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## *Social, economic and environmental challenges in primary lithium and cobalt sourcing for the rapidly increasing electric mobility sector*

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STRADE is an EU-funded research project focusing on the development of dialogue-based, innovative policy recommendations for a European strategy on future raw materials supplies. In a series of policy briefs and reports, the project will offer critical analysis and recommendations on EU raw materials policy.

*This policy brief focuses on the challenges in the raw materials sector that will arise from the rapidly proceeding electrification of road transport. The required raw materials for batteries, particularly lithium and cobalt, will face a rapid increase in demand. Europe is highly import-dependent on both raw materials and battery cells. This policy brief identifies arising challenges for battery manufacturers, mining companies as well as the small-scale mining sector and gives recommendations for EU policy in this strategically relevant field.*

## 1. Introduction

Today, road transport accounts for more than 20% of the EU's greenhouse gas emissions [1]. The EU has reaffirmed the target of $CO_2$ emission reduction in the transport sector of at least 60% below 1990 levels by 2050 [2]. A shift from internal combustion engines to carbon-free electric vehicles (EV) is needed to meet these goals, moreover the upcoming diesel bans further boost the transformation of the transport sector. The increasing demand for materials needed to produce components for electric vehicles as well as questions of possible shortages and supply risks were broadly published in the last months; particularly lithium, cobalt, nickel, manganese, graphite, and copper are in the public focus.

The International Energy Agency (IEA) forecasts that approximately 7 million electric vehicles could be sold annually in 2030 in Europe and almost as many hybrid vehicles with smaller batteries (6 million). The European Battery Alliance, launched in October 2017, assumes that the EU could capture a cross-sectoral battery market of up to EUR 250 billion a year by 2025, served by at least 10 to 20 giga-factories to cover EU demand.

The ambitious target to meet significant shares with European cell manufacturing capacities requires tremendous efforts by the European industry – especially in view of the fact that mass production of lithium-ion battery cells is not yet taking place in Europe, and Japanese, South Korean and Chinese players heavily dominate the global market. The European industry has to cope with two main challenges against the background of an extremely rapid global technological development: stable raw material sourcing and the fast development of high-level technology competitive with Asian and US industries. Currently, only two promising European consortia, Northvolt and TerraE, are assumed to take up production in the next few years[1]. Despite this starting point, the EU Strategic Action Plan on Batteries, published in May 2018, aims to bring Europe to leadership in this upcoming key industry.

Key challenges in raw material sourcing are not only associated to economic aspects of stable raw material supply but also to environmental and social challenges. This policy briefs outlines these aspects with a focus on the primary raw materials lithium and cobalt, since they will see the greatest increase in demand relative to current primary extraction levels. At present they are also the two battery raw materials with the highest concerns and risks. Besides this, it should be noted, that the demand for other raw materials will also increase due to the uptake of electric vehicles; e.g., the World Bank predicts at least a ten-fold increase in the demand for aluminum, nickel, iron and manganese for energy storage technologies [3]. However, the

[1] Northvolt already started construction works in June 2018 and plans to start initial production in 2020 and full battery cell production in 2023 in Sweden. TerraE aims at a cell production plant in Germany. The next step of TerraE is the development of demonstrators.

overall aluminum, iron and manganese demand will not be strongly affected by new energy storage capacities due to the greater demand in other sectors (construction, infrastructure, machinery etc.). In contrast, nickel, graphite and platinum (for fuel cell electric vehicles) have a higher relative relevance. Particularly nickel is an important substitute for cobalt in current and next-generation lithium-ion battery technologies. Moreover, emerging alternative future battery technologies such as the redox-flow battery require nickel. But due to the limitations of this policy brief, the reader is referred to the 2017 Oeko-Institut study "Ensuring a Sustainable Supply of Raw Materials for Electric Vehicles" [4][2] which gives more details on nickel, graphite and platinum. The relevance of Russia for Europe's nickel supply will be discussed in the upcoming STRADE report on EU cooperation with industrial countries.

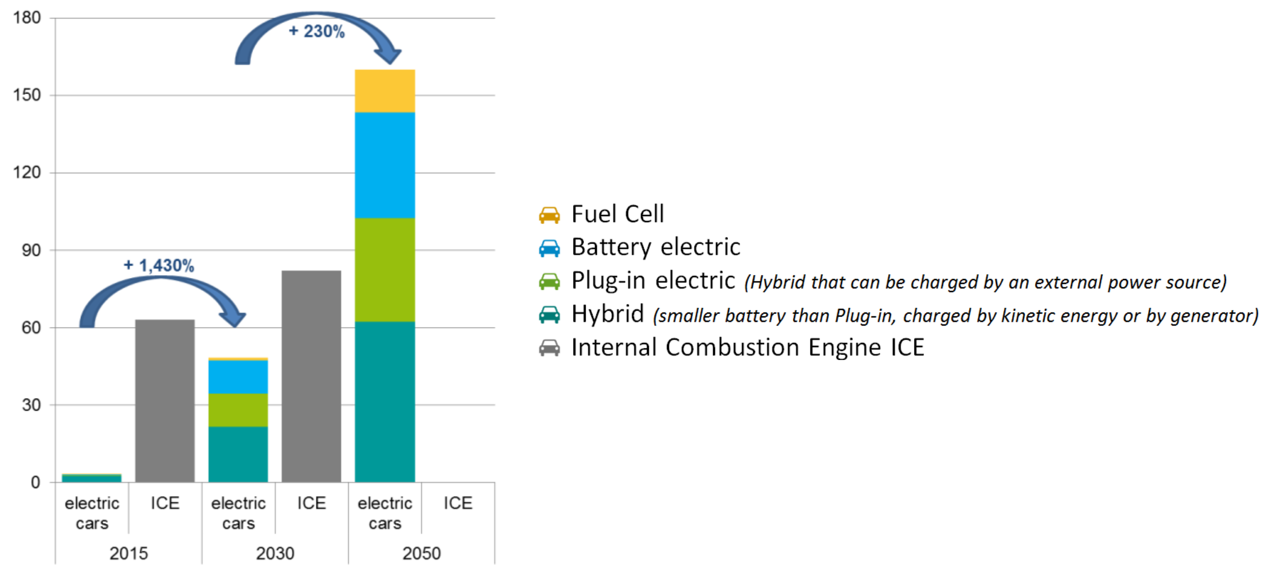
It should also be noted that this policy brief strongly focusses on the pressing challenges associated with lithium-ion batteries for electric cars. The broader picture of raw materials needed for the global transition to a fossil-free future – with increasing demand for many metals and minerals at varying degrees [3] – will be illustrated in upcoming STRADE reports.

## 2. Scenarios for EV deployment

This policy brief refers to a scenario of future global demand for cobalt and lithium in EV batteries presented in the 2017 Oeko-Institut study "Ensuring a Sustainable Supply of Raw Materials for Electric Vehicles" commissioned by Agora Verkehrswende [4]. The scenario is one of two which model the future development of electric transport. This policy brief refers to the politically more ambitious scenario which assumes that the transport sector has to make important contributions to the global 2 degree goal[3] for limiting climate change. The development of the future EV fleet is estimated by using projections of the International Energy Agency (IEA) [5].

For passenger vehicles – the most relevant vehicle type for the battery market – , Figure 1 exemplarily illustrates the modeled high growth for global electric vehicles sales from 2015 to 2030 (1430%) and from 2030 to 2050 (additionally 230%). It also shows the modeled tremendous increase in absolute global sales with around 3 million electric cars in 2015 and around 160 million in 2050.

### Figure 1: Annual passenger vehicle sales in the 2 degree scenario (in million)



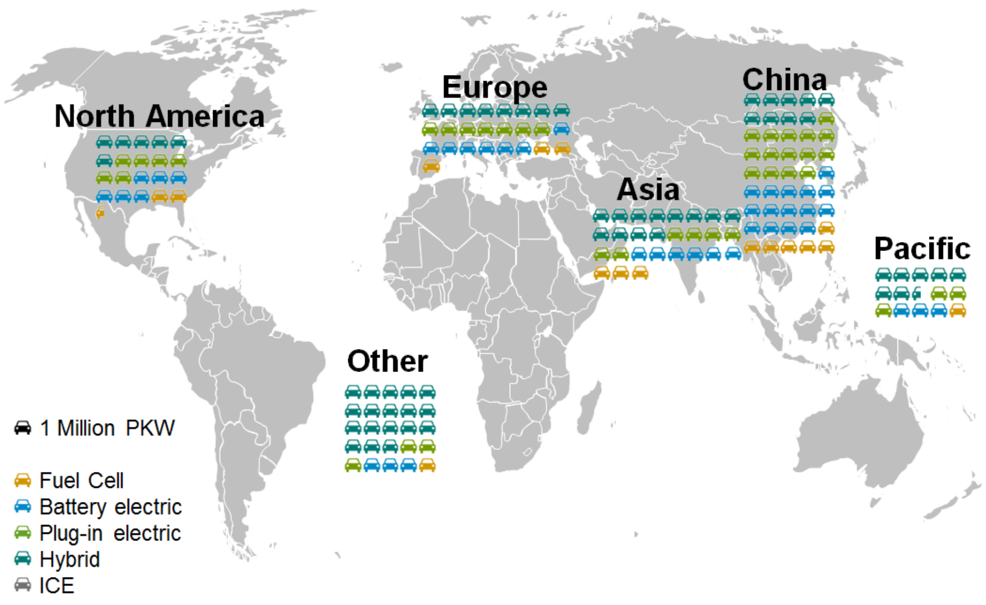

Source: Oeko-Institut [4] calculations based on [5]

2 The study concludes that global nickel reserves and resources are spread across a number of countries and will comfortably exceed growth in demand. For natural graphite, it notes the potential for substitution by synthetic graphite. Concerning platinum a decrease in demand for conventional catalytic converters is expected to be offset by an increase in demand for fuel cells. In addition, recycling programmes will further reduce pressure on primary platinum production.

3 During the UN Climate Change Conference in Paris in 2015, the states agreed to limit temperature rise to no more than 1.5°C. The 2 degree-goal remains below this target, but it can be seen as a broad accepted minimum baseline. To achieve the 2° goal, the transport sector needs to make a contribution.

Figure 2 shows the projected regional distribution of electric passenger cars sales in 2050: The market with the highest sales will be China, followed by North America, Europe and Asia. The European share was projected at around 16% and around 26 million electric cars in 2050.

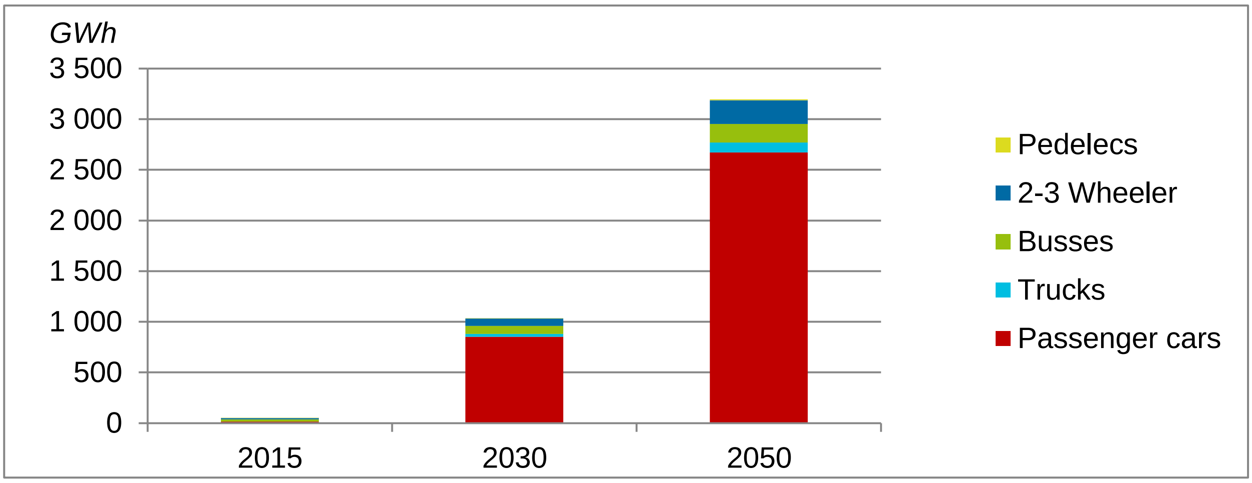
**Figure 2: Global distribution of passenger vehicle sales in 2050**




Source: Oeko-Institut calculations based on [5]

Based on the EV development, the Oeko-Institut calculated the potential future battery capacity demand which arises from the transport sector. Figure 3 shows the required battery capacities for all types of electric vehicles (passenger vehicles, busses, trucks, pedelecs and 2-3 wheelers) in 2015, 2030 and 2050. The passenger vehicles are the main driver, with other vehicle types adding comparably smaller additional demand.

**Figure 3: Annual sales of lithium-ion battery capacity in the 2 degree scenario (in GWh)**




Source: own calculations based on [5]

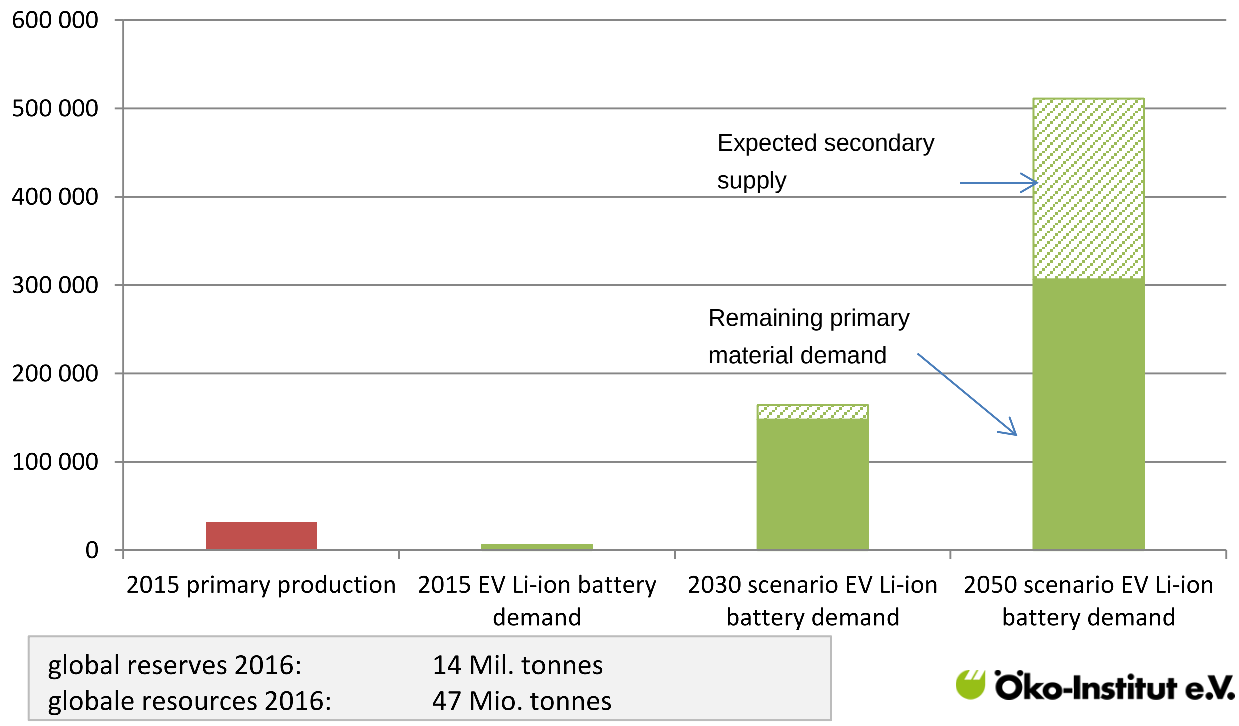
The scenario further assumes that lithium ion batteries[4] which are currently the state of the art will also remain the dominant energy storage technology in the 2030s. Studies of other authors come to similar results [6][7][8][9]; there is a broad consensus that a rapid increase in demand for lithium-ion batteries for EVs will also result in a sharp increase in lithium and cobalt demand. Hereby, the projection until 2030 is relatively certain, provided that global policies favour EV deployment and no rapid unexpected technological changes will occur. The 2050 perspective however has a much greater degree of uncertainty, in terms of technology development. Therefore, the model assumes that Li-ion battery specifications will principally remain the same beside some optimization in terms of efficiency. If new technologies will be developed and enter markets before 2050, the related resource demand might change.

## 3. Lithium

### 3.1. Global lithium demand for electric vehicle deployment

The scenario presented in Chapter 2 indicates a significant uptake of EV sales in the future. Figure 4 shows the corresponding increase in lithium demand needed to produce batteries for the electric vehicles. Until 2050 the estimated demand could be as high as 500,000 tonnes. Demand is expected to already exceed current annual mine production by a factor of five as early as 2030. Recycling can only contribute to a small extent to the rising demand in 2030 (share of 10% assumed[5]), because the amount of lithium in waste streams will still be limited. In 2050, a mature e-mobility sector can be assumed, providing more end-of-life material which will be available for recycling (share of 40% assumed).

**Figure 4: Global lithium demand for lithium-ion batteries in electric vehicles (in tonnes) according to the 2-degree scenario**




Source: [10] [4]; hatched lines = secondary material usage

Figure 4 only includes the projected lithium demand for batteries for electric vehicles. The total lithium demand is even higher taking into account battery applications in IT, power storage or electric tools.

4 Former battery technologies such as NiMH batteries are phased out, as Li-Ion batteries are much more efficient. A mix of the following lithium-ion battery technologies is considered in the analysis: NMC (nickel - manganese - cobalt); NCA (nickel-cobalt-aluminium); LFP (lithium-iron-phosphate).

5 The future share of secondary materials covering battery demand for EVs has been discussed with experts in a stakeholder workshop. For more details see [4].

Moreover, lithium is used in other applications like ceramic and glass, lubricating greases, continuous casting mold flux powders, polymer production and air treatment. Nonetheless, EV batteries will remain the dominant application in the mid-term perspective since annual growth rates for EV demand are forecasted at around 25% in the next 15 years. In line with this, a 2017 World Bank report also shows that grid-based energy storage will have a significantly lower need for battery capacities than the automotive sector [3].

## 3.2. Global lithium supply situation

### *Current primary production*

Current global lithium mine production comes from two types of deposits. About half of global lithium comes from hard rock mining, which takes place in Australia, China, Zimbabwe, Portugal, and Brazil; the other half comes from extraction from brines in Chile, Argentina, China, and USA; artisanal mining only plays a very minor role (e.g. in Brazil [11]) [12]. The detailed numbers are shown in Figure 5. The only European producer is Portugal with relatively small volumes (400 t/a).

Primary lithium production is dominated by only four companies which cover almost 90% of world production: Talison Lithium (Australia) 39.8%; SQM (Chile) 22%; Albemarle (USA) 16.2%; FMC (USA) 9.7%) [13]. Moreover the Chinese company Tianqi has an increasingly growing role in the sector. The company acquired a 24% share in SQM recently. Tianqi also holds a 50% stake in Talisons's Greenbushes lithium mine [14]

### *Reserves, resources and future primary production*

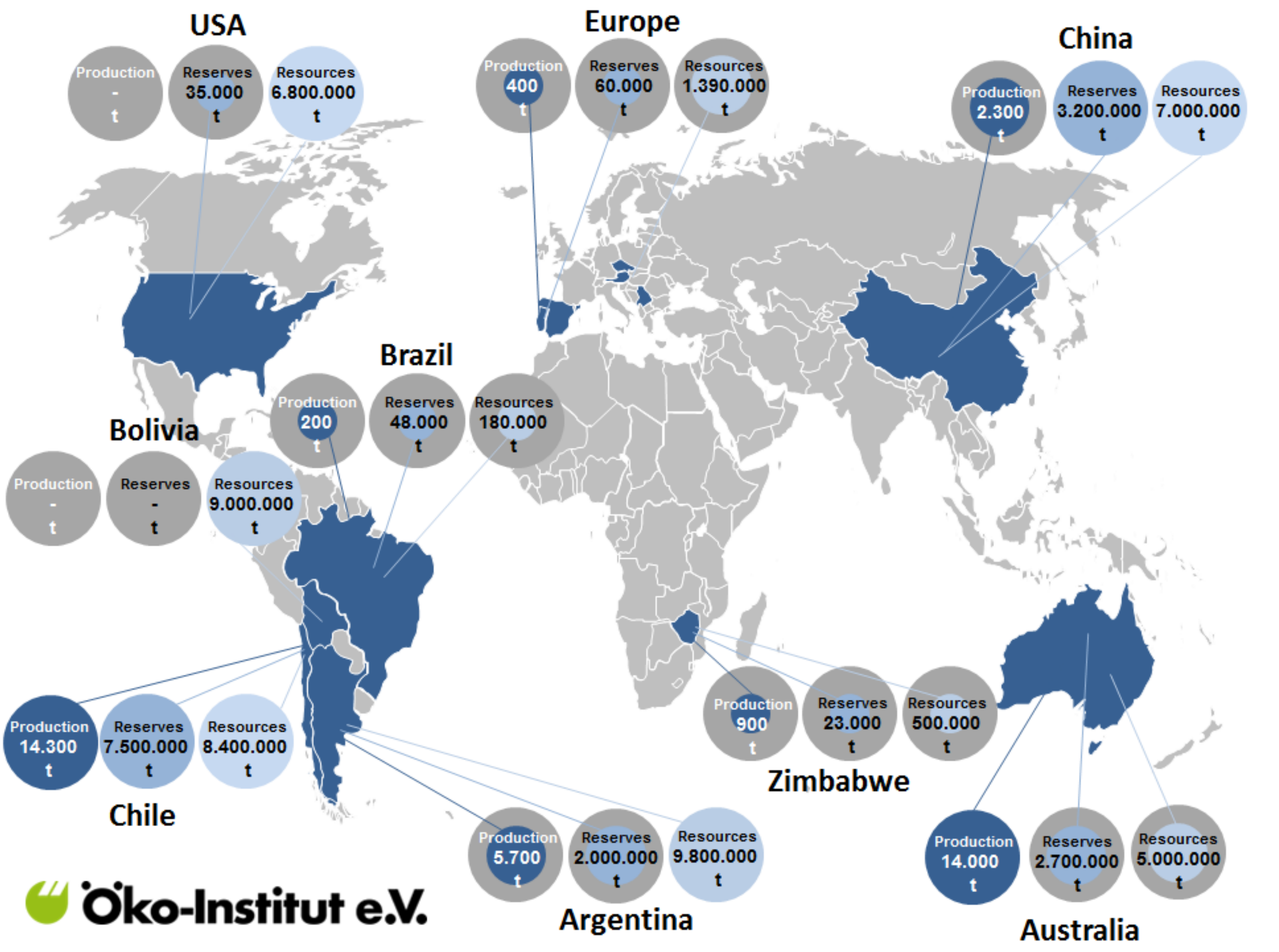
Around 76% of global lithium reserves are brine-based deposits, and while they are more capital-intensive than hard-rock deposits and slower to respond to market conditions, brine projects have inherently lower costs and greater economy of scale.

The reserves[6] published by USGS in 2018 (16 Mio. t) are almost four times as high as those published ten years ago. This indicates that the increasing lithium demand is linked to high exploration efforts. The budget for exploration in lithium projects has increased significantly. In 2017 the expenditures for lithium exploration were four times as high as in 2015. Also the number of exploration companies has increased sixfold within the same time span. In 2017 more than a quarter of the exploration budget was invested in Australia, followed by the USA with 13%. Latin America accounts for circa one fifth of the budget, with Argentina being the largest in the region with 12% of the budget. Notably 8% of the exploration budget has been spent in Serbia [15]. As Figure 5 shows, South America has the potential to become the main lithium supplier with its 'lithium triangle' – Argentina, Chile and Bolivia – and their salt flats located in the Andean mountain region. The largest reserves are in Chile, Australia, China and Argentina. The world's largest lithium resources[7] are located in six large brines in Argentina and in the Bolivian Salar de Uyuni [16] [17][10]. The figure only visualises the most recent data published by the USGS. Small outputs are summarised under the category "others". Therefore, some countries with smaller production and reserves are not in shown in the map below.

6 Reserves are the economically extractable minerals and are part of the resources. Reserve data are dynamic – for example they may increase when raw material prices increase, further deposits are explored or new technologies or economic variables improve their economic feasibility [10].

7 Resources are the natural occurring deposits in or on the earth's crust (solid, liquid, gaseous) in such form and amount that economic extraction of a commodity is currently or potentially feasible [10].

**Figure 5: Main lithium primary production, reserves and resources in 2016**




Source: Data based on [10]

In addition to the European mine production in Portugal, there are promising reserves in the Czech Republic[8] with an expected annual mining production of 2,800 tonnes of lithium content [12]. Another 2,000 tonnes of lithium content might be produced in Finland according to a recently released feasibility study by the company Keliber [18]. In view of the modelled global lithium demand of 160,000 tonnes in 2030, it becomes clear that further locations will have to be developed if import dependency shall be significantly reduced. As noted above, an interesting European deposit has been identified in Serbia with the “new mineral” Jadarite. This deposit needs further research and testing [12]. The Swedish government has funded exploration in Sweden; a study by the Swedish Geological Survey announcing a potential for several critical minerals including lithium [19]. Among other locations in Europe, exploration is also ongoing in Wolfsberg in Austria [20] and Zinnwald in Germany [21]. A recent publication of the Geological Survey of Finland reports on well-known deposits in the country with around 45,000 t Li content and additionally up to 510,000 tonnes of Lithium in undiscovered pegmatite lithium deposits [22]. The European Strategic Action Plan on Batteries (2018) announces commodity mapping in several countries, particularly Austria, the Czech Republic, Finland, Ireland, Portugal, Spain, and Sweden [23].

Current global reserves are 50 times as high as the projected annual primary consumption for 2050. However, strong exploration efforts have stimulated a high increase in reserves and resources in the past decade [10], and it is to be assumed that this trend will continue[9]. Due to the extremely dynamic development of new projects, experts expect no long-term shortage. Nevertheless temporary supply

[8] The Australian company European Metals, which owns the exploration rights in the Czech Republic, expects that mining could start in 2019. The deposits are located around Cinovec, a region with a tradition of mining [20].

[9] The authors are aware that this simplified calculation does not consider more detail specifications, e.g. the required chemical compound or the required purity in the end product. Nevertheless, the calculation gives a first idea of the challenges in the cobalt sector.

shortages might occur since lithium demand may undergo a drastic increase within a short time period. Although many lithium projects are currently being initiated, approval procedures, mine construction and the installation of processing plants will take several years. Regarding technological requirements, the 2018 EC report on raw materials for battery applications points out that only a few lithium projects have the capacity and ability to produce very high-grade lithium compounds that batteries need [24].

In 2016, the value of the lithium used in a mid-range battery electric vehicle (BEV) was around $406[10], not including losses in battery production. As there is little potential for substitution and efficiency for the lithium used, strong lithium price increases could presumably slow down the expansion of e-mobility to some extent. But in contrast to lithium the price impact of cobalt (see Chapter 4) is higher.

***Recycling material – Secondary production***

Within the European Battery Directive[11], electric vehicle traction batteries fall into the category of industrial batteries. No collection target is yet in place, however disposal is not allowed and so far – in theory – batteries should be completely collected separately from other batteries. The plants which process the end-of-life batteries are required to reach a recycling rate of 45 % according to the European Battery Directive. More recently, during the evaluation of the battery directive, this approach is under dispute. Particularly a higher recycling rate or specific targets for lithium recycling are discussed.

In the past, recycling processes only recovered expensive metals such as cobalt and nickel. Because lithium is comparably cheap and more difficult to recycle – it usually becomes part of the slag fraction - lithium has not been recovered until 2017. This changed with the announcement of the Belgian company Umicore to start recycling lithium from the slag fraction [25]. Similar approaches are ongoing, e.g. in Korea [26]. If a revised EU Battery Directive would introduce a lithium recycling quota, the development of lithium recycling facilities would be significantly supported. Additionally, increasing lithium prices will be a main driver for the development of lithium recycling routes.

Outside the industrialized countries, particularly in developing countries, no collection systems for used EV batteries exist yet. In these countries, the primary challenge is the implementation of collection and recycling facilities to eliminate the risk of explosion of used batteries, even if no lithium recovery takes place in the first phase. Figure 4 shows that the scenario assumed a secondary share of 40% of total global demand[5]. Achieving this share needs targeted efforts. In February 2018 China took an important step in this direction by announcing that it will assign responsibility for battery recycling to the manufacturers of EVs and require them to set up facilities to collect and recycle spent batteries [27].

## 3.3. Social and environmental challenges

### 3.3.1. Environmental challenges

***Australia and China***

More than 40% of today's lithium production comes from hard rock mining. Mostly the mineral spodumene is extracted in Australian open pit and underground mining operations. The associated environmental impacts are similar to the extraction and refining of other ores. An overview of these typical environmental risks can be found in the STRADE Policy Brief 04/2016. It can be assumed that due to Australia's strict environmental protection laws appropriate standards are applied and therefore risks are limited.

There are also significant lithium reserves in China, with the highest lithium concentrations in Tibet [28]. The general environmental developments in China's mining industry are outlined in STRADE Policy Brief 03/2018. It shows that the Chinese mining industry is currently undergoing a transformation toward higher environmental standards. At the same time, however, it also shows that there is little publicly accessible information and that the domestic mining sector has so far hardly been opened up to cooperation and activities with foreign actors. The most recent green mining standard in China has been translated by STRADE and can be accessed on the project-homepage.

***Latin America: water consumption and hydrology***

10 For a 30 kWh battery, type NMC 6:2:2, average prices May 2017 – Apr 2018; the price includes only the value of lithium in the lithium carbonate market price and does not reflect the costs of lithium lost in the processing and manufacturing steps.

11 Directive 2006/66EC on batteries and accumulators and waste batteries and accumulators

In the public debate, lithium production is much more present in Latin America – especially in Chile, which accounts for around one third of world production. The deposits are located in salt lakes in extremely arid areas. Traditional extraction is carried out by pumping brines to the surface and subsequent evaporation and precipitation of different salts resulting in e.g. a lithium chloride concentrate. The evaporated water is removed from the local water circuits. The withdrawal of larger volumes may have an effect on the hydrology of the surrounding areas [29]. According to Frankel & Whoriskey [30], scientists still disagree as to what extent salt lakes are connected to other water sources in the area. Ecosystems and agricultural uses, such as grazing or quinoa production, will be affected [31], and water-related conflicts have already occurred [32] [30].

A comparison of the specific water consumption in the mining industry reveals the significance of the scarce resource during the process: water consumption in ore mining is in the order of 100 - 500 $m^3$/ton of metal at a metal content of 1% [33]. In the case of salt lakes, the Li concentration is decisive for the water consumption; for example, around 1400 $m^3$ of water evaporate for 1 ton of lithium[12] in the Salar de Olavorz in Argentina. The additional water treatment for further process steps is not yet included. The comparison shows that the water problem has a high relevance in brine extraction because the high specific water consumption and the arid climate coincide. A 2010 UN expert group pointed out that *"The extraction of lithium through evaporation of brines in salt flats can have significant impacts on the often delicate balance of limited fresh and/or ground water"* and therefore insisted on *"comprehensive environmental impact assessment studies and monitoring to prevent, minimize and mitigate any negative impacts on the flora, fauna and ecosystems in the salars and the adjacent area"* [35]. The traditional evaporation technology using solar radiation has two other disadvantages in addition to the high water consumption: Firstly, resource efficiency is low. Less than 60% of the lithium is recovered because a large part of the lithium is lost during months of evaporation due to dust discharge. Secondly, a major economic disadvantage is also the long duration of the evaporation process of about 18 months [13].

### Water-efficient technologies for lithium extraction from brines

Intensive work is currently being carried out on water-saving technologies in which the water is recovered and fed back into the salt lake. For example, the French company ERAMET, together with research partners, developed a Direct Extraction Process and operates a pilot plant in Argentina [36]. Further companies with similar processes in development are Tenova [31] (global mining engineering group), Enirgi (Canada) [37], Volataic Minerals Corp. (Canada) und Posco (Korea). The build-up of closed circuits significantly increases the recovery rate and reduces the time required from several months to only a few hours [13]. The successful implementation of these efficiency technologies plays a key role in more sustainable lithium recovery from salt lakes.

### Handling of toxic chemicals in Latin America

Another important point for a responsible lithium-extraction is the careful handling of toxic chemicals, which are used after concentration in the course of further processing. In Argentina, for example, there have been complaints from communities about pollution of water bodies, which also serve to supply people and agriculture [32].

### Landscape and biodiversity in Latin America

A further highly relevant issue is the destruction of South America's unique natural landscapes in the form of salt lakes. Particularly the largest lithium resource, the Salar de Uyuni in Bolivia, has an outstanding unique natural landscape and biodiversity (lagoons, flamingoes) and is a fragile ecosystem in one of the most arid regions in the world. Water resources in Salar de Uyuni are considered as non-renewable resources (or renewed very slowly), and mining in this highly sensitive area is connected with a high risk of negative impacts [29]. However, the salt lakes are very large, so it should at least be possible to obtain large-scale unimpaired salar zones in Latin America.

### Conclusion on challenges in Latin America and proposal for a BAT guiding document

The great challenge for environmental protection in lithium extraction in South America is to take the environmental problems outlined above into account from the early planning stage – even though the dramatically increasing demand for primary lithium will place great pressure on the rapid installation of high

[12] Own calculation; Li-concentration in Salar de Olavorz 690 mg/l; most brines have Li-concentration from 300 – 1500 mg/l [34]

production volumes and the opening of new brine sites. Acceptance by the local population will only be gained if companies are obliged to operate with high-quality technology in a way that conserves water and resources and reduces emissions.

In particular, STRADE proposes that the EU initiate and support the development of a “best available techniques” guiding document for lithium extraction from brines. A European-Latin American working group could be the starting point for such an initiative and invite international experts into this process. Such a document would be a good support for public authorities, businesses and the population concerned, and an important reference for demanding high standards of water and resource efficiency.

### 3.3.2. Socio-economic challenges

In Latin America, there are various socio-economic issues related to lithium production. On the one hand, there are strong social conflicts in many South American countries over mining. Due to the negative experiences from the past decades, the skepticism towards mining is generally high and the mining industry frequently has lost and will have to regain the social license to operate at many locations. Further details are described in the STRADE Policy Brief 05/2016 on socio-economic challenges in the non-fuel mining sector.

Regarding lithium production from salt lakes in Latin America, further specific concerns of local and indigenous communities have to be considered. In Bolivia, for example, indigenous communities in the area of the Salar de Uyuni rely on salt harvesting, llama herding, the production of quinoa grains and, recently, on tourism. Here, important concerns are related to land-ownership, resource royalties, local benefit-sharing from industrial mining, a potentially serious water crisis and environment damage from toxic chemicals and insufficient lithium waste-management [38][35].

One of the top priorities in all three countries in the lithium triangle (Chile, Argentina, Bolivia) is the development of local value chains, though the countries have different starting points and follow different approaches. After the crisis years in Argentina, a predominant goal is to rebuild confidence among foreign investors and create attractive conditions on the issues of export taxes, harmonizing tax regulation, standard royalty rates, and access to information on land claims. Forecasts predict a strong expansion of lithium production in Argentina until 2027 [39].

Bolivia, blessed with the world’s largest single lithium resource in the Salar de Uyuni, wants the entire chain of value-added activities to take place in Bolivia. This shall include battery plants or even car factories in the country. In addition, these projects are required to have a majority state ownership [40]. Following a recent tender for the construction of a lithium carbonate production plant at Salar de Uyuni, three companies from China, Spain and Germany have applied. Bolivia has announced plans to invest nearly $1 billion in a plant at Salar de Uyuni and to start construction already in 2018 [41]. A large battery factory is to be built nearby, which shall be operated as a joint venture with foreign companies. Particularly Chinese companies hope to win the bid [42].

In Chile, licenses are granted by the Chilean economic development agency Corfo. Since lithium is considered a strategic resource, the award of mining licenses is managed restrictively. Around 20%[13] of Chile’s annual lithium production shall be allocated to lithium manufacturing projects inside of. With this goal in mind, Corfo invited bids in 2017 for the production of lithium cathodes, metallic lithium or other lithium compounds within Chile. Three Chinese, one Russian, one South Korean, one Chilean and the Belgium company Umicore advanced to a short list; final decisions are still pending [39]. The processing companies will be offered favourable lithium supply contracts over a period of about 27 years. The related lithium mining will be done by Rockwood Litio which is part of the Albermarle corporation at the Salar de Atacama [43].

# 4. Cobalt

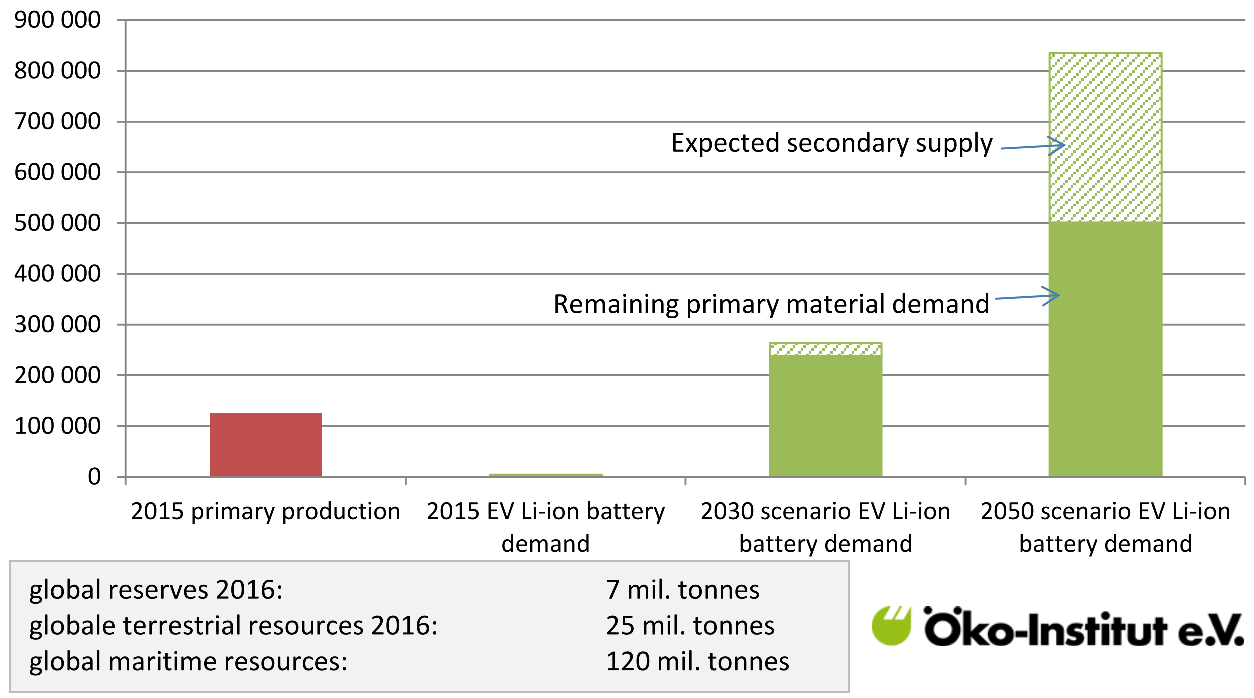
## 4.1. Global cobalt demand for electric vehicle deployment

The scenario presented in Chapter 2 indicates a significant uptake in EV sales in the future. Figure 6 shows the corresponding increase in cobalt demand needed to produce batteries for the vehicles. By 2050 the estimated demand could be as high as 800,000 tonnes compared to 2015 primary production of 126,000 tonnes. Demand is expected to already exceed current primary production by a factor of two as early as 2030. As already described in the chapter on lithium, recycling can only contribute to a small extent to the rising demand in 2030, because the amount of cobalt in the waste streams will still be limited. In 2050, a mature e-mobility sector will probably provide more end-of-life material available for recycling.

[13] 16,000 t Li carbonate which equals 3,000 t Lithium

Figure 6 only includes the projected cobalt demand for batteries for electric vehicles. The total cobalt demand is even higher when taking into account battery applications in IT, power storage or electric tools. Moreover, cobalt is used in other applications like super alloys, hard metals, catalysts and magnets. Nonetheless, EV batteries will remain the dominant application in the mid and long-term perspective since annual growth rates for EV demand are forecasted at around 25% in the next 15 years.

**Figure 6: Global cobalt demand for lithium-ion batteries in electric vehicles (in tonnes)**




Source: [10] [4] [44]; hatched lines = secondary material usage

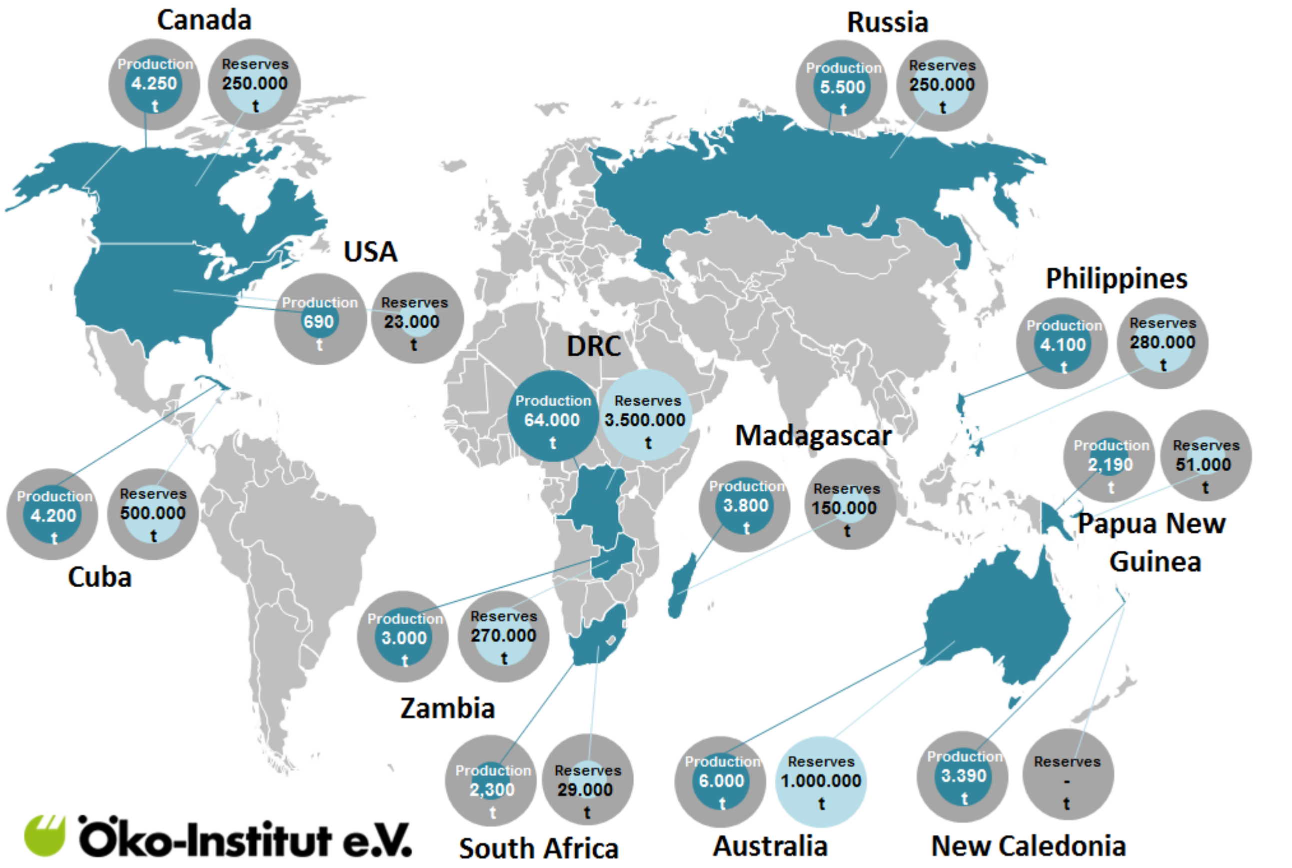
Cobalt is used in the battery types NMC (mainly) and NCA which are preferably used for e-vehicles due to their high energy density and are expected to dominate the future market. The high cobalt price and potential supply bottlenecks have led to intensive research into reducing the amount of cobalt. This development is taken into account in the scenarios[14], however there is still research underway on further optimising resource efficiency.

## 4.2. Global cobalt supply situation

Figure 7 visualizes the main primary cobalt producing countries and the main reserves.

[14] The scenarios assume that NMC will have the largest share in all electric vehicle types. The resource efficiency for cobalt has been increasing when shifting from NMC 1:1:1 technology (molecular ratio: 1 share nickel, 1 share manganese, 1 share cobalt) to a share of 6:2:2. Future generations might use 8:1:1 technology using even less cobalt. This technology is not included in the scenarios because it remains to be seen whether a broad application will be feasible.

## Figure 7: Main cobalt primary production and reserves in 2016

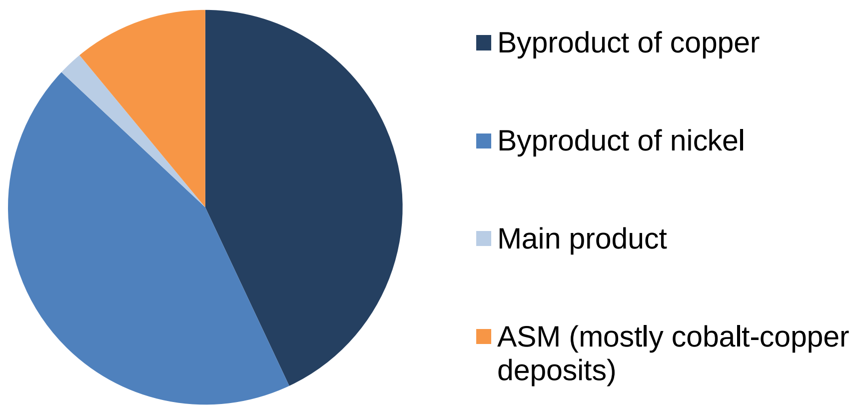



Source: Data based on [17]

### *Current primary production*

Cobalt is mainly mined in large scale operations as a by-product of copper (43%) and nickel (44%) extraction. Currently only one modern large scale mining operation (Bou-Azzer, Marocco) is extracting cobalt as the main product contributing to roughly 2% of world production. The remaining production of around 11% is extracted by artisanal and small-scale miners (ASM) mainly in cobalt-copper deposits in the DRC [45] (see Figure 8).

## Figure 8: Cobalt supply by type of mining in 2015




Source: [45]

In 2016, the global primary production was 110,000 tonnes, with almost 60% (64,000 tonnes) from the DRC. The remaining production was distributed among a variety of countries with the most important being Australia (6,000 tonnes) and Russia (5,500 tonnes) [17]. Further volumes in the range of 2,000 to 4,500 tonnes were mined in Canada, Cuba, Philippines, Madagascar, Zambia, New Caledonia, South-Africa and Papua New Guinea [10], and in Finland (2,500 tonnes) [46]. In the DRC, ASM plays an important role with a contribution of around 20% to the country's cobalt output [47]. Accordingly the ASM production of 12,000 tonnes in the DRC alone surpassed the primary production of any other country [10]. Small amounts of cobalt were also mined as a byproduct of nickel in New Caledonia, an overseas territory of France.

A small number of companies dominate the market. The large scale mining company Glencore produced 28,300 tonnes of cobalt (ca. 25% of world production), mainly from Katanga (Southern DRC) and is the major cobalt producer [48] followed by mining sites which are also located in the south of the DRC and operated by China Molybdenum (8%), Fleurette Group (7%), Vale (5%) and state-owned Gécamines (4%) [49]. Increasing Chinese investments have resulted in Chinese companies together accounting for 24% of total mine production in the DRC in 2016 [50].

The global refining capacities are dominated by China (46%). Around 23% of global refining capacities are installed in Europe, mainly in Finland[15] (12,000 tonnes), Norway (3,500 tonnes), and Belgium (6,000 tonnes). Russia, one of the world's biggest producers of nickel, had a refined cobalt production of around 5,500 tonnes in 2016 [17].

### *Reserves, resources and future primary production*

Current global reserves of 7 million tonnes [10] are only 9 times as high as the projected annual cobalt used for batteries in 2050. From the 7 million tonnes of global reserves, 50% are located in the DRC, followed by Australia with a share of 17%. The authors are aware that this simplified calculation does not consider more detailed specifications, e.g. the required chemical compound or the required purity in the end product. Nevertheless, the calculation gives us a first idea of the challenges in the cobalt sector.

More than 25 million tonnes of terrestrial cobalt resources have been identified, mainly associated with copper-/nickel containing ores [10]. Roughly two thirds of the terrestrial resources are located in the DRC [51]. Since global copper and nickel explorations are ongoing, these activities will probably also increase cobalt reserves.

Additionally, more than 120 million tonnes of cobalt resources are identified in manganese nodules and crusts on the floors of the Atlantic, Indian, and Pacific Oceans [10].

Looking at Europe, the Geological Survey of Finland (GTK) estimates 113,000 tonnes cobalt reserves and 370,000 tonnes cobalt resources to be contained in the three Finnish mines which already produce cobalt [46]. In addition, no significant cobalt reserves in Europe (not including Russia) were reported by recent publications from USGS, BGS and Minerals4EU [52] [53] [17]. However, they point out that promising cobalt resources have been identified in Slovakia (Dobsina, Kolba), Finland (Jouhineva) and Sweden [54][55], and additional cobalt resources are known of in Germany and Norway [55]. The European Strategic Action Plan on Batteries also announced the mapping of potentials in Finland, France, Sweden, and Slovakia [23]. For Russia, USGS has reported cobalt reserves of around 250,000 tonnes [17].

The reserve figures show the outstanding role of the DRC for the future cobalt supply in the short, mid and long term. It is to be expected that the share of cobalt coming from the DRC will further increase significantly. Glencore announced that it would double its cobalt production in the next two years in the Katanga project in the DRC. According to current projections, this would give Glencore control of about 40% of the world cobalt supply. [56]. The DRC's market share may rise to 73% by 2025 [57] [58].

### *Recycling material – Secondary production*

Since the high value of cobalt makes recycling profitable, cobalt has already been recycled from catalysts, super alloys and batteries. An input of approximately 35% secondary cobalt across all applications can be estimated [4]. European lithium-ion battery recycling with the recovery of cobalt is already taking place e.g. in Belgium (Umicore), Germany (Accurec, Redux/Saubermacher), Switzerland (Glencore, Batrec Industrie), and Finland (AkkuSer Oy) [59].

Nevertheless, the current amounts of cobalt being recovered from waste streams are small compared to the expected upcoming demand for batteries. Thus recycled cobalt currently cannot supply high shares of the

[15] Freeport Cobalt Oy in Finland is the world's biggest single producer of battery chemicals, although most of the raw material is currently coming from the DRC. Norilsk Nickel Harjyvalta Oy produces around 1000 tpa cobalt phosphate from imports from Russian Norilsk plants and from other sources.

upcoming demand for batteries in the near future. The scenarios assume that secondary cobalt production will gradually increase along increasing cobalt content in battery waste streams and supply around 40% of the cobalt used for batteries in 2050[5]. This requires the development of comprehensive collection systems and recycling worldwide.

***Supply bottlenecks***

Current global battery cell production is highly dominated by Asian (China, Japan, Rep. of Korea) companies. In order to reduce European dependency on Asian cell suppliers, various European manufacturers are planning to enter European cell production [60]. A stable cobalt supply is a major challenge here. Firstly, the sharp rise in the price of cobalt in recent years is an important issue. Cobalt prices increased significantly from between US$20,000/t and $30,000/t in 2016 to $90,000/t in May 2018 [61] [62]. Calculated with a cobalt price of $90/kg (May 2018) the cobalt used in a mid-range battery electric vehicle (BEV) with optimized cobalt content would be around $1200[16], not including losses in battery production. Since alternative battery types with similar performance need further time for development, there is little potential for immediate substitution of cobalt. However, a further reduction of the cobalt content in batteries coming from further technology development[17] might ease the tense demand situation.

Secondly, there are also serious concerns about possible bottlenecks. The current as well as the future cobalt production is highly concentrated: it is dominated by the DRC with its ongoing political instability and by only a few mining companies. The same applies to global refining which is dominated by Chinese companies supplying mainly Chinese downstream manufacturers. S&P Global forecasts a mine production of around 219,000 tonnes in 2022 [61], and further mining production capacities will be required if global e-mobility actually picks up speed (see Figure 6). Another bottleneck might arise from the rapid need for increasing smelting and manufacturing capacities and the time span needed for the installation.

The situation is exacerbated by the challenging framework conditions. European future cell producers not only have to implement the mass production of a new technology, they also have to build up a stable network of suppliers and compete with longer established companies for raw materials.

## 4.3. Social challenges

### 3.3.3. Child labour

The biggest social challenge in the cobalt supply chain is child labour in the ASM sector, which accounts for around 20% of production in the DRC [63]. Globally, ASM has thus achieved a share of around 10%. Through publications by Civil Society Organisations (CSO), in particular through the publication of the 2016 Amnesty study "That is what we die for", large downstream companies from the automotive and IT industries have come under strong public pressure to ensure that their supply chain is free of child labour.

It should be noted that cobalt deposits are mainly located in the south of the DRC and should not be confused with conflict minerals that are being mined in the east of the country [63].

The OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas is an internationally recognised guideline for the responsible sourcing of conflict minerals but is also widely accepted as a framework for the sourcing of cobalt. The forthcoming EU directive on conflict minerals does not cover cobalt as it is not a "conflict mineral". Nevertheless, the public pressure on the big downstream companies and their self-interest in a good reputation is so great that they are looking for ways to deal with the issue.

At a first glance, the easiest way to do this is to avoid purchasing cobalt from the DRC. However, this is not a realistic scenario, as around 50% of cobalt is currently supplied by the DRC, with an even larger share in the future. Moreover, this strategy is accused of being purely greenwashing and not mitigating the real problems in the DRC. In addition, it is probably not possible to exclude cobalt from ASM and from child labour from any supply chain since there is a lot of informal trade. The alternative strategy, which is becoming increasingly considered by downstream companies, is an active involvement in the DRC to improve local working conditions in ASM and to eliminate child labour by supporting children and their families (stable household incomes, education etc.) in the context of holistic approaches. However, this poses major challenges

[16] For a 30 kWh battery, type NMC 6:2:2, the calculation only includes the value of cobalt in the battery and does not reflect the costs of cobalt losses in the processing and manufacturing steps.

[17] E.g. shift from NMC 6:2:2 technology to 8:1:1 technology will reduce cobalt demand.

because the situation in ASM has to be seen in conjunction with many other factors. Nevertheless, the target must be the engagement for children and their families and not merely child labour-free sourcing.

The DRC still ranks among the poorest countries in the world, at position 176 out of 187 countries (2015 UN Data) [64] and ASM is an essential source of revenue for up to 150,000 ASM workers in the regional cobalt mining [47]. Though ASM only has a 20% share in DRC production, it creates many more jobs than large scale mining (LSM). For comparison, Glencore, the largest cobalt producer in the DRC provides only a total of 15,000 jobs including subcontractors in all of its operations in the DRC [65]. Some of the ASM workers are local farmers which work in mining besides farming, sometimes with their whole family including children. Schools are often not available. Parallel to the mining by locals, many migrant workers hope to benefit from the cobalt "rush".

Mostly this kind of operation is carried out informally without a mining permit. Insufficient work safety standards lead to injuries, deaths and long-term illness of the mine workers. In particular the near surface underground mining in handmade shafts and tunnels is very dangerous since the shafts can collapse and bury workers beneath them. Dust from the operations can cause harm to the lungs and become a long-term health problem. [66] [47].

The DRC government has failed to enforce the ban on child labour and the 2002 Mining Code which principally addresses artisanal miners in both environmental and social terms. This goes along with a very low governance performance and high corruption[18]. More details can be found in the STRADE country report on the DRC [68].

Numerous traders – mainly Chinese – and the Chinese company Huayou Cobalt with its Congolese subsidiary CDM operate along the supply chain within the DRC. Due to the numerous small and frequently illegal dealers, which mostly sell cobalt ore to China, the market is very intransparent. So it is hardly possible to obtain cobalt without child labour via this channel [69].

Huayou Cobalt plays a decisive role as the largest player with its own smelter in the DRC and obtains up to 30% of its cobalt from ASM [70]. Following negative headlines in the 2016 Amnesty report, the Group adopted new supplier due diligence policies and has taken initial steps towards more responsible sourcing of ASM cobalt by CDM according to the 2017 Amnesty report. Huayou Cobalt further reports on the building of a school, having an agricultural education project and providing infrastructure for local communities. It is also one of the founding members of the Responsible Cobalt Initiative (see Chapter 5) [71].

Surveys conducted by Amnesty for the 2017 report have shown that most manufacturers of batteries and battery components – the majority is located in China – have made little effort to achieve human rights due diligence. Things look a little better for electric vehicle manufacturers, but most of them have shown only minimal to moderate efforts. 2018 CNN interviews with car manufacturers give the impression that they are now initiating due diligence schemes very seriously. BMW is even considering buying cobalt directly from miners to avoid child labour [72]. As mentioned before, such approaches can be promising if they include an active involvement in the DRC to improve local working conditions in ASM and support families in achieving stable household incomes without child labour. More detailed information on the challenges in ASM and the need for holistic approaches within the context of integrated rural development is discussed in the STRADE policy brief on the artisanal and small-scale mining (ASM) sector and its importance for EU cooperation with resource-rich countries [73].

#### 3.3.4. Other social challenges and efforts for positive impacts

As described in more detail in the STRADE Policy Brief 05/2016, the LSM sector principally also faces various socio-economic challenges. For this reason, CSOs such as Amnesty demand that a monitoring of human rights violations also take place for LSM and that due diligence efforts are not limited exclusively to ASM. An example for LSM and the challenging business environment in the DRC is the case of Glencore, which accounts for 27% of global cobalt production in 2016, of which over 84% is produced in the DRC [50] and which has to contend with accusations of corruption and bribery [74] [75]. More details are given in the STRADE country case study on the DRC [68]. Nevertheless, experts point out that LSM operations in the DRC mostly try to follow responsible mining principles.

An important issue set out in the Africa Mining Vision is the creation of higher value-added shares in African mining countries. Within the DRC, basic prerequisites for industrial value creation remain weak, from infrastructure (transport & energy) to a skilled labour force and capital markets. While the political situation in

[18] The DRC belongs to the seventeen states with the lowest World Bank government effectiveness indicator and the thirteen states with lowest World Bank corruption control indicator [67].

the country remains tense (President Kabila must step down by December 2018 for new elections to take place), the government has made attempts to encourage value-added activity in its mining sector. This has largely been done through the 2018 amendments in the Mining Code, which demand local supplier development by large mining companies. From requirements to source materials and services from Congolese companies, to payments to fund research centers, the DRC government is attempting to use its natural resources to develop industrial capacity. However, the success of this endeavor remains to be seen.

Probably, a large number of development assistance projects addressing ASM and the corresponding communities will be set up in the near future, initiated directly or indirectly by global downstream companies in order to take responsibility for improved local conditions. It is an important task for companies and governments, both from the DRC and from the countries of origin of the downstream companies to develop joint integrated concepts. An uncoordinated coexistence of many diverse projects will not be useful to the common goal. Since the EU is the home region of various big car manufacturers, support in coordination is also a responsibility of the EU. This also includes considering concepts for the post-mining phase.

## 4.1. Environmental challenges

### 3.3.5. Terrestrial mining

Large scale mining of cobalt as a byproduct from **copper deposits** mainly takes place in the DRC and Zambia [76]. Typical environmental challenges in this type of operation are the occurrence of sulfidic minerals posing a risk of generating acid rock drainage (Acid Mine Drainage – AMD) (compare STRADE Policy Brief 04/2016) [76]. Toxic pollution is inherently connected to cobalt mining since the ore is associated with various heavy metals [77]. Case studies in the Zambian Copperbelt indicate that heavy metal pollution is highest in the direct vicinity of mines and that they are transported within larger areas by rivers [78].

Cobalt mined as a **byproduct of nickel** is mostly extracted from magmatic sulphide deposits in e.g. Russia, Australia and Canada. Due to the sulfidic nature of the deposits, a potential for AMD exists. Almost all of the cobalt mined in Russia comes from Norilsk. The reports on the Russian companies' environmental performance are ambivalent. On the one hand, Norilsk was rated as one of the most polluted places in the world around one decade ago [79][80], particularly due to the very high toxic air emissions. Recently, the media further reported on leakages into a river which occurred in 2015 and were untransparently handled [81]. On the other hand, Norilsk closed its nickel refinery to reduce air pollution. Following the closure, the company received an environmental award [82]. In the coming years the management plans to spend one billion Euros to enhance Norilsk's environmental performance and to reduce $SO_2$ emissions by 75% by 2023 [83].

### 3.3.6. Deep sea mining

The resources of cobalt in the sea are much larger than those on land. With higher cobalt prices some of them might become economically feasible. The most important kinds of sea deposits concerning cobalt are a) manganese nodules that are located at depths between 3500 and 6500 meters and b) cobalt crusts on the flanks of seamounts at depths of 800 to 3000 meters. Both types of deposits are usually polymetallic[19]. Cobalt grades in the nodules are on average 0.15 - 0.25% but can reach up to 2.5% according to the Cobalt Institute – for reference, typical economic grades on land resources are between 0.1 and 0.4% Cobalt [84][85].

Deep sea mining of ores has so far been limited to exploration, but in 2019 the first commercial project, the Solwara 1 project of the Canada-based company Nautilus Minerals aims to start mining copper and gold from poly-metallic sulphides at a depth of 1500 meters in the national Exclusive Economic Zones (EEZ) of Papua New Guinea, provided that sufficient financing is available [86]. Japan plans to enter deep sea mining in its EEZ in the mid-2020s [87]. Namibia has already been mining diamonds in its EEZ for many years[20]. Critics argue that the environmental damage is unpredictable and fear massive damage to the sensitive and largely unexplored marine ecosystems with their long-lasting regeneration processes. The concerns relate on the one hand to biodiversity and on the other hand to a potential negative impact on the $CO_2$-uptake of

[19] Manganese nodules consist mainly of manganese, nickel, copper, cobalt, molybdenum and rare earths; cobalt crusts of manganese, nickel, cobalt, iron, platinum, rare earths, tellurium. A third kind of deposits, the massive sulphides (= polymetallic sulphides, consisting of gold, silver, copper, zinc etc.) has no relevance as cobalt resource.

[20] Namibia started offshore exploration in 1990s. Nowadays, around 90% of Namibia's diamond revenues come from sea bed mining with 50% state ownership [88]

the seas which occurs through micro-organisms, making oceans an important carbon sink and indispensable for global climate protection [89] [90] [91]. The concerns regarding climate change impacts mainly relate to potential future deep sea mining on a large scale in various areas, whereas concerns about biodiversity losses highly depend on the location. Following these principal arguments, the European Parliament called for a moratorium on deep sea mining in January 2018 [92].

Different to the regulation of the nations' Exclusive Economic Zones, the UN Convention on the Law of the Sea (UNCLOS) regulates – among other things – the world oceans' deep sea beds outside of the Exclusive Economic Zones (200 - 350 nautical miles off the coast) which are regarded as common heritage of mankind and not subject to sovereign rights. The focus is the exploration and exploitation of the resources that benefit all, provided that the activities are carried out in an environmentally compatible manner. The administration is subject to the International Seabed Authority (ISA) which can award exploration and mining licences to states or companies sponsored by states. To date, 27 exploration contracts have been approved but no exploitation license granted. ISA is currently developing a mining code. Advocates for strict environment regulations complain about too little transparency in the ISA processes and call for stricter regulations [93][94][95].

European companies see their position in future deep sea mining primarily as technology and equipment suppliers and have an interest in establishing themselves as market leaders. In this context, the industry is committed to environmentally compatible mining and calls for political support for technology development. The European Innovation Partnership (EIP) lists several European research projects on deep sea mining, and Member States such as Germany have also launched framework programs [96][97]. Some European countries also hold ISA exploration licenses[21].

## 5. European and international engagement in sustainable battery value chains

Awareness of the social and environmental challenges along the battery supply chains – particularly for lithium and cobalt – has risen sharply globally and has led to a number of European and international initiatives. Six of them are briefly outlined:

- The EC launched the **European Battery Alliance** in October 2017 as a cooperation platform with key industrial stakeholders, interested Member States and the European Investment Bank. Its **Strategic Action Plan on Batteries**, published in May 2018, aims to put Europe on a firm path toward leadership in a key industry for the future [23]. The Strategic Plan describes some tasks on the subjects of recycling, resource efficiency and substitution. For responsible sourcing of primary raw materials, it still remains very vague. It points out as a key action to *use all appropriate trade policy instruments (such as Free Trade Agreements) to ensure fair and sustainable access to raw materials in third countries and promote socially responsible mining.* Additionally, it announces upcoming work on the key determinants for the production of sustainable batteries. More details shall be provided on the *promotion of the batteries industry in the first quarter of 2019.*
- In February 2017 the automotive partnership **'Drive Sustainability'** was launched. The group on ethical sourcing of raw materials of ten global car manufacturers including the manufacturers BMW, Daimler, Volkswagen, Ford, Toyota, Honda and Volvo aims to work together in supply chain due diligence. One main target is the standardization and harmonization of supply chain approaches [98].
- In September 2017, the **Global Battery Alliance** was launched. This public-private coalition includes large upstream companies and mineral traders, downstream companies from the ICT and the automotive sector, international organizations (including the OECD and the Chinese CCCMC) and NGOs. It aims at creating a responsible value chain for the fast-growing battery market powering the technology and clean energy revolution. [99]
- In November 2016, the Chinese CCCMC launched the **Responsible Cobalt Initiative** (RCI) with support from the OECD. In 2017, the RCI had 24 members including Apple, BMW, Dell, HP, Huawei, Sony, Samsung SDI, LG Chem, Hunan Shanshan, L & F, Tianjin B & M and Huayou Cobalt. Recently, the Chinese battery manufacturer CATL also became RCI member. The initiative aims at addressing environmental and social risks along the cobalt supply chain with the elimination of child labour as one of its primary goals. It is currently developing an auditing scheme and considering local development projects in the DRC.
- The **Responsible Minerals Initiative** (RMI), formerly known as the conflict-free sourcing initiative, also develops tools for due diligence of cobalt and seeks to publish a reporting template with a list of global

[21] UK, Belgium, Germany, France, Bulgaria, Czech Republic, Poland and Slovakia [85]

cobalt refiners [100][101]. The RMI has more than 300 members; among them are large European car manufacturers.

- The **Cobalt Institute,** with members active in LSM of cobalt and cobalt chemical production, also develops due diligence frameworks. The Cobalt Institute has no Chinese members apart of one company from Hong Kong [102].

This brief list shows that there are already a number of activities and initiatives in the battery value chain, in addition to the numerous general commodity-wide initiatives and commodity partnerships. It is encouraging that there is a high level of awareness on the subject; now the great challenge lies in the successful coordination and implementation of responsible sourcing with positive impacts on the ground.

# 6. Conclusion & Recommendations

The global transition to a fossil-free future will increase the demand for many metals and minerals to varying degrees. This policy brief addresses one specific aspect within this broader picture: the rapidly increasing raw material demand for batteries for electric vehicles and related challenges. This issue was chosen because of the intense discussions on the European level and its strategic relevance for the European industry. The largest concerns are expressed regarding lithium and cobalt in the supply chain of lithium-ion batteries; therefore the policy brief focused on these two metals.

### *Stable supply from European and non-European primary sources*

As new players, the future European battery cell manufacturers face the great challenge of building up a stable network of suppliers. In view of the tense demand situation, the many technological challenges and global competition for battery raw materials, this is an ambitious project. The highest supply risk lies with cobalt where production is concentrated mainly in the politically unstable DRC and only a handful of companies producing the main output. It is an important task of the EU and its Member States to support EU companies in raw material sourcing for cobalt and other battery materials. At European level, the European Battery Alliance forms the basis for joint action. In the case of lithium, the existing EU raw material partnerships with Argentina and Chile can also be used for political support. Russia is an important nickel supplier for the EU and a deeper cooperation for EU's nickel and cobalt supply might be considered.

Exploration and mining efforts – particularly for lithium, cobalt, nickel, graphite and manganese – within the EU should be strongly supported and promoted, although considerable quantities of imports would still be necessary to meet the EU's primary demand and feed the EU's existing and upcoming refining capacities. Besides the reduction of import-dependency, mining within the EU offers the big advantage of originating from responsible sourcing, and provides EU companies the opportunity to develop advanced and environmentally-friendly technologies that can also be applied to improve the global mining sector.

### *Stable supply from secondary sources*

Due to the high demand pressure on primary production, all measures to reduce the demand for primary battery raw materials mitigate potential supply shortages. These include recycling, substitution and greater resource efficiency; Europe can draw on extensive know-how and competence in technology development in all three fields. EU and national funding is an important tool here, and EU and MS R&D funding should be continued.

Particularly the collection and recycling of end-of-life batteries is a must for avoiding pollution and massive environmental challenges and for realizing the circular economy approach. For the time being, there is a time-lag of about 10 years before batteries reach their end of life and are available for recycling. Due to this time lag, it may be difficult for commercial companies to spend sufficient money in the short term on R&D on recycling. EU and governmental institutions should fill this gap and sponsor the R&D at universities and other organizations in the meantime.

The revision of the battery directive offers the opportunity to set material-specific recycling targets. A binding target for lithium recycling would strongly support the broad implementation of lithium recovery. The EU should also develop an efficient recycling procedure to make sure that there is as little "drain" of recycleable batteries as possible outside the EU, similar to WEEE regulation. This should be done in cooperation with the battery and car producers.

### *Closer EU-Africa cooperation*

This policy brief underlines with the example of cobalt from the DRC the linkage between African and EU raw material flows. As already expressed in other STRADE documents, STRADE proposes more intensive dialogues and cooperation with Africa and the alignment of the African Mining Vision and the EU Raw Materials Initiative (RMI).

### *Cooperation with Russia*

The policy brief has also shown the high relevance of Russia for EU's current nickel supply and the potential for increasing cobalt imports from Russia. A better EU-Russia relationship and raw material diplomacy with Russia should be considered.

### *Cooperation with Latin America on extended lithium value chains in mining countries*

The countries of the Latin American lithium triangle are very interested in building up further shares in the battery value chains in their countries. The EU should support these efforts with partnership approaches (technology development, financing, economic cooperation).

### *Lithium extraction from brines with high water and resource efficiency*

Lithium extraction from salt lakes (brines) currently accounts for around 50% of global lithium production and is mostly located in Latin America. The biggest challenge is to make the extraction process water- and resource-efficient, so that the surrounding arid ecosystems in the Andes are not severely affected. When traditional evaporation technology is replaced by advanced closed-loop technology, water loss is drastically reduced and the recovery rate of lithium increases significantly. These technologies are already in the pilot stage. STRADE recommends that the EU support technology development and application in partnerships with local companies & academia. This also includes support for extensive environmental impact assessments and local stakeholder and community participation, which should be carried out carefully despite high demand pressure calling for fast action. In particular, STRADE proposes an EU-Latin America working group which initiates the international development of a "best available techniques" guiding document for lithium extraction from brines.

### *Responsible sourcing of cobalt*

Currently, the pressure on downstream companies is high to ensure that cobalt is mined without child labour. Various large manufacturers are developing due diligence strategies based on the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas, and there are already several European and international initiatives to this end. It is recognized that the goal is not to avoid artisanal small-scale mining, which is an essential source of income, but to create better local conditions for small-scale miners and the communities concerned. Many large downstream companies along the battery value chain are expected to become involved in development projects in the DRC over the next few years. This commitment is an important element of responsible sourcing efforts. However, it is important that the un-coordinated coexistence of numerous development assistance projects in the DRC is avoided. Development cooperation has always been faced with the difficulty of coordinating various international donors. This is made even more difficult by the commitment of companies in the DRC which are new players in this field. It is therefore an important task of the EU to coordinate the activities of EU companies within the framework of the European Battery Alliance and the regional European and MS embassies. On the part of the European automotive industry, the Drive Sustainability initiative should play a coordinating role for its member companies. It is also vital that all European actors involve local authorities, the DRC government and local civil society.

The upcoming EU conflict mineral legislation regulates the EU imports of conflict minerals, but not of cobalt. STRADE proposes to collect experience from this approach and to monitor which due diligence tools perform best in the field of conflict minerals. After this analysis it remains to be discussed whether a legally binding approach for cobalt supply chains might be a useful tool and it should be checked whether local development projects already lead to significant changes on the ground. In the meantime, STRADE suggests that the European partnership for Responsible Minerals (EPRM) include cobalt in their scope in the short term.

## Project Background

The Strategic Dialogue on Sustainable Raw Materials for Europe (STRADE) addresses the long-term security and sustainability of the European raw material supply from European and non-European countries.

Using a dialogue-based approach in a seven-member consortium, the project brings together governments, industry and civil society to deliver policy recommendations for an innovative European strategy on future EU mineral raw-material supplies.

The project holds environmental and social sustainability as its foundation in its approach to augmenting the security of the European Union mineral raw-material supply and enhancing competitiveness of the EU mining industry.

Over a three year period (2016-2018), STRADE shall bring together research, practical experience, legislation, best practice technologies and know-how in the following areas:

1. A European cooperation strategy with resource-rich countries
2. Internationally sustainable raw-material production & supply
3. Strengthening the European raw-materials sector

## Project Identity

| | |
|---|---|
| **Project Name** | Strategic Dialogue on Sustainable Raw Materials for Europe (STRADE) |
| **Coordinator** | Oeko-Institut; Doris Schueler, Project Coordinator, d.schueler@oeko.de |
| **Consortium** | |
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| **Website** | www.STRADEproject.eu |

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