ADVANCING PUBLIC TRANSPORT

KNOWLEDGE BRIEF

LARGE-SCALE BUS ELECTRIFICATION

THE IMPACT ON BUSINESS MODELS

JULY | 2021

INTRODUCTION

In recent years, there has been an explosion in the development, technology maturity and deployment in the electrification of mobility within cities, both in terms of individual and collective transport modes. UITP has been at the forefront, proactively steering and promoting the electrification of mobility.

The issue of funding and cost-efficiency has increasingly become a driving concern for project development, technology selection and deployment[1]. This is an issue particularly for public administrations and transport operators, due to the sheer scale of such types of projects and short timeline, as cities strive to become carbon neutral. They require a coherence and consistency in policies, as well as availability of annual budget items for investment and maintenance.

This Knowledge Brief outlines the impact of large-scale electrification trends on the sector and the effect on operators' business models. The change is significant enough to alter funding models and financing tools and a city's governance structure. It may also require revisions in the arrangements for operations as the shape of the network and the nature of its financing may change. Lastly, an overview will be provided of the main impacts on the business models. These include a forecast of both medium- and long-term impacts to operators' management and a business model canvas[2].

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1 UITP (forthcoming). Cost effective methodologies to decarbonise public transport. Report
2 The business model canvas is a tool that breaks down different company processes and helps in collecting insights about a business.

IMPACT OF COVID-19 ON THE ELECTRIFICATION AGENDA

COVID-19 will have drastic implications for the electrification agenda, such as potential service cuts, size reduction or delay in the deployment due to the change in customer habits and the lack of funding. Operations may be affected and the authorities and operators will need to readapt themselves to the new normal. It is too early to assess or map the consequences. However, despite apparent financial restraints on many authorities, there remains a desire to push ahead with the climate change agenda.

GROWING TRENDS IN ELECTRIFICATION

Cities are increasingly keen to decarbonise their public transport by deploying electric mobility options. In recent years, many new policies have sought to decarbonise both municipal fleets and the wider public transport network. For example, Berlin, Germany, has a fleet of around 1,800 buses and a target of 100% local emission-free public transport by 2030 or the city of Montreal, Canada, which expects to run 100% electric buses by 2025. The main drivers for cities relate to climate change and air quality, but noise pollution, active mobility and wider health benefits are also cited.

A 2019 UITP survey estimated that in the coming 10 years, electric buses would be the predominant choice for clean fleets[3]. However, they are not the only choice: Natural gas and hybrid buses were also considered viable technologies, with fuel cells gaining increasing interest. Most respondents reported their city or network to be at the deployment stage of the technology, followed by the procurement stage or actual large-scale deployment.

These figures are based on estimates and are still dependent on future decisions. Experience gathered will certainly feed into future purchasing decisions, as well as technological development in the coming years. The choice of technologies is still open for question and the intake of technologies within operators' fleets, which range from a single choice of technology to a more varied approach.

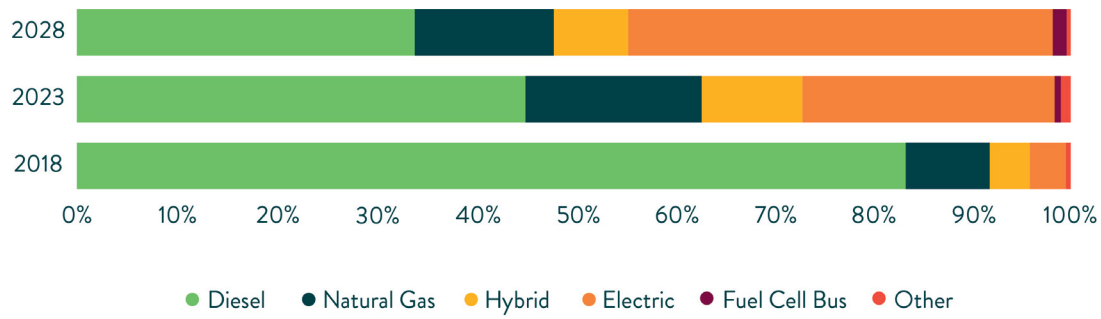
Cities are designing plans to execute decarbonisation strategies, making sure they implement appropriate technologies[4]. Around 87% of respondents reported they had or electrification targets or were in the process of establishing them. Further highlighting that much work was still required to build an integrated approach, including the operator, transport authority and energy provider.

SUCCESSFUL DECARBONISATION: THE ALLOCATION OF RESOURCES

It is paramount to understand how a large-scale transition means for full fleet electrification and its costs. In terms of resources, 46% of respondents had already allocated sufficient resources for bus electrification in their cities and a further 27% were currently holding discussions. The additional expenses were generally linked to the purchasing of fleet, the retrofitting of depots and charging infrastructure.

One reported approach is cost integration, that is the calculation of costs as a percentage of the existing costs for the financing bodies and competent authorities. This approach would enable to benefits from lower interest rates and state guarantee, especially for the acquisition. The additional costs for electric bus operation had been estimated between 3-11% of the total cost for the bus services. Such developments are required to be put in perspective, especially considering funding revenues and

Expected evolution of bus fleets 2019-2028



3 UITP,2019. *Transforming Business Models: Survey overview of large-scale electric bus deployment.* Transport Economics Working Group. Accessible to UITP members on MyLibrary.
4 UITP (forthcoming) *Cost Effective Methodologies to Decarbonise Public Transport*, report

a general tendency of declining local public budgets. Another approach falls under the responsibility of the operator, as a respondent highlighted, *"transport operators are in charge of the electrification and therefore allocate funds in their own annual budget"*.

In terms of financing tools, there is a preference towards grants and subsidies. Such programmes can either be specific or, as in the case of Wiener Linien in Vienna, a part of the city's overall funding.

HAMBURG'S DEPLOYMENT OF ELECTRIC BUSES

The German city of Hamburg will procure only emission-free buses from 2020 onwards. The operator, Hamburg Hochbahn, has developed a long-term strategy to meet this target. This strategy provides the direction of required development of infrastructure, software and skills. The city's electric network provider is included as a partner, to better integrate the electricity demand in an overall electric supply strategy for the city.

ELECTRIFICATION OF THE BUS FLEET IN DENMARK

Many of Denmark's cities have established targets for clean fleets and deployment of zero emission buses (ZEBs). The Capital Region of Denmark has a vision of phasing out diesel buses by 2030.

The city of Copenhagen has a target of 100% ZEBs by 2025, and the city of Frederiksberg by 2030. Both cities require that all new bus contracts from 2019 only use ZEBs. The operation of bus services started on 14 April 2019 with the inclusion of 20 electric buses, funded through a European Investment Bank loan.

FUNDING AND FINANCING LARGE-SCALE ELECTRIC FLEETS

FINANCING THE DEPLOYMENT OF BUS FLEETS

The main challenge for electric bus deployment is sourcing enough resources for both the operational and capital expenses. While operators' own resources are a key component in the financing cost, most survey responses included a mix of various external financing instruments.

In most cases, the financing of upfront costs for electrification, especially the purchase of electrification assets, was reported to be carried out through the operators' own resources. In some cases, the public administration's budget was used. Long-term loans from public financial institutions and medium-term financial lease from private financial institutions were also a financing source.

THE UK'S PROMOTION OF CLEAN TECHNOLOGIES

The United Kingdom launched the Transforming Cities Fund, which provided £840m in investment to 10 shortlisted cities to transform and upgrade infrastructure and transport links. This national fund supported both small schemes with a ceiling of up to £40m and larger ones with a £250m limit.

In parallel, the Ultra-Low Emission Bus Funding enables the distribution of grants from a £48m national fund, with the objective to increase the uptake of ultra-low emission buses (ULEB). It is expected that, through speeding up the full transition to a LEB and ULEB fleet in England and Wales from this fund, the need for subsidies will be reduced. The second objective seeks to support the improvement of local air quality.

The Zero Emission Buses programme in the UK, with the city of Coventry selected for the first entirely ZEB fleet and significant use of electric buses in other locations such as London, Harrogate and York; and in Glasgow in time for the COP26 Climate Change conference in November 2021.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In Europe, the predominant tools are a long-term financing from the European Investment Bank (EIB)[5] and support provided through European research agendas, such as H2020[6] funding programmes. Recently, the European Union has been offering, through the Connecting Europe Facility (CEF), a grant programme for alternative fuels and for purchasing clean bus fleets. This is the case of TMB Barcelona's bus electrification, which it is annually funded by regional, local and national administrations and long-term financed by European public & commercial banks and grants. Depending on the country, some national and regional grants are available. The city of Budapest shows a combination EU and national grants as the main expected sources, with loans from the municipality and the operator's own resources playing a smaller role.

In the United States, electric bus projects have been predominantly funded using the federal low-no grant[7]. It has been observed that grants from both regions have been limited and linked to specific programmes.

The two other main countries with high ambitions for a large-scale deployment of electric buses are India and China. The Chinese Ministry of Transport provided manufacturers of new energy buses with subsidies and tax benefits worth $81,600 per electric purchase. India instead set up the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) and its second programme FAME2, using both fiscal tools and tax subsidies[8].

DEPLOYMENT OF CHARGING INFRASTRUCTURE

The deployment of ZEB technology goes hand in hand with the deployment of charging infrastructure. One of the most important issues highlighted from the survey is the management of construction, maintenance and ownership of the charging infrastructure. This has a direct influence on the success of decarbonisation and local emission reduction strategy, particularly:

- The division of roles, namely between the transport authority, transport operator and the electricity distribution company.
- The need for coordination between energy output, energy grid and public transport can favour a centralised approach, to reduce inefficiencies.

5 EIB provides resources based on the 'leveraged principle', meaning that they will never finance 100% of an operation, but rather offer a stabilising fund to kick-start the operation, enabling transport agencies and operators alike to on-board risk-adverse financial institutions into participating into the formula.
6 EU Horizon 2020 funding EU's research agenda
7 Low or No Emission Vehicle Program
8 Find out more in UITP's Reports *Performance evaluation framework: For electric buses in India* and *Electric bus procurement under FAME-11: Lessons learnt and recommendations*

- The process of obtaining authorisation for the construction of infrastructure is long, especially when the infrastructure is in public spaces.
- Electrifying depots requires extensive and costly civil projects (planning permission, build permits), adding more complexity to the mobility sector. This also requires lengthy and costly engagement with Distribution Network Operators (DNO).
- Charging infrastructure has a longer economic life and depreciation period than the term of most operating contracts.
- Where there is competitive tendering of routes or sub-networks, there needs to be coordination across several tenders over the location and operation of depots to ensure optimal network planning.

The operator is generally responsible for the electrification assets. Yet, some respondents indicated that, while transport operators owned the depot for the duration of the concession, at the end it would be very likely transferred back to the transport authority. At the present time, most assets are owned by either the operator or authority, though soon they could also be rented or acquired through third-party financial instruments.

AN OVERVIEW OF DIFFERENT FUNDING MODELS

Public transport operators

The funding structures to promote electrification have identified several types of models used. The main stakeholders are the transport authorities, in-house operators, private operators, bus suppliers and banks[9]. The two main models are public ownership, particularly seen in the main cities of France, Germany and Spain, and private ownership whereby operators own, operate and maintain their fleets, and seen in the UK, the Netherlands and Scandinavian countries.

Leases can be used with both public and private models, though there are also new options to lease the battery but not the remainder of the bus. As the battery is a significant part of the overall cost, this may reduce the initial capital cost. Industries such as Proterra[10] are increasingly active in this market, which may also be an opportunity for new entrants and financiers[11].

The notion of 'Joint Procurement' helps to take advantage of economies of scale that enable upfront cost reduction by teaming with another operator, widening the contract with the bus supplier. This concept is not without challenges, particularly how to streamline different needs and technical requirements of different cities into a single order. The example of the San Gabriel Valleys/ Foothill Transit purchase of 361 bus vehicles in the USA is certainly one to highlight. Such an option is yet to be used by European operators or authorities.

Allocation of asset ownership in the electrification of buses

9 UITP, 2020. *Bus tender structure Report*. Report. Contains chapter on tendering for e-buses
10 Electric vehicle technology manufacturer especially found in the North American market
11 BNEF, 2018. *Electric Buses in Cities: Driving towards Cleaner Air and Lower CO2*

FULLY ELECTRIFIED FLEET IN SHENZHEN, CHINA

The city of Shenzhen has a population of 13 million. As such, it requires an extensive transport network for an annual passenger capacity on 800m passenger/km. Shenzhen Bus Group operates a fleet of 12,769 buses and taxis. In 2018, the entire fleet was electrified, becoming the first fully electric network.

A key driver was the 2015 Shenzhen Municipal Government directive, requiring a full electrification of vehicles in the public transport industry to be launched by the end of 2018. In parallel, a purchasing subsidy policy was implemented to encourage public transport enterprises to purchase electric buses and subsidising large-scale charging device investors according to their consumption of electricity. Licensing restrictions were also established for new vehicles running traditional fuel and granting of more new licenses for electric vehicles.

Private transport operator: Ownership or responsibility

In competitively-tendered contracts, private transport operators can be entrusted with supplying and owning the charging infrastructure. Charging infrastructure is estimated to have a lifespan of 15 years, longer than a typical bus contract. Should private operators finance and own the charging infrastructure, it will require in return a fair compensation for the venture. Introducing massive zero emission programmes come together with a review of the length of the contract, and the return on capital employed. Not all operators can finance such projects, that also require design and operational expertise. This means that large-scale zero-emission projects can have a direct effect on the competitive landscape.

The ownership of the charging infrastructure may also give the incumbent operator a competitive edge in future service re-tendering. This is mostly because the incumbent does not need to build new and expensive infrastructure. To keep competition alive, transport authorities may need to look at mechanisms to ensure a hand over at the end of operating period at specified residual values.

Moreover, this model may lead to the decrease in the potential of optimisation within a city or region. Before transitioning to large-scale electrification, the design of the service must be considered, otherwise the infrastructure location and technology will be based on the existing level of contracted operation, as opposed to the best network design options for tomorrow. A lack of specification might result in heterogeneous network infrastructure and fleets, especially in a context with multiple simultaneous operators. This presents a challenge at shared stations where several charging points may be needed to cater all different charging standards.

In short, if opting for private operator ownership of the infrastructure, transport authorities must provide clear guidelines and build the operational framework with its private partner.

Public authority

Ownership of charging infrastructure can become the responsibility of public authorities. This model ensures that the infrastructure will not play a decisive role in any future tenders, as all operators will have equal access to it. On the other hand, this will mean that the public authority will have to fund the construction of the infrastructure. It is recommended that either the authority or the operator retain ownership of the infrastructure, allowing more competition between operators as well as reduced risk premiums. Return on experience still lack to evaluate

how such a division between ownership of the asset and responsibility to operate and maintain them translates, in terms of optimisation of the lifespan of the assets.

The Munich transport authority (MVV) tendered the electric infrastructure and the buses separately. This was done to take over the cost risk, with the operators leasing the infrastructure during their contracts. A similar approach is also being followed in Finland, where the public authority owns the depots and rents them out to different operators.

Contracting charging infrastructure to a third-party

The final possibility of contracting charging infrastructure to third-parties, such as bus manufacturers or the electricity utility company, is relevant for both public and private operators. For example, electricity utility companies can own, and be responsible for, providing and maintaining this type of infrastructure, as well as renting it to operators. Their in-house knowledge, particularly on technical matters and operating challenges of electricity networks, makes them good candidates for the job.

Another option is for bus manufacturers themselves to construct and own the charging infrastructure. With the increased risks involved in these new technologies, bus manufacturers are stepping in to offer services beyond the provision of vehicles. This option is viable for small-scale operations with a private operator, as well as large-scale citywide deployment by publicly-owned operators. However, it may lead to an infrastructure optimised to one manufacturer's equipment, and therefore a potential barrier to entry.

THE EVOLUTION OF BUSINESS MODELS

The strategic guidelines are provided to the operator by its Executive Board, which are translated to the tactical level, especially during the implementation stage. Key areas such as purchasing, infrastructure, operations, maintenance and training requirements need to be specified. The results and operations show the total costs and the company's direction.

Electrifying urban mobility not only requires changing the fleet and urban infrastructure, but also has important implications for operators' business models[12]. The main methodology for the comparison and choice of technology is Total Cost Ownership (TCO). Generally, the models reported in the 2019 survey were to be built either in-house by the operator or the authority. In most cases, respondents considered that the integration of positive or negative externalities were either neutral or not well integrated in the TCO model.

From the survey results, the most pressing challenges in the large-scale deployment of electric buses are the electricity supply, the batteries and the charging infrastructure. These are followed by the asset and fleet, the overall management, the use of ICT and Data, and challenges linked to operational management. These changes also require new risks to be identified and managed, as well as the potential revision of companies' risk management strategies. A positive view was observed on how new risks were dealt internally. However, in many cases, the ZEB fleets are still not large enough to affect the risk management processes significantly.

Public transport operator business models

PROFIT BASED

INDIVIDUAL - STAKEHOLDERS

Who cares & Who pays

- City
- Region
- State
- Employees
- Unions
- Media
- Suppliers (Power companies & manufacturers)
- Customers
- New players

NON-PROFIT BASED

SOCIETY - SHAREHOLDERS

Type of contract	Who pays	Who leads
Awarding Contract	Asset ownership	Management
• In-House	• PTO	• Strategy
• Tender	• Authority	• Change
• Deregulated	• Industry	• Risk
	• Bank	• Culture

12 Business model can be defined as a plan for the successful operation of a business, identifying sources of revenue, costs, the intended customer base, products, and details of financing.

There are also changes in companies' budgets, their balance sheet and profit and loss statement (P&L). In the case of the balance sheet, there was an increasing impact on the non-current assets and capital grants for the medium-term, impacting the total overall. The value of rolling stock was expected to be higher due to the higher prices of the electric vehicles and their batteries, though maintenance may be simpler and involve a lower number of parts. However, such estimates may vary depending on the rollout strategy, the contractualisation process of future tenders and other external factors.

The most significant impact for the long-term balance sheet referred to the installation of new equipment and the capital grants, despite a small overall impact on the balance sheet's net-worth. Except for current assets and net-worth, all the other sections show expected increased costs.

For the medium-term P&L, respondents reported a significant increase in expenses linked to purchases. Overall, the outcome showed a positive trend, with an increase in depreciation and interests. In the long-term, the expenses section remains neutral despite an increase for purchases and other services, along with a decrease in energy costs. While the impact on personnel might be affected, the capacity of the batteries does not increase as expected. In such a case, existing operations and schedules may have to be split up. This scenario may highlight the need for more buses and personnel.

The outcome of P&L still shows an increase in costs due to depreciation and interest. Some respondents reported expectations of lower energy costs and lower maintenance and costs, entailing less personnel. The role of new technologies is also reported as a potential driver for the need of additional skills. Finally, depreciation is also expected to increase due to higher asset values.

On the revenue side, no major impact was foreseen. Survey respondents perceived that the increase in revenues should be covered either through local subsidies or compensation subsidies. A small sample of respondents reported an assessment of the impact on their coverage ratio, but the majority had not considered ridership development in the medium-term or the balance between fares and subsidies.

OPERATOR BUSINESS MODEL FRAMEWORKS

Once a pathway towards electrification has been identified for a network, the changes and implications need to be mapped. Their implications for each operator's business model will affect its capacity to deliver electrification in a financially sustainable manner. With such a concern in mind, a business model canvas analysis was carried on the different operation types (deregulated, non-commercial by PTO, and non-commercial in-house[13]). This exercise included the feasibility of the electrification objective, and its desirability and viability[14].

Operators may feel different impacts within the identified categories, as they are very much dependent on the needs of the city, its network, customers and its specific contracting pattern. Equally, ongoing changes in route developments due to the technology choice, such as the case in Copenhagen and London can also have an impact.

IMPLICATIONS FOR THE BUSINESS MODEL

Funding and financing

The move towards decarbonisation will have a direct and substantial effect on operator business models, further amplified by COVID-19. This change will have consequences on all types of operators, whatever the regulation model and local context.

First, the cost of operations is likely to increase in the short-term, not necessarily compensated by direct benefits to customers in terms of enhanced driving experi-

13 As the majority of UITP operators members are within the last two, in order to make a more comprehensive report we will deal with these two: concession tenders and local public contracts.
14 The inclusion of the city's view in terms of costs and benefits was also included as a variable in the model. For more information: UITP, 2019. *Business Model Canvas: Transforming business models for large scale bus electrification*, UITP working group deliverable. Available to members on MyLibrary.
15. UITP (forthcoming) *A cost-effective appraisal methodology for decarbonisation of public transport*.

ence or reduced sound pollution. Despite the environmental benefits, without any change to the passenger services the service to both operators and authorities could become more expensive[15].

Secondly, investment cost of infrastructure should be considered seriously and compared objectively prior to the investment decision. Additional ZEBs could be required due to their current operational range capability and charging limitations, compared to the diesel options. The vehicle range can be influenced or dependent upon factors such as regional climate, route topography and heating, ventilation and air-conditioning (HVAC), and energy usage.

New technology requires a substantial test period for both industry and operators to understand fully both operational impacts and how to meet the cost challenge. The lack of data and the need to make many assumptions make it imperative that financial and operational considerations are factored into the decision making when forming a bid. This significant increase in costs related to deploying electric buses may be a reason to discuss alternative modes, such as light rail projects, for long-term solutions on lines which might develop future high demand.

This cost gap is key to planning electrification. In this analysis, respondents have mostly seen it as fixed. In practice, it can evolve as more cities shift to electric buses. The second factor to note is the balance between vehicle costs (often capitalised) and fuel costs. Electric vehicles have higher upfront costs and lower fuel costs, the extent to which these offset higher staffing costs from shorter routes will also matter. With this in mind, authorities and operators will need to watch trends in relative costs.

Electric buses require a totally new approach from the industry.

The design of networks requires a new way of thinking in collaboration with city planners and operators/managers to optimise the network, fleet profile and manage cost. New staff capabilities are required for operators and authorities, such as ZEB experts.

Collaboration between transport authorities and operators

Relationships between the authority and operator will change. Electrification requires a good strategy and an efficient delivery to cope with all the changes. Strategies and planning must start and be spearheaded by the transport authority or competent authority, whilst keeping the operators' interest at heart.

Pre-Invitation to Tender (ITT) consultations with interested bidders to influence design of tender are advisable. International operators possess experience from various markets and strive for the best solution for clients, i.e. a successful tender, with an affordable and attractive offer. Moreover, potential bidders may also host study visits to show how operations are being run. These strategies will have to determine the most appropriate technologies to be deployed.

Whatever technology is chosen there will be:

- A need for infrastructure and vehicles with a longer life span (15 years and more) than typical contract duration.
- A need for lengthy authorisation procedures for infrastructure.
- An impact on urban public space.
- A need to coordinate electricity supply and grids and public transport infrastructure and charging strategies/management; economies of scale.

There is no one size fits all approach, bespoke solutions will need to be developed and tailored for each individual contract.

Taking all of this into account, centralised and coordinated planning is crucial. Transport authorities, cities, and regions have a direct role to play in the development and execution of the strategy and rollout of the decarbonisation scheme, but they should count on the operators' experience in operating networks. In line with the intro-

duction of new technologies, transport authorities should encourage fostering of innovation, research and development, and interfacing with start-ups for technological developments.

Changes in contract design and awarding

It is assumed that ZEBs will last longer than conventional diesel buses. This is mainly due to electric vehicles having fewer moving parts and reduced vibration, and so wear and tear will decrease.

While the technology is mature enough to support large-scale deployment of ZEBs, a key challenge is the translation into planning and contracting. Uncertainties present risks which will have to be carried out by either the authority or operator. If the operator is to fully bear that risk, service contract prices will rise due to risk premiums. To avoid increases in contract prices and risk allocation, the strategy must be clear. This will have a direct impact on contract submission and risk premiums.

Adopting a clear strategy built around local context can minimise risks and costs.

Another aspect related to contracts is the alignment of depreciation and contract, as well as the repayment periods for the battery and vehicle lifecycle. At the moment, public service contracts for running bus services are typically 8-10 years, whereas battery lifecycles on the other hand have been being estimated at 6-8 years. This means that the operator will have to introduce the price of a new battery that will only serve for 2 years. Another relevant aspect is vehicle lifecycles which are estimated to increase, impacting future contracts. Some bus manufacturers are already introducing bus models estimated to have a lifetime of 15 years. Electric charging infrastructure is also estimated to have the same lifetime. The higher the coverage of the useful economic life, the lower the residual value risk priced.

Transport authorities should consider residual value guarantees for transferring assets to remove the risk. For instance, EU guidelines allow up to 10-year contract periods for bus tenders where bidders have to make significant investments. Such guarantees were offered in recent Dutch bids for instance, including both fleet and infrastructure.

With these different lifecycles and amortisation periods, a solution could be separating contracts for electric depots and charging infrastructure with the operations. This would avoid excessively high prices for operators who will have to get rid of their vehicles, if they are unsuccessful in retaining the contract at the end of their service.

CONCLUSIONS

The electrification of bus operations will enable the decarbonisation of cities. This will require a new business model paradigm, starting from companies' boards all reaching staff and unions. Consideration from all stakeholders, to understand passenger be-

haviour and mobility needs, should drive the reinvention and adaptation of operators. In particular, the planning and funding from transport authorities is crucial to provide the most efficient service to those who pay: Customers and citizens.

This Knowledge Brief has provided an overview of the impacts that large scale deployment of electric buses could bring for operators and transport authorities. The topics of funding and financing were addressed, followed by some expected impacts on the business model for operators and other stakeholders. The scale and scope of the challenge are certainly concerning for public administrations and transport operators due to the types of project and the short timelines.

The expected impact of such a change in technology will be influenced by the local context and the governance structure of each city.

KEY PRINCIPLES

- Decarbonisation will have a direct and substantial effect on operator business models.
- The impact of the COVID-19 will have uncertain but long-lasting implications to the decarbonisation of the fleet.
- The cost of operations will increase in the short term not necessarily compensated by direct benefits to customers, though clearly there are benefits to society.
- Significant increase in costs related to deploying electric buses may be a reason to discuss and compare alternative modes for long-term solutions.
- Electrification requires a good strategy and an efficient delivery to cope with all the changes. Strategies and planning must start immediately and be spearheaded by transport authorities whilst keeping the operators' interest at heart.
- New technology requires a substantial test period for industry and operators to understand fully both operational impacts and how to meet the cost challenge.
- There is no one size fits all approach, bespoke solutions will need to be developed and tailored for each city and individual contract.
- Risks will have to be borne by either the authority or operator. Risk allocation can have a direct impact on contract submission and risk premiums, but they may be minimised if a clear strategy is developed.
- The length of contracts may need to change to take account of the depreciation of vehicles and batteries life cycle.
- Transport authorities should consider residual value guarantees for transferring assets to remove the risk.
- Consider different lifecycles and amortisation periods with separate contracts for electric depots and charging infrastructure on one side, and operations on the other.

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