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Cooperation opportunities for German companies in the Canadian raw materials sector

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DERA Rohstoffinformationen

Cooperation opportunities for German companies in the Canadian raw materials sector

In collaboration with:

CANADIAN GERMAN CHAMBER OF INDUSTRY AND COMMERCE INC.
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DEUTSCH-KANADISCHE INDUSTRIE - UND HANDELSKAMMER

TORONTO

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1 Introduction and aims of the study

Germany is an important industrial nation and one of the biggest consumers of raw materials in the world. It is still a mining country, producing mostly construction raw materials such as sandstone, gravel or limestone (BGR 2017A). But as far as metals, industrial minerals or energy resources are concerned, Germany is strongly dependent on imports from other countries (Figs. 1 & 2). In 2017, Germany imported raw materials worth more than EUR 162bn (Fig. 1)

In order to secure a sustainable raw material supply for Germany, the German Mineral Resources Agency (DERA) was established in 2010, as a structural measure of the German Federal Government's raw materials strategy. DERA is part of the Federal Institute for Geosciences and Natural Resources (BGR). Additionally, the German Federal Ministry for Economic Affairs and Energy (BMWI) financed the development of the Competence Centres for Mining and Mineral Resources, which are affiliated to the German Chambers of Industry and Commerce. The first Competence Centre was founded in 2012 in Toronto. Today, there are seven Competence Centres around the globe: one each in Canada, Peru, Chile, Brazil and Australia, and two in Africa, one in Southern Africa[1] and one in Ghana[2].

The aim of these institutional measures is to secure a sustainable raw material supply for Germany, to raise awareness among German companies of potential price and supply risks along the supply chain, and to back their measures to diversify their raw material sources.

In 2011, DERA in cooperation with the Competence Centre for Mining and Mineral Resources in Canada published the study "Möglichkeiten deutscher Unternehmen für ein Engagement im kanadischen Rohstoffsektor". At that time, the potential of eight out of 14 raw materials defined as critical by the EU was investigated (AHK-DERA 2011). In 2017, the number of critical raw mate-

1 Responsible for South Africa, Zambia, Zimbabwe, Democratic Republic of Congo, Angola, Botswana, Lesotho, Mozambique, Namibia, Tanzania, Central African Republic.
2 Responsible for Ghana, Burkina Faso, Gabon, Guinea, Mali, Morocco, Sierra Leone, Togo.

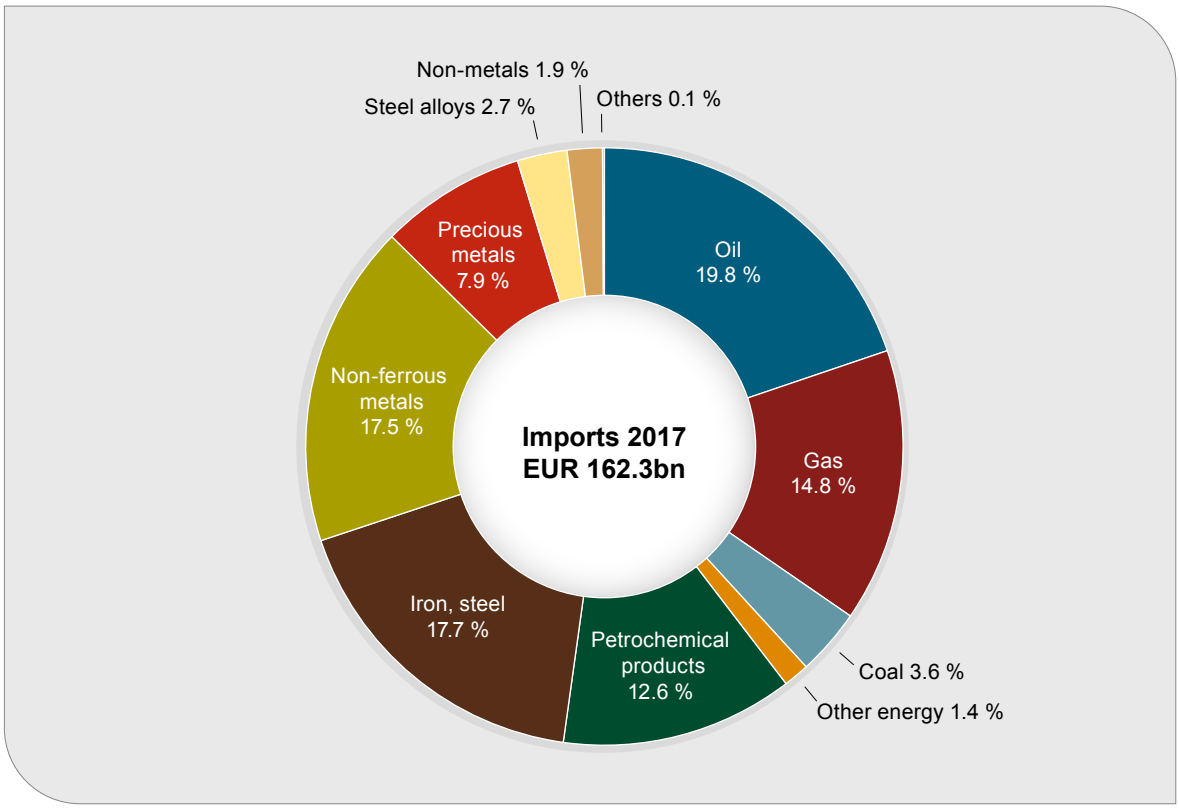

Fig. 1: Value of German imports of mineral and energy raw materials in 2017 (BGR 2019).

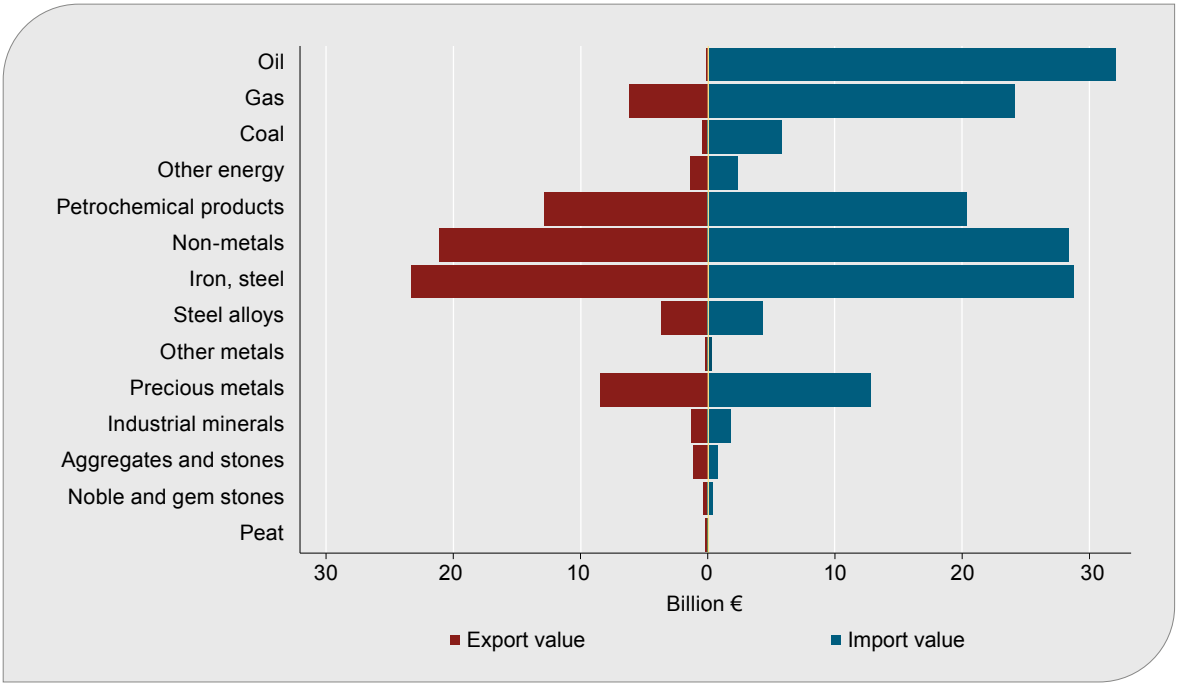

Fig. 2: Trade balance of German imports and exports in 2017 (BGR 2019).

rials increased to 27, including platinum group elements (PGE), and light and heavy rare earth elements, each group counting as one. That trend shows that a sustainable supply of important raw materials is becoming more and more challenging.

This study focuses on battery commodities such as cobalt, nickel, graphite or lithium, as representing the growing importance of these commodities now and in the near future. Besides battery raw materials, the study also focuses on the raw materials that play an important role in current trade relations between Canada and Germany, iron ore, for instance, and on raw materials that are important for many other emerging technologies, such as copper or aluminium.

From a raw materials and political perspective, Canada is a so-called “global player”. The country is in many respects an interesting partner for Germany. Canada is rich in resources and one of the most important suppliers on the world market. For twelve metals and mineral resources, e. g. potash, diamonds, uranium, aluminium, cobalt, gold and nickel, Canada is among the top five global producers (MAC 2017). Although Canada’s resource potential is extremely high, it presents a number of challenges, as a large share of these resources are located in northern, remote and isolated regions that have not been fully explored to date. An example: 76 % of mining projects north of 60 degrees latitude are undeveloped, as are 61 % south of 60 degrees latitude (CMMP 2019).

Canada’s provincial governments have developed some infrastructure projects, which are at different stages of realisation. Examples are the Plan Nord in Québec (for more information, please refer to the infobox on page 9 & 10) or the Ring of Fire in Ontario, a hotspot of exploration activities in the north of Ontario, where one of the largest chromium deposits in the world as well as associated nickel and PGE deposits are expected.

Canada is a country with a stable and transparent political system and jurisdiction. That makes it a highly attractive business and trade partner for German enterprises. In the course of the energy transition and the development of innovative products and emerging technologies, the demand for raw materials will increase significantly in Germany and also globally, especially for lithium, cobalt and nickel, but also for other mineral raw materials like copper. Without high-tech raw materials, there can be no emerging technologies “Made in Germany” (BDI 2018). Canada has a similar focus to Germany in terms of supporting and implementing measures concerning renewable energy, increas-

ing efficiency, artificial intelligence, digitalisation and automation in mining. Therefore, Canada offers interesting investment opportunities for Germany. Germany for its part can also be an attractive partner for Canada.

With its sound political, economic and legal framework, Canada offers a promising range of growing opportunities for German companies, supported by the German Federal Government's raw materials strategy. The following sections start with an overview of regional facts and information on how best to involve the Indigenous population in mining and exploration activities. After that, the raw materials sector will be introduced, including the structure of mining companies, processing stages available in the country, the role of local associations, and information on trade between Germany and Canada. Then, the potential of selected raw materials in Canada will be discussed, including information about current topics such as sustainability, resource efficiency, environmental protection and innovative technologies, and focusing especially on the changes since the last publication in 2011. Financing tools and contact information that is relevant to the German and Canadian mining sectors can be found at the end of the study.

Société du Plan Nord

In 2011, the Québec government unveiled the Plan Nord, a sustainable development programme for the development of resources in northern Québec. Over a 25-year timeframe, the Fonds du Plan Nord will have spent an amount comparable to its income of around CAD 2.7bn. The Plan Nord will apply to the area north of the 49th parallel, which is almost 1.2 million km^2, representing 72 % of Québec's total land mass. The area has a population of over 120,000, of whom one third are Aboriginals from four nations. The population is strongly involved in the implementation process of the Plan Nord. The Secrétariat aux affaires autochtones, the Secrétariat à l'implantation de la stratégie maritime, and Investissement Québec will provide support in implementing the actions of the Plan Nord.

The Plan Nord will focus on the exploration of mineral deposits, though priority will be given to establishing renewable energy sources, and to the development and improvement of the transport and communications infrastructures. Additionally, tourism, cultural development, forest resources and the eco-responsible use of local products will be promoted (Plan Nord 2019).

The area covered by the Plan Nord contains numerous deposits, especially of nickel, cobalt, PGE, zinc, iron ore and ilmenite. In addition, an enormous undeveloped potential is expected for apatite, lithium, vanadium, diamonds, graphite and rare earth elements. Mining in this area currently provides 12,700 jobs. The 17 planned mining projects, currently at an advanced stage, will generate more than CAD 22bn in investments and create more than 10,000 jobs. In 2013, the area covered by the Plan Nord listed more than 230 exploration projects. Not all will be developed to the mining stage, but the mining sector will contribute significantly to Québec's economic growth in the coming years (Plan Nord 2019).

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Continuation infobox

2 Regional studies

Canada covers an area of around 10 million km², making it the second largest country on earth after Russia. It is a federal state with ten provincial and three territorial governments. While the territories are subjects of the federal government for administrative purposes, the provinces act more independently with regard to mining (mineral rights, environmental assessments, etc.) and exploration (permits, licensing, etc.; Fig. 3; La Flèche 2017). Canada is a parliamentary democracy as well as a constitutional monarchy and part of the Commonwealth. The parliamentary system is divided into three administrative levels: municipal governments, provincial governments and the federal government.

The responsibilities for mining issues are shown in Figure 3. Minerals, metals and other natural resources are owned and managed by the governments of the provinces or territories where they are located. The federal government owns resources on federal lands, in offshore waters and on the continental shelf. The federal, provincial, and territorial governments have shared responsibility in a number of areas, such as taxation and the environment (Fig. 3). In Germany, by comparison, mining law, i. e. all legal rules relating to resources or mining, is based on the Federal Mining Act and the executive authorities are the respective federal states (BBergG 1980).

In 2018, Canada had a population of 37 million people, approximately 3.7 inhabitants per km². Germany, by comparison, has 231 inhabitants per km². Remote areas have a low population density, resulting in a poor infrastructure. During wintertime, some places in the north of Canada are only accessible via ice roads or not at all by land. One fifth of the Canadian population live in cities. The biggest cities are Toronto, Montreal, Vancouver, Calgary and Edmonton (population in descending order). A peculiarity in Canada's demographics

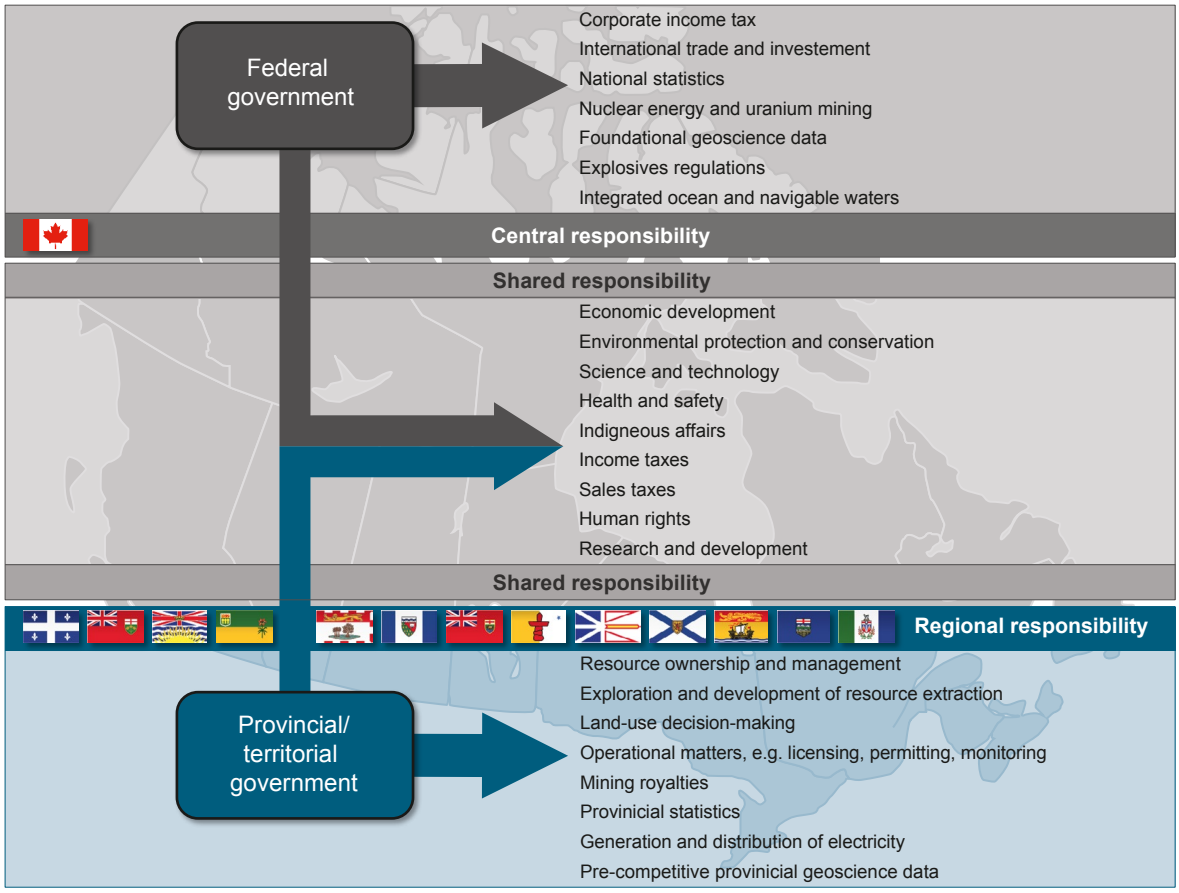


Fig. 3: Division of responsibilities for mining issues in the Canadian government (Government of Canada 2016a).

are the more than 1.6 million Indigenous people, among them more than 850,000 First Nations, 450,000 Métis and 60,000 Inuit, who live in more than 1,200 communities. This is relevant for the mining industry, as many mineral deposits and mines are located close to Indigenous communities. More information about how best to involve the Indigenous population in mining and exploration activities is discussed in Section 3.

The varied geographical conditions combined with the exceptional political separation of powers have serious effects on energy costs. Electricity suppliers for the southern provinces, located close to the border with the United States, offer significantly lower prices than those in the Northwest Territories. The north of Canada has a poorly developed infrastructure and therefore not all parts are connected to the local power grid. Mining companies are forced to generate power on site using diesel generators. That type of power generation typically costs around CAD 1 million per megawatt (MW), with operating costs of 25 – 30 cents per kilowatt hour (kWh, Fortune Minerals 2017). This affects the distribution of exploration activities, since not only geological conditions are an important factor for project evaluations, but infrastructure aspects have to be considered as well.

3 Indigenous peoples

In order to fully assess Canada's mining business potential, it is important to understand the importance of its Indigenous peoples and their rights. The following explanations show what steps have to be taken during the project process.

In 2016, the Indigenous population in Canada comprised approximately 1.6 million people, accounting for about 5 % of the total population and with a trend for growth. In Canada, Indigenous is defined as First Nations, Métis and Inuit (StatCan 2018). First Nations are generally Indigenous people in Canada, Inuit are Indigenous people from the Arctic region, and Métis are people who have both Indigenous and European roots (AADNC 2019).

There is great diversity within the Indigenous cultures. Canada has more than 617 different Indigenous peoples with twelve different language groups (AADNC 2019, StatCan 2018), some of them as different as Mandarin and German. The cultures themselves sometimes also differ considerably. If a company is dealing with Indigenous representatives as part of its activities, it not only makes sense but is necessary to obtain specific information about the individual peoples living in the area of interest. For example, if exploration and mining projects involving an Indigenous people enter the consultation phase, it is essential to use the correct terminology and to master the pronunciation of the respective people's name. The exact name can easily be requested directly from the respective negotiating partner. There are also a few things to consider in general when dealing with the Indigenous peoples.

Political

Canadian and international law guarantee the protection of the Indigenous peoples and their traditional territories. The federal and provincial governments are aiming for a real partnership with the Indigenous communities as part of the reconciliation process. These communities should not only benefit from the fact that natural resources are being mined in their territories, but they should also be included to a considerable extent in the decision-making process, particularly regarding the decision whether and how such projects can be implemented (Ontario 2019).

Legal

There is also change on the legal side. Article 35 of the Constitution of Canada currently recognises and affirms the existing Indigenous and contractual rights of the Indigenous peoples of Canada (Government of Canada 2019). However, these rights are not determined by law but more and more shaped by constitutional judgements. This very complex balancing process includes the honour of the Crown and its commitments to the Indigenous peoples, the level of influencing indigenous (land) rights, and conflicting interests of other groups.

In general, it can be said that, for projects affecting Indigenous rights and/or territories, there is an obligation on the Crown (authorities) to seriously consult the relevant Indigenous peoples before issuing a permit (no simple pro forma consultation) and include their concerns in the decision-making process (duty to consult; Wilson 2017). Article 19 of the UNDRIP (United Nations Declaration on the Rights of Indigenous Peoples) goes even further, stating that there is not only a "duty to consult", but the obligation to obtain the approval of the Indigenous peoples involved ("duty to obtain free, prior and informed consent", UN 2008).

On 10 May 2016, the Minister of Indigenous and Northern Affairs, Carolyn Bennett, announced to the United Nations that Canada was now a full UNDRIP supporter "without reservation". She further stated that UNDRIP would be implemented in Canadian law through Article 35 in accordance with the Constitution of Canada, and that Canada had a robust legal framework for the protection of Indigenous rights (Government of Canada 2016b).

Economic

The mining industry is the largest private employer for Indigenous people (CMMP 2019) in Canada. This is partly due to the fact that most mining projects are located in their territories. Many Canadian mining companies have been pursuing a cooperative partnership with the Indigenous peoples. This includes, for instance, the obligation to provide adequate education and training for local youth and general vocational training (NRCAN 2019a). Long-term career opportunities should be created and it should also be ensured that the local population is informed about the relevant programmes.

Some Canadian companies have recognised the potential of the Indigenous peoples and are investing accordingly. BC Hydro, for example, created a Strategic Aboriginal Engagement Committee in 2014 (BC Hydro 2014). The company London Drugs provides a scholarship programme especially for Indigenous youth (Londondrugs 2019). For German companies, it would also be advisable to make investments at an early stage in order to gain well-trained Indigenous local workers and their loyalty for the long term. The more a company's portfolio incorporates sustainability and environmental protection, the more likely it is that cooperation with the Indigenous peoples will be successful.

Culture and values of the Indigenous peoples

The Indigenous peoples see themselves as protectors of their respective territories. The focus is not on aspects of property law, but on the preservation of and care for the territory as a whole. Indigenous peoples have always made their decisions with a view to sustainability, thousands of years before Western nations did (Coastel First Nations 2019).

The Indigenous peoples do not have the western understanding of property, such as can be found in the German legal system in Article 14 (1) of the German Basic Law (GG). According to basic western understanding, the property of a (legal) person can be freely bought and sold, while the Indigenous understanding is closer to the meaning of Article 14 (2) GG (property obligation). The long-term relationship between the Indigenous peoples and their territories also plays a role. As mentioned earlier, there is archaeological evidence that Indigenous peoples lived on the North American continent over 10,000 years ago. The land that they live on is not just essential to their livelihood; it is also their home and home to generations of their ancestors (CBC 2017).

Every Indigenous people has a complex political and legal system (JFK 2016). However, unlike in western systems, rules are communicated orally, often as stories that are passed on from generation to generation. Cooperation, trust and respect are at the core of Indigenous cultures.

In every decision, the focus is on its effects on the collective. In general, attempts are made to find consensus in the group; individual decisions are not welcome (Indigenous Works 2019). It is also assumed that everyone is true to their word. As mentioned above, the Indigenous culture is heavily based on oral tradition.

If a mining company's project might affect the rights of Indigenous peoples, it is advisable to seek advice from a Canadian lawyer specialising in Indigenous rights. Being fully informed regarding the duties maximises the chance of a successful project implementation. Furthermore, during the consultation process, it is advisable to contact the respective First Nations well before the start of a project and to obtain comprehensive information about the relevant culture. Another aspect is that the Indigenous peoples have knowledge of the local territories that can be of great value for a project. Taking a cooperative approach already in the planning phase makes sense from an economic point of view.

In British Columbia, for example, the company ICTINC Indigenous Corporate Training Inc. was founded under Indigenous leadership, offering courses in "Indigenous corporate training" to make it easier for entrepreneurs to establish contact and negotiate with the Indigenous nations (ICTINC 2019).

Companies should therefore get in touch with the Indigenous population that might be affected early on, before the start of a project. If the above recommendations are followed, a good foundation can be built for a successful business relationship.

4 Economic situation and trends

Canada's economy is the tenth largest in the world, with continuous growth since 2010. Alberta, British Columbia, Saskatchewan and Ontario are the fastest growing provinces. Encouraged by private consumption, rising investments and government spending, domestic demand is driving the economy.

The annual GDP growth rates were 1.9 % in 2018 and 1.6 % in 2019. For 2020, analysts from Germany Trade & Invest expect an annual GDP growth of 1.7 % for Canada (GTAI 2019). The dominant role of household consumption is likely to decrease slightly over the next few years in favour of private and public investments.

Canada is a trading nation: trade generates more than 65 % of the Canadian GDP. The most important trade partner is the USA, with a share of two thirds. The Canadian economy is therefore strongly connected to the US economy and influenced by the US economic situation. Canada is also the biggest consumer of products from the USA. Furthermore, the USA have a proportion of 50 % of foreign direct investments in Canada and therefore a strong position on the Canadian market. Those investments are mostly US retail chains with subsidiaries in Canada. This could be of interest also for German companies. Due to its current dependency on the USA, Canada is open to intensifying its trade relations with other partners outside the USA, not only to minimise the impact of difficult political situations in the USA, but also to diversify their sources of income. Germany is perceived as a strong partner country and has good opportunities for focusing its economy more on cooperation with Canadian partners.

The Comprehensive Economic and Trade Agreement (CETA) between the EU and Canada was introduced in September 2017. Part of this agreement is the elimination of customs duties. European companies are therefore exempt from 99 % of Canadian customs duties. Additionally, Canada has opened up the tendering procedures of the provinces and municipalities, i. e. the levels of administration at which the bulk of public contracts are awarded, to European bidders (EU 2017b). For Canada, the CETA agreement opens access to a market with more than 510 million consumers and an economic area achieving 22 % of the world's GDP as well as economic growth of 1.9 % in 2018, with average growth of 2.2 % from 2015 to 2018

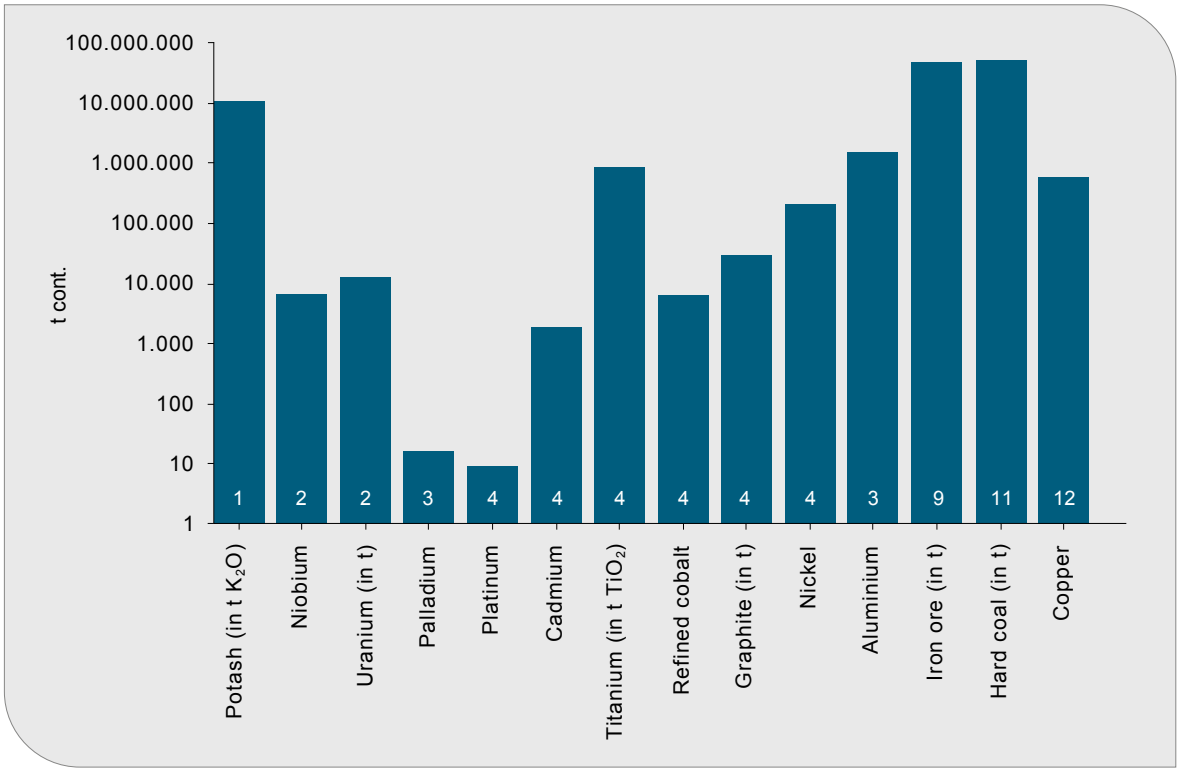


Fig. 4: Canadian raw material production, including world rank, in 2017 (BGR 2019).

(BDC 2018). On the other hand, German companies can launch their products and services on the Canadian market more easily and quickly.

As mentioned earlier, Canada is one of the main producer of potash, PGE, uranium, niobium, aluminium, sulphur, gold and diamonds in the world (Fig. 4). Significant amounts of important raw materials for the battery industry, such as nickel, cobalt and graphite are also mined. In 2017, raw material production in Canada was around CAD 45.3bn, CAD 25.8bn for metallic and CAD 19.5bn for non-metallic raw materials. The main producers of raw materials in Canada are the provinces of Ontario (CAD 10.1bn), British Columbia (CAD 9.2bn) and Québec (CAD 8.9bn; Fig. 5)

Based on geological and economic conditions, several mining-related clusters have been identified throughout the country (Fig. 6). Sudbury in Ontario, for instance, is the most important location for mining suppliers. The Toronto Stock Exchange (TSX) and TSX Venture Exchange (TSXV) are located in Toronto, Ontario. They are the most important contacts in the world for equity financing in the mining industry (for more information, please refer to the info box on page 20).

Montreal is where the biggest aluminium and iron ore producers are based. Because of low energy costs in Québec, it is the centre of aluminium production. Bauxite, which is needed for aluminium production, is imported and the product exported to the whole world (Fig. 6).

Saskatoon in Saskatchewan is one of the most important locations in the world for uranium and potash production; the deposits there stand out because of their exceptionally high uranium and potash content (Fig. 6).

Vancouver in British Columbia is an important location for exploration companies, many of whom explore projects both in Canada and worldwide (Fig. 6).

Québec is leading in the processing and refining of raw materials, especially with its aluminium industry: nine smelters, four refineries, and two secondary smelters are located there. Ontario has three smelters and three refineries, two secondary smelters and one conversion facility. All other provinces and territories together have eight smelters and refineries.

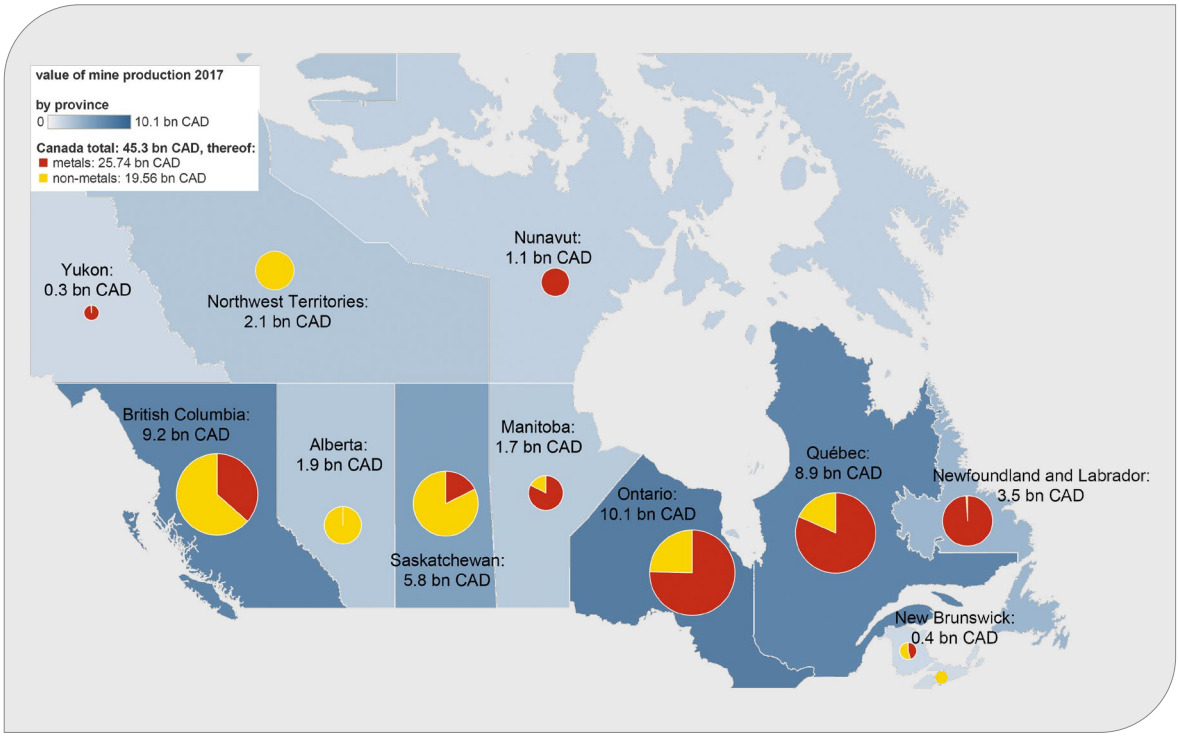


Fig. 5: Raw material production of metals and non-metals by Canadian provinces and territories in 2017 (NRCAN 2018).

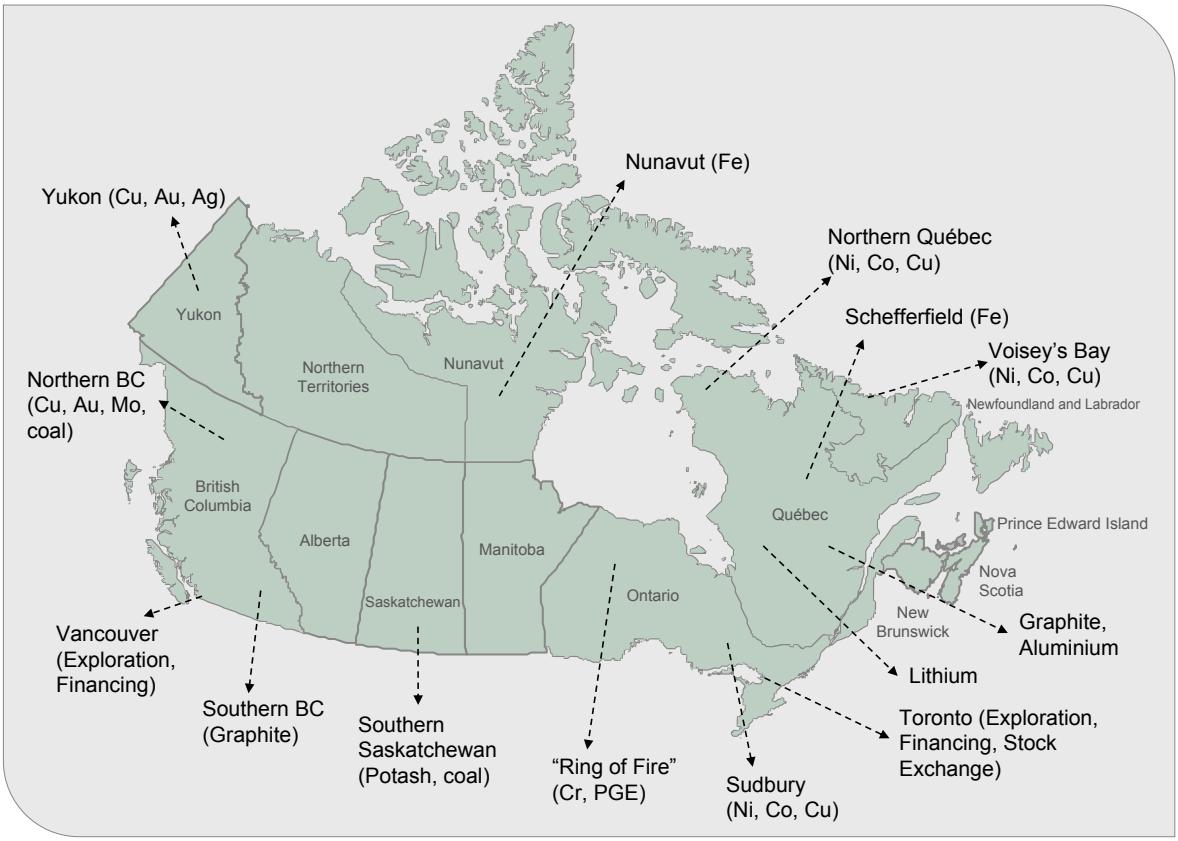


Fig. 6: Canadian mining clusters (NRCAN 2019b).

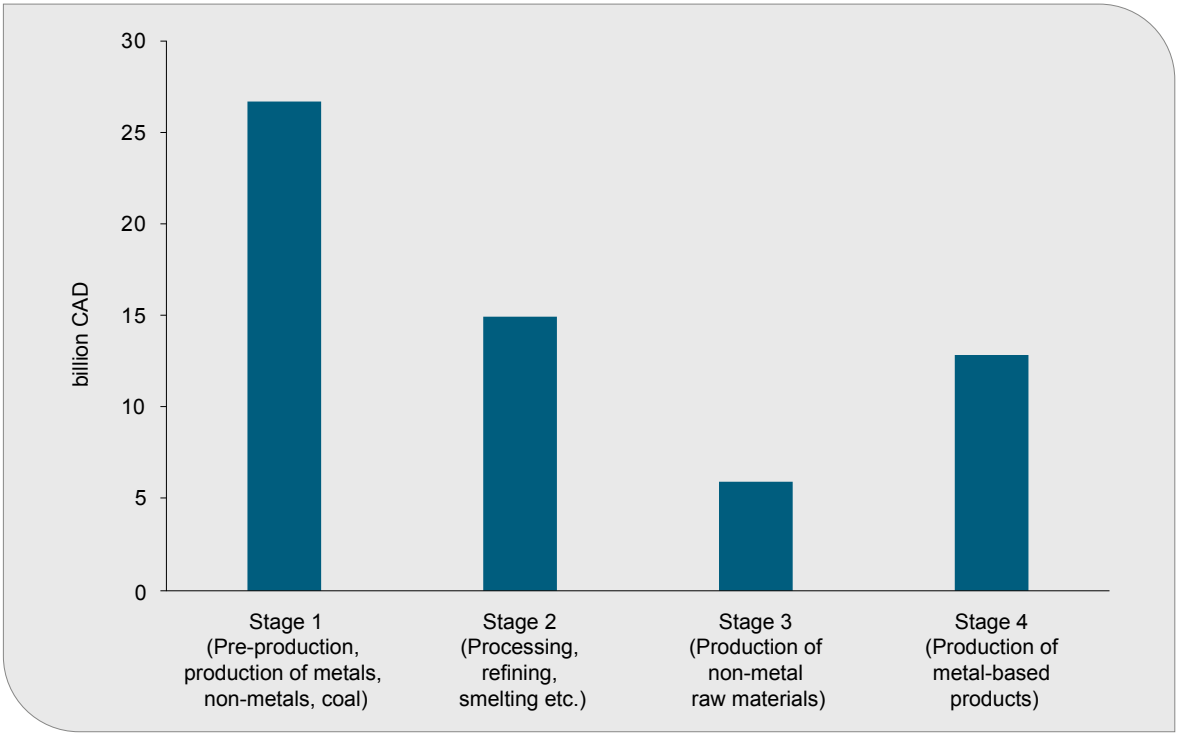


Fig. 7: Mine production divided into four value-added stages. Production at stage 3 is based on industrial minerals e.g. lime, cement, glass, ceramics. Production at level 4 is mainly including forged products, stamping, wires and tools (MAC 2018).

The mining industry (including oil and gas) in Canada is the fourth biggest industry in Canada, after the service, real estate and manufacturing industries. It accounted for 8.6 % (CAD 152bn) of Canada's GDP in 2017. The mining industry (without oil and gas) had a share of 3.3 % (CAD 58.3bn) in the GDP and a share of 19 % in total exports, divided into four value-added stages (Fig. 7; MAC 2018).

The Canadian mining industry focuses on the production of concentrates and pre-products. Most exported products are pre-products, which are processed into higher value products in other parts of the world.

Around 53.4 % of all mined raw materials and their products are exported directly from Canada to the USA. Europe has a share of only approximately 21.7 %, followed by China and Japan (NRCAN 2019b). Gold, iron and steel, aluminium, copper and coal account for the largest shares in exports (NRCAN 2019b). Both Canadian and German exports could potentially increase their share in total exports to the respective other country.

Due to falling commodity prices in recent years and the associated decline in investments in the junior mining sector, the Canadian federal government has started to support a strategic partnership between associated industries in Canada (National Collaboration Strategy 2017). Furthermore, different initiatives such as the Canadian Extractive Sector Trade Strategy have been launched to boost international trade agreements and closer collaboration between stakeholders, and to enhance the focus on sustainability and green mining at the international level (Canadian Mining and Energy 2015).

The following sections will discuss the potential of different commodities and cooperation opportunities for German companies in the sector. In Canada, mining companies fall into two categories:

Junior mining companies focus on prospecting and exploring (mining) projects, so-called greenfield projects. These projects are financed by stock exchange transactions, where a large number of shares are offered and traded in the form of penny stocks. Generally, the exploration business is a high-risk business, as only 0.1 % of exploration projects will be turned into an active mine later on. Most of these exploration companies are listed on the TSXV.

Senior mining companies operate active mines that are already at the production stage. Many senior companies are also active in exploring new projects or expanding existing mines or plants in order to guarantee follow-up projects or broaden their project portfolio. The most important diffe-

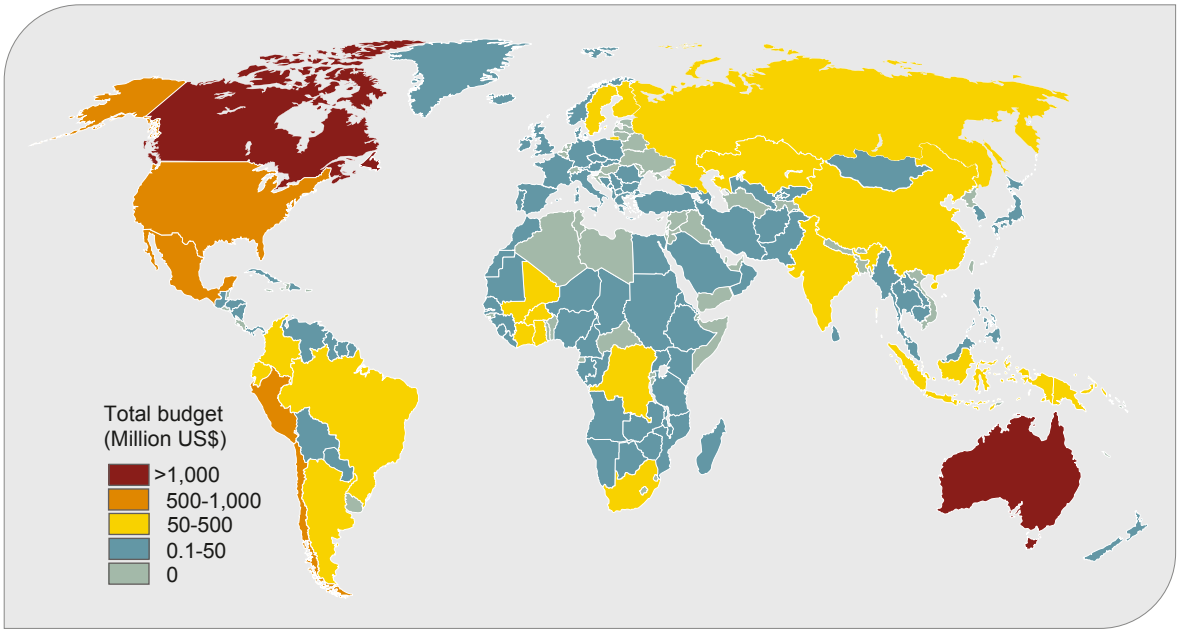


Fig. 8: Worldwide exploration budgets of non-ferrous metals. Canada has the largest budget in 2018 (according to S&P Global 2019b).

rence to the juniors is that senior companies generate money with the production of raw materials and are therefore listed as traditional stocks on the TSX.

In 2017, 13.8 % of the global exploration budget of CAD 10.4bn were invested in Canada, ranking Canada first for the 16th time in a row for destinations of capital investment (Fig. 8), followed by Australia (13.6 %) and the USA (7.7 %; S&P Global 2019b). Most exploration budgets in Canada are invested in gold projects (approximately 62 %).

In 2016, the exploration budget was around CAD 11.5bn, used mostly for the expansion of existing operating plants. Around CAD 6.8bn were used in Saskatchewan province, most of it for the final development of the Legacy project (now Bethune Mine) of the Canadian subsidiary of the German company K+S Potash. Between 2012 and 2017, the company invested around CAD 4.1bn in that project and the mine has been operating successfully since May 2017. It is the company's largest investment abroad, aimed at strategically securing the future of the company.

In 2017, Québec (21 % of the exploration budget) and Ontario (28 %) were the most important provinces for exploration projects and investments. Canada's three territories in the far north received at least 20 % of the Canadian exploration budget. That amounted to three times their share in the production value and an increased investment compared to 2016 (CAD 970m). This is a good indication of the increasing interest in the north of Canada. Although this region presents enormous challenges regarding its climate and logistics, it carries huge undeveloped resource potentials.

One reason why Canada is the centre of exploration activities are the worldwide unique financing possibilities for exploration projects, such as the so-called flow-through shares (cf. 7 Financing).

Canada's interest in investment is also expressed in the so-called Investment Attractiveness Index published every year by the Fraser Institute in the Survey of Mining Companies, which rates mining regions in terms of their investment attractiveness. In 2018, Nevada, USA, was in first place, followed by Western Australia and the Canadian provinces Saskatchewan and Québec (Fig. 9; Fraser Institute 2019). A total of four Canadian provinces and territories are in the top 10: besides Saskatchewan and Québec, there are also Yukon and the Northwest Territories (Fig. 9). Table 1 shows 12 of the top-ranked Canadian provinces and territories in a global comparison.

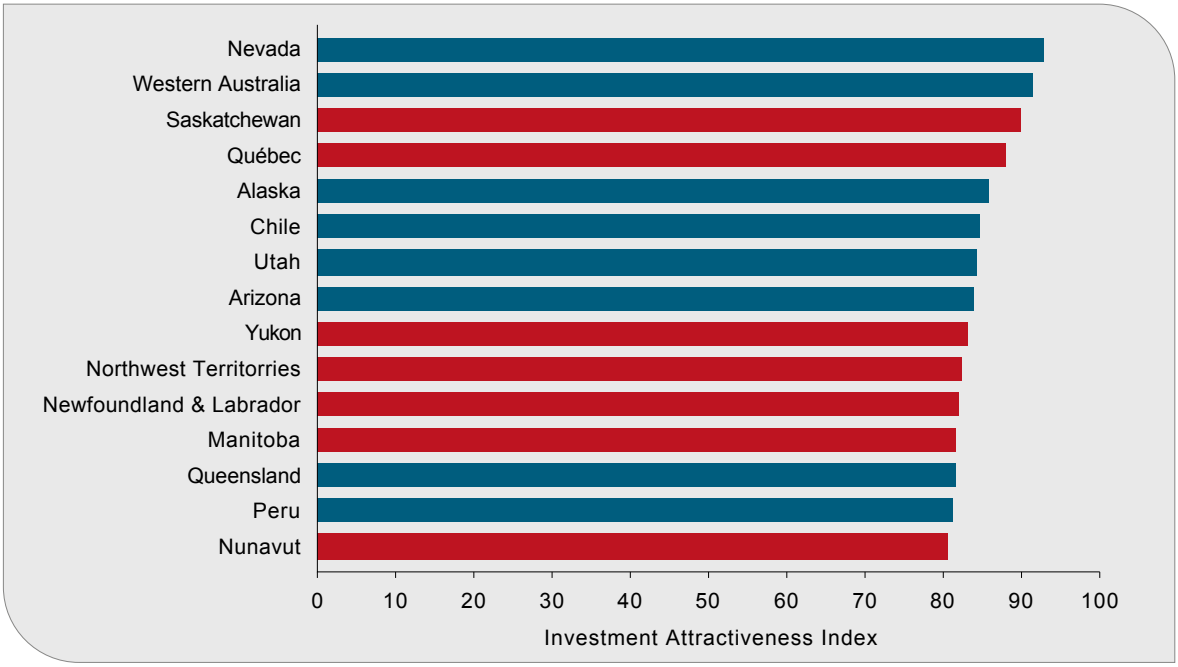


Fig. 9: Ranking of the Fraser Institute's Investment Attractiveness Index worldwide in 2018 (Fraser Institute 2018).

Tab. 1: Ranking of the Fraser Institute's Investment Attractiveness Index for the Canadian provinces in 2018 (Fraser Institute 2018).

	Rank/Number of regions evaluated				
Canada	**2018**	**2017**	**2016**	**2015**	**2014**
Alberta	51/83	49/91	47/104	34/109	28/122
British Columbia	18/83	20/91	27/104	18/109	29/122
Manitoba	12/83	18/91	2/104	19/109	5/122
New Brunswick	30/83	30/91	40/104	45/109	19/122
Newfoundland and Labrador	11/83	11/91	16/104	25/109	8/122
Northwest Territories	10/83	21/91	21/104	35/109	15/122
Nova Scotia	57/83	56/91	52/104	59/109	49/122
Nunavut	15/83	26/91	31/104	23/109	34/122
Ontario	20/83	7/91	18/104	15/109	23/122
Quebec	4/83	6/91	6/104	8/109	10/122
Saskatchewan	3/83	2/91	1/104	2/109	2/122
Yukon	9/83	13/91	15/104	12/109	6/122

Toronto Stock Exchange

Located in Toronto, the TSX-TSXV belongs to the TMX Group. It is the most important stock exchange in the world for exploration and mining, listing a total of over 1,200 companies on the TSXV and almost 200 companies on the TSX. These companies run more than 5,530 mining operations in Canada and other parts of the world, accounting for more than 25 % of the world's active mining projects and 50 % of mining companies listed worldwide (TMX Group 2019). The stock market value of these companies is in excess of CAD 250bn (PWC 2019). Most of the operations are exploration projects, of which 55 % are located in Canada. Of the 45 % outside Canada, 20 % are in South America, 11 % in the USA, 7 % in Africa and the remaining 12 % in other countries (MAC 2018). Most of the companies listed on the TSX are senior companies, which operate active mines and generate cash flow with the production of raw materials (TMX Group 2019). Junior companies are listed mostly on the TSXV and are more active in exploration. They finance their exploration activities by issuing shares to external investors. There are far fewer requirements for capital resources and the shareholding structure, so it is easier for small companies to raise the necessary money for their exploration activities. In return, they have to fulfil more regulations and publication requirements, e.g. in terms of management, audits, share allocation, financing and information policy towards their shareholders. In 2018, the companies listed on the TSX/TSXV (TMX Group 2019) raised 34 % (CAD 6.5bn) of the worldwide investment budget.

5 Raw material potential and trade

This section describes the potential of selected raw materials in Canada and trade relations between Germany and Canada. The focus here is on mineral raw materials such as cobalt, nickel, graphite and lithium, which are e.g. important for electric vehicles. Energy raw materials are also discussed.

5.1 Mineral raw materials

Planned cell manufacturing plants in Germany and Europe (Fig. 10) will lead to an increasing demand in battery raw materials. To secure the supply of these raw materials in the future, the diversification of supply sources is of major importance for German companies. Canada hosts a significant potential of many of these important raw materials, which this section describes in more detail, as well as dealing with raw materials that play an important role in the trade relations between Germany and Canada, such as iron ore. The section also discusses raw materials essential for other so-called future technologies, such as copper and aluminium.

5.1.1 Cobalt

The cobalt market is divided into two main areas of application, cobalt metal and cobalt chemicals (Fig. 11). In 2017, approximately 63 % of cobalt was used as chemicals and 37 % as metals (Al Barazi 2019). The most important field of application with approximately 46 % is in rechargeable batteries, such as lithium-ion (LIB), nickel-metal hydride (NiMH) and nickel-cadmium (NiCd) batteries. The second largest field of application is in superalloys (16 %). The cobalt requirement for LIB in electric vehicles in particular will increase significantly in the next few years (Fig. 11).

Cobalt is produced mostly as a by-product of nickel and copper mining. In 2017, worldwide cobalt mine production totalled 118,523 t (Co cont.), with 3,607 t (Co cont.) mined in Canada. Global production of refined cobalt was 116,937 t (Co cont.), of which 6,507 t (Co cont.) were produced in Canada. Canada is therefore the fourth largest producer of refined cobalt after China, Finland and Belgium. The companies Vale and Glencore mine and produce nickel-copper-cobalt concentrates from mines in Ontario (Sudbury), Québec (Raglan), as well as in Newfoundland and Labrador (Voisey's Bay). Glencore also uses secondary materials for the production of refined cobalt, some of which is imported from Germany. Germany produced 825 t of refined cobalt in the form of cobalt mattes in 2017 (DESTATIS 2019).

In total, more than 130 cobalt exploration projects are listed for Canada (S&P Global). Various mine expansions are planned, e. g. by Vale or Glencore. The most advanced cobalt projects in Canada are

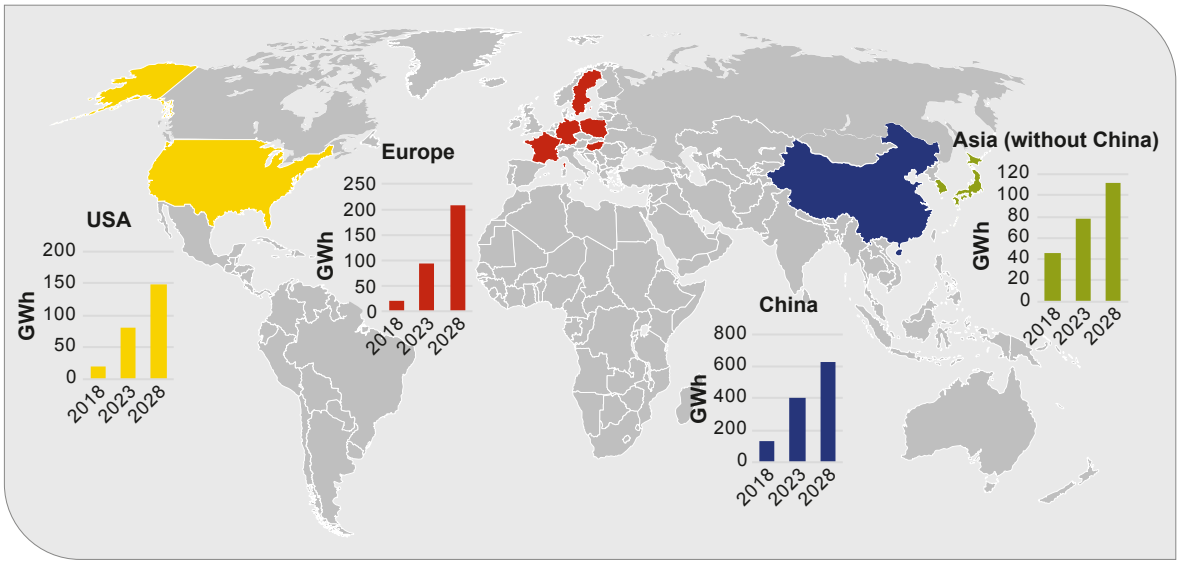


Fig. 10: Planned worldwide lithium-ion cell manufacturing plants (Infinity Lithium Corparation 2019).

summarised briefly in Table 2. Canada's cobalt mining output could increase to approximately 6,395 t (77 %) by 2026 (Al Barazi 2018).

Trade

As Germany produces only small amounts of cobalt, its economy depends on imports of cobalt. In 2017, Germany imported cobalt and cobalt products totalling EUR 179m (Fig. 12). Over 98 % of these were intermediate products such as cobalt mattes or oxides and hydroxides. The remaining 2 % included secondary pre-products such as wastes and scraps (Fig. 12). Approximately 10 % of German imports of cobalt mattes came from Canada, while the majority originated from Belgium and Finland.

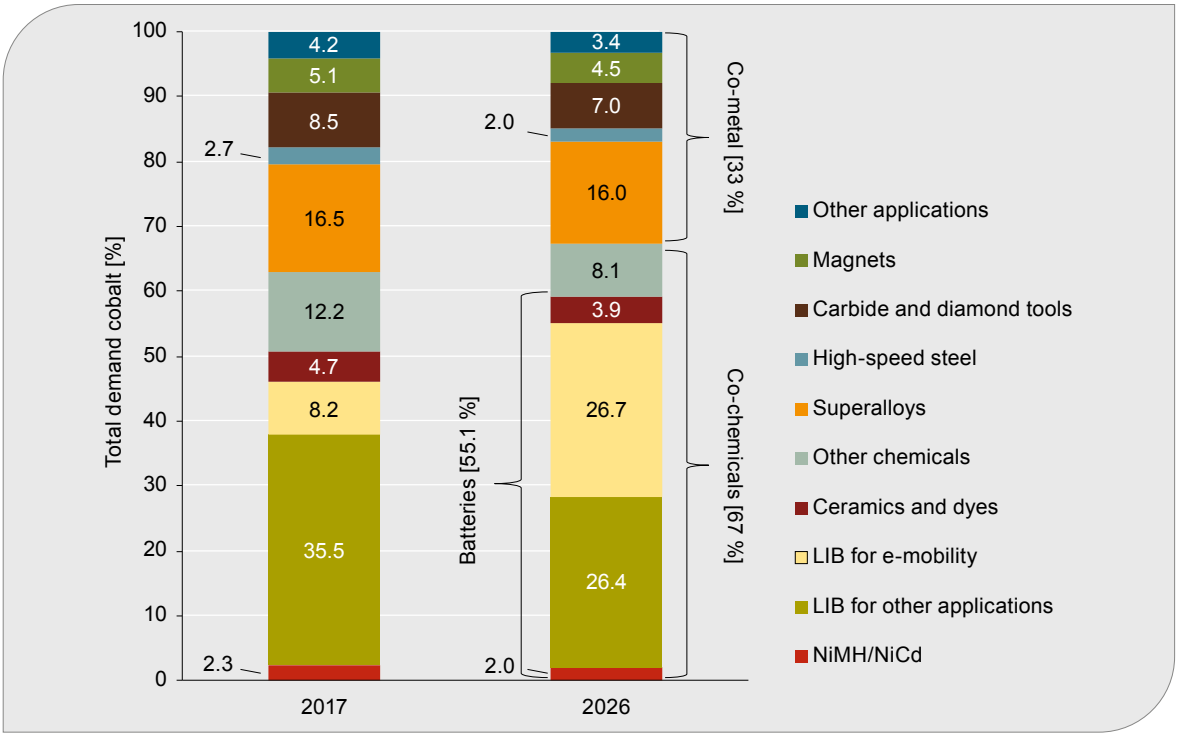


Fig. 11: Total cobalt demand by application for 2017 and 2026 (Al Barazi 2018).

Tab. 2: Overview of the most advanced cobalt projects in Canada.

Project	Owner	Project stage	Production [t Co cont./a]	Co conc. [%]	Production start	Reserves [1,000 t]	Resources [1,000 t]
Nico	Fortune Minerals Ltd.	Feasibility	300	0.110	2021	33,077	30,922
Victoria	KGHM Polska Miedz SA	Feasibility	NDA	0.05	2023	NDA	13,563
Dumont	Waterton Global Resources Mgmt, RNC Minerals, Investissement Québec	Feasibility	900	0.011	2020	1,178,600	2,933,100
Voisey's Bay	Vale SA	Under construction	2,600	0.30	2021 (ramp up)	31,000	23,000

NDA: no data available

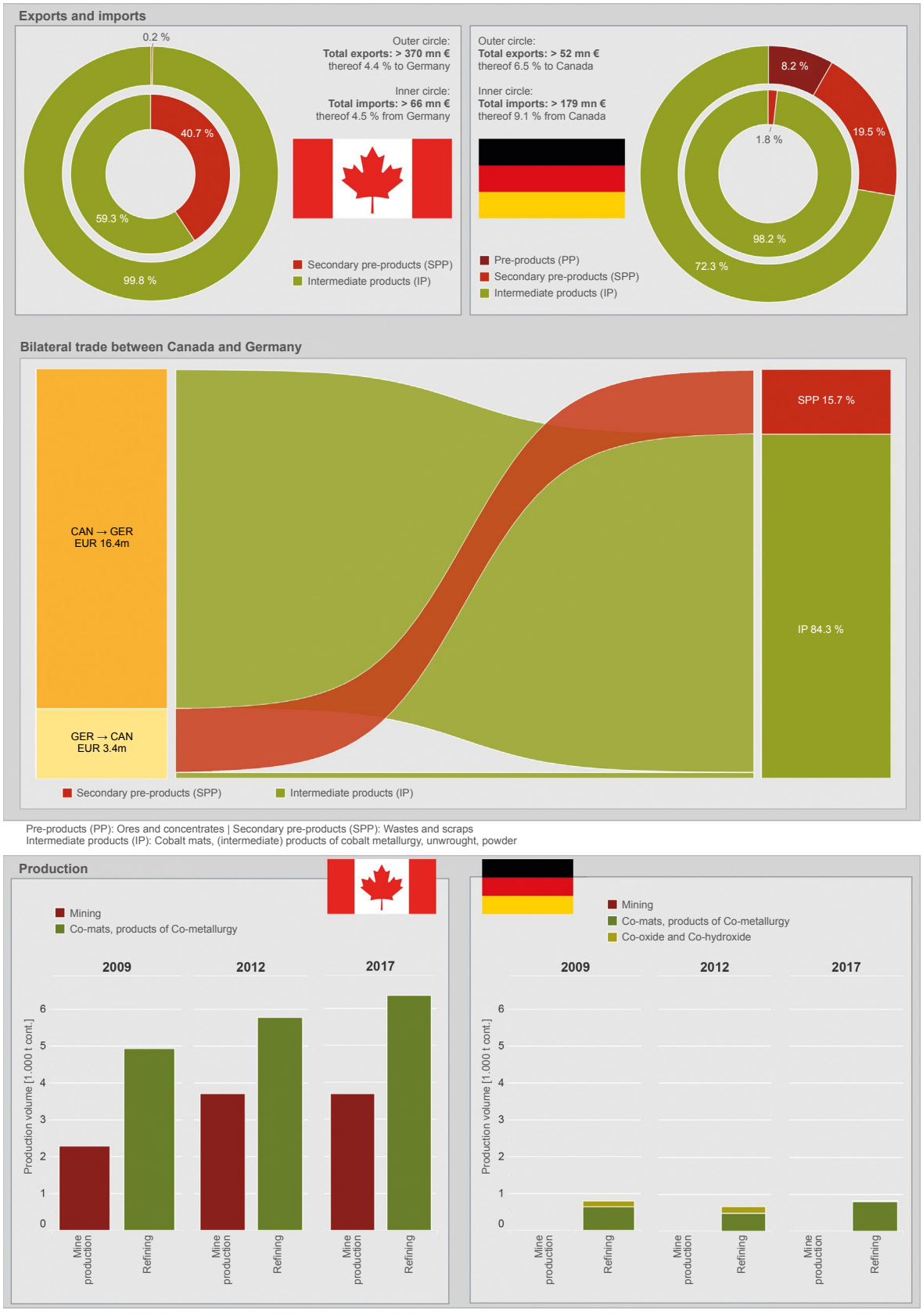


Fig. 12: Trade data for cobalt and cobalt products between Canada and Germany in 2017 (BGR 2019, IHS Markit 2019, DESTATIS 2019).

Germany exported cobalt and cobalt products totalling EUR 52m in 2017, mainly cobalt mattes and other intermediate products. Most exports went to Italy and France, only approximately 6.5 % went to Canada. However, around 42 % of the exported wastes and scraps went to Canada for recycling (BGR 2019).

Canada exported cobalt and cobalt products totalling EUR 370m in 2017, almost all of which in the form of cobalt mattes (Fig. 12). About 4.4 % of total exports were shipped to Germany; the majority went to Norway, Japan or directly to the USA (IHS Markit 2019). Glencore exported most of its intermediate products to Norway for further processing. Canada imported cobalt ores mainly from the USA, while intermediate products also came from Germany. The total value was around EUR 66m (Fig. 12).

Looking at the trade balance between Germany and Canada, the total value of imports and exports

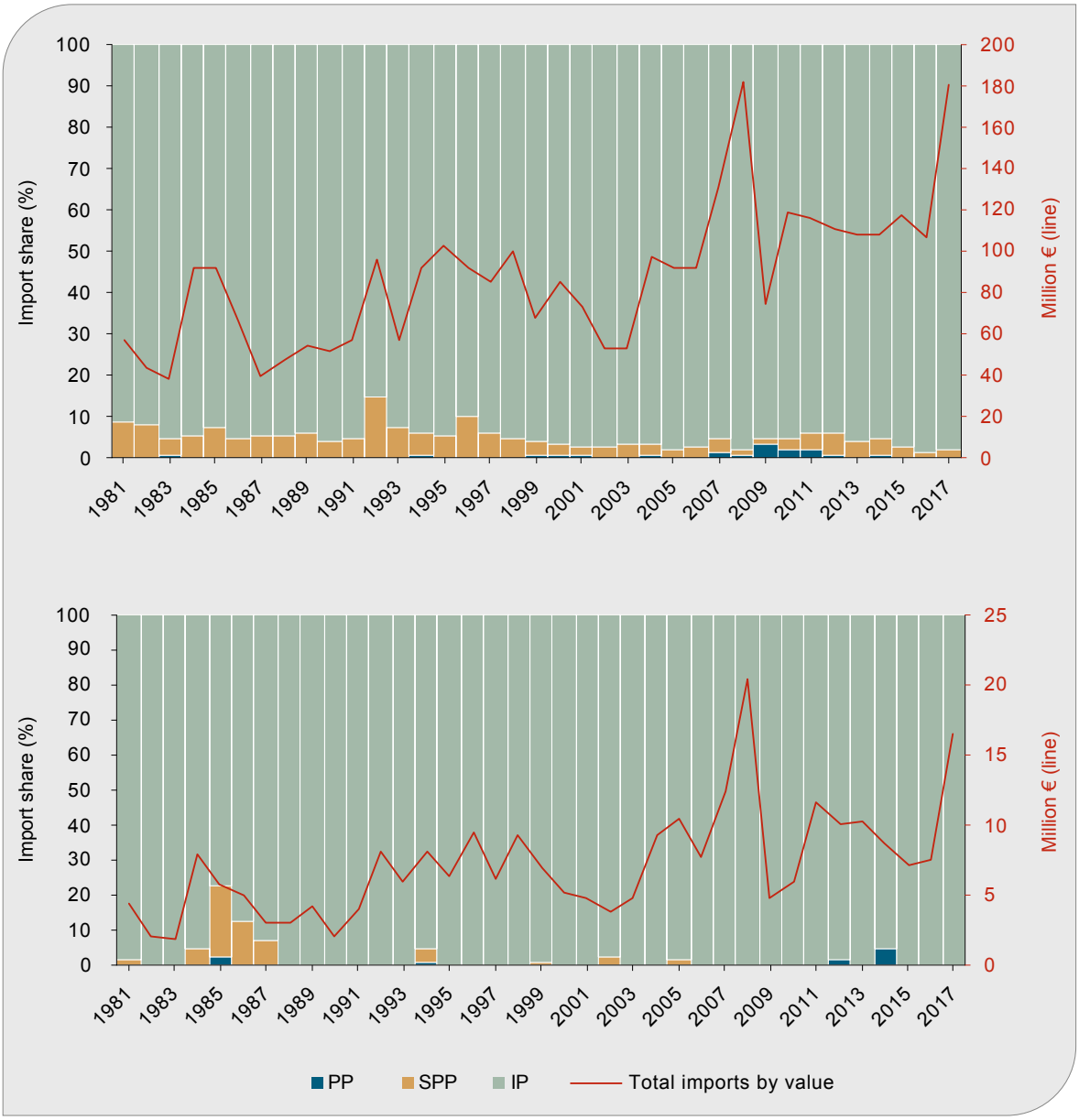


Fig. 13: Germany's total imports of pre-products (PP; ores and concentrates), secondary pre-products (SPP; wastes and scraps) and intermediate products (IP; cobalt mattes, unwrought cobalt, powder) of cobalt (top) and imports of cobalt from Canada (bottom) from 1981 to 2017 (BGR 2019).

between the two countries was around EUR 20m. The cobalt products that went from Canada to Germany, comprising only of intermediate products, accounted for the largest part by far (EUR 16.4m). Cobalt products exported from Germany to Canada were worth around EUR 4m and consisted almost entirely of secondary pre-products (wastes and scraps; Fig. 12).

In the last 35 years, the value of imports of cobalt pre-products and intermediate products to Germany has almost tripled overall. While the import of pre-products (ores and concentrates) and secondary pre-products (wastes and scraps) has remained roughly constant, the import of intermediate products (cobalt mattes, etc.) has increased significantly (Fig. 13, top).

A similar picture emerges for imports from Canada. In the past few decades, hardly any pre-products have been imported, while the import of intermediate products has roughly quadrupled (Fig. 13, bottom).

5.1.2 Nickel

Nickel is an important metal for the steel industry, with around 70 % of the nickel produced worldwide used to produce stainless steels. Furthermore, it is needed for the production of alloys, together with other metals such as copper, or as a coating material. Around 3 % of nickel is currently used for the production of batteries (Nickel Institute 2019). Depending on how successful the substitution of nickel in LIB will be, demand could increase significantly over the next years, especially for class 1 nickel.

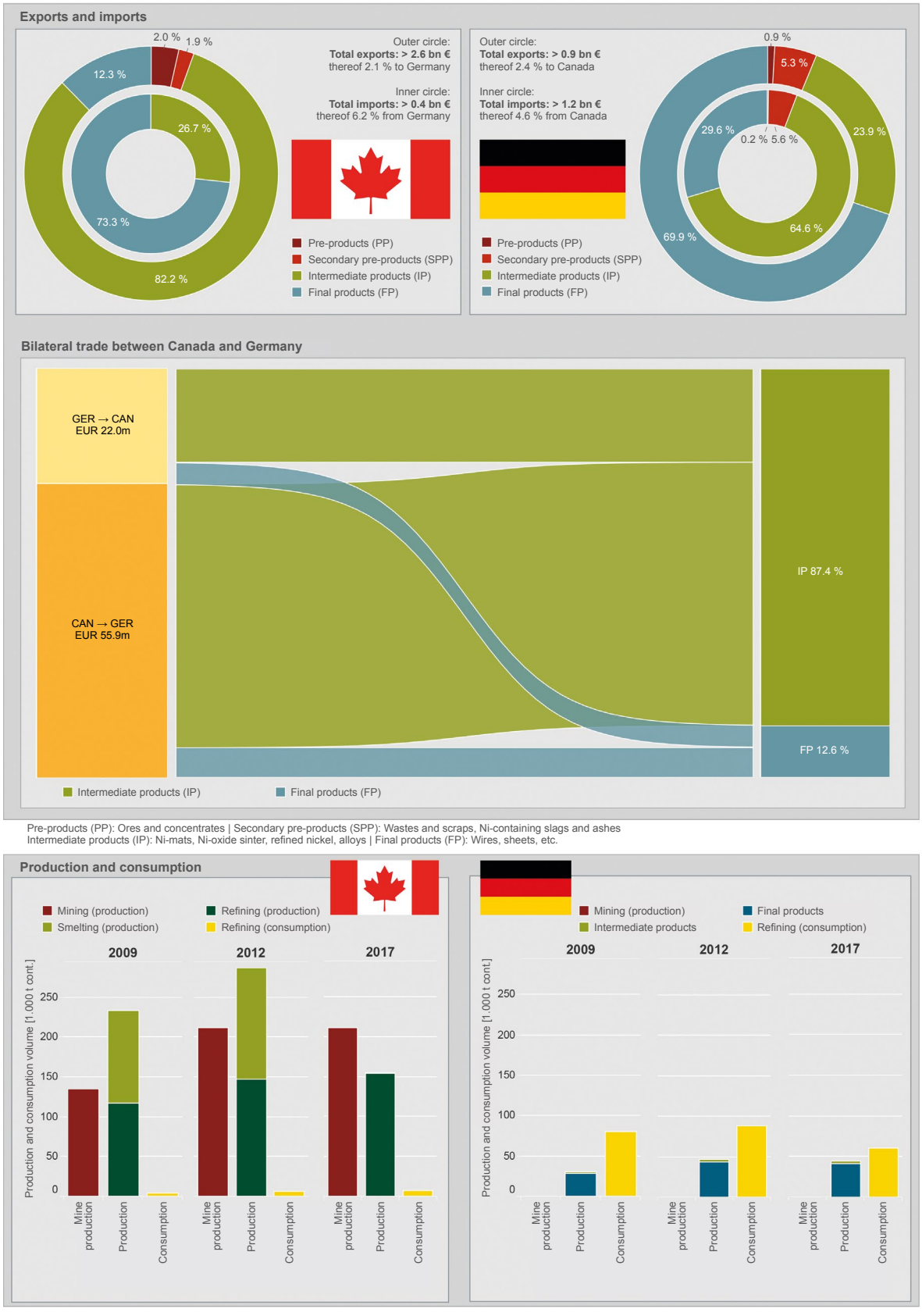
Canada is the fourth largest nickel producer in the world. In 2017, the country had an output of 214,000 t of Ni cont. Most of the nickel is used for the production of class 1 nickel exclusively. Canada ranked fifth in the production of refined nickel in 2017, with 154,200 t (BGR 2019). The main producers in Canada are Vale S.A., with its mines of the Ontario and Manitoba divisions and Voisey's Bay; Glencore Plc, with its Fraser, Nickel Rim South and Raglan mines; and Sherritt for metal production. Vale and Glencore are planning to expand their current operations in Sudbury (Copper Cliff South and Nickel Rim South respectively). Vale is also planning expansions at Voisey's Bay. Projects that promise a feasible production start are listed in Table 3.

While Germany did not mine any nickel in 2017, it produced 50,000 t of intermediate and final products of nickel such as mattes, oxides and hydroxides, alloys, wires or sheets (Fig. 14).

Tab. 3: Overview of the most advanced nickel projects in Canada.

Project	Owner	Project stage	Ore production [t/a]	Ni conc. [%]	Production start	Reserves [1,000 t]	Resources [1,000 t]
Dumont	RNC Minerals, Waterton Global Resources Mgmt, Investissement Québec	Feasibility	19,176,000	0.27	2020	1,178,600	2,933,100
Eagles Nest	Noront Resources Ltd.	Feasibility completed	NDA	1.68	2022	11,131	21,581
Victoria	KGHM Polska	Feasibility	NDA	2.70	2023	NDA	13,563
Voisey's Bay	Vale SA	Under construction	NDA	2.20	2021 (ramp up)	31,000	23,000

NDA: no data available



Pre-products (PP): Ores and concentrates | Secondary pre-products (SPP): Wastes and scraps, Ni-containing slags and ashes
Intermediate products (IP): Ni-mats, Ni-oxide sinter, refined nickel, alloys | Final products (FP): Wires, sheets, etc.

Fig. 14: Trade data for nickel and nickel products between Canada and Germany from 2017 (BGR 2019, IHS MARKIT, DESTATIS 2019); no data available for smeltting production 2017 at the time of publication.

Trade

In 2017, Germany imported nickel and nickel products totalling EUR 1.23bn, mainly intermediate and final products (refined nickel, alloys, wires, etc.; Fig. 14). 4.6 % of nickel imports originated from Canada, including mainly refined nickel. More detailed definitions of pre-products, intermediate and final products are shown in Fig. 14.

Germany's nickel exports had a value of EUR 0,92bn in 2017 and included mainly final products. 2.4 % of nickel exports went from Germany to Canada, mainly in the form of nickel mattes (Fig. 14).

Total Canadian nickel imports had a value of EUR 0.4bn (Fig. 14); three quarters of these were in the form of final products, mostly imported from the USA (GTIA 2019).

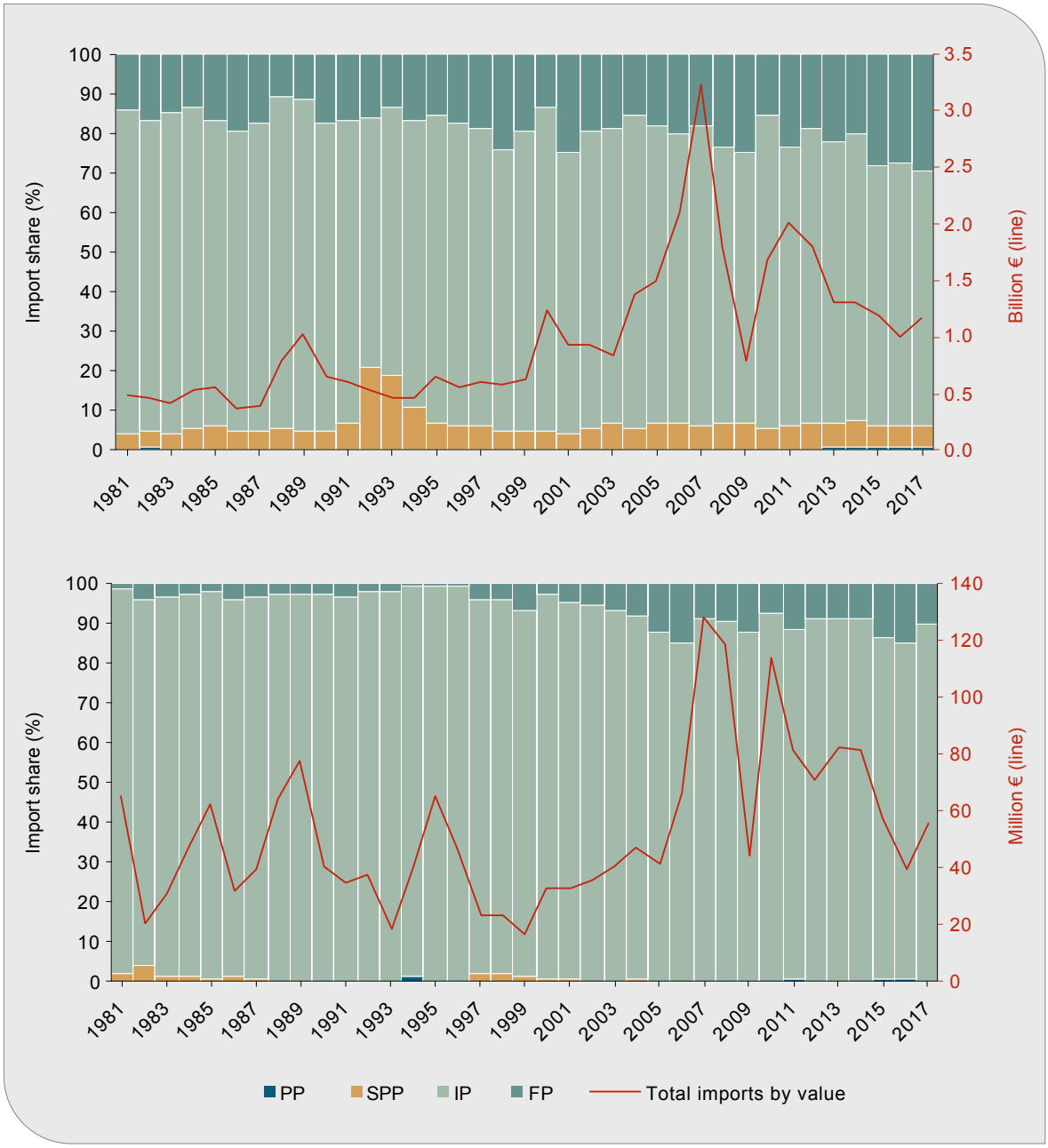


Fig. 15: Germany's total imports of pre-products (PP; ores and concentrates), secondary pre-products (SPP; wastes and scraps), intermediate products (IP; nickel mattes, refined nickel, alloys, etc.) and final products (FP; wires, sheets, strips, etc.) of nickel (top) and imports of nickel from Canada (bottom) from 1981 to 2017 (BGR 2019).

Canadian exports of nickel and nickel products in 2017 were worth EUR 2.6bn in total and took primarily the form of intermediate products (Fig. 14). As with cobalt, they mainly went to Norway for further processing, to the USA and to China. Only about 2.1 % of Canadian exports went to Germany.

The overall trade balance of imports and exports of nickel between Germany and Canada was approximately EUR 77m, consisting of 87 % intermediate products and 12 % final products (Fig. 14). Of these, intermediate and final products worth EUR 55m went from Canada to Germany, with EUR 22m going the other way (Fig. 14). Pre-products do not appear in these bilateral statistics.

A look at German nickel imports over the past 35 years shows that the share of pre-products (PP; ores and concentrates) and secondary products (SPP; wastes, scraps, ashes) in total imports has risen slightly in the last few years (Fig. 15, top). The value of imports of intermediate products (IP; nickel mattes, nickel oxide sinter, alloys, nickel sulphates and oxides/hydroxides and refined nickel) and final products (FP; sheets, strips, wires, rods and powder) has roughly doubled (Fig. 15, top).

After many fluctuations, the value of imports of intermediate and final products from Canada has also roughly doubled since the early 1980s (Fig. 15, bottom).

5.1.3 Graphite

The worldwide graphite market is divided into natural graphite and synthetic graphite. The main application for the entire graphite market, currently around 31 %, is for electrodes used in the aluminium and steel industries. However, only synthetic graphite can be used for this. Natural graphite is mined worldwide in the form of either flake graphite or amorphous graphite. The respective areas of application require different specifications of the final product. Natural graphite is used mainly in the refractory industry, with a share of 19 % in the overall (synthetic and natural) graphite market and of 45 % in the natural graphite market (DERA 2019). Other areas of applications include foundry products (14 %), lubricants, carburising agents, friction linings (together around 25 %) and batteries (15 %; BGR 2019). In the future, the largest driver of graphite demand will be rechargeable batteries, which use graphite as an anode material. Applications for electric vehicles in particular will have an increasing impact on demand in the future.

Graphite is mined mainly in open pits. In 2017, around 1.4m t of natural graphite were mined worldwide. The share of flake graphite was around 60 %. With approximately 30,000 t of graphite, Canada is currently one of the most important producers of flake graphite after China, Brazil and India (BGR 2019). The production of synthetic graphite in Canada was suspended in 2014. Increasing exploration activities in East Africa led to the commissioning of a new graphite mine in Mozambique in 2018. With an annual production of 100,000 t, the country has become the third largest graphite producer in the world after China and Brazil (USGS 2019).

The well-known Canadian graphite deposits are mainly located in the provinces of Ontario and Québec, with some also in Manitoba and British Columbia. The two main producers of graphite in Canada are Imerys and Eagle Graphite. The exact production figures of Eagle Graphite are unknown due to uneven production. However, it is assumed that the company is responsible for less than 20 % of total production in Canada (BGR 2019).

Almost all graphite mines and graphite projects described in the 2011 study (DERA 2011) have been completely closed or temporarily stopped. Only Bissett Creek, which is considered one of the largest flake graphite deposits in North America, is still active. The company Northern Graphite announced that production would begin in 2020 (S&P Global 2019). While numerous other mining projects for the production of flake graphite are known, only a few are already at the feasibility stage (Table 4).

The graphite produced in Canada is of a high quality and generally suitable for the production of batteries. Downsides are the relatively high operating costs, the remote locations, especially in the north of Canada, and the poor connection to the infrastructure. Having said that, the expansion of the infrastructure, especially in the remote northern areas, is an inherent part of the Canadian Minerals and Metals Plan and should be prioritised in the future (CMMP 2019).

Tab. 4: Overview of the most advanced graphite projects in Canada (S&P Global 2019a; NRCAN 2018; Nouveau Monde Graphite 2019).

Project	Owner	Project stage	Production concentrate [t/a]	Cg conc. in reserves [%]	Production start	Reserves [1,000 t]	Resources [1,000 t]
Matawinie	Nouveau Monde Graphite Inc.	Feasibility completed	100,000	4.35	2022	59,800	95,500
Bissett Creek	Northern Graphite Corp.	Feasibility completed	44,200	2.06	2020	28,300	65,529
Lac Guéret	Mason Graphite Inc.	Feasibility completed	51,900	27.77	2020	4,741	78,604
Lac Knife	Focus Graphite Inc.	Feasibility completed	44,300	15.13	NDA	7,857	6,543

NDA: no data available

Production at the Black Crystal mine operated by Eagle Graphite is uneven, running only a few months a year (as mentioned above). However, the company plans to switch production to colloidal graphite, which is used to produce LIB (BGR 2019). In addition to the successful mining of graphite, many of the projects also work on pilot plants for the production of colloidal graphite.

Trade

AMG Graphite GK operates the only active graphite mine in Germany. Its annual production rate is less than 1,000 t. Germany is one of the world's most important exporters and importers of graphite and is therefore largely dependent on imports of graphite. In total, Germany imported graphite and products worth EUR 108m in 2017, of which only about 0.2 % came from Canada, while more than 50 % came from China. Synthetic graphite made up the largest share of graphite imports, accounting for around 62 % of total imports (Fig. 16). From Canada, Germany imported mainly flake graphite, principally from the province of Québec (NRCAN 2018, Statistics Canada 2018).

The value of German imports of graphite products has doubled since 1997, but the shares of natural and synthetic graphite have remained constant. Natural graphite accounts for around 35 % of total imports and synthetic graphite for 65 % (Fig. 16).

Around 6.6 % of Germany's total exports of graphite products went to Canada, primarily colloidal and semi-colloidal graphite. These were mainly exported to the province of British Columbia (NRCAN 2018; Statistics Canada 2018). Most German graphite was exported to other European countries, especially to France, Poland, the Czech Republic, Austria and, outside Europe, to South Korea (BGR 2019).

Canada processes most of the graphite mined domestically directly on-site into a concentrate of up to 99 % C. Only a small amount is exported as ore. In 2017, Canada exported graphite products worth EUR 27m in total, mainly flake graphite and graphite powders (IHS Markit 2019), accounting for around 60 % of total exports with a value of approximately EUR 16m.

In addition to its Lac-des-Îles graphite mine and the Terrebonne processing plant in Québec, the French company Imerys owns a graphite mine in Switzerland. Therefore, part of the graphite mined in Canada is exported to Switzerland for further processing. Most Canadian graphite, around 80 %, however, is exported to the USA (BGR 2019).

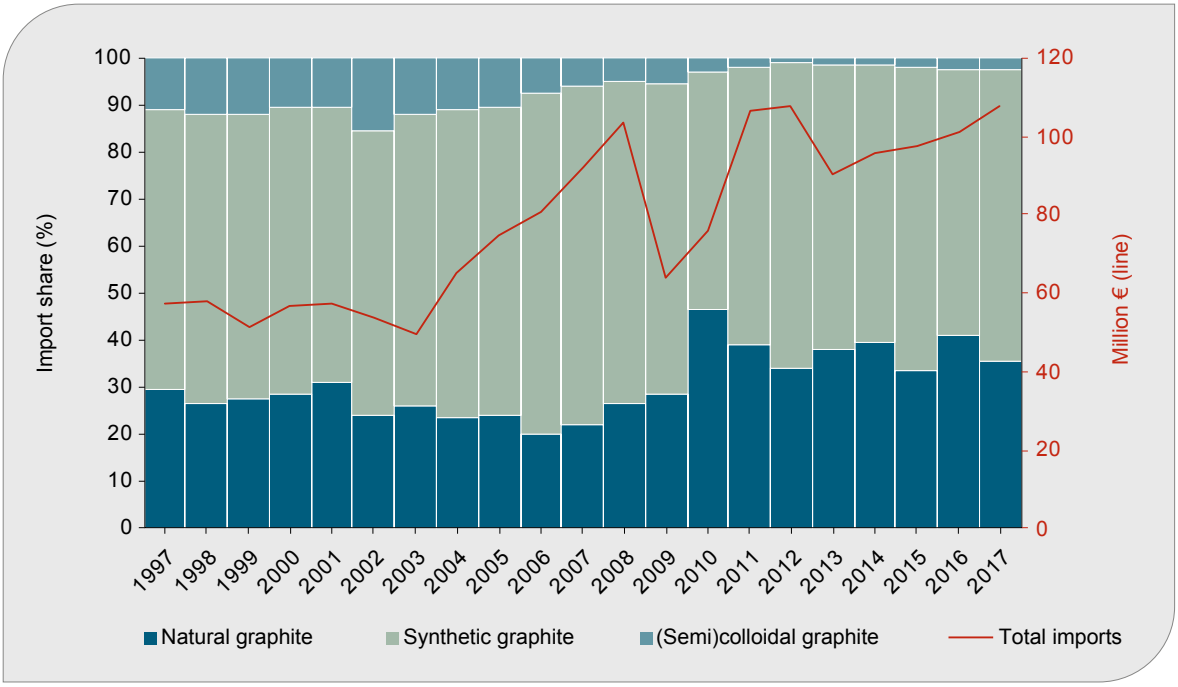


Fig. 16: Germany's total imports of natural, (semi)colloidal and synthetic graphite (IHS Markit 2019).

In 2017, Canada imported around 30,000 – 40,000 t of graphite to convert it to a higher quality product (BGR 2919). The majority of the imported graphite came from China and the USA (IHS Markit 2019).

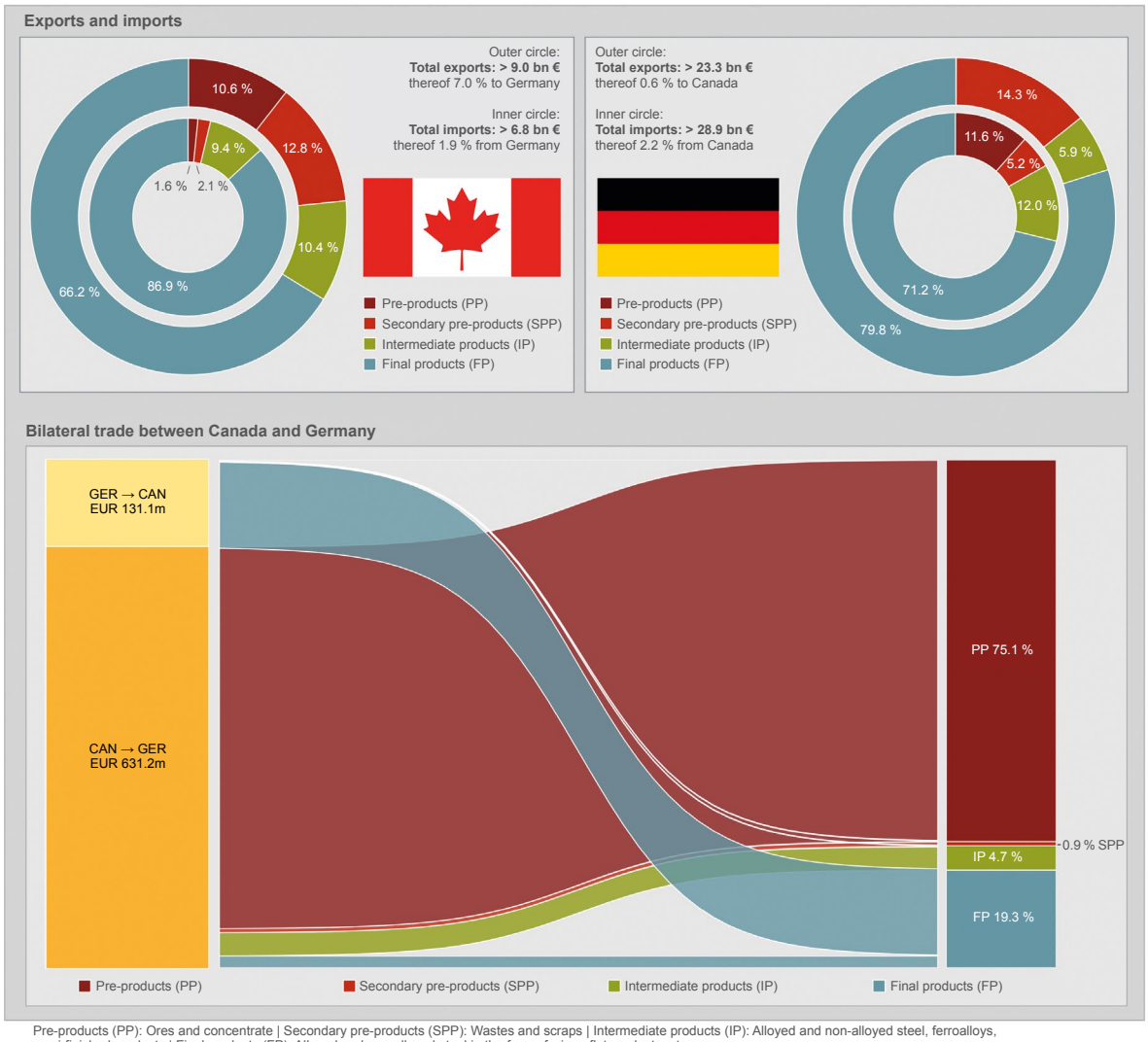
5.1.4 Iron ore

Iron is the most important metal used in the steel industry, with around 98 % of iron ore mined worldwide destined for this industry (NRCAN 2019b). As the world's seventh largest steel producer, Germany is dependent on iron ore imports, some of which are from Canada. The main iron ore producers in the world are Australia, Brazil and China. Total worldwide production in 2017 was 230m t (Fe cont.). Canada contributed 50m t, approximately 2.2 % of global production, and ranks in 9th place in a worldwide comparison. A total of 51 % of Canadian iron ore was mined in Québec, 44 % in Newfoundland and Labrador, and 5 % in Nunavut. The production of crude steel was around 13.6m t in 2017 (NRCAN

Tab. 5: Overview of the most advanced iron ore projects in Canada.

Project	Owner	Project stage	Production ore [m t/a]	Mn conc. [%]	Fe conc. [%]	Production start	Reserves [1,000 t]	Resources [1,000 t]
Roche Bay	Advanced Explorations Inc.	Feasibility	20	0.061	26.25	NDA	314,802	344,598
Scully	Tacora Resources Inc.	Feasibiltiy completed	17	2.58	34.83	NDA	443,673	971,383
Kamistiatusset	Alderon Iron Ore Corp.	Feasibility completed	22.9	NDA	28.80	NDA	668,500	1,797,100

NDA: no data available



Pre-products (PP): Ores and concentrate | Secondary pre-products (SPP): Wastes and scraps | Intermediate products (IP): Alloyed and non-alloyed steel, ferroalloys, semi-finished products | Final products (FP): Alloyed and non-alloyed steel in the form of wires, flat products, etc.

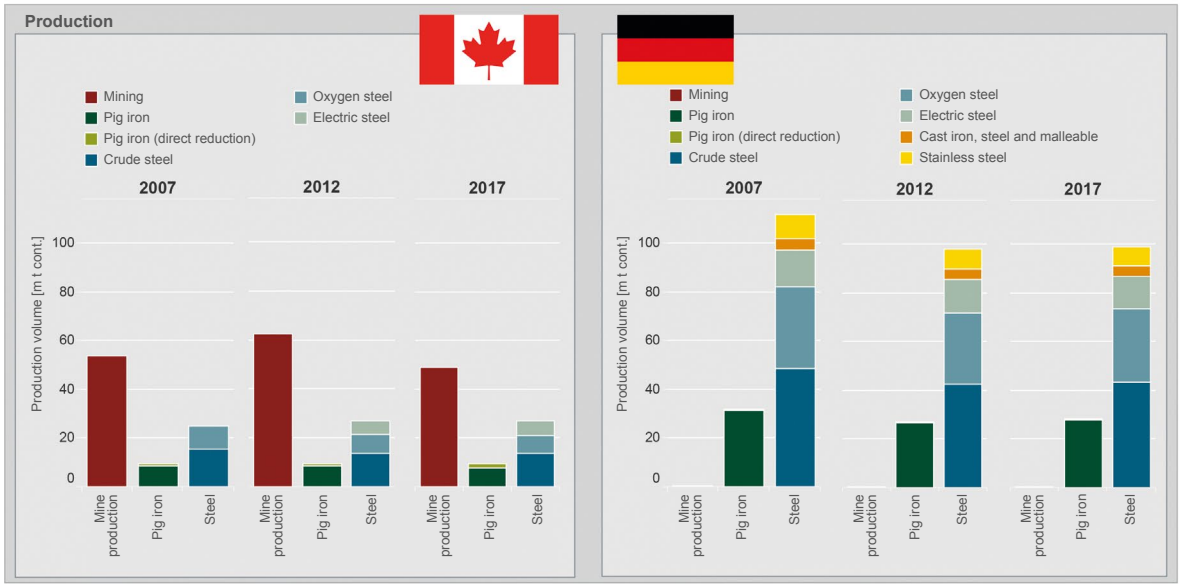


Fig. 17: Trade data of iron and iron products between Canada and Germany in 2017 (BGR 2019, IHS Markit 2019).

2019); this has changed only slightly in the past ten years, as has the production of pig iron (Fig. 17). Germany produced 27.8m t of pig iron and 43.6m t of crude steel in 2017. There is no domestic mining of iron ore for steel production (Fig. 17).

The Canadian iron ore projects listed in Table 5 are all at the feasibility stage or have completed the feasibility study. Manganese deposits in Canada are exclusively linked to large iron ore deposits. Because of the very low manganese content, the ore does not meet the requirements of the steel industry and is therefore of little interest to the German economy. The manganese concentrations found in the iron ore deposits are nonetheless listed in Table 5.

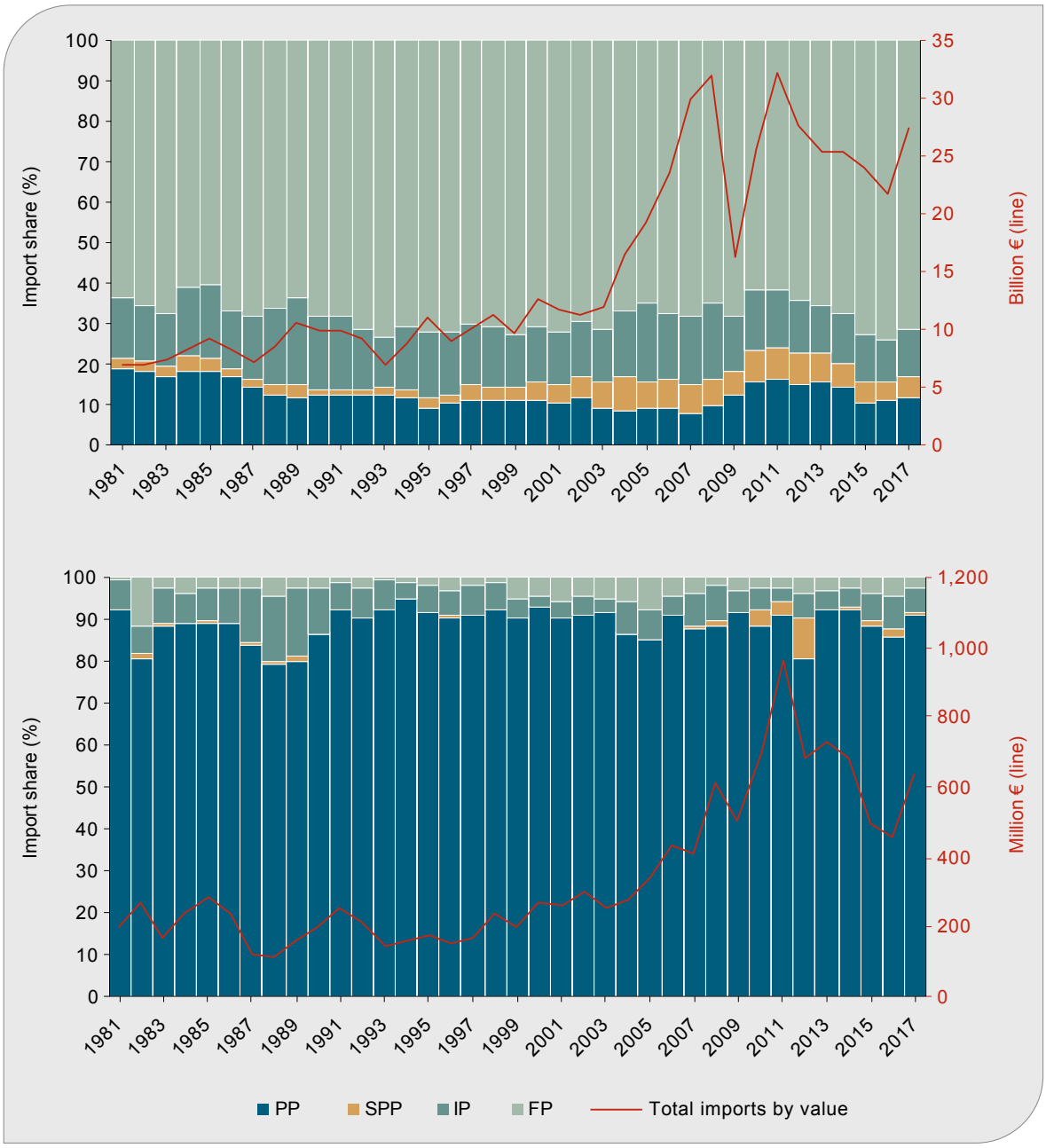


Fig. 18: Germany's total imports of pre-products (PP; ores and concentrates), secondary pre-products (SPP; wastes and scraps), intermediate products (IP; alloyed and non-alloyed steels, ferroalloys, semi-finished products, etc.) and final products (FP; steels in the form of wires, flat products, etc.) of iron (top) and imports of iron from Canada (bottom) from 1981 to 2017 (BGR 2019).

Trade

In order to produce the volumes of steel mentioned above, Germany is dependent on imports of iron ore and its products. In 2017, Germany imported iron ore and its products worth EUR 28.9bn in total. In addition to ores and concentrates, imports include ferroalloys, wastes and scraps, and especially steel in the form of wires, etc. Only 2.2 % of total imports came from Canada, with ores and concentrates, ferroalloys, as well as alloyed and non-alloyed steel accounting for the largest share (Fig. 17). Iron ore and pig iron were primarily imported from Brazil.

Germany exported iron ore and its products worth EUR 23.3bn in 2017. Most of this was exported to Europe, with only 0.6 % going to Canada.

Canada exported iron ore and its products worth EUR 9bn in 2017, mainly iron and steel, slags, and oxides and hydroxides. The main destinations were the USA, China and Japan. Canadian imports amounted to around EUR 6.8bn and mainly consisted of final products, such as steel in the form of wires, etc. (Fig. 17).

The total value of iron products traded between Germany and Canada was about EUR 760m (Fig. 17). The largest part, about 75 %, were pre-products such as ores and concentrates, mainly exported from Canada to Germany. Alloyed and non-alloyed steels and ferroalloys, which accounted for about 5 % of the total, went in the same direction. Around 20 % of the total trade was made up of final products such as steel in the form of wires, etc., which were almost exclusively exported from Germany to Canada (Fig. 17).

The total value of German iron and steel imports has increased about fourfold since 1981. Final products such as wires, steel, powders or slags represent the largest share (Fig. 18, top). The respective shares of pre-products, secondary pre-products, intermediate and final products remained roughly constant in the period under consideration (Fig. 18, top).

Compared to worldwide imports, mainly of final products, imports from Canada consist largely of pre-products. Not much has changed in recent decades (Fig. 18, bottom). In absolute terms, the share of final products has increased slightly (Fig. 18, bottom), but it has decreased somewhat in relation to the preliminary products (Fig. 18, bottom).

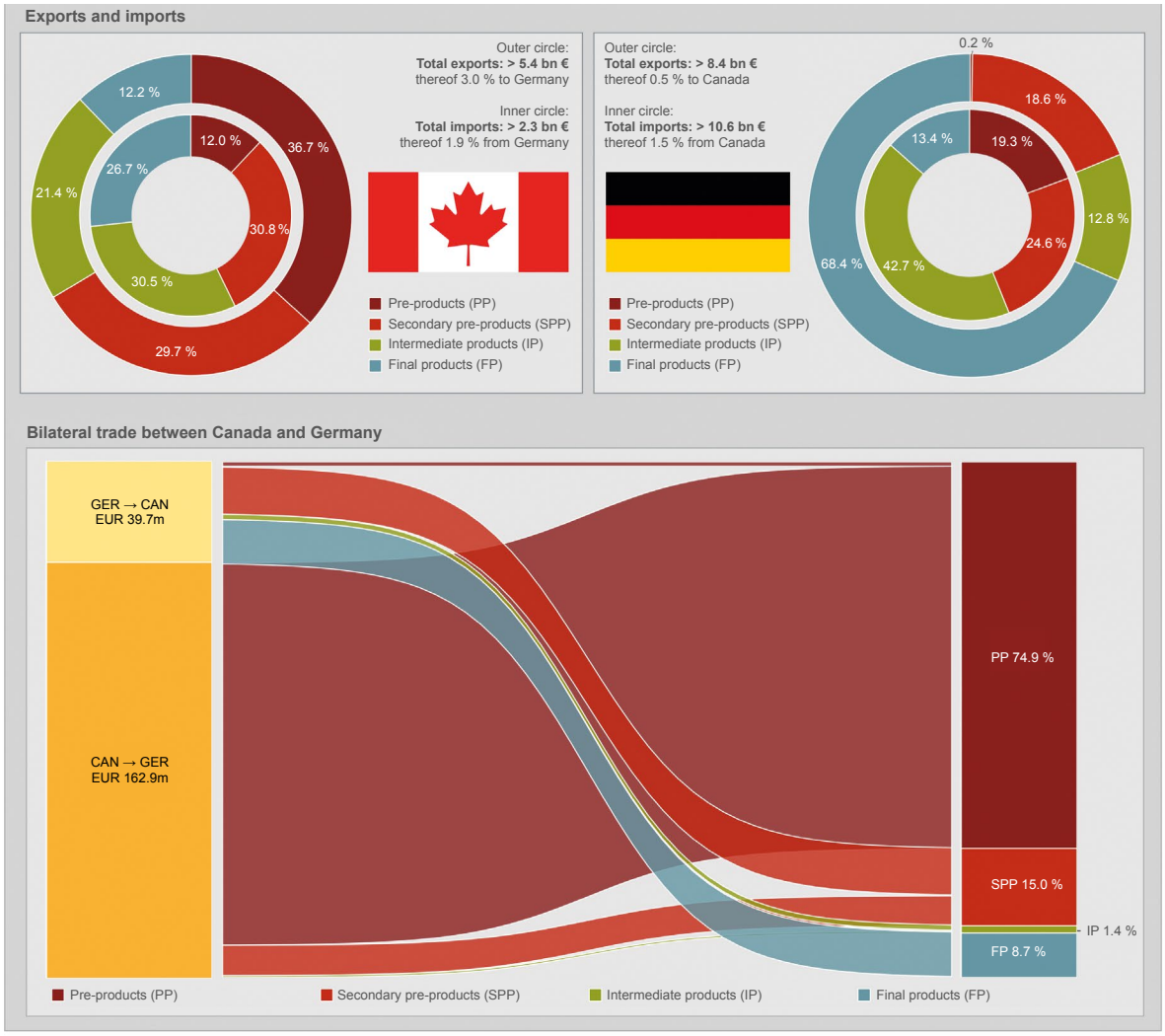
5.1.5 Copper

The main application for copper is in the electrical industry. In Germany, approximately 57 % of copper is used in the electrical and cable industry. The construction sector is a second important field of application (15 %), followed by the automotive industry (9 %; DERA 2019b).

Tab. 6: Overview of the most advanced copper projects in Canada.

Project	Owner	Project stage	Production Cu concentrate [t/a]	Cu conc. in reserves [%]	Project start	Reserves [1,000 t]	Resources [1,000 t]
Ajax	KGHM Polska Miedz SA	Feasibility completed	NDA	0.29	2018	426,000	171,000
Kemess North	Centerra Gold Inc.	Feasibility completed	19,000	0.266	2021	107,381	337,519
Morrison	Pacific Booker Minerals Inc.	Feasibility completed	NDA	0.33	NDA	224,251	39,142
Casino	Western Copper & Gold Corp.	Pre-production	NDA	0.18	2024	1,122,661	1,776,000

NDA: no data available



Pre-products (PP): Ores and concentrates | Secondary pre-products (SPP): Wastes and scraps | Intermediate products (IP): Refined products, etc. | Final products (FP): Wires, pipes, etc.

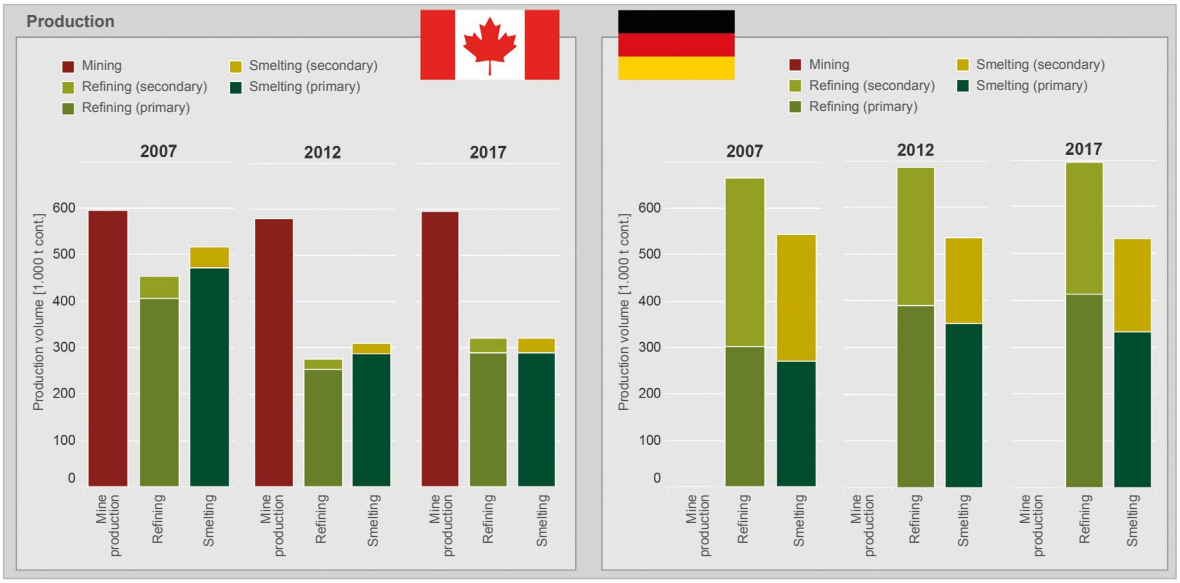


Fig. 19: Trade data of copper and copper products between Canada and Germany in 2017 (BGR 2019, IHS Markit 2019).

In 2017, around 20m t of copper were mined worldwide, including 605,000 t in Canada, which therefore ranks 12th in a global comparison. Approximately 50 % of the copper was produced in British Columbia, followed by Ontario, and Newfoundland and Labrador. With a production of 330,000 t of refined copper, Canada was ranked 18th worldwide (NRCAN 2019b).

There are currently 30 active mines and a variety of copper projects at different stages of exploration in Canada. Table 6 shows a brief overview of the mining projects for copper in Canada that currently look most promising.

Trade

Germany has no domestic mine production of copper and is therefore completely dependent on imports of copper ores and concentrates. Although, in 2017, Germany produced 694,000 t of refined copper, its production of pure copper and other copper products, including copper from recycling, does not cover domestic demand.

Germany imported 1.25m t of copper ores and concentrates worth EUR 1.9bn in 2017, mainly from Peru and Chile (25 % each), and also from Brazil (19 %). Total imports of copper and its products, including ores and concentrates, refined copper and all other copper products, had a value of EUR 10.6bn (BGR 2019). Only 1.5 % of these came from Canada (Fig. 19). Germany's copper exports were around EUR 8.4bn, of which about 0.5 % went to Canada.

Canada's total copper exports were EUR 5.44bn in 2017, mainly ores and concentrates as well as refined copper. More than 90 % of the refined copper were exported from Canada to the USA, while only 3 % of total exports went to Germany (Fig. 19). The total value of copper imports was approximately EUR 2.3bn. 75 % of Canadian imports, mostly ores and concentrates as well as wastes and scraps, came from the United States, while only 1.9 % came from Germany (Fig. 19).

The bilateral trade in copper products between Canada and Germany totalled around EUR 202m. Copper products worth EUR 160m went from Canada to Germany and products worth EUR 40m from Germany to Canada. 75 % of exports from Canada to Germany were in the form of pre-products (ores and concentrates; Fig. 19); 15 % were secondary products (wastes and scraps), which were exported in roughly equal proportions from Germany to Canada and from Canada to Germany (Fig. 19). Intermediate and final copper products, which were exported almost exclusively from Germany to Canada, accounted for about 10 % of the total trade balance between Germany and Canada (Fig. 19).

In 1981, pre-products and secondary pre-products had accounted for approximately 30 %, and intermediate and final products for 70 % of German imports of copper and copper products, in terms of their monetary value. By 2017, this ratio had shifted towards 40 %–60 %. The total value of German copper imports has roughly tripled since 2003 (Fig. 20, top).

This development is reflected more clearly in German copper imports from Canada. Before 1997, these consisted mainly of intermediate and final products (85 %). Since 1998, however, more than 80 % of imports from Canada have consisted of pre-products (Fig. 20, bottom). The total value of imports from Canada has tripled in the past three decades, except for the period 1994–2004, where they fell to a minimum (Fig. 20, bottom). Given the small quantities imported from Canada, it is difficult to determine precisely whether these imports came from other countries instead. A possible curtailment of copper production in Canada at the time is unlikely to have been the cause, since copper production, despite small fluctuations since 1980, has always been constant at around 600,000 t (Fig. 19; BGR 2019).

The value of imports from Canada rose sharply after 2004 and stagnated from 2012. However, as mentioned above, there has been a shift to pre-products and secondary products such as ores and concentrates, as well as wastes and scraps (Fig. 20, bottom).

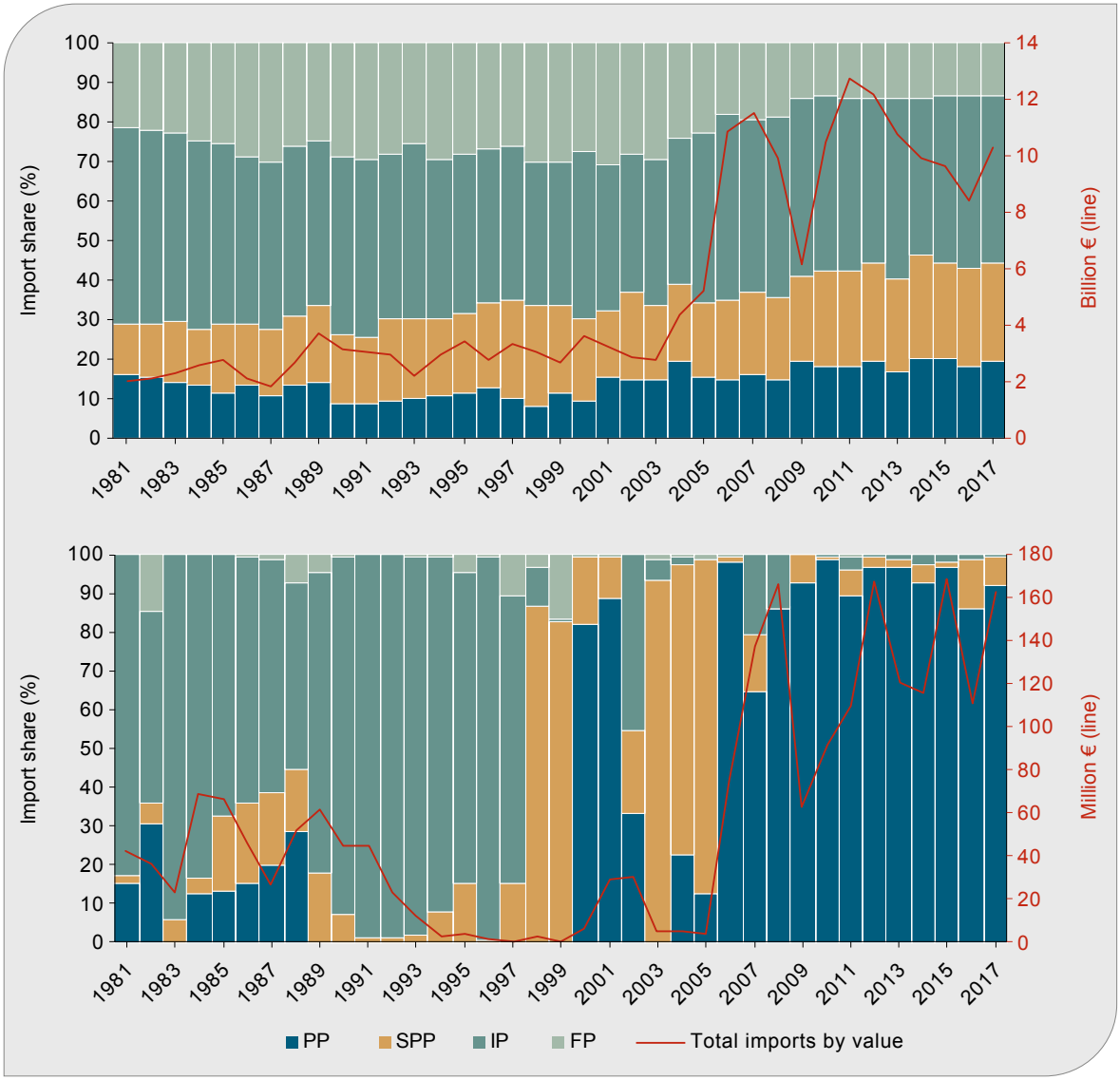


Fig. 20: Germany's total imports of pre-products (PP; ores and concentrates), secondary pre-products(SPP; wastes and scraps), intermediate products (IP; refined copper, etc.) and final products (FP; wires, pipes, etc.) of copper (top) and imports of copper from Canada (bottom) from 1981 to 2017 (BGR 2019).

5.1.6 Aluminium

With a production of 3.2m t of aluminium (5 % of world production) in 2017, Canada can be ranked third in a global comparison (Fig. 4). Aluminium production takes place mainly in Québec, although one aluminium smelter is located in British Columbia. Energy for the production of aluminium is generated by hydropower in Canada, which has the smallest CO_2 footprint in the world for aluminium production. It has the fifth lowest production costs after Saudi Arabia, Qatar, Iceland and Norway (NRCAN 2019b).

5.1.7 Potash

Canada produced 20.3m t of potash in 2017, making it the largest potash producer in the world, followed by Russia, Belarus and China. In 2017, worldwide potash production was 67.9m t. The largest Canadian deposits are located in Saskatchewan. The country also has the world's most important potash reserves of 23 % (4.2bn t). Potash Corporation of Saskatchewan is the largest producer of potash in the world and operates several mines in Saskatchewan and New Brunswick, as well as many projects that are at various stages of exploration.

Since May 2017, K+S AG has been one of the major potash producers in Canada with its Bethune Mine. Canada is also the largest exporter of potash worldwide, having exported around 19m t of potash in 2017, or 36 % of total global exports (NRCAN 2019b).

As Germany itself produces sufficient amounts of potash for its own needs, Canada is not the most important trading partner for Germany in this area. However, there could be some bilateral trade, because Germany produces to different specifications than Canada. For example, the potash produced in Canada has significantly higher K_2O concentrations than the German product, which has been shown to have significant magnesium sulphate contents instead. German production of potassium sulphate is therefore important for agriculture and industrial salts.

In 2017, both Germany and Canada supplied the US market (12 % of German and 55 % of Canadian exports) and the Chinese market (3.5 % of German and 10 % of Canadian exports; IHS Markit 2019). Apart from that, German exports were mainly limited to Europe and Australia. Canada, on the other hand, exported potash not only to the USA and China but also to Brazil and the Asian region (India, Indonesia, Thailand, Vietnam; IHS Markit 2019).

5.1.8 Lithium

Due to the rise in demand for raw materials for electric vehicles, lithium projects are playing an increasingly important role and Canada continues to expand its lithium potential. Although current projects in Canada cannot compete with the large lithium producers in Chile or Australia, Canada can contribute to some diversification of the supply with its annual production of a few million tons. Canadian deposits are primarily located in Québec and Ontario. The most advanced projects are the Whabouchi project operated by Nemaska Lithium, and North American Lithium operated by Contemporary Amperex Technology. Both projects are at the pre-production stage. Numerous other projects are currently at the feasibility or pre-feasibility stage. The most important information about these projects is summarised in Table 7.

5.1.9 Rare earth elements

Canada is not currently a producer of rare earth elements (REE), although 20 out of 63 advanced REE exploration projects worldwide are located in Canada. Many deposits in Canada have a high content of heavy REE (NRCAN 2019b), with at least six of the advanced projects having a 20 % share of heavy REE in the total REE content (Table 8).

Tab. 7: Overview of the most important Canadian lithium projects (Schmidt 2017).

Project	Owner	Project stage	Production [t/a Li cont.]	Li conc. in reserves/ resources [%]	Project start	Reserves/ Resources [m t]
Whabouchi	Nemaska Lithium Inc.	Pre-production	33,000	1.28/1.57	2019	36.6/6.7
Rose/ Eastmain	Critical Elements Corporation	Feasibility	6,500	0.85/1.35	2020	26.8/7.9
Separation Rapids	Avalon Advances Materials	Pre-Feasibility	22,500	1.40/1.41	2021	NDA/0.06
North American Lithium	Contemporary Amperex Technology	Pre-production	20,000	0.85/1.20	2019	20.3/47
James Bay	Galaxy Resources Ltd.	Feasibility	NDA	NDA/1.40	NDA	NDA/0.13

NDA: no data available

Tab. 8: Overview of the most important REE projects in Canada with more than 20 % HREE (NRCAN 2019b).

Project	Owner	Production REE [t/a]	Share of heavy REE [%]	Project start
Buckton	DNI Metals	NDA	24	2020
Foxtrot	Search Minerals	10,000	21	2020
Nechalacho	Avalon Advances Materials	10,000	28	2020
Kipawa	Matamec	6,000	36	2020
Strange Lake	Torngat	11,500	47	2020
Grand-Vallée	Orbite Aluminae	1,000	20	2020

NDA: no data available

5.1.10 Chromite

Canada has no significant chromite mining at present, but chromite deposits are currently explored in the so-called Ring of Fire, located 240 km west of James Bay in Northern Ontario and covering an area of approximately 5,000 km². With the chrome reserves discovered in this area, Canada can become an important chromite and ferrochrome producer. This is certainly the reason why more than 35 mining companies have been registered in the Ring of Fire since 2011.

5.1.11 Other mineral raw materials

Since the present study cannot cover every single raw material, it focuses on some raw materials. Other raw materials of which Canada is an important producer are summarised in Table 9.

5.2 Energy raw materials

Canada is an important producer of energy raw materials such as oil and gas, coal and nuclear

Tab. 9: Canadian production of selected raw materials in 2017 (BGR 2019, USGS 2019, NRCAN 2018).

Mineral	Production	Unit	Volume (Canada)	Total volume (world)	Share in total volume [%]	Rank
Niobium	Mine production	t cont.	6,981	69,100	10.10	2
Diamonds	Mine production	m carats	23.2	150.9	15.4	2
Titanium	Mine production	t TiO_2	880,000	5,540,000	15.88	4
Sulphur	Mine production	1,000 t	5,464	79,842	6.84	4
Platinum	Mine production	kg cont.	9,500	199,000	4.77	4
Palladium	Mine production	kg cont.	17,000	225,000	7.56	3
Gold	Mine production	kg cont.	172,877	3,230,000	5.35	5
Rock salt	Mine production	1,000 t	11,250	281,103	4.00	5
Bismuth	Mine production	t	25	16,900	0.15	7
Molybdenum	Mine production	t cont.	5,290	297,000	1.78	8
Zinc	Mine production	1,000 t cont.	344	12,500	2.75	8
Tellurium	Refined production	kg cont.	49,000	470,000	10.43	2
Zinc	Refined production	1,000 t cont.	598	13,214	4.53	4
Cadmium	Refined production	t Inh.	1,802	25,400	7.09	4

fuels. Their potential in Canada is discussed in more detail in the following section.

5.2.1 Crude oil

Canada has conventional crude oil reserves of around 565m t. However, at around 26bn t, the reserves of non-conventional crude oil from oil sands are of far greater importance. In addition, the country has an estimated 68m t of shale oil reserves. Canada holds the largest crude oil reserves in the world after Venezuela and Saudi Arabia (BGR 2019a). With an annual production of 224m t of crude oil in 2017, the country is the fifth largest producer of crude oil in the world. Around 70 % of total production come from the oil sands that are located in the province of Alberta. Most of the country's conventional crude oil reservoirs are also found in this area, with others located in Saskatchewan and off the coast of Newfoundland and Labrador (NRCAN 2019b).

Oil sands production in Canada started in 1967. In 2000, the production of crude oil from oil sands was around 35m t, and in 2017 it was already 156m t. Around 55 % of the crude oil from oil sands is extracted using in-situ techniques, the remaining 45 % from open pits. Due to its high density and viscosity, the oil or bitumen obtained from oil sands has comparatively unfavourable properties and has be processed into so-called syncrude (NRCAN 2019b).

About 80 % of crude oil production are exported, almost exclusively to the USA. In recent years, Canada has made efforts to diversify its oil exports to emerging Asian countries. As production volumes have increased significantly over the last years, the pipeline infrastructure for transport is reaching its capacity limits. As a result, more oil has to be transported by rail. Crude oil and its products represented around 15 % of total Canadian exports in 2016.

Canada's oil pipeline network is well developed, both nationally and to the USA. The eastern part of the United States with Chicago and Detroit is particularly well connected, but also distant areas such as Wyoming and Oklahoma in the centre of the USA. As oil sands production is expanding, new pipeline projects are being planned. Canada's oil sector is privately owned. There are a large number of Canadian corporations such as Suncor, the largest Canadian oil producer and leading gas producer. In addition, US and Chinese oil companies in particular are involved in the Canadian production of crude oil and processing, either through the purchase of or participation in companies or via the direct acquisition of licences (CAPP 2019).

Canada has 14 refineries; three of them are located in Alberta, while the other refineries are on the west coast and especially in the more densely populated eastern parts of the country. With a share of almost 40 % of primary energy consumption, petroleum is the most important energy source in the country.

5.2.2 Gas

Canada is the fourth largest producer of natural gas in the world. In addition to conventional natural gas reservoirs, the country can rely on significant amounts of non-conventional reservoirs of shale gas, tight gas and coal seam gas.

Natural gas reserves in Canada amounted to around 2,040bn m^3 in 2017 (17th place and 1 % of the world share) and resources are estimated at around 34,201bn m^3 (4th place and 5.4 % of the world share; BGR 2019a).

Canada produced 176bn m^3 of natural gas in 2017. The vast majority comes from the Western Canadian Basin, particularly Alberta (two thirds of Canadian production) and British Columbia. A small percentage of natural gas production originates from Canada's only current offshore fields off the coast of Nova Scotia in the Atlantic Ocean. Significant amounts of natural gas are also expected off the Pacific coast of Canada, but their exploration has been prevented by moratoriums since 1972.

The production of natural gas from conventional reservoirs is declining due to the gradual depletion of the reservoirs, resulting in the increasing extraction of natural gas from tight gas reservoirs. Furthermore, Canada has been the second country in the world to successfully explore shale gas reservoirs, which can be found in the western part of the country. It is estimated that tight gas and shale gas together will account for around 80 % of production in 2035. However, the development and use of shale gas reservoirs is controversial in

Canada, as it is in Germany, particularly because of the use of hydraulic stimulation ("fracking"). Moratoriums are in place in some provinces in the eastern part of the country.

The Canadian natural gas market is closely connected to the US market. In 2017, over 50 % of Canadian natural gas production went to the USA, Canada's only export destination for natural gas. The existing pipeline networks supply natural gas from sources in western Canada primarily to consumers along the American west coast and in the Midwest. Eastern Canada with its industrial centres in Ontario and Québec, on the other hand, obtains natural gas from the United States and via trans-Canadian pipelines as well as via a liquefied natural gas (LNG) loading terminal on the Atlantic coast. The share of imports from the United States has increased because of shale gas production in the northeast of the United States, which provides a greater supply with shorter transport routes. In this light and due to increasing demand in Ontario and Québec, trans-Canadian pipeline transport capacities have been expanded for several years now (NRCAN 2019b). Overall, the shale gas boom in the United States has led to a greater supply of natural gas on the North American market in the past decade and, as a result, to significantly lower natural gas prices. Against this background, Canada is striving to open up further sales markets for natural gas. Especially in the west of the country, numerous loading terminals for LNG are planned, to open up the Asian region as a market via the Pacific. None, however, is under construction as yet.

5.2.3 Coal

Canada is one of the major countries for coal in the world. It held 0.6 % of the world's hard coal reserves in 2017 (4.35bn t), ranking it 12th in the world. Hard coal resources are estimated at around 183bn t (7th place and 1 % of world share). Canada's mine production for hard coal was 52m t (11th place and 0.8 % of world share) with a consumption of 29m t (18th place and 0.4 % of world share). Canada exported 31m t of hard coal, mainly to Asia, of which around 90 % was coking coal. Canadian imports, primarily from the USA, amounted to 7.5m t (NRCAN 2019b).

Coking coal accounts for a large share of hard coal production and exports. In 2017, around half of Canada's hard coal mining was coking coal (26.9m t). Almost all of Canada's coking coal production is exported, making it the world's third largest coking coal exporter (around 9 % of world share) after Australia and the United States. Germany imported a total of around 12.9m t of coking coal for the production of pig iron and the steel industry. Around 1.5m t of coking coal came from Canada.

Canada hosted 2.2bn t of lignite reserves in 2017 (19th place and 0.7 % of world share) and 118bn t of resources (9th place and 2.7 % of world share). Its production of lignite amounted to 9.2m t (18th place and 0.9 % of world share). Coal deposits are mainly located in the western provinces of British Columbia, Alberta and Saskatchewan. There are currently 19 active coal mines (open pits) in Canada (NRCAN 2019c).

The majority of Canada's total coal consumption is used for power supply. In Saskatchewan, a 120 MW unit of the SaskPower-owned Boundary Dam lignite plant has been equipped with CO_2 capture technology (oxy-fuel process). Using this technology, 1m t of CO_2 per year have been captured since 2014. The CO_2 is transported via pipeline to the Weyburn oilfield to be reinjected. This helps boost oil recovery rates and thus also the profitability of the CO_2 capture and storage (CCS) project.

Canada is a member of the international Powering Past Coal Alliance and, like Germany, is planning to phase out fossil fuels by 2030. However, exceptions will probably be made for power plants that use the technology for capturing CO_2 and storing their carbon dioxide emissions (PPCA 2019).

5.2.4 Nuclear fuel

Imports of uranium to Germany will fall significantly in the coming years, because of Germany's nuclear phase-out. Nevertheless, the topic of nuclear fuel is briefly mentioned in this study because Canada is one of the leading uranium producers in the world, together with Australia and Kazakhstan. It currently hosts 18 % (228,000 t) of global uranium reserves (2nd largest in the world).

Canada's uranium resources totalled 1.46m t in 2017 (2nd place and 13 % of world share). Uranium production was 13,000 t in 2017 (2nd place and

22 % of world share; BGR 2019). All active uranium mines with the largest deposits in the world are located in the Athabasca Basin in Saskatchewan. McArthur River and Cigar Lake are the two largest and most productive mines in the world. In a global comparison, they have very high contents of uranium, at up to 15 %. The main producers in Canada include the Canadian company Cameco, the French company Orano (formerly Areva), and the Canadian-Russian company Uranium One. More than 80 % of Canadian uranium are exported worldwide (also to Germany). Because of stagnating global uranium demand, which goes hand in hand with low spot market prices, many mines around the globe are scaling down or temporarily ceasing production, including the market-dominating mines in Canada (McArthur River, Key Lake, McClean Lake, Rabbit Lake). Scaling down production is intended to reduce the large quantities of uranium currently on the world market. Nevertheless, numerous uranium exploration projects in Canada are still ongoing.

Canada has 19 nuclear reactors (18 in Ontario and one in New Brunswick), which cover around 15 % of the country's electricity demand. Nuclear energy is considered relatively "clean" energy in Canada and has a promising future. In the next 15 years, Canada will invest around CAD 25bn (around EUR 16.5bn) into the modernisation of existing reactors. The country plays a dominant role globally in nuclear research and development in the fields of reactor systems and medicine. The most important export goods are its CANDU reactors (CANada Deuterium Uranium) developed by the federal Crown corporation Atomic Energy of Canada Limited (AECL). Thirty-one CANDU reactors are currently in operation in seven countries.

6 Demand for technologies

The following section outlines the demand for technologies to maintain and develop Canada's industry, particularly the mining and exploration sectors.

In addition to the trends in wind and solar power outlined in section 6.1, there are connected and partially overlapping sectors in which the Canadian mining industry is promoting environmentally friendly practices and developments at an academic, political and economic level. As mentioned earlier, Germany has a good reputation and is a valued business partner with its high-quality products and services (see section 4). The sections below give some examples of opportunities for cooperation between German and Canadian companies at different levels.

6.1 Renewable energy in mining

Renewable energy plays an important role in Canada's energy supply. With the use of around 100m TOE, tons of oil equivalent, of renewable energies (17 % of Canada's primary energy consumption) in 2017, Canada is one of the top five consumer countries in the world. Around 66 % of Canadian electricity was generated from renewable sources, compared to only 36.2 % in Germany. Around 98,600 MW of installed capacity in Canada are currently available for electricity generation from renewable sources (6th place, 5 % of world share). The main energy source is hydropower, of which Canada is in fact the second largest producer worldwide. But biomass and "modern" renewable energies, such as wind and (less so) solar power, are also gaining importance in the electricity sector. Their current share is already around 7 %. The expansion of wind power in particular is being pushed ahead. In addition to electricity generation, renewable energies are used primarily in the heating sector in the form of biomass (wood, wood pellets). Around 5 % of Canadian households use only wood for heating.

The International Energy Agency (IEA) has determined that the global energy sector must undergo a fundamental transformation in order to be able to counteract climate change in the long term. This means that the share of renewable energies in the total capacity must increase from 15 % in 2015 to 65 % in 2050, so as to achieve the long-term climate goals (IEA 2017). This necessary transition is currently being implemented, with individual political strategies of the participating countries pushing ahead with measures at different intensities (IEA 2016). The IEA expects an increase of 825 gigawatts (GW) or 42 % for the renewable energy industry between 2015 and 2021 (IEA 2016).

As the demand for solar cells is increasing, so is the demand for the metals and raw materials required for their production and for an expansion of the infrastructure, in particular copper (Clean-energy Canada 2017). This is both a challenge and an opportunity, especially for the Canadian mining industry, which can provide a considerable proportion of the raw materials for this transformation. In 2017, the global solar industry fed 94 GW more power into the grid than in the previous year. That is equivalent to over 65 % of the capacity of the entire Canadian network (Statcan 2019). A new record was thus set, since the solar industry has expanded considerably in recent years. A life cycle analysis carried out by Environment Canada and Natural Resources Canada shows that solar photovoltaic (PV) technologies have fewer negative environmental impacts than fossil fuels (Government of Canada 2012). No greenhouse gases or other pollutants are released during normal operation of solar power systems. The energy payback time (EPBT) has decreased significantly in recent years, to around one year at present. Small amounts of heavy metals and other chemicals such as cadmium and lead are produced during the manufacturing of PV cells, but this effect can be reduced if recycling materials are used or if the cells are recycled as well. Furthermore, water use in connection with solar energy is minimal. On the other hand, the installation of solar cells still requires considerable space. But this negative effect can be compensated by the use of wasteland or, with respect to the mining industry, the use of dumps etc.

For Canadian mining, these developments offer opportunities at two levels. Firstly, the opportunity to export the raw materials required for the implementation of environmentally friendly energy generation internationally. And secondly, at the operational level, they offer mining companies the chance to equip their own mines with wind and solar technologies for energy production, thus promoting more environmentally friendly mining of the required raw materials.

Canada's mining industry sets good examples here, concentrating its efforts in the Towards Sustainable Mining (TSM) programme. Participating members of the Mining Association of Canada (MAC) present the use of best practice guidelines and reporting protocols to various stakeholders on an annual basis. Participation in the TSM programme is mandatory for MAC members for their operations in Canada. It lets companies manage risks, measure results, and enable progress in three key areas. These core areas are communities and people, energy, and the environment (MAC 2019). Objectives include successful cooperation with local interest groups, offering employees a safe and healthy workplace, minimising negative effects on the environment, reducing greenhouse gas emissions, and improving energy efficiency. The companies evaluate themselves annually using a series of reports. The assessment takes place at company level. The final report is sent to the MAC and eventually published.

MAC is the first industry association in the world to have its members' performance assessed externally. MAC honours members who stand out for their commitment to the community or to the environment with an Excellence Award (MAC 2019). The industry-wide recognition of this award offers companies an additional incentive to comply with the guidelines set out in this initiative. Consequently, environmental protection and investments in climate-neutral and environmentally friendly processes and machines have a high priority at the participating companies, especially at management and strategic levels.

Other associations have already adopted the TSM programme, both in Canada and worldwide. British Columbia and Québec are about to follow the example of the TSM programme, and it is also increasingly attracting interest internationally. The Finnish Mining Association, the Cámara Argentina de Empresarios Mineros (CAEM), the Botswana Chamber of Mines, and now also the Chamber of Mines of the Philippines (COMP) have implemented or are, at the time of publication of this study, about to implement the TSM programme. COMP is the first Asian mining association to adopt TSM and the fourth association in less than two years (CISION 2017). In September 2019, the Instituto Brasileiro de Mineração (IBRAM), the national mining association in Brazil, announced that it would adopt the TSM initiative, in view of the mining disasters in recent years (IM 2019).

The TSM programme is binding only for members of the Mining Association of Canada, but MAC membership is generally not mandatory for mining companies in Canada. However, in order to ensure a nationwide quality standard with regard to sustainability in the mining industry, binding industry-wide regulations are desirable.

In addition to Canadian legislators, industry has also recognised that renewable energy solutions are gaining importance in Canadian mining. The focus here is clearly on wind and solar power and only to a much smaller extent on hydroelectric power, which is used more in other industries. Renewable energies bring some advantages in the long term. In addition to reducing operating costs, these solutions can help companies hedge against volatile energy prices. In addition, greenhouse gas emissions are reduced, which at the same time weakens the cost factor of the CO_2 tax. Maintaining the social licence to operate by reducing local noise and air pollution is also supported, as is improving energy access in remote regions if a mining project is off-grid and the installation can serve to electrify surrounding communities (CCSI 2018).

Canada is investing in sustainable mining, both politically and economically. This is welcomed by German companies, which have also recognised the need for such investments. Since there is growth worldwide in the field of renewable energies and Canada has a significant share of the raw materials required for this, there is unexploited potential for German companies to enter into partnerships even at an entrepreneurial level.

Case study: renewable energy

The Diavik mine in the Northwest Territories, the northernmost mine in the world, uses wind power to meet its electricity needs. Until 2012, it was exclusively supplied with electricity from diesel generators. This involved transporting 50m litres of fuel every year over a 353 km long ice road that was only accessible in winter, costing a total of CAD 70m annually.

In 2006, the winter was unusually mild, so the ice road could only be built very late, melted very early, and never reached its full capacity. Several million litres of diesel had to be flown in that year, at a greatly increased cost. It became too risky to rely solely on that one particular energy source.

By installing 100 m high wind turbines, each equipped with an Enercon E70 generator and specially adapted to the harsh weather conditions, the company saved CAD 5m in fuel costs in 2013 alone. The CAD 31m investment in the turbines will have paid off in eight years (Canadian Mining & Energy 2014).

6.2 Electrification

Energy costs account for up to a third of the total costs for mining companies. In the interests of economy, it is a factor that is managed intensively and regularly monitored for efficiency gains. In addition, the demand for CO_2 reductions in this sector is inevitable nowadays and in the future: one way to achieve this is electrification.

Up to 40 % of the energy expenditure of an underground mine is used solely for the operation of the ventilation systems. Since the use of diesel engines causes a significantly higher demand for fresh air, the switch from diesel to electrical operation is not only economically viable, but also enables a higher level of health and safety on site due to lower emissions (EY 2019).

According to current data from 2018, fewer than 1 % of the vehicles used in mining are currently battery-operated. However, according to a European supplier, this is likely to change quickly, and the majority of trucks and loaders will be replaced by electrical devices in the next seven to ten years. This is due to advances in technology and the falling costs of lithium-ion batteries (Bloomberg Quint 2018).

Case study: electrification

Goldcorp's Borden Mine in Chapleau, Ontario, will be the first underground mine to replace all of its fleet with electrical vehicles. Goldcorp received CAD 5m from Natural Resources Canada's Clean Growth Program for the Mine of the Future project. The programme provides a total of CAD 155m to support the transition to renewable energies in the energy, mining and forestry industries (CIM Magazine 2019). Both the company itself and various interest groups benefit from the switch from a diesel fleet to battery-powered vehicles. The project will also create around 250 new jobs. Replacing diesel significantly improves working conditions by removing diesel particles and gases such as nitrogen oxides and sulphur dioxide from the air (CIM Magazine 2019). The changeover will avoid around 50 % of total greenhouse gas emissions, approximately 5,000 t of CO_2 per year, and reduce energy and maintenance costs. As up to a third of the operating costs of a mine are attributable to the use of energy, the savings potential of an energy-efficient company policy is obvious. Goldcorp is working with Sandvik Mining and MacLean Engineering to electrify its fleet. Digital and intelligent control elements, including tele-remote technologies, are used to maximise equipment usage. The use of biomass as a heating material is also being considered (CIM Magazine 2019).

6.3 Automation

Along with electrification, the topic of automation is becoming increasingly important. Electrification will accelerate the automation and deployment of the Internet of Things (IoT), as more reliable electric motors require less maintenance and less human intervention. With electrification, automation through drones, autonomous vehicles and remote-controlled operating systems will be introduced into mining operations (EY 2019). The most advanced mining companies are already relying on robots for a number of technological processes such as drilling and the transportation of raw materials. However, this is not yet the case for the majority of the market. Technavio analysts predict a growth of 27 % of the robotics market in the mining industry by 2022 (Mining.com 2019).

The move towards deeper mines is also evident on the Canadian market. At the beginning of 2018, the mining company Glencore announced that it would invest nearly CAD 1bn to mine new ore underground to a depth of 2,500 m. The project is scheduled to start operation in 2023 (CanadianMining Journal 2019).

With increasing depth, mines become more expensive and riskier to operate. Technologies such as automated vehicles, robotics and image processing systems can reduce risks for employees as, for instance, vehicles underground can be operated from a surface control room. The same applies to, for example, drones, which are increasingly used in the exploration business to explore remote areas that are difficult to access. Drones serve as carriers for various measuring devices. The data they collect are analysed, some with big data technologies, and can be used to create 3D models of the deposits to evaluate their raw material potential (Mining.com 2019).

6.4 Data acquisition, machine learning, artificial intelligence

The demand for data and digital competence at all stages of the mining value chain will increase, which will require a reorganisation of most occupations as the human-machine interface develops and spreads. In Vancouver, a company called MineSense is already using machine learning to analyse data from sensors installed on buckets, excavators, and conveyor systems, in this specific case for the mining of copper, nickel, zinc and iron. The technology scans the electromagnetic signatures in the ore and uses X-rays to instantly detect metal concentrations in each bucket load or in the ore as it moves along a belt. Higher precision and the ability to adjust changing ore conditions in real time lead to lower energy, water and chemical consumption and less waste during processing (The Globe and Mail 2018). This technology is already being actively used in a copper mine in British Columbia.

According to a survey carried out by Ernst & Young, some mining companies share the opinion that intensive cooperation is necessary, both with suppliers (original equipment manufacturers, OEM) and across industries (EY 2019). This cooperation can create benefits for both sides, such as the partnership between Newmont Goldcorp, Sandvik and MacLean at the Borden mine (MM 2019). Future mines will be low carbon, electrified and autonomous, so new technologies will have to be developed and tested to ensure the competitiveness of the mining industry. This not only requires new control systems and equipment, but also efficient management systems that meet the future demands of a sustainable industry. A new way of interacting within a digital system is required, in which the data streams and processes of the mining companies and the OEMs are synchronised. In this respect, there is also business potential for German companies in the areas listed above. This can be exploited more intensively, especially with regard to industrial development in Germany, which has significantly fewer active mines but a strong supplier industry.

7 Financing

The following section presents financing tools on the German and the Canadian sides, as well as government funding schemes to support national mining projects or projects abroad, to secure offtake agreements for the German economy or exports and imports in order to guarantee a reliable raw material supply on the German side.

On the German side:

7.1 Untied Loan Guarantees (UFK)

Untied Loan Guarantees are an integral element of the German Federal Government's raw materials strategy. Untied Loan Guarantee provide lenders to raw material projects abroad with cover against commercial and political credit default risks. In principle, a project needs to be eligible for cover in the light of raw material supply considerations and has to be in the national and macroeconomic interest of Germany. Additionally, the conclusion of a long-term supply contract for the financed project's raw material to a German offtaker is a prerequisite for cover (Fig. 21; AGAPORTAL 2019).

The granting of an untied loan guarantee must be justifiable in terms of the risk involved for the Federal Government of Germany, i.e. considering the borrower's creditworthiness and the political risks relating to the loan granted, it should be reasonable to expect a loss-free loan repayment.

For more information and contact details, please go to www.agaportal.de/ufk-garantien

7.2 KfW Bankengruppe

KfW Bankengruppe offers various development loans for international projects. The KfW entrepreneurial loan (Unternehmerkredit), for example, is used for the long-term financing of investments abroad at favourable conditions and primarily aimed at domestic and foreign small and medium-sized companies and freelancers (KFW 2019). In particular, the programme aims to promote research and development projects by technology-oriented companies as well as providing invest-

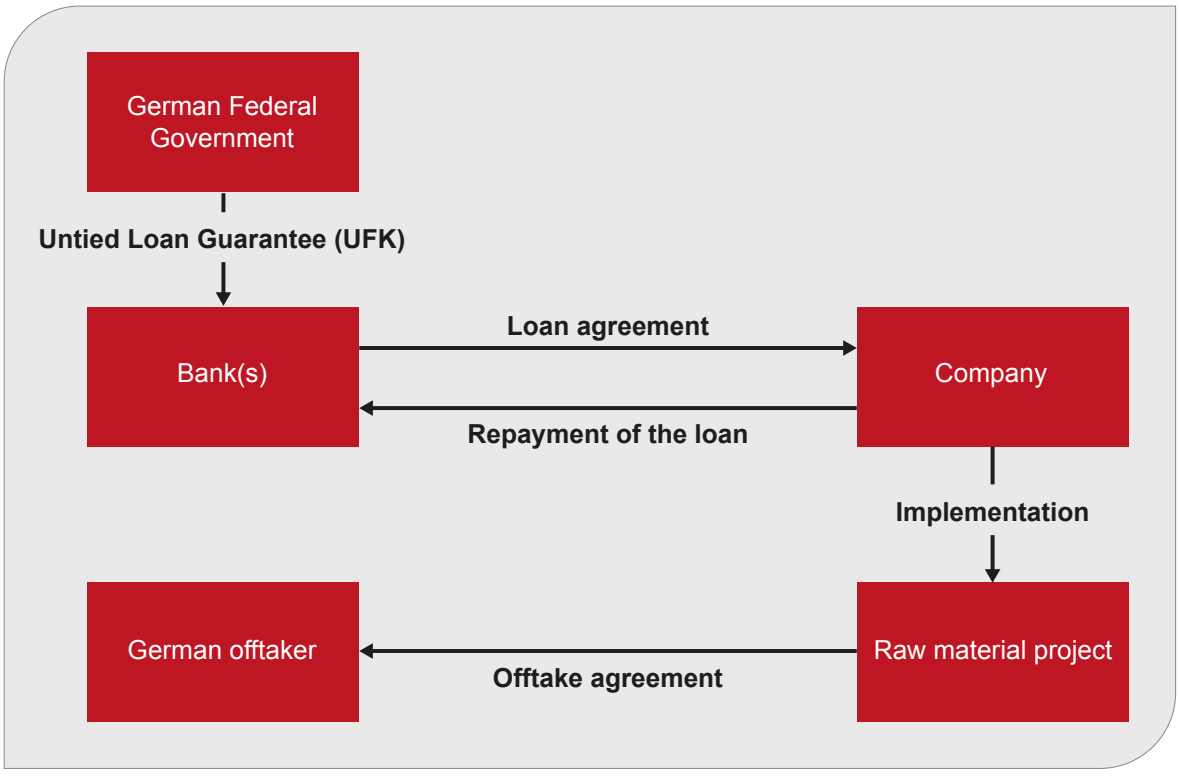


Fig. 21: Basic structure of incorporating an Untied Loan Guarantee in a raw material project (AGAPORTAL 2019).

ments for German companies entering the market or start-ups (KfW 2019). In this context, KfW finances start-ups, acquisitions and joint ventures. Development loans for projects relating to the environment, renewable energies, or energy efficiency are also available.

For more information and contact details, please go to www.kfw.de

7.3 Hermes Cover

State export credit (Hermes Cover) guarantees are a key foreign trade promotion instrument of the German Federal Government. They protect exporters against bad debt losses incurred for commercial or political reasons and, in many cases, are a prerequisite for obtaining the necessary sales financing. Hermes Cover is only made available where the private sector does not offer appropriate or sufficient insurance cover. Hermes Cover helps to open up markets that are difficult to access, and to maintain business relations in challenging circumstances. Hermes Cover is available to all German export companies irrespective of their size or line of business. However, transactions of small and medium-sized enterprises are considered to be particularly deserving of support (Agaportal 2019).

7.4 Federal funding programmes

Other funding programmes are focused on specific technologies or the support of specific research or economic sectors. Such programmes are offered by, for example, the Federal Ministry for Economic Affairs and Energy (BMWi) in the fields of innovation and new energy technologies, or by the Federal Ministry of Education and Research (BMBF) in the fields of energy efficiency, environmentally friendly technology, as well as material innovation and resource efficiency. Information on current funding programmes and tenders can be obtained directly from the ministries.

On the Canadian side:

7.5 Investissement Québec

Investissement Québec offers financing options in the context of the realisation of mining projects, for expansion within a market or when entering a new market, as well as for the development of new technologies or innovations.

Investissement Québec offers financing solutions such as loans at competitive interest rates, loan guarantees, or equity financing in the form of bonds or subordinated debentures. The mining projects must be located in Québec; the minimum requirement for equity financing is a PEA (pre-economic assessment), and, for debt financing, a definitive feasibility study. Both foreign and Canadian companies are supported, provided a project has good profit prospects and drives Québec's economic development.

7.6 Ressources Québec

Ressources Québec is a subsidiary of Investissement Québec and consists of two units:

- SOQUEM (Société québécoise d'exploration minière), responsible for the mining industry
- SOQUIP (Société québécoise d'initiatives pétrolières), responsible for the oil and gas industry

Ressources Québec supports mining companies at every stage of their mining projects from exploration to processing. It offers a comprehensive portfolio of financing products such as equity investments, debentures and various types of loans. As with Investissement Québec, both foreign and Canadian companies are supported, provided a project has good profit prospects and drives Québec's economic development.

7.7 Flow-through shares

At Canadian federal level, so-called flow-through shares are among the most common financing instruments. These are shares (or the right to purchase shares) that allow the investor to claim a tax credit, thereby reducing his income tax payable in

the year of purchase. In addition, the provinces of British Columbia (20 %), Saskatchewan (10 %), Manitoba (30 %) and Ontario (5 %) grant additional tax credits related to the provincial share of income tax. Québec offers the greatest tax savings potential, with 150 %. The tax benefits can only be claimed in Canada. Flow-through shares are intended to promote investments in the exploration and development of raw material projects in Canada, with the aim of supporting junior companies in particular.

More information can be obtained from the Canada Revenue Agency at www.cra.gc.ca or from the investment department of the Canadian embassy in Berlin.

8 Conclusions

Canada is a country with stable conditions for long-term investments, thanks to its low country risk, which offers numerous investment opportunities. Canada's raw material potential is enormous. Numerous exploration projects are currently running alongside existing mining operations, especially in the remote northern areas where raw material deposits are almost untouched.

Many programmes run by the government, or by the individual provinces, are concerned with expanding the infrastructure of these areas in order to facilitate access to raw materials. Canada's raw material potential also includes those materials that are important for e-mobility – nickel, graphite, cobalt and lithium – which are becoming increasingly important as demand is rising steadily. This will result in interesting investment opportunities both in the mining sector and for suppliers in the next few years.

In research, Canada is very active in the mining sector. Across the country, research institutions are working in close cooperation with the industry to develop methods aimed at making the mining and processing of raw materials more efficient and environmentally friendly. Green mining plays an important role. Canada is very successful when it comes to the use of renewable energies in the mining sector. In these areas, there are always opportunities for cooperation, but also investment potential, both for research institutes and for companies.

In addition to the exploration of new raw material potential, current production in active mines is steadily increasing to meet the growing demand. Canadian cobalt production alone is expected to increase by almost 77 % until 2026.

Germany, on the other hand, is facing economic challenges. There is a high dependency on imports of metals and energy raw materials and an increasing demand for raw materials in many sectors. The markets for mineral raw materials remain volatile. In view of this, the diversification of supply sources for German industry is necessary and an important step for security of supply. At the same time, there is a strong interest among mining companies in meeting technological challenges with cooperation along the entire value chain.

This study shows that partnerships – in a wide range of participation models – would be desirable for both countries and that the political, economic and legal framework on both sides provides a good basis for successful cooperation.

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10 Appendix

Contact information relevant to the Canadian and German mining sector

From the German and the Canadian side, the following contact information offer the opportunity to receive and answer questions and suggestions about raw materials and mining and to find the right contact. If you are interested to get in touch with one of these institutions, please contact us.

Contact for the German foreign trade

DERA
The German Mineral Resources Agency (DERA) is the national information and consultancy platform for mineral raw materials.

Phone: +49 (0)30 36993-226
E-mail: dera@bgr.de

Competence Centre for Mining and Mineral Resources
The Competence Centre for Mining and Mineral Resources is part of the Canadian German Chamber of Industry and Commerce Inc. and is the first point of contact for Canadian and German companies and organisations interested in enhancing bilateral strategic partnerships in the mining and mineral resources sector.

Phone: +1 416 598-3355
Contact: www.kanada.ahk.de/kontakt/

Federal Ministry for Economic Affairs and Energy (BMWi), Berlin
Unit IVB5; Raw Materials Strategy, mineral resources; supervision of BGR

Phone: +49 (0)30 18615-7745
E-Mail: buero-ivb5@bmwi.bund.de

The German Federation of International Mining and Minerals Resources (FAB) at the Association Commodities and Mining (VRB)

Phone: + 49 (0)30 315182-0
E-mail: info@v-r-b.de

The Mechanical Engineering Industry Association (VDMA)

Phone: +49 (0)69 6603-0
E-mail: info@vdma.org

Canadian government agencies

Embassy of Canada to Germany

Phone: +49 (0)30 20312-0
E-mail: brln@international.gc.ca

Natural Resources Canada (NRCan)
NRCan is the ministry of the government of Canada responsible for natural resources, energy, minerals and metals, earth sciences, forests and remote sensing

www.nrcan.gc.ca/home

Indigenous Services Canada
Gatineau, Québec

www.canada.ca/en/indigenous-services-canada.html

Crown-Indigenous Relations and Northern Affairs Canada
Gatineau, Québec

www.canada.ca/en/crown-indigenous-relations-northern-affairs.html

Environment and Climate Change Canada
Gatineau, Québec

www.canada.ca/en/environment-climate-change.html

Employment and Social Development Canada
Gatineau, Québec

www.canada.ca/en/employment-social-development.html

Canadian associations

The Canadian Institute of Mining, Metallurgy and Petroleum (CIM)
Montreal, Québec

www.cim.org

The Mining Association of Canada (MAC)
Ottawa, Ontario

www.mining.ca

Prospectors & Developers Association of Canada (PDAC)
Toronto, Ontario

www.pdac.ca

Provincial authorities and other institutions

Alberta – Alberta Energy
Edmonton, Alberta

www.alberta.ca/energy.aspx

British Columbia – Ministry of Energy, Mines and Petroleum Resources
Victoria, British Columbia

www.gov.bc.ca/ener/index.html

British Columbia – Geoscience BC
Geoscience BC is an independent, non-profit organisation in British Columbia that works in collaboration with First Nations, local communities, the government, universities and the raw materials sector in the field of earth sciences.

www.geosciencebc.com/s/Home.asp

British Columbia – ICTINC
Indigenous Corporate Training Inc. was founded in British Columbia under indigenous leadership and offers special corporate indigenous training courses to make it easier for entrepreneurs to contact and negotiate with indigenous nations.

www.ictinc.ca/about-us

Manitoba – Department of Growth, Enterprise and Trade
Resource Development
Winnipeg, Manitoba

www.manitoba.ca/iem/index.html

New Brunswick – Energy and Resource Development
Fredericton, New Brunswick

www2.gnb.ca/content/gnb/en/departments/erd/natural_resources.html

Newfoundland and Labrador – Natural Resources
St. John's, Newfoundland

www.nr.gov.nl.ca/nr/mines/index.html

Northwest Territories – Department of Industry, Tourism and Investment
Yellowknife, Northwest Territories

www.iti.gov.nt.ca

Nova Scotia – Department of Lands and Forestry
Halifax, Nova Scotia

www.gov.ns.ca/natr

Nunavut – Department of Economic Development and Transportation
Iqaluit, Nunavut

www.gov.nu.ca/edt

Ontario – Ministry of Energy, Northern Development and Mines
Sudbury, Ontario

www.mndm.gov.on.ca/en

Ontario – Centre for Excellence in Mining Innovation (CEMI)
CEMI is a Canadian mining industry research initiative, collaboratively funded by the private sector and government. Its mandate is to develop research excellence in the areas of mineral exploration, deep mining integrated mining engineering and environment and sustainability.

www.cemi.ca/

Prince Edward Island – Department of Communities, Land and Environment
Charlottetown, Prince Edward Island

www.princeedwardisland.ca/en/topic/communities-land-and-environment

Québec – Société du Plan Nord
The Plan Nord is an economic development strategy launched by the government of Québec to promote the potential for mining, energy, tourism and social and cultural development in Québec north of the 49th degree of latitude.

https://plannord.gouv.qc.ca/en/spnen/

Québec – Parc industriel et portuaire de Bécancour (SPIPB)
SPIPB promotes the economic development of the province of Québec by developing and operating an autofinanced industrial park and port facilities.

www.spipb.com/en/home

Québec – Investissement Québec
Investissement Québec is offering financing solutions for new mining projects, market expansion or if entering new markets.

www.investQuébec.com/Québec/en/

Québec – Ressources Québec
Ressources Québec supports companies at every stage of their natural resource exploration, development and processing projects or energy production, storage, transport and distribution projects. It offers a full range of financial products, including investments in share capital, debentures and various types of loans.

www.investQuébec.com/international/en/about-us/our-subsidiaries/ressources-Québec.html

Québec – Ministère de l'Énergie et des Ressources naturelles (MERN)
MERN offers access to SIGÉOMIN, a unique spatially-references geomining information system, free of charge. This system contains all the geoscience data accumulated in Québec over the last 150 years with information on mining projects, company information, geology, etc. It offers interactive maps, cartographic web services as well as bibliographic information, reports and maps. The data was collected during geological mapping, prospecting, and exploration by the ministry, mining companies or universities.

More information: https://mern.gouv.qc.ca/
Access to database: http://sigeom.mines.gouv.qc.ca/signet/classes/I1102_indexAccueil?l=a#

Québec – COREM
COREM is the largest organisation in Canada totally devoted to mineral processing. COREM provides a wide range of mineral processing and analytical services to companies that explore and develop ore bodies and transform or recycle mineral substances.

www.corem.qc.ca/en

Saskatchewan – Mineral Exploration and Mining
Saskatoon, Saskatchewan

www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/mineral-exploration-and-mining

Yukon – Department of Energy, Mines, and Resources
Whitehorse, Yukon

www.emr.gov.yk.ca

Deutsche Rohstoffagentur
Bundesanstalt für Geowissenschaften und Rohstoffe

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