



TREND  
RAIL

# Popular Among Industry, Civil Society and Public Authorities, Rail Continues its Expansion

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Trains play a sometimes-ambiguous game. On the one hand, their low carbon intensity makes them the preferred target of public policies for a modal shift, whether for short (urban rail) or long distances (high-speed lines). On the other hand, coal, metals and the various goods they transport are sometimes closely linked to industries that emit large amounts of carbon dioxide. China, in particular, continues to develop its rail network, deploying transport infrastructure around the world, and increasing its economic and political influence.



## DATA OVERVIEW

### Having reached the limits of efficiency, rail transport wages its bets on electrification and renewables to reduce carbon emissions

"High speed, low carbon"<sup>a</sup>. The French national rail company (SNCF) best known for its high-speed trains (TGV) has got the message: in a social and economic environment increasingly concerned about its carbon impact, the future may lie on the railway track. In fact, as a means of passenger transport, trains emit some of the lowest levels of greenhouse gases (GHG): on average, a train's carbon intensity is around 15 gCO<sub>2</sub>e<sup>1</sup> per passenger-kilometre<sup>b</sup>, less than a tenth of that emitted by large cars and planes<sup>2</sup>, with similar efficiency levels for transporting freight. While railways represent about 9% of the global transport of passengers and 7% of global freight, trains only total 2% of energy demand from the transport sector, and 1.3% of its direct CO<sub>2</sub> emissions<sup>3</sup>. In 2019, direct global emissions from rail transport amounted to 101 MtCO<sub>2</sub>, a very slight increase compared to 2018 (+0.4%). Taking into account the entire life cycle ("well-to-wheel") of trains and railroads (construction of tracks, tunnels and bridges, manufacture of trains, etc.), these emissions are between three and four times higher.<sup>1</sup>

This performance can be put down to the very high rate of electrification of the global railway network, which has led to a decrease in diesel-operated trains: the percentage of electrified rail tracks rose from 36.7% in 2015 to 40.2% in 2019. For passenger transport, it even reaches 75%<sup>2</sup> (60% in 2000).

In India, despite a slow start for the national railway electrification program, which aims at total electrification of the network (only 600 km having been electrified as of 2013-2014), as reported on 31 March 2021, over 6,000 km were electrified in 2020-2021, taking the total to 45,000 km, which is 71% of the network.<sup>4</sup> The country aims at "carbon neutrality" for its rail system in 2030, through electrification and the use of low-carbon energy. Some trains have been running on bio-diesel since 2015. Urban railway management companies are also moving in this direction: in early 2020, the company that runs the metro rail in the city of Hyderabad announced a partnership with Amp Energy to install a solar park with a total capacity of 7.8 MW to power the metro.<sup>5</sup>

These electrification efforts only have an impact on GHG emissions reduction if they are fueled by low-carbon energy. **Figure 1** shows that a train running on electricity from coal-fired stations emits at least as much as a diesel train. Like India, France (via the SNCF) has set a target of increasing the share of renewables in its rail network: 40% to 50% of renewable energy by 2025. In early 2021, the renewables branch

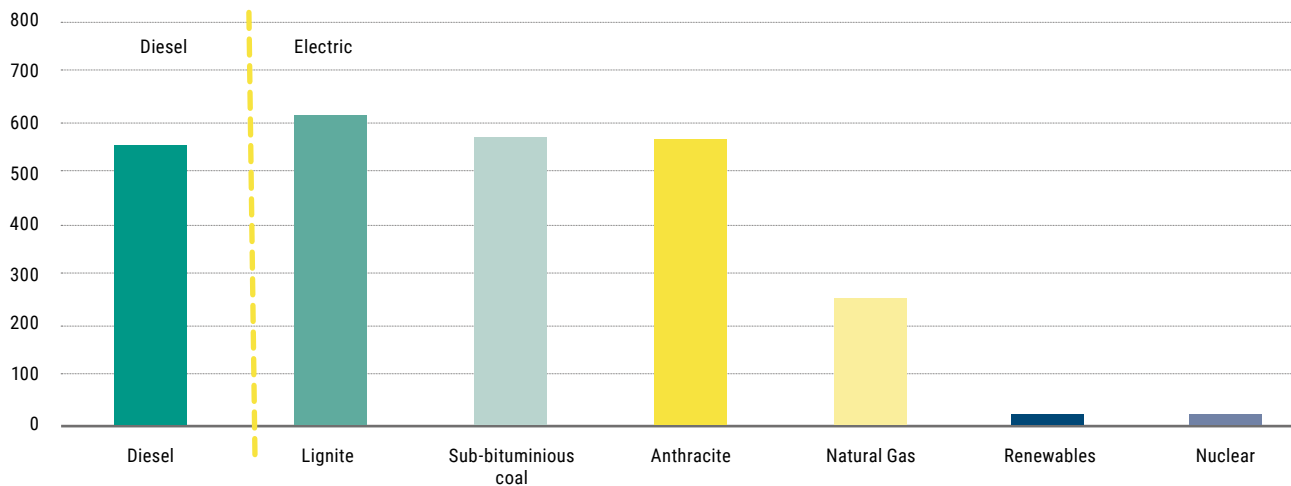
<sup>a</sup> [Advertisement](#) for the SNCF disseminated in France in 2021.

<sup>b</sup> A passenger-kilometre, which corresponds to the transportation of one passenger over one kilometre, is the reference unit to measure the volume of passenger transport. Similarly, a tonne-kilometre corresponds to one tonne of merchandise transported over one kilometre. These units therefore depend on the carbon footprint of the means of transport used and its fill rate (passengers or goods).

**FIGURE 1**

**AVERAGE WELL-TO-WHEEL CARBON INTENSITIES FOR DIESEL-POWERED TRAINS, COMPARED TO ELECTRIC TRAINS USING VARIOUS PRIMARY SOURCES**

Source: IEA, 2021



of Électricité De France (EDF) and the SNCF rail group signed a Power Purchase Agreement by which EDF committed to provide the rail company with production from a 20 MW solar farm for twenty years starting from 2023<sup>6</sup> (see **Energy sector**). The German company Deutsche Bahn has reported that its trains operated with 61% of renewable energy in 2020, and is aiming at 100% by 2038<sup>7</sup>. East Japan Railway, the biggest rail company in the country, has been investing in solar energy since 2013, and has announced new investments in early 2021 to reach carbon neutrality before 2050<sup>5</sup>. After the decommissioning of the country's nuclear power stations that followed the Fukushima disaster in 2011, the share of rail transport in Japan's GHG emissions went from 4.2% in 2010 to 5% in 2015<sup>2</sup>. Lastly, the British company Network Rail is also aiming at carbon neutrality by 2050, while Scotland wants to achieve the same objective before 2035. In total, almost 11% of the energy used to run trains comes from renewable sources<sup>5</sup>.

However, the considerable investments required for electrification can be dissuasive for railway companies and states. To attempt to get around cost problems, the rail sector has started looking at hydrogen. Cheaper than infrastructure work, the industrial development of trains equipped with hydrogen fuel cells could enable a rapid transition from diesel to low-carbon trains because they can operate on non-electrified lines. Although hydrogen production currently emits high levels of GHG, since 2019-2020 it has attracted a great deal of attention, in particular because it can be produced by the electrolysis of water, which, if fuelled by renewable energy, could lead to low-carbon production (see **Industry sector**). Alstom, whose investments we reported on last year<sup>8</sup>, has maintained its position as a market leader. Forty-one of its fuel cell trains, *Coradia iLint*, are to be put into operation in Germany following a two-year pilot phase. This model has already been subject to its first test journeys in Poland, where most trains currently run on diesel<sup>9</sup>. At the start of the year, the French major bought out Helion Hydrogen Power, a French SME covering the entire value chain of high-power fuel

cells<sup>10</sup>. Other examples of the development of hydrogen trains have been observed in India<sup>11</sup>, Spain, Germany, Italy and the Netherlands (see **Signals**). In France, four regions have placed orders with Alstom for dual-mode electric-hydrogen trains to replace dual-mode electric-diesel versions. Operations are due to start in 2025<sup>12</sup>.

Investment capacities were also seriously undermined by the Covid-19 pandemic, which was detrimental to the sector's activities and financial results. In July 2020, the International Union of Railways (UIC) anticipated a 30% drop in global demand for rail passenger transportation over the year. The International Energy Agency (IEA) reported that in India all passenger rail services came to a standstill, along with 60% of freight transport — a pause that nevertheless enabled electrification works to be carried out. In Europe, rail operators registered financial losses of 2.5 billion dollars at the height of the first lockdown from January to April 2020, and losses of up to 19 billion dollars for Asian operators<sup>13</sup>. Over the whole year, the SNCF lost 14% of its turnover (-6.8 billion euros) and saw its operational margins dissolve<sup>14</sup>, despite an emergency support plan of 4.7 billion euros from the French state and exceptional measures (furlough, investment postponements, etc.)<sup>15</sup>. Deutsche Bahn, the other major European rail operator, announced losses of 5.7 billion euros in 2020 due to movement restrictions<sup>16</sup>. East Japan Railway lost 41.4% of its revenues over the 2021 financial year that ended in March<sup>17</sup>.

The American continent accounts for one-third of the world's railways (32% in km), but only 2% of passenger traffic<sup>18</sup>. The main operator, Amtrak, saw a 97% drop in passenger numbers during the first months of the pandemic, before going back to two-thirds of its pre-Covid level this summer<sup>19</sup>. Freight rail transport is, on the other hand, highly developed in the United States, mainly operated by the American Railway Association. Loads decreased by 12.9% from 2019 to 2020<sup>20</sup>, with a shift from raw materials like coal towards manufactured goods<sup>21</sup>.

In contrast, the economic rebound in Asia enabled operators to cover their losses, sometimes even exceeding the previous year's performance in the freight sector. Indian Railways, for example, the biggest rail company in the world, recorded over 5.1 billion dollars<sup>c</sup> of loss in income from passenger transport, but saw its annual freight revenues increase by 2% from 2019 to 2020<sup>22</sup>. China Railway also increased its gross revenues by 14.6% over the whole year<sup>23</sup>.

Despite the effect of the pandemic, which generated a 11% drop in rail emissions in 2020 according to Enerdata, investments in decarbonization are not enough to compensate the structural increase in rail emissions over recent years (+13% between 2015 and 2019 according to Enerdata), in particular when taking their life cycle into account. This increase is related to the massive expansion of the rail network and railway activity at the global level, on every front: passenger transport, freight, and urban rail.

This expansion is sometimes the result of policies aimed at encouraging rail instead of other more emitting forms of transportation. The European Union declared 2021 the "European Year of Rail" and is organizing a series of initiatives to develop rail usage<sup>d</sup>. Night trains are even making a gradual comeback on the continent, after being dropped years ago (see **Signals**). To encourage the modal shift, the new French "climate law" adopted in early summer 2021 abolishes domestic flights for journeys where a train alternative under 2 hours and 30 minutes exists. Whether it involves conventional rail, high-speed or urban trains, the climate benefits of the modal shift towards rail will depend on several factors (construction work and materials used, operation by diesel or low-carbon electricity, user numbers, etc.) and in some cases could even turn out to be nil<sup>24</sup>.

For several years, the vast majority of rail expansion has been at the initiative of a single country: China. Spurred by a strategy to boost its economic growth and geopolitical influence, China has been rolling out new passenger and freight transport lines in its own territory and around the world, without showing any real volition for a modal shift that would benefit the climate.



## THE OBSERVATORY'S LENS

### China sets the world on its tracks

#### China chugging ahead in rail activity growth

In 2018, the volume of passengers traveling by train exceeded four billion passenger-kilometres, 6% more than in 2016<sup>2</sup>. That is around 8% of motorized transportation of passengers in the world, concentrated in a handful of countries: 90%

of passenger rail transport takes place in India, China, the European Union and Japan<sup>24</sup>. Its growth has been largely driven by the roll-out of high-speed and subway networks, in particular in China. In the space of just ten years, since 2010, China has built two-thirds of the world's high-speed railway tracks<sup>26</sup> (totalling 37,900 km, with another 3,700 km planned in the coming months<sup>25</sup>), along with the biggest underground network in the world, which overtook the European network in 2015<sup>24</sup>. The volume of high-speed passenger-kilometres multiplied by 15 from 2010 to 2019<sup>2</sup>, outstripping the growth of air passenger transport<sup>26</sup>. More than 50 new high-speed lines were opened between 2018 and 2020<sup>2</sup>. In 2019, Chinese high-speed rail ensured 20% of rail traffic between cities, which is double its rate in 2010<sup>2</sup>.

The high growth of rail freight in the world is also largely led by China: 11,000 billion tonne-kilometres were transported in 2018, 12% more than in 2010, and China is one of the regions where the increase in freight has been the greatest (almost double in 2016 compared to 2000 – **fig. 2**). The history of rail freight is closely related to that of coal, and mining industry development often goes hand-in-hand with rail network development. Even today, the Haoji line, the longest rail freight line in the world inaugurated in China in September 2019, exclusively transports coal. At a cost of 27 billion dollars, it measures 1,813 km and is designed to transport 200 million tonnes of coal per year from mines in the north of the country to thermal power stations in the south, replacing former transportation by sea<sup>27</sup>. At the global level, coal and fossil fuels represent 28% of rail freight<sup>28</sup>. In the United States, coal represents 30% of rail freight in volume and 13% of its revenues<sup>29</sup>. As a result, the global slowdown in coal consumption (see **Energy sector**) could threaten the economic models of some rail freight companies.

Although the growth in absolute value of rail freight has increased, it does show some signs of flagging. In fact, the modal share of "surface" rail freight (i.e. excluding air and sea)<sup>e</sup> dropped from 2000 to 2016<sup>24</sup>, in all regions in the world (**fig. 2**). For a global average of 28% in 2016, it was about 30% in North America and India, 10% in Europe, and 75% in Russia, the country in which it is highest. The biggest decrease in modal share was in China (from over 50% in 2000 to 39% in 2016).

In reality, not content with just developing freight on its own territory, China has pursued multiple partnerships throughout the world to draw new trade routes, some of them railways, in the frame of its flagship economic project, the Belt and Road Initiative.

#### After a euphoric start, the Belt and Road Initiative is losing steam

Initiated in 2013 by Xi Jinping, the Belt and Road Initiative (BRI), sometimes referred to as the "New Silk Road", aims to

<sup>c</sup> The figure put forward is ₹38,017 crores, a unit used in India equivalent to ten million; thus ₹38,017 crore equals ₹38,017 billion, about \$5.1 billion.

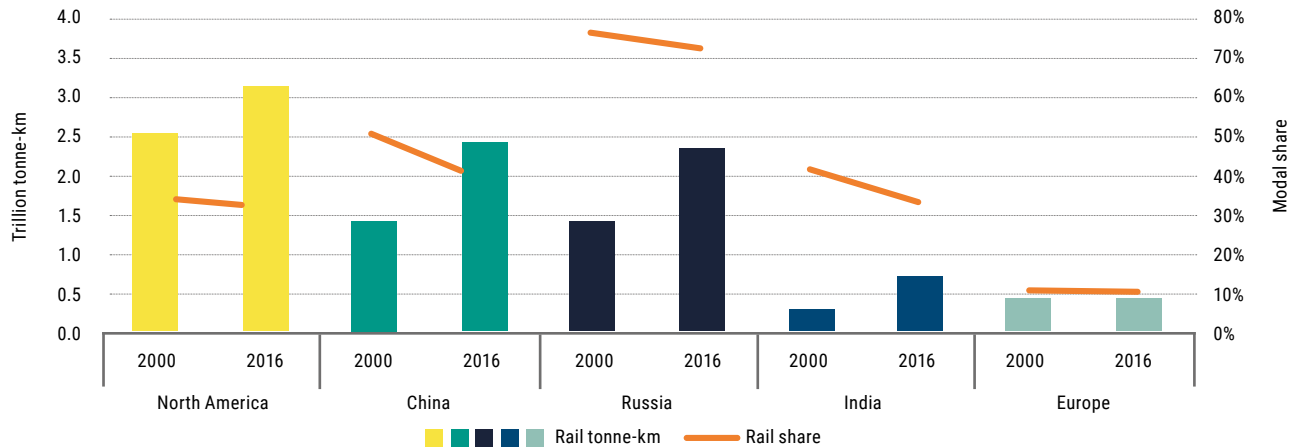
<sup>d</sup> The strategy comprises of several objectives, such as the creation of a standard European rail area, and the doubling of high-speed rail traffic by 2030 and freight traffic by 2050.

<sup>e</sup> Taking into account aviation and in particular maritime, which transports more than three-quarters of global goods in tonne-kilometres, the modal share of rail in goods transportation is 7%. Source: [REN21](#), 2021

**FIGURE 2**

**RAIL FREIGHT ACTIVITY AND MODAL SHARE OF SURFACE TRANSPORT OF GOODS**

Source : [IEA, UIC, 2019](#)



develop commercial transport infrastructures on road, rail and sea between China and the rest of the world (**see Keys to Understanding**).

**KEYS TO UNDERSTANDING**

**THE CHINESE BELT AND ROAD INITIATIVE**

Sometimes called the “New Silk Road”, the “One Belt, One Road” initiative, which has since become the “Belt and Road Initiative” (BRI) is a development program for trade routes and infrastructure initiated by the Xi Jinping government in 2013. Until now, its main lever has been the granting of loans to finance infrastructure projects via the two main Chinese “policy banks” (investment banks run by the Chinese state): the export-import bank (Eximbank) and the development bank (China Development Bank). The BRI is organized around major “corridors”, like the China-Europe corridor and the China-Pakistan corridor (**fig. 3**), and generally involves trade agreements and/or trade facilitation and access to resources for Chinese companies. It is relatively difficult to establish the exact number of BRI projects and the amounts involved. Numerous projects labelled “BRI” have no strategic importance for Chinese trade, while other projects that claim no BRI connection seem to have all the appropriate characteristics. Currently, 138 countries have been associated with the BRI in one way or another, mostly as part of a project to build railways, ports, pipelines or communication infrastructures. In total, an estimated 460 billion euros of BRI loans have been granted since 2013.

Source: [Financial Times, 30/04/2020](#)

Following a peak of 75 billion dollars of loans granted in 2016, several experts agree that the BRI is losing steam around the world, and the pandemic could have accelerated the trend.<sup>30</sup> In 2020, many countries requested to postpone the reimbursement of their loans to China in order to devote public money to emergency measures to deal with the pandemic,<sup>31</sup> starting with Pakistan, in April 2021, two years after the start of construction of *Main Line-1*, the flagship project

of the China-Pakistan corridor. In total, up to 40% of BRI-related projects may have been impacted by the pandemic (delays, postponements, cancellations),<sup>36</sup> and rail projects are no exception. In 2020, the railway between China and Malaysia and the high-speed rail project in Thailand were also put on hold.<sup>32</sup> The Kenyan parliament successfully called on the government to renegotiate the terms of its loan from China Eximbank for the construction of the Nairobi-Mombasa line, and the operating costs paid monthly to Afristar, which operates the subsidiary line of the China Road and Bridge Corporation that constructed the line.<sup>33</sup>

Despite these difficulties, numerous other major BRI projects were successfully completed in 2020. In Nigeria, the 157-kilometre Lagos-Ibadan railway line, built by a Chinese company, started operating in April 2020, several years after schedule. In Turkey, the first freight train on the China-Turkey corridor covering 8,693 kilometres set off for a 12-day trip in December 2020.<sup>2</sup> Projects in Cambodia (construction of the Phnom-Penh – Sihanoukville line and the extension of Phnom-Penh and Siem Reap airports) and in Laos (construction of a high-speed railway) have not been impacted by the pandemic.<sup>34</sup>

Globally, the impetus that BRI has given to rail freight is not about to stop, quite the opposite. Although global goods transport decreased by 36% in 2020,<sup>2</sup> trains have helped to get it back on track to recovery. In fact, maritime freight had difficulties establishing a solid recovery in international trade after the economy picked up again in late 2020; this was due to the unequal distribution of containers on trade routes, triggering a sharp rise in the cost of container transport (**see Maritime trend**). Taking advantage of this weakness in the system, 2,000 trains carrying manufactured goods arrived in Europe from China in January and February 2021, which is twice as many as during the same period the previous year, while, despite the pandemic, the number of trains running from China to Europe had already increased by 50% in 2020 compared to 2019, and had grown sevenfold compared to 2016.<sup>35</sup>



### In Africa, strategic resources give rail a new boost

Africa possesses significant mining and energy resources and a market with considerable potential, making it a strategic hub for the BRI. In total, 40 of the 55 African countries have signed an agreement or developed a project in partnership with China in the frame of the BRI. At the end of 2020, about 90 projects connected to the BRI were underway in Africa.<sup>36</sup>

China is making investments in Africa to develop the railway network, facilitating trade with the continent. A key example is the Nairobi-Mombasa line inaugurated in 2017, financed by China Eximbank, the Chinese import-export bank, and built by Chinese companies as part of the Belt and Road Initiative. The railway line links the capital to the container port in Mombasa, whose activities reached record levels in 2019, and is due to be extended to Naivasha, to facilitate exchanges with Uganda and Rwanda.<sup>37</sup> In mid-2021, a 125 km line was opened in Guinea between Boffa and Boké by the Singaporean-Guinean-Chinese consortium SMB-Winning, the continent's leading producer and exporter of bauxite. This line, which connects the mines to a large inland port, will initially be exclusively devoted to transporting minerals, before being extended to transportation of other merchandise.<sup>38</sup>

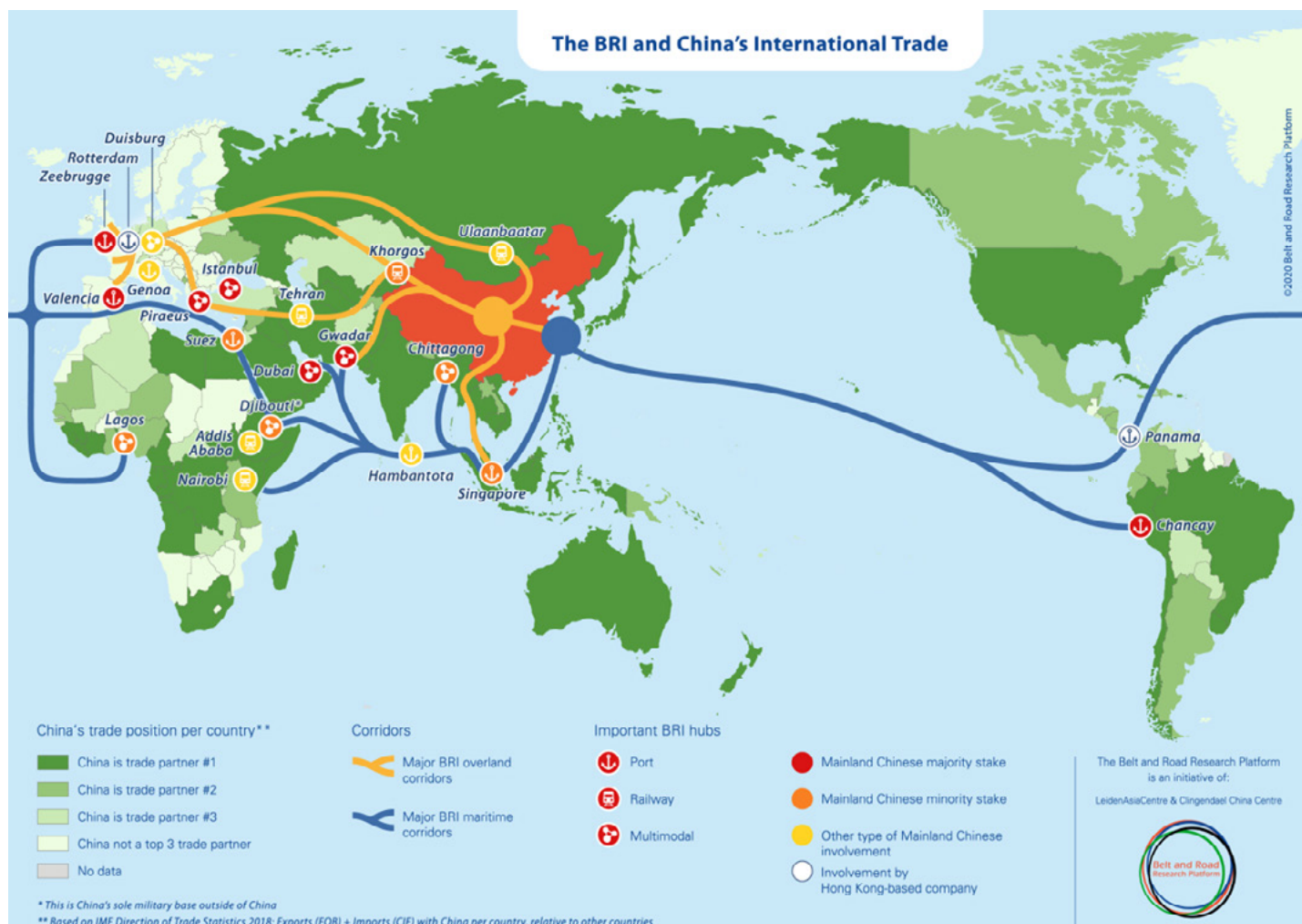
China is also involved in setting up urban rail systems (metro lines, trams and light railways) in Africa, where they have undergone considerable expansion. Most of the 501 urban rail systems in place in 2020 (compared to 478 in 2017)<sup>2</sup> are located in Europe, but the biggest growth over the last ten years has taken place in Africa (+333% since 2010), Asia (+69%) and Oceania (+50%). In Abuja (Nigeria), a series of Chinese loans and a technical partnership agreement with the China Civil Engineering Construction Corporation (CCECC) concluded in 2007 have led to the construction of an underground railway in operation since 2018 following a series of delays.<sup>39</sup> Addis-Ababa (Ethiopia) ordered 41 trains from the manufacturer China CNR to set up a light railway line in operation since 2015.<sup>40</sup> In Egypt, a railway from Cairo to the new administrative capital was financed by a 1.2 billion dollar loan from Eximbank. It is due for launch at the same time as the inauguration of the new city, scheduled for the end of 2021, and will be operated by the French company RATP.<sup>41</sup>

In total, the Chinese Loans to Africa Database lists 274 Chinese loans to African states (or companies held by African states) from 2000 to 2019 in the transport sector (construction of roads, railway lines, ports, airports, metros, purchases of equipment, etc.), representing a total of over 46 billion dollars.<sup>42</sup> Transport

**FIGURE 3**

### MAIN INFRASTRUCTURES IN THE BELT AND ROAD INITIATIVE

Source : [Belt and Road Research Platform](#), 2021





is the main sector concerned by these loans (almost a third of the total amount lent since 2000), ahead of electricity (\$38.0 billion) and the mining sector (\$18.4 billion). But after reaching a peak of almost \$29 billion in 2016, Chinese loans to Africa (in all sectors) dropped sharply the following year (\$12.7 billion) and do not seem to have picked up again since (\$9.9 billion in 2018, \$7 billion in 2019).<sup>42</sup> The reasons for this include the failure of several key BRI projects, like Hambantota Port in Sri Lanka,<sup>43</sup> the fear of falling into debt and being too dependent on Chinese financing, and vociferous objections from civil society concerned by environmental impacts. One example is the project to open an iron mine in Guinea, where the construction of infrastructure to export bauxite to Ghana came up against strong opposition.<sup>44</sup> In Kenya, in November 2020, a widespread social movement succeeded in ensuring the cancellation of a coal-fired power station in the north of the country initiated by Chinese companies and mainly financed by the Chinese bank of commerce and industry<sup>45</sup>.



## KEY TAKEAWAYS

**In passenger transport, freight and urban rail alike, China is moving quicker than the rest of the world. Even more so, China is behind the roll-out of the global railway network. Through its Belt and Road Initiative, a major program to develop roads and trade infrastructure initiated by the Chinese government in 2013, rail projects have mushroomed in Asia, Europe and Africa. The deal is always the same: China finances largescale projects (ports, railways, roads, airports, etc.) and in exchange obtains special access to resources and local trade. Undoubtedly, far from aiming at a modal shift from road or air freight, the development of Chinese rail is much more about economic and political strategy than climate concerns. Multiple failures, sometimes due to opposition from environmental associations, have nevertheless begun to curb the trend.**



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