Uptake of alternative fuels in the European Union bus sector

Jonatan Gómez Vilchez

European Commission¹, Joint Research Centre (JRC), Ispra, Italy
E-mail: jonatan.gomez-vilchez@ec.europa.eu

¹The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

ABSTRACT

After having been deployed with success in China, electric buses seem to be emerging as the preferred option for reducing oil dependency, noise and tailpipe air pollutant and greenhouse gas emissions from public transport. This paper presents a system dynamics model of the European Union bus market, including urban buses and coaches. The study focuses on the future uptake of alternative fuels in this sector, particularly on electric bus sales and stocks. The paper explores the potential impacts of minimum public procurement targets in 2025 and 2030 on annual CO₂ emissions from diesel buses and on battery cost. Further research is needed for a detailed analysis of purchase incentives at the country level.

Keywords: electric buses, public transport, alternative fuels, system dynamics
1. INTRODUCTION

According to EEA (2017b), almost 19% of European Union (EU) transport greenhouse gas (GHG) emissions are caused by heavy-duty trucks and buses. To support its goal to drastically reduce emissions from transport (EU, 2017b), the European Commission proposed in 2018 CO₂ emission reduction targets for heavy-duty vehicles for the first time. Initially applicable to large trucks, it is expected that buses and coaches will be included in 2022 (EU, 2019). The DIONE fleet impact model (Harrison et al., 2016) reports in its baseline scenario a 7% increase in tank-to-wheel CO₂ emissions from buses in the EU between 2010 and 2050, generating almost 47 megatons of CO₂ emissions by mid-century.

Public transport initiated modern mobility (Bunting, 2004) and continues to meet the need for passenger travel\(^1\). Depending on vehicle occupancy rates, fuel consumption per passenger can be lower in public transport than in private transport. Furthermore, the shift from car to public transport reduces congestion (Metz, 2012). In the EU, the most common type of public transport is bus travel (ACEA, 2017). With almost three quarters of the EU population living in cities (Eurostat, 2017), urban buses are expected to play an important role in fostering sustainable transport.

In 2013, 79% of the European bus stock was powered by diesel and 10% by biodiesel (ZeEUS, 2016). Faced with air pollutant concentration levels above the EU limit values (EEA, 2017a), cities are announcing the banning of internal combustion engine (ICE) vehicles in the future (for a list, see Table A in WB (2018)). EC (2015) identified biofuels, electricity, hydrogen, and natural gas (including biomethane) as the most promising energy sources to displace diesel in the bus sector. To facilitate an increase in the use of alternative fuels in the EU transport systems, Directive 2014/94/EU requested that Member States adopted national policy frameworks (NPFs) containing “measures that can promote the deployment of alternative fuels infrastructure in public transport services” (EU, 2014: 11). An assessment of the NPFs revealed that the level of ambition of these measures varies significantly by country (see the Appendix).

\(^1\) Less influentially in the United States, where it accounts for only 2% of passenger travel (Sperling & Gordon, 2009), than in other regions.
Fig. 1 shows the number of buses and coaches in use in the EU28 in the years 2005, 2010 and 2015 and the demand this stock of vehicle served, measured in passenger-km (PKM). As can be seen, the behaviour over time of both variables was relatively stable. In 2010, urban buses accounted for 39% of buses and coaches in the EU28 (TRACCS, 2017). In terms of trips, UITP (2016) reported that over 32 billion local public transport journeys were made on EU buses (including trolley-buses) in 2014.

![Figure 1. Stock of buses and coaches used to meet demand in the EU](image)

Source: own work based on data from EC (2018b)

The demand for bus and coach travel varies significantly by country, as can be seen in Fig. 2. In 2016, the most extensive use of these vehicles was made in Hungary (21%) while the EU28 average stood at over 9%. In contrast, buses and coaches represented only 3% of the modal split of passenger transport on land in the Netherlands.

![Figure 2. Demand for bus and coach travel as a percentage of land transport passenger demand (excluding two-wheelers) in 2016, by country](image)

Source: own work based on data from EC (2018b)
Fig. 3 shows that 68% of the EU stock of buses and coaches were in use in six of the twenty-eight Member States in 2016. The UK sticks out with a stock of 161,500 buses and coaches\(^3\). With an estimated fleet of 9,462 buses (TfL, 2018), London stands at a level similar to AT, NL and SK (see Eurostat (2017)).

Previous SD work on alternative fuels use in transport has mainly focused on the passenger car market. This paper focuses on the EU bus sector, particularly on electric buses. Hybrid buses are beyond the scope of this paper. The main reason for this is the large battery an electric bus currently features, which may be relevant in the context of the European Battery Alliance (EC, 2018a) as well as for achieving battery price reductions and improving the value proposition of electric cars vis-à-vis petrol and diesel cars. The objective of the study is to explore the market uptake of electric buses in the EU in the next years as well as to tentatively quantify its potential impact on battery prices. The dynamic problem to be addressed concerns the preservation of public transport services while significantly reducing its adverse emissions impacts.

The structure of this paper is as follows: after the introductory section, section 2 provides further information on electric buses, in section 3 the proposed model is presented, section 4 shows the results and conclusions are drawn in section 5.

\(^3\)However, DfT (2018) indicates that about 55% of these are minibuses, as defined for statistical purposes in that country.
2. DATA ON ELECTRIC BUSES

In 2016, over 54,000 buses and coaches were registered in the EU28, adding to a stock of almost 899,000 buses and coaches (Eurostat, 2017). According to EVI (2018), there were ca. 100,000 electric buses sold and 370,000 electric buses in use worldwide in 2017, most of them in China (see the Appendix). Most of the Chinese electric buses and coaches are battery electric (BEV), rather than plug-in hybrid electric (PHEV), and were sold by BYD and Yutong (GIZ, 2018). The number of manufacturers offering electric versions of buses and coaches is on an upwards trend. Table 1 shows a selection of electric bus models and their relevant characteristics. There are other important manufacturers not shown in that table because they have not fully entered the EU yet. Among them are BAIC Foton, CRRC, Zhongtong Bus active in China as well as New Flyer and Proterra in North America. As can be seen, lithium iron phosphate (LFP), manufactured by several suppliers, emerges as the preferred lithium-ion battery chemistry. Nickel manganese cobalt (NMC) batteries are being deployed in 2019.

Table 1. Main characteristics of electric buses available in the European market

<table>
<thead>
<tr>
<th>Type</th>
<th>Length</th>
<th>Manufacturer</th>
<th>Model</th>
<th>Battery</th>
<th>Capacity [kWh]</th>
<th>Charging time</th>
<th>Supplied by</th>
<th>Seats / max. PAX</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHEV</td>
<td>12m</td>
<td>Busnova / SAFRA Standard</td>
<td>LFP</td>
<td>132</td>
<td>4-6 h</td>
<td>EVE System</td>
<td>N/A / 100</td>
<td>2017</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ADL</td>
<td>Enviro200 EV</td>
<td>E</td>
<td>324</td>
<td>4 h</td>
<td>BYD</td>
<td>N/A / 90</td>
<td>2016</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ALSTOM / NTL Apta</td>
<td>Sodium nickel</td>
<td>N</td>
<td>309</td>
<td>7-8 h</td>
<td>Fiamm</td>
<td>N/A / 77</td>
<td>2017</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ALSTOM / NTL Apta</td>
<td>NMC</td>
<td>N/A</td>
<td>N/A</td>
<td>Foresee Power</td>
<td>N/A / 95</td>
<td>2019</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bolkore BlueBus</td>
<td>Lithium metal polymer</td>
<td>N</td>
<td>240</td>
<td>5 h</td>
<td>Blue Solutions</td>
<td>N/A / 97</td>
<td>2016</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Botanikaya Siete S12</td>
<td>LFP</td>
<td>N</td>
<td>215</td>
<td>2-8 h</td>
<td>Botanikaya</td>
<td>N/A / 79</td>
<td>2015</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BYD 12m</td>
<td>LFP</td>
<td>N</td>
<td>330</td>
<td>4-4.5 h</td>
<td>BYD</td>
<td>31 / 90</td>
<td>2013</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Irizar ie</td>
<td>Sodium nickel</td>
<td>N</td>
<td>376</td>
<td>6-7 h</td>
<td>Fiamm</td>
<td>N/A / 82</td>
<td>2014</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Daimler eCuro</td>
<td>NMC</td>
<td>N/A</td>
<td>243</td>
<td>AKASOL</td>
<td>29 / 93</td>
<td>2019</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Skoda Electric Perun-HD</td>
<td>LFP</td>
<td>N/A</td>
<td>230</td>
<td>4-6 h</td>
<td>various</td>
<td>N/A / 82</td>
<td>2013</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Solaris Urbino 12 electric</td>
<td>LFP/ Lithium titanate</td>
<td>≤ 240</td>
<td>32 min - 1 h</td>
<td>Solaris</td>
<td>38 / 90</td>
<td>2012</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>VDL Citea SLF-120</td>
<td>various</td>
<td>133</td>
<td>5 min - 4.5 h</td>
<td>various</td>
<td>N/A / 92</td>
<td>2014</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Volvo 7900 electric</td>
<td>LFP</td>
<td>76</td>
<td>3-6 min</td>
<td>SAFT</td>
<td>35 / 95</td>
<td>2016</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yutong E12</td>
<td>LFP</td>
<td>234</td>
<td>5.5 h</td>
<td>CATL</td>
<td>N/A / 77</td>
<td>2017</td>
<td></td>
</tr>
<tr>
<td>BEV</td>
<td>12m</td>
<td>Irizar ie tram</td>
<td>various</td>
<td>150</td>
<td>5-10 min - 2 h</td>
<td>various</td>
<td>N/A / ≤ 150</td>
<td>2017</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Solaris Urbino 18 electric</td>
<td>LFP/ Lithium titanate</td>
<td>≤ 240</td>
<td>32 min - 3 h</td>
<td>Solaris</td>
<td>46 / ≤ 129</td>
<td>2013</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Botanikaya Siete S18</td>
<td>LFP</td>
<td>215</td>
<td>3-8 h</td>
<td>Botanikaya</td>
<td>N/A / 137</td>
<td>2016</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>BYD 18m articulated</td>
<td>LFP</td>
<td>547</td>
<td>2 h</td>
<td>BYD</td>
<td>≤ 60 / ≤ 180</td>
<td>2016</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yutong E12</td>
<td>LFP</td>
<td>234</td>
<td>5.5 h</td>
<td>CATL</td>
<td>N/A / 77</td>
<td>2017</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Solaris Urbino 18 electric</td>
<td>LFP/ Lithium titanate</td>
<td>≤ 240</td>
<td>32 min - 3 h</td>
<td>Solaris</td>
<td>46 / ≤ 129</td>
<td>2013</td>
<td></td>
</tr>
</tbody>
</table>

Notes: (i) N/A means ‘not available’, (ii) PAX means ‘passengers’, (iii) ‘year’ refers to the introduction into the European market’, (iv) figures in italics reflect estimated average values.


Fig. 4 shows the market share of the best-selling electric bus manufacturers in Europe in 2018, compared to the previous year.

---

4 Both figures include trolley-buses and reflect 2015 values for Romania due to lack of data availability.
Fig. 4 shows the stock of alternative fuel buses\(^5\) in the EU, which has so far been dominated by CNG (including biogas) buses (in 2016 and 2017, 46 and 44 liquefied natural gas (LNG) buses were sold (EAFO, 2018)). Since 2016, this market is however declining while the electric bus stock is growing. By country, more than 50\% of electric bus sales or stock in the EU in 2018 were in NL, UK, FR, PL and DE (EAFO, 2018). In addition, there were 49 hydrogen buses in use in 2018 (EAFO, 2018).

\(5\) Note that EAFO (2018) follows UNECE (2014) and reports buses as the sum of M2 and M3 categories.
3. THE PROPOSED MODEL

3.1 Key assumptions

The model time horizon runs from 2005 to 2050. For the period 2005-2010, (TRACCS, 2017) is used, which disaggregates buses into urban (buses) and coaches.

3.1.1 Sales, stock and scrappage

We disaggregate sales, stock and scrappage by powertrain technology. In line with TRACCS (2017), urban buses and coaches are subscripted and a distinction between new and second-hand sales is made. For simplicity, no ageing chains are used. Fig. 6 shows the stock-and-flow structure at the core of the model.

The scrappage rate is determined by the stock and the average lifetime. Between 2005 and 2014, the average of the bus fleet in the EU has remained very stable at 9.4 years (EEA, 2016). We assume a constant average bus lifetime of 14 years, shorter than the 20-year lifespan stated by ForeseePower (2018) for the new Alstom’s electric bus and slightly longer than the minimum period of service for large buses required by FTA (2008) and the 12-year LFP battery warranty offered by BYD (2019).

3.1.2 Average fuel consumption and annual bus mileage

Based on EU28 average values, the fuel consumption of diesel urban buses and coaches in 2010 was respectively 38.7 litres/100km and 33.9 litres/100km (TRACCS, 2017).
Table 2. EU28 bus fuel consumption [litre/100km]

<table>
<thead>
<tr>
<th>Year</th>
<th>Urban Petrol</th>
<th>Urban Diesel</th>
<th>Coaches Petrol</th>
<th>Coaches Diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>46.5</td>
<td>41.0</td>
<td>54.6</td>
<td>35.1</td>
</tr>
<tr>
<td>2010</td>
<td>44.0</td>
<td>38.7</td>
<td>50.7</td>
<td>33.9</td>
</tr>
</tbody>
</table>

Source: own work based on data from (TRACCS, 2017)

For the electric bus modes listed in Table 1, fuel economy values range from 0.8-1.5 kWh/km for 12-metre and 1.15-1.30 kWh/km for 18-metre buses (see ZeEUS (2017)). Gao et al. (2017) estimated that the energy consumption of an electric bus ranges from 1.24 to 2.48 kWh/km. More recently, ITDP (2018) reported real-world Chinese electric bus data showing energy consumption of 1.063 kWh/km. We assume that an electric bus uses 1.10 kWh/km.

ITDP (2018) also reported a daily average operating mileage equal to 174.4 km. This is above the number reported in the EU28 for the year 2010, when average mileage stood at 44,706 km/year for urban buses and 57,729 km/year for coaches (TRACCS, 2017).

### 3.1.3 Capital and operating expenditures

For the calculation of capital expenditures (CAPEX), the assumed electric bus battery capacity is crucial. In its report, EVI (2018) assumed electric bus battery capacities equal to 250 kWh (p. 86) and 330 kWh (p. 73). For European buses, we assume an average value equal to 132 kWh for PHEVs (from Table 1) and 250 kWh for BEVs. However, for China a single value (325 kWh) is assumed. The reason for this is due to the evidence that the aforementioned main manufacturers in that country sell 12-metre electric buses with 324-330 kWh battery capacities. Tsiropoulos et al. (2018) report the following lithium-ion battery pack costs: 200 €/kWh in 2017, 96-127 €/kWh in 2025 and 75-101 €/kWh in 2030. This would bring the cost, only for the battery, of an electric bus to €50,000-65,000 in 2017 and €22,000-28,600 in 2030 (assuming that average cost is also applicable to LFP batteries and no energy density effects as well as depending on the battery capacity and cost estimate adopted). In addition, the industry mark-up needs to be determined.

Based on information from T&E (2018), we estimate that the purchase price of diesel and electric buses are €182,500 and €350,400 per unit, respectively. According to the
same authors, electric buses are nonetheless cheaper on a total cost of ownership (TCO) calculation basis that comprises the internalization of external costs such as noise, air quality and climate. Based on figures from EMT (2018), we estimate that the purchase price of CNG buses in Europe is at present around €300,000 per unit. The current price differential between diesel and electric buses can be reduced through purchase incentives. The UK is supporting electric and hydrogen buses with a £48 million scheme (DfT, 2019). Based on information on the winning bidders, we estimate that the average purchase subsidy is around €207,500 per electric bus and €251,500 per hydrogen bus. With such level of incentives in place, the TCO calculation is even more favourable to electric buses.

For the estimation of operating expenditures daily operating mileage (shown in the previous section) is key. In the aforementioned calculation reported by T&E (2018), electric buses clearly beat diesel buses already today with operating costs (excluding the operating cost of recharging infrastructure) of ca. 0.3€/km, compared to more than 0.6€/km for diesel buses. Given the energy consumption value assumed in section 3.1.2 and an average EU28 electricity price for non-households equal to 0.11€/kWh (Eurostat, 2017), we assume that an electric bus has an operating cost of 0.12€/km (energy only, excluding maintenance).

3.1.4 Deployment of recharging infrastructure

Two recharging options for electric buses are opportunity and overnight recharging. The latter presently dominates (EVI, 2018). Directive 2014/94/EU made a distinction between a normal power and a high power recharging point and defined the latter as “a recharging point that allows for a transfer of electricity to an electric vehicle with a power of more than 22 kW” (EU, 2014: 10). EVI (2018) anticipates that electric buses will primarily be recharging using fast (≥ 50 kW) infrastructure. Based on an assessment of publicly accessible recharging points (see EU (2017a)), we implicitly assume in this work that the current and future fast recharging infrastructure is sufficient to meet the electricity demand from electric buses.

6 Assuming the following exchange rate: £1 = €1.17.
3.2 **Policy targets**

The policy measure examined in this paper is public procurement, which accounts for 14% of gross domestic product (GDP) in the EU (EP, 2018a) and was regarded in a 2017 public consultation as an important measure to foster low-emission vehicles uptake (EP, 2018b). Among the alternative fuels identified are electric, hydrogen or biogas (EC, 2017). The potential for procurement of public transport vehicles at the local level is particularly high (EU, 2017c). Indeed, European cities such as London, Paris, Copenhagen and Barcelona have pledged to purchase only electric buses after 2025. Amsterdam’s municipal public transport operator is even more ambitious and aims at operating only electric buses by 2025 (WB, 2018).

Specifically, we examine bus procurement 2025 and 2030 targets. Although minimum procurement targets have been proposed per Member State (see Table 5 in Council (2018)), we construct a ‘Targets’ scenario by assuming these procurement targets across countries: 50% in 2025 and 75% in 2030 (5% of which are PHEVs and the rest BEVs).

4. **RESULTS**

4.1 **Evolution of the bus stock**

Fig. 7 shows the simulated stock of urban buses and coaches in the EU, compared with historical data. By 2030, total bus stock is simulated to exceed 0.8 million vehicles in the EU. Thus the bus market remains relatively stable over the period.

![Figure 7. EU28 urban bus and coach stocks, data versus simulation](image-url)

Source: data from TRACCS (2017) and own simulations using Vensim®
Fig. 8 shows the simulated growth in the number of fully electric buses in use in the EU28 until 2050 under the ‘Targets’ scenario, at the expense of diesel buses. Fig. 9 provides more detailed information on PHEV and BEV stocks by type of bus.

Finally, we use emissions factors for diesel fuel from IPCC (2006) to tentatively estimate the reduction in annual tailpipe CO$_2$ emissions from diesel buses in the ‘Targets’ scenario with respect to the ‘No targets’ scenario. Our simulations suggest 12%, 21% and 45% emissions reductions in respectively 2025, 2030 and 2050.
4.2 Comparison with similar studies

EVI (2018) presented two scenarios with different electric bus market shares in Europe in 2030: almost 20% under their ‘New Policies’ scenario and over 40% under their ‘EV30@30’ scenario. In both cases, fully electric buses dominate over PHEVs.

Further extending the model time horizon, a study by the European Road Transport Research Advisory Council (ERTRAC) reported four scenarios of the EU city bus and coach stock. These are shown in Fig. 10 as follows: ‘mixed’ scenario (S1), ‘moderately electrified’ (S2), ‘highly electrified’ (S3) and ‘highly electrified plus H2’ (S4).

Our simulation results would roughly match the ‘New Policies’ scenario in 2030. For 2050, they would be closer to S1 for city buses and point to a more optimistic view on the future deployment of BEV technology for coaches.

![Figure 10. EU28 city bus and coach stock in 2050, by scenario](image)

Source: Krause et al. (2019) [under review]

4.3 Impact on battery demand and resulting price

In 2016, there was more demand for lithium-ion batteries from electric buses than from electric cars globally (BNEF, 2017). The same authors forecast that the electrification of the bus sector will be quicker than for light duty vehicles (BNEF, 2018). Avicenne (2018) projects that battery demand from electric buses will grow from 21 GWh in 2017 to almost 50 GWh in 2025. Restricting ourselves to the EU context, we simulate battery demand from electric buses to reach 4.9 GWh/year in 2025 and 7.4 GWh/year in 2030.
Next, we used these results as inputs to a different system dynamics model. The results are shown in Fig. 11, measured in dollars per kWh. As can be seen, taking into account the experience from manufacturing electric bus batteries leads to a lower battery cost curve. Though the simulated cost reduction between simulation runs is not dramatic, it appears to be sufficiently attractive in 2019-2020 once the size of electric bus batteries are considered.

Figure 11. Battery cost, with and without link from electric bus manufacturing
Source: own simulations using Vensim®

5. CONCLUSIONS AND OUTLOOK

In sum, a system dynamics model was developed to represent the EU bus market, with a focus on the future uptake of alternative fuels. In particular, electric bus sales and stocks were analysed. The key feedback process modeled in this paper goes from electric bus sales to battery cost via expected cumulative experience (adding that of buses to the pre-existing manufacturing experience from passenger cars), which can be fed back into the purchase price of electric buses.

In conclusion, electric buses seem to be emerging in recent times as the preferred option for reducing oil dependency, noise and tailpipe air pollutant and GHG emissions from bus and coach travel in the EU, after having been deployed with success in China.

---

7 The Powertrain Technology Transition Market Agent Model (PTTMAM). A previous version of this model is available at: https://ec.europa.eu/jrc/en/pttmam.
Whereas the Chinese bus market has played a crucial role to facilitate economies of scale in the lithium-ion battery manufacturing sector, there are signs it is becoming saturated (SustainableBUS, 2019). With annual sales of over 50,000 buses and a stock slowly approaching one million units, the EU bus sector is sufficiently large to supersede China in its role of large-battery consumer.

Among the limitations of this study are the model simplifications needed to analyse the EU bus sector, which is very heterogeneous (see e.g. SDG (2016)) and the insufficient analysis of further alternative fuel options. Two examples for long-range operations are LNG (Scania, 2018) and hydrogen (FCEB, 2019).

Further work will revolve around modeling additional policy measures such as purchase incentives at the country level, allowing for quantification of required budgets. Furthermore, there remains the opportunity to integrate the results of the proposed model into PTTMAM.

Another increasingly interesting research area is the competition between traditional public transport with new mobility-as-a-service businesses and the upcoming wave of autonomous vehicles. These developments are expected to set into motion feedback processes that are likely to lead to a deterioration of public transport (Naumov et al., 2018). This would make the goal of doubling the market share of public transport by 2025 (UITP, 2019) more challenging to attain.

References


EC. (2017). Declaration of intent on promoting large-scale deployment of clean, alternatively fuelled buses in Europe. European Clean Bus deployment Initiative.


Appendix

Fig. A1 shows that the level of comprehensiveness of measures supporting the deployment of alternative fuels infrastructure (AFI) ranges from low (four Member States) to high in the case of the UK.

Figure A1. Level of comprehensiveness of measures that promote AFI deployment in public transport services, by country
Source: (EU, 2017a)

Fig. A2 shows the evolution of the total and electric bus stock (including trolley-buses) in urban China between 2010 and 2017. The bus fleet of the Chinese city of Shenzhen, with over 16,359 units in 2017, is reportedly fully electric (WRI, 2018).
Figure A2. Stock of buses in urban China