ADVANCING PUBLIC TRANSPORT

IMPLEMENTATION OF ELECTRIC BUSES IN CHINA – KEY LESSONS

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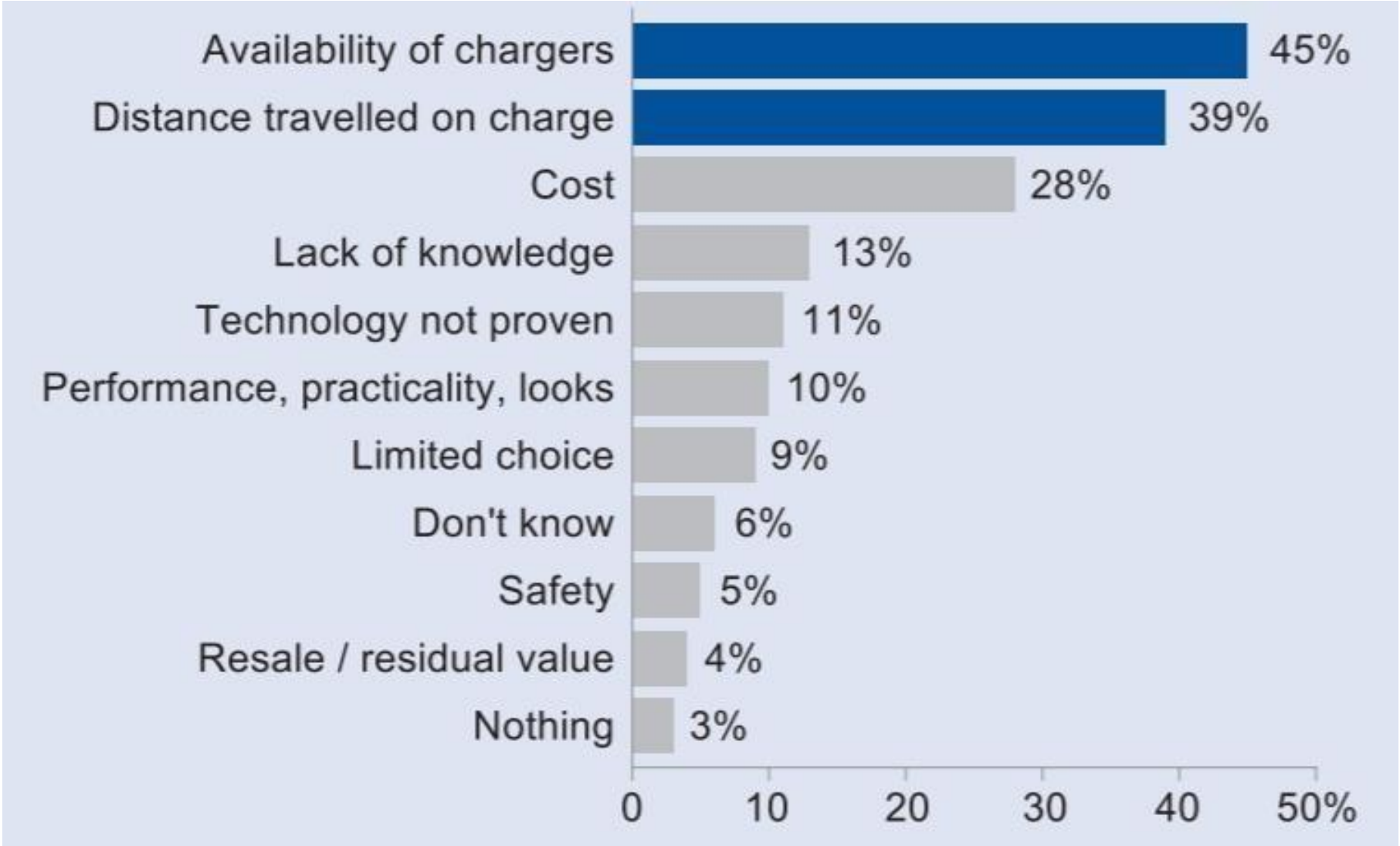
E-VEHICLE HISTORY

- In 1900 38% of vehicles sold in the US were electric powered
- Commercial vehicles used a model of battery swapping with the vehicle owner / operator owning sets of lead-acid batteries
- Road building encouraged longer distance travel
- Speed of gasoline refuelling an advantage
- Mass production of the Model-T Ford cost $650 versus $1,750 for the equivalent electric vehicle
- 1912 - invention of the electric starter motor

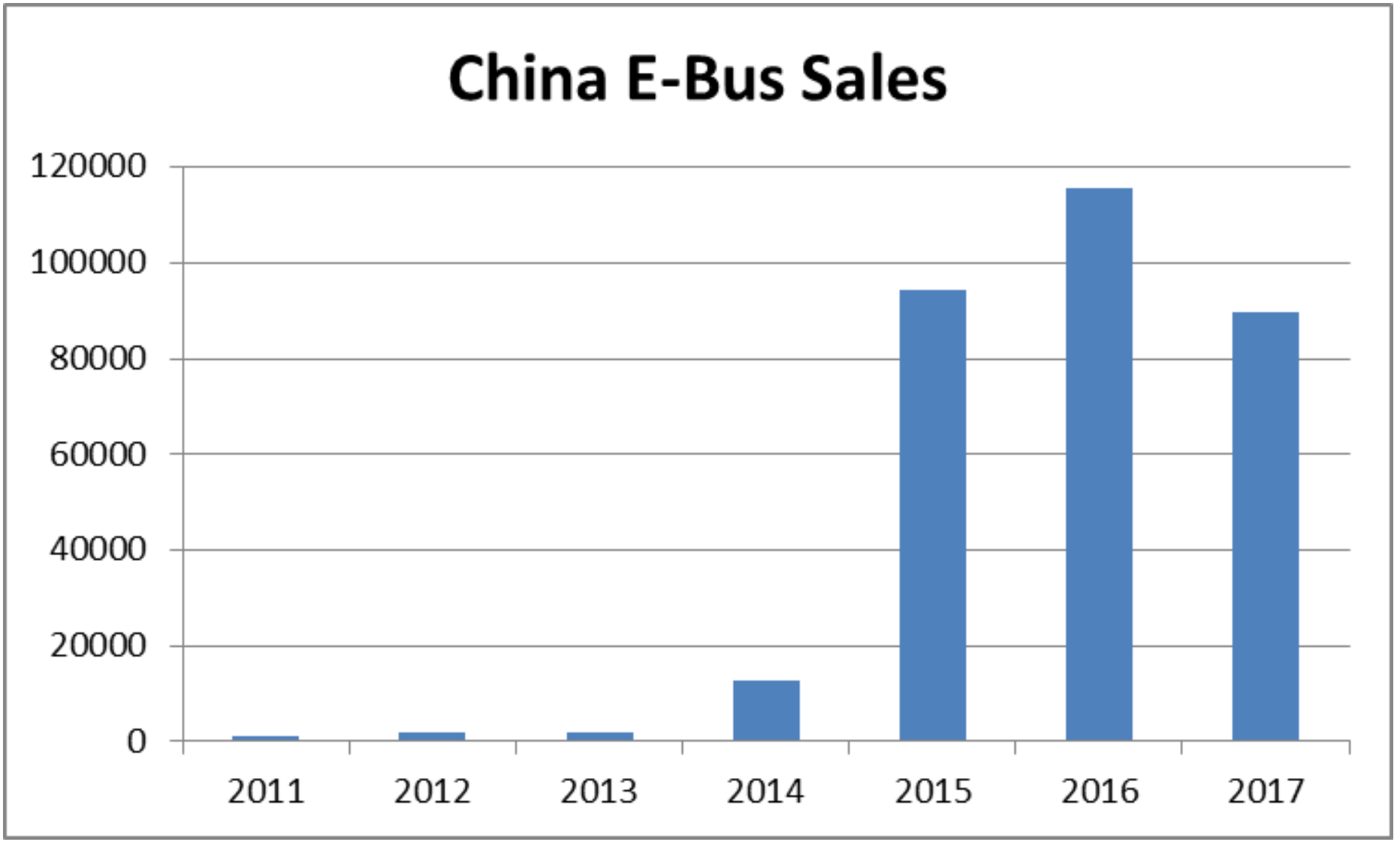
CURRENT CHINA MARKET

- 90,000 e-buses sold last year bringing the total e-bus fleet up to over 316,000
- Represents around 92% of the global e-bus fleet
- 9 out of top 10 suppliers are local Chinese
- The major suppliers are BYD, Yutong, Nanjing Golden Dragon, Foton, Zhongtong and Yinlong
- Historically there has been up to 1,000,000 RMB available in subsidy in China but this creates it's own problems
- Shenzhen has a full electric fleet of 16,359 e-buses with 510 charging stations and a total of over 8000 charging points

BARRIERS TO EV ADOPTION



316,978 E-BUSES IN CHINA



"SUBSIDY IS THE ENEMY OF INNOVATION"

- Up until last year the Beijing government offered RMB500k (USD 80k) subsidy per e-bus and a similar amount was matched by the local government to give a total subsidy of RMB 1 million (USD 160k)
- Bus price is approximately RMB 2 million (USD 320k)
- Battery costs are approximately RMB 1 million(USD 160k)
- Subsidy (paid to OEM) was being abused and engendered lower quality product
- Central government gradually reducing subsidy over coming years
- Hence a peak of sales in December 2017

SHENZHEN EXPERIENCE (1)

- Shenzhen, a city of 12 million+ citizens was chosen by the China government to be 1 of 13 cities to trial new energy vehicles in 2009
- In 2017 RMB 3.3m (USD 520k) was given out as subsidies for vehicles and infrastructure
- Mixed fleet with major supplier BYD
- Buses can achieve around 200km per charge so some need to be recharged during the day. Flat topography
- Buses running 60,000km per year which attracts an extra government incentive of 500,000RMB (USD 80k)

SHENZHEN EXPERIENCE (2)

- Battery risk is borne by the supplier with an 8 year warranty. Whilst the majority of buses are around 3 years old nearly all are on their first life batteries
- Battery charging is sub-contracted and charged back at RMB 0.6/kWh (USD 10c)which is a lower cost than diesel. The sub-contractor is responsible for the infra-structure
- Less maintenance required than a diesel bus
- Availability up at around 95%
- Operations are profitable
- Started trials of automatic driving buses last December

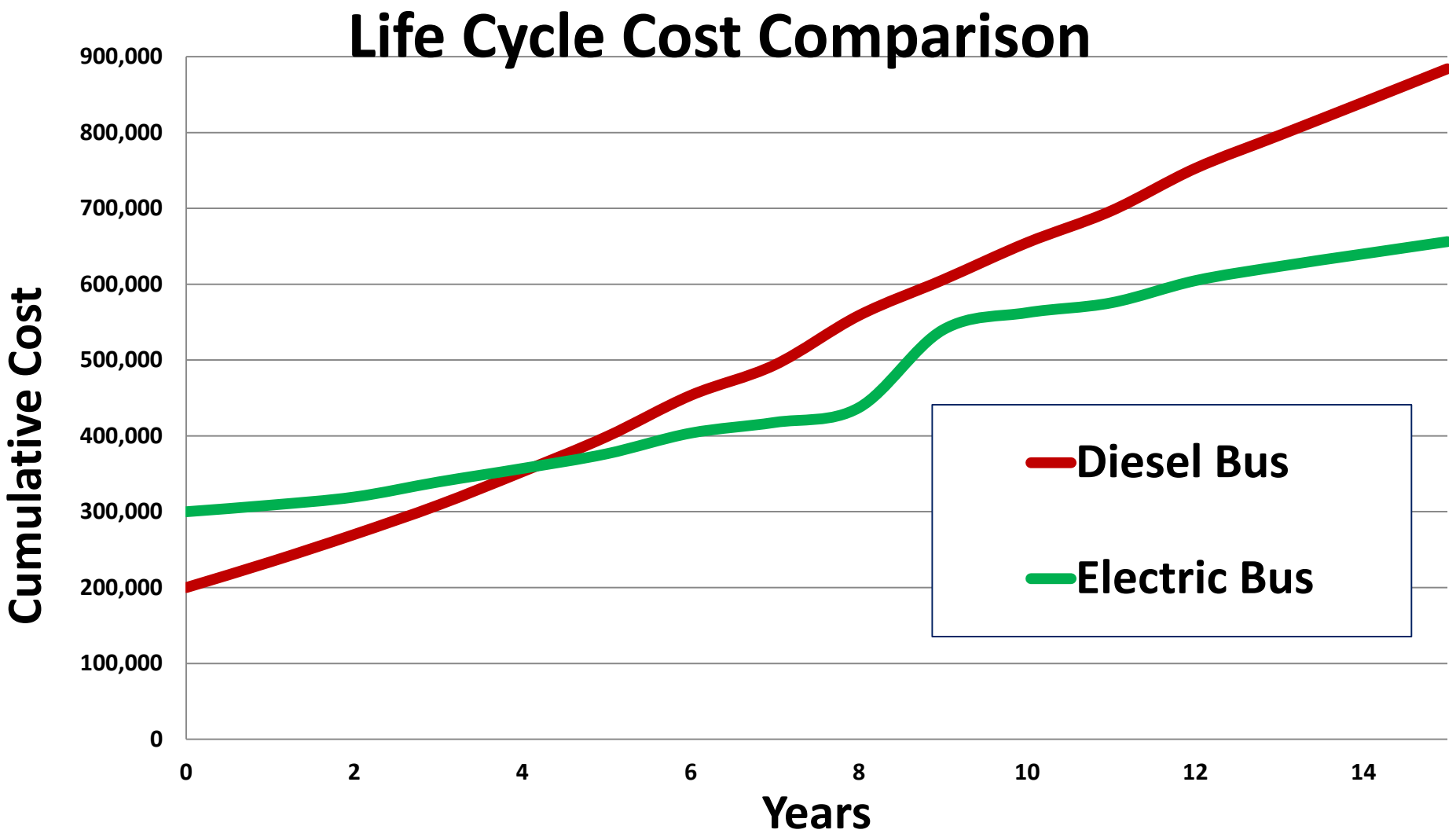
COST OF OPERATION MODEL

Assumptions

- Zero Inflation
- Values are USD
- No tax on fuel

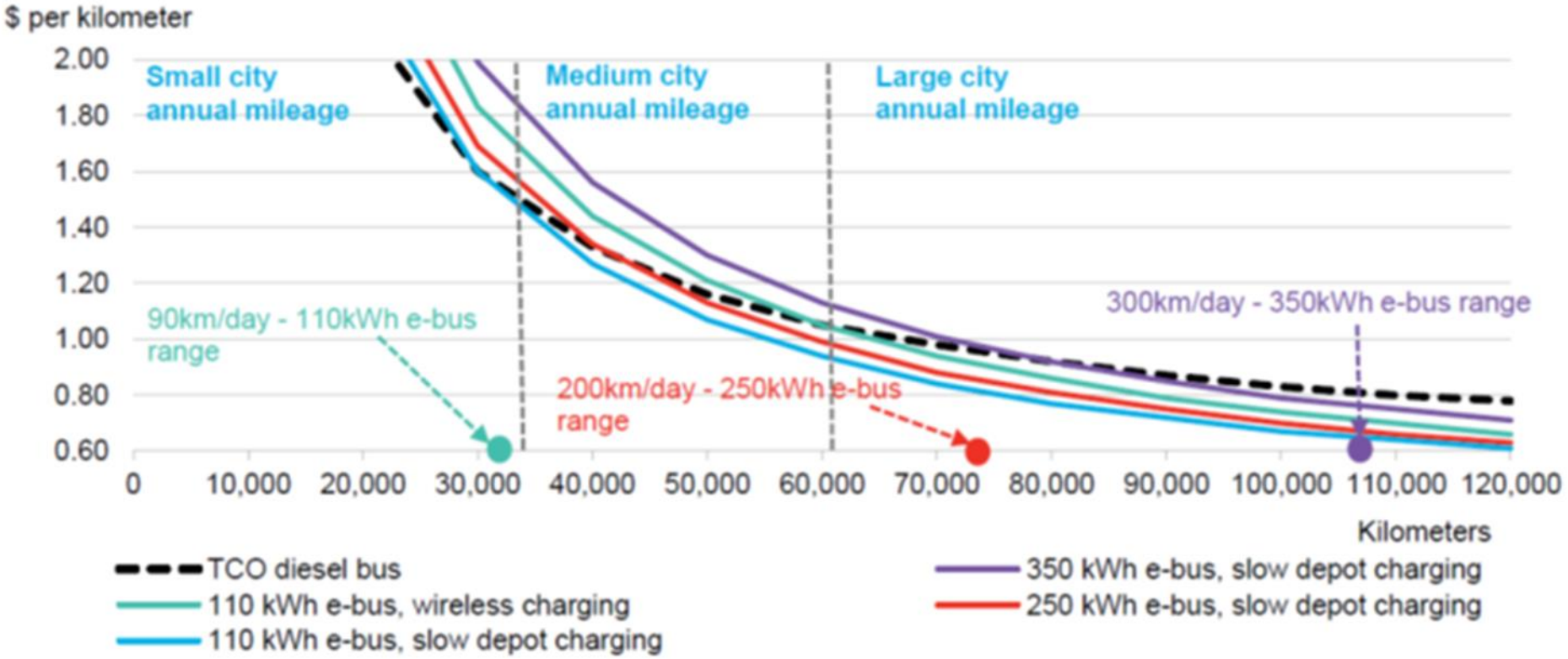
					DERV	BEV
Assumptions				**Capital Purchase Cost**	**$ 200,000**	**$ 300,000**
Bus operating Day	14	hours				
Average Speed	16.0	kph		**Operating Costs**		
Annual mileage	75,628	km		Annual Energy Consumption (litres/kWh)	37,814	60,502
				Fuel Cost per Annum	$ 23,823	$ 5,748
DERV fuel conspumption	2.0	km/l		Annual Urea Cost	$ 2,269	$ -
BEV Energy Consumption	0.8	kWh/km		**Total Annual Fuel Running Cost**	**$ 26,092**	**$ 5,748**
Diesel Fuel Cost	0.63	$/litre		**Mean Annual Maintenance Costs**	**$ 19,513**	**$ 17,995**
Urea consumption by fuel	6	%				
Urea Price	1	$/litre		**Mean Annual Total Running Costs**	**$ 45,605**	**$ 23,743**
Labour Hourly Rate	350	$				
Electricity Cost	0.10	$		**15 Year Cost of Ownership**	**$ 884,073.37**	**$ 656,140.02**

GRAPHICAL COMPARISON



BLOOMBERG STUDY

Figure 1: Total cost of bus ownership comparison with different annual distance

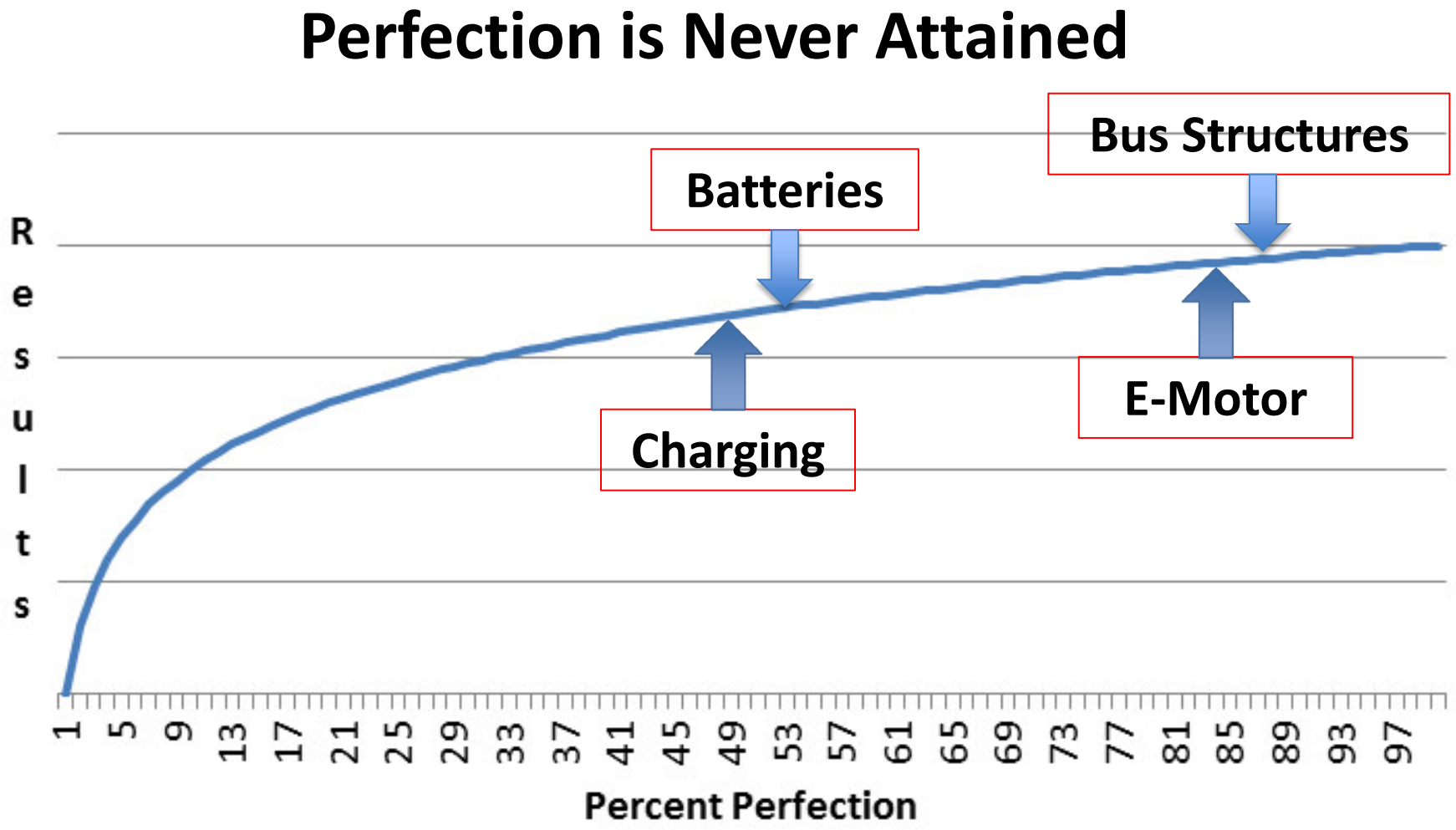


Source: Bloomberg New Energy Finance, AFLEET, Advanced Clean Transit Notes: Diesel price at $0.66/liter ($2.5/gallon), electricity price at $0.10/kWh, annual kilometers traveled – variable. Bus route length will not always correspond with city size.

HONG KONG EXPERIENCE

- Government has provided subsidy for the trial of 36 e-buses to be operated over a 2 year trial basis
- The charging infrastructure issues have been left up to the operator and OEM to resolve
- Vehicles have been operated as 'orphans'
- Perceived reliability has been an issue as well as the lack of being able to operate full days
- No conclusion at present and no follow up proposed

ELEMENTS OF E-BUS



BATTERIES

Selection Criteria

- Weight per kWh
- Space per kWh
- Cost per kWh
- Cycles to deterioration
- Chemical and mech safety
  - Impact
  - Isolation
  - Water

Major suppliers BYD, CATL, ZTE and Microvast

CHARGING

Plug-In Recharge

- Low cost
- Trailing cables
- One vehicle for several hours
- Typically depot based
- Any substantial numbers require sub stations

Opportunity Recharge

- Overhead or Inductive
- Infrastructure shared
- Typically en-route although can be depot based similar to fuel pump arrangement
- Higher Charge rates available

LESSONS ON E-BUS ADOPTION

Concerns

Battery Life

Range Anxiety

Recharging Infrastructure

High Capital Cost

Operational Costs

Reliability Concerns

Solutions

Warranty or leasing

Infrastructure

Policy

Greater efficiency will reduce battery requirement and cost

Electricity $0.1 per kWh

Battery – motor what's the problem?

E-BUS EVOLUTION –STEP 1

China

- Government has directed e-bus adoption through policy and heavy subsidy. This is also driven through a desire for non-reliance on fossil fuels
- Policy has ensured that there are no obstacles to infrastructure issues which hamper e-bus growth
- China now has the largest fleet of e-buses in the world with over 90% of the world's e-bus fleet
- One third of buses sold in China are now e-bus
- Product quality threshold is compromised by previous subsidies – "subsidy is the enemy of innovation". Incentives are more effective
- China is a command economy rather than a demand economy

E-BUS EVOLUTION STEP 2

Rest of World

- Slow uptake on e-bus due to infrastructure and political issues. Policy and possible subsidy on infrastructure will still be required
- Major OEM's reluctant to go into e-bus business as it is a substitute business and need to prove reliability meet's their customer expected standards
- Future products will need to justify themselves commercially on cost of ownership
- Recent Bloomberg report predicts 50% of buses will be electric by 2025
- New models of bus ownership and operation will evolve

SUMMARY

- China has lead the way in e-bus introduction and is improving in quality but the lessons must be learnt
- The successful implementation of e-bus requires strong backing of government policy to facilitate a planned infrastructure implementation
- Products need to be developed to compete in a commercially stable environment that offer competitive advantage
- Incentives not subsidy (ref. Norwegian model)
- New technology risk and fear is removed from the operator
- E-buses will dominate the market within the next 10 years driven by increased urbanisation

THANK YOU

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