Feasibility of Electric Bus Operation in Urban Areas, Case Study- Delhi

Pintu Saini

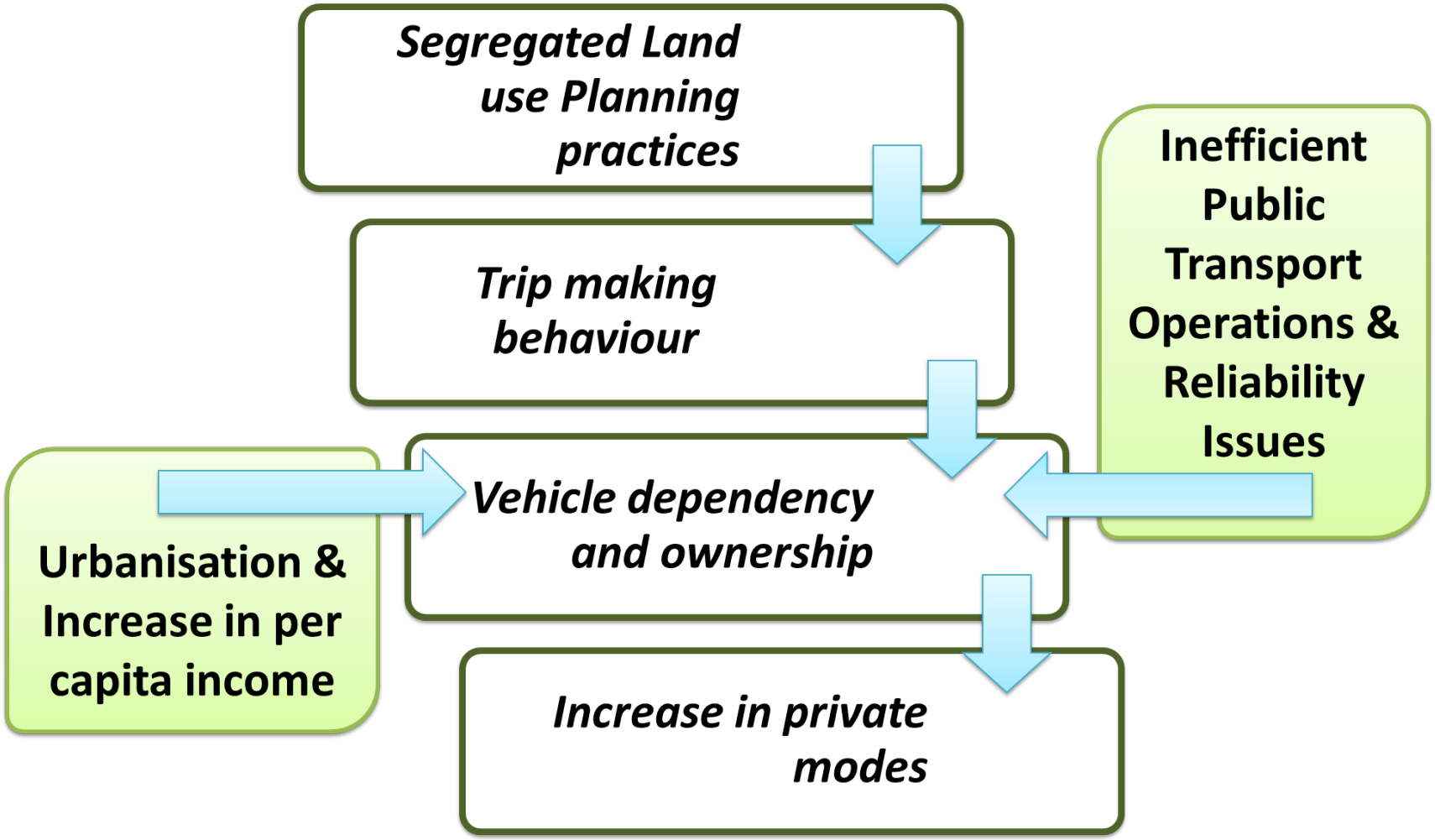
Research Associate, Dept. of Transport Planning, SPA Delhi

&

Dr. P. K. Sarkar

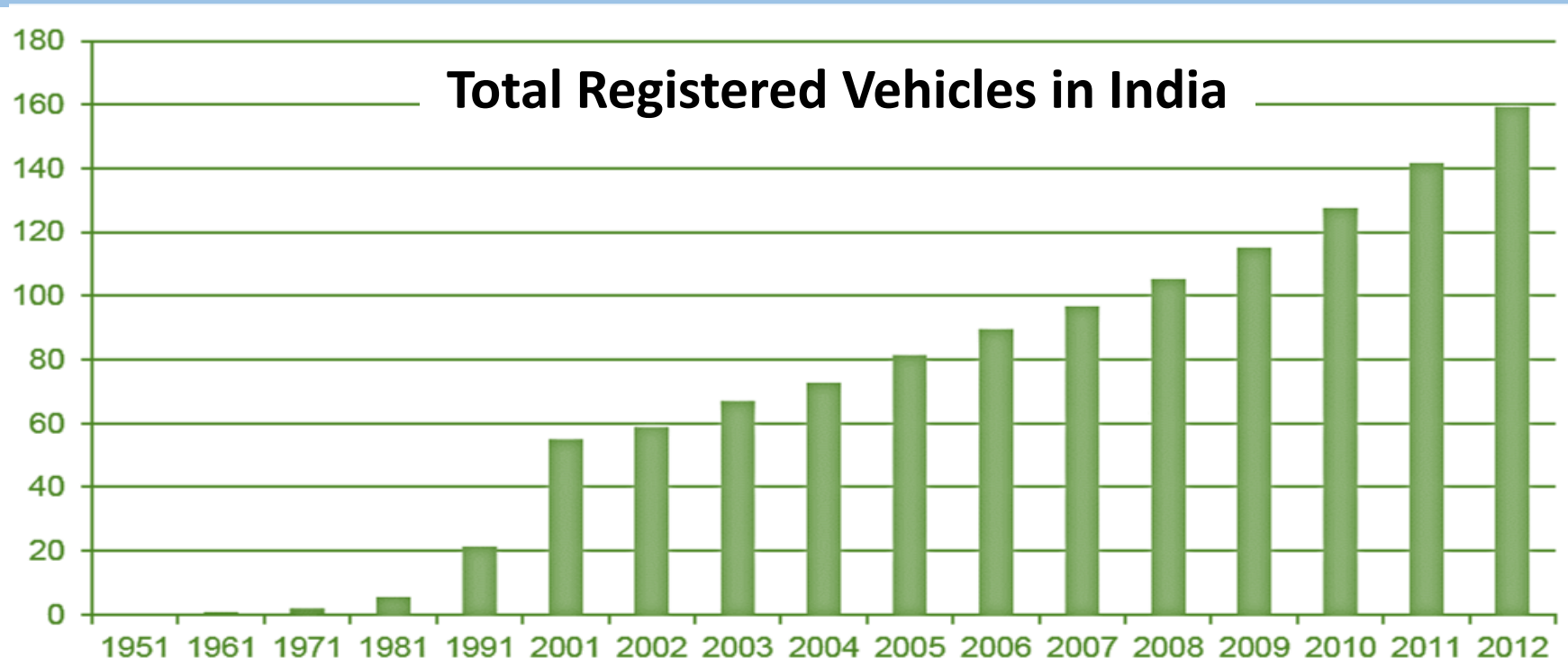
Prof. Dept. of Transport Planning, , SPA Delhi

Existing Scenario



Source: Author

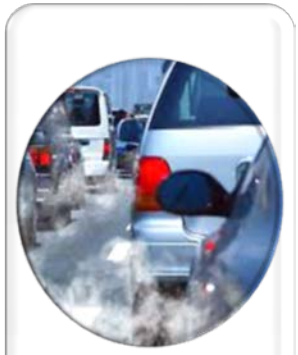
Existing Scenario



- The total number of registered motor vehicles in India has increased rapidly over the past decade.
- From 55 million in 2001 to 142 million in 2011.
- The CAGR of registered motor vehicles was 10% against a population CAGR of 2% during 2001–2011.
- Of the total registered vehicles, two wheelers and cars contributed approximately 83% in 2012 (Ministry of Road Transport and Highways 2012b).

Source: MoRTH

Existing Issues



Air pollution

Congestion

Noise pollution

Health impacts

Delays

Accidents/ fatalities

Impacts on global atmosphere

Encroachments

Source: Compiled by Author

Air Pollution

Air pollution is one of the major problems every city around the world is facing these days

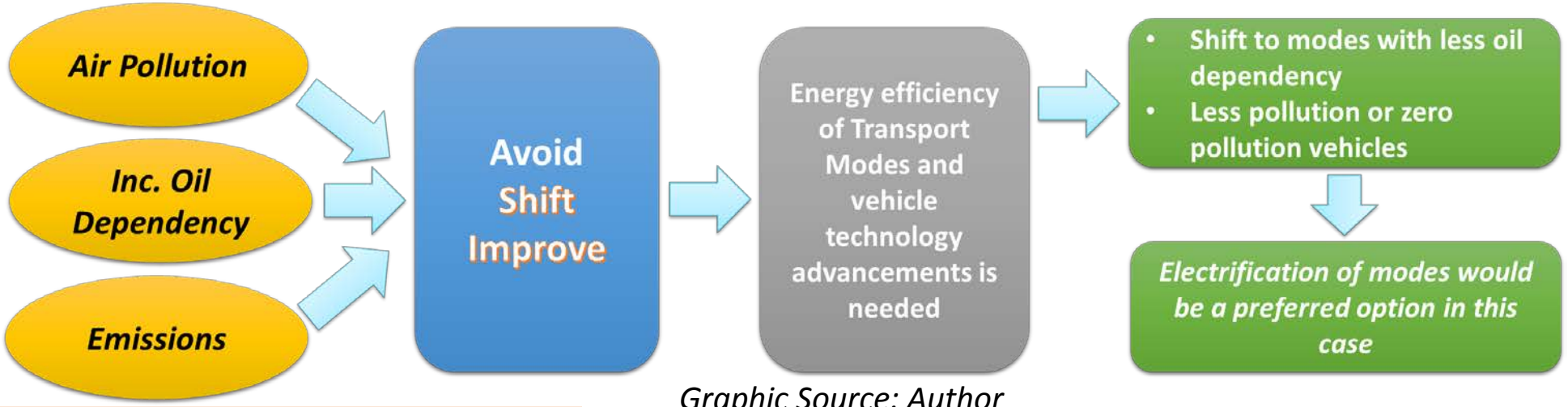
Phenomenon of rapid motorisation leading to emissions

Graphic Source: Author

Research has estimated that 3283 Indians died per day due to outdoor air pollution in India in 2015, making the potential number of deaths due to outdoor air pollution in India in 2015 to 11.98 lakh.

Source: Global Burden of Disease (GBD), a comprehensive regional and global research program including 500 researchers representing over 300 institutions and 50 countries
Referred from: Airpocalypse- Assessment of Air Pollution in Indian Cities)

Need of the Study



Graphic Source: Author

Existing modes with Electrification

Private Modes	Car	
	2 wheelers	
IPT	Auto	
	Rikshaws	
Public Transport	Metro	
	Bus	**Bus???**

Electric Bus

Buses, being the traditional and predominant mode, must be explored for electrification

Source: Compiled by Author

Global Practices

China

China is pioneering in electric buses.
China homes around 1,70,000 electric and hybrid electric buses.
Most of the buses are provided by BYD

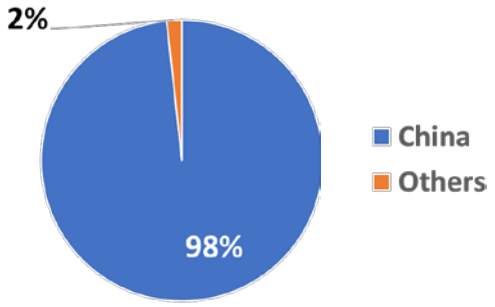
U.S.

Most of the E-buses ae provided by Proterra followed by New Flyer and BYD.
In 2015, More than 80 Battery-Electric buses were operating in the U.S. 72% are Proterra
Others OEMS: New Flyer and BYD

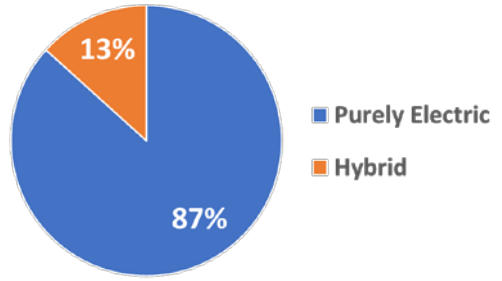
Gothenburg, Sweden

The bus is provided by Volvo.
The bus is based on the fast charging or opportunity charging system
The route is on test run for results evalution.

Electric Buses Distribution Worldwide



Electric buses v/s Hybrid electric worldwide



Total E Buses (2015)- 173000

Source: Global EV Outlook 2016, International Energy Agency

	BYD	Proterra	Volvo
Bus Cost (Cr)	3 Cr	5 Cr approx.	--
Range (kms)	250+ in 5-6 hrs charge	53 kms in 10 min charge	6-7 km in 3-4 min charge
Battery type	Li-Ion	Li-ti-Ion	Li-Ion
Battery Capacity	324 Kwh	8 x 368v	250 Kwh

Source: Compiled by Author

Trials in Indian Cities

Bangalore

- Electric bus trial in Bangalore in 2014.
- One Bus was put on trial provided by BYD.
- Trial period of 3 months.

Bus Cost-3 Cr App.
Range- 250+ kms

Delhi

- Electric bus trial in Bangalore in 2016.
- One Bus was put on trial provided by BYD.
- Trial period of 4 months.

Bus Cost-3 Cr App.
Range- 250+ kms

Manali-rohtang Road

- Bus provided by BYD and Ashok Leyland
- for 1-day trial period each

Ashok Leyland Bus:
Bus Cost-1.9 Cr App.
Range- 120 kms

Similar trials have taken place in cities like

Hyderabad- BYD Bus
Rajkot- BYD Bus
Chandigarh-TATA motors & BYD Bus

Chinese Manufacturer BYD have been successful in conducting trails in many Indian cities.

Source: Compiled by Author from various sources

Why Delhi?

1 Being a capital city, must set example of innovative practices

2 Pollution levels

- *City has witnessed worst pollution levels.*
- *Among various reasons, pollution from transport sector also dominates.*
- *Delhi, having a larger modal share of buses can have notable emission savings after adoption of E-buses.*

3 Successful Trials

- *Successful trials of electric bus in Delhi have provided evidences of its success.*

4 Fits Operational Requirements

In Delhi, a bus covers around 200 kms/day = *BYD bus can cover around 250+ kms/charge*

One charge per day will fulfill operational needs and will also battery swapping will not be required.

Source: Author

Assumptions for the study

1 Type of Bus

- Looking at successful trials, **BYD bus** is selected for the present study.
- **Bus Cost- 3Cr**
- **Range- 250+ kms/charge**
- **Charging time- 5-6 Hours**

2 Type of Charging System

- Looking at global practices, there are 2-3 types of charging types.
- For the current study, **overnight/one time charging option is considered.**
- This is due to BYD bus charging system and also due to its less costs.

Source: Author

Life Cycle Analysis

Life cycle analysis involves comparison of-

	CNG Bus	Electric Bus
Bus type	Low floor AC bus	Low floor AC bus
Manufacturer	Tata	BYD
Life span of bus	7.5 lakh kms or 12 Years	4000 charging cycles or 12 years
Seating capacity	31	31

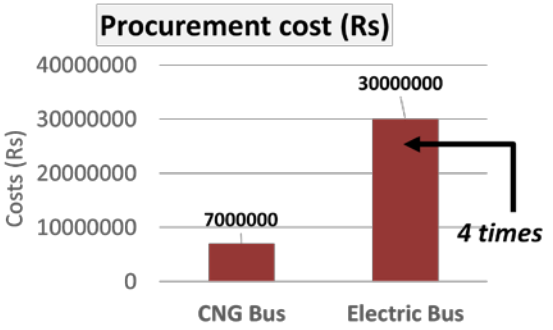
Total Kms operated in a year per bus-

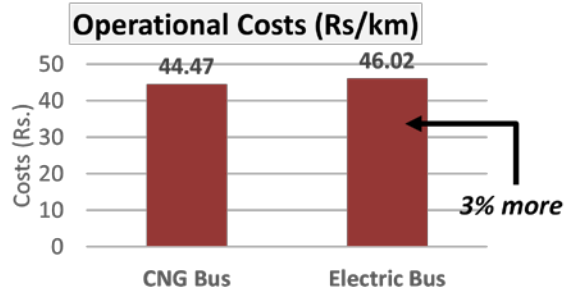
- Kms covered per bus per day- 200 kms
- Average operational days in a year- 340
- Total kms covered in a year= 200 x 340= ***68,000 kms***

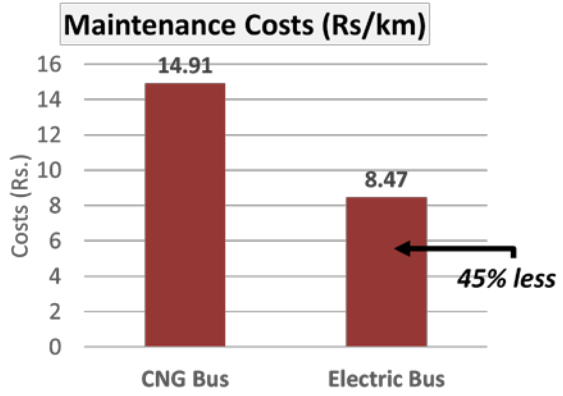
Source: DTC, 2017

Financial Analysis

Year	CNG Bus						Electric Bus					
	Cost of Bus	Total Operational Costs for 68,000 kms	Total Maintenance Costs for 68,000 kms	Total Expenditures	Total Earning for 68,000 kms	Net Operating Income	Total Capital Cost	Total Operational Costs for 68,000 kms	Total Maintenance Costs for 68,000 kms	Total Expenditures	Total Earning for 68,000 kms	Net Operating Income
	7000000			7000000		-7000000	23900000			23900000		-23900000
2016	0	3023960	1013880	4037840	2059040	-1978800	0	3129360	575960	3705320	2652000	-1053320
2017	0	3132760	1052069	4184829	2161992	-2022837	0	3239214	589995	3829209	2784600	-1044609
2018	0	3289024	1091937	4380961	2270092	-2110869	0	3354098	611325	3965424	2923830	-1041594
2019	0	3453101	1133564	4586665	2383596	-2203069	0	3474260	633517	4107776	3070022	-1037755
2020	0	3625382	1177033	4802416	2502776	-2299640	0	3599958	656606	4256564	3223523	-1033041
2021	0	3806277	1222433	5028710	2627915	-2400795	0	3731464	680633	4412097	3384699	-1027398
2022	0	3996217	1269854	5266071	2759311	-2506761	0	3869065	705638	4574702	3553934	-1020768
2023	0	4195654	1319393	5515047	2897276	-2617771	0	4013059	731663	4744722	3731630	-1013092
2024	0	4405063	1371151	5776214	3042140	-2734074	0	4163762	758753	4922516	3918212	-1004304
2025	0	4624942	1425235	6050177	3194247	-2855930	0	4321505	786956	5108461	4114122	-994338
2026	0	4855815	1481755	6337570	3353959	-2983611	0	4486635	816318	5302953	4319829	-983124
2027	0	5098232	1540828	6639060	3521657	-3117403	0	4659515	846892	5506407	4535820	-970587
				62605560	32774000	-36831560				78336151	42212220	-36123931







- Financial analysis between electric bus and CNG bus provides net operating income as negative.
- Net operating income for electric bus is less negative than CNG due to less maintenance cost of bus.
- Financial analysis suggests the need of intervention for costs reduction for electric bus to make it feasible.

Source: Authors Analysis

Economic Analysis

Health cost savings

Name of Pollutants	Emissions from CNG Buses (g/km)	Health cost (Rs. per Kg)	Emissions for 68000 km (in kg)	Total Health cost savings (Rs.)
CO2	719	2.52	48892	123147
CO	1.77	1.05	120	126
Nox	5.35	248.13	364	90270
CH4	1.455	57.93	99	5732
SO2	0.71	71.29	48	3442
PM	0.4928	1993.07	34	66789
HC	0.88	15.43	60	923
			Total	**2,90,428**

Fuel cost savings

CNG Bus mileage (km/kg)	2.6
CNG Price(Rs/Kg)	30
Fuel Efficiency (Rs/Km)	30/2.6=11.5
Annual kms operated per bus	68000
Total Fuel cost savings (Rs.)	**7,84,615**

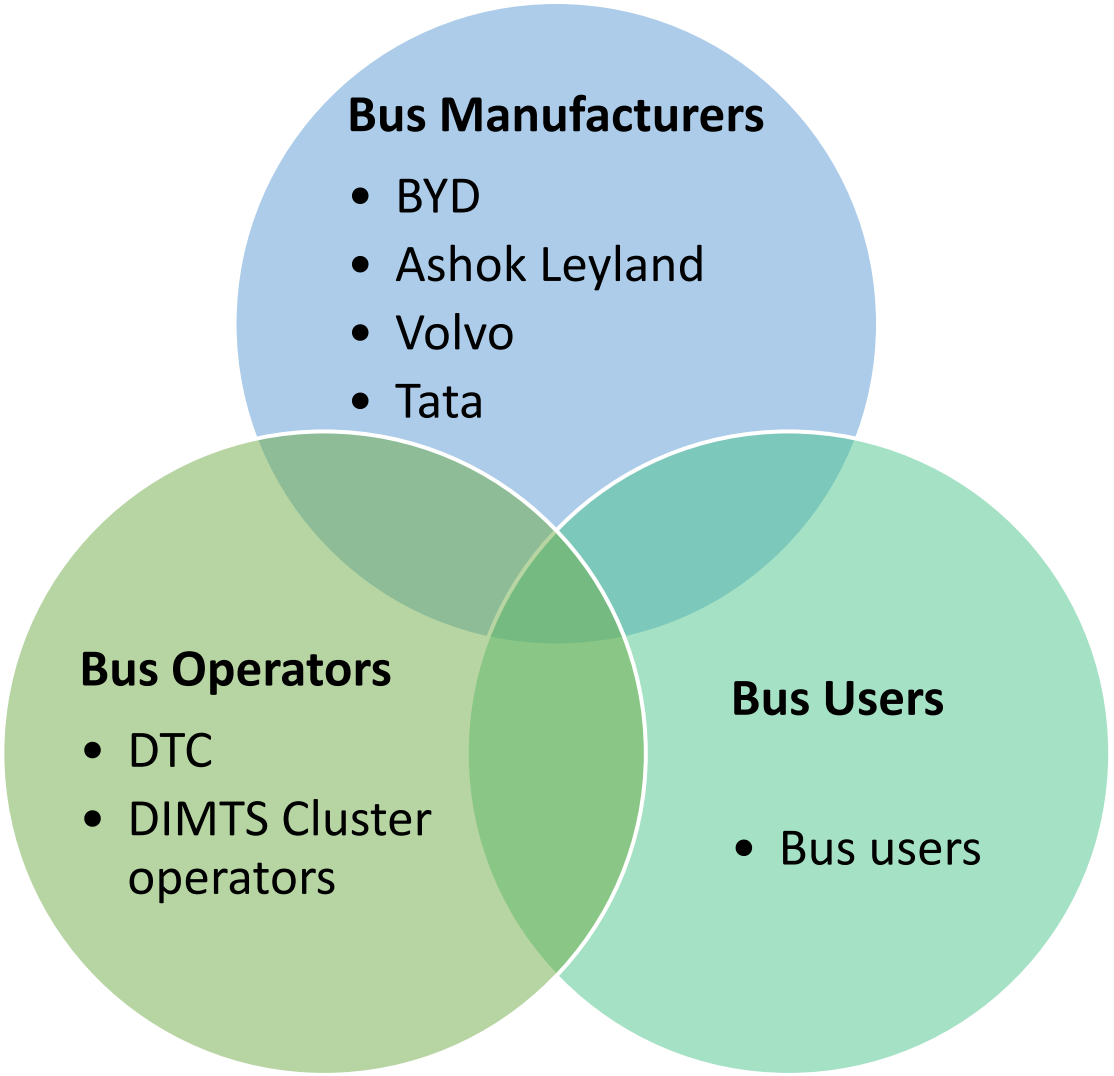
Total savings

Number of buses	CO2 Savings (ton)	Health Costs savings (Lac)	Fuel Cost savings (Lac)	Total Savings (Lacs)
1	48	2.90	7.84	10.74
100	4889.2	290.42	784.61	1075.03

- Economic analysis shows that after applying all the benefits, operating costs are recovered, but capital cost of the bus is making total income as negative.
- This shows for the feasibility of the overall system, strategy has be adopted for reducing the cost of the bus.

Source: Authors Analysis with reference from various literature

Stakeholder Perception Survey



Bus Manufacturer Survey

- Manufacturer survey revealed the need of government policies and incentives for easy introduction in market.

Bus Operator Survey

- Operators survey revealed the need for bus cost reduction, govt. incentives and electricity subsidisation for feasible operation.

User Survey

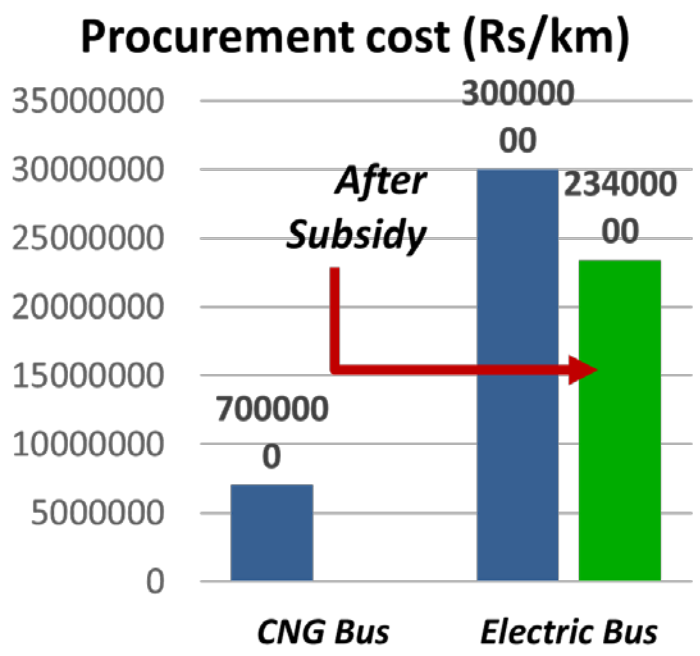
- Users survey revealed their willingness for adoption of electric buses for Delhi.
- Survey revealed that more than 75% of thee users are ready to use the buses even if the fares are increased by 33%.

Source: Authors Analysis

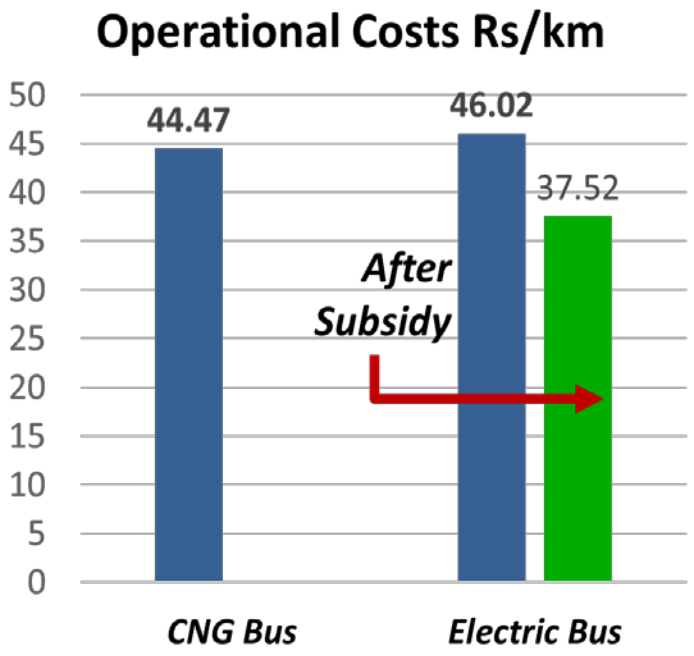
Scenario's

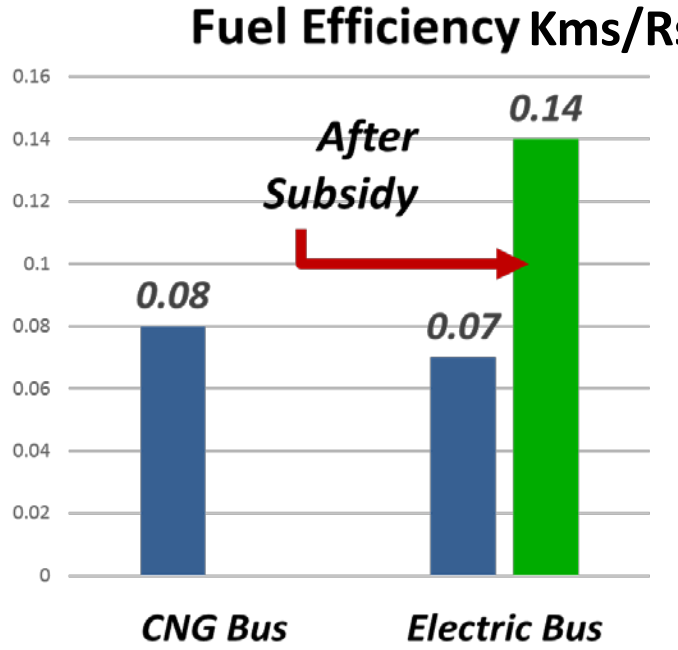
1. Electricity Subsidization
2. Bus Cost becomes half
3. Fare increment by 33%
4. Bus cost equal to normal AC bus
5. Installation of solar based charging system

Effects of Bus Cost Subsidisation



Effects of Electricity Subsidisation





Source: Authors Analysis

Scenario's

Bus Cost Reduction

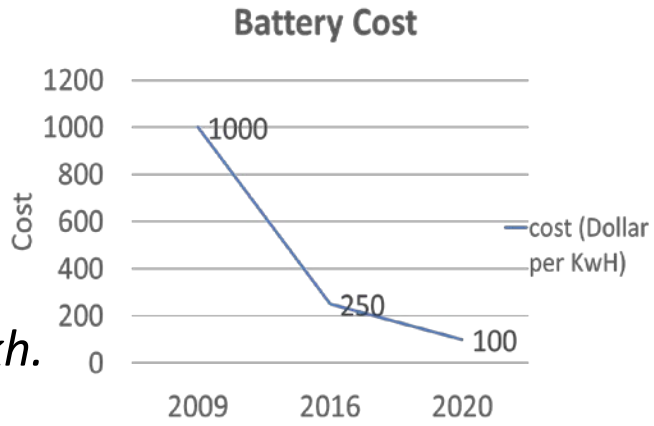
1. **Tax Exemption** as done in various countries

- *Exemption from **acquisition tax** and from the **excise tax** in **China** for electric cars*
- ***France** began offering in 2013 **purchase incentives** of 6 300 euros for BEVs and PHEVs*
- *Cars emitting zero CO2 at the tailpipe are exempt from paying **registration tax in Netherlands .***

3. **Subsidy on E- Bus Purchase**

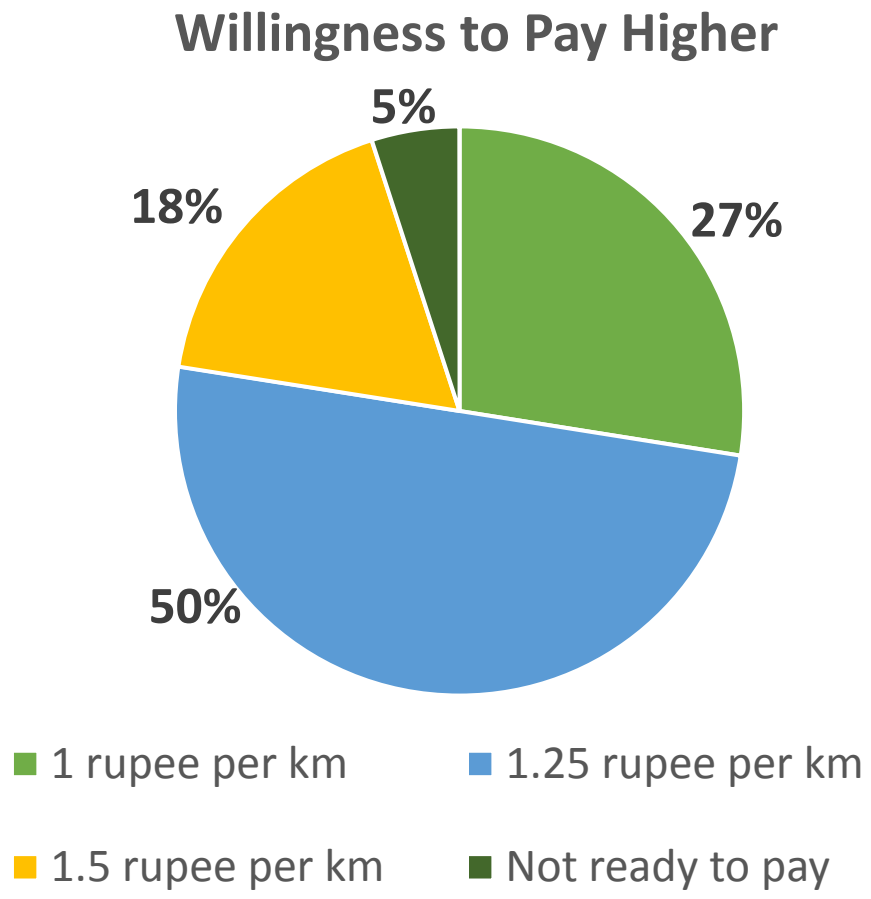
2. **Battery Technology Improvement**

- *Current recommendations by transport minister have emphasized on the **use of Lithium ion battery for buses earlier used for aviation sector.***
- ***MoU between ISRO and BHEL** to help develop low-cost lithium ion batteries.*
- *ISRO have **developed batteries costing Rs 5 lakh,** about a tenth of the imported ones which was 55 lakh.*



Scenario's

Fare Increment



Use of Solar Energy

Taking a case of 25 buses, if those are being put on solar instead of charging using electricity, costs are-

Using Electricity

- Unit cost- 10.66 Rs.
- For 25 years-
- Total costs- **94.8 Cr**

Using Solar

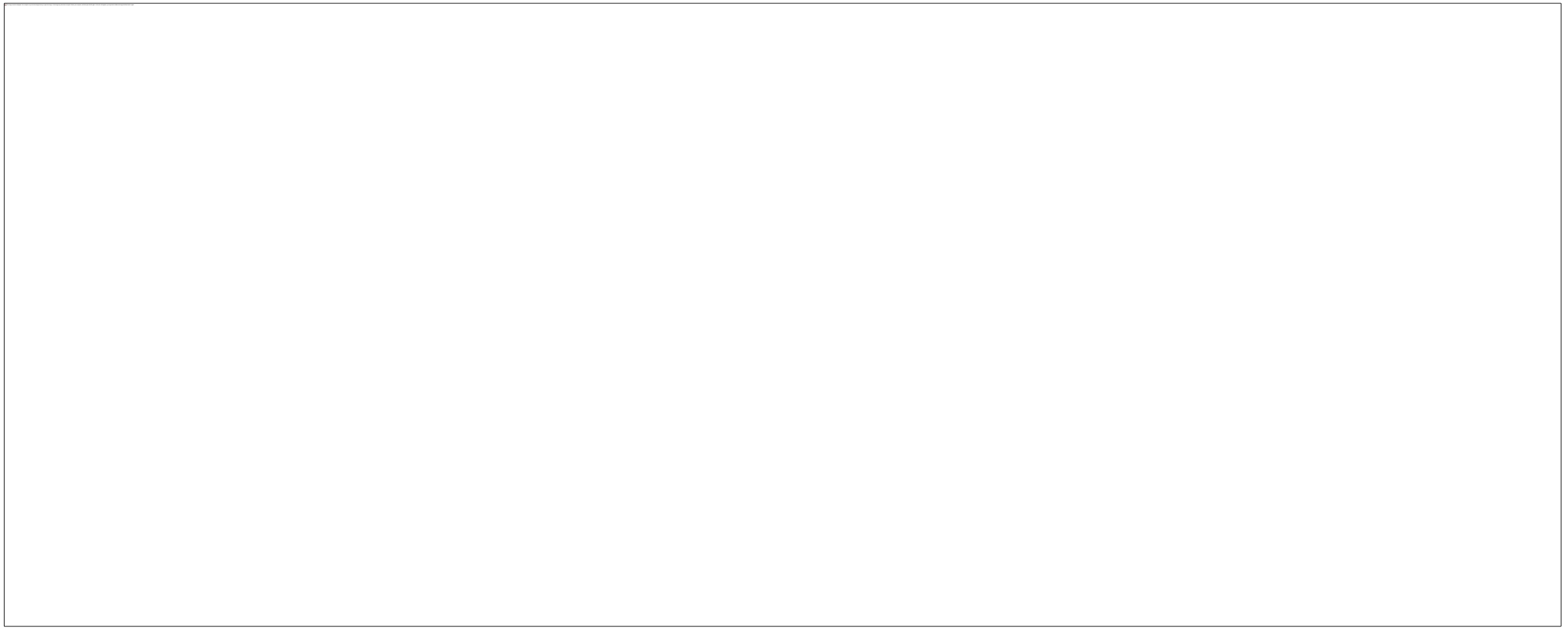
- For 10,00,000 WaH = 4.5 Cr
- For 10,000 units
- i.e. 1,00,00,000 WaH= 4.5 x10= 45 +0.5 (Annual Maintenance)
- Total Cost= **45.50 Cr (52% less)**

For a period of 25 years, total saving of around 49.3 Cr for 25 buses

Over the life time of the solar system, there will be a savings of around 1.20Cr per Bus.

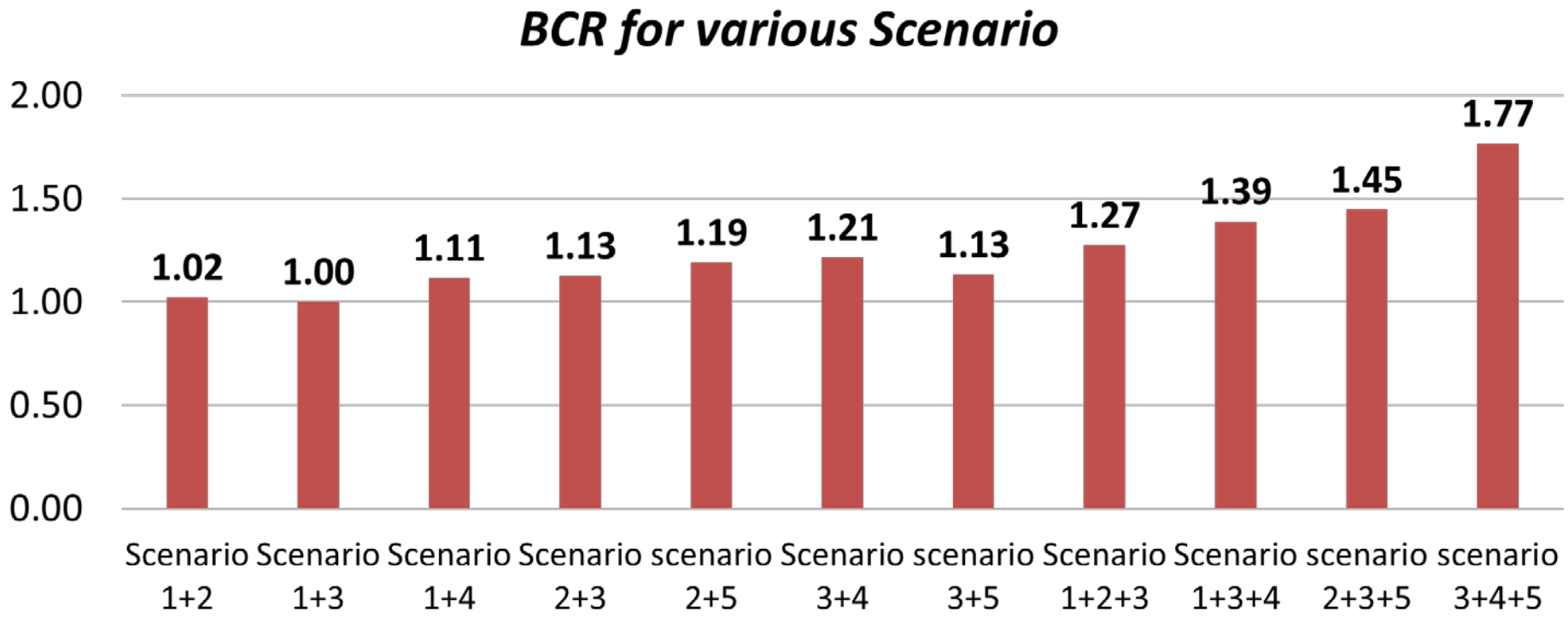
For 100 buses, savings of around 120 Cr. over the life time

Evaluation of Scenarios



Evaluation of Scenarios

1. Electricity Subsidization
2. Bus Cost becomes half
3. Fare increment by 33%
4. Bus cost equal to normal AC bus
5. Installation of solar based charging system



Scenario 3+4+5,where fare increment, cost of bus equal to normal bus and adoption of solar strategies are adopted, is most desirable as it is having lowest rate of returns an Highest BCR.

General Recommendations

1. Bus cost reduction through subsidy and battery technology advancement.
2. Cost reduction through tax exemptions will be a great move.
3. Making operation feasible by electricity subsidization.
4. Fare increment can be done and is acceptable to a certain level for making operation feasible.
5. Adoption of solar system will provide significant cost and emission savings in long term.

References

•National Energy Policy. (2001). *Reliable, Affordable, and Environmentally Sound Energy for America's Future.* National Energy Policy Development Group.
•T.V. Ramachandra and Shwetmala. (2009). Emissions from India's transport sector: Statewise synthesis. *Atmospheric Environment*, 1-8.
•Aber, J. (2016). *Electric Bus Analysis for New York City Transit.* Columbia University.
•Akshaya Kumar Sen, Geetam Tiwari and Vrajaindra Upadhyay. (2010). Estimating margina lexterna lcosts of transport in Delhi. *Transport Policy, 17*, 27-37.
•Bjorn Nykvist & Mans Nilsson. (2015). Rapidly falling costs of battery packs for electric vehicles. *Nature Climate Change, 5*, 329-332.
•CARB. (2016). *Advanced Clean Transit Battery Cost for Heavy-Duty Electric Vehicles.* Discussion Draft.
•CSE. (2015). *Delhi Clean Air Action Plan.*
•Bus operation data from Delhi Trasnport Corporation (DTC), 2016
•(2016). *ELECTRICITY- Cooperation for sustainable and attractive public transport.* Status Report.
•GGGI and CSTEP. (2015). *Electric Buses in India: Technology, Policy and Benefits.* GGGI, Seoul, Republic of Korea.
•IEA. (2016). *Global EV Outlook* .
•Kadafa, A. A. (2012). Environmental Impacts of Oil Exploration and Exploitation in the Niger Delta of Nigeria. *Global Journal of Science Frontier Research Environment & Earth Sciences, Vol. 12*(Issue. 3), pp. 18-28.
•MoEFCC, G. (2016). *Air Pollution in Delhi-An Analysis.* ENVIS Centre CPCB.
•Rameshwar Dayal Sharma, S. J. (2011). Growth rate of Motor Vehicles in India -Impact of Demographic and Economic Development. *Journal of Economic and Social Studies, Vol. 1*, pp. 137-150.
•Ramprasad Sengupta and Subrata Mandal. (2005). *Health Damage Cost of Automotive Air Pollution : Cost Benefit Analysis of Fuel Quality Upgradation for Indian Cities.*
•Robert Earley, Liping Kang, Feng An and Lucia Green-Weiskel. (2011). *Electric Vehicles in the Context of Sustainable Development in China*. Background Paper CSD19/2011/BP9, Commission on Sustainable Development. United Nations Department of Economic and Social Affairs.
•S. R. Adheesh, M. S. (2016). Air-pollution and economics: diesel bus versus electric bus. *Current Science, Vol. 110*, pp. 858-862.
•Santosh A Jalihal and T S Reddy. (2006). CNG: An alternatie fuel for public transport. *Journal of Scientific and Industrial Research, Vol. 65*, pp. 426-431.
•Singh, S. K. (2012). Urban Transport in India: Issues, Challenges, and the Way Forward. *European Transport \ Trasporti Europei*(Issue. 52).
•UN-Habitat. (2013). *Planning and Design for Sustainable Urban Mobility.* Global Report on Human Settlements.