

Route and Facility Planning for Deployment of Electric Buses in Bengaluru

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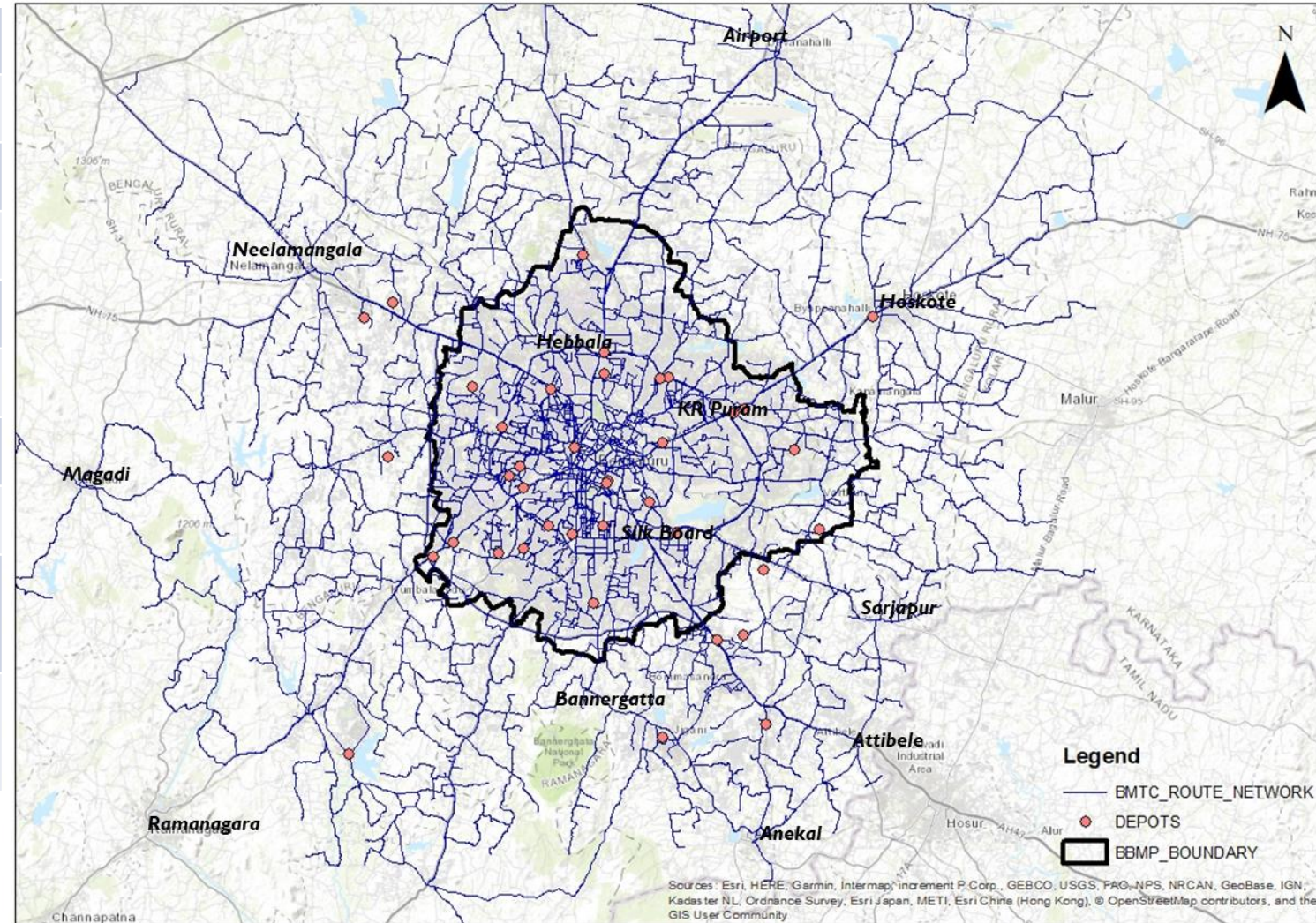
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Introduction

- BMTC is public transport bus service provider in Bengaluru
- BMTC is revamping the bus services with a vision :
"To provide quality, safe, reliable, clean, and affordable travel while being sustainable, self-sufficient, and technologically advanced in the future urban-transport scenario and hence to increase public transport use in Bangalore"
- Various strategies planned to achieve the objective are:
 - Improvement of operational efficiency
 - Introduction of cleaner vehicle technology through adoption of e-buses
 - Integrated public transport
 - Technological solutions
 - Demand management measures and policy interventions

Existing BMTC Performance

Fleet size	6521
Daily Passengers	3.5 Million
Number of routes	2263
No. of bus trips	69648
No. of bus stations	54
No. of depots	45
Coverage	2522 kms
25% of the city area has buses in 1 min	
97% of the highly dense area has bus availability within 500 m	
82% of the establishments are within 250 m of a bus route	



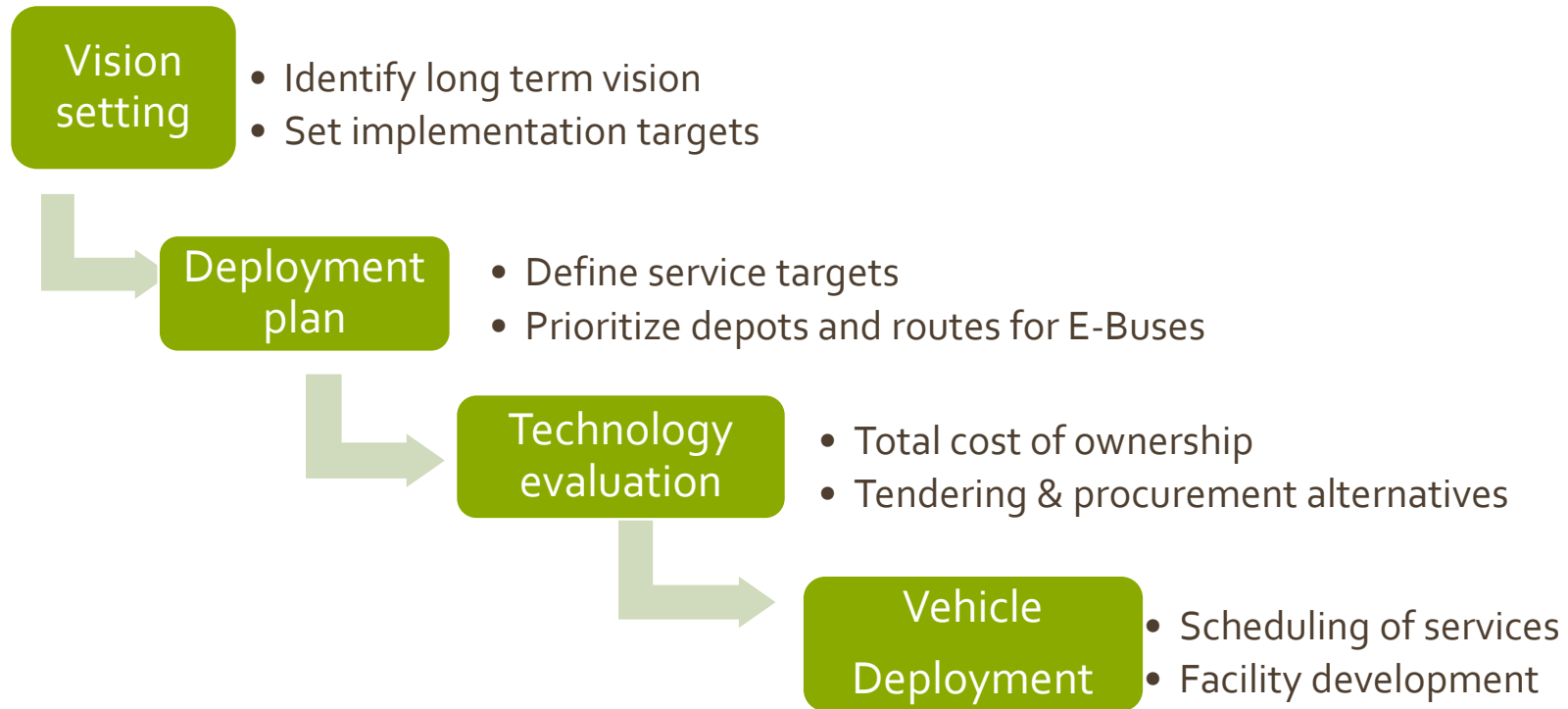
Need for electrification of bus transport

- Electrifying buses will result in achieving the largest passenger-km of electrification possible
- Targeted deployment through Government backed STUs and SPVs can transform the entire urban bus sector
- The depot spaces available with bus operators offer adequate space for charging infrastructure thereby easing the implementation process
- City bus services have the highest vehicle utilisation among urban vehicles due to their daily operations of 200-250 km.
- Given the lower operational cost of EVs they offer the shortest payback period among all vehicles

Objective of the Assignment

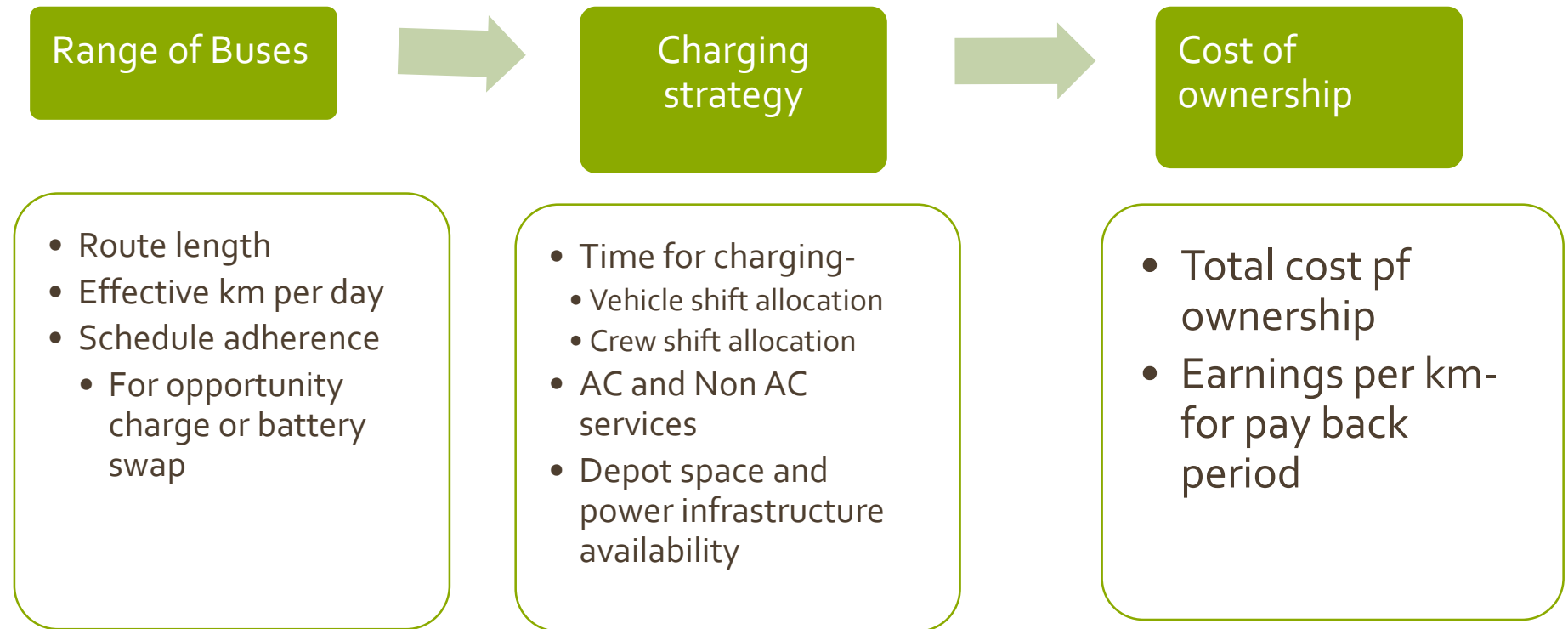
1. To develop a methodology for 100% transition to e-bus fleet in BMTC
2. To validate the methodology develop for first phases of buses
3. To identify operational requirements and constraints for e-bus deployment

Approach

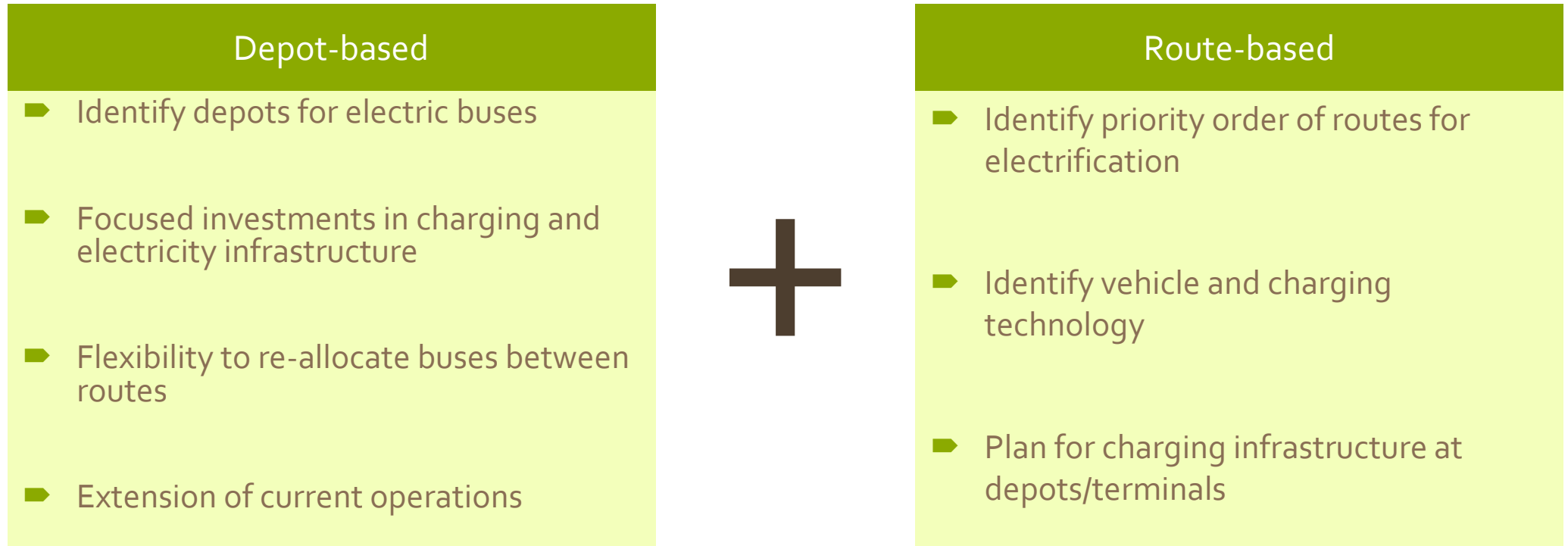


Deployment Plan

Decision Making Criteria



Approach for deployment



A combination of depot-based and route-based approach is adopted for BMTC

A priority order of depots is prepared following which a priority order of routes will be identified

Depot Selection Criteria



Electricity Infrastructure Cost



Minimise cost based on infrastructure availability. This will consider the easiness to set up electricity infrastructure also



Charging infra utilization



Maximise number of buses using the charging infrastructure



Geographic Location



Minimise dead mileage of routes. peripheral depots for vehicle utilisation

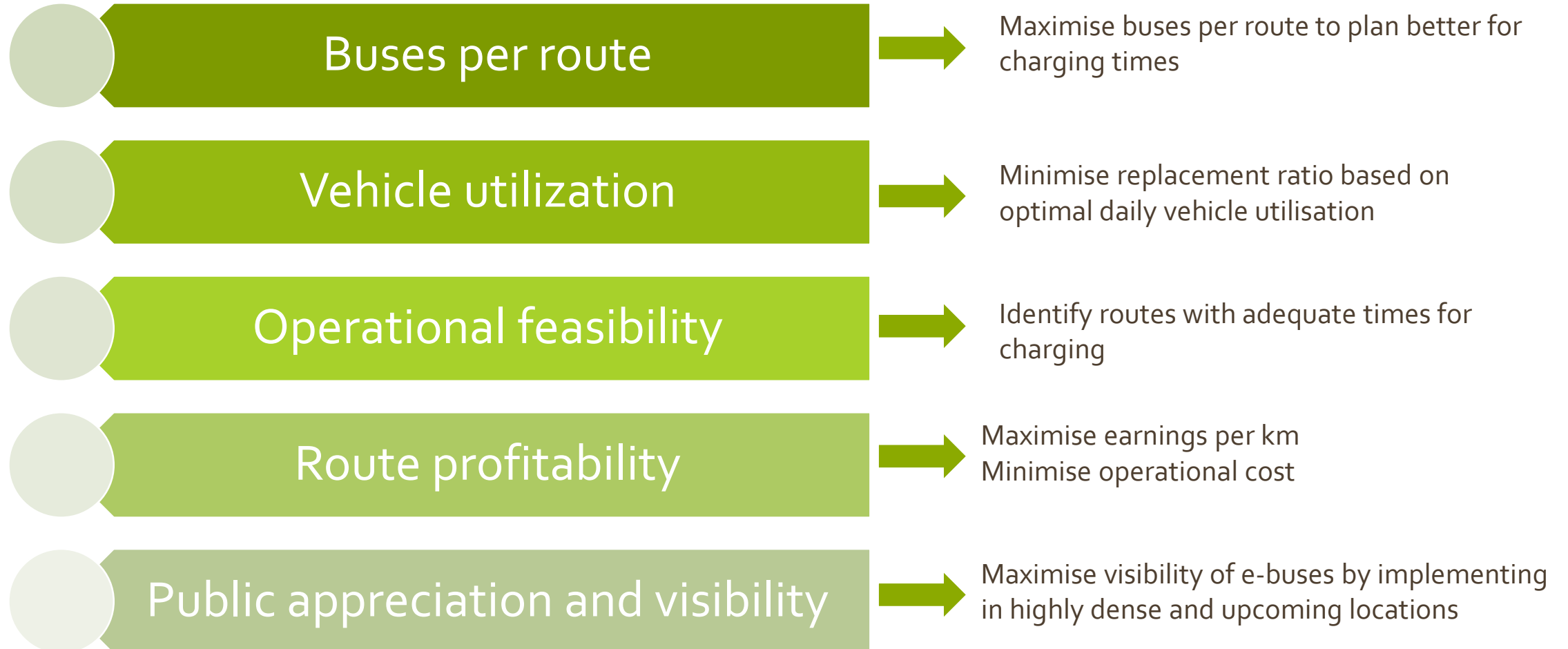


Depot Area



Potential of depot expansion and complete electrification

Route Selection Criteria



Planning for pilot deployment of e-buses

Pilot deployment for 500 e-buses, wherein two scenarios for deployment were evaluated

Categories	AC Services		Non-AC Services	Total
	Airport Services	Other AC Services		
Current Distribution	106	629	5455	6190
Proposed Scenario 1	50	350	100	500
Proposed Scenario 2	20	80	400	500

Comparison of two scenarios

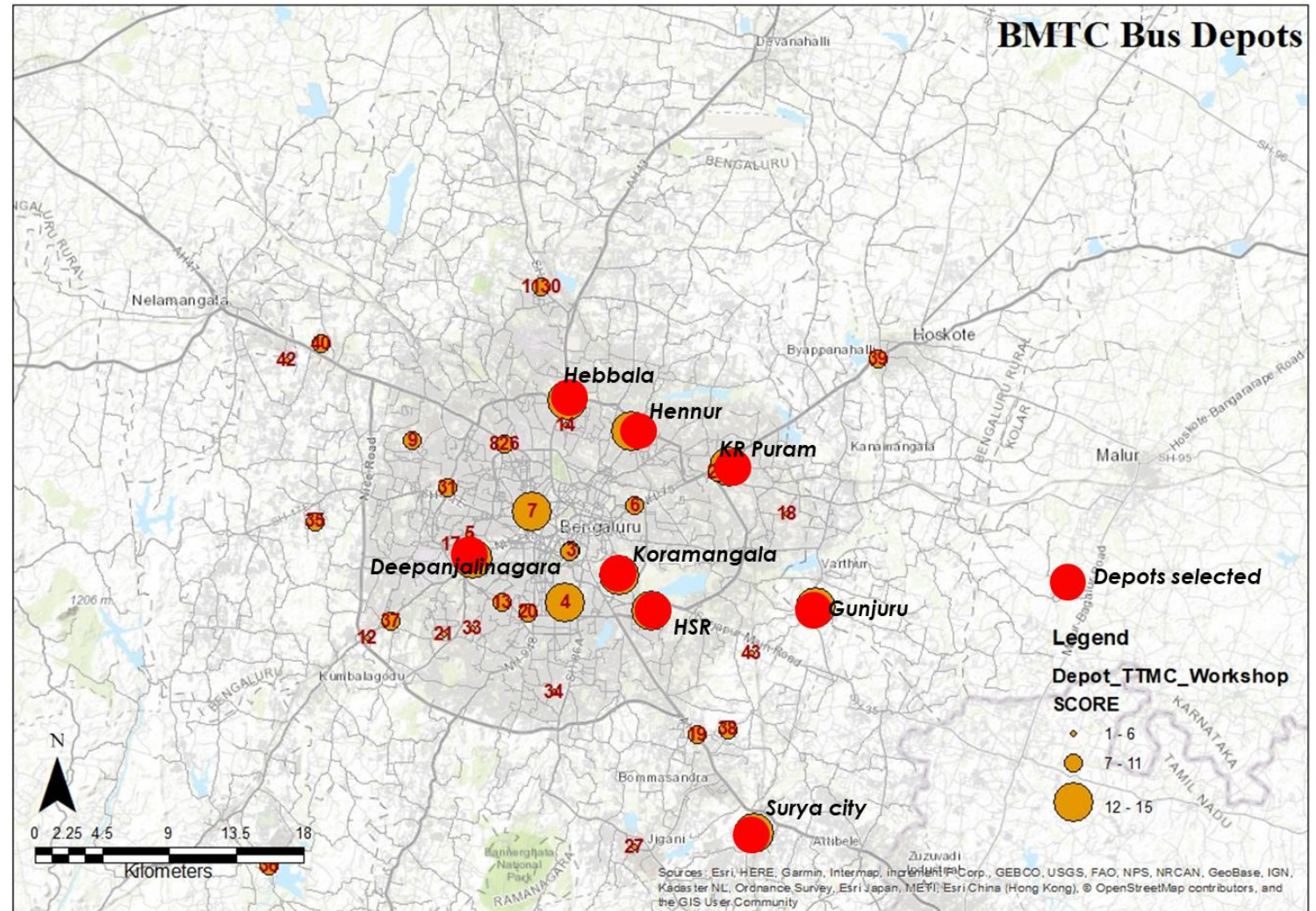
Parameter	Scenario 1	Scenario 2
Number of AC depots	4	3
Number of Non-AC depots	3	5
Weighted Average Vehicle Utilization (Per year)		
Airport AC Services	1,38,405 km	1,42,755 km
Other AC Services	68,015 km	1,37,245 km
Non-AC Services	69,424 km	72,128 km
Weighted Average EPKM	Rs 63.25/km	Rs 53.26/km

Average EPKM being major deciding factor, scenario 1 is selected for deployment of e-buses

Depot Priority Order

Based on 4 criteria explained earlier

- BMTC has 45 depots currently operational and 6 depots under development
- Ranking of depots based on the criteria
- 13 depots identified with potential for transformation
- Based on operational feasibility 8 depots are shortlisted



Depot Priority Order

SL. NO.	DEPOT	Rating- Area	Rating- Electricity Infra cost	Rating- Location	Total Rating
1	Depot-32 (Surya City)	5	5	5	15
2	Depot-16 (Deepanjalinaraga)	4	5	5	14
3	Depot-07 (Subhashnagara)	5	5	3	13
4	Depot-25 (HSR Layout)	5	3	5	13
5	Depot-41 (Gunjuru)	5	3	5	13
6	New Depot- Kodathi	5	3	5	13
7	New Depot- Sadarmangala	5	3	5	13
8	Depot-15 (Koramangala)	4	5	4	13
9	Depot-04 (Jayanagara)	5	4	3	12
10	Depot-10 (Kacharakanahalli)	4	3	5	12
11	Depot-22 (Peenya 2nd Stage)	4	3	5	12
12	Depot-28 (Hebbala)	4	3	5	12
13	Depot-29 (K.R.Puram)	4	3	5	12

Route Priority Order

Number of buses along the in the selected depots

Average vehicle utilization greater than 180 kms per day

- The battery capacity will decrease over the life time. Hence, if we select only higher utilization routes, more buses would be required for same service supply in future.
- The routes with effective kms 150-250 kms are found to have lower replacement ratio hence given highest priority

Operational Feasibility

Geographic Location preference to peripheral locations

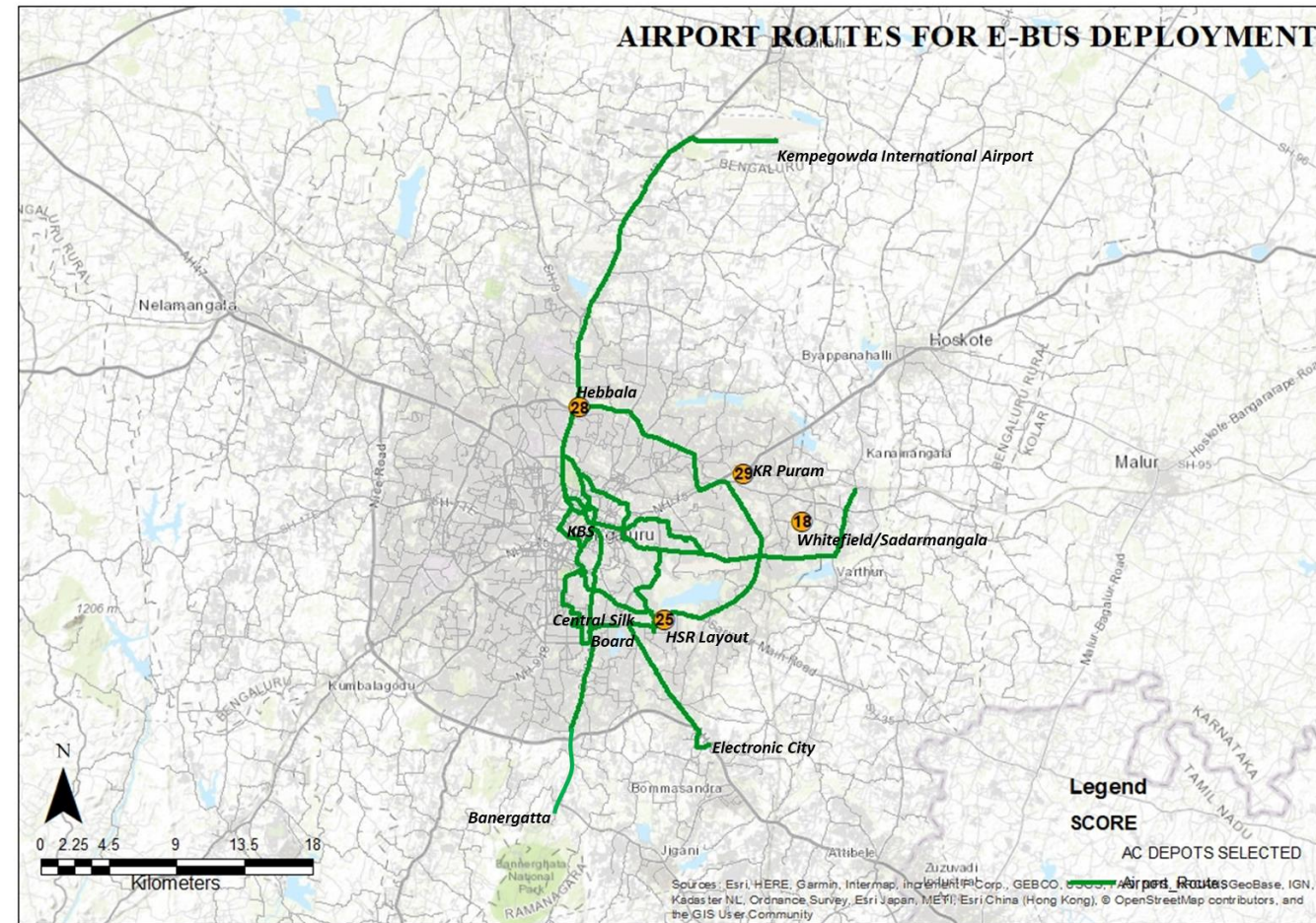
Average Earning per km above Rs 40 per km

- The operating cost per km of electric buses is lower compared to diesel buses
- Higher the earning per km, higher would be the revenue for any particular route
- The C schedules of BMTC (loss making schedules) will be converted to A or B schedules
- The routes with higher EPKM (>40 Rs/Km) are given preference.

Public Appreciation and Visibility

Route Priority Order- Airport Schedules

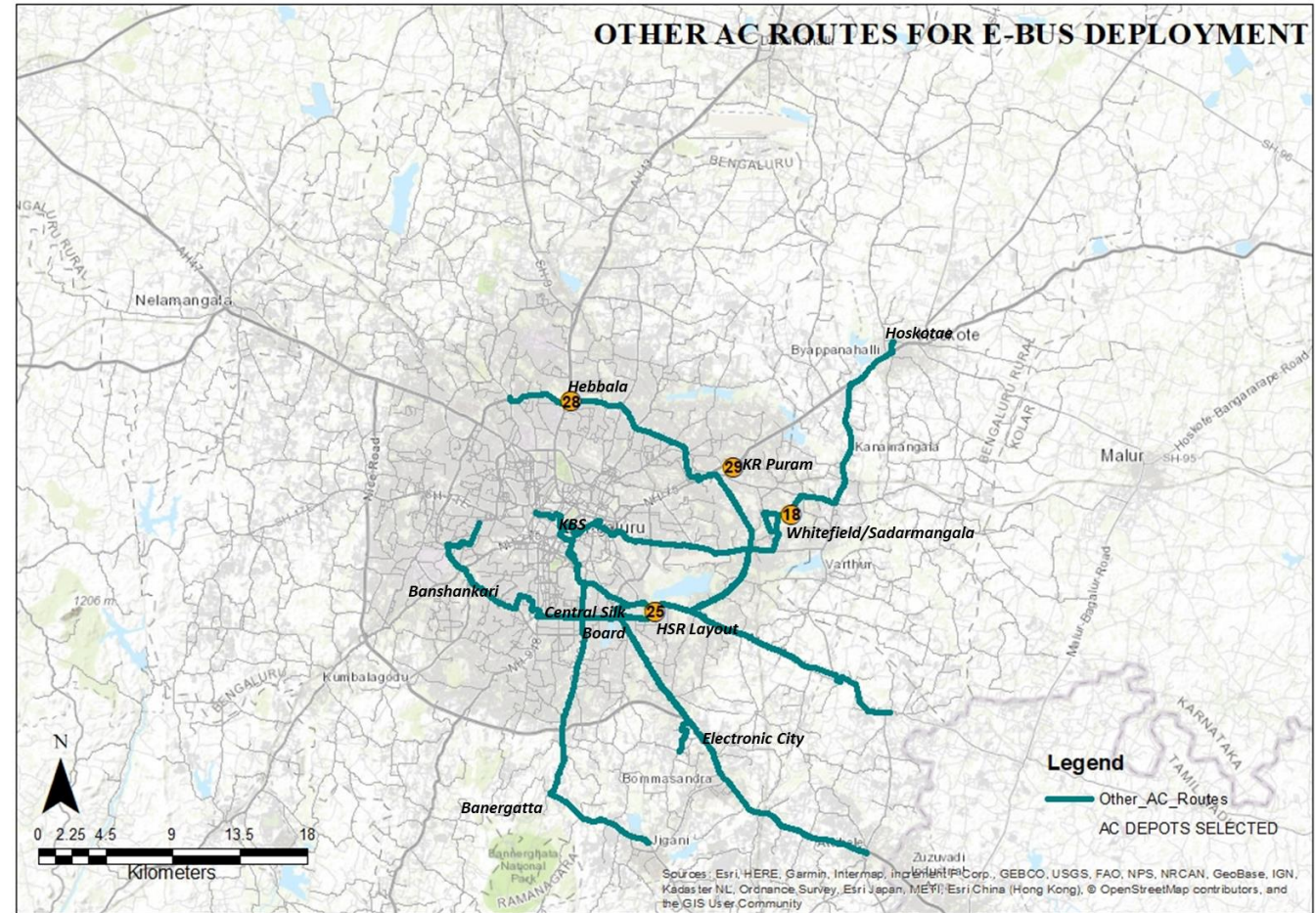
				Depot				
SL N o	Route No	From	To	18	25	28	29	Total Schedul es
1	KIAS8	Electronic City	Kempegowda International Airport	0	6	12	0	18
2	KIAS4	HAL Main Gate		9	0	0	0	9
3	KIAS6	Kadugodi Bus Station		6	0	0	0	6
4	KIAS12	BTM Layout		0	6	0	0	6
5	KIAS8E	ELC Wipro Main Gate		0	0	5	0	5
6	KIAS14	Royal Meenakshi Mall BG Road		0	0	1	0	5
7	KIAS7A	HSR Layout BDA Complex		0	4	0	0	4
8	KIAS7	HSR Layout BDA Complex		0	4	0	0	4
Total				15	20	18	0	57



Airport routes from top ranking depots identified for more public appreciation and visibility

Route Priority Order- Other AC Schedules

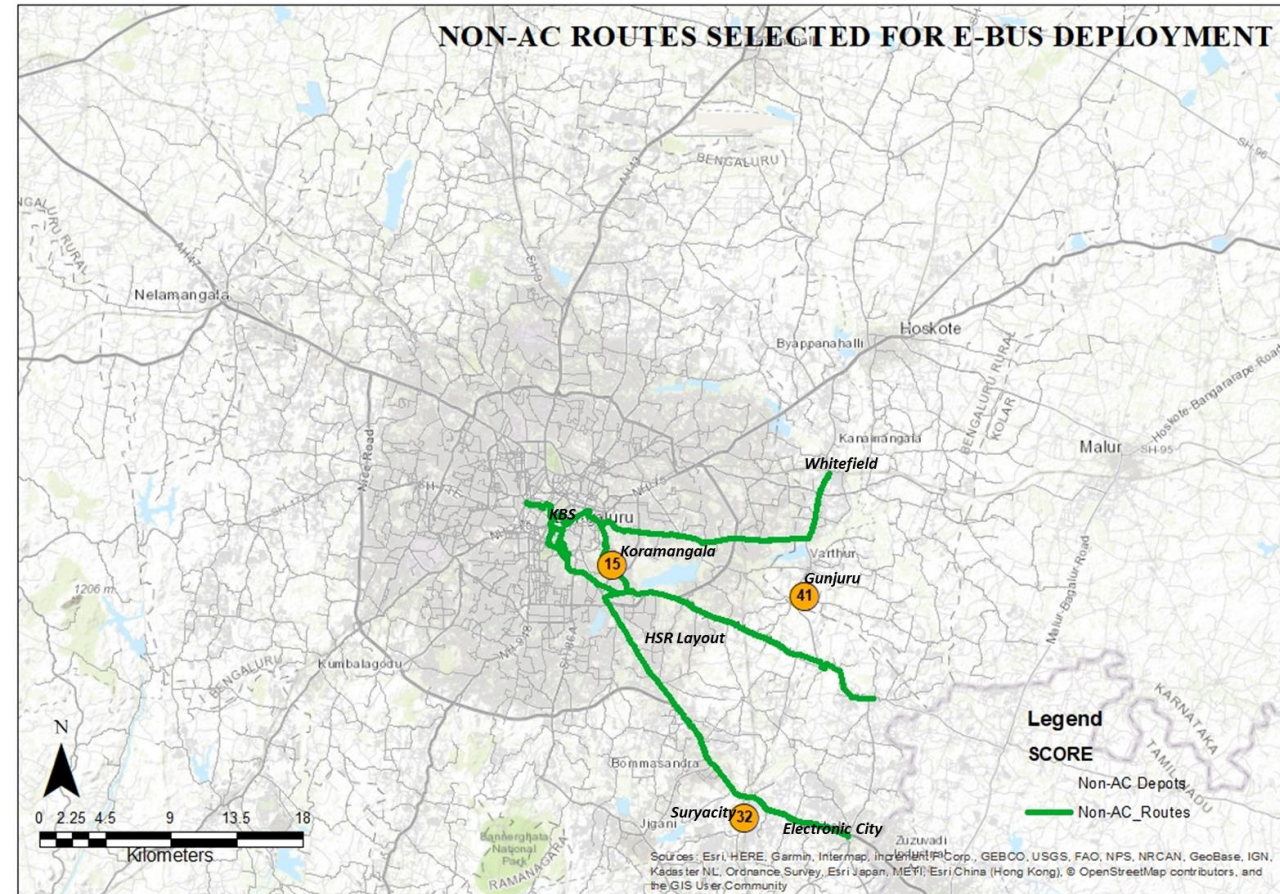
				Depot				
SL No	Route No	From	To	18	25	28	29	Total Schedules
1	V335E	Kempegowda Bus Station	Kadugodi Bus Station	6	0	15	0	78
2	V360B	Kempegowda Bus Station	Attibele	0	27	6	0	60
3	V500CA	Banashankari TTMC	ITPL	5	19	5	6	58
4	V500D	Hebbala	Central Silk Board	0	18	33	2	54
5	V500K	Vijayanagara	ITPL	0	6	0	0	27
6	V500A	Banashankari TTMC	Hebbala	0	6	11	2	24
7	V342F	Kempegowda Bus Station	Sarjapura	0	10	0	0	13
8	V335EK	Kempegowda Bus Station	Hosakote	0	0	5	1	11
9	V505	ITPL	Electronic City	1	4	0	3	9
10	V500BC	BEL Circle	Banashankari TTMC	0	0	9	0	9
11	V365J	Kempegowda Bus Station	Jigani APC Circle	0	0	0	2	7
12	VMF1C	Central Silk Board	Swamy Vivekananda Metro Station	2	0	0	5	7
Total				14	90	84	21	357



Other AC schedules selected at locations with more tech-parks, upcoming developments etc.

Route Priority Order-Non-AC Schedules

SL No	Route No	From	To	Depot			Total Schedules
				15	32	41	
1	KBS3 A	Kempegowda Bus Station	Attibele	5	10	0	60
2	KBS1I	Kempegowda Bus Station	Kadugodi Bus Station	0	0	16	33
3	360K	Kempegowda Bus Station	Attibele	15	5	0	26
4	G2	Mayohall Central Maall	Sarjapura	5	0	0	21
5	342F	Kempegowda Bus Station	Sarjapura	5	0	0	16
6	342H	St Johns Hospital	Sarjapura	10	0	0	13
Total				40	15	16	169



Facility Planning- Depots

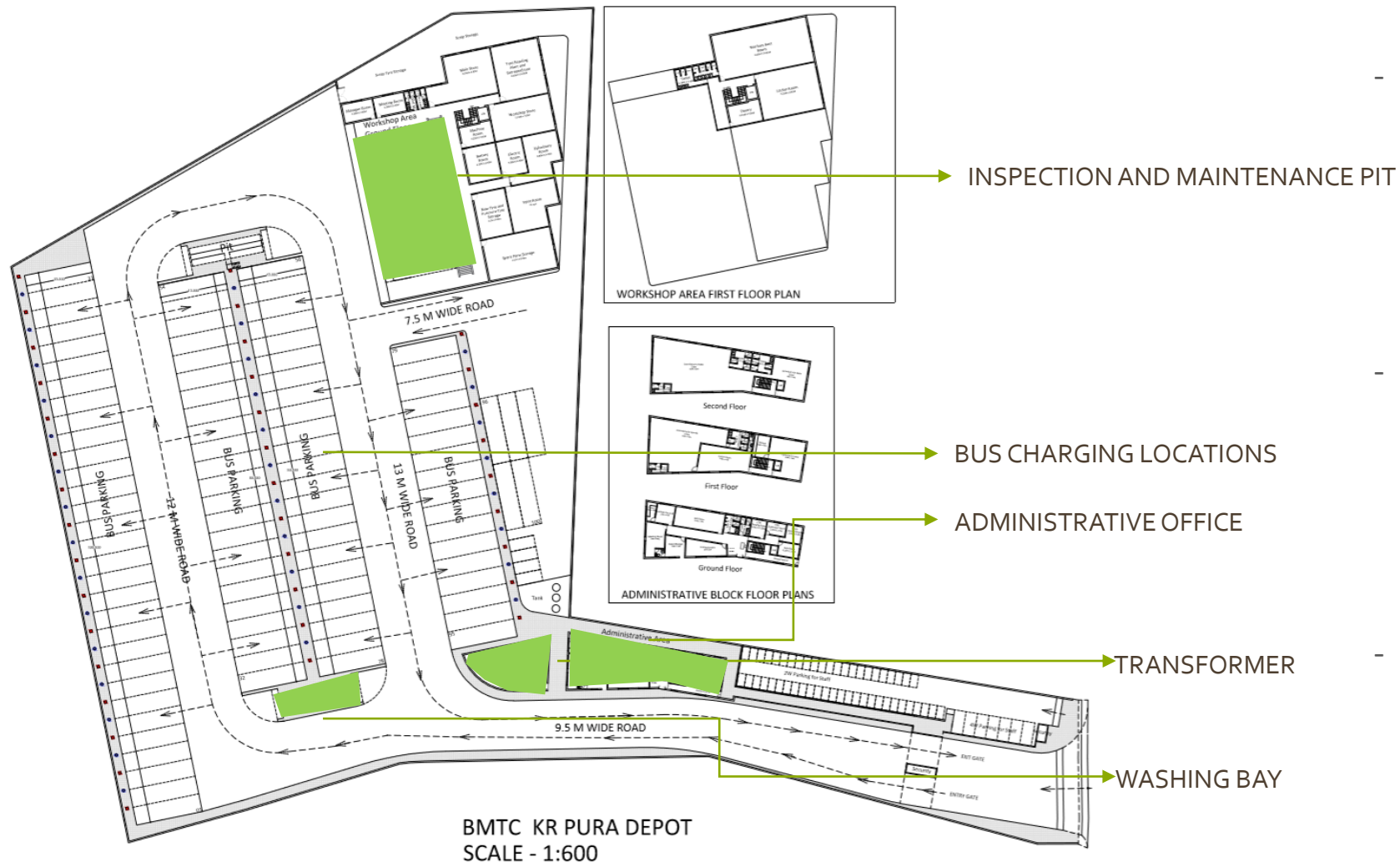
DEPOT		18 (SADARAMANGALA)			25 (HSR LAYOUT)			28 (HEBBALA)			29 (K R PURAM)		
AREA (ACRES)		1.18			4.25			3.19			3.30		
CAPACITY		60			150			120			150		
SCHS ALLOTTED		58			145			142			69		
DIFF		18			20			17			-81		
ROUTES		VAJRA	VAYU VAJRA	TOTAL	VAJRA	VAYU VAJRA	TOTAL	VAJRA	VAYU VAJRA	TOTAL	VAJRA	VAYU VAJRA	TOTAL
TYPE		14	4	18	22	5	27	21	3	24	20	1	21
	D/O	0	0	0	0	0	0	9	0	9	0	0	0
	G/S	6	1	7	48	1	49	34	1	35	33	0	33
	N/O	18	19	37	62	20	82	62	16	78	23	1	24
	N/S	0	0	0	2	1	3	2	0	2	3	0	3
	SPLIT	14	0	14	11	0	11	17	1	18	9	0	9
TOTAL SCHEDULES		38	20	58	123	22	145	124	18	142	68	1	69

Facility Planning-KR Puram Depot



Current scenario of
KR Puram Depot

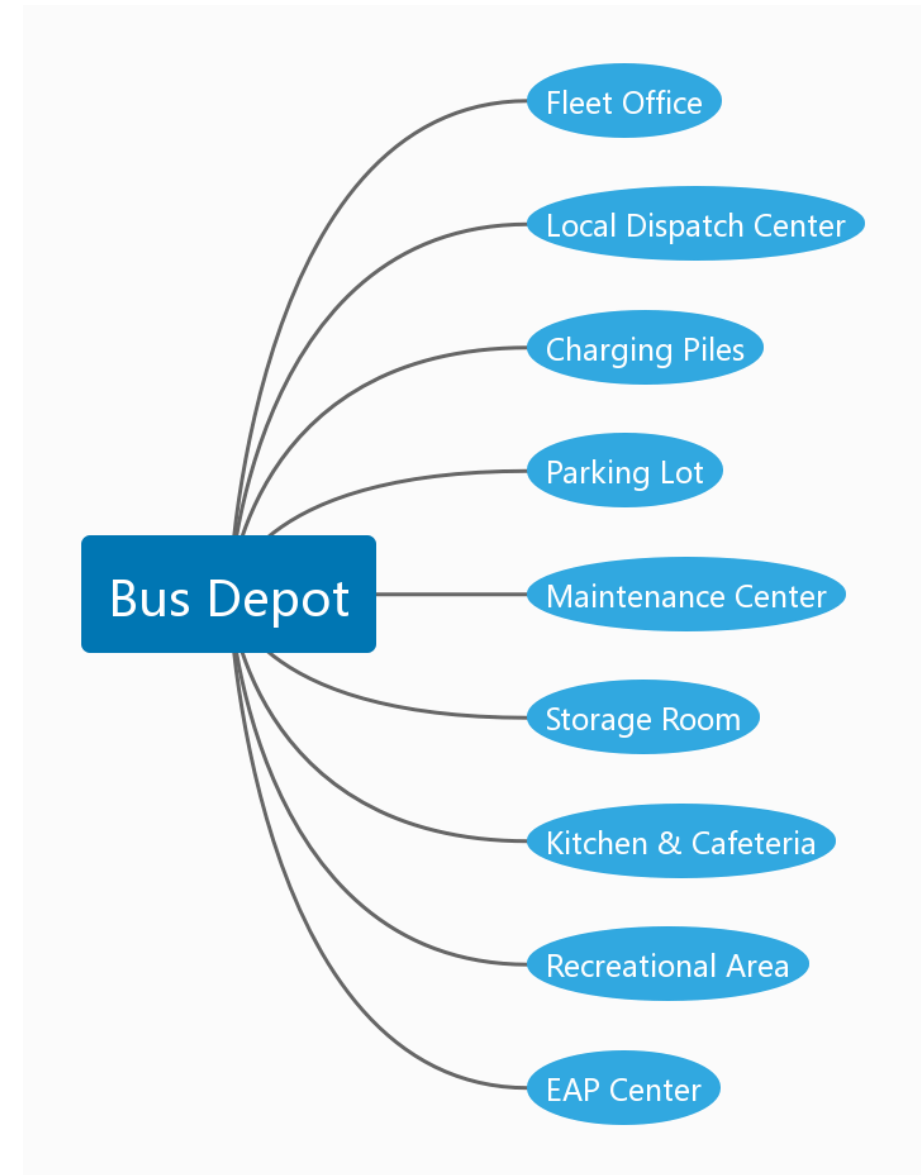
Facility Planning-KR Puram Depot



- Area required for one bus including depot requirements, such as parking, workshops, staff amenities, administrative block etc. 150 sq.m
- 40% buses are always out for operations. Currently about 50% of buses are night out shifts and only 50% are parked in the depot during night time
- Charging assumed slow charging (75KVA) requiring 6 hours of charge

Facility Planning at Depots

- The facilities required at a depot include:
 - Bus Management Facility
 - Entry/Exit with security room
 - Bus parking
 - Charging
 - Washing
 - Vehicle Maintenance Facility
 - Workshops & maintenance pits
 - Administrative Block Facility
 - Operational block
 - Staff recreation
 - Other utilities
 - Transformers



Implementation details

- The E-buses would be procured under GCC mode of contract
- The depots and charging facilities will be developed by private concessionaire
- For longer routes (airport schedules), charging infrastructure will be provided at airport

Way forward and further work

- **Scheduling of services**
- To include ample charging time for buses at depots
- **Depot Electricity Infrastructure**
- Dependent on the charging typology selected (Slow/Fast/Rapid)
- Some depots may require sub-station/transformers etc for upgradation
- Few schedules may require opportunity charging. For examples, the airport routes in Bangalore need opportunity charging at Airport

Thank You