Life cycle analysis of transport modes

Proposed study for the National Transport Development Policy Committee

by

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Rail Bhawan

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Structure of the presentation

Creating Innovative Solutions for a Sustainable Future

- Background
- Proposed study
- Expected outputs
- Duration and timeline
- TERI's experience
- Points for discussion

Background

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- In order to compare the life cycle impacts of select modes of transport (urban roads, BRT, MRT, National Highway and inter-city rail), NTDPC had asked TERI to develop a proposal to carry out a study on life cycle analysis (LCA) of identified modes of transport
- Aim- To make informed choices for environment-friendly modes for the country
- TERI has experience in carrying out LCA studies for road, energy, buildings and industrial sector
- TERI has developed the proposal in consultation with NTDPC

Objective of the study

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To conduct a life cycle analysis of different transport modes to estimate their impact on energy consumption and carbon emissions.

Scope of life cycle analysis

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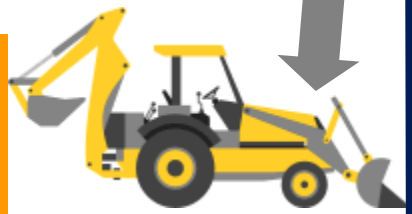
Direct energy and material consumption for construction, operation & maintenance

Production of construction materials

Transportation of construction materials



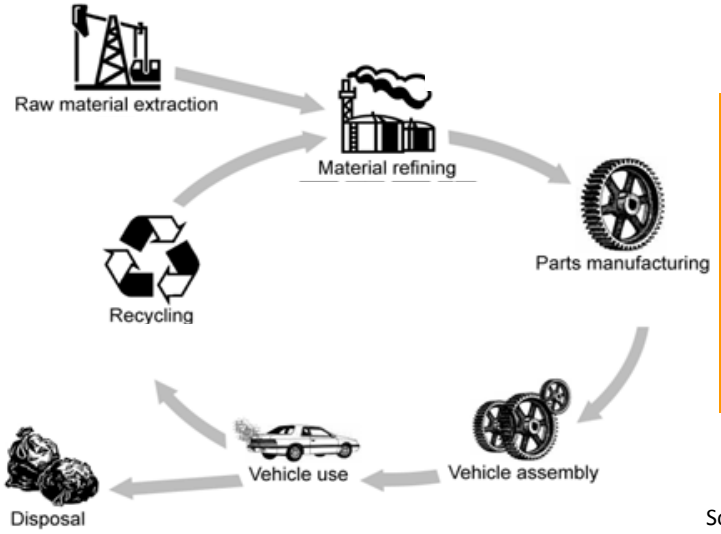
On-site Construction activity

Urban road
BRTS
MRTS
Inter-city road
Inter-city rail

Maintenance of the transport corridor

Operations on the transport corridor

Indirect energy and material consumption for manufacture of vehicles



Car
Bus
Truck
Rail coach (IR)
Rail coach (Metro)

Source- O'Brien et al (2001)

Indirect energy consumption for production of fuels like petrol and diesel

Petrol, Diesel, CNG, Electricity

Well to Pump

Source- Wang M et al (2007)

Tasks and methodology

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Production of construction materials | Transportation of construction materials | On-site Construction activity | Operations on the transport corridor | Maintenance of the transport corridor

Components of LCA	Included	Corresponding task	Methodology
Direct energy consumption - Embodied energy of construction materials	√	Derive the **per unit embodied energy/carbon values** for the main construction materials	Secondary literature review to derive India-specific embodied energy/ carbon values
Indirect energy consumption - Energy consumed for constructing infrastructure/buildings, manufacturing machinery, etc. used for production of construction materials)	X	*Rational for not including* • Common infrastructure for producing construction materials for several projects • Embodied energy cannot be included in one project • Should be attributed to all the projects • Value may be insignificant	

Tasks and methodology (contd.)

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Production of construction materials | **Transportation of construction materials** | On-site Construction activity | Operations on the transport corridor | Maintenance of the transport corridor

Components of LCA	Included	Corresponding task	Methodology
Direct energy consumption – Energy consumed by vehicles transporting construction materials	√	Derive the energy consumption/ **carbon emissions to transport one unit of the construction material**	Information to be collected from a fleet operator
Indirect energy consumption - Embodied energy of fuel used	√	Derive the India-specific **embodied energy values for transportation fuels**	Secondary literature review to derive India-specific embodied energy/ carbon values
Apportioning the embodied energy of vehicles to per unit TKM transported	√	Derive the factor to **apportion embodied energy** value of a vehicle transporting construction materials **to each TKM** carried by it throughout its life	Information to be collected from fleet operator and vehicle/auto-component manufacturers

Tasks and methodology (contd.)

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Production of construction materials | Transportation of construction materials | **On-site Construction activity** | Operations on the transport corridor | Maintenance of the transport corridor

Components of LCA	Included	Corresponding task	Methodology
On-site energy* consumption (direct energy consumption)	√	Derive the **energy and quantity of materials consumed** on-site to construct **one unit of the corridor**	Collect primary information from project contractors **OR** Collect information from agencies like NHAI, MoR, DMRC
On-site material consumption and vegetation removal	√		
Indirect energy consumption (energy consumed for manufacturing construction equipments used on site)	X	*Rational for not including* • Lack of information • Number of equipments used • Common to several projects – need to proportionately distribute embodied energy – may not be significant per project	
Removal of vegetation	√	Derive the **carbon sequestration potential lost** due to removal of vegetation	Secondary literature review to derive the carbon sequestration potential lost

***Embodied energy of fuel used will be included**

Type of information required-

Data on construction activity of sample projects (Highway, Rail, Metro rail, BRT and Urban road):

-Quantity of materials and energy used on-site

-Source of materials/energy, mode of transportation to site, average leads, quantity transported

-Construction duration and length of corridor

-Removal of vegetation

Approach	
Collecting information from contractor	**Collecting information from government agencies**
Advantages • Collection of all required data possible (our prior experience substantiates this) • Reliability of data (data will reflect actual consumption)	**Advantages** • Comparatively less time • Single agency contact
Disadvantages • More time • Multiple agencies would have to be contacted *Support of project contractors critical*	**Disadvantages** • May not get all the required information (on-site energy consumption, leads for materials, etc.) •Estimates available with the agencies may not indicate the actual consumption •Availability of data will have to be established before deciding the approach *Support of government agencies critical*

Examples of some key construction equipments

Fixed machinery	Crushers
	Batch type Hot mix Plant
	Drum type Hot mix Plant
	WMM Plant
	Concrete batching plants
Movable machinery	Paver
	Soil Compacters (Rollers)
	Motor grader
	Excavator
	Transit Mixer/CC Mixer
	Tandem Roller
	Pneumatic Tier Roller
	Dumpers
	Front end loaders
	Wheel loader
	Crane
	Water tanker
	Bitumen sprayer
	Broomer
	Tippers
	Vibrator
	Tractor trolley
	Tractor Compressor
	Tar Boiler

Tasks and methodology (contd.)

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Production of construction materials | Transportation of construction materials | On-site Construction activity | **Operations on the transport corridor** | Maintenance of the transport corridor

Components of LCA	Included	Corresponding task	Methodology
Direct energy consumption by vehicles moving on the transport corridor	√	Derive **energy consumed to move one passenger km/ freight km** by a specific mode on the transport corridor	Secondary literature review to derive India-specific conversion factors to estimate energy consumed to move one passenger km/ freight km by a specific mode on the transport corridor Traffic data for sample corridors
Indirect energy consumption – Embodied energy of vehicles	√ (assuming that the vehicle is used only on the transport corridor for its total life)	Derive the **embodied energy of vehicles**	Carry out primary surveys and collect data from the selected vehicle/auto-component manufacturers to derive embodied energy values for the selected modes (including the maintenance activities)

Tasks and methodology (contd.)

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Production of construction materials | Transportation of construction materials | On-site Construction activity | Operations on the transport corridor | **Maintenance of the transport corridor**

Components of LCA	Included	Corresponding task	Methodology
Maintenance activity -Material transportation (direct impact and embodied energy) -Material use (embodied energy) -Energy use (direct impact and embodied energy)	√	-Derive the energy consumption/ carbon emissions to transport one unit of the construction material -Derive the energy and quantity of materials consumed for maintenance activities	Collect information on- -Quantity of materials transported along with modes and leads information -Quantity of materials and energy used Collect primary information from project contractors **OR** Collect information from agencies like NHAI, MoR, DMRC

Life Cycle Impact

Expected outputs

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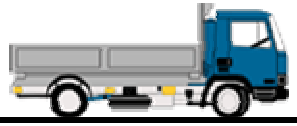
Impact of Construction phase	Embodied energy of construction materials Embodied energy to transport construction material (Direct energy + Embodied energy - vehicle + Embodied energy of fuel) Energy consumed on-site (Direct energy + Embodied energy of fuel) Carbon sequestration potential lost due to removal of vegetation	CO_2e per km
+		
Impact of Operation phase	Direct energy consumption by vehicles Embodied energy of vehicles	CO_2e per PKM/TKM
+		
Impact of Maintenance phase	Embodied energy of construction materials Embodied energy to transport construction material (Direct energy + Embodied energy - vehicle + Embodied energy of fuel) Energy consumed on-site (Direct energy + Embodied energy of fuel)	CO_2e per km

Comparison between modes – based on life cycle impacts

Highway	Intercity rail	Metro rail	BRT	Urban road
				

Expected outputs (contd.)

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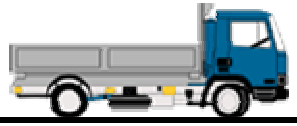
Support in decision-making

- Inputs for long-term vision for transport, 12th FYP – Promoting low-carbon growth
  - Which modes to promote?
  - Where to invest?
  - How to reduce negative energy/environment impacts?
    - Vehicle technology
    - Construction technology
    - Maintenance technology
- This type of informed approach towards long term policy making – **Can form the basis for developing city-level/state-level transport NAMAs…**

Highway	Intercity rail	Metro rail	BRT	Urban road
				

Duration and timelines

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Duration of the proposed study – 7 months

Impact of Construction phase	→	By August end
Impact of Operation phase	→	By November end
Impact of Maintenance phase	→	
Final report	→	By December end

Relevant strengths of TERI

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- Centre for transport research
- Life cycle approach adopted for research in various sectors:

Key projects	Key clients
•Carbon footprint of road sector •Carbon footprint of household energy use •Carbon footprint of IT industries •Comparison of cement concrete and bitumen roads •Life cycle cost of green buildings •Resource efficient construction materials	•Asian Development Bank •Veolia Environment Institute •HCL •Cement Manufacturers Association •HSBC, MNRE, KFW, NHB •UNDP/GEF

- Energy, Environment and Economic modeling expertise
- Industrial energy efficiency group

TERI Study…

Carbon footprint of road sector in India

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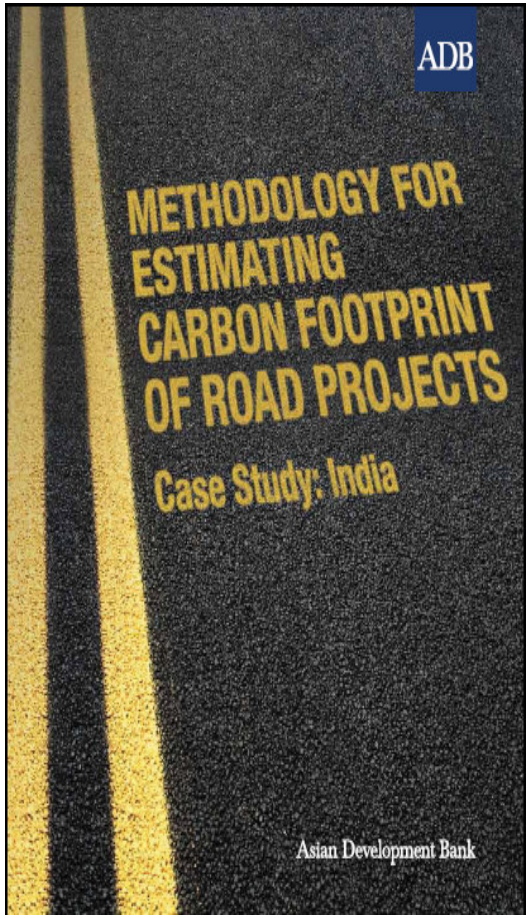
- Study carried out for ADB
- Status - completed and published
- Objective
  - Develop a comprehensive approach to calculate the carbon footprint of road projects
  - Calculate the change in GHG emissions from improved road operations
  - Examine options for mitigating any increase in GHG emissions



TERI Study…

Carbon footprint of road sector in India (contd.)

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Scope of Carbon Footprint Analysis

Sources of CO_2 / Road life cycle stages	Construction materials	Fossil fuels		Removal of vegetation		Machinery/ Vehicles
	Embodied carbon	Embodied carbon	Direct CO_2 emission	Carbon sequestration potential lost	Direct CO_2 emission	Embodied carbon
Road construction	√	√	√	X	√	X
Road operation	X	√	√	X	X	X
Road maintenance	√	√	√	X	X	X

TERI Study…

Estimating Carbon Footprint of urban household energy use

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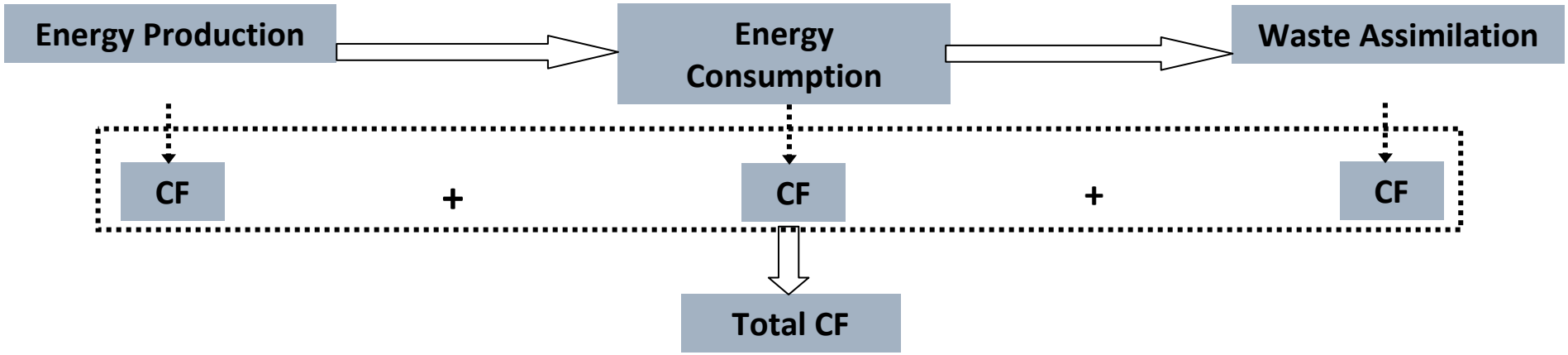
- Study carried out for Veolia Institute of Environment, France
- Status - completed
- Aim
  - **To develop a methodological framework for estimating the household energy footprint**
  - **To the framework in two cities (in India and China)**
- Carbon Footprint (CF)– life cycle approach



TERI Study…

Fuel Saving on Cement Concrete Roads

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- Study conducted for Cement Manufacturers Association
- Status- completed
- Aim
  - **To compare the characteristics of bitumen and cement concrete roads over physical, economic, and energy-environment parameters**
- Life cycle approach
  - **Energy consumed in the construction of pavements**
  - **Energy consumed by vehicles (field experiments)**
  - **Physical properties of pavements**
  - **Cost of construction and maintenance of pavements**

Points for discussion

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- Approach for data collection for construction and maintenance activity
- Scope of life cycle analysis
- Phasing the study

Thank you