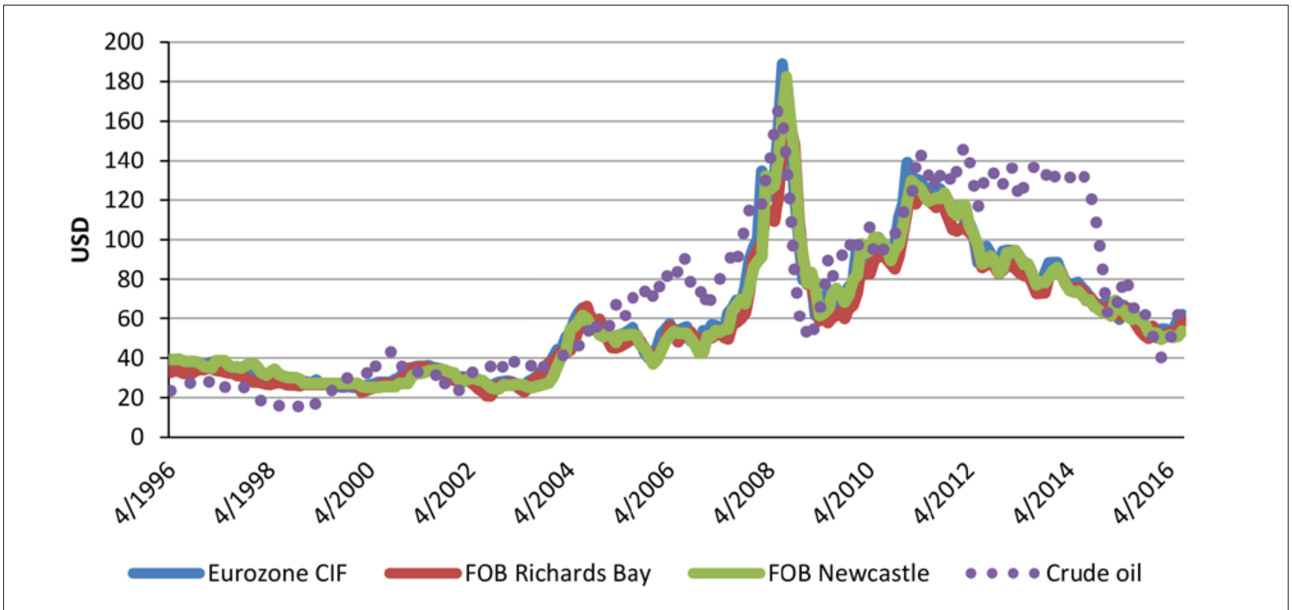
Capital costs of coal production – for prospecting and exploration and the development of mines and associated infrastructure – are a relatively small proportion of overall costs (IEA 2014c, 53). Variable costs are the more significant component, and include the costs of labor, materials, transport, taxes and royalties. These costs will range, especially based on the distance to market but also depending on the type of mining operation, mining conditions, local labor market and productivity (Ritschel and Schiffer 2007; IEA/OECD 2014, 56). While opencast mines allow for the utilization of large-scale machinery with low labor intensity, underground mines require more labor-intensive smaller-scale production processes. 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) cost[2], freight rates and the exchange rate. Steam coals are graded according to their quality characteristics, such as energy content, ash content and sulfur content, and prices will vary accordingly (Li 2010) (see section 2.3 for a discussion of relative performance of Colombian coal compared to other competitors).

The world steam coal market was traditionally divided into a Pacific market and an Atlantic market, with prices differing due to geographical separation and other market conditions (Li 2010). However, with increasing trade between the regions, the traditional divide has blurred and prices are now more closely linked (Thurber and Morse 2015). At present, world steam coal prices are weak due to slowing demand growth and an over-supplied market (IEA 2014e, 186) but also due to low oil prices which factors in via required fuel supply to 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.

Figure 2: Monthly prices for steam coal in USD/t (CIF Eurozone, FOB Richards Bay, and FOB Newcastle) and crude oil in USD/bbl (crude oil index) between April 1996 and April 2016.



Source: HWWI commodity prices in the Thompson Reuters Datastream database.

2.3 Relative performance of Colombian coal compared to other competitors: coal quality, energy content, production costs

As mentioned above, steam coal is not a homogenous good. Rather, different suppliers provide different coal with different moisture, energy, sulfur, and ash content. The quality is also reflected in prices, where coal with high energy content, low moisture, sulfur and ash content is most desirable, and therefore also best priced (al-

2 FOB costs include all cost incurred from the point of production to loading the coal on a ship ready for shipment.

so see Box 3). Data on energy content of coal from different destinations is shown in Table 2. According to this study the decline in coal quality is not only due to a shift towards lower rank coals, like 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 and therefore one can observe a decline in the energy content of the coal supplied by these suppliers. On an energy basis, Colombian steam coal has a price advantage due to its high quality and low production costs in open cast mining operations.

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

Node	Calorific value in kcal/kg	Energy content in GJ/t
USA Powder River Basin	4781	20.004
USA Appalachia	6949	29.075
Colombia	6375	26.673
South Africa	6400	26.778
India West	5209	21.793
Indonesia	5450	22.803
China Shanxi, Shaanxi, Inner Mongolia	6597	27.600
Australia Queensland	6500	27.196
Australia New South Wales	6300	26.359

Source: Holz et al. (2015) based on Platts (2009), Indian Bureau of Mines (2012), Ritschel and Schiffer (2007), and Tewalt et al. (2010).

As depicted in Figure 3 inland transportation infrastructure is another key cost component which governs the relative competitiveness of steam coal producers. While in Colombia and Indonesia coal deposits are located close to or right at the shore, steam coal from South Africa but in particular from Russia requires long rail haulage which increase its respective FOB costs.

A third decisive component is the distance to market for the respective coal producer. Colombia, together with the USA and South Africa has a favorable 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 et al. (2015) for 2010. It is worth mentioning, that two factors heavily influence future freight rates: First, fuel costs are a major cost component and therefore future freight rates will depend on future fuel prices, especially on oil prices; and second, dry bulk shipping is subject to general trend of international trade such as investment cycles and inter- and intra-market competition. With currently very low oil prices (see Figure 2) and a cool down in global economic growth, freight rates for coal have substantially decreased. E.g. rates for coal from Colombia – Puerto Bolivar delivered to Rotterdam were halved from levels around 15 USD/t from 2010–2013 to 8 USD/t in August 2015 (Platts 2015) (see Table 3 and Figure 3).

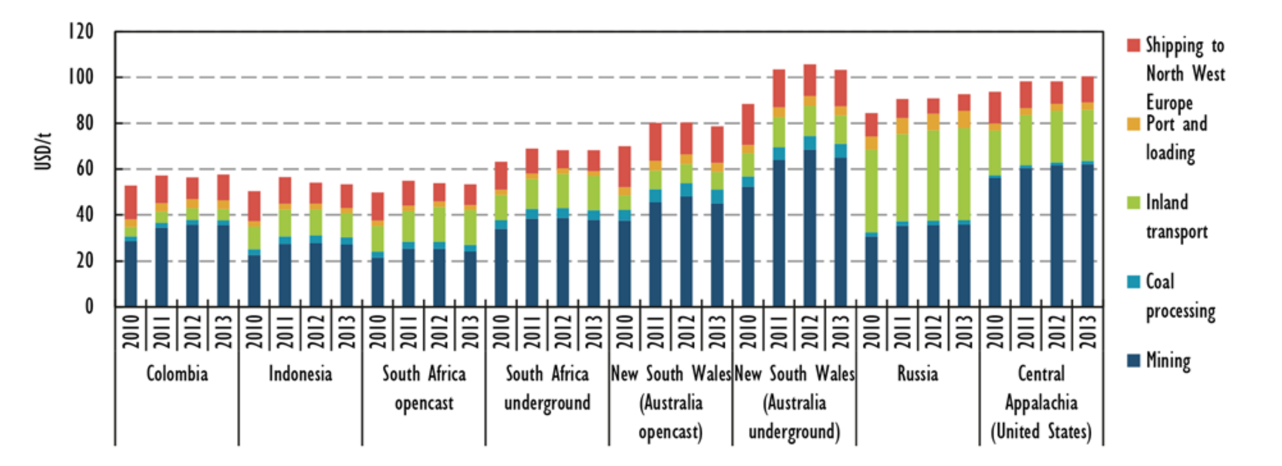
Table 3: Freight rates for selected routes (in USD/t)

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).

Figure 3 illustrates the added up costs of mining, coal processing, inland transport and port handling costs for the main steam coal exporter, namely Indonesia, Australia, South Africa, Russia, Colombia and the U.S. east coast Appalachia region. The figure illustrates the relative competiveness of Colombian coal on the European market.

Figure 3: Indicative steam coal supply costs to North West Europe by supply chain component and by country, 2010–13, excluding taxes and royalties (in USD/t).



Source: IEA/OECD (2014) © IEA/OECD 2014 Medium-Term Coal Market Report, IEA Publishing. Licence: www.iea.org/t&c

Box 3: Substitutability of different coal sources from the point of view of power producers

Steam coal is a heterogeneous commodity with specific moisture, ash content, sulfur content and calorific value, depending on the respective deposit of origin. 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 the plant efficiency and increase maintenance requirements and material wear. 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 sulfur content requires higher flue gas temperature 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).

There are three consequences from this observation:

1) The degree to which a particular supplier of steam coal can be substituted depends on the specifics of the power plant and of the coal it is designed for.
2) 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 needs future preparation and beneficiation before it could substitute Colombian coal in high efficiency supercritical and ultra-supercritical boilers.
3) 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 2015a, 440).

3 COAL MINING IN COLOMBIA

3.1 Current state of the coal sector

Since 2000, the Colombian economy has been one of the most dynamic economies in South America, successfully attracting foreign investors from all parts of the world. At the end of 2015, its GDP climbed to 225.6 billion USD after a decade of high annual growth rates. Between 2004 and 2007, the economy grew at an average of 6.2 %/y. Due to the world economic crisis in 2008/2009, economic growth cooled down to 1.9 %/y; however, soon after, it got back on track, climbing by 4.4 % and 6.6 %. In 2015, the weak Peso and declining commodity prices hampered the Colombian economy. Though, with an annual growth rate of 3.1 % it was still one of the most dynamic countries in Latin America, mainly driven by the construction sector as well as real estate and financial services. (AA 2016)

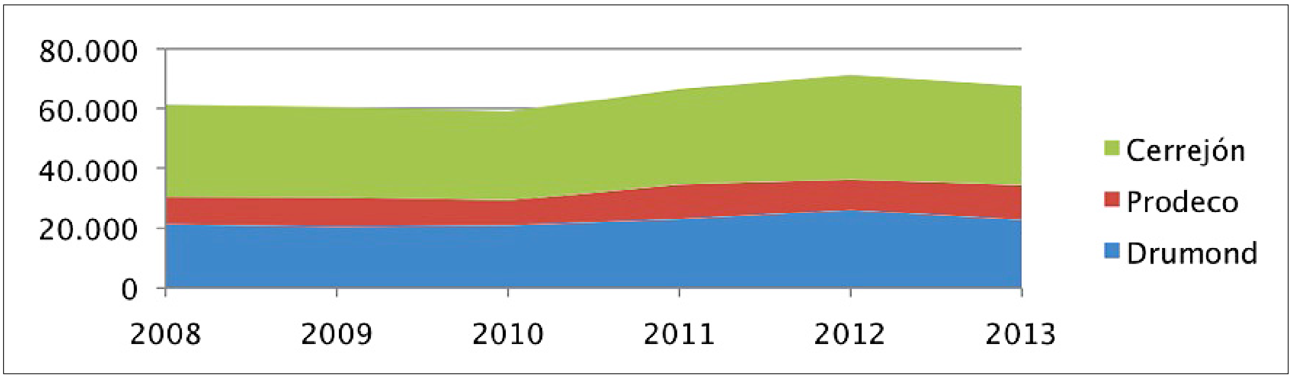
The economy of Colombia is based on agriculture, industry, tourism, mining as well as oil and natural gas production. In terms of exports, Colombia relies heavily on oil and steam coal. Further, flowers, bananas, nickel, and gold are also important export goods. Most exports are bound to the USA and the European Union, with which Colombia signed free trade agreements in May 2012 and August 2013, respectively.

The extraction of fossil resources sums up to 7.7 % of the GDP in 2013. The major share can be traced back to oil and gas with 5,6 % and coal contributing 1,3 % (UPME 2014). The oil and gas sector is hereby dominated by state-owned companies while the coal sector is dominated by three foreign firms (FES 2014):

- Cerrejón (owned by a consortium of BHP Billiton, Anglo American and Glencore; employing around 15,000 people);
- US-based Drummond (employing around 9,000 people);
- and Prodeco (owned by Swiss-based Glencore; employing around 6,000 people).

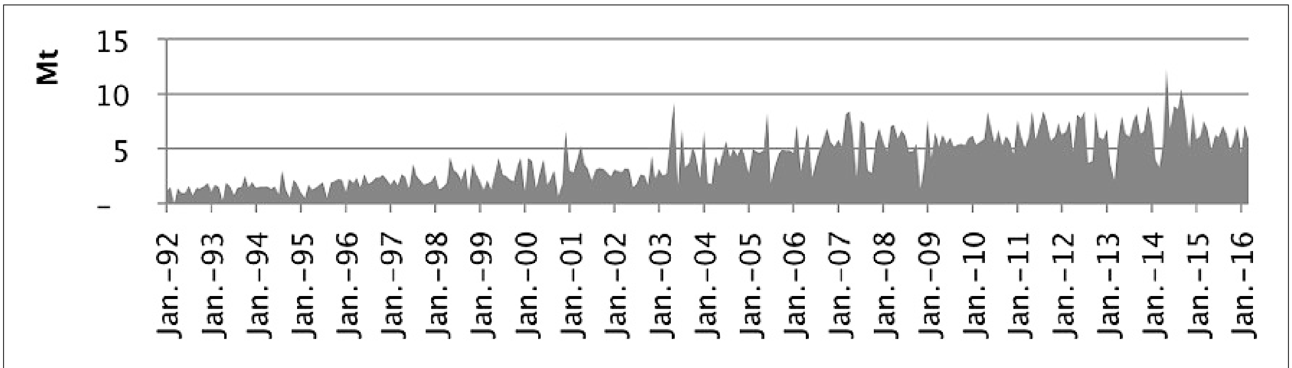
Production and export volumes evolve concurrently and have almost tripled since 2000. Traditionally, the export ratio is greater than 90 % as electricity generation relies heavily on hydropower, and requires only small amounts for domestic consumption (USGS 2015). Figure 5 shows the monthly Colombian steam coal exports since 1992 until January 2016 that were continuously growing but starting to shrink in the last months (DIAN-DANE 2016).

Figure 4: Annual production volumes of the biggest Colombian coal firms from 2008–2013 (in Mt).



Source: Own depiction based on FES (2014, 28).

Figure 5: Monthly Colombian steam coal exports from 1992–2016 (in Mt).



Source: DIAN-DANE (2016).

3.2 Mining activities

In 2011, mining has been acknowledged as one of the "five locomotives" for the economic development, by President Santos. Traditionally, mining in Colombia has two components: formal, large-scale mining activities and informal small-scale mining. While the former is usually carried out by large international firms, the latter, is of artisanal subsistence character, which typically is insecure and lacks of proper tools (MINMINAS 2015). Since the 1990s and especially after the passing of a new mining law in 2001, Ley 685, the mining sector has undergone substantial transformation, e.g. the slimming down of the mining administration or the re-formulation of fiscal policies in order to attract foreign direct investment (Dietz 2016). Today, the government is less involved in Colombia`s coal mining business. Instead the "Ministerio de Minas y Energía (MINMINAS)" is responsible for the general policy making and the regulation of Colombian mining activities. It regulates in particular the generation, transmission, interconnection, distribution and also approves generation and transmission programs. Further, it supervises agencies like the "Unidad de Planeación Minero Energética (UPME)", which is responsible for planning mining activities (USGS 2006).
Estimates regarding steam coal reserves vary significantly. Bright (2011) indicates the reserves with 6.434Gt (much higher than 5.041 Gt of probable coal reserves by the EIA (2015a)), which is less than 2 % of the global reserves. Coal quality is rather high and ranges from lignite to anthracite, however, most coal is ranked as steam coal, which can, but is not limited to, be exploited in open pit mines with seams up to 7 m high (ibid.). The industrial usage of coking coal, e.g. in steel sectors, is therefore of no importance for Colombia. Mining costs for thermal coal are competitive with other producers such as Australia and Indonesia.
The majority of the coal mines and their operation are located in two areas – La Guajira and Cesar. The two regions account for over 90 % of the annual production in 2015 (UPME 2016). The coal mine "Cerrejon Zona Norte", located in La Guajira, is the largest open pit mine in South America and run by Cerrejon. Its annual production peaked in 2014 with 34 Mt. The second largest steam coal producer is US-based Drummond Ltd. which operates two major mines near La Loma in the department of Cesar. In January 2014, the Colombian government forced Drummond to stop exporting due to pollution caused by loading coal onto ships, as the first producers affected by the recently increasing awareness of the Colombian government (USGS 2015). The third biggest operator Prodeco is operating its mine Calenturitas located between the municipalities El Paso, La Jagua de Ibirico and Becerril; in the department of Cesar. Its production reached 11 Mt in 2015.

Other smaller coal mining companies operating in Colombia are (CAN 2016b):

- Murray Energy Corporation (bought Colombia Natural Resources (CNR) from Goldman Sachs in August 2015; exporting from the public port in Santa Marta; operating the La Francia mine in northern Colombia with ~3 Mt/a),
- Pacific Coal (operating the Cerro Largo mine in Cesar Department with ~ 0.6 Mt/a, its La Caypa mine in La Guajira with ~1.1 Mt/a, and an underground coking coal operation in Boyaca Department);
- Minas Paz del Río (being controlled by the Brazilian company Votorantim; extracting coal and iron in the Boyaca Department aiming at an increase of coal production to ~2.5 Mt/a)
- Carbones del Caribe (being a subsidiary of Cementos Argos mining in the Puerto Libertador area in the Cordoba department ~ 0.4 Mt/year).

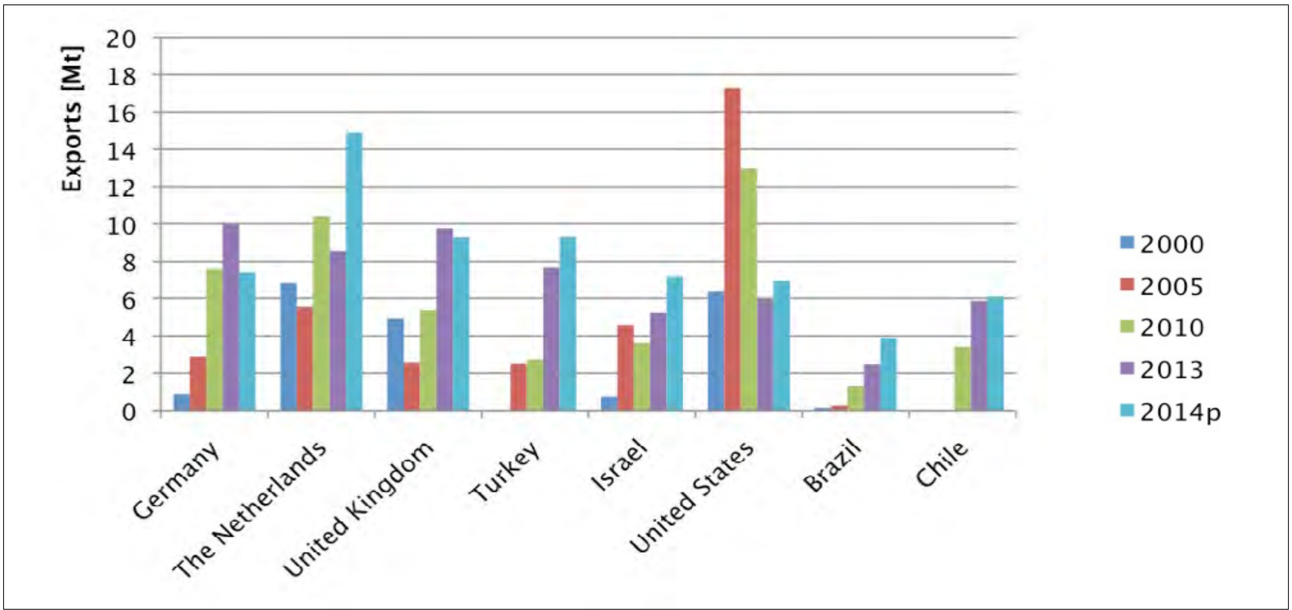
3.3 Steam coal exports

Infrastructure for transport to and at the export terminals is undergoing expansion or has recently been expanded. 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). The "Cerrejón Zona Norte" mine is an integrated system, meaning it comprises mining activities as well as the Caribbean coast export terminal in Puerto Bolivar and the connecting railroad (EIA 2015a). Coal from the coalfields in Cesar is transported by rail to the Santa Marta port on the Caribbean Coast using parts of the Fenoco railroad network. The ownership of Fenoco railroad has changed recently. The coal producers Coalcorp, Caribe and Prodeco purchased stakes of Fenoco, as Drummond had used the full capacity of the railroad before, impairing the export capabilities of its competitors (Bright 2011). Due to the growing opposition to loading operations in Santa Marta, new ports were planned and constructed to replace and extend existing capacities. As a result Prodeco, the third largest coal producer, has built and now operates the "Puerto Nuevo" in Ciénaga, also on the Caribbean coast, which is linked to the Fenoco railroad system and has a capacity of 21Mt per year. Next to Prodeco's Puerto Nuevo, Drummond Ltd has upgraded its directly loading facility Puerto Drummond, doubling its capacity from 30Mt/a year to 60Mt/a (Bright 2011; Buendia and Gagan 2012; Reuters 2013).
To determine partners particularly interesting for the future development of Colombian steam coal exports, data concerning the exports from 2000 until 2014 taken from IEA Coal Information (2015c) is depicted in Figure 6.[3]

3 Figures for Germany, however, were inconsistent from 2010 onwards and were therefore derived from statistics by VDKI (2015).

Table 4 depicts the main coal trade partners of Colombia and Colombia`s share of their total imports. From 2000 until 2014 exports to most countries have increased significantly. The United States, one of the most important trade partners, however has halved its imports in the last years. These figures also do not include the reduction of export volumes from 2014–2016 (see Figure 5) but convey a good impression of the last years. Currently, most exports go to Europe, particularly to the Netherlands, the UK and to a smaller extent to multiple other countries. The single European market with its main harbors in Amsterdam, Rotterdam, and Antwerp (ARA) as well as several transition points, however, causes distortions in the statistics complicating matching origin and final destinations of steam coal (also see Box 2 on tracking the origin of coal supply). Furthermore, the USA, Israel and Turkey are major importers of Colombian coal, which can be reached by the Atlantic Ocean. Import partners in Latin America are Brazil and Chile. The aforementioned countries are considered to be of utmost importance for the future economics of Colombian steam coal exports, and therefore, are analysed regarding its future steam coal demand in the following chapters.

Figure 6: Main export destinations of Colombian steam coal (in Mt).



Source: IEA (2015c) and VDKI (2015, 51). The figures for 2014 are derived from provisional data based on submissions received in early 2015.

Table 4: Main coal trade partners of Colombia and Colombian share in total imports.

Country (total imports in 2014)	% of imports from Colombia				Country (total imports in 2014)	% of imports from Colombia			
	2005	2010	2013	2014p		2005	2010	2013	2014p
Brazil (<10 Mt)	10	41	33	59	Korea (50–100 Mt)	1	1	0	0
Belgium (<10 Mt)	0	5	12	13	Malaysia (10–50 Mt)	-	0	-	-
Canada (<10 Mt)	11	22	34	40	Mexico (<10 Mt)	-	16	17	8
Chile (<10 Mt)	-	53	60	65	The Netherlands (10–50 Mt)	37	55	42	29
China (>100 Mt)	-	3	0	0	Philippines (10–50 Mt)	-	-	-	-
Denmark (<10 Mt)	21	29	39	41	Poland (<10 Mt)	2	1	1	1
France (<10 Mt)	18	23	21	22	Portugal (<10 Mt)	44	49	80	88
Germany (10–50 Mt)	10	20	17	15	Spain (10–50 Mt)	9	28	23	38
Hong Kong (10–50 Mt)	-	-	-	-	Taiwan (50–100 Mt)	-	4	-	-
India (>100 Mt)	-	0	0	-	Thailand (10–50 Mt)	-	1	-	-
Israel (10-50 Mt)	-	34	41	49	Turkey (10–50 Mt)	20	18	34	39
Italy (10-50 Mt)	16	10	11	13	UK (10–50 Mt)	9	31	26	27
Japan (>100 Mt)	-	0	0	0	USA (<10 Mt)	74	83	84	79
					Total (1125 Mt)	9	9	8	8

Source: Own calculation based on IEA data from IEA Coal Information (2015c).

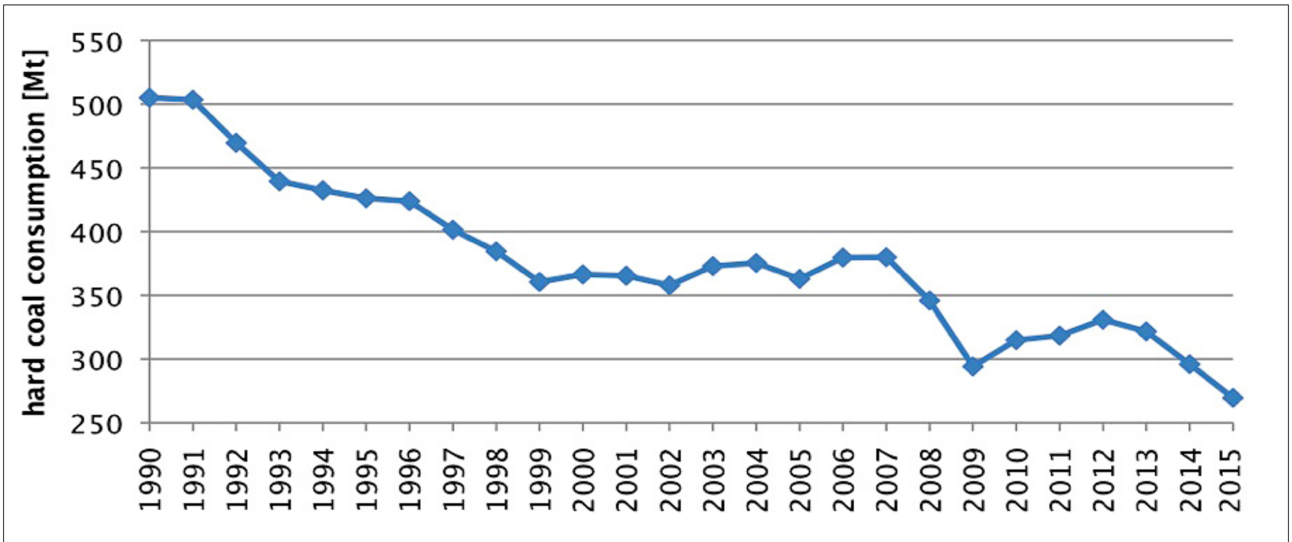
4 TRENDS INFLUENCING THE FUTURE DEMAND FOR COLOMBIA`S STEAM COAL

This chapter examines possible trends for future Colombian steam coal exports. A description of overall trends on the global steam coal market is therefore followed by a more detailed description of the most important Colombian coal importing countries. Possible effects on Colombian export figures are then drawn examining also possible new trading partners.

Steam coal is predominately used in the power generation sector. As such, its fate is bound to drivers of electricity demand and, in turn, the share of coal in the power generation fuel mix. Therefore the future shape of the world steam coal market will be determined by: future electricity demand, performance of renewable energy sources and gas and nuclear generation, future environmental regulation, future climate change mitigation measures, future technological development and deployment of carbon capture, transport, and storage (CCTS).

The general trend of a continuously growing coal sector has changed in the last years. On a global level coal power plant capacities of more than 165 GW have been retired since 2010 or are announced for closure. The majority of this share of around 100 GW (half of it already being closed down in 2016) is located in the United States (Littlescott 2016). Parts of these closures are driven by the end of the lifetime of older facilities. Another reason, however, is the continuous reduction of coal power plant utilization figures in the last decade. U.S. and Indian power plants have observed a reduction of their load factors from more than 70 % in 2004 to around 55 % and 65 % in 2015. Figures for China and the EU even shrank from around 60 % to 50 % in 2015 (Shearer et al. 2016). Rising shares of cheaper renewable energy sources as well as existing overcapacities in many countries are the main drivers for these developments. As a consequence of this EU hard coal consumption was halved since 1990 (see Figure 7) (Eurostat 2016).

Figure 7: EU-27 Gross inland consumption of hard coal, 1990–2015 (in Mt).



Source: Eurostat (2016).

4.1 Coal consumption trends in current import countries

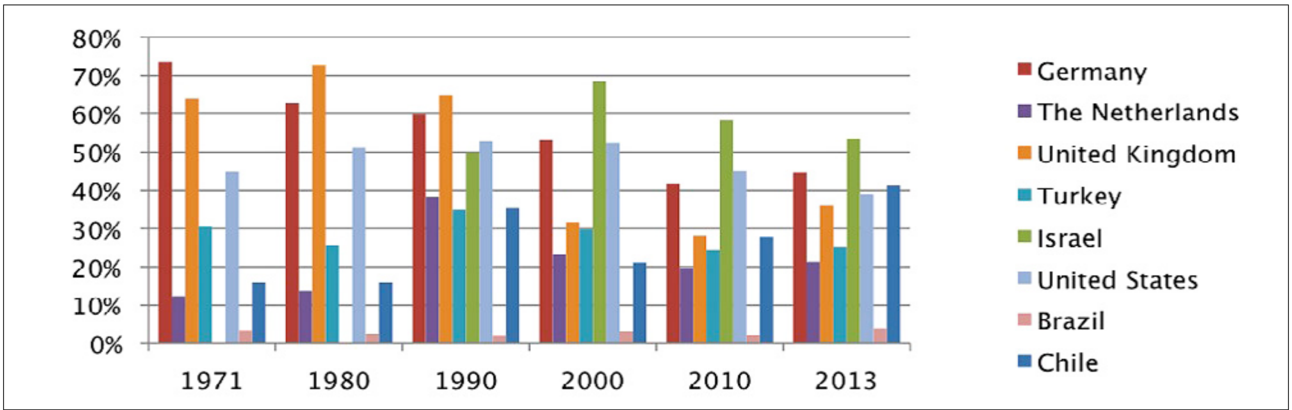
The traditional main importers of Colombian steam coal are located in Europe, USA and to a smaller extent in Latin America. European countries, however, vary in their energy mixes as well as local resources and therefore need to be examined individually. In addition, national energy policy gives different emphasis on matters of climate policy or other aspects such as energy security. As a consequence, different interpretations of reducing CO_2 emissions of the electricity sector either lead to a support of renewable energy sources, nuclear capacities or of the CCTS technology. Table 5 summarizes key figures of the examined countries. Figure 8 shows the share coal-fired generation in the electricity mix of the examined countries from 1970 to 2013 (IEA 2015c).

Table 5: Fact sheet for selected countries for the year 2014

	Income level	GDP in Billion USD	Population in Million	CO_2 emission intensity in tCO_2/capita	Coal trend
Brazil	Upper middle income	2417	206.1	2.2	rising
Chile	High income, OECD	259	17.76	4.6	rising
China		10351	1364.27	6.7	shrinking since 2014
Germany	High income, OECD	3868	80.89	8.9	shrinking
India		2042	1295.29	1.7	rising
Israel	High income, OECD	306	8.21	9.0	shrinking
Netherlands	High income, OECD	879	16.87	10.1	shrinking
Turkey	Upper middle income, OECD	799	77.53	4.4	rising
United Kingdom	High income, OECD	2990	64.61	7.1	phase out until 2025
USA	High income, OECD	17348	318.91	17.0	shrinking

Source: World Bank Group (2016).

Figure 8: Share of coal-fired generation in the electricity mix of selected Colombian coal trade partners from 1970 to 2013 (in %).



Source: IEA (2015c).[4]

4.1.1 Germany

Germany is the fourth largest economy with a GDP of 3.868 tnUSD. In the last decade, Germany experienced one heavy economic recession in 2009, in which the economy shrunk by 5.9 %, followed by two years of strong economic growth (2010: 3.9 %, 2011: 3.7 %). For the next couple of years, the Worldbank (2016a) projects moderate economic growth rates averaging 1.5 % per year.

The electricity market is dominated by four companies, namely E.ON, RWE, Vattenfall and EnBW, with a market share of 73 % of the electricity supply. However, since 2010 their market share has decreased significantly by 10 % points (Bundesnetzagentur 2014), which is due to the phase out of nuclear energy and the trend towards a decentralized renewable power generation structure. While the "big-four" lack behind in renewable energy generation, they possess most fossil fuel-fired power plants. Except for steam coal and lignite, Germany does not possess any substantial fossil resources. Neither of them is, however, international competitive, which is why both resources are subsidized by the state (BMWI 2016). The subsidies for producing steam coal will be stopped by 2018, with annually declining subsidies. Between 2009 and 2015, the subsidies arise to 1.2 billion – 1.7 billion € per year.

Despite strong economic growth since the 1990s, its primary energy demand declined (Klein 2012). In 2010, the German government published the "Energiekonzept" which outlines the national energy politics and the intended tools for reaching the climate goals. It sets minimum reduction targets of emissions by 40 % and 80 %

4 The IEA only includes data for Israel from 1990 onwards for the share of coal in the electricity sector.

in 2020 and in 2050, respectively, compared to 1990 levels. In terms of the electricity demand, the "Energiekonzept" intends to reduce the demand by 10 % in 2020 and by 25 % in 2050 as compared to 2008, while the share of renewable energies on the electricity generation shall increase above 35 % in 2020 and 80 % in 2050 (BMWI 2010). After the nuclear accident in Fukushima, the German government agreed on phasing out all nuclear power plants by 2022. As of 2015, nine plants have been closed, while the remaining eight plants will close according to their individual schedule.

In July 2015, the German government agreed on closing several coal-fired plants. The plan provides for phasing out lignite-fired power plants with an overall capacity of 2.7 GW in the years 2017–2019. A large number of studies indicate a pathway to obtain an almost complete decarbonization of Germany's electricity generation by 2050 going along with a coal phase-out until 2040, amongst them the regular "lead studies" for the government (Nitsch 2013), as well as from the Federal Environmental Agency (Umweltbundesamt: Klaus et al. 2010) and the German Advisory Council on the Environment (SRU 2013).

The domestic production of steam coal in Germany fell sharply from 38 Mt in 1990 to 18.5 Mt in 2000. Since 2010 steam coal production has declined further, falling to its minimum with 3.5 Mt in 2013. To cover the slightly increasing demand, while production declined, Germany's imports more than quadrupled between 1990 and 2014. In 1990, imports were 11.8 Mt, however, in 2000, imports climbed to 23.3 Mt already and further grew to 38 Mt in 2010. In 2013, imports reached their all-time maximum with 46.5 Mt. Historically, most imports originate from Russia (in 2013: 11 Mt), Colombia (7.8 Mt) and the US (7.5 Mt). However, Colombian imports after peaking in 2011 with 10 Mt, decreased to 7.3 Mt in 2014 (IEA 2015c; VDKI 2015)

4.1.2 The Netherlands

As most European countries, the Netherlands were struggling economically in the last decade. Since 2009, there have been three recessions including the worst one in 2009, in which the economy shrunk by 3.8 %. In 2011 and 2012, the Dutch economy lost 1.1 and 0.4 % respectively of its size. For the next years, the WorldBank expects a moderate annual growth by about 1.7 % until end of 2018 (WorldBank 2016b).

The Dutch electricity market has been deregulated and fully opened to competition since 2004. On a somewhat concentrated market, the five companies of Nuon (Vattenfall), Essent (RWE), E.ON, Eneco and Delta manage 55 % of the installed capacity in 2013 (Deloitte 2015). While the Netherlands have no indigenous coal production and fully depend on international imports, they possess large natural gas fields in the North Sea and, the biggest one, in the Groningen area (IEA 2014b). However, due to their long shorelines, which provide unlimited access to cooling water for power plants, and their two major ports, the Netherlands are primed for coal-fired power plants, and thus, have attracted big investments in coal technology, mostly from Germany.

The current and future energy situation is shaped by the "National Energy Agreement for Sustainable Growth", published in 2013 (SER 2013), particularly with respect to coal. As of the 7 coal-fired power plants in the Netherlands, the agreement calls to phase out the five oldest coal-fired power plants, combining for a total 2693 MW. Three of which were closed by January, 1st 2016 and two more are scheduled to be shut down by July, 1st 2017 (IEA 2014b; industcards 2016). However, in contrast to most European countries, the Netherlands also plan on building new coal-fired power plants with a combined capacity of 3.5 GW, and thus exceeding the capacity of the recently abandoned ones. The biggest one "Maasvltake 3" (1100 MW), operated by E.ON, is fired by coal and biomass and got its operation permit in 2016 (industcards 2016). RWE built a 1600 MW coal and biomass fired power plant in Eemshaven (Eemshaven A+B), for which they eventually got the permission to operate it in September, 2015, after there had been trials questioning the compliance with nature conservation guidelines (IWR 2015). Moreover, GDF Suez began constructing another 800 MW power plant running on coal and biomass in 2013. However, although being completed in 2013, it is still in the test phase (World Coal 2014). In June 2015, for the first time ever, a court decision in the Netherlands legally requires the State to take further precautions against climate change. The government, however, decided to appeal against the verdict of the district court in The Hague despite calls from top scientists, lawyers, citizens, and companies.

Although, the Netherlands never used more than 10 Mt/a, their imports of steam coal by far exceed this value. While until 2010 their imports were only about double their yearly usage, their imports increased to 20 Mt in 2012 before leaping to 42.5 Mt in 2013 and 44.5 Mt in 2014 (projected) (cf. IEA 2015c). In 2013, their main partners were Colombia, which accounted for about 18 Mt, as well as the USA and South Africa. Most of the imported steam coal is being exported again via their main ports in Rotterdam and Amsterdam. In 2013, 31 Mt were exported of which 28 Mt were destined for Germany. Especially, Rotterdam has developed into the energy hub of Europe providing storage facilities and refineries for steam coal, oil and LNG as well as a strong chemical industry in the surroundings (IEA 2014b).

4.1.3 United Kingdom

With a GDP of almost 3 tnUSD, the UK is the tenth biggest economy worldwide. In the last decade the UK experienced two recessions in 2008 and 2009, in which their economy shrank by 0.5 % and 4.2 %, respectively (World Bank Group 2016). However, the economy recovered well and is expected to reach annual growth rates averaging 2.5 % over the outlook period (DECC 2016).

The power generating market is divided by "The Big Six". These six major electricity suppliers: British Gas, EDF Energy, E.ON UK, npower (RWE), Scottish Power and SSE, supply over 50 million people with gas and electricity (ofgem 2015). The UK possesses major resources for both green energy as well as fossil fuels. In terms of fossil resources, the UK has major natural gas field in Scottish sea covering almost 50 % of their yearly natural gas consumption, yet, their productivity has been on the decline over the last years (DECC 2015). Since the run on shale gas, extensive amounts of shale gas have been found under the British mainland, although it is uncertain how much is economically exploitable (Smith, Turner, and Williams 2010). Further, the UK has 26 Mt of permitted reserves of coal in 32 already producing sites and another 12 Mt in mines which have not started producing yet, leaving the UK with 38 Mt of coal reserves (British Geological Survey 2014).

The current energy politics are shaped by the UK Low Carbon Transition Plan, which was published in 2009 as an extension of the Climate Change Act 2008. It cuts CO_2 emission by 18 % below the 2008 levels in 2020 and by 80 % below the 1990 levels in 2050. 40 % of the electricity demand shall result out of low carbon sources, including 30 % of renewables. The remaining share will be covered by the planned reintroduction of nuclear energy in 2025 as well as the implementation of the CCTS technology (HM Government 2009). Since the end of 2010, coal-fired power plants with a combined capacity of 10.5 GW have been closed (8.85 GW) or converted to biomass (1.65 GW). The reason for the shut downs is the large combustion plant directive of the EU, which forces old power plants to shut down if they do not fulfill the emission requirements on sulfate dioxide and nitrogen oxides. With the "Energy Bill 2012–2013" the British government introduced the so-called "emission performance standard" restricting the construction of new coal power plants (DECC 2013). In November 2015, energy secretary Amber Rudd declared in a statement to phase out all UK coal plants by 2025 and to restrict their use by 2023 (Rudd 2015).

The steam coal use in the UK declined from 96.21 Mt in 1990 to 51 Mt in 2000, mostly due to a decreasing coal demand in power plants. Steam coal production decreased in total by some 88 % from 91 Mt in 1990 to 18.15 Mt in 2010 and, eventually, to 12.67 Mt in 2013. While in the 1990s domestic production almost met the demand, the UK imported rapidly increasing amounts of coal since the early 2000s. In 2010 imports totaled to 20 Mt before doubling to 40 Mt in 2012 and increasing to 43 Mt in 2013. The main supplier is Russia delivering between 12 and 19 Mt annually, followed by Colombia (8–11.7 Mt per year) and the US, who export 4.5 to 9.5 Mt of steam coal per year (IEA 2015c).

4.1.4 Turkey

Turkey is one of the fastest growing global economies and currently the 17th largest in world and 6th largest in Europa (IEA CCC 2014; World Bank Group 2016). In the last decade, it experienced one major recession in 2009, in which the economy shrunk by 4.4 %. However, due to the following two years with exceptionally high growth rates (9.2 % and 8.8 % in 2010 and 2011), the Turkish economy recovered fast. Since then, growth has moderated to 3–4 % per year, mostly because of geopolitical developments and political uncertainties. Forecasts expect the same growth rates for the future, which are well above the global average.

In 2001, the publicly-owned companies, particularly the "Electricity Generation Company (EÜAS)", dominated the market with some 78 %, however, until 2009 their market dominance diminished to some 46 %, including several coal-fired plants being privatized (IEA CCC 2014). Investments, both foreign direct investments and local investments, have increased greatly since opening up the market to investors. Coal field, mining, exploration and supply to power plants is still dominated by federal companies ("Turkish Coal Enterprise (TKI)", "Turkish Hardcoal Enterprise (TTK)", EÜAS, "Turkish General Directorate of Mineral Research Exploration (MTA)"), which are controlled by the "Ministry of Energy and Natural Resources (MENR)". Turkey holds larger amounts of coal resources. However, those are limited to extensive amounts of lignite (11.8 Gt) and to 1.3 Gt of hard coal, of which 530 Mt are proven and economically recoverable reserves (Ersoy 2015; IEA CCC 2014). Lignite mines are spread over the country, whereas hard coal is limited to one major field close to Zonguldak (IEA CCC 2014).

In order to reduce its import dependency, the Turkish government aims at using indigenous resources, which are limited to coal, and therefore, explains the Turkish run on new coal-fired capacities (Hartlieb, Ruppel, and Wagner 2016). The most recent and defining initiative with respect to coal is the "coal strategy" published by the MENR (2014). It focuses on mainly three pillars and acknowledges the importance of coal, particularly domestic coal, for the future of the Turkish energy sector. Firstly, Turkey aims at full utilization of existing lignite and hard coal reserves for electricity generation until 2023. Secondly, more coal-fired plants shall be built firing primarily domestic coal.[5] Thirdly, domestic coal production is scheduled to increase and new coalfields to be explored (ISPAT 2015; IEA CCC 2014). However, the Turkish civil society shows first signs of objecting to these plans (Yeldan and Voyvoda 2015; Şahin et al. 2016).

Steam coal use grew significantly from 3.1 Mt in 1990 to a consumption of 22.5 Mt in 2013. Thus, to cover its demand, Turkey relies heavily on imported steam coal (IEA 2015c). Turkey profits from its geographical location as it is allows to import resources from every part of the world (IEA CCC 2014), but traditionally relies on imports from Colombia and Russia, with each partner exporting between 7–9 Mt annually, followed by South Africa (~3 Mt per year) (IEA 2015c).

4.1.5 Israel

Unlike most developed economies, Israel did not suffer from a recession in the last decade, however, their economy dipped in 2009 when it grew by only 1.3 %. The economy recovered fast with annual growth rates higher than 5 % and is forecasted to continue growing above OECD and world average values with around 3 %. Due to its geographic location and historic differences with its neighboring countries, Israel is an "electricity island", meaning there are no connections to the neighboring countries (Niv 2010). Thus, a high availability and reliability of its energy sources are of utmost importance (Ministry of National Infrastructures 2010). The market is dominated by the state-owned "Israel Electric Corporation (IEC)", which controls 77 % of the 17 GW installed capacity (Israel Ministry of Environmental Protection 2015). The remaining share is distributed among private companies and decentralized generators.

There are two coal fired plants in Israel, both on the Mediterranean coast and built in the late 1970s and early 1980s. Overall, coal-fired capacity accounts for 30 % of the installed capacity, while natural gas plants contribute 60 % (IEC 2012). It, however, possesses extensive natural gas resources offshore, especially since the discovery of the "Leviathan" field, which is the largest natural gas field discovered in the last decade. In total, the Israeli offshore fields are expected to have more than 700 bcm of natural gas, which should cover the Israeli demand for more than 50 years, while additional extensive findings are likely. Further, Israel has some oil shale deposits, however, only small fractions are economically exploitable, and thus, are not expected to play a significant role in the future (OECD 2013a).

The "Policy of the integration of renewable energy sources into the Israeli electricity sector" enacted by the "Ministry of National Infrastructure" (2010) defines the framework for the development of the Israeli electricity sector. This framework was just recently, in the course of COP21, updated and extended by the Ministry of Environmental Protection (2016) such that, in 2030, the electricity demand will be reduced by 17 % relative to the "Business-as-usual-scenario" and 13 % and 17 % of renewable energies are being integrated in 2025 and 2030, respectively. Further initiatives aim at reducing the GHG emissions per capita to 7.7 tCO_2 by 2030 (Israel Ministry of Environmental Protection 2015).

Steam coal use has tripled since 1990 from 3.73 Mt in 1990 to some 11.7 Mt in 2013. Israel has no domestic production, due to the lack of steam coal resources, and is therefore, entirely dependent on imports. Half of the imports originate from Colombia; South Africa and Russia each account for one quarter of the yearly imports. Like the electricity generation, the entire import process (procurement as well as shipping) is handled by the state-owned the National Coal Supply Corporation (LTD) (2016).

For future projections the Ministry of Environment (2015; 2016) provides a "Business-as-usual" (BAU) and an alternative scenario. Under the government's BAU scenario the primary steam coal demand is not expected to change significantly compared to 2015. The primary coal demand under the alternative scenario is expected to drop sharply by almost 100 PJ until 2020, which is mostly due to the rapidly increasing capacity of natural gas. Unlike the BAU scenario, the alternative scenario has a rather downward trend and is to require almost half of the primary steam coal demand in 2030.

5 Currently, there are seven steam coal-fired plants in total, of which six run on imported coal and only one on domestic steam coal. Existing steam coal-fired capacity totals to 5 GW. As of end 2013, there are 14 hard coal plants (10.3 GW) in the application phase, eight (3.5 GW) are under examination evaluation and four (2.5 GW) are already approved and under construction, which are in total 26 plants for 16.2 GW which are scheduled to start generating (Deloitte Turkey 2013).

4.1.6 USA

In 2014, the USA was globally the largest economy again outnumbering the EU after it was only second in 2013. In the last decade, it experienced one major recession in 2008–2009, in which the economy shrunk by 3.1 %, and only slowly recovered in the following years. However, stable growth of 1.9–2.4 % is predicted for the next years. The USA has the world's largest coal resources (World Energy Council 2013), with the vast majority of its coal production being steam coal from mines in the Powder River Basin (PRB), Appalachia and the Illinois Basin (EIA 2015a). PRB is of particular interest for both the US and the international steam coal market. Powder River Basin coal is mined from cheap and efficient surface mines, at a very low average cost of USD 12.5 per ton (IEA/OECD 2014, 30).

Under the umbrella of the Clean Air Act of 1970, the US Environmental Protection Agency has introduced several regulations since 2011 that heavily influence the future of coal-fired power generation in the USA:

- 1) the Cross-State Air Pollution Rule which regulates power plant emissions that contribute to ozone and/or fine particle pollution across state borders (EPA 2015b);
- 2) the Mercury and Air Toxics Standards which regulate mercury emissions and other hazardous air pollutants from power plants (EPA 2015a); and
- 3) the Clean Power Plan which regulates the emissions of existing power plants, and Carbon Pollution Standards for new generation units benchmarked against gas-fired power plants (final rules pending submission for publication in the Federal Register) (EPA 2015c; EPA 2015d).

Steam coal use historically underpinned industrialization and economic growth in the USA, but has seen a steady decline over the past decade. The share of coal in in total electricity generation declined from 52.3 % in 2000 to 39.1 % in 2013 (IEA 2015c, III.64). There are some cyclical factors involved, such as the recession during 2008 and 2009, but on a structural level, power generators are increasingly switching from steam coal to gas (IEA 2014e, 195). This is largely on economic grounds and in particular due to the boom in production of low-priced domestic shale gas, but is also being driven by environmental policies.

Against the background of declining demand over the past decade, domestic coal prices have weakened (Sussams and Grant 2015, 16–17). By 2016 numerous producers (including Peabody Energy Coperation, Arch Coal Inc., and Alpha Natural Resources, listed first, second and forth in the top five U.S. coal mining companies) have filed for bankruptcy (Sussams and Grant 2015, 18; Mooney and Mufson 2016; EIA 2016), and 271 mines were idled or closed in 2013 (EIA 2015c). Steam coal production declined around 20 % between 2005 and 2013 (though preliminary data for 2014 shows a very slight increase in production, of around 1 %) (IEA 2015c, IV.424).

Given the aging coal-fired power plant fleet (with 85 % older than 30 years and 50 % older than 40 years (Sussams and Grant 2015)), the environmental policies mentioned above will lead to power plants increasingly being decommissioned rather than refurbished (IEA 2014e, 196), and future coal-fired power generation capacity additions will be minimal (EIA 2015e, 26). Analysts do not expect these trends to be affected by the possibility of future suspension or repeal of any of the environmental policies[6], given that investment decisions are already being made on the basis of these policies – and moreover, on the basis of the favorable economics of alternative fuels (Harvey 2015; Reuters 2015a; Sussams and Grant 2015).

In the context of declining domestic demand, it has been argued that Powder River Basin (PRB) coal can also be competitive on the international market, and especially the Pacific coal market (IEA 2013, 99). However, this is dependent on export infrastructure. Currently, the only way to export coal from the west coast is via Canadian ports in British Colombia, which is preceded by a long distance rail transport. Furthermore, it seems that very little potential for US coal shipments out of Canada exists, because Canadian ports are running almost at full capacity (with expansions primarily undertaken to support Canadian coal exports rather than US coal exports). There are plans to construct export terminals along the US West Coast, in Oregon and Washington, but at the same time there are extensive concerns about local health and environmental impacts and consequences for global CO_2 emissions (Western Interstate Energy Board 2015).

There are differing perspectives on the potential effects of PRB exports on world steam coal markets. Power and Power (2013) argue that PRB exports will replace high price supplies, which will reduce the world price and induce additional demand. However, EPRINC (2012) argues that PRB exports will only replace other infra-marginal supplies, with no price effect and without inducing additional demand; the IEA (2013, 119–20) comes to a similar conclusion. From a more general viewpoint, Morse and He's (2015) finding that China's import levels are a dominant factor in determining world prices implies that PRB exports would not have major effects on the world market (assuming that the demand is not very price elastic).

6 Currently the Clean Power Plan is put on hold by the US Supreme court (Adler 2016).

In the U.S. Energy Information Administration's Annual Energy Outlook 2015, the reference case predicts that total coal production will increase at an average rate of 0.7 percent per annum between 2013 and 2030, and then plateau (EIA 2015e, 22). It also predicts increased exports of steam coal from the Interior and Western coal mining regions (which include the Illinois Basin and Powder River Basin) (EIA 2015e, 23; EIA 2015b).

On the demand side, the Annual Energy Outlook projects that 40 gigawatts of coal-fired capacity will be decommissioned between 2013 and 2040 and the share of coal in total electricity generation will decrease from 39 percent to 34 percent over that same period (EIA 2015e, 24–26). These projections account for the effect of the Mercury and Air Toxics Standards, but not the Clean Power Plan – which the EIA notes would have a material impact on projected levels of coal-fired generation (EIA 2015e, 22). In comparison, the IEA, under its New Policies Scenario (which does account for the effect of the Clean Power Plan), projects that the share of coal in total electricity generation will decrease to 22 percent by 2040 (2014e, 620).

4.1.7 Brazil

Apart from 2009, Brazil enjoyed strong, slightly above the regional average, economic growth (between 3–7 % per year) over the last decade. However, the economic growth cooled down recently and stalled in 2014. For the next couple of years, the Worldbank projects a major recession, hitting the Brazilian economy hard. In the 1990s the electricity sector was almost exclusively controlled by the government, however, Brazil initiated a privatization process in 1996. In terms of generation, 60 % of the installed capacity is still owned by federal- or state-controlled companies. Eletrobras dominates the market and accounts for 40 % of the overall capacity, 9 % are controlled by GDF Suez and AES. The remaining 31 % are distributed among other private companies. (MME 2015)

Brazil possesses extensive amounts of fossil resources. It owns with 453 bcm, primarily offshore, the second largest reserves of natural gas in South America. It, further, holds the second-most oil reserves in South America (15 million barrels), 94 % offshore of the reserves in deep water fields (EIA 2015d). With some 6,630 Mt, Brazil has the third largest steam coal reserves in the western Hemisphere, which are located in the southern states, Rio Grande do Sul, Santa Catarina and Paraná. Most of the reserves are sub-bituminous steam coal of rather poor quality with high ash yield and sulfur values. As, due to the poor quality of the coal, geological research has only limitedly taken place in the past, actual deposits are believed to be significantly higher, given more investments in exploration (GMI 2015; Vasconcelos 2015; Román 2014).

In the most recent ten-year expansion plans (PDE) 2024, Brazil acknowledges the need for a significant expansion from 132 GW to 206 GW of installed capacity to cover the future demand. Especially the Northern and North Eastern states will increase their capacity significantly by 51 GW. Renewable energy will continue to play a predominant role in the electricity mix and are expected to increase their share to 86 % in 2024, mostly driven by significant expansions of wind energy in the North Eastern states, and further capacity increases of hydro energy in the Amazonas area. To be less vulnerable to droughts and to produce closer to the major demand hubs located in the South East, Brazil tries to diversify its energy sources and plans on constructing thermal plants in the southern states (Ventura 2014). Most of the increase will be due to expansions of natural gas fueled capacity, which will be supported by investments in LNG terminals to prevent natural gas shortages.[7]

In terms of production, the GMI (2015) indicates the yearly production at 3.04 Mt of coal in 2014. In a study on Brazil's energy policy Román (2014) notes that most of Brazil's coal demand comes from the iron and steel industry and is not used for electricity purposes. Due to the poor quality of the domestic coal, all coal for industrial purposes is imported from Colombia. Steam coal imports increased from 0.345 Mt in 1990 to 7.5 Mt in 2013. Steam coal imports originate from mainly three countries, namely Colombia, Russia and South Africa.

7 By the end of 2014, thermal power plant capacity was 21 GW, but included only seven coal-fired plants with an overall capacity of 3 GW. Four of the seven plans were built in the late 1960s/1970s. Three new coal projects started operating since 2012, reliant on Colombian coal (Vasconcelos 2015).

4.1.8 Chile

Chile is on the verge of becoming a developed country. With an annual GDP growth rate of 5,4 % on average between 1990 and 2010, Chile outpaced all other Latin-American countries, mainly driven by its industrial sector (Ministerio de Energía 2012; AA 2015). It is expected to keep growing above world average by 2.4 %, 2.9 % and 3.1 % from 2016 to 2018, due to a strong domestic demand and favorable market conditions (MaRS Advanced Energy Center 2015; WorldBank 2016). Chile privatized its electricity sector as one of the first countries worldwide in the early 1980s. The country is separated into four regionally disjointed gas and electricity networks serving different parts of the country.

Chile has almost no fossil resources (APEC 2006), and thus, depends on fossil fuel imports and renewables energies. Due to its geographic advantages, particularly hydro energy contributes greatly to the power generation. Coal reserves are limited to one recently opened mine – the "Mina Invierno", which began producing in 2013 (MaRS Advanced Energy Center 2015). Here, 73 Mt of subbituminous coal reserves, with a calorific value of 4100 kcal/kg, can be exploited at an maximum annual production of 6 Mt, limited by to the "resolución de Calificación Ambiental". Yet, in 2015 only 1 million ton was produced. (Mina Invierno 2016)

Chile's energy policy is driven by two fears – droughts and natural gas supply insecurities. Traditionally, natural gas has been imported from Argentina (IEA 2012). From 2004 onwards, restrictions in the supply of natural gas from Argentina and only little rainfall in the years 2007–2010 resulted in a serious energy crisis and led to a transition to a more coal-based electricity system, which was not part of the original long-term energy strategy (Ministerio de Energía 2012). In recent years, the Chilean society showed growing opposition and concerns about the electricity mix and its focus on coal. The increase in conflicts results in delays for implementing investments and completing important electricity infrastructure projects, which affect the energy security. Ongoing trials on electricity matters cause uncertainty for investors and society (Ministerio de Energía 2012).

The regulatory support for the future energy policy "The National Energy Strategy 2012–2030" was defined and published by the Ministry of Energy and the Ministry of Environment (Ministerio de Energía 2012). Its main target is to increase the share in power generation of the "non-conventional renewable energies[8]" from 3 % to 10 % in 2024. Furthermore, the strategy aims at increasing the share of traditional hydroelectricity to 48 %. Thus in total, at least 58 % shall by generated by renewable energies of any kind by 2024 (Ministerio de Energía 2012). Regarding the role of coal, their strategy also acknowledges that their energy security will not do without coal playing a major role. Since 2008 several coal plants have been approved or are under construction already and there are more to come in the next few years. (Ministerio de Energía 2012) In 1990, the use of steam coal for electricity purposes was 3.23 Mt, however, the use of coal increased to 10.75 Mt in 2013, of which 9.74 Mt were imported from mainly Colombia, but also the US and Australia (IEA 2015c).

4.2 Evolvement of possible new export partners

The following part provides an analysis of regions with a potential increase in coal demand and therefore might be potential new future export partners for Colombia. A special emphasis is put on the two biggest countries China and India as their development is evaluated as most important.

4.2.1 China

For over a decade up until recently, the narrative of China's steam coal demand has been one of continual, rapid growth. As a result, China is now responsible for over half of the world's steam coal consumption or 3400 Mt in 2013, and estimated 3280 Mt in 2014 (IEA 2015c, III.32). The rapid growth in steam coal demand was primarily due to a large increase in power demand over the past decade (IEA/OECD 2014, 23); in 2013 the share of coal in total electricity generation was 78.1 percent (IEA 2015c, III.65). China is also the world's largest coal producer, supplying almost exclusively its own demand (IEA 2015c, V.25). The main coal deposits are located in the interior provinces of Shanxi, Inner Mongolia, Xinjiang, Shaanxi and Henan; whereas demand is concentrated in coastal regions, where the coal deposits are small and tend to have high mining costs and poor quality (Wang and Ducruet 2014, 4–5).

China's steam coal demand is primarily met by production from its own coal reserves, though some demand is met through imports. 230 Mt of steam coal were imported in 2014, representing about 7 % of domestic consumption (but constituting about 22 % of total global steam coal trade) (IEA 2015c, III.44,III.32,III.40). The geographical mismatch between supply and demand means that domestically-produced coal has high associated transport costs. 60 % of China's coal production is transported by railway, along with 30 percent by water and the remain-

8 In Chile, that is: wind energy, solar energy and smaller hydroelectric plants (less than 20 MW).

der by road. In the past, insufficient rail and shipping capacity has resulted in congestion and supply bottlenecks (Wang and Ducruet 2014). Therefore, the rationale for importing steam coal is largely one of cost-minimization, rather than domestic supply shortages. In a situation termed the “coal-power conflict”, liberalization of the coal sector has caused domestic coal prices to increase, to the extent that imported coal is sometimes more affordable for power generators (for whom the price of electricity is still government controlled) (Rui, Morse, and He 2015, 81–84). Recent investments in transport infrastructure (EIA 2015 f, 27) are designed to alleviate these issues; as will Chinese government’s strategy of integrating coal producers and power generators to establish “coal-power bases”; which enable the transport of “coal-by-wire” (Rui, Morse, and He 2015). Though Peng (2015, 68) argues that reforming the power sector would be a more comprehensive solution. For the meantime, this arbitrage behavior by Chinese power generators has material implications for global steam coal trade and prices (Morse and He 2015, 407). A 6 % tariff on imported steam coal was reintroduced in late 2014 (having previously been phased out between 2005 and 2007) (*Reuters* 2014), in order to stabilize the domestic market (which is oversupplied, with the majority of producers thought to be unprofitable at current prices) (Commonwealth of Australia 2015b, 29).

China’s future steam coal demand will be shaped by the magnitude and sectoral composition of its economic growth, reductions in energy-intensity and environmental policies. Additional critical factors will be local pollution and water shortage at mining and electricity production sites (Cheng et al. 2016). In particular, recent years have seen increased ambition around addressing greenhouse gas emissions and air pollution from coal combustion, which implicitly or explicitly entail reduced coal consumption[9] (cf. Table 6 for a summary of policy measures). Overall, this set of environmental policies will help driving future reductions in China’s coal consumption. Analysis indicating that China’s coal price elasticity of demand is increasing supports the effectiveness of a national emissions trading scheme as a mechanism for reducing coal consumption (and associated emissions) (Burke and Liao 2015).

Table 6: Summary of policy measures in China targeting reduction of coal consumption directly or indirectly.

	Target year	Decrease in carbon-intensity of GDP	Share of non-fossil fuels in TPES	Comments
12th Five-Year Plan (2011)[10]	2015	17 % from 2011	11.4 %	Decrease in energy-intensity of GDP: 16 % from 2011
Action Plan on Prevention and Control of Air Pollution (2013)[11]	2017			Share of coal in TPES: 65 %
Energy Development Strategy Action Plan (2014)[10]	2020		15 %	Cap on coal consumption: 4200 Mt
National Plan on Climate Change (2014)[10]	2020	40–45 % from 2005	15 %	
Intended Nationally Determined Contribution (2015)[12]	2030	60–65 % from 2005	20 %	
Supply-Side Structural Reforms (2016)[13]	2019–2021	Reduce coal production mine capacity by 500 Mt through direct regulation and by additional 500 Mt through reconstruction and consolidation; moratorium on approval of new mines		
“Promoting the orderly development of China’s coal” Plan (2016)[14]	2019	No approval of new coal-fired power station, halt for approved plants not yet under construction, scrappage of old inefficient plants before expiration of technical lifetime		

Source: Own compilation based on various sources.

9 Even though total coal consumption is targeted, there are more available substitutes for steam coal rather than coking coal, so steam coal will be most affected.

10 Grantham Research Institute (2015).

11 X. Lin and Elder (2014). The Clean Coal Action Plan involves a range of measures and targets to improve the quality of coal consumed and the efficiency with which it is combusted (China Coal Resource 2015). From the start of 2015, quality standards for ash and sulfur content have been imposed on both imported and domestically-supplied coal (Reuters 2015b).

12 INDC People’s Republic of China (2015). China also plans to introduce a national emissions trading scheme in 2017, covering a number of key emissions-intensive sectors (“U.S.-China Joint Presidential Statement on Climate Change” 2015). Between June 2013 and June 2014, pilot emissions trading schemes commenced in five cities and two provinces (Zhang 2015).

13 The State Council of the People’s Republic of China (2016).

14 Boren (2016), see http://www.gov.cn/xinwen/2016-04/25/content_5067562.htm for the official press release. According to Forsythe (2016) the main driver behind this policy may be economic rather than environmental concerns, as existing coal-fired capacity faces low utilization rates.

In its New Policies Scenario (NPS), the IEA World Energy Outlook (WEO) predicts that China`s coal demand will stay constant over the next 25 years (IEA 2015a, Table 7.2). However, there are strong indications that the peak of coal use for power generation may already be starting to occur. Preliminary data for 2014 shows that steam coal consumption was 3.5 percent lower than in 2013 (IEA 2015c, III.21) despite increased power demand, suggesting that its share in the fuel mix has dropped. This view is confirmed by figures published by the Chinese National Bureau of Statistics suggesting a 1.9 % drop in energy-related carbon emissions, which mainly originate from a drop in annual coal consumption of 3.7 % (Slater 2016; Yeo 2016). While the WEO discusses the possibility of a decline of coal consumption in China, and warn against negative effect on the global coal industry (IEA 2015a, 291), it excludes this trend from its central scenario. Against the background of continued policy interventions further reducing future coal demand and supply (cf. Supply-Side Structural Reforms and "Promoting the orderly development of China's coal" Plan described in Table 6) are very likely. Therefore the WEO projections from the 450ppm Scenario, which forecast a compound annual growth rate of -1.8 % from 2013 to 2040, seem to be more in line with the realities in China (see Figure 9 on page 30).

4.2.2 India

India's steam coal demand has accelerated rapidly over the past decade. In 2014, with consumption of 760 Mt (according to preliminary data), India became the second largest steam coal consumer in the world behind China on a tonnage-basis (IEA 2015c, III.30-III.32). In 2013 the share of coal in total electricity generation was 72.8 percent (IEA 2015c, III.65).

India has considerable coal reserves, though they typically consist of poor quality coal with low energy content and high inherent ash content. Though production has been ramping up predominantly by boosting output from in lowest energy content grades (IEA 2015a, 513), India's coal production sector has been systematically lagging behind the stark increase in demand. Next to the typical problems of a state-own enterprise (Coal India Limited (CIL)) that contributes 80 % to India's coal production, the sector struggles to cope with a linkage system of coal distribution and prices, a poorly developed interface between the coal and the power sector, and complications and uncertainty around land-rights and acquisition that hinder the development of new mine projects (Carl 2015, 124), and from insufficient transport capacity and low productivity (Commonwealth of Australia 2015a). As such, imports of steam coal have more than doubled in the last few years to reach 180 Mt in 2014, representing almost a quarter of domestic demand (and constituting 17 % of the total global steam coal trade) (IEA 2015c, III.44,III.31,III.40).

Future growth in coal demand will be shaped by India's economic growth (especially in the energy-intensive manufacturing sector), increased electrification to overcome high levels of energy poverty (IEA 2015a, 448), and to some extent, environmental policies. In its "intended nationally determined contribution" (INDC) India has committed to reduce the carbon-intensity of GDP by 33 to 35 % from 2005 levels by 2030 and, conditionally, to increase the share of non-fossil fuels in power generation capacity to 40 % by 2030 (Government of India 2015a). Moreover it targets to increase solar generation capacity to 100 GW and total renewables capacity to 175 GW by 2022 (Government of India 2015c). As an additional policy measure India has introduced a tax on imported coal of 0.8 USD in 2010, and has twice doubled the tax to 3.2 USD for 2015–2016 (Mittal 2014; Ministry of Finance 2015). Additionally, air pollution from coal combustion has the potential to become a significant issue for India (IEA 2015a, 504), and may compel more ambitious policies to curb coal consumption in the future.

A key question in relation to India's future steam coal demand is the extent to which it will continue to be met by imports. In the short term, it is likely imports will continue to increase, although this may be constrained by logistical factors such as port capacity (IEA 2015a, 518). In the longer term, because imported coal is significantly more expensive than domestic coal (even once adjusted for differences in energy content) (Carl 2015, 153), the Indian government is aiming to reduce import dependency – possibly to the extent of becoming self-sufficient in steam coal (*Reuters India* 2015). A strong domestic production targets of 1500 Mt/a for 2020 is in place, but its success will depend on whether present constraints on production can be overcome (EIA 2015b). Coal quality is a further consideration. A majority of 85 % of the young Indian coal-fired generation fleet (two thirds are have age 20 and younger) has sub-critical design tailored for high inherent ash and low energy content Indian coal and cannot easily take other coal types but required blending if imported coal needs to be used which entails reduction plant efficiency (IEA 2015a, 440). Only new generation of power plants is suitable for imported coal (Carl 2015, 129). At the same time the Indian government has announced that the Thirteenth Five Year Plan (which commences in 2017) will require all new coal-fired generation capacity to use supercritical technology (Government of India 2015b). However these would induce an ongoing need to import coal (Commonwealth of Australia 2015a, 82–83).

4.2.3 Japan

Japan is the world´s third largest economy and the fifth largest emitter of CO_2 emissions. It used to have a reputation as climate leader hosting also the first international climate conference in Kyoto in 1997. After the climate conference in Paris in 2015, however, the future for Japan's climate policies remains very uncertain. Being located on an island it is highly vulnerable to climate change impacts and therefore has incentives to comply with decarbonization targets. On the other hand, Japan is the only G7 member that is planning to open dozens of new coal-fired power plants, endangering national as well as global climate targets. Japan´s emission reduction target of 26 % for 2030 and at 80 % for 2050 are criticized to lie well above the 2° C benchmark (Dimsdale 2016). Consequently, Japan´s rating by the Climate Action Tracker initiative (CAT 2015) turned out to be "inadequate" in terms of supporting the 2° C target. The Russian Federation was hereby the only developed country with a lower score. Japan, being the second largest electricity market in the OECD is hereby dominated by ten vertically integrated regional monopolies as well as the former national electricity development company (called JPower). These companies control 76 % of Japan´s generation capacity and are in charge of the transmission, and distribution system. The Japanese electricity system is the only one in the world that is divided into two different frequency zones (the eastern having 50Hz and the western 60 Hz) (Caldecott et al. 2016).

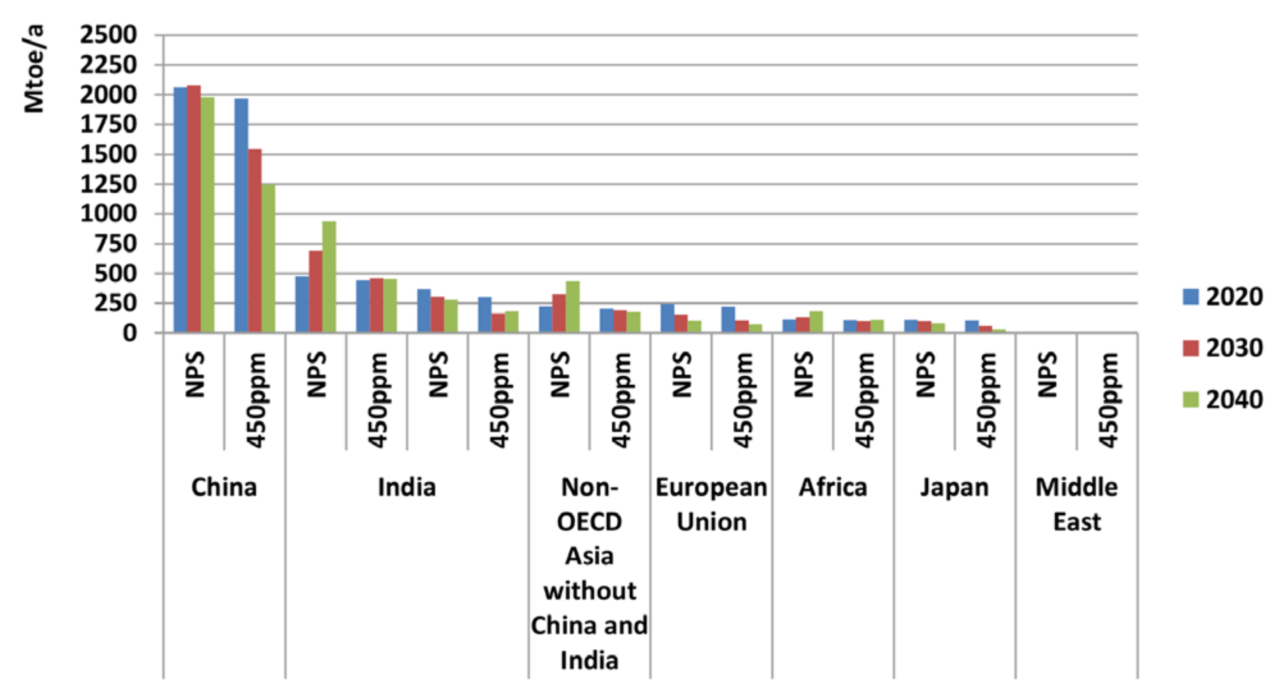
The Tohoku Earthquake leading to the Fukushima Daiichi nuclear disaster in 2011 caused a dramatic shift in Japanese´s climate and energy policy. Following this accident, the government ordered the shutdown of all 54 operating nuclear plants that were supplying 30 % of Japan's electricity at that point. This drop-back was mostly compensated by liquefied natural gas (rising from 29 % to 43 %), oil (8 % to 18 %) and coal (25 % to 28 %). Renewable energy sources, particularly solar PV, have increased their electricity share steadily and are estimated to reach 7 % in 2016. In 2015 the first five nuclear blocks restarted their operation and shall be followed by eight further plants in 2016 (Yanagisawa et al. 2015).

Current policies aim at complementing this increase of nuclear capacities with newly constructed coal power plants. The existing plans for 47 new coal units account for 22.5 GW – twice as many as all other G7 members combined (Dimsdale 2016). A reason for the construction of coal power plants in Japan can be seen in cheaper fuel prices for coal compared to gas or oil (Caldecott et al. 2016). Japan, in addition, is the largest financier of coal overseas and a promoter of the so-called high efficiency and low emissions (HELE) coal power plants (Grandia 2016). These HELE coal power plants are suited for burning coal of high quality from Australia but might also use Colombian coal. The construction of these power plants, despite higher efficiency values, however, is incompatible with the 2° C target as shown by a study conducted by Ecofys (Wong, Jager, and Breevoort 2016). Until now only four coal plants with an overall capacity of 1.9 GW have started construction. Succeeding in the construction of all currently planned units would exceed the required capacity to replace the retiring fleet by 191 %. Such overcapacities, combined with rising competition from renewable energy sources, might result in significant stranded coal assets (Caldecott et al. 2016).

4.3 Effects on the Colombian coal sector

The findings from the last chapters clearly show that the next decades are going to change the global steam coal market in various ways. This complicates giving precise projections resulting in scenarios varying in their altitude as well as in regional distortions. The world energy outlook by the IEA (2015a) uses different scenarios to describe consistent visions regarding future coal trends shown in Figure 9. The New Policies Scenario (NPS) hereby assumes currently discussed climate policy schemes to remain in practice. These measures are still insufficient with limiting global warming to 2° C but already cause major changes in the global steam coal market. A decrease of consumption in the EU, USA and China is, however, offset by increasing consumption in Africa, South-East Asia and India. A more stringent scenario in line with the 2° C target (450ppm) leads to a strong cut in EU and Japan. Consumption in China and the USA is cut by 50 % compared to 2015 figures. Additional reductions in coal consumption in Non-OECD Asia are complemented by a constant Indian demand. Other scenarios by the New Climate Institute (2016) conclude that the share of coal usage for electricity production (without CCTS) has to be reduced from currently 40 % to 20 % in 2020 8 % by 2030 before being completely phased-out in the 2040s to be in line with the 2° C target. Limiting global temperature rise well below 2° C and to drive efforts to increase the target even further to 1.5° C as stated in the Paris Agreement on Climate Change (UN 2015b) need even faster and stronger reductions in coal consumption.

Figure 9: Possible development of coal consumption in the New Policies Scenario (NPS) and a scenario in line with the 2° C target (450ppm) in selected regions (in Mtoe/a).



Source: IEA (2015a).

4.3.1 Trends of existing trade partners

The traditional main importers of Colombian steam coal are located in Europe, USA and to a smaller extent in Latin America. Future coal demand in the EU has two parallel storylines which more or less follow an east-west divide: Against all efforts of climate change mitigation the Eastern European states (most notably Poland, and Czech Republic) pursue a course of supporting coal-fired electricity generation by backing up their domestic coal industry: As a consequence, coal mining companies being under economic pressure due to the plummeted global coal prices were given state subsidies or were renationalized. This reduces the possibility for additional imports from Colombia. Turkey and Israel, on the other hand, are planning to construct several new coal fired power plants. Colombian coal, however, will have to compete with local suppliers as well as with shipments from the USA, South Africa, and Russia.

The second storyline is the one of the Western European countries which 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. Portugal is planning to phase-out in 2020, followed by Finland in the 2020s. The UK has announced to phase-out coal until 2025, the same is true for Denmark and Austria (CAN 2016c; Jacobsen 2014). Germany's less advanced coal phase-out is currently being discussed for the 2040s, but there is a general consensus that it is necessary to achieve legally binding CO_2 reduction targets. Other Western and Southern European countries (France, Spain, Italy etc.) are also embarking on a similar pathway with declining coal demand in the medium term. As a consequence the role of the Netherlands as the European hub for coal imports is also likely to decline.

Traditionally, the USA were 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 with increasing shares of renewables this situation has changed fundamentally. There is high pressure on the domestic production sector and prices have fallen by up to 50 % from 2010 to 2015. Even if the era of cheap gas would end in the near term, environmental regulation in place prescribes a coal phase-out. This gloomy outlook for the U.S. coal sector leaves no space for future coal exports from Colombia to the USA. On the contrary, the USA might become a competitor on the Pacific market in the unlikely event that the current opposition of the U.S. West Coast states against constructing coal export terminals for Powder River coal from Wyoming brakes down.

Brazil will continue to rely mainly on renewable energy sources for its power generation and on LNG imports for thermal power generation rather than strongly increasing the share of coal. Chile benefits from vast renewable potential and aims at increasing its share of renewable energy supply. Due to security of supply considerations, however, Chile also plans to maintain its coal-fired generation base. Although also developing domestic resources, it will therefore, continue relying on coal exports. Colombia will most likely play an important role as exporter, but could face increasing competition from US suppliers. The same is true for future supplies to Mexico.

4.3.2 Potential new export markets

As demonstrated in the analysis above, if there will be any new market opportunities for Colombian steam coal, they will be mostly located in the Pacific region. The recent widening of the Panama Canal is expected to increase the competitiveness of Colombian steam coal exports on the Pacific market, as it allows vessels to avoid travelling around South America (Bright 2011). This prospect triggered the construction of the "Puerto Brisa" in Dibulla, La Guajira. Owing to its favorable location close to the Panama Canal, the 30Mt/a terminal is to be used for exports intended for China and South-East Asia (Puerto Brisa 2015; Buendia and Gagan 2012). 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 in 2011, negotiations on the proposed Pacific rail line had stalled since until recently China confirmed looking for local partners, which is also expected to speed up the planned expansion of the associated "Puerto Buenaventura" (Buendia and Gagan 2012; Volckhausen 2014). However, there are also critics, strongly doubting economic feasibility, and therefore, expecting this project never to happen (ERGO 2011).

Several factors speak against China becoming a large importer of Colombian steam coal. Currently the Pacific market is dominated by Indonesia and – to a smaller extent – Australia which can supply coal to China at lower costs than Colombia. With new quality standards on imported coal Colombian coal gains advantage against low quality Indonesian coal, though. On the other hand, demand for imported coal in China is likely to decrease rather than increase due to ease in inland coal transport, and its "coal-by-wire" program. And most importantly, a forecasted decline in coal demand leaves little room 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 that 85 % of the young 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 additionally, regulation to equip new-built power plants with supercritical technology becomes effective, then these might be more suitable for Colombian and Australian coal and open up new market opportunities.

Japan and South Korea are planning to construct new coal power plants suited for burning coal of high quality from Australia but might also use Colombian coal. News spread when first shipments of ~0.6 Mt from Colombia were announced to arrive in South Korea in June 2016. These shipments only constitute a minor share of Korea`s 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-years low (Gloystein 2016). Power plants in South-East Asia, on the other hand, are designed for low quality supply from Indonesia which can deliver coal at low cost due to short distances and easy maritime access. This makes it very difficult for Colombian coal to enter these markets.

5. FURTHER GLOBAL TRENDS INFLUENCING FUTURE COAL CONSUMPTION

This chapter analyses different technical and political trends that could influence future global coal consumption. A focus is hereby put on the carbon capture, transport, and storage (CCTS) technology as well as possible supply and demand-side policies.

5.1 What is the influence of the CCTS technology on the international demand for coal?[15]

5.1.1 Description of the technology

One technology supported by many power utilities for combining coal electrification with decarbonization is carbon capture, transport, and storage (CCTS). The technology consists of three stages starting from capturing CO_2 from large stationary emitters, such as power plants or industrial facilities, then transporting it to an underground storage site, and then compressing it in suitable geological formations. Most studies refer to this technology as CCS, though neglecting the essential "T" representing the important transportation part of the value chain. The idea that CCTS could be part of a path toward a sustainable energy system emerged in the late 1990s and became even more prominent with the IPCC (2005) special report. The vision of the technology includes burning fossil fuels without the negative externalities of CO_2 emissions to complement the low-carbon technologies renewable energies and nuclear. Consequently, the IEA Roadmap (2009) estimated that reducing CO_2 emissions by 50 % in 2050 compared to the 1990 level, without the use of CCTS, would increase global mitigation costs by up to 71 %. Even higher cost increases of 29–297 % are confirmed by scenarios of the newest report from the IPCC (2014) for reaching the 2° C target without the CCTS technology. The large-scale combination of the CCS value chain, however, is still not proven, as documented in a special issue by Gale et al. (2015) commemorating the 10th anniversary of the IPCC (2005) special report. Experiences show that applying CCTS as decarbonization technology for the electricity sector is unlikely as renewables provide a cheaper alternative. The only existing CCTS small-scale applications are in combination with CO_2-Enhanced Oil Recovery (CO_2-EOR) (Hirschhausen, Herold, and Oei 2012). Such carbon capture and usage (CCU) concepts, including CO_2-EOR or urea production, however, have limited global potential and have very low CO_2 mitigation effects: In CO_2-EOR processes the majority of the injected CO_2 diffuses in the underground storage. Also, the additionally extracted oil is leading to further emissions (Gale et al. 2015).

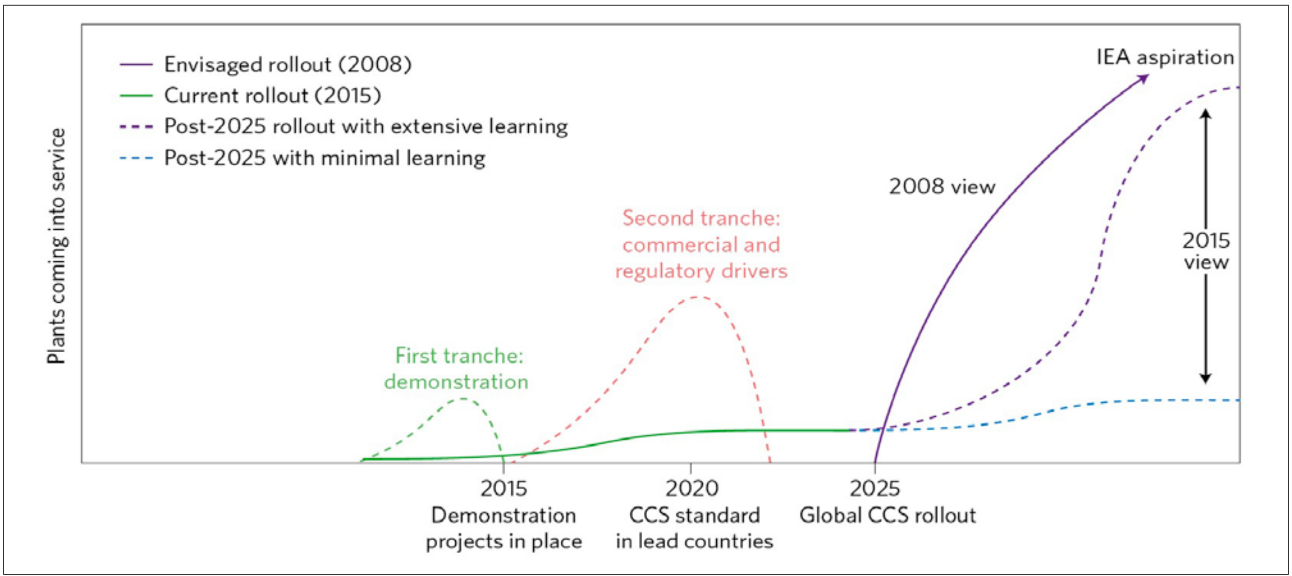
5.1.2 Low chances for a roll-out of the technology until 2030

Eckhause and Herold (2014) show that the success of a global CCTS rollout depends on the existing governmental funding schemes. Splitting funding over a number of projects in general increases the likelihood of success in finding a new technology. This, however, also creates the risk that the split funds are insufficient to produce any successful project, as happened in the case of European CCTS funding. The European Commission tried funding numerous projects of different capturing technologies (pre-combustion, post-combustion, oxyfuel), various sources (power plants, industry) and numerous countries (DE, ES, FR, GB, IT, NL, PL, RO) via the European Energy Program for Recovery (EEPR) and two follow-up New Entrance Reserve (NER300) programs (Lupion and Herzog 2013). All projects, however, withdrew their applications during the process, were shut down, or have kept postponing their final investment decision for several years (Hirschhausen, Herold, and Oei 2012).

There still exists a cognitive dissonance in the prediction of top-down models, which continue to place hope in the CCTS-technology, and bottom-up experiences: On the one hand, longer-term energy system models insist on the need of CCTS to attain ambitious decarbonization scenarios (IPCC 2014). The EU Energy Roadmap 2050 still projects on average 133 GW of CCTS power generation capacity by 2050, which is equivalent to 1 Gt CO_2 captured per year (EC 2011). The World Energy Outlook by the IEA (2014e) even estimates more than 800 GW of globally installed CCTS capacity by 2040 in their 450 ppm scenario. First movers, such as the U.S., Canada, Norway, and the UK, on the other hand, have shifted their attention toward CO_2-EOR. This has little to do with the original idea of CO_2 mitigation through CCTS, as the newly extracted oil and gas leads to additional CO_2 emissions (Gale et al. 2015; MIT 2007). European countries with formerly ambitious research and development (R&D) and demonstration objectives, such as the Netherlands, Germany, and Poland, have shelved all their pilot projects. The world's two largest coal burning nations, instead of becoming interested beneficiaries of the technology, are pursuing their own, very modest research (China) or ignoring CCTS altogether (India) (Wuppertal Institute 2012; GCCSI 2014). The chances for the CCTS technology to reach technological maturity before 2030 are estimated to be very low. This excludes the option for coal power plants to capture their CO_2 emission. Sticking to decarbonization targets therefore implies a phase-out of all coal power plants in the next decades.

15 The sections on CCTS hereby summarize findings from Hirschhausen (2012), Oei et al. (2014), and Mendelevitch (2014).

Figure 10: High hopes and current trends for a possible future CCTS rollout



Source: Reiner (2016).

5.2 Global climate policies addressing coal consumption[16]

Global climate policies can be organized along different metrics. One common metric is to sort them according to the side of the market for emission-intensive goods that they address: those policies targeting the consumers are referred to as demand-side policies, while those addressing the production are referred to as supply-side policies. Another frequent metric is to order the policies according to their general approach: Market-based economic instruments can take the form of taxes/subsidies, or tradable allowances/credits, as well as border tax adjustments and are directed to influence the decision-making of profit-maximizing firms (Kolstad et al. 2014, 364). While these instruments rely on the incentivizing desired behavior of private actors, additional approaches can implemented if the conduct is not satisficing or there is a lack of political feasibility for a particular economic instrument. Purely regulatory approaches are an alternative. They establish a rule (standard) that a regulated entity has to comply with, while threatened with a penalty in case of non-compliance. Hybrids of regulatory and market-based approaches are widely applied (incentive regulation). Besides, information programs and governmental provision of goods and services can be used as additional instruments to achieve climate objectives.

5.2.1 Demand-side policies

Demand-side policies for reducing emissions, which provide indirect incentives to reduce coal consumption, have received the most attention in the academic literature and have been most commonly introduced in practice. Carbon pricing instruments place an explicit price on emissions – either directly, as a carbon tax, or indirectly, through a cap-and-trade scheme (OECD 2013b). Such instruments have been implemented (or are scheduled to be implemented) in 39 countries, and at the jurisdictional level in a further 3 countries (Kossoy et al. 2015, 22). There are many other policy instruments which generate an implicit carbon price, such as taxing energy use, imposing emissions standards, or mandating the use of low-emissions energy sources. Other demand-side policies include measures that promote energy efficiency and reduced energy consumption. All these types of policy instruments are used across many countries, and may serve other goals in addition to reducing emissions (OECD 2013b). The Grantham Research Institute maintains a database of global climate legislation which details different policies that have been implemented (Grantham Research Institute 2015).

Under the right conditions, market-based carbon pricing instruments are theoretically the most efficient policy instruments for reducing emissions (e.g. Stavins 2003). Practical outcomes appear to support the theory, with cap-and-trade schemes and carbon taxes found to drive more abatement at lower cost compared to some other policy instruments (OECD 2013c). However the effectiveness of these instruments may be undermined by inadequate design and implementation. For instance, prior to the commencement of the European Emissions Trading Scheme (EU ETS) it was predicted that its effectiveness would be reduced due to suboptimal permit allocations (Kemfert, Diekmann, and Ziesing 2004), and this has now eventuated in practice (Ellerman, Valero,

16 The section draws heavily on Collins and Mendelevitch (2015) and Oei et al. (2014a).

and Zaklan 2015; Neuhoff et al. 2015). Consequently, the EU ETS and similar economic instruments in place worldwide have only generated low carbon prices (averaging €5 per ton of CO_2 in 2014 (IEA 2015b, 23)). In contrast, higher carbon prices are needed to drive substitution away from coal in the power generation sector – for instance, one recent estimate of the price that would drive coal-to-gas switching in Europe is around €40 (Gray 2015, 49). Moreover, it is likely that even higher carbon prices are necessary to drive the closure of old, fully-depreciated, coal-fired generators (IEA 2014a, 17).

In the absence of full participation in a global climate policy, demand-side policies are susceptible to carbon leakage: emissions-intensive activities shift to non-participating countries, such that emissions reductions in the participating countries are partly offset by emissions increases in the non-participating countries (see e.g. Felder and Rutherford 1993; Sinn 2008). Richter (2015) provides an overview of empirical studies of the carbon leakage effect, which is undisputed in existence, but controversial in magnitude. Ex-ante, the supply elasticity of coal is found to be crucial for the magnitude of the effect, with higher elasticity leading to stronger leakage effects (Burniaux and Oliveira Martins 2012). Using General Equilibrium frameworks that incorporate the interaction between trade and the environment, most studies find only moderate rates of leakage (Felder and Rutherford 1993; Paltsev 2001; Di Maria and Werf 2008). High rates of carbon leakage are estimated by Babiker (2005), who criticizes overly simplistic assumptions on market and industry structure. Employing an integrated assessment framework, Arroyo-Currás et al. (2015) identify a limited leakage of 15 percent, if the U.S., the EU and China act as pioneer regions. In an ex-post empirical study of the effect of the Kyoto Protocol on GHG emissions, Aichele and Felbermayr (2015) find a change in the production patterns of emission-intensive goods and thereby evidence for carbon leakage of about 8 percent. Combined with earlier findings by Aichele and Felbermayr (2012), the carbon leakage rate is estimated at roughly 40 percent.

To close the gap for leakage and to arrive at a global carbon policy in international climate change negotiation authors of the Economics of Energy & Environmental Policy Symposium on "International Climate Negotiations" (Gollier and Tirole 2015; Weitzman 2015; Cramton, Ockenfels, and Stoft 2015) argue in favor of a uniform carbon price. By contrast, Stiglitz (2015) reasons in favor of a flexible and differentiated approach including carbon taxes, a system of cap-and-trade, and regulatory mechanisms but also a green fund to account for shared responsibility.

A "green paradox" has also been theorized, where the expectation of future demand-side policies could induce resource producers to increase their present rates of extraction in order to maximize net present value (Sinn 2015). While Haftendorn, Kemfert, and Holz (2012) suggest that in practice the green paradox may not be relevant to the steam coal market, Bauer et al. (2013a) find a short term reduction of coal prices due to stringent climate policy.

Table 7 describes several possible regulatory demand side policies for reducing coal-based power generation. These include minimum fuel efficiency or greater flexibility requirements, national minimum prices for CO_2 emissions allowances, capacity mechanisms, a residual emissions cap for coal-fired power plants, emissions performance standards, and policies regulating transmission grids. Some countries in the EU but also across the Atlantic have taken initiative by adopting complementary measures; namely the UK (CO_2 emissions performance standards (EPS) and a carbon price floor), the USA (EPS and an additional retirement plan for older plants), and Canada (EPS).

5.2.2 Supply-side policies

Against the background of little progress on the demand-side there is a growing strain of literature on policies which address the supply of coal. One type of supply-side policy acts to directly remove coal reserves from production – whether to a partial extent (focusing on high-extraction-cost reserves for economic efficiency) (Harstad 2012), or to a further extreme, the progressive closure of the entire coal industry (Collier and Venables 2014). Another type of supply-side policy is a depletion tax (or alternatively, a depletion quota), which is analogous to the demand-side policy of a carbon tax (or for a depletion quota, a carbon budget). For instance, Richter et al. (2015) proposed a tax on the energy content of steam coal, levied by a coalition of major coal exporters. Their modelling shows that a tax levied by a coalition of major coal exporters is preferable to a tax levied by a single major coal exporter, and that a production tax generates better outcomes than an export tax (though they note a production tax is likely to be politically contentious). A supply-side policy for coal could also take the form of an export-licensing regime adopted by a coalition of major coal exporters, in analogy to the existing safeguards regime for uranium exports; based on the reasoning that the regulation of commodity exports on the basis of their harmful or unethical end use is a widely accepted principle, and should be extended to coal (A. Martin 2014). Lazarus, Erickson, and Tempest (2015) provide a comprehensive taxonomy of supply-side climate policies.

Table 7: Regulatory demand side policies for reducing coal-based power generation.

Prop. Measure	Expected Effect	Possible advantages	Possible shortcomings	Proposed/ Discussed by
EU-ETS reform	Price signal through the introduction of market stability reserve (MSR); additional measures: 900 mn EUA from backloading directly in MSR, start of MSR in 2017 instead of 2021	EU-wide instrument; thus, no cross-border leakage effects targets several sectors besides electricity	Structural reforms uncertain from today's perspective; the extent of the impact is unpredictable due to high surplus of certificates	German government (2014)
CO2 floor price	CO_2 certificates would become more expensive	Investment security for operators	Feasible prices probably too low to result in a switch from lignite towards natural gas in the short-term	BÜNDNIS 90/ DIE GRÜNEN (2014)
Minimum efficiency	Closure of inefficient power plants	More efficient utilization of raw materials	Open cycle gas turbines (OCGT) could also be affected; complex and time-consuming test and measurement processes	BÜNDNIS 90/ DIE GRÜNEN (2009)
Flexibility requirements	Closure or singling out of inflexible power plants	Better integration of fluctuating renewable energy sources	Combined cycle gas turbines (CCGT) could also be affected; complex and time-consuming test and measurement processes	Matthes et al. (2012)
Coal phase-out law	Maximum production [TWh] or emissions allowances [tCO_2] for plants	Fixed coal phase-out plan & schedule investment security	Outcome of auctioning of allowances would be difficult to predict	Greenpeace (2012), DIE LINKE (2014)
Emissions performance standard (per unit; for new plants and retrofits)	Restrictions for new plants and retrofits (without CO_2 capture) [< x g/MWh]	Prevention of CO_2-intensive (future stranded) investments	Minor short-term reduction in emissions	IASS Potsdam (2014), Ziehm et al. (2014), BÜNDNIS 90/DIE GRÜNEN (2015), Oei et al. (2014; 2014b)
Emissions performance standard (emissions cap for existing plants)	Reduce load factor for depreciated coal-fired power plants (e.g. > 30y) [< x g/MW]	Preservation of generation capacities	Negative impact on economic efficiency of power plants might lead to closure of older blocks	IASS Potsdam (2014), Ziehm, et al. (2014) , BÜNDNIS 90/DIE GRÜNEN (2015); Oei et al (2015)
Capacity mechanisms or reserve for coal plants	Incentive for construction of less CO_2-intensive power plants when including environmental criteria	Support of gas power plants; or moving coal power plants into a reserve to reduce their emissions and prevent supply bottlenecks	Difficult to set up criteria that is in line with EU state aid laws if payments should only be given to selected units	Matthes et al. (2012), Reitz et al. (2014; Reitz, Gerbaulet, von Hirschhausen, et al. 2014); Oei et al (2015)
Climate contribution fee	Additional levy for old CO_2 intensive power plants	Limiting output of most CO_2 intensive generation facilities; preserving capacities; compatible with EU-ETS	Older units might become uneconomic if the fee is too high	BMWI (2015), Oei et al. (2015)

Source: Own depiction based on Oei et al. (2014a)

Collier and Venables (2014) make the case that, in the absence of full participation in a global climate policy, a targeted supply-side policy will be more effective in reducing emissions from coal combustion than a demand-side policy. In particular, carbon leakage is minimized under a supply-side policy rather than a demand-side policy if the price elasticity of demand is high relative to the price elasticity of supply – which is considered to be the case for coal in the long-run (Collier and Venables 2014). The threat of a green paradox is also thought to be eliminated with a properly designed supply-side policy – in particular, one that targets high-cost coal deposits for closure (Hoel 2013). Other benefits of supply-side policies are that they achieve predictable and observable outcomes with low transaction costs (Collier and Venables 2014). It has also been suggested that supply-side climate policies may drive greater emissions reductions for a given marginal cost, and will limit over-supply of fossil fuels and associated "carbon lock-in" effects (Lazarus, Erickson, and Tempest 2015). Important new source: (Hagem and Storrøsten 2016)

An important consideration in relation to supply-side policies is whether producers should be compensated for the loss in profits associated with the coal that is not produced. A number of studies suggest that under a policy of freely allocated depletion quotas, enhanced scarcity rents for fossil fuels that are extracted can offset the loss in profits (Eisenack, Edenhofer, and Kalkuhl 2012; Kalkuhl and Brecha 2013; Asheim 2013) and similarly for a policy which confiscates fossil fuel reserves (Asheim 2013). These findings indicate that there is no need for overall compensation under those policies. However there may still be a need for compensation payments between producers to alleviate internal distributional effects, whereby producers with low-extraction-cost reserves will benefit at the expense of other producers (Asheim 2013).

To date, there has been limited experience with the implementation of supply-side policies. The concept of preserving fossil fuel reserves has some precedent in the Yasuni-ITT Initiative, which was a proposal by the Ecuadorian government in 2007 to preserve oil reserves, but ultimately was not carried through (P. L. Martin 2014). A recent initiative that directly targets future coal supply is the "No New Coal Mines" campaign. It is supported by the Australia Institute and argues in favor of a global moratorium on new coal mines that should be debated at the 2015 Paris Climate Conference (Denniss 2015).

6. CONCLUSION

Continued global action for combatting climate change is having major consequences for fossil fuel producing countries and especially with respect to coal reserves as most carbon-intensive fuel. The carbon capture, transport, and storage (CCTS) technology will not be an option to prolong the usage of coal power plants. Sticking to decarbonization targets therefore implies a phase-out of all coal power plants in the next decades. This is going to affect also Colombia that is estimated to have around 5 Gt of probable coal reserves. The vast majority of the extracted coal is currently being exported, mainly to Europe, the USA as well as to Brazil and Chile. Future coal demand in most European countries and in the USA, however, is shrinking and will most likely continue doing so in the next decades. Reasons for this are increasing shares of renewable energy sources, stricter national environmental standards as well as for the case of the USA alternative cheap gas supply. Various countries have already phased-out coal power plants or are currently discussing phase-out corridors for the next decades. The consequence for Colombia is higher competition from competitors in an environment of low prices. Those markets that are still likely to grow, namely Turkey and the MENA region will be canvassed by the USA and South Africa, shrinking potential profits. Other potential consuming countries, such as Poland or Czech Republic, are likely to use subsidies and measures of renationalization to protect domestic companies from foreign imports such as from Colombia.

An outlook on the North American coal sector leaves no space for future coal exports from Colombia to the USA. There is high pressure on the domestic production sector and prices have fallen by up to 50 % from 2010 to 2015. On the contrary, the USA might become a competitor on the Pacific market in the unlikely event that the current opposition of the U.S. West Coast states against constructing coal export terminals for Powder River coal from Wyoming brakes down. In Latin America Brazil, Chile and Mexico remain coal importers, but Colombia might observe increasing competition from various suppliers from the Atlantic as well as Pacific coal market.

One opportunity for Colombia therefore lies in shifting their interest onto the Pacific coal market. This strategy is supported by the recent widening of the Panama Canal and further still uncertain plans regarding an expansion of "Puerto Buenaventura" on the Colombian Pacific coast. Currently, the Pacific market is dominated by Indonesia and – to a smaller extent – Australia. Demand for imported coal in China, however, is likely to decrease as well due to ease in inland coal transport and a forecasted decline in coal demand. Power plants in India and South-East Asia are currently mostly supplied by low quality coal from Indonesia which can deliver coal at low cost due to short distances and easy maritime access. This makes it very difficult for Colombian coal to enter these markets. A more likely recipient are newly constructed power plants in Japan or South Korea which are otherwise supplied by coal from Australia. An increased competition will hereby, however, go along with a reduction of coal prices also on the Pacific coal market.

This study examined possible future trends of the international steam coal market with a focus on export potentials for Colombia. The study puts an emphasis on business and economic considerations taking into account future aspects of climate policy. The findings show that major shares of former export quantities are about to vanish in the next years. Possible newly constructed power plants are unlikely to compensate for all these shares. Increasing competition on the Atlantic as well as Pacific coal market will furthermore reduce coal prices and consequently also revenues of the mining companies. The increasing number of filed bankruptcies and lay-offs, including three out of the top four US coal mining companies in 2015, might just be the beginning of a carbon bubble devaluating stranded carbon investments. An increasing number of pension and insurance funds consequently started to divest their portfolios into more sustainable sectors. Continuing or even increasing mining volumes in Colombia should therefore be evaluated more closely from an economic perspective. Ignoring the described risks could lead to additional stranded investments in mining facilities, being another example for how the resource course slows down the economic growth of Colombia and in particular of the regions La Guajira and Cesar.

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