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Analysis for Bus Electrification in Lima using PAYS for Clean Transport

Clean Energy WORKS

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1. Executive Summary

Upfront costs are a chronic barrier to electric vehicle sales, even for electric vehicles that have a lower total cost of ownership than the fossil fueled vehicles they replace. This barrier is particularly acute in the global market for electric transit buses, which is a priority for public health and climate action in many leading cities. The result is a critical constraint on growth in pace and scale of deployment of technology with a better business case than most other types of electric vehicles.

Utilities can help overcome this barrier by making a site-specific investment in the on-board battery and charging station on terms that assure positive cash flow for the customer and cost recovery for the utility. This potential breakthrough is based on the Pay As You Save® (PAYS®) system, an existing, proven financing approach previously applied to energy efficiency in buildings. With an endorsement from the Global Innovation Lab for Climate Finance there are already signs of confidence that it has dramatic potential to transform global markets for electric vehicles, starting with buses.

With support from Convergence Blended Finance, Clean Energy Works conducted a feasibility study for Lima, Peru using the PAYS for Clean Transport Model and found the following key results with existing available data:

- An **electric bus in Lima reduces CO_2 emissions by 85% over the lifetime of the bus,** contributing to climate mitigation and a reduction in local air pollution.
- An **electric bus costs slightly less than a diesel bus** when considering the total cost of ownership over 14 years.
- **PAYS would reduce the incremental CapEx for electric buses by 74%**, underscoring a benefit of the PAYS for Clean Transport investment mechanism.

These are very promising results for the implementation of electric technologies in transit and the innovation of PAYS for Clean Transport in a region that has yet to see large-scale electric bus uptake. It shows the potential using PAYS for leveraging concessional capital as the market matures and prices reduce.

The results are sensitive to assumptions about electric bus purchase cost and maintenance costs. Clean Energy Works found that during this study new data emerged from Santiago indicating much lower maintenance costs for electric buses after one year of operation compared with data provided for this initial analysis. Should this trend continue, it will have a significant impact on the total cost of ownership for electric buses and their business models in the region.

There are, however, barriers in the Lima context, which could prevent PAYS for Clean Transport from being sucessfully implemented. The lack of solvent bus operators is a key barrier since one of the fundamental assumptions of the PAYS model is that bus operators can afford the cost of purchasing a new diesel bus, through either cash or financing. Additionally, this solution may face regulatory uncertainty as well as market uncertainty since this would be the first case in a new sector for this type of financial instrument.

Furthermore, this study also uncovered technological, institutional, and regulatory barriers in addition to the high up-front cost, not unique to Lima, which need to be cleared for utilities to play a pivotal role in electrification of transport.

Clean Energy Works identified potential solutions and proposed an adapted model for PAYS for Clean Transport in Lima improving access to capital, concessional, commercial and blended finance, as well as implementing risk mitigation strategies such as reserve funds and insurance warranty.

With this analysis and experience Clean Energy works found that the key next steps to the adoption of PAYS for Clean Transport or any novel electric bus financing mechanism include engagement with electric utilities, financial institutions, and local and regional allies in order to support existing ongoing reforms, test proposed models, and find solutions to remaining barriers.

This paper presents the financial analysis that led to the findings, lessons learned from the study, and potential paths forward to continue promoting electric buses and new financial instruments in Lima and the rest of Latin America.

2. Introduction

The transition to battery electric buses (BEBs) can deliver many benefits in terms of air quality, greenhouse gas emissions, and fuel and maintenance savings, yet as a new clean energy technology and a climate mitigation measure, it is capital intensive. The upfront cost for BEBs can be as much as three times that of a diesel bus. To overcome this upfront cost barrier, pursuit of fleet transitions currently requires strong political will from decision makers at all levels, across city and national agencies. Cities, transit agencies, bus operators, and utilities must work together to transform this political will into policy action that will result in procurement and deployment of clean electric transit buses. The transition also requires the support of private sector companies such as bus and charging infrastructure manufacturers.

In 2018, the Global Innovation Lab for Climate Finance (the Lab) endorsed Pay As You Save (PAYS) for Clean Transport, as a viable financial instrument to accelerate investments in bus electrification. PAYS specifically addresses the upfront cost barrier through utility investment and cost recovery.

With the support of Convergence Blended Finance, Clean Energy Works worked to move PAYS for Clean Transport from the Lab to the streets by dedicating the first international feasibility study and financial analysis to Lima, Peru. Clean Energy Works completed this study with additional assistance from the Inter-American Development Bank, the World Resources Institute, and the Climate Policy Initiative.

This section provides a brief overview of Lima's local context and the PAYS for Clean Transport instrument, followed by the main results and learnings from the Lima analysis.

2.1 About Lima and Transport

Lima, Peru's capital city, sits within a metropolitan region of about 10 million people, and in 2014, the World Health Organization ranked Lima worst for air pollution among all Latin

American cities, citing a 75% contribution of mobile sources.[1] One of the reasons for this ranking comes from the mass transit system. Regular buses, bus rapid transit (BRT), and small vans account for about 75.5% of trips,[2] and most of these vehicles do not have appropriate emissions and fuel standards. Fortunately, things are starting to change. In 2015, Lima signed onto the C40 Cities Clean Bus Declaration of Intent, one of 24 cities committing to rapidly accelerating the uptake of clean bus technologies, and at the end of 2019, Lima began testing its first battery electric bus. This political commitment was one of the criteria that was used to select Lima in consultation with the Inter-American Development Bank as a study city for PAYS for Clean Transport.

2.2 PAYS for Clean Transport

PAYS for Clean Transport[3] is based on the Pay As You Save® (PAYS®) mechanism, where a utility makes site-specific investments to help reduce the upfront cost of energy upgrades or zero emissions energy technology.[4] These investments are recovered through a fixed tariffed charge that the customer pays on their monthly energy bill until the utility's costs are recovered. The terms of a PAYS tariff are set so that monthly cost recovery charges are less than the estimated value of energy savings. To make the investment cost-effective, the customer may need to contribute an upfront co-payment that is far smaller than the initial upfront cost barrier.

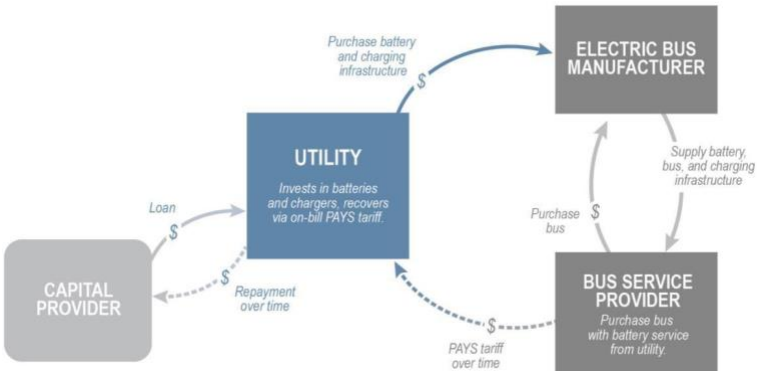
The Lab has described the PAYS mechanism in detail in its Instrument Overview,[5] and a brief summary is included here. The financial model assumes four key stakeholders for the transaction:

- **Utility:** supplies electricity as fuel to the bus service provider; and it can make site-specific investments if its regulators approve such a tariff structure.
- **Bus Service Provider:** purchases and/or operates buses, could be the transit agency
- **Electric Bus Manufacturer:** sells buses, including batteries and charging equipment
- **Capital Provider:** provides debt finance as required, could be a finance institution, development bank, commercial investor, etc.

The initial model is illustrated below (Figure 1) and shows the different parties to the transactions, their distinct roles, and the resource flows. The model, as adapted to Lima, is illustrated in Figure 4.

1 https://www.efeverde.com/noticias/autos-usados-principal-problema-de-contaminacion-del-aire-en-lima/
2 http://www.cies.org.pe/sites/default/files/investigaciones/dp_transporte_urbano_sep.pdf
3 https://www.cleanenergyworks.org/clean-transit/
4 Pay As You Save® (PAYS®) is a registered trademark in the United States of Energy Efficiency Institute (EEI). Co-Principals Harlan Lachman and Paul A. Cillo created the PAYS system between 1998 – 1999.
5 https://www.climatefinancelab.org/wp-content/uploads/2018/02/Pay-As-You-Save-for-Clean-Transport_Instrument-Overview.pdf

Figure 1. PAYS for Clean Transport Instrument Mechanics



The utility and the bus service provider agree to terms-of-service that allow the utility to pay for the primary components of the incremental upfront costs of electric buses – namely batteries and charging stations.

The tariff charge persists over the warrantied life of the equipment until the utility's costs are recovered, at which point the battery and charging station would be owned by the bus operator. The tariffed charge is capped at 95% of the projected annual savings in the first year, yielding a positive cash flow for the operator that is 5% of the estimated annual savings gained by switching to a battery electric bus.

Because a tariffed on-bill investment is structured differently than a loan, it allows bus operators to keep the transaction off of their balance sheets and allows the transaction to take place even if counterparties might be considered less than credit worthy, such as emerging cities.

3. Total Cost of Ownership of Diesel and Electric Buses for Lima

Clean Energy Works used the PAYS for Clean Transport model to estimate total cost of ownership (TCO) that was developed with the Global Innovation Lab for Climate Finance during its evaluation of the mechanism. TCO is a financial metric that considers factors that affect upfront capital costs as well as operation, maintenance, and fuel costs over the life of the bus. The model compares BEBs with diesel-powered buses. For the Lima analysis, all data was provided by the analytics firm BASE.[6] These inputs have the best available data to date and results should be interpreted as indicative, rather than as precise estimates**.** All inputs are found in Appendix 1 at the end of the report.

[6] BASE was hired by IDB to do a feasibility study for BEBs and provided Clean Energy Works with Lima specific data after gathering it from local suppliers, manufacturers, utility and bus operators.

Figure 2. Total Cost of Ownership of Transit Buses in Lima, Peru
(Net Present Value, 2019)

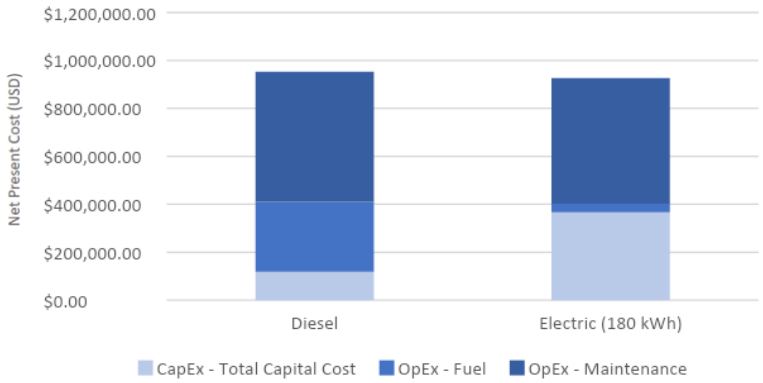


Figure 2 presents the results for the TCO in Lima for 12-meter BEBs vs. diesel buses. For procurement year 2019, a diesel bus is estimated to have a slightly higher total cost of ownership than a battery electric bus over the assumed 14-year lifetime. The BEB along with its charging infrastructure is anticipated to cost $25,100 less over its 14-year operating lifetime than the diesel transit bus.

The primary difference is the initial capital cost of the electric technology, which is three times higher for the BEB, including a battery replacement in year seven and charging equipment. The fuel cost is also a big difference being much lower for electric technology, this is due to much higher fuel economy for BEBs. The maintenance cost estimated for Lima, for both diesel and electric, is relatively high compared to documented data from other cities. These maintenance costs are expected to come down as the new technology is deployed, and in fact, initial data from the implementation of e-buses in Santiago show that their maintenance numbers are much lower than the estimate used for this analysis in Lima.[7] With lower maintenance costs, the TCO for electric buses will look more promising and could be lower in less than the period analyzed (14 years).

Furthermore, for electric bus technologies there are particularities of the bus routes, such as terrain, and other operating local factors, such as driving behavior, as well as whether that affect vehicle performance and cost estimates for the TCO. Once operators in Lima gather more data from the current BEB pilot underway, and the market for this technology evolves and grows in Peru, the difference between a diesel and an electric bus TCO will be more significant.

4. PAYS for Clean Transport for Lima

As a strategy to reduce the higher up-front cost of the battery technology option, Clean Energy Works modeled the potential of a PAYS for Clean Transaction in Lima. This mechanism allows a utility to pay for the upfront cost of the on-board battery and charging station and recover its

[7] Through a presentation to the Zero Emissions Bus Rapid-deployment Accelerator (ZEBRA), the bus operator Metbus in Santiago reported diesel maintenance cost as 0.3 USD/km, which is significantly lower than the figured reported for Lima of 1.18 USD/km. Metbus also reported reductions of 70% on maintenance cost for electric buses after one year of operation.

cost from the bus operator through a PAYS tariff as explained in Section 2.2. The inputs used for the PAYS analysis are shown in Table 1.

Table 1. Inputs for a PAYS Program for a 2019 Procurement in Lima

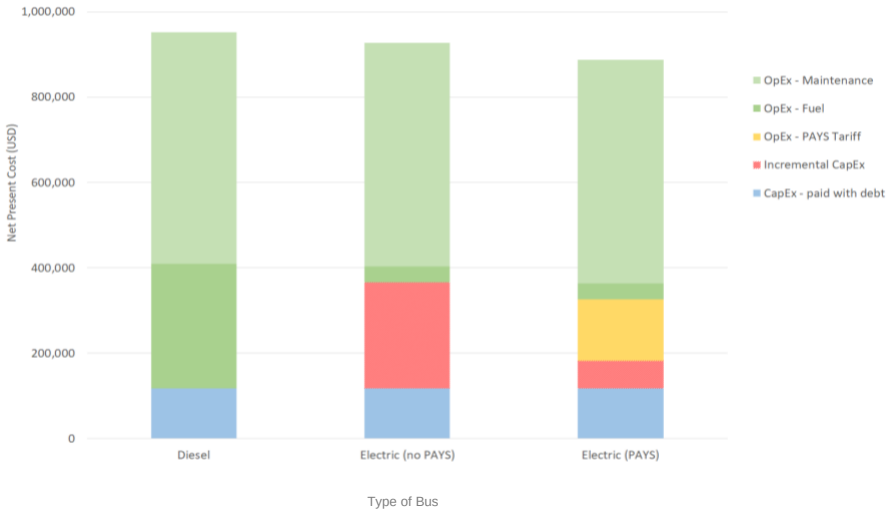
Parameter	Value
Cost of capital (for bus service provider)	8%
Cost of capital (for utility)	7%
Warranty of Battery	7 years
Number of Batteries	2
Years of cost recovery on tariffed terms	14 years
Cap on estimated annual savings committed to cost recovery	95%

Figure 3 shows the expected total cost of ownership in Lima for a diesel bus, a BEB, and a BEB purchased under a PAYS program in 2019, and the different allocation of expenses that make up those totals.

A PAYS for Clean Transport investment model in Lima further reduces the total cost of ownership for a BEB and compared to a scenario without PAYS by about 7.5%. This is due **to the lower cost of capital for utilities** as main actors in a PAYS transaction.

The other key difference between purchasing a BEB with PAYS vs. without is that a PAYS transaction for on-board batteries and charging stations would reduce the incremental upfront cost by 74% and this is due to the conversion of the cost from CapEx to OpEx through the PAYS tariff.

Figure 3. Total Cost of Ownership for Diesel, BEB and BEB with PAYS
(Net Present Value, 2019)



This reduction in incremental CapEx means that the amount of funding that could be used to assist in the purchase of one BEB without PAYS, could be used to purchase four BEBs with a PAYS program. **This would reduce reliance on concessional funds that are limited and would help deploy more BEBs faster for the same amount of funds coming from capital providers**, the utility, or commercial banks.

The mechanics of the instrument would work as follows, a bus service provider or operator in Lima participating in a utility's PAYS program would pay or finance the same amount of capital as it would for a diesel bus, and it would utilize additional concessional or blended finance to afford the remaining incremental cost of a BEB. A utility would agree to pay the incremental upfront cost of an electric bus, corresponding to the battery and charger, and would recover these costs through tariffed charges. The bus operator agrees to pay a fixed tariffed charge in their monthly electricity bill. The tariffed charge would span the expected life of the bus with a battery replacement considered in year seven as outlined in Table 1.

A PAYS program would substantially help operators to make this transition to BEBs. Further, this initial analysis was completed for only one bus, but additional economies of scale for charging infrastructure would reduce operation costs in the long term.

5. What's Needed to Electrify Public Transit in Lima and Beyond

Using the metrics of total cost of ownership and adding environmental benefits, quantified for Lima as 85% reduction on CO_2 over the life of the bus, it is clear BEBs offers greater economic and public health benefits. Moreover, using a PAYS financial instrument, it is also clear that BEBs can be a cost-effective mechanism for their procurement and operation. While Latin America is advancing as a major player in electric mobility in mass transit, full bus fleet transitions remain elusive.[8] Several barriers, in addition to the higher upfront cost, include local institutional and technological issues that must be overcome to achieve scale, while seeking to expand from one city or a few pilots to the elimination of diesel fleets throughout the region.

The following section contains a short description of the main institutional and technological barriers identified in the Lima case, many of which are also faced by other cities in the region.

5.1 Barriers to Transport Electrification

- **Staff capacity**. Some public institutions that are responsible for and spearheading transportation electrification (i.e. transit agency, city government) lack capacity compared to the staff in private companies and private utilities. Further, the staff of bus operator companies (mostly private) have other priorities. Without added capacity, the transition to electric buses will be slowed as regulators and operators attempt to surmount a steep learning curve for this new technology.

- **Procurement policies**. Given that electric mobility and clean technologies are still considered leading-edge, it is expected that procurement policies, which would have been put in place decades before, have not yet been appropriately updated to adapt to this new context. A requirement to purchase the least cost product or least cost service is an example of such policies. In the context of electric mobility technologies, it should be reformed to consider the total cost of ownership of cost-effective technologies to maximize benefits over the lifespan of the technology, not just comparing the initial capital investment.

[8] https://www.greencarcongress.com/2019/06/20190617-byd.html

- **Institutional arrangements**. The public transport sector in the region has varying structures that stem from the waves of privatization and formalization of transport services. The transit agency typically regulates the service but does not operate individual buses. Instead, private companies own the buses and provide bus service. Through a concession, the transit agency aggregates operators for specific routes and services, paying them a per-km or per-passenger rate for providing service. To facilitate the management of the monetary resources and transactions between the transit agency and the operators, *fiducias*, or fiduciary agencies, collect the fares from the operators and distribute the resources in the manner agreed to by the transit agency. These multiple layers of financial and operational complexity must be considered when electrifying bus fleets. Lima's Transit Agency is Protransporte (Instituto Metropolitano Protransporte de Lima), and it is undergoing reforms intended to improve services and regulate (and legalize) all modes of transportation, including Metro, BRT, buses and minivans.

- **Lack of local supply chain.** In Peru, there is not yet a local supply chain or local market for BEB manufacturing and assembly, which also drives up the maintenance cost of the buses. These costs are anticipated to decline since BEBs have a simpler drive train than diesel buses with fewer parts to maintain, and less brake wear due to regenerative braking. At this time however, due to the lack of in-country parts availability, cost to import parts and associated duties, as well as the learning curve of this new technology to maintenance workers, maintenance costs are estimated to be higher in Peru than in other locations explored to date.

- **Unpriced climate costs for CNG bus technology.** Although CNG buses were not modeled for this report, buses powered by gas technology are much cheaper when the cost of greenhouse gas pollution is not included.[9] In Lima, CNG buses may be more cost-competitive with diesel buses than BEBs, altering the value proposition of transitioning to BEBs, regardless of the PAYS offer.

5.2 Barriers to implementing PAYS for Clean Transport

While the barriers discussed in previous section apply to any financial instrument used to procure BEBs in Lima, Clean Energy Works focuses on helping cities overcome the high upfront barrier, so this section is dedicated to specific barriers for a PAYS transaction in Lima.

- **Solvent bus operators.** One of the fundamental assumptions of the PAYS model is that bus operators can afford the cost of purchasing a new diesel bus, through either cash or financing. In Lima this is not the case, due to the changing institutional arrangements described in the prior section and other factors (i.e. low ridership, low quality service) currently most bus operators do not recover all their costs and do not have a good financial standing to replace their diesel buses. Protransporte is evaluating this situation and changing the way the remuneration and cost recovery is calculated. However, until those reforms are in place, access to financing for operators is an unanticipated barrier for PAYS.

- **New utility regulations.** Another key factor for a PAYS program to succeed is the active role of the utility and its regulatory framework. Though the PAYS transaction is fundamentally a utility investment, some still perceive it as a loan. Because of this lack of

[9] The purchase price of Compressed Natural Gas (CNG) Bus was quoted in $160,000, while the BEB was quoted at $325,000 (with one battery of 180 kWh). For comparison, the diesel bus purchase price was $118,000.

clarity, the PAYS could be subject to financial regulations rather than strictly utility regulation that govern traditional terms of service agreements (tariffs).[10] Such a determination would need to be made by local attorneys and regulators, but until that point, the uncertainty could affect the market. More local research is needed to determine the specific regulations that need to change to secure implementation.

- **Seeking a first case for a new financial instrument.** While PAYS is a proven model for energy efficiency upgrades in buildings in the United States, there is not yet any example in the transportation sector, which creates uncertainty for some stakeholders. Although the award from Convergence Blended Finance has helped to educate and inform key stakeholders in Lima, more awareness, training and capacity-building on the model will be necessary. Once PAYS for Clean Transport is implemented with a first case, we expect confidence in the PAYS model in public transit to rise.

6. Lessons Learned from the Lima Analysis

6.1 Adjusting Assumptions in Initial Model to Account for Local Context

The initial model for PAYS for Clean Transport was based on assumptions of conditions that were disproven during the study. The experience showed that the local context of Lima and the barriers presented in Sections 5.1 and 5.2 require additional elements to be taken into account. As a result, Clean Energy Works adapted the original Figure 1 for the PAYS instrument, that has all the stakeholders and flows, to include additional elements needed to be taken into account and produce Figure 4 as shown below.

Figure 4. PAYS for Clean Transport adapted with additional blended finance solutions.

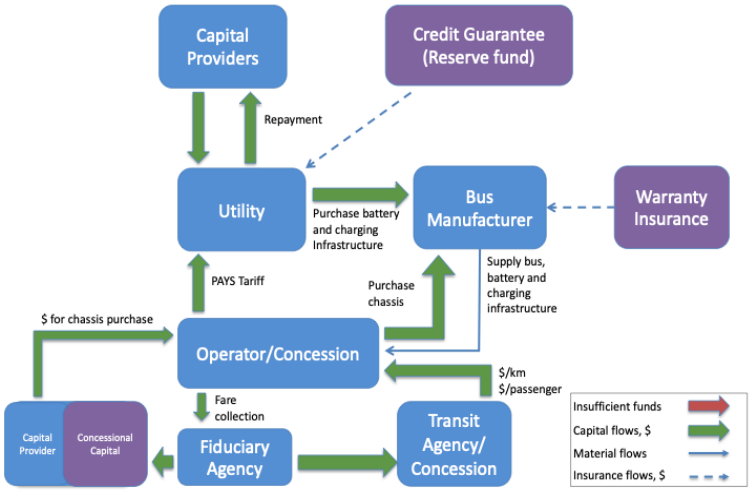


Figure 4 includes the additional actors in the institutional context of Lima and other Latin American cities, and it illustrates additional financing flows from / to different stakeholders.

[10] In the United States, as of this publication, PAYS transactions for energy efficiency have not been treated as traditional financing options and therefore not subject to consumer protection laws since the program is offered under a terms of service agreement, rather than a lien or loan program.

These additional financial flows aim at improving access to sources of capital and reducing risks for a PAYS transaction.

First, it includes access to **capital providers and concessionary capital** (lower left corner) for bus operators and concessions, who were previously assumed to have sufficient access to capital to replace diesel buses with more diesel buses. Instead the bus operators appear to face an affordability gap even for replacing existing diesel buses with new diesel buses. As discussed in Sections 5.1 and 5.2, this is the result of chronic insufficiency in remittances from the fiduciary agency collecting and distributing system revenues. The use of **concessionary capital**, which Lima can access through institutions such as Inter-American Development Bank, is included to be used by the bus operator to cover the remaining incremental CapEx illustrated in Figure 3.

Second, it includes a **reserve fund or credit guarantee** (top center) that could be tapped to reduce risk for the utility in the event that transit operators that are operating electric buses do not pay their electricity bill and PAYS tariff.

Finally, a **warranty from the manufacturer** (right side) is vital to mitigate technology risk, yet the terms offered in Latin America are not as robust as in the United States. The commercial terms for risk mitigation would serve a purpose similar to insurance for an extended warranty product for technologies that have not been in the field long enough to get actuarial data on performance.

6.2 Continuing Engagement with Cities

The choice of Lima for this analysis was made in consultation with the Inter-American Development Bank among others, recognizing Lima's motivation to generate benefits to local air quality and public health and climate risk mitigation. However, due to the institutional barriers identified in Lima, other cities with different regulatory contexts for advancing electric mobility may be better positioned to introduce an innovation in finance to support a faster path to scale.

To that end, Clean Energy Works is engaging with the Zero Emissions Bus Rapid-deployment Accelerator (ZEBRA), a collaboration to accelerate electric bus deployment in Latin American cities led by C40 and the International Council for Clean Transportation (ICCT) supported by Partners for Growth (P4G). ZEBRA is working in Santiago, Mexico City, Sao Paulo and Medellín. Clean Energy Works has used this venue to introduce the concept of PAYS to new audiences (mostly bus operators) and receive feedback that both improved and validated our understanding on how the model might operate. Much of the discussion within this collaboration centers on how to overcome institutional barriers that are common across Latin American cities and aligning on the need to identify front runners among utilities and operators, especially in the ZEBRA cities, which have the motivation and capacity to innovate. This engagement is one of the ways that Clean Energy Works is continuing to seek first movers for PAYS program.

6.3 Engagement with Utilities

The Lima feasibility study as well as engagement with ZEBRA have highlighted the importance of the role of the utility in a PAYS transaction and in improving the nascent ecosystem of electric mobility stakeholders. ENEL and ENGIE are the most important global utility sector players in

Latin America and have already participated in BEB transactions in the region.[11] The institutional challenges identified in this report have been validated by both utilities, and they continue seeking opportunities to accelerate electrification. For example, one utility is exploring an instrument for leasing batteries to taxi operators with sound balance sheets in Mexico City, which is producing lessons for the whole field.

Other local utilities, such as CELSIA and ENSA, are also interested in benefiting from electric mobility and could be engaged with replication possibilities within their service areas. The discussions with these utilities will proceed to discover if there are any other institutional barriers that would warrant pro-active attention.

Clean Energy Works has also noted the need to engage with experts on utility regulations in each region to address one of the barriers identified in Section 5.2. the need for regulatory framework to the introduction of PAYS tariffed terms of service. There are far fewer regulatory agencies than the number of utilities, yet for a single multi-national utility, there are multiple regulatory jurisdictions. Therefore, this aspect of engagement in support of utility innovation depends entirely on the specific location, which we will seek to identify based on interest of utility partners.

6.4 Engagement with Financial Institutions

The Inter-American Development Bank, the World Bank and its affiliates, including Global Infrastructure Facility, facilitate lending in the region. The development banks are interested in innovative approaches to reducing greenhouse gas emissions and in building support for a pipeline of projects through collaborative platforms like ZEBRA. Continued engagement with financial institutions will help identify solutions for the hurdles that utilities, cities, and bus operators face in using a PAYS tariff to accelerate electrification of transit systems.

The support from financial institutions will be key to PAYS for Clean Transport transactions in emerging cities, where with weaker currency and more volatility in markets, the higher upfront cost is even a bigger barrier. With limited funds from concessional sources or limited access to credit for cities, there is need to explore additional financing strategies to afford the higher upfront cost of BEBs. Clean Energy Works recognizes the remarkable depth of expertise in cities as well as utility industry engagement at the International Finance Corporation (IFC) and we will continue to explore the potential for engagement with IFC partners.

7. Conclusions

Battery electric buses in Lima have a great potential to be a cost-effective carbon mitigation strategy, costing less than the fossil fuel alternative using a total cost of ownership comparison and reducing greenhouse gas emissions at the same time. This analysis is sensitive to assumptions about estimated maintenance costs and battery cost and durability, both of which have trends that favor electric vehicle technology as we noted in preliminary results from Santiago.

[11] https://www.reuters.com/article/us-chile-environment-electricvehicles/chile-drives-electric-vehicle-rollout-in-latin-america-idUSKBN1O80HZ

In order to reduce the persistent barrier of BEB's much higher upfront cost, this analysis explored the potential to use a PAYS for Clean Transport mechanism for Lima's procurement. The model showed a reduction of 74% in the incremental capital cost when utilities are part of the transaction and invest in the on-board battery and charger of the electric bus. However, various technological, institutional and regulatory barriers were identified that need to be mitigated to make this transaction possible.

The key next steps to the adoption of PAYS for Clean Transport or any novel BEB financing mechanism includes engagement with electric utilities, with financial institutions and with local and regional allies in order to support existing ongoing reforms, to find solutions to remaining barriers, and improve data quality and availability. Local experts in transit, utilities, and finance operating in a single in-country context are best positioned to map the path of needed reforms for scaling up financing, including the use of PAYS for Clean Transport. The policy reforms that Protransporte is taking in Lima would clear the way for a solvent bus operator business model and would also create an action path for PAYS implementation. We also recognize that Lima may require a combination of solutions to address issues beyond the increased upfront cost.

The proposed adapted PAYS for Clean Transport for Lima, could be applicable to other cities in the region given similar institutional structures. Its proposed modifications such as access to concessional capital and blended finance for operator, a reserve fund and guarantees for utilities and an insurance warranty could be further tested as potential solutions in other cities. Through regional partners such as ZEBRA collectively we can identify the front runner cities and those willing to innovate. We can connect project developers and local operators with financial institutions and utilities in those cases where institutional and regulatory hurdles are being resolved more diligently.

Clean Energy Works has validated these results from Lima with a range of stakeholders in multiple institutional contexts (e.g. ZEBRA workshops, P4G convenings, meetings with IDB, IFC, and World Bank). One of the main conclusions is that PAYS for Clean Transport will likely be implemented first where there is an alignment of factors: motivated utility, front runner transit agency, solvent bus operator, adequate regulatory framework, and ready finance institution.

Based on lessons learned in Lima and in the rest of our portfolio, Clean Energy Works will continue working with allied experts through platforms for international collaboration to support actors in additional utilities and cities that are willing to undertake a financial analysis and a proof of concept for PAYS for Clean Transport.

Appendix 1 - Inputs

The main data inputs used in the model are presented in Table 2. All data points were supplied by BASE, a contractor to IDB.

Lima's utility company, ENGIE Peru, provided BASE with the information about rates. It is assumed the bus will be charged off peak in the depots at night. The rates used in this modelling are the current rates for off peak charging and do not reflect any special BEB tariff rates.

Table 2. Inputs and Assumptions for Lima BEB's PAYS Analysis

Item	Units	Value	Assumptions
Bus lifetime	Years	14	
Distance travelled per year	Km	56,784	
DIESEL BUS			
Diesel bus cost	$	$ 117,858	Includes value-added tax (IVA).
Diesel price	$/litre	$ 0.98	
Fuel economy	litres/km	0.5	
Maintenance costs	$/km	1.18	
ELECTRIC BUS			
Electric bus cost	$	$ 366,703	Includes battery replacement at year 7 and value-added tax (IVA)
Battery pack cost	$/kWh	$ 543	Includes IVA. 2019 Price from vendors
Battery pack size	kWh	180	
Fuel economy	kWh/km	1.05	
Maintenance costs	$/km	1.14	
Off-peak charging	%	100%	
Residual value of battery	$/kWh	0	
Length of battery warranty	years	7	
ELECTRICITY TARIFF			
Off-peak demand charge	$/kW	$ 10.05	
Off-peak electricity price	$/kWh	$ 0.07	
PAYS TARIFF			
PAYS Tariff duration	year	14	
INFLATION			
Electricity price inflation	%/year	1.9	
Diesel price inflation	%/year	4.5	
ELECTRICITY			
Emissions Factor	tCO2/MWh	0.19	
DIESEL TECHNOLOGY	Euro IV		
Emissions Factor	tCO2/lt/	0.0027	