International Experience with Electric and Zero Emission Buses

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International Seminar

Electric Mobility in Public Bus Transport: Challenges, Benefits and Opportunities

9 May 2018

Ministry of Cities - Brazil

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THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Buses are a visible entry point for cleaner fuels and vehicles

Old diesel technology can give the best BRT the worst image

INSISTEN EN DUDAS EXPRESADAS POR ENTES DE CONTROL, CONCEJALES Y AMBIENTALISTAS

Desde el Congreso piden revocar licitación para renovar buses de Transmilenio

Bogotá 18 Abr 2018 - 11:47 PM
Por: -Redacción Bogotá -bogota@elespectador.com

Senadores y representantes cuestionaron el proceso y pidieron una nueva convocatoria que incluya buses de tecnología limpia. Critican al alcalde Peñalosa porque en la licitación "prima el interés financie bienestar de los bogotanos".

Después de críticas, Peñalosa cambia puntos de licitación para nuevos buses de Transmilenio

Bogotá 24 Abr 2018 - 10:27 AM
Por: -Redacción Bogotá -bogota@elespectador.com

Quienes incluyan buses con tecnología Euro VI, una de las más limpias que se conocen en la actualidad, podrán tener hasta 400 puntos. En la primera propuesta presentada por el Distrito este ítem solo representaba 50 puntos.

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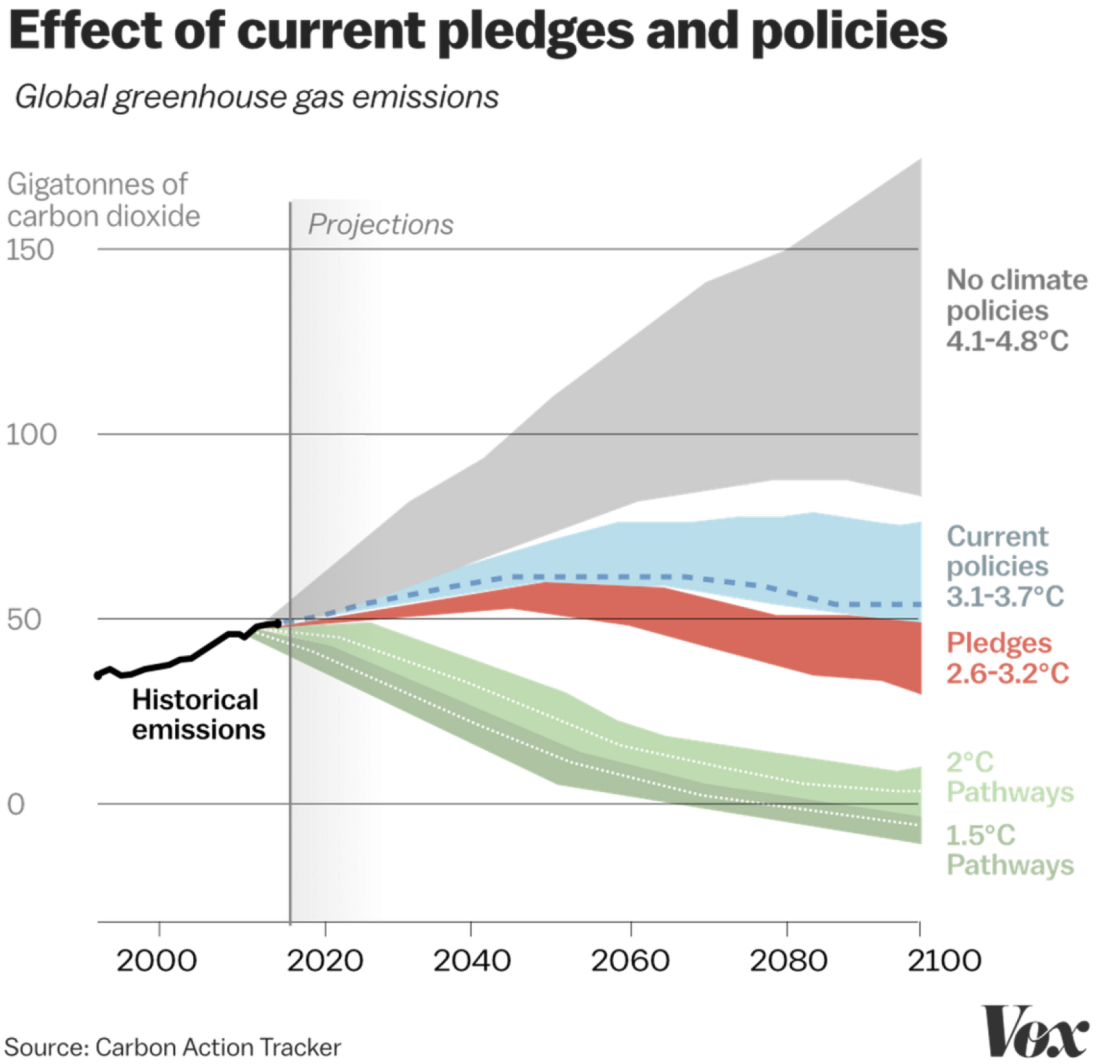
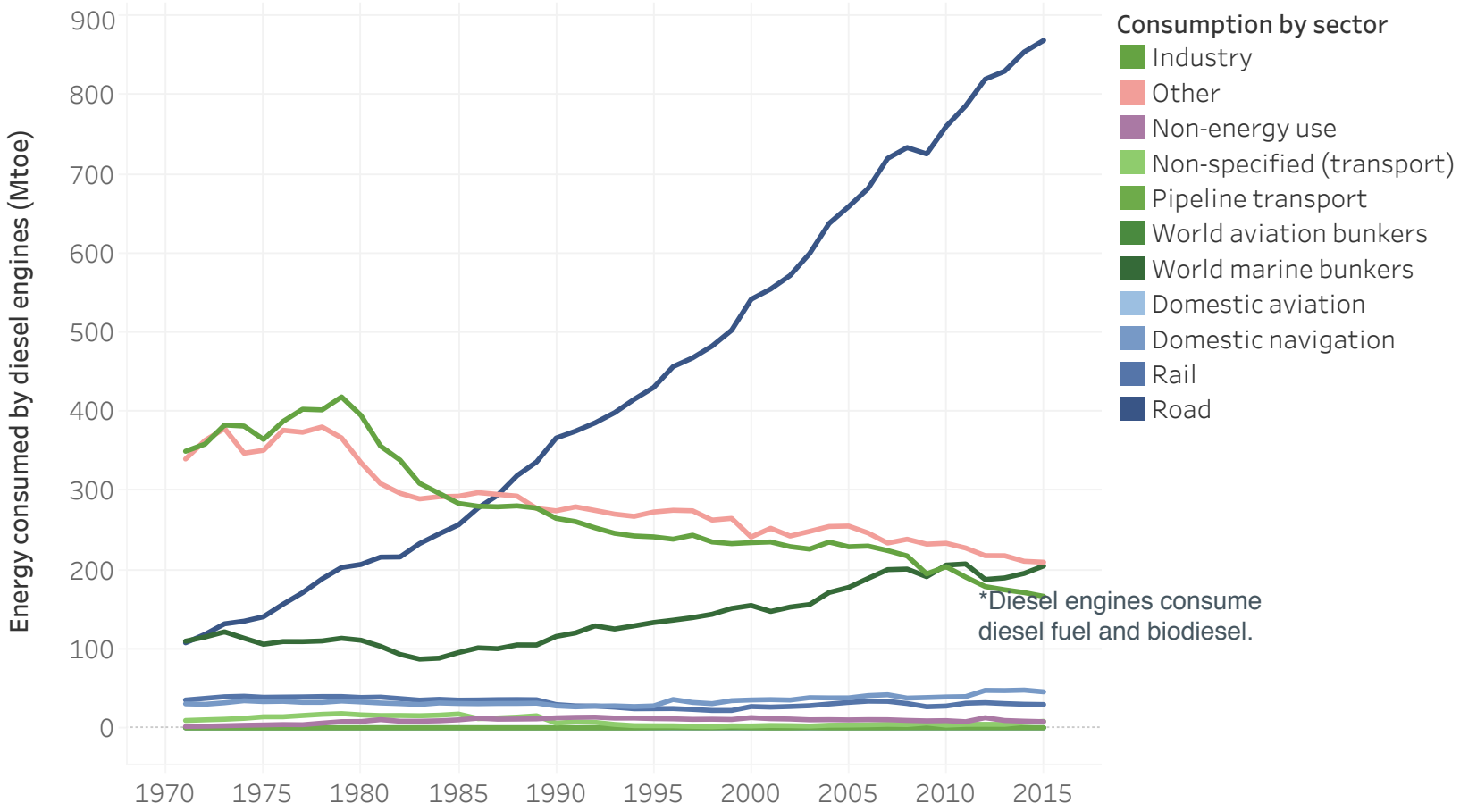
9 out of 10 people breathe polluted air

But we also face a climate challenge



Energy consumption of on-road diesel engines* has increased more than 400% since 1980



Based on IEA data from the World Energy Balances Data Service

China Airpocalypse (2013 Jan)

China National Ten Measures (2013)

60% of new buses in major cities must be NEVs

- Battery electric
- Plug-in Hybrid Electric
- Fuel Cell Electric

Figure 1. Vehicle population in China's provinces and municipalities in 2014 (10,000 units)

China Industrial Policy: 48 Billion USD in NEV Subsidies since 2009

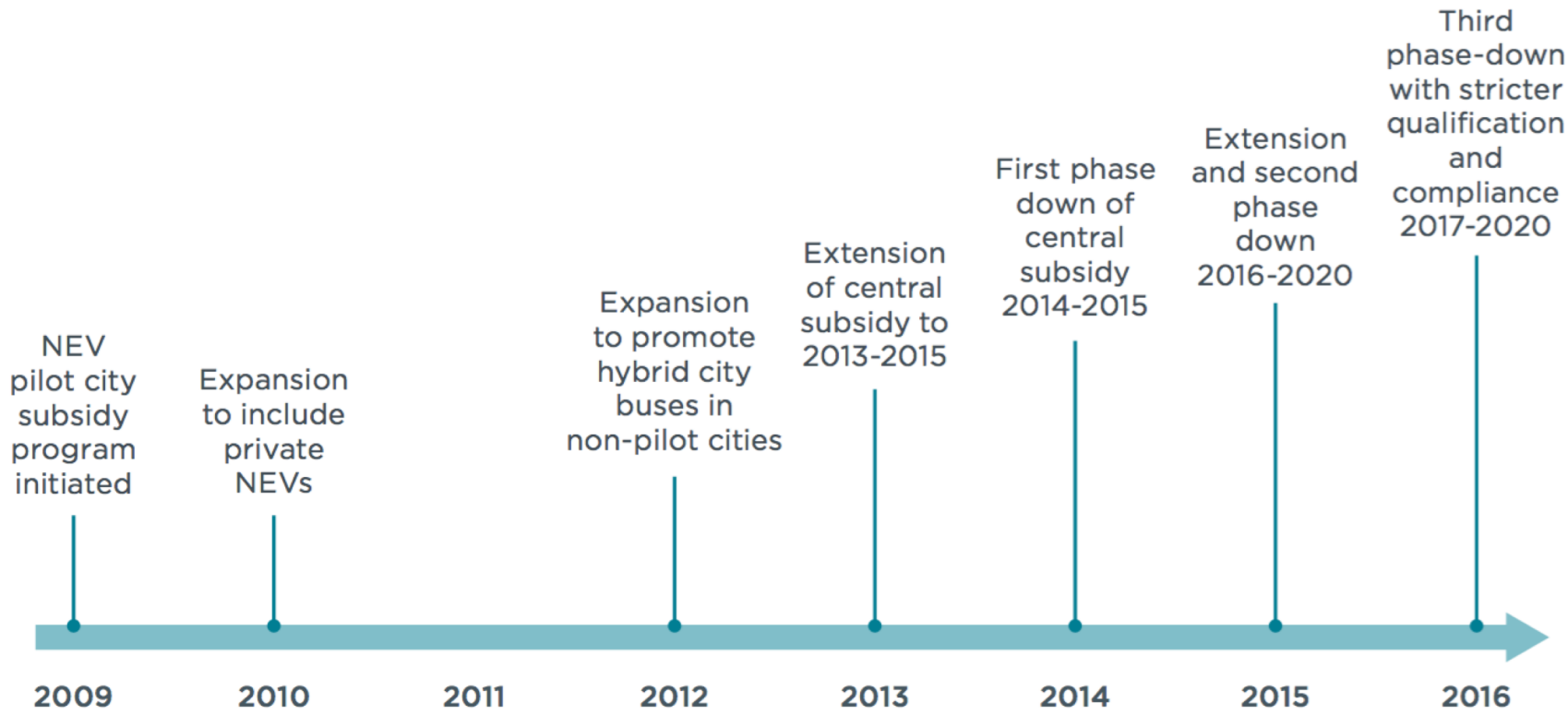


Figure 1. Timeline of China's national NEV subsidy policies.

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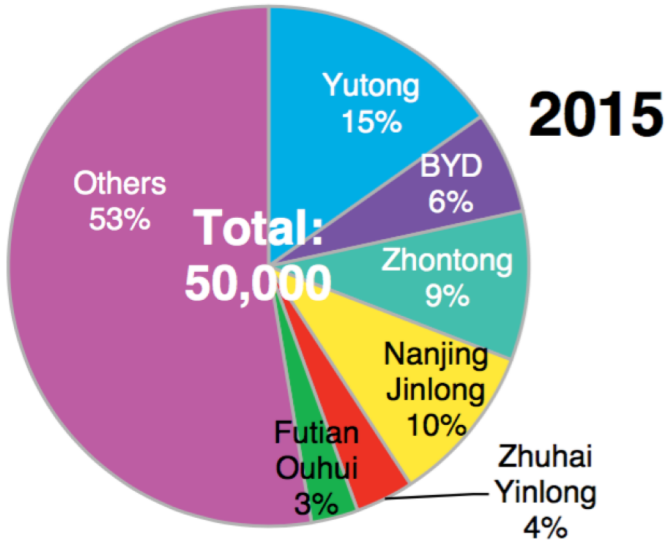
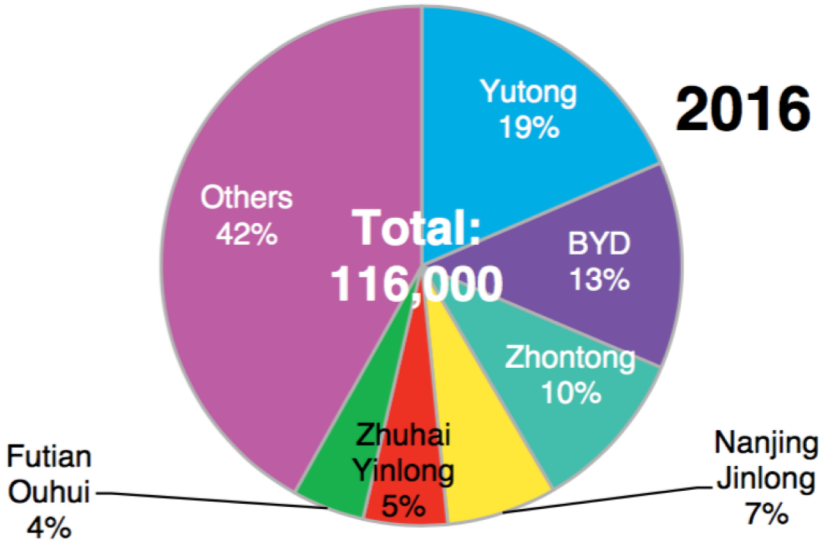
Cui, H. Adjustment to Subsidies for New Energy Vehicles in China. Policy Update *ICCT* **2017**, 1–11.

Chinese manufacturers dominate sales



Source: Bloomberg New Energy Finance, OFweek



Source: Bloomberg New Energy Finance, OFweek

Electric Buses in Cities; Bloomberg New Energy Finance, 2018; pp 1–63.

California

Source: Frank Schulenburg, CC BY-SA 4.0,

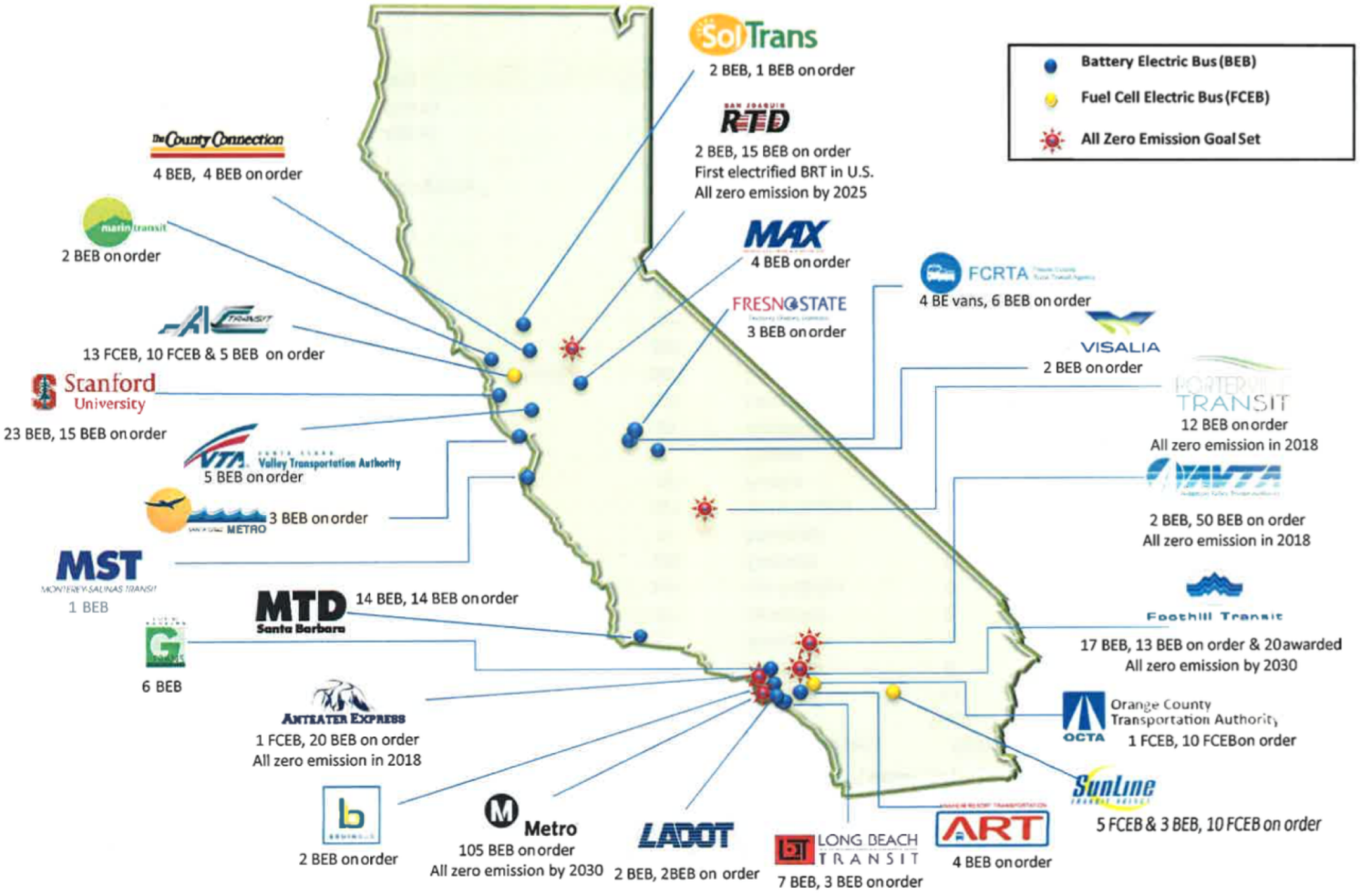
California statewide goals

- Meet federal ozone air quality standards in 2023 and 2031
- 40% reduction in GHG emissions from 1990 by 2030
- 80 % reduction in GHG emissions from 1990 by 2050
- 50 % reduction in petroleum consumption by 2030

Requires maximum deployment of zero emission technologies

Battery and Fuel Cell Electric Buses in California[1]

(107 in operation and 340 on order/awarded as of September 2017)



[1] Buses in transit fleets and universities

California Statewide Fiscal Incentives

Approved Funding Plan - Vouchers

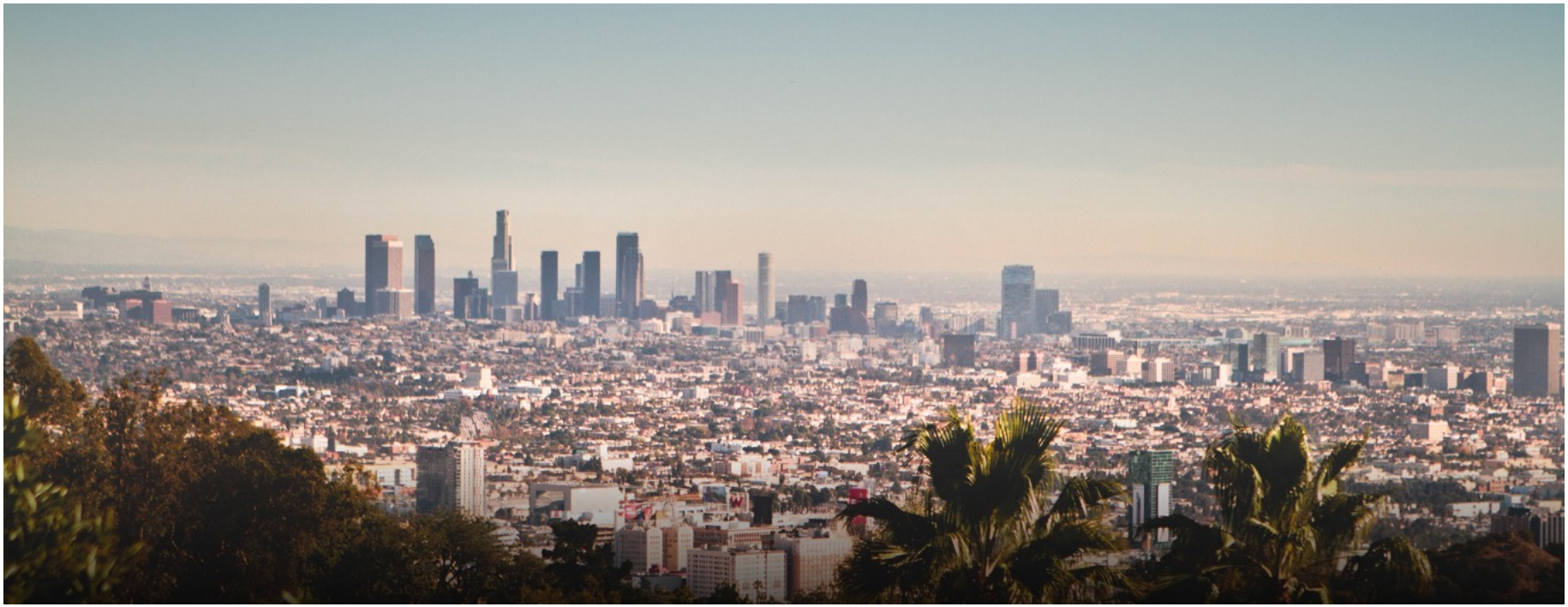
- Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) and Low NOx Engine Incentives
- $188 million for FY 17-18
  - Increased voucher amounts
  - $35 million set aside for ZEBs
  - Rest is first come first served for ZE trucks, ZEBs, low-NOx engines, other
- Infrastructure voucher enhancement
  - Up to $30,000 per charger for BEB
  - Up to $100,000 per FCEB with purchase of 5 or more

Category	Base Amount*
Low NOx Engine (8.9 Liter)	$10,000
Zero Emission Bus (20 ft – 24 ft)	$80,000
Zero Emission Bus (25 ft – 29 ft)	$90,000
Zero Emission Bus (30 ft – 39 ft)	$120,000
Battery Electric Bus (40 ft – 59 ft)	$150,000
Battery Electric Bus (60 ft)	$175,000
Double Decker Bus (40 ft)	$175,000
Fuel Cell Electric Bus (≥ 40 ft)**	$300,000

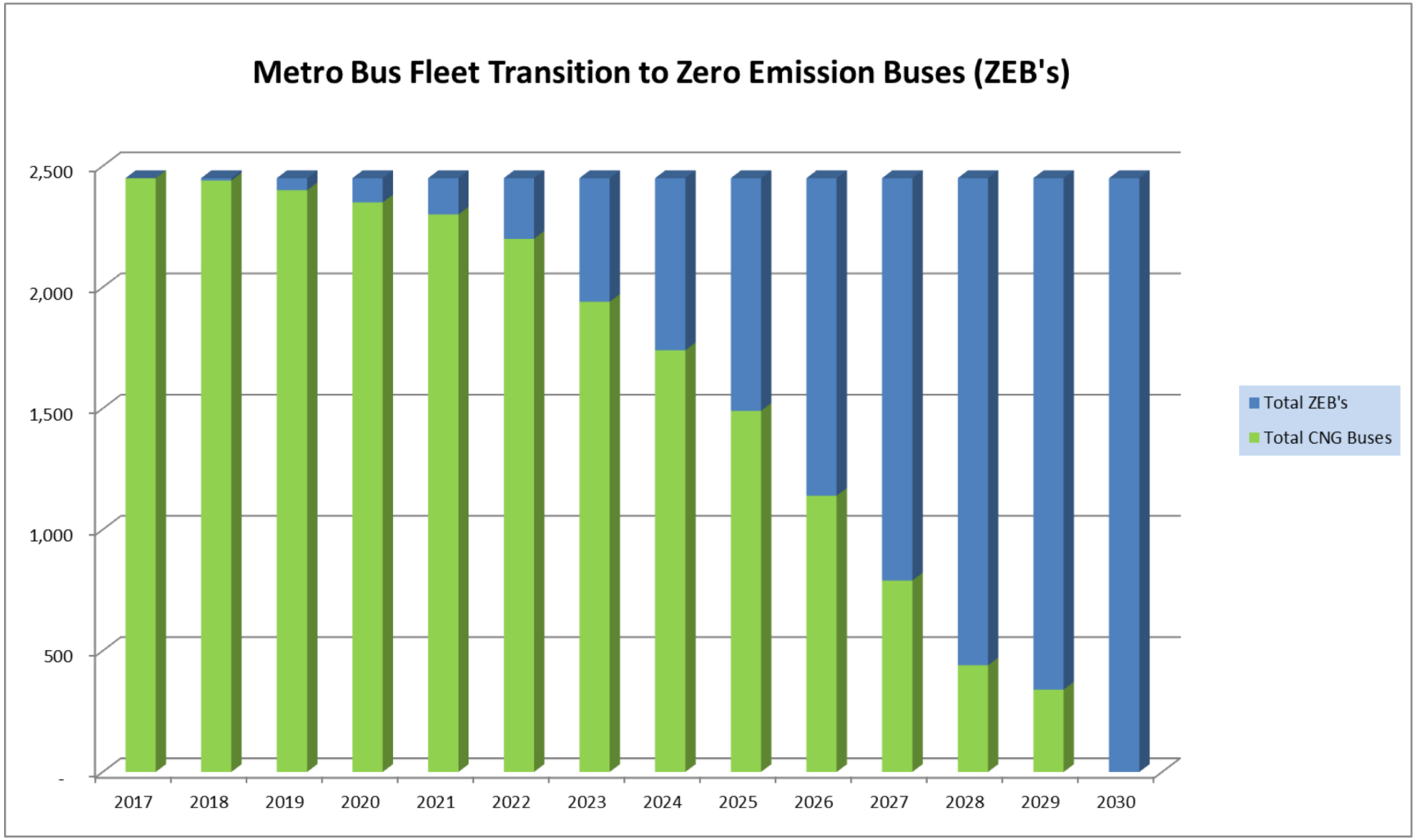
* Up to $15,000 more for use in a disadvantaged community

Proposed FY 2017-18 Funding Plan https://www.arb.ca.gov/msprog/aqip/fundplan/proposed_1718_funding_plan_final.pdf

Los Angeles



City of Los Angeles: 100% ZEB Goal by 2030



Challenges Transitioning to 100% Zero Emissions

1. Long-term **demand for equal or greater service** and operating performance
    1. 400+ km range in stop/go driving with 1.4 passenger load factor
    2. Less than 14,000 kg curb weight for 12m ZEB
    3. 400km range throughout the 12 year vehicle life
    4. 100km/h top speed; ability to sustain 10% grade
2. New Up Front **Investment in Charging Equipment** and Infrastructure
3. Known and unknown **technology risks**, particularly batteries
4. Additional **funding** needed to deploy 100% ZEB program.

Impacts to other capital and operating costs, deployment schedule and/or service levels and reliability. May require replacement on greater than 1:1 ratio.

Los Angeles – Two Phase Plan

Phase 1:

- Electrify 2 BRT lines
- Continue replacing existing fleet with low-NOx CNG engines (~ 200 per year)
- Develop ZEB Technology Assessment and Master Plan (2019-2020)

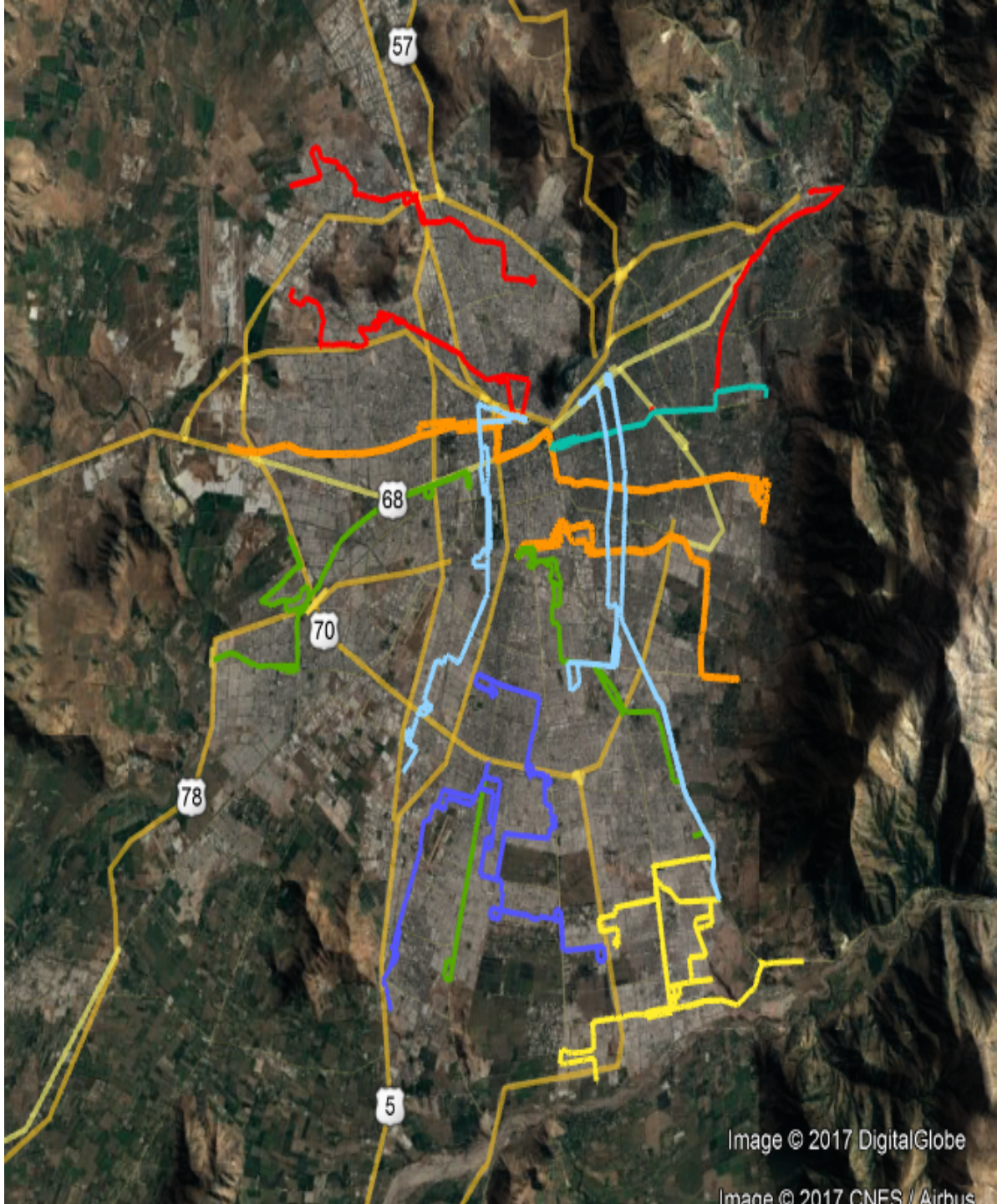
Phase 2:

- Implement ZEB Master Plan to deploy 100% zero emission buses.

Metro Orange Line – Project Details

- 40 New Flyer All Electric Buses 18m, and 5 BYD 18m buses
- 2 - Shop Chargers Installed at Division 8 in Chatsworth
- 8 - En-Route Opportunity Chargers Installed at MOL Terminals in Chatsworth, Canoga and North Hollywood

BEB ROUTE DESIGN FOR SANTIAGO PUBLIC TRANSPORT SYSTEM



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Santiago Principle: Diesel Equivalent Operation

Routes with highest potential to meet the following:

- **Productivity**: the size of the fleet and the number of drivers must be the same with BEB, and TCO must not be much higher
- **Operation**: BEB must operate with same frequencies and regularity
- **Reliability** System of buses and recharging solutions must run with similar reliability

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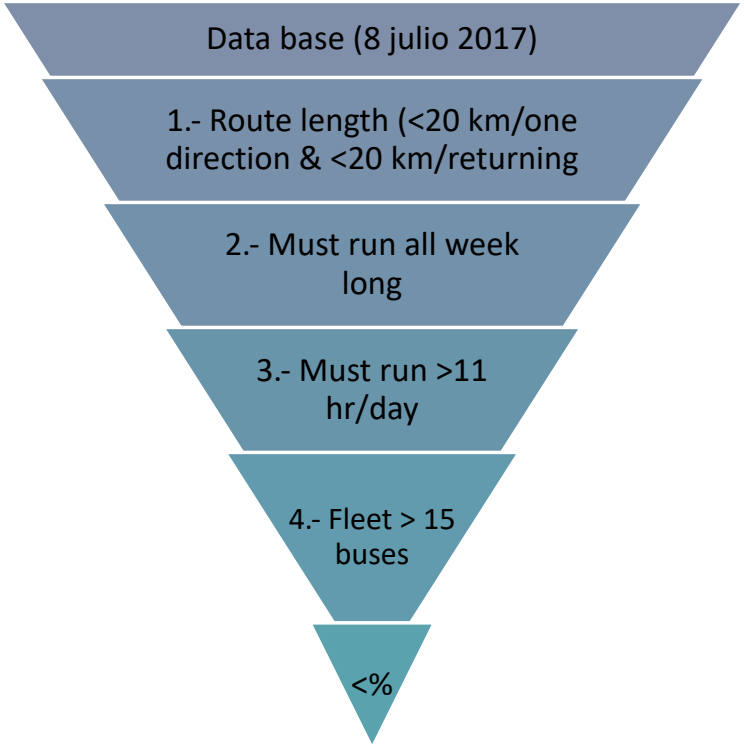
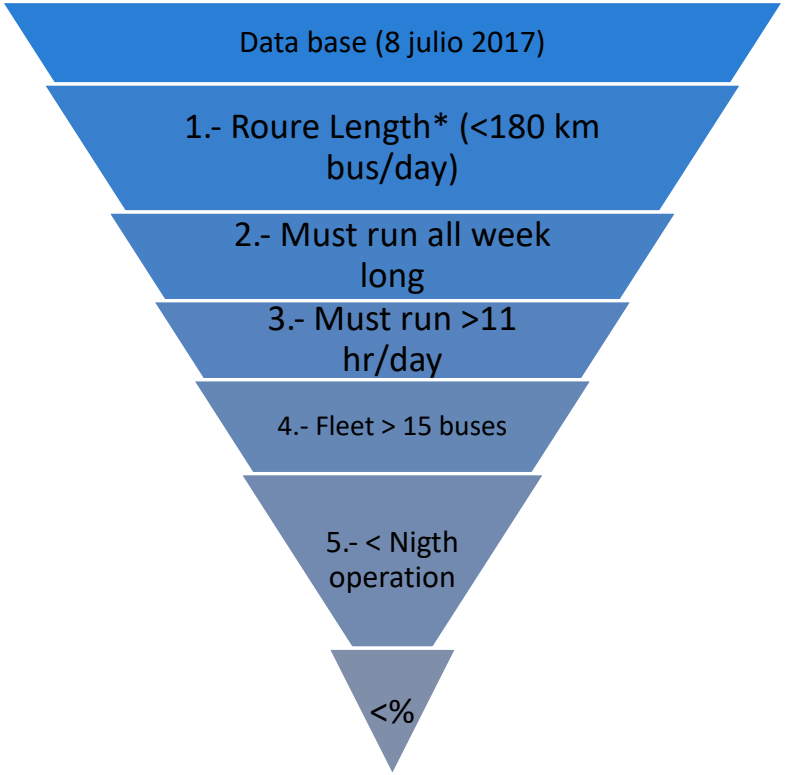
Criteria for route selection

Opportunity Charging



Depot Charging



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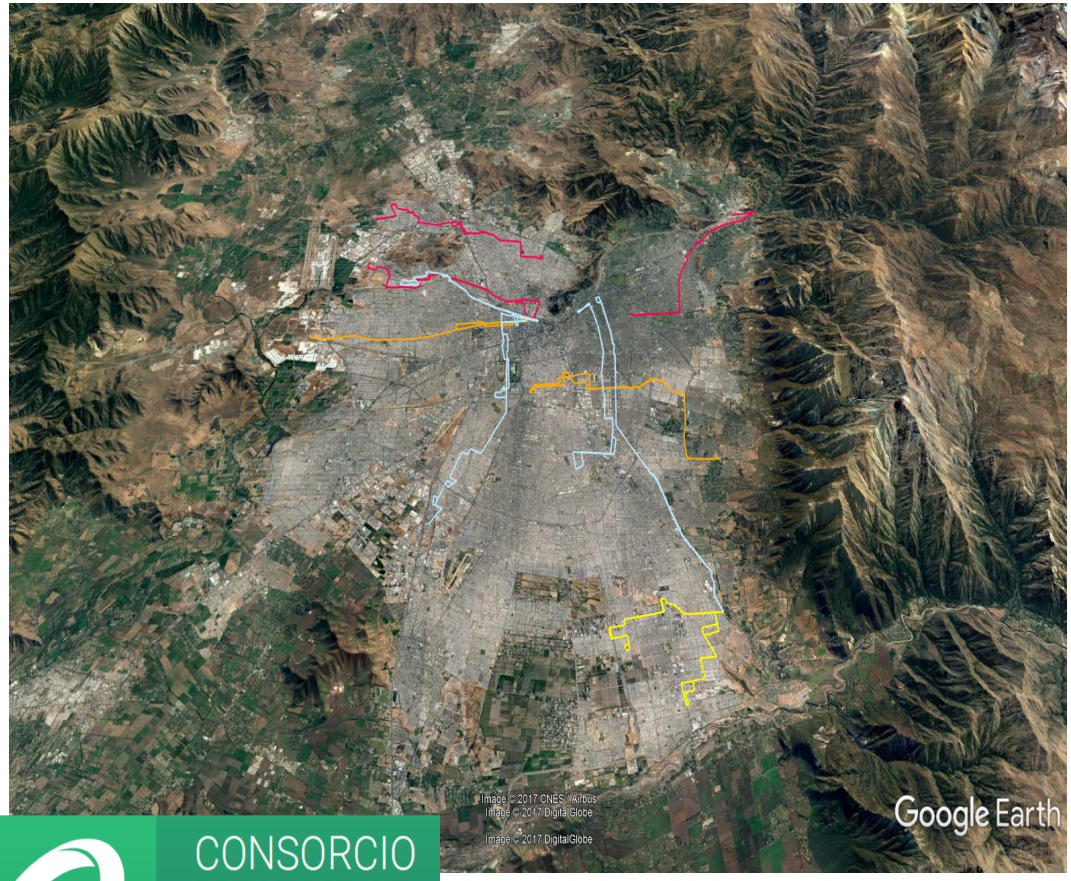
- Ten routes selected for TCO analysis
- Final recommendations under development



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UN	Ruta	Longitud (km)	Operación (hr/día)	Flota mínima necesaria (bus/día)	Pendiente promedio %		Pendiente máxima %	
					Google earth			
1	103Ida	**13.22**	20	17	0.9	-1.1	4.2	-6.4
1	103Ret	**14.95**	20	17	1.1	-0.8	6.3	-3.0
1	104Ida	**19.72**	24	43	1.3	-1	6.1	-3.8
1	104Ret	**19.33**	24	43	1	-1.4	2.1	-9.1
1	121Ida	**16.95**	19	19	0.8	-0.6	3.9	-4.8
1	121Ret	**18.46**	19	19	0.7	-0.9	5.4	-3.9
2	G11Ida	**14.62**	20	15	1	-1	3.4	-5.9
2	G11Ret	**17.99**	20	15	1.1	1	5.9	-4.1
2	G13Ida	**12.33**	19	27	1	-0.7	5.5	-4.1
2	G13Ret	**11.8**	19	27	0.6	-1	2.9	-6.6
2	G22Ida	**13.24**	19	19	0.9	-0.9	5.5	-4.8
2	G22Ret	**14.59**	19	19	0.7	-0.7	2.8	-4.6
3	I08Ida	**8.71**	19	20	0.7	-0.7	3.7	-2.7
3	I08Ret	**8.0225**	22	20	0.9	-1.1	5.1	-4.2
3	I09Ida	**17.55**	20	22	0.8	-0.6	5.1	-4.7
3	I09Ret	**18.1**	20	22	0.6	-0.9	4.7	-6.9
3	E04Ida	**14.25**	19	15	0.6	-1.1	2.9	5.7
3	E04Ret	**14.57**	19	15	0.9	-0.7	4.2	-2.7
3	301cIda	**15.93**	24	15	0.5	-0.7	2.7	-5.0
3	301cRet	**15.72**	22	15	0.7	-0.7	4.2	-4.4
4	402Ida	**14.37**	20	22	1.4	-1.2	8	-6.4
4	402Ret	**14.97**	20	22	1.1	-1.3	4.2	-8.4
4	403Ida	**18.45**	24	16	2	-1.2	9	-4.3
4	403Ret	**16.7**	24	16	0.8	-1.8	3.7	-8.0
4	D05Ida	**16.72**	20	23	1.6	-0.7	7.2	-3.8
4	D05Ret	**17.2**	20	23	0.7	-1.5	3.8	-7.2
5	501Ida	**11.08**	19	28	2.3	-1.4	11.9	-14.8
5	501Ret	**10.84**	18	28	1.8	-2	15.3	-13.4
6	B03Ida	**17.37**	23	18	1.2	-0.9	4.5	-6.4
6	B03Ret	**14.82**	21	18	0.9	-1.2	3.5	-9.0
6	B06Ida	**16.91**	20	20	1.1	-1	8.9	-4.8
6	B06Ret	**16.16**	19	20	1.1	-1.2	5.3	-9.2
6	C05Ida	**14.85**	20	22	2.8	-2.2	9.3	-13.5
6	C05Ret	**16.03**	20	22	2.1	-2.2	8.6	-12.3
7	F10Ida	**14.02**	21	20	1.2	-1	5.1	-4.4
7	F10Ret	**13.93**	20	20	1.1	-1.4	3.1	-5.1
7	F13Ida	**9.42**	19	21	1.3	-1.1	5.6	-6.5
7	F13Ret	**9.88**	19	21	0.9	-1	2.9	-3.5
7	F14Ida	**14.42**	20	28	1	-1.1	4.9	-4.3
7	F14Ret	**15.4**	20	28	1.1	-1.2	7.1	-8.1

Shenzhen, China: 16,359 electric buses

https://qz.com/1169690/shenzhen-in-china-has-16359-electric-buses-more-than-americas-biggest-citiess-conventional-bus-fleet/

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China City Targets for NEV Buses

City	Target	Scope	Base Year	Target Year
Beijing	60%	Existing fleet	2017	2020
Shaanxi	7000	Existing fleet		2020
Hainan	90%	New and replacement buses		2020
Guangdong	75%	Existing Fleet		2020
Pearl River Delta	90%	New and replacement		2019
Chongming Island	100%	Existing Fleet		2020
Harbin	80%	Existing Fleet		2020
Changsha	100%	Existing Fleet		2020

Conclusions: Dual Transition Strategy

National Actions

- Fiscal incentives
- National targets
- Evaluation

Local Actions

1. Demonstration
2. Route electrification
3. ZEB Strategy
   - % ZEB Target
   - Implementation Plan

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