ELECTRIC BUS TECHNOLOGY IN INDIA

NISHANT ARYA

EXECUTIVE DIRECTOR-JBM GROUP

&

CHAIRMAN-JBM SOLARIS ELECTRIC VEHICLES

Supported by

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UITP – DIMTS Bus Seminar
11-12 May 2018, Delhi

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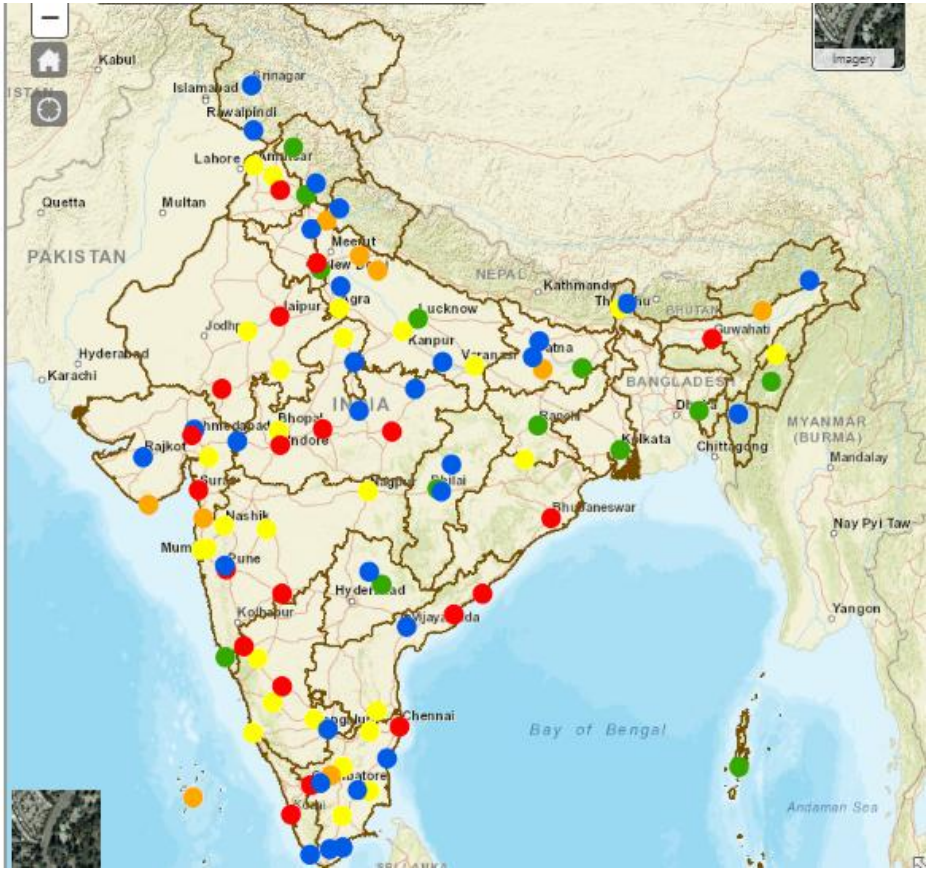
INDIA: RAPID URBANIZATION

- India is a fastest growing economy and needs an efficient & reliable urban transport infrastructure
- 30% of urban population contributes 63% of India's GDP
- Urban mobility is causing challenges of high congestion, environmental pollution, health issues & traffic fatalities
- With urban population projected to grow more than double in next decade, effective remedial measures are the need of hour e.g.; Smart Cities

Urbanisation levels in India

- 1951: 17%
- 2011: 31%
- 2030: 41% (Projected)

Smart Cities



- **By 2030, India will see the rise of 68 urban centres.**
- **Public sector agencies have begun to encourage the use of public transportation through new mobility business models**

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BUSES: PREFERRED MODE OF PUBLIC TRANSPORT

URBAN

All transport: 83.9%

Bus
62.35%

Auto Rickshaw
46.78%

Railway/ Metro
15.65%

Taxi
9.81%

Rickshaw
7.86%

Others
6.07%

Percentage of Household's expenditure on different modes of Transport

RURAL

All transport: 82.9%

Bus
65.8%

Auto Rickshaw
37.9%

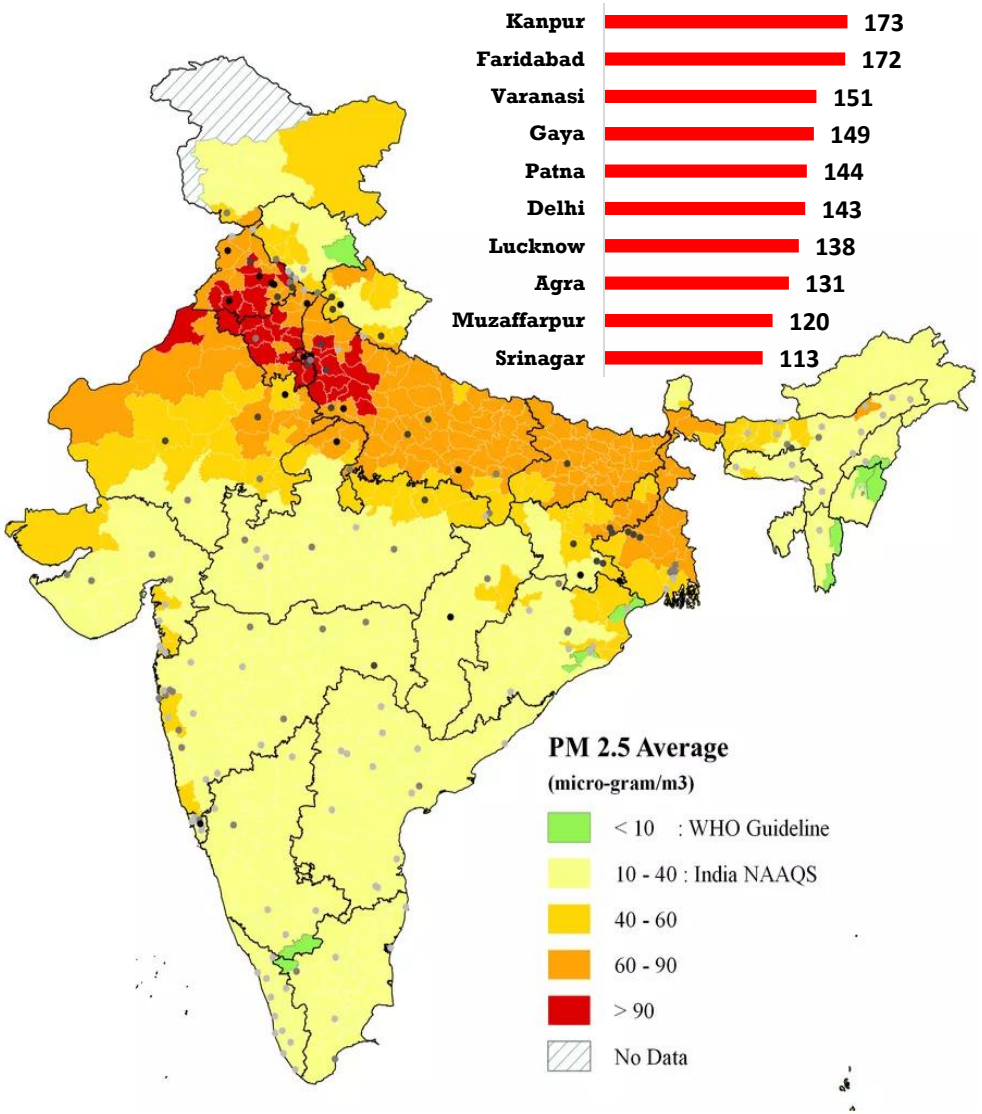
Railway/ Metro
6.1%

Taxi
9.1%

Rickshaw
4.9%

Others
0.13%

AIR POLLUTION: CITIES IMPACTED PAN INDIA



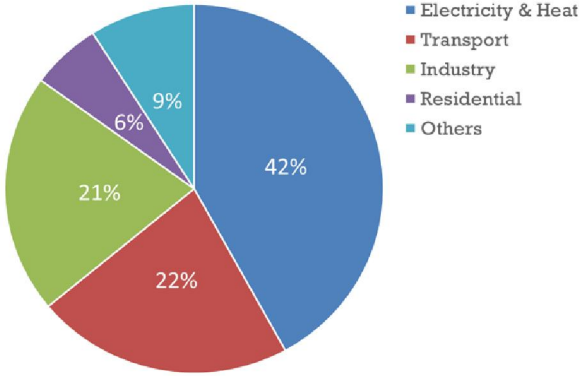
- According to the World Health Organisation (WHO), India has 14 out of the 15 most polluted cities in the world in terms of PM 2.5 concentrations -- the worst being Kanpur with a PM 2.5 concentration of 173 micrograms per cubic metre, followed by Faridabad, Varanasi and Gaya
- Air pollution is the fifth leading cause of death in India, having grown six-fold within 16 years
- India, accounts for 34% (2.38 million) of the 7 million premature deaths globally caused by household and ambient air pollution together globally every year

TRANSPORTATION: MAJOR AIR POLLUTER DUE TO CONVENTIONAL FUELS

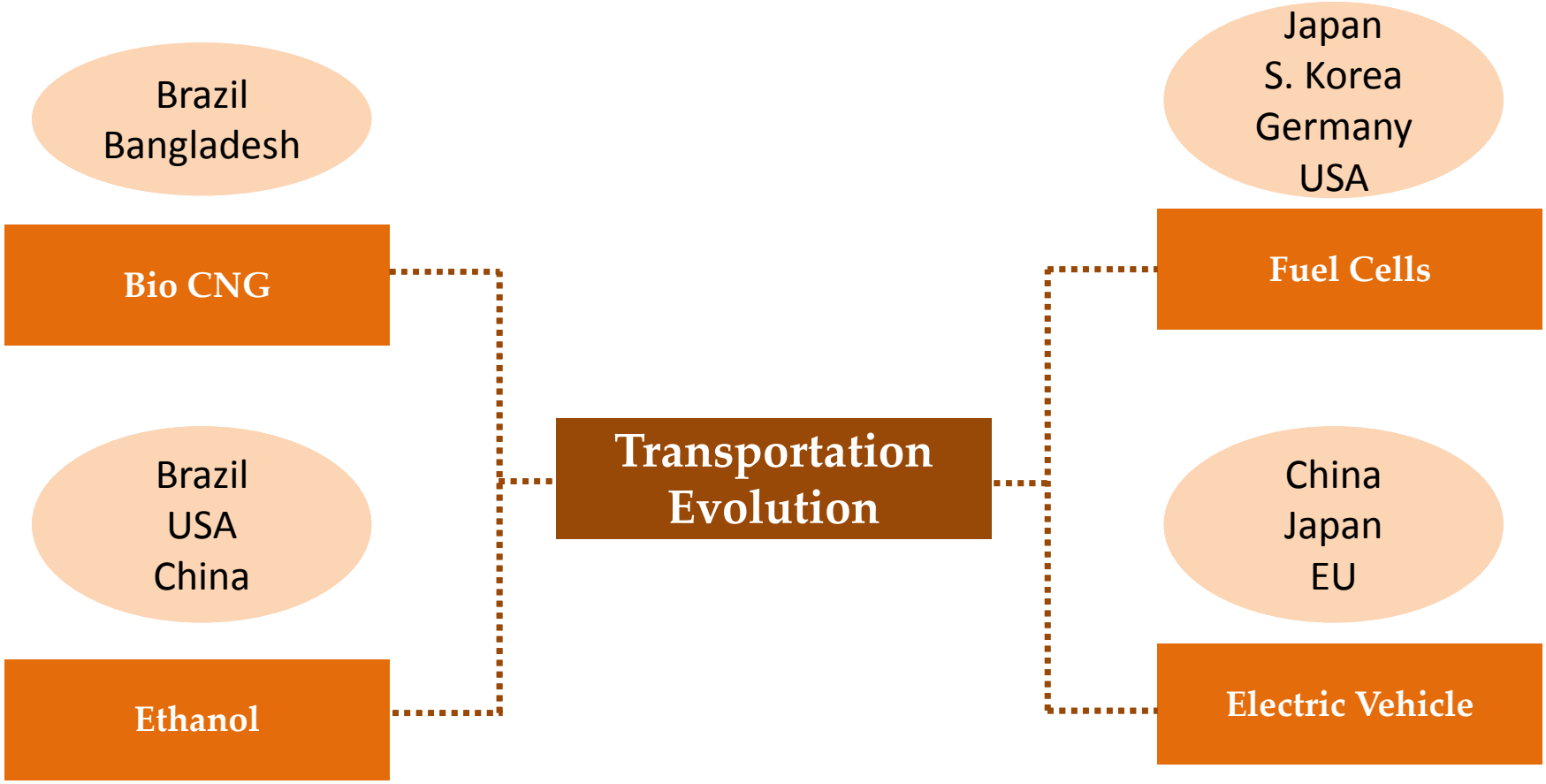
- Indian cities have multiple times of the WHO safe limit of PM 2.5 & PM 10
- Concentration of dangerous carcinogenic substances such as SO_2 & NO_2 have reached dangerous levels
- According to a report published in the latest issue of *Current Science*, the average CO_2 level was 399 parts per million (ppm).

Sector	PM 10	PM 2.5	CO_2
Industry	3.29	6.34	10.87
Transport	35.71	35.63	34
Biofuel	1.47	2.66	1.99
Others	5.66	4.03	Nil

Transport is 2nd largest contributor of pollution



TRANSPORTATION : EVOLUTION TO ALTERNATE FUELS



This list is illustrative

ELECTRIC MOBILITY ECOSYSTEM

E-MOBILITY STAKEHOLDERS

Partnership among Cities, Operators, Energy suppliers & OEMS for a Robust E-mobility Solution

Cities

- Eliminate Particulates
- Lower Emission
- Reduce Noise & Congestion
- Improve Quality of life
- Raise Profile
- Promote Sustainability

Customers / Transport Operators

- Upgrade & Maintain Services
- Reduce Cost
- Improved Efficiencies
- Create Infrastructure

Discoms

- Sell Electricity
- Secure New Customers
- Maintain the Grid

OEMs

- Sell Vehicles
- Sell Solution and Services
- Maintain Customers

Each stakeholder with their competencies have opportunities to collaborate with a common ground

GLOBAL SCENARIO: POLICY TRENDS

Policy makers across globe need to support the introduction of Electric Mobility

Key incentives for Cities and Operators – to build Charging Infrastructure

- Enhanced funding from Central and/ or local governments
- Tax reduction for zero emission fleet
- State sponsored projects for electric infrastructure
- Legal solutions conducive for building infrastructure faster and easier

Inhibitors for Conventional Fuel Vehicles

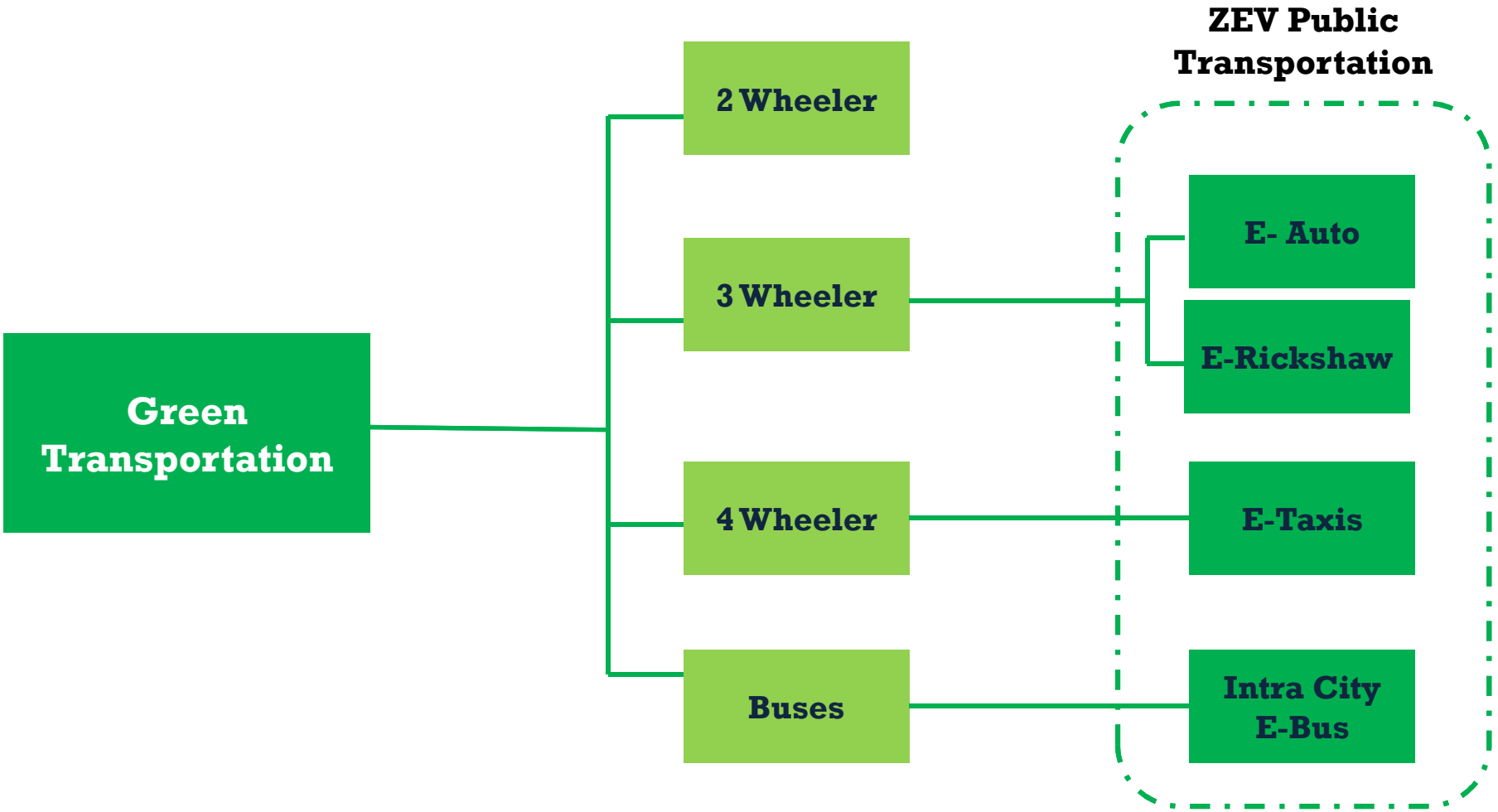
- Zero emission zones in the city centres, environmental sensitive locations & tourist attractions
- Higher taxes for diesel/ high emission solutions
- Quotes for the countries e.g.; at least 20-30% of fleet based on electric / zero emission transport systems

PUBLIC TRANSPORTATION: THE BIGGER PICTURE

Mass migration of people into cities for better opportunities is leading to more noise, pollution, congestion & stress.

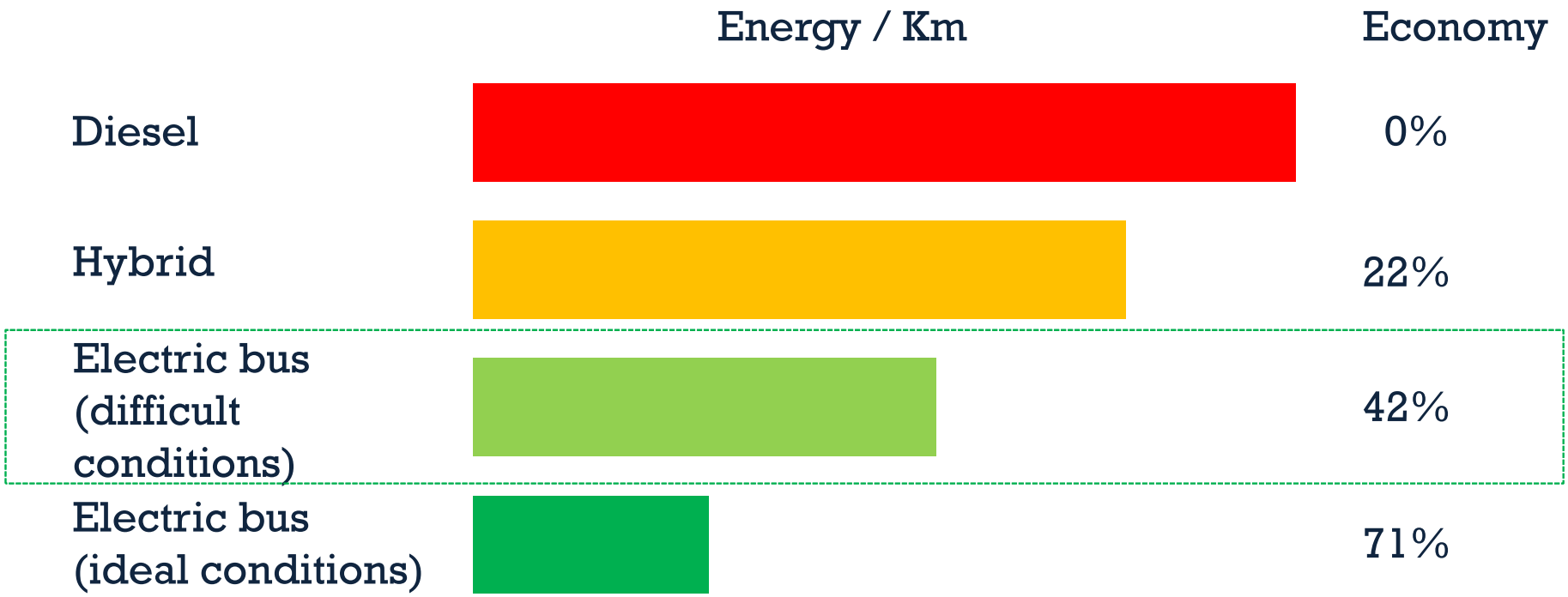
India must evolve the sustainable mass transportation infrastructure

TRANSPORTATION: SHIFT TOWARDS ZERO EMISSION VEHICLES



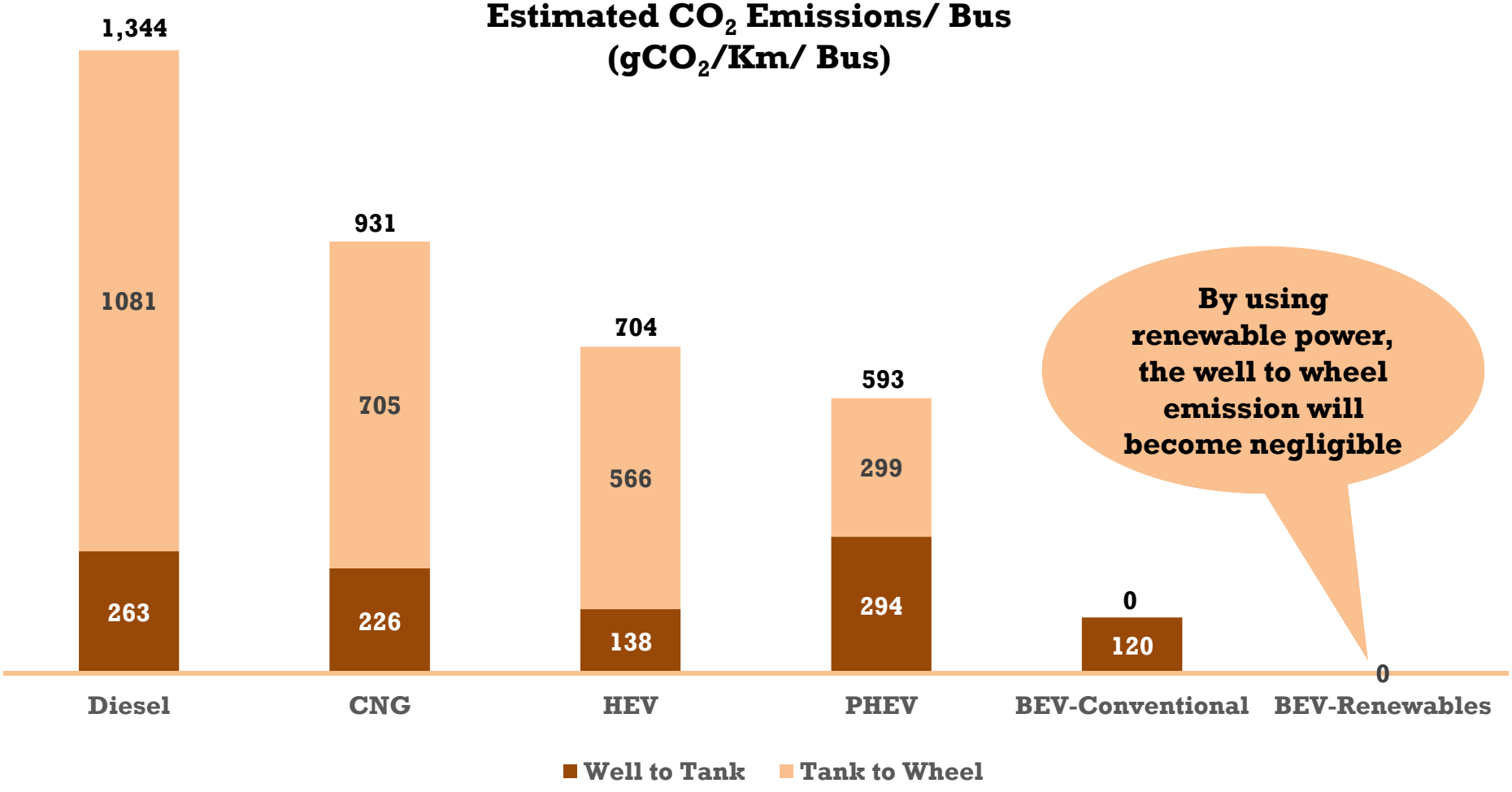
Government primary focus is on EV Public Transportation

WHY E–BUSES ?



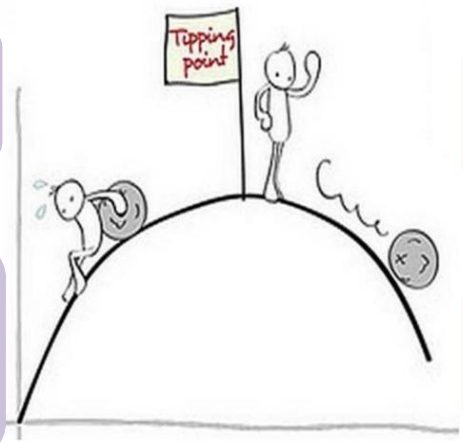
Future public transportation must be energy efficient

E-BUSES ACHIEVE



KEY DRIVERS FOR E-BUS TRANSITION

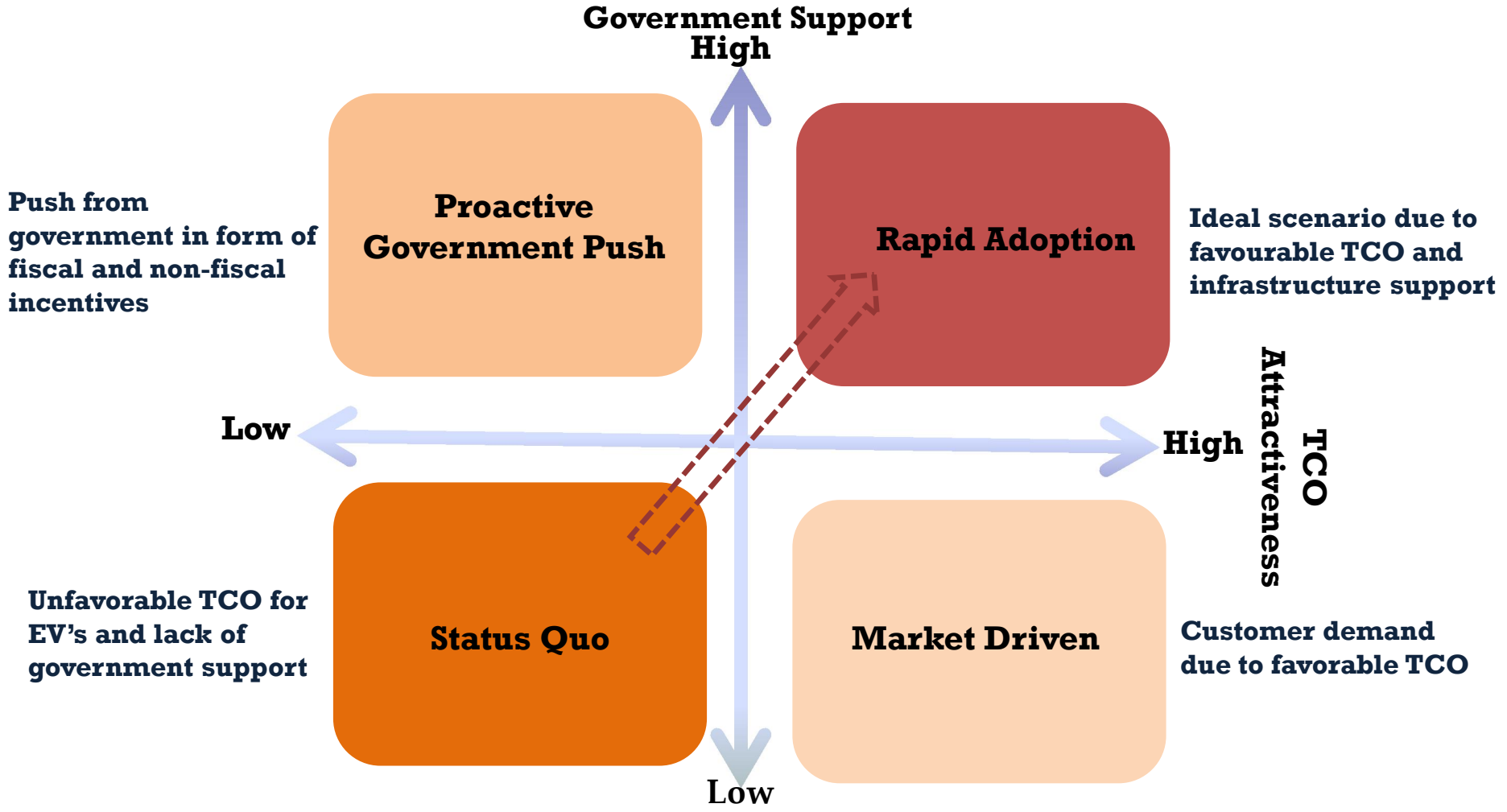
Limiting Factors	Current Updates	Growth Drivers
High Upfront Vehicle Cost	e.g.; E Buses 2.5~3.5 Cr → 1.2~2.5 Cr	Optimal battery price & higher energy density yielding better TCO
Real & Perceived Range Anxiety	Drive Range: 100 ~300 Km solutions available	Stricter CO_2 emission standards→ Bharat VI implementation in 2020
High battery weight for slow charging	Fast charging solution optimizes battery weight & increases passenger capacity	Fast charging set-up facilitating high uptime for bus fleet
High dependency on Government subsidies	Necessary during transition phase	Power availability and network of Charging Infrastructure



We have reached the Tipping point in favour of the EV's

SCENARIOS BASED ON E-BUS TOTAL COST OF OWNERSHIP (TCO)

Possible EV Scenarios for India



Government policy framework coupled with constant evolving EV Technologies leading to a viable TCO

SOLAR POWER SUCCESS: LEARNINGS & BENCHMARKS

Insights from Solar Success in India

- Clear Govt roadmap: 100 GW Solar by 2022 has resulted in accelerated actions by the industry In FY17, 4~5 GW was installed which increased to 8 ~10 GW in FY18
- Generation based Incentives / Performance linked VGF
- Declining Module cost accelerated tariff reduction from INR 17~18 to INR 2.5 ~3.0 in a span of last 7 years
- Appropriate technology for Indian conditions

Learnings for Electric Bus Adaption

- Clear roadmap for next 5 years for all EV stakeholders like OEMs, key aggregate manufacturers, infrastructure providers to invest & recognize EV as a focus for future
- Electric bus should be mandated in T1/ T2 / T3 cities and all smart cities, reaching 100% of fleet pan India latest by 2030
- Target localization upto 70% of the input value in next three years to enable local industry
- Decreasing trend of battery cost along with its localization will support in significant cost down for electric buses
- Building proper network & charging infrastructure for higher number of buses in upcoming years

BUS CHARGING OPTIONS

Plug-in Charging
(Depot / Terminal)
50 to 200 kW charging power

Pantograph
(Opportunity Charging)
Upto 450 kW charging power

Induction
Upto 200 kW charging power

Not recommended for India at present due to high cost & infrastructure related issue

BUS CHARGING COMPARISON

	Slow Charging (A)	Fast Charging (B)	Opportunity charging (C)
Description	On board Slow charging (Overnight).	Off Board Fast Charging (At Depot and at End Terminals)	Ultra Fast Charging (En Route Top Up)
Power input for charger	415 V; 250 A	415 V; 250 A	415 V; 500 A
Charging Time	6 ~ 8 Hours	1 ~ 2 Hours	5 ~ 30 minutes
Connection Type	Plug In	Plug In	Pantograph
Efficiency	85~ 90%	≥ 94%	≥ 94%
Charger Cost	Low	Moderate	Very High
Battery Cost / Size	Very High	Moderate	Low

Considering battery & vehicle cost optimization, the recommended solution is B or C

- ***Eliminates dead weight of battery***
- ***Higher operational efficiency***
- ***Range extension***
- ***Increased Power to Weight Ratio***
- ***Enhanced passenger capacity***
- ***Higher fleet utilization***

WAY FORWARD : OPTIMAL BATTERY PACK WITH FAST CHARGING

Battery Size

Heavy bus battery e.g.; 300 kW	• High battery / bus cost • Increased TARE weight with reduced passenger load • Less power to weight ratio with less efficiency • High maintenance / running cost
Optimum bus battery e.g.; 160 kW	▪ Lower battery / bus cost ▪ More passengers ▪ High Energy Efficiency ▪ Low maintenance / running cost

Charging Options

Overnight charging for 6~8 hours at depot	▪ Heavy battery ▪ Lower efficiency due to battery dead weight ▪ High vehicle cost ▪ More charging stations per fleet required
+ Quick Terminal charging during daytime	▪ Operational flexibility ▪ Range extension ▪ Less Chargers required ▪ Economical investment

CHALLENGES FOR E- BUS

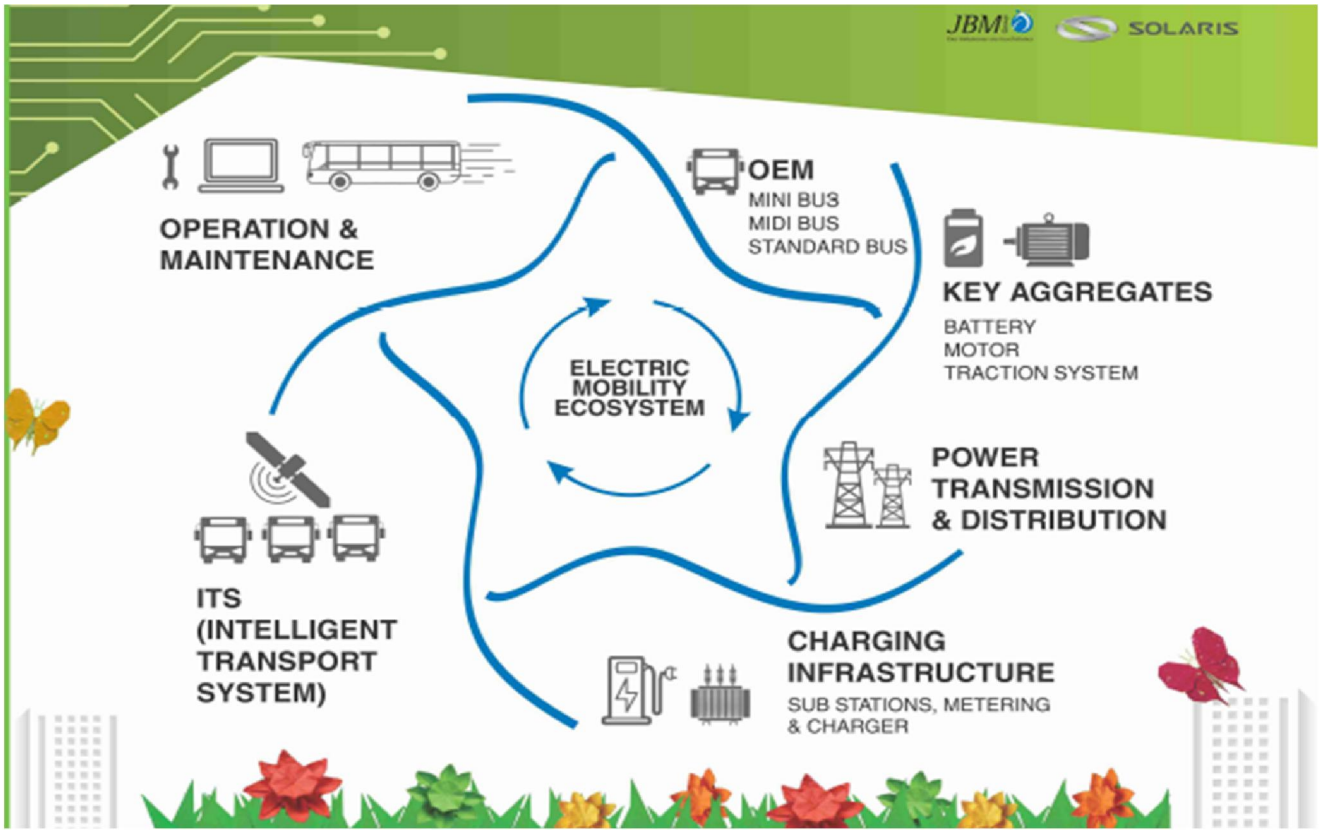
- Technical training for maintaining High Voltage systems
- Optimization of battery pack size & charging infrastructure
- Standardization of key aggregates like battery, charger specifications, traction motor & controller
- Localization of high voltage components with scale
- Selection of optimum operating pattern including charging
- Grid infrastructure availability
- Ease of Access to Affordable Financing

JBM SOLARIS ECOSYSTEM APPROACH

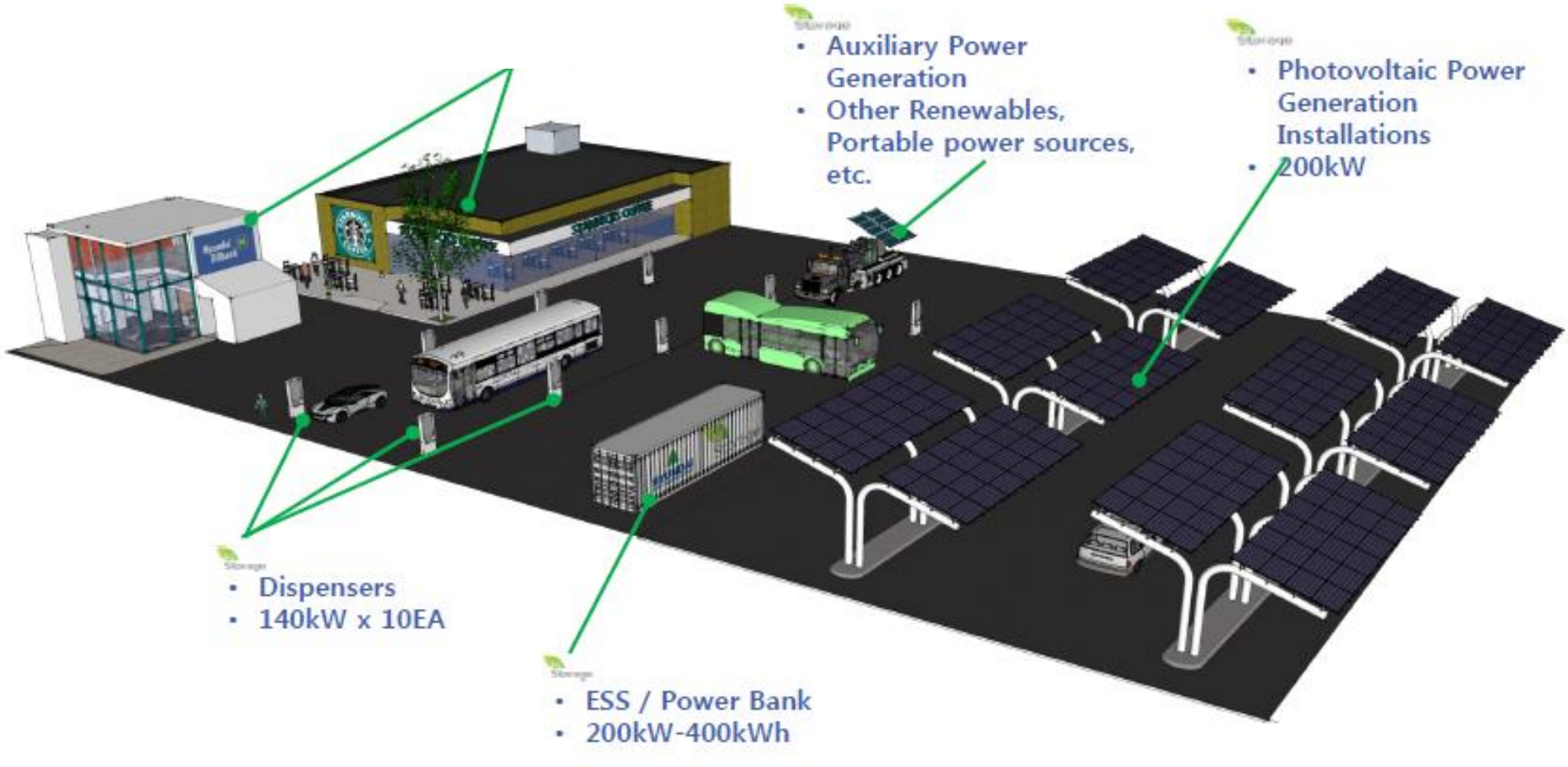
About Solaris

Largest designer & manufacturer of Electric Public Transport vehicles in Europe

About 17,000 vehicles sold across 30 countries



INTEGRATED GREEN MOBILITY SOLUTION



THANK YOU

JBM Solaris Electric Vehicles

 # 100% Electric with Zero Emission
 # Estimated Savings over 10 years Bus Life

- ***960 equivalent tonnes of CO_2***
- ***350,000 litres of diesel***

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