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Comprehensive Environmental Performance Evaluation of Suburban Railways using LCA

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International Transport Forum

International Transport Forum
Life Cycle Assessment Methods to Support India's Efforts to Decarbonise Transport
Workshop 14 April 2021

Objectives and Scope of the Research

Component	Mumbai Suburban Railway	Public Bus Transport, Taxis and Auto-rickshaws	Metro Transit System
Vehicle			
Manufacturing	Electric Multiple Unit	Vehicle	Metro coach
Operation	Traction electricity	Tail-pipe emissions Fuel production	Traction electricity
Maintenance	Periodic overhauling Refurbishment	Vehicle maintenance	Coach maintenance
Infrastructure			
Construction	Ballasted track Power supply installation FOB's and Platforms Transport of materials	Bituminous road Transport of materials	Slab track (RHEDA 2000) Track fastenings (Vossloh) Viaduct and Tunnel Elevated stations Underground stations Transport of materials
Operation	Auxiliary electricity	Roadway lighting	Auxiliary electricity
Maintenance	Track maintenance	Periodic & seasonal maintenance	Track maintenance
Time horizon	2013-37	2013-2027	2021-2050

Outline of the Presentation

- **LCA of Mumbai Suburban Railway**
  - Objective and scope of the study
  - System boundary
    - Construction and maintenance of railway infrastructure
    - Manufacturing and maintenance of EMUs
    - Operation phase (traction and auxiliary electricity)
  - Effect of vehicle ridership and type of electricity used
  - Sensitivity analysis

Life Cycle Assessment of Mumbai Suburban Railway (Shinde et al., 2018)

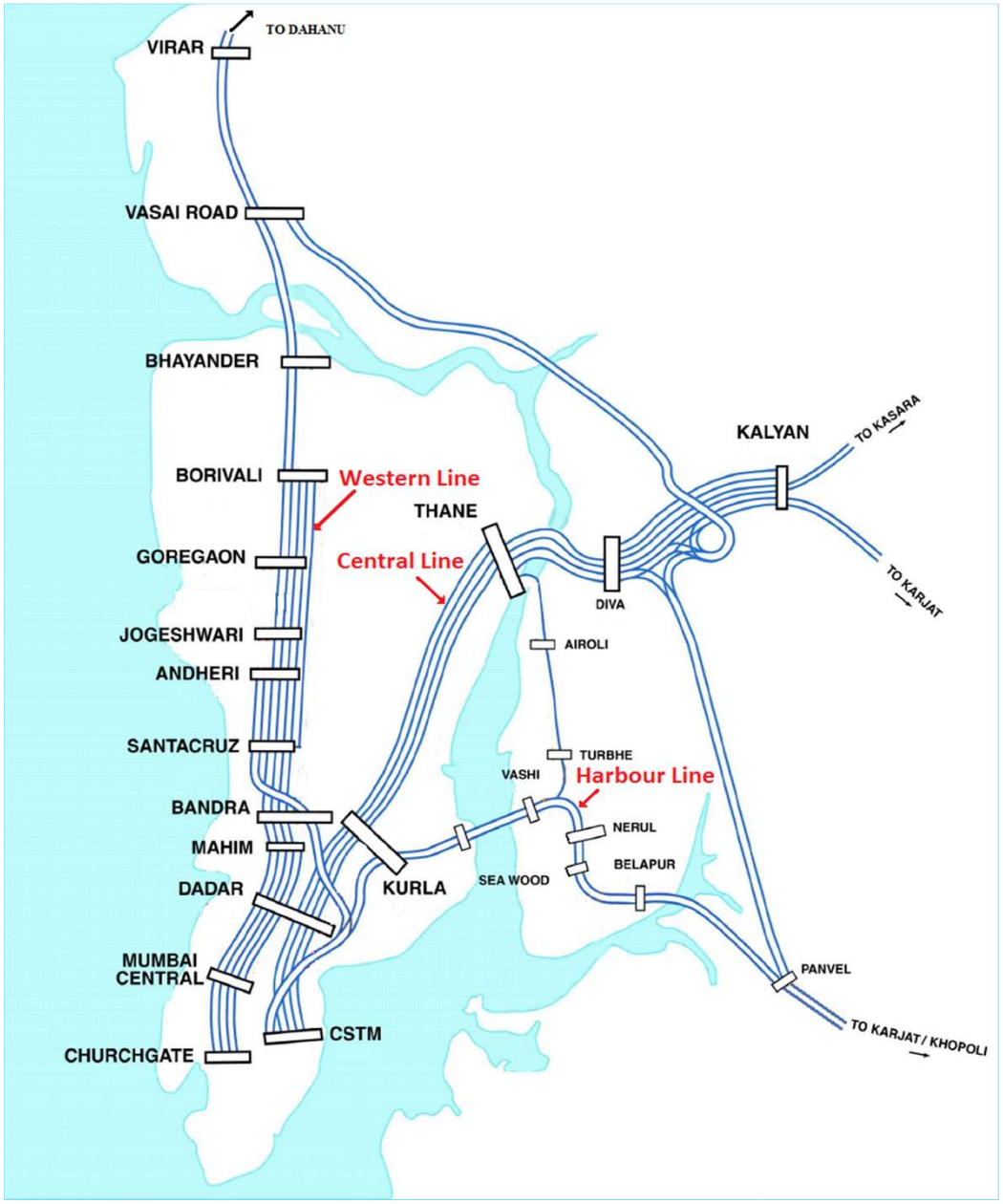


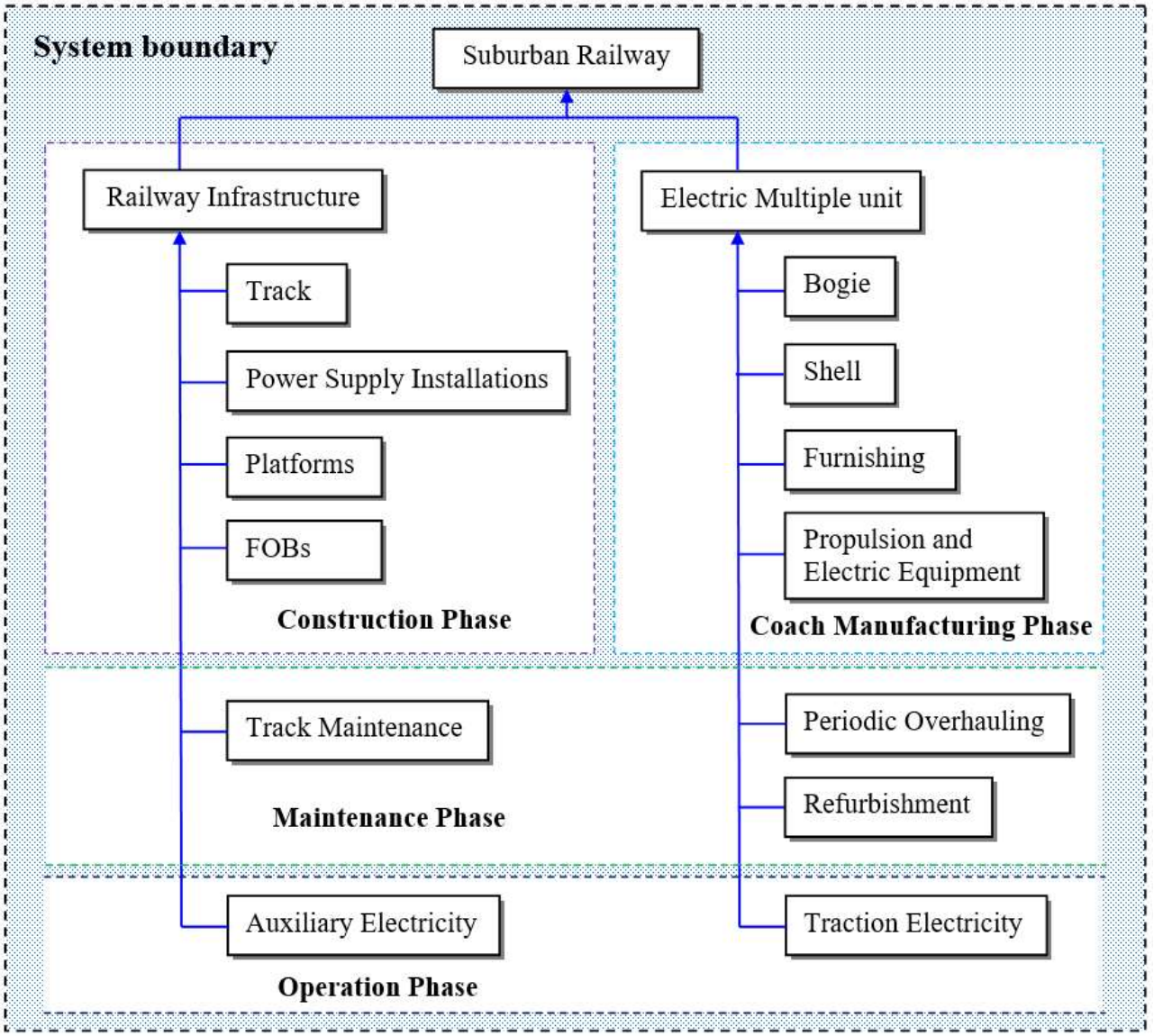
Figure: Schematic Diagram of Mumbai Suburban Railway

Table: Track length of sections on MSR

Railway Line	Route Length (km)	Track Length (km)		Total Track Length (km)
		52 kg/m Rails	60 kg/m Rails	
Central Line	182.02	171.51	372.84	459.45
Harbour Line	75.44	65.27	85.61	150.88
Western Line	60	-	288.56	288.56
Total Length	**317.46**	**236.78**	**747.01**	**983.79**

Shinde A.M., Dikshit A.K., Singh R.K. and Camapana P.E. (2018). "Life Cycle Analysis based Comprehensive Environmental Performance Evaluation of Mumbai Suburban Railway, India", *Journal of Cleaner production*, 188, 989-1003.

System boundary



Indian Railway Track

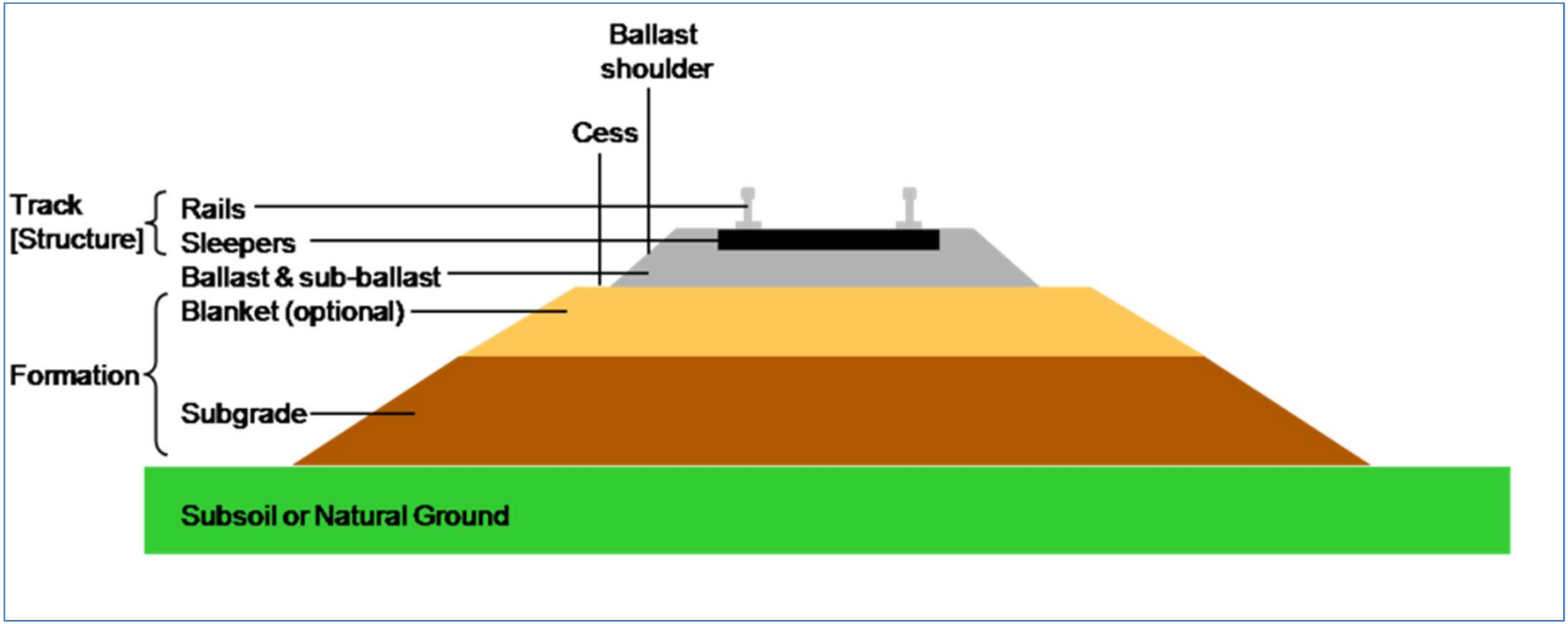
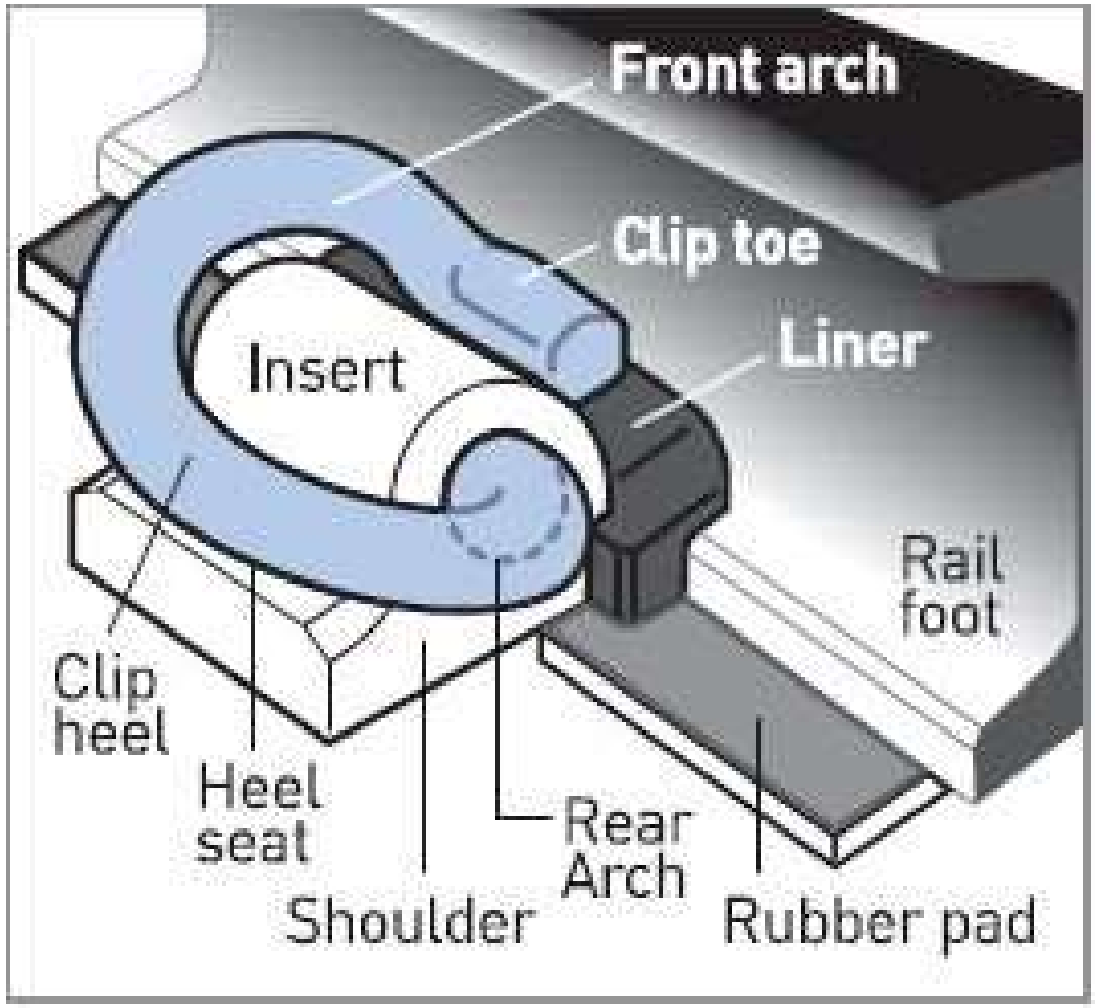
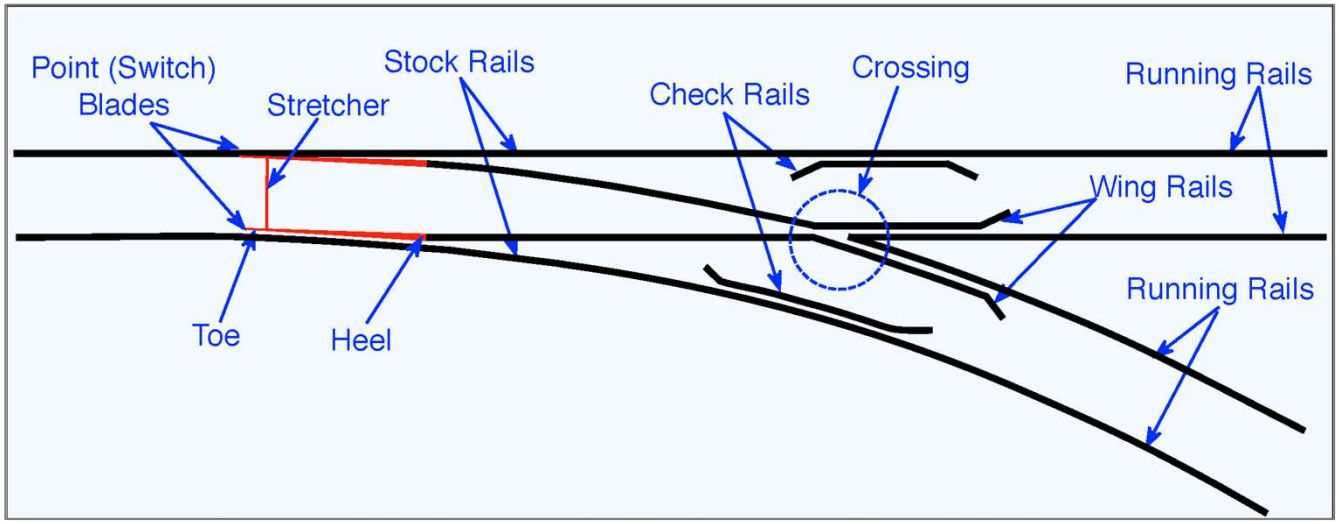


Figure: Cross section of rail track formation

Ballasted track bed



Points and Crossings



Passenger Platforms

Figure: General arrangement of 10.67 m wide passenger platform (RDSO, 2003a)

Foot over bridges (FOBs)

Power Supply Installations (Traction Substation)

Source: http://www.scr.indianrailways.gov.in/view_section.jsp?lang=0&id=0,1,291,358,1061,1065

Power Supply Installations (Overhead equipment)

Electric Multiple Unit (EMU) with 12 coaches

DTC = Driving Trailer Coach MC = Motor Coach TC = Trailer Coach

Table: Electricity consumption (million kwh), ridership and passenger km travelled (billion) data for MSR

Years	Traction Electricity	Auxiliary Electricity	Total Electricity consumption	Electricity mix considered	Ridership	PKT
2013-17	1984	577	2561	2014	14.6	489
2018-22	2104	628	2732	2018	15.5	519
2023-27	2231	736	2967	2023	16.4	550
2028-32	2366	818	3184	2028	17.4	584
2033-37	2509	871	3380	2033	18.4	619
Total	11195	3630	14824		82.3	2761

As per the results from CTS model, Compound Annual Growth Rate (CAGR) of 1.18% has been used for forecasting the operation phase of MSR (MMRDA, 2008).

- Average trip length = 33.55 km (MMRDA, 2017)
- PKT = Ridership * Average trip length

Assessing Life Cycle Impacts

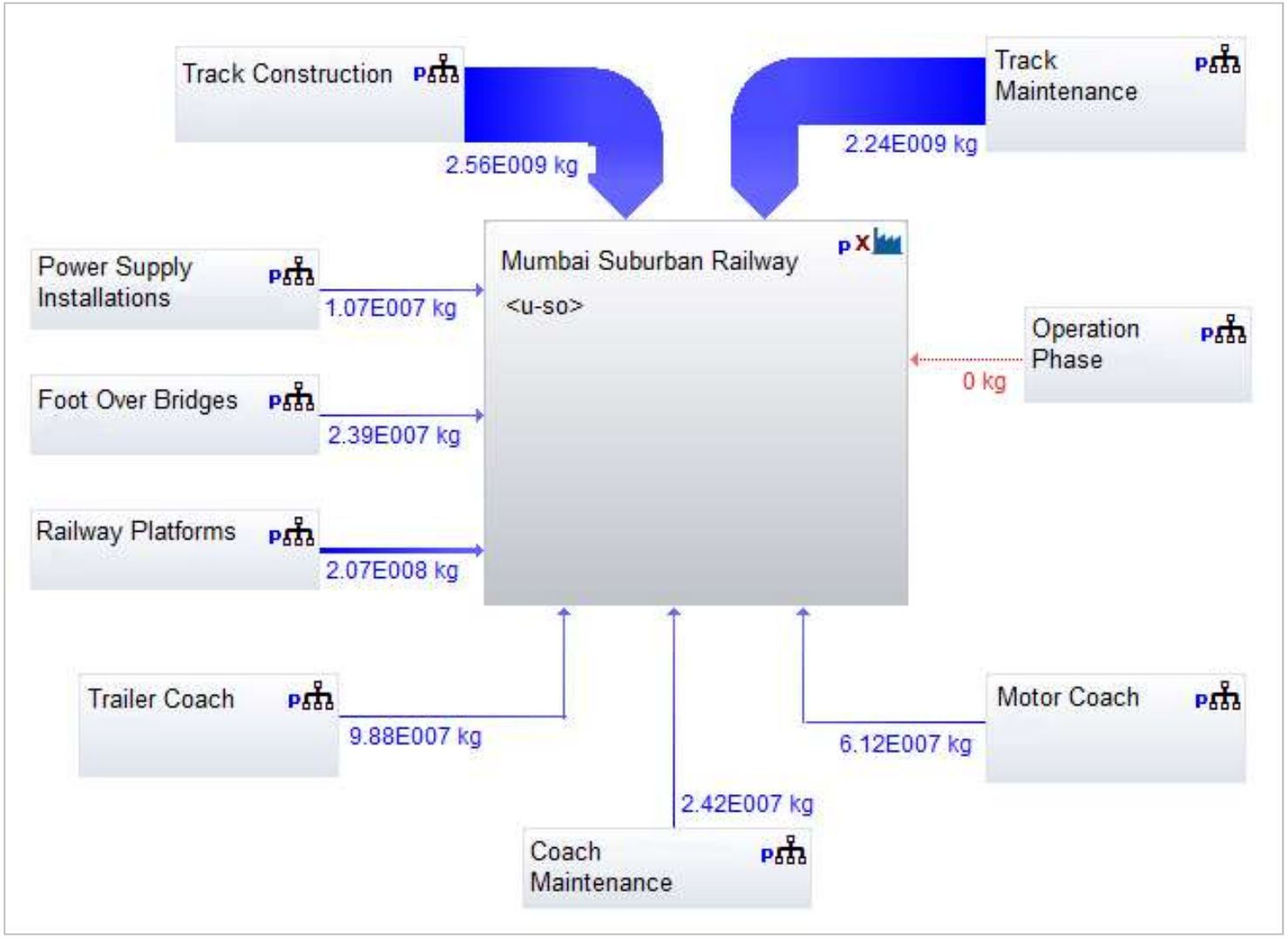
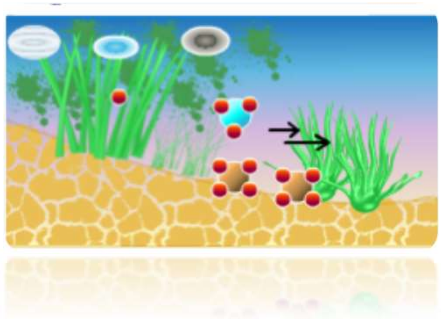


Figure: Top level plan for impact assessment of Mumbai Suburban Railway in GaBi

Assessing Life Cycle Impacts

CML 2001 method (University of Leiden 2001) impact assessment method

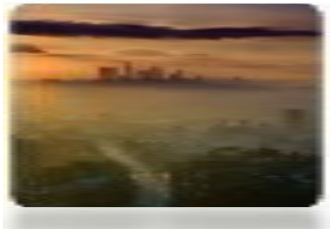
Global Warming Potential (CO_2-eq)



Eutrophication Potential (PO_4-eq)

Photochemical Ozone Creation Potential (C_2H_4-eq)

Acidification Potential (SO_2-eq)



Ozone Depletion Potential (R11-eq)

Abiotic Depletion Potential (kg Sb-eq)
Primary Energy Demand (J)

Functional unit: *per PKT* in the service lifetime of the vehicle
per VKT in the service lifetime of the vehicle

Life cycle per PKT impact of Mumbai Suburban Railway

Impact Category	Life Cycle Phases				Mumbai Suburban Railway
	Construction Phase	Coach manufacturing	Operation Phase	Maintenance Phase	
GWP (mg CO_2-eq/PKT)	218	147	5532	270	6168
AP (µg SO_2-eq/PKT)	573	838	47458	835	49704
EP (µg PO_4-eq/PKT)	54	50	3140	64	3308
POCP (µg C_2H_4-eq/PKT)	83	62	2418	116	2680
ODP (pg R11-eq/PKT)	852	992	155	714	2713
ADP (ng Sb-eq/PKT)	599	8072	2630	3758	15059
PED (KJ/PKT)	2.1	2	90	3.4	97.5

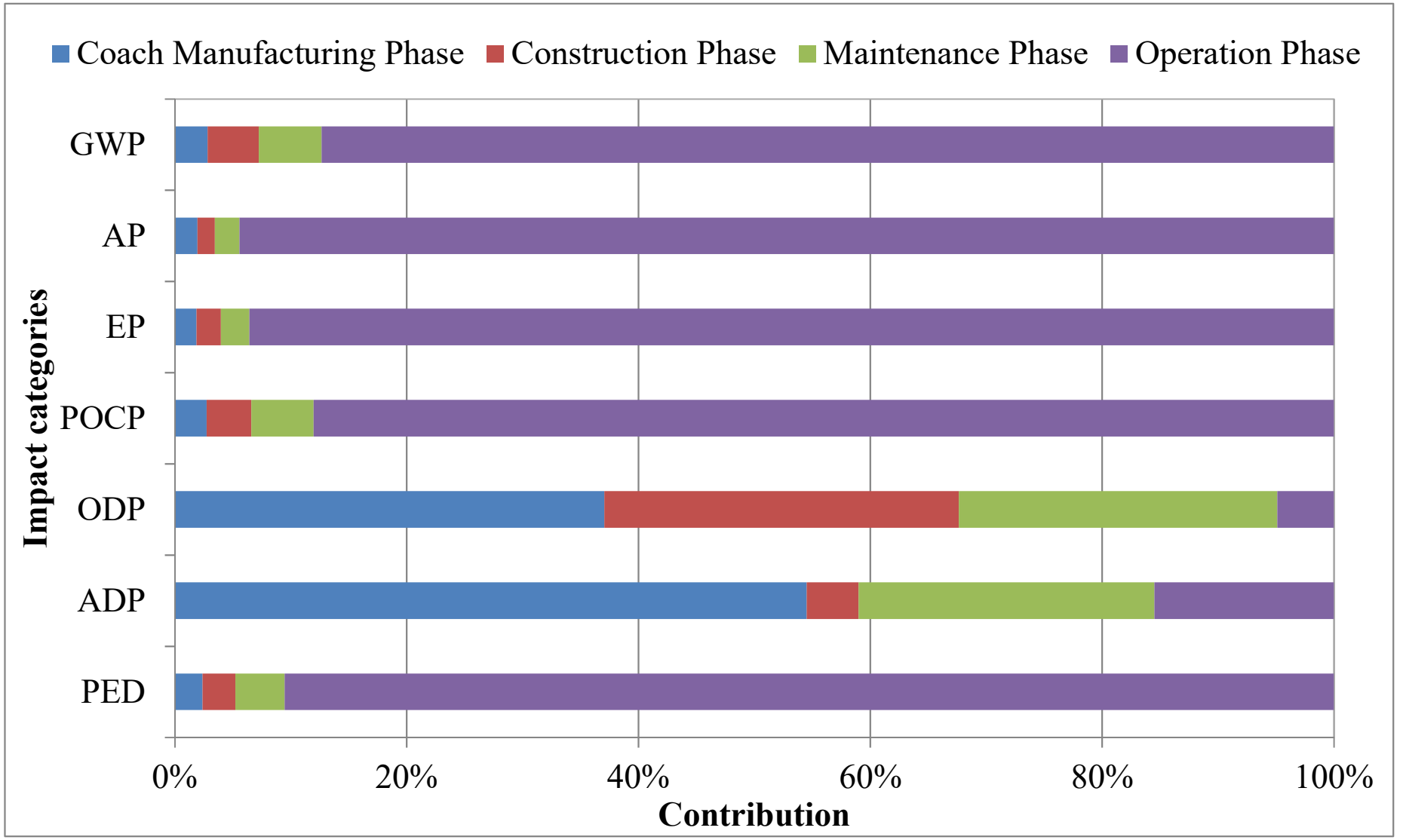


Figure: The relative contribution of each phase to environmental impacts of MSR

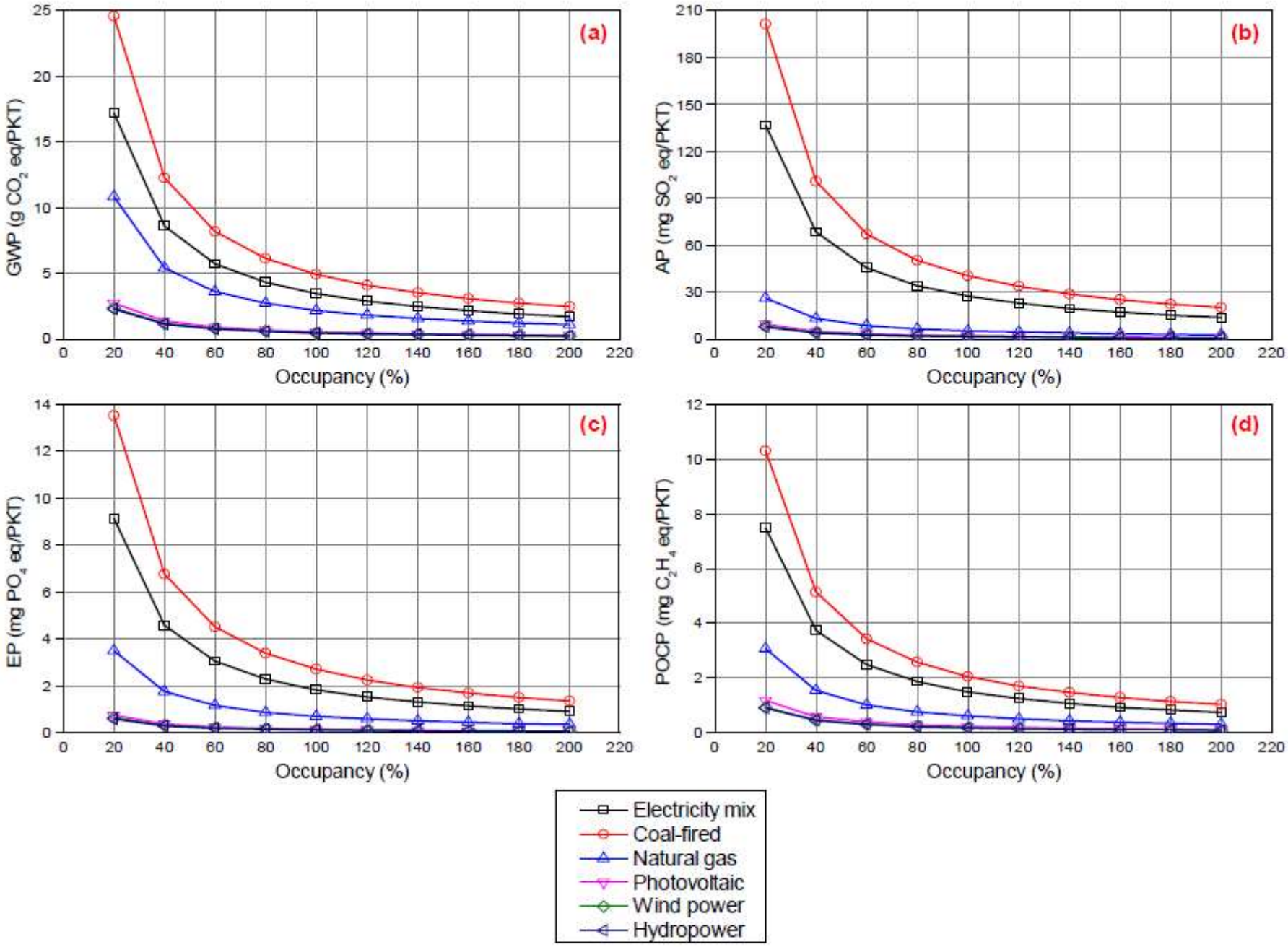


Figure: Influence of alternative electricity generations on life cycle impact of MSR

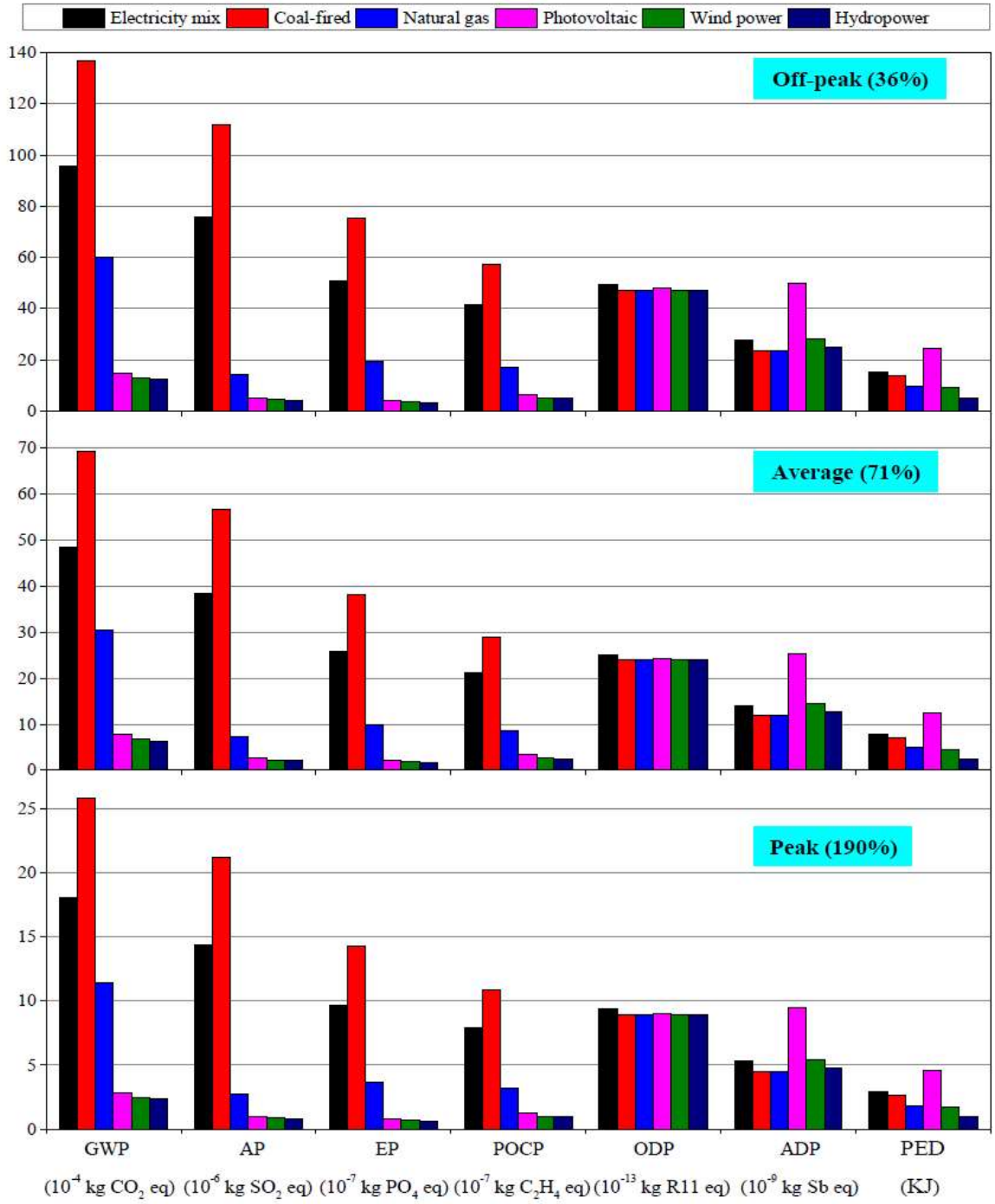


Figure: Life cycle impact of MSR with alternative electricity generations at off-peak (36%), average (71%) and peak (190%) hour occupancy of trains

LCA of Public Road Transport Modes in MMR (Shinde et al., 2019)

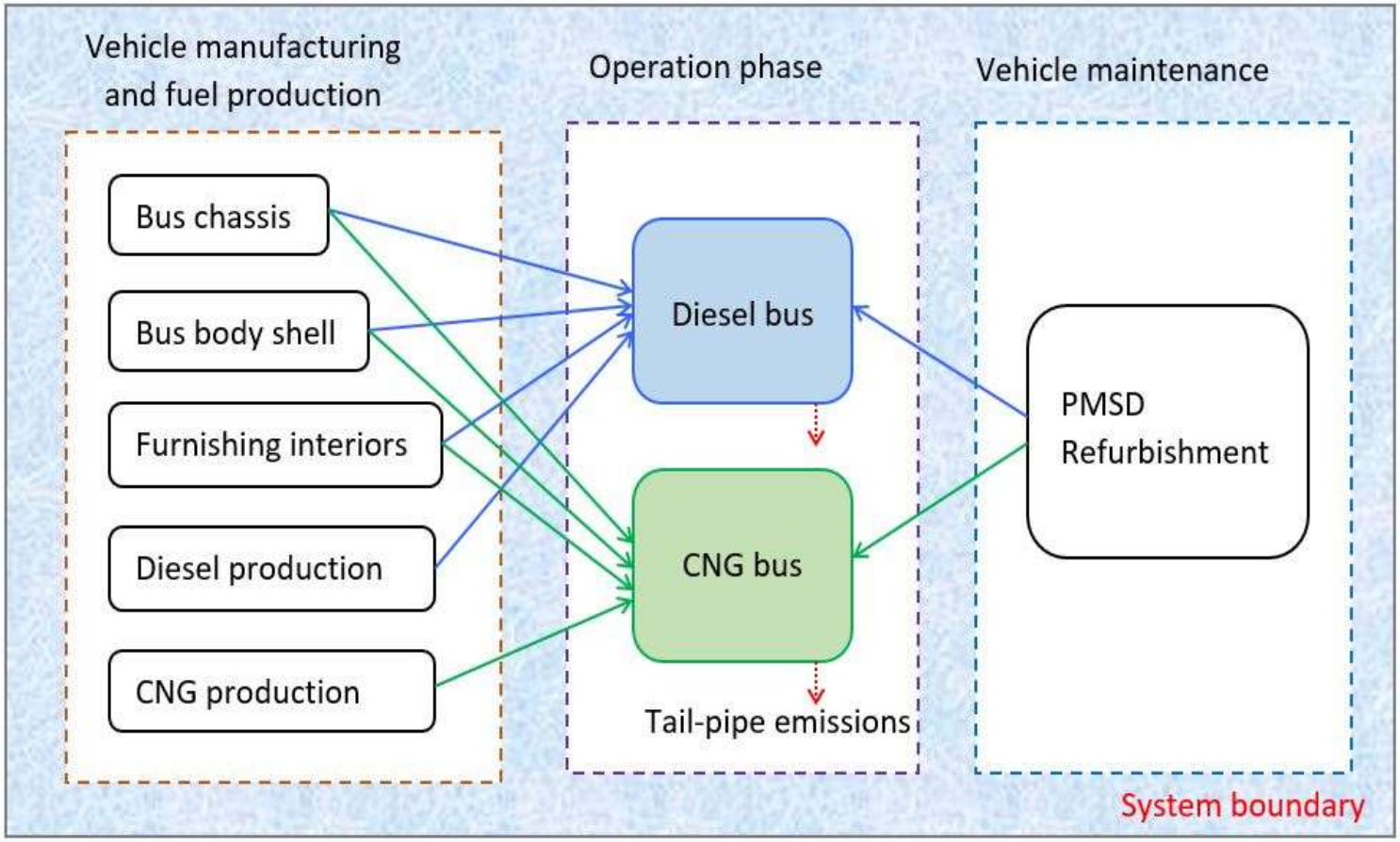


Figure: System boundary of public bus transport

Shinde A.M., Dikshit A.K. and Singh R.K. (2019). "Comparison of Life Cycle Environmental Performance of Public Road Transport Modes in Metropolitan Regions", *Clean Technologies and Environmental Policies*, 21(3), 605-624.

LCIA results for Public Bus Transport

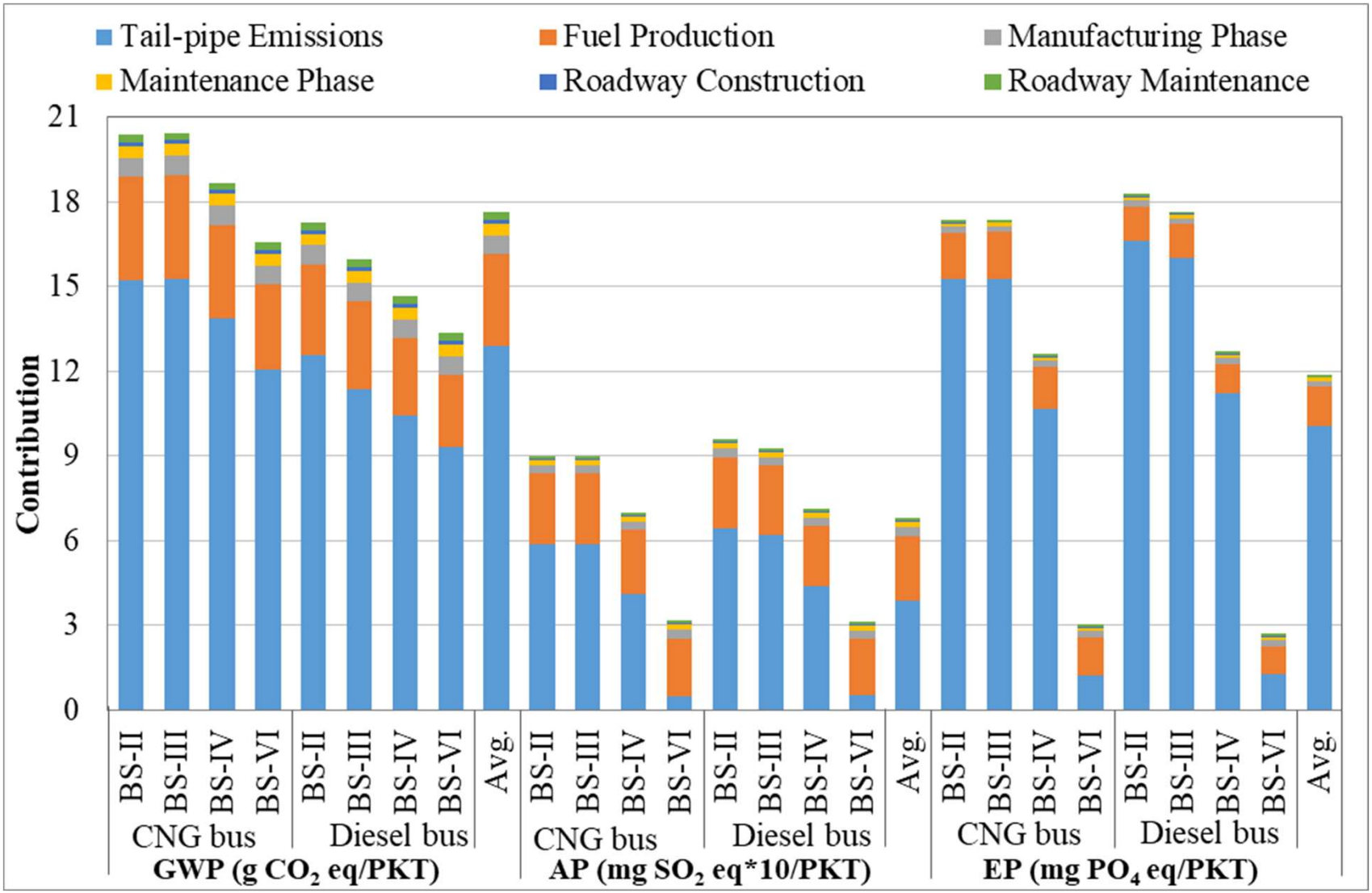
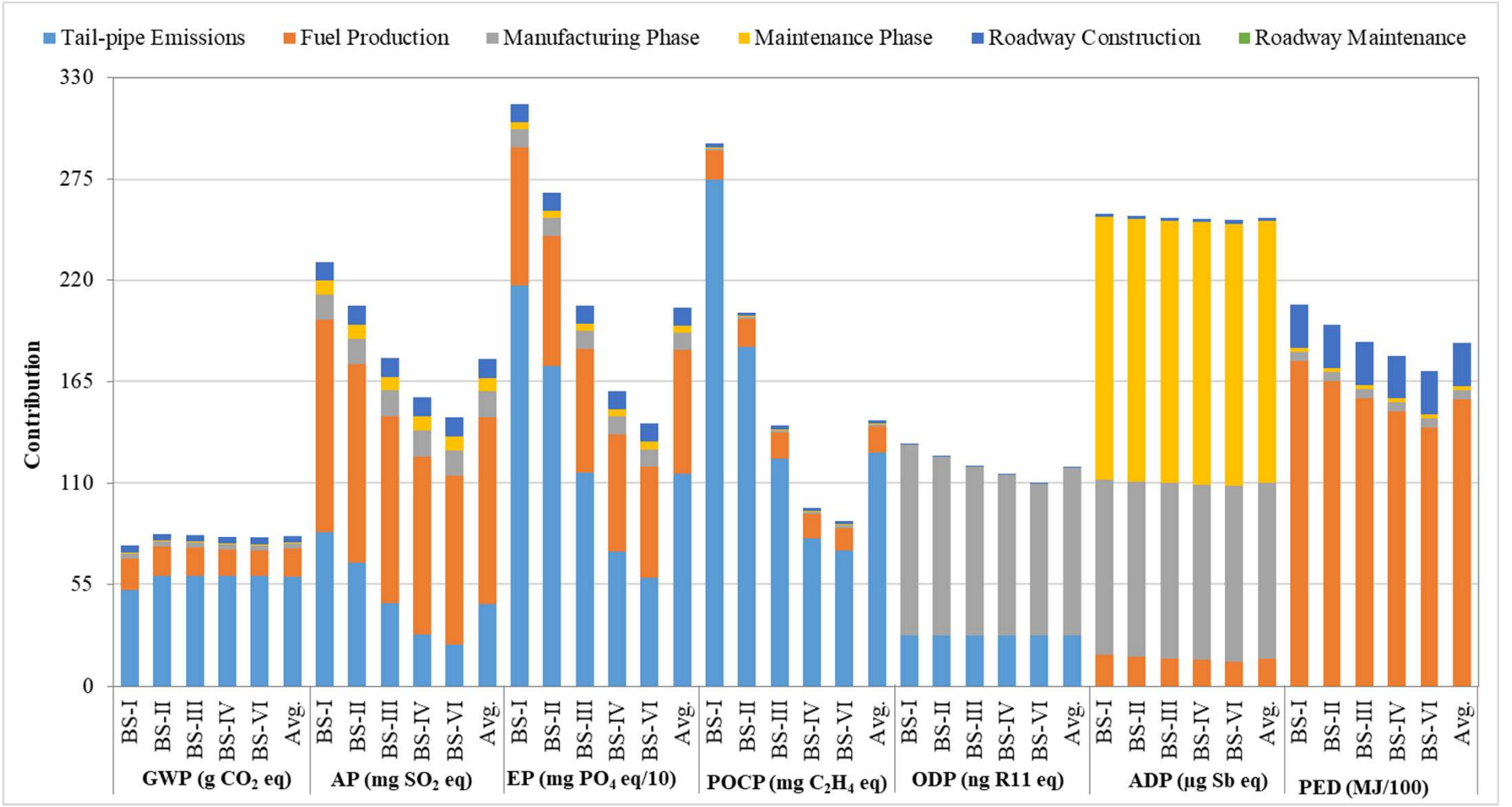


Figure: Comparison of per PKT environmental impact of CNG and diesel buses

LCIA results for Auto-rickshaws



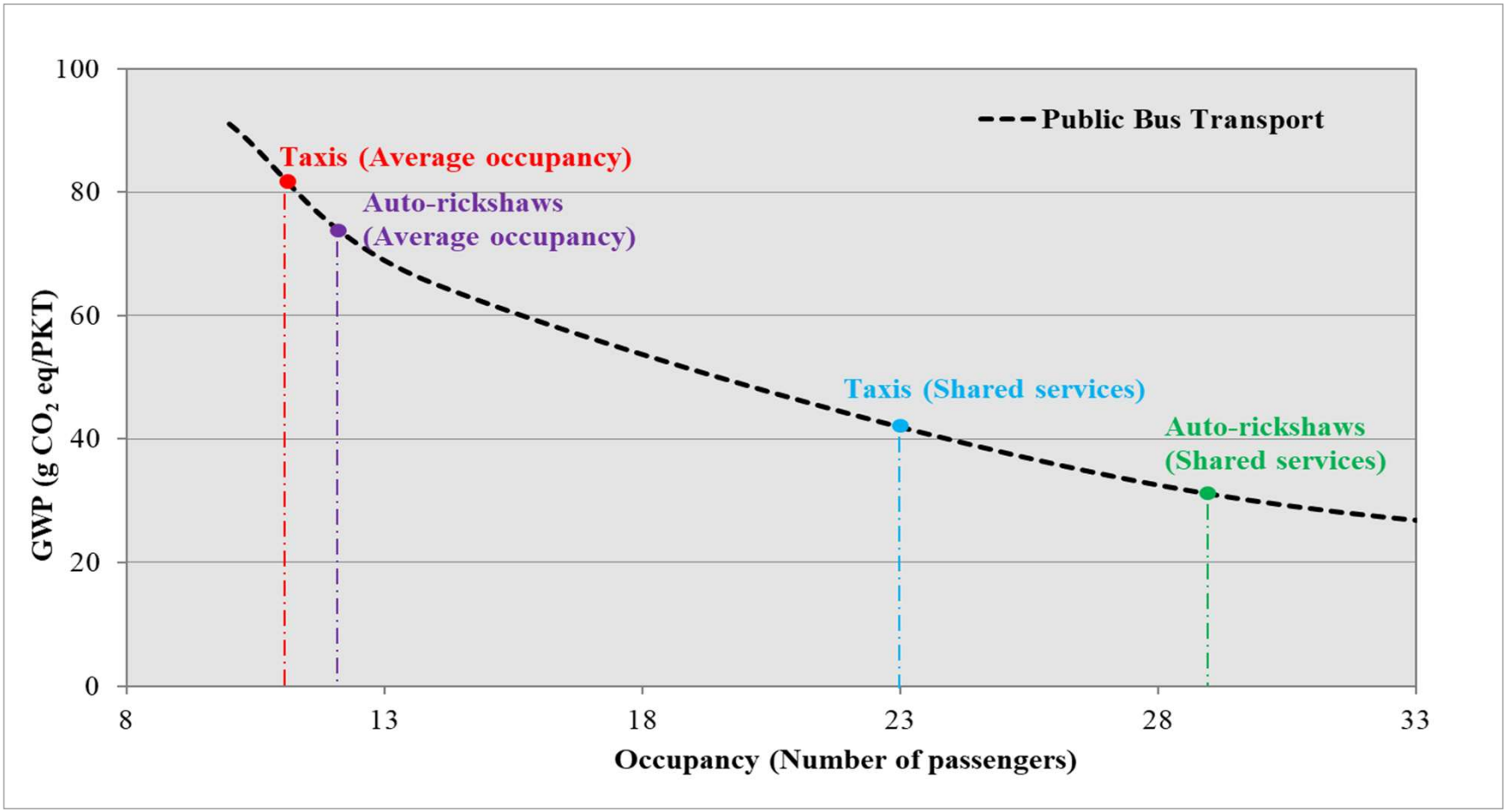


Figure: Occupancy equivalence (number of passengers) for GWP

Thank You

Acknowledgement:

- Prof. Anil K Dikshit, IIT Bombay
- Dr. Rajesh Kumar Singh, Sphera India
- Prof. Pietro Campana, Malardalen University, Sweden

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