An aerial night photograph of a city, likely Berkeley, California, showing a large stadium with a domed roof in the foreground and a cityscape with lights extending to the water in the background. The sky is a gradient of blue and yellow.

What do India's transport energy data tell us?

**A Bottom-up Assessment of Energy Demand in India
Transportation Sector**

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Mission



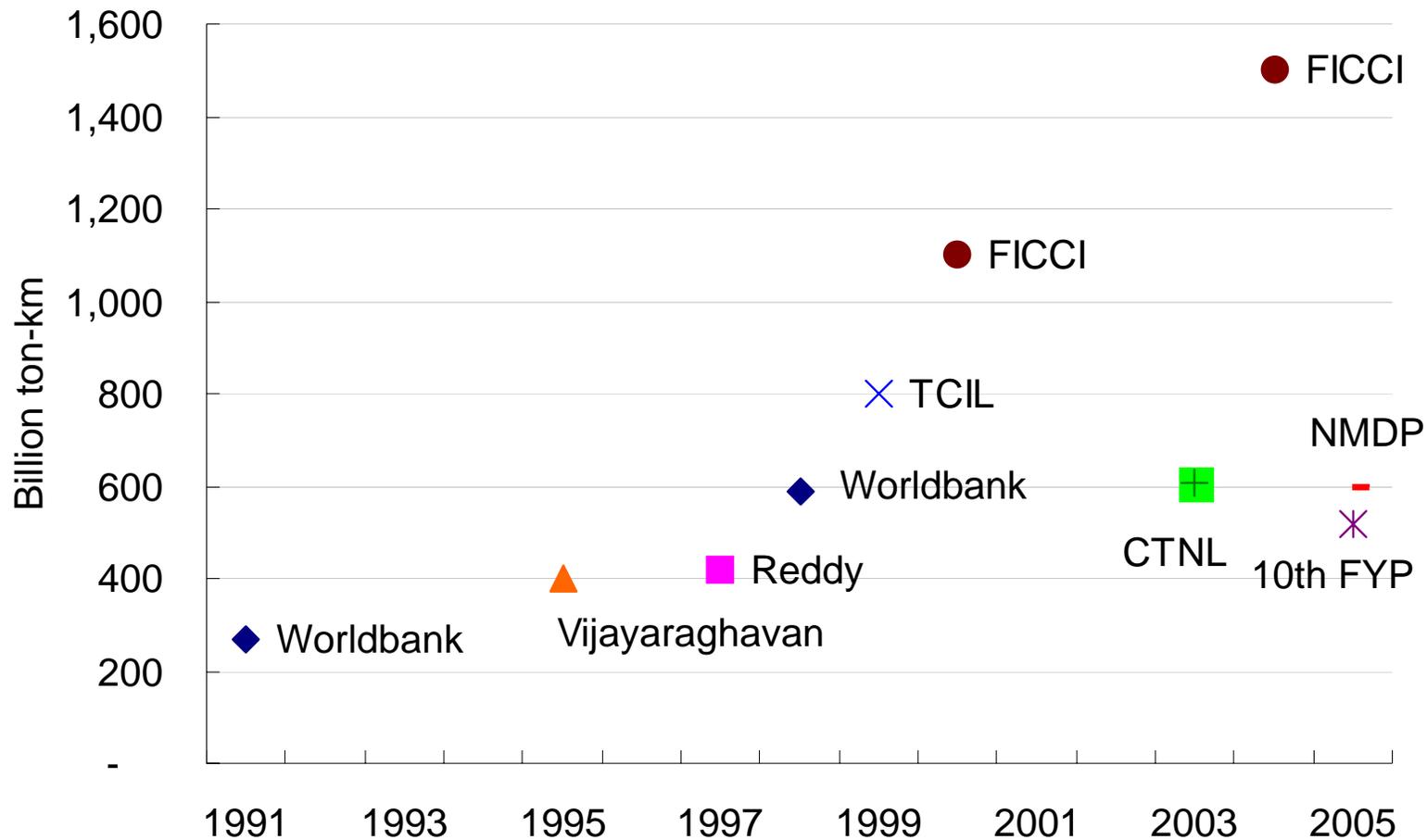
- **A part of a larger effort at LBNL (Global Energy Demand Collaborative Project) to provide sector, country and ultimately global analysis of energy use patterns at the level of sub-sectors and end uses**
- **The need to evaluate current and future sources of energy-related effects at a greater level of accuracy and detail**
- **Disaggregated analysis is highly desirable in order to guide mitigation efforts, including policies towards increased efficiency**
- **Variety of studies covering various sub-sectors and use patterns, but none which attempts to integrate all available data into a comprehensive picture of the sector**

Background and purpose of this research



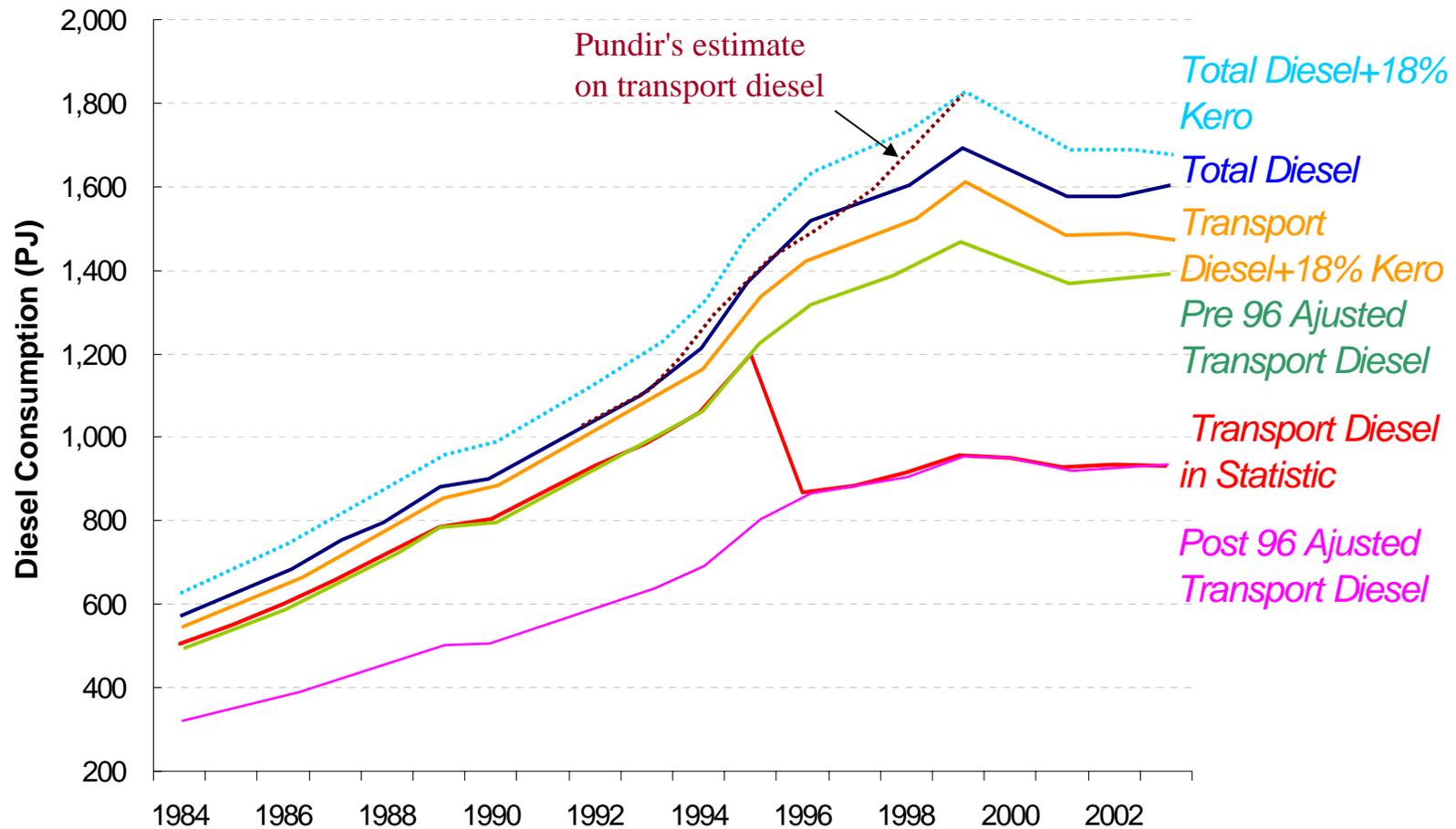
- Existing energy data do not provide information on driving forces behind energy use and sometime show large inconsistencies.
- Many previous studies address only a single transportation mode such as passenger road travel; did not include comprehensive data collection or analysis has yet been done, or lack detail on energy demand by each mode and fuel mix.
- We intent to develop a data base on all transport modes including passenger air and water, and freight in order to facilitate the development of energy scenarios and assess significance of technology potential in a global climate change model.

Mystery 1: Freight Ton-km



Note: FICCI (Federation of Indian Chambers of Commerce and Industry), TCIL (Telecommunications Consultants India Ltd)
CTNL (Consolidated Toll Network Ltd), NMDP (National maritime Development Programme)

Mystery 2: Diesel Consumption



Bottom-up methodology



$$E = \sum_k \sum_t \sum_r V_{t,r} \times Km_{t,r} \times LF_{t,r} \times EI_{k,t,r}$$

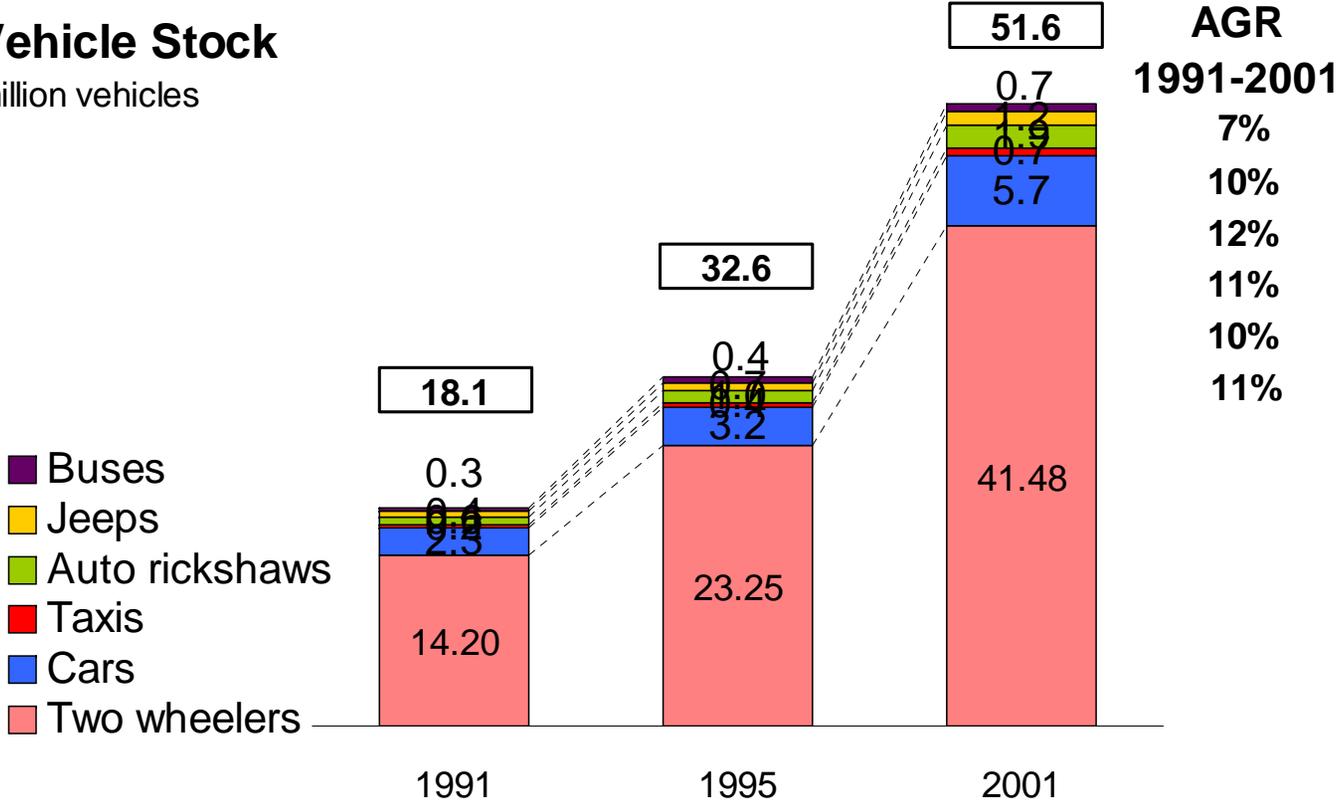
where:

E	=	final energy demand in the transport sector,
k	=	fuel type
t	=	transport type (passenger, freight)
r	=	mode type (road, rail, water, air, pipeline)
$V_{t,r}$	=	number of vehicles of transport service of type t in mode r
$Km_{t,r}$	=	distance traveled of transport service of type t in mode r
$LF_{t,r}$	=	load factor of vehicles of transport service of type t in mode r
$EI_{k,t,r}$	=	average energy intensity of energy type k for transport service of type t in mode r in MJ/(passenger-km-year) and MJ/(tonne-km-year).

Passenger Vehicle Stocks



Vehicle Stock
million vehicles



source: Statistical Abstract, India, 2003

Car ownership (cars and jeeps) increased from 0.33% to 0.67% cars per capita in 1991-2001

Vehicle Utilization in Road Passenger



	Travel distance (km)	Occupancy (person)
Car, Taxi and Jeep	12,600.6, 9919 for car, 35,000 for taxi	3.18, 2.5 according to Bose (1998)
Bus	88,342	41.6
Auto rickshaw	33,500	1.76
Two-wheeler	6,300	1.5

Source: Singh, 2006. Bose, 1998

Derived Energy Intensities in Passenger Transport (MJ/Passenger-km)



Road		Rail		Water		Air	
Car, Taxi and Jeep	0.94	Steam	1.28 in 1996, 11.34 in 2000	Inland	0.4	Jet Kerosene	2.5
Bus	0.19	Diesel	0.24	Coastal	0.49	Aviation gasoline	1.5
Auto rickshaw	0.58	Electricity	0.12				
Two-wheeler	0.53						
<i>Source</i>	<i>Singh,2006</i>	<i>Ministry of Railways</i>		<i>LBNL China Energy Demand Model</i>			

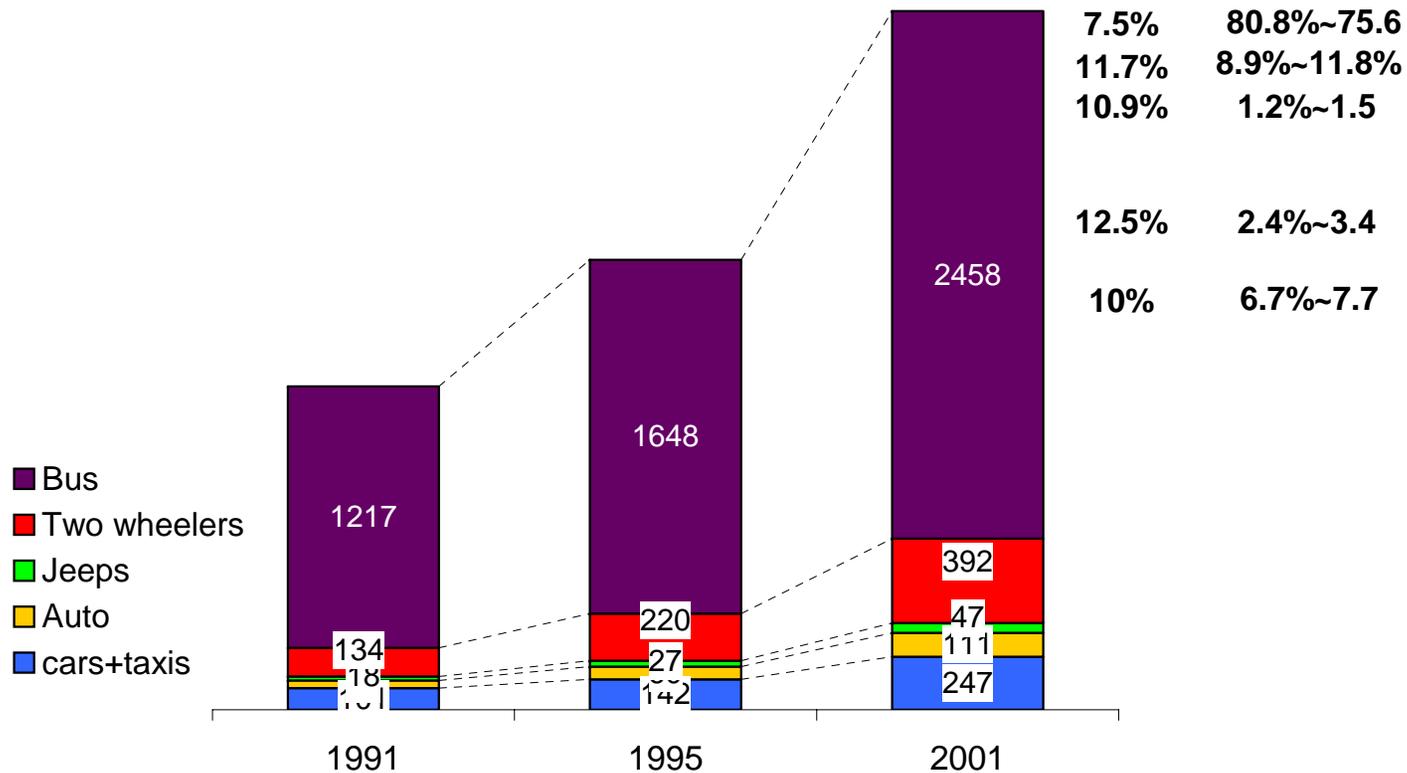
Source: Singh,2006; Ministry of Railways ;LBNL China Energy Demand Model

Road Passenger Transportation Mobility Vehicle Type



Passenger Road Travel billion pass-km

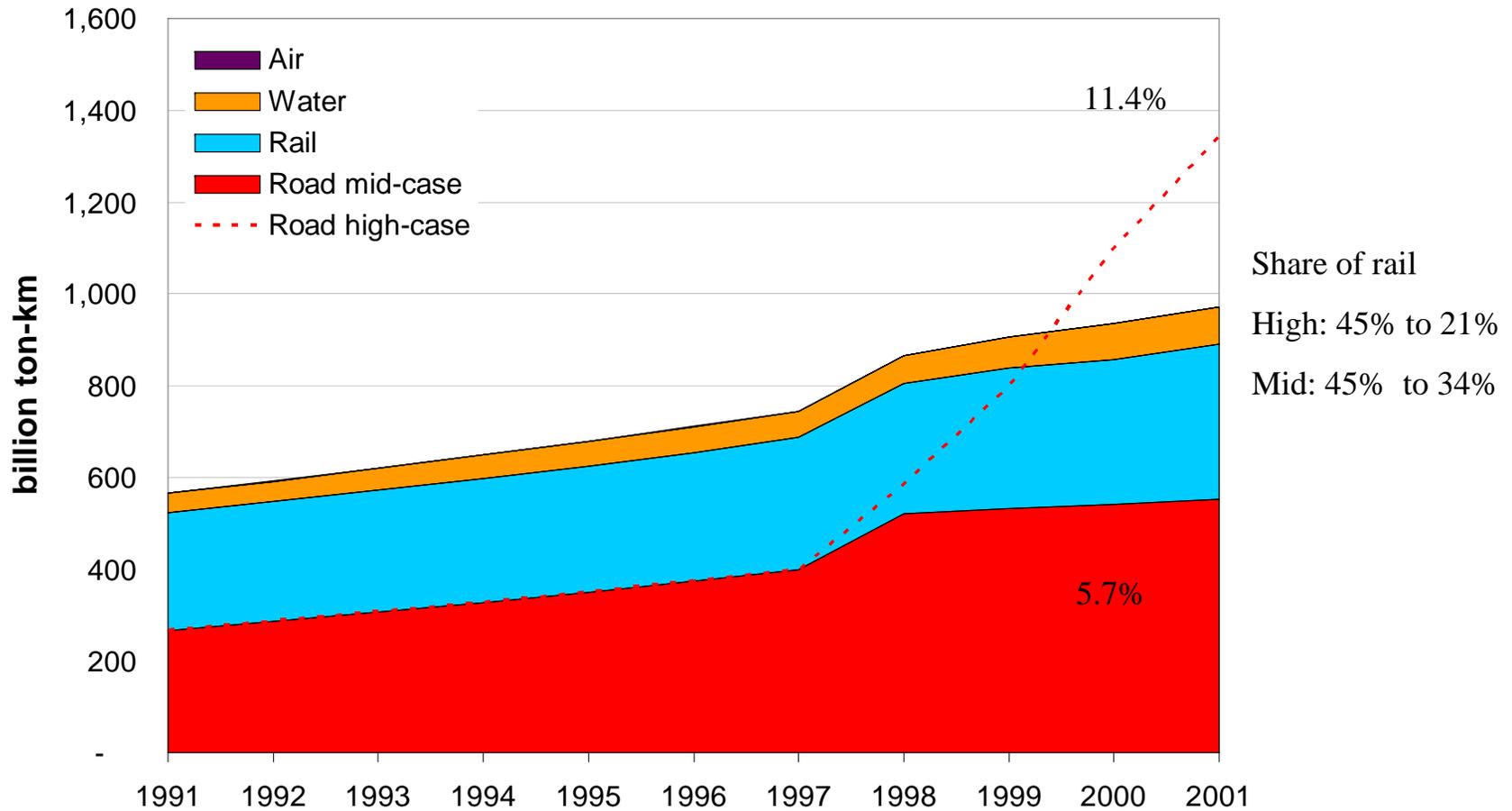
AGR 1991-2001 Share 1991-2001



Freight Transportation Mobility by Mode



Freight



Energy Intensities in Freight Transport (MJ/ton-km)

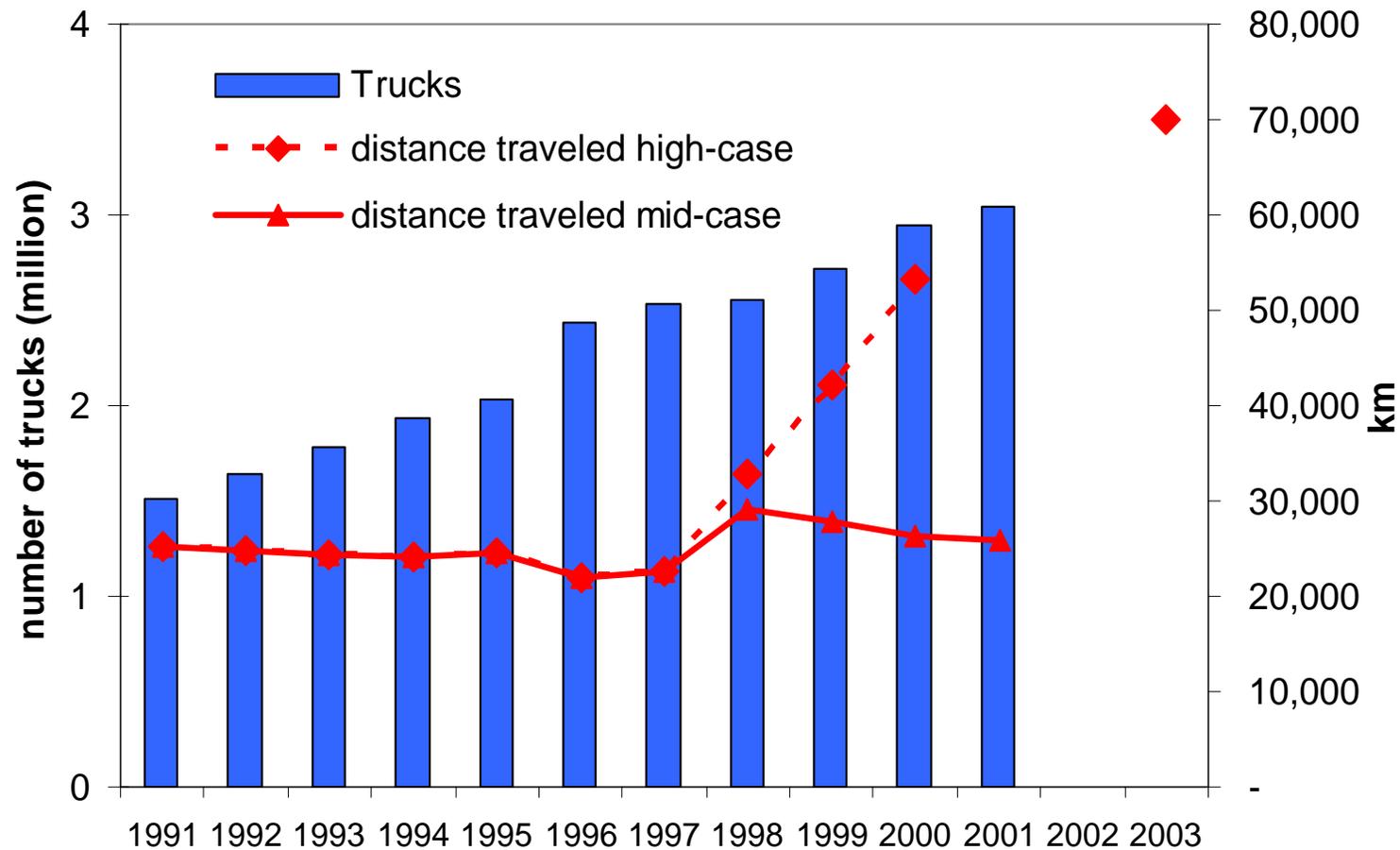


Road		Rail		Air		Water
Truck	1.85	Steam	3.3 in 1991, 15.88 in 2000	Jet Kerosene	17.3	0.3 in 1991 0.28 in 2000
Tractor	2.64	Diesel	0.117	Aviation gasoline	16.6	
		Electricity	0.064			
<i>Source</i>	<i>Singh,20 06</i>	<i>Ministry of Railways</i>		<i>LBNL China Energy Demand Model</i>		

Source: Singh,2006; Ministry of Railways ;LBNL China Energy Demand Model

Note: calibrated based on fuel consumption reported in TERI,2001 and IEA,2004

Change in Truck Stock and Utilization



World bank report: 60,000 to 100,000 km

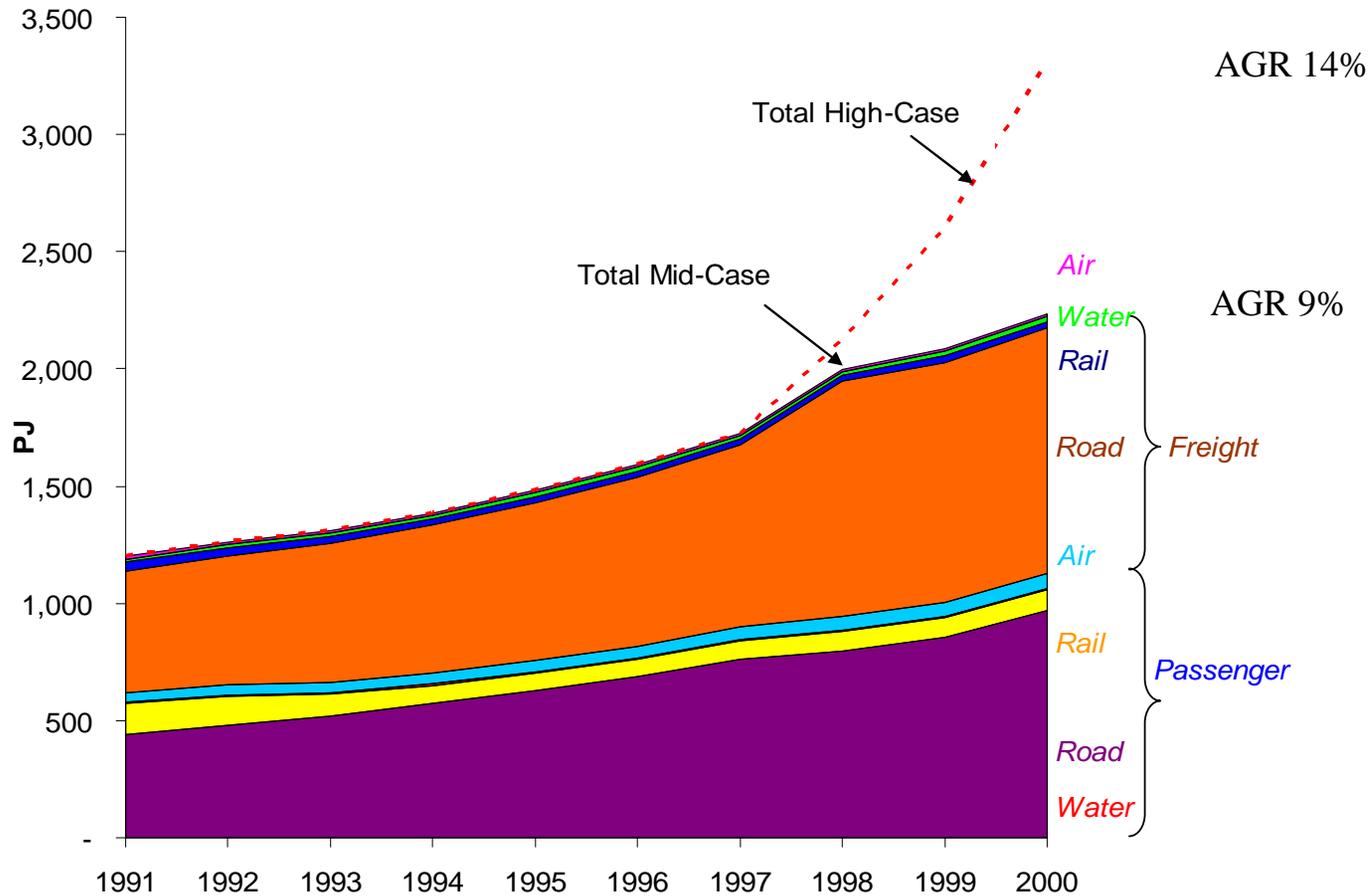
Overloading report: 250 days and 280km per day, indicates 70,000 km

source: Statistical Abstract, India, 2003; LBNL estimate

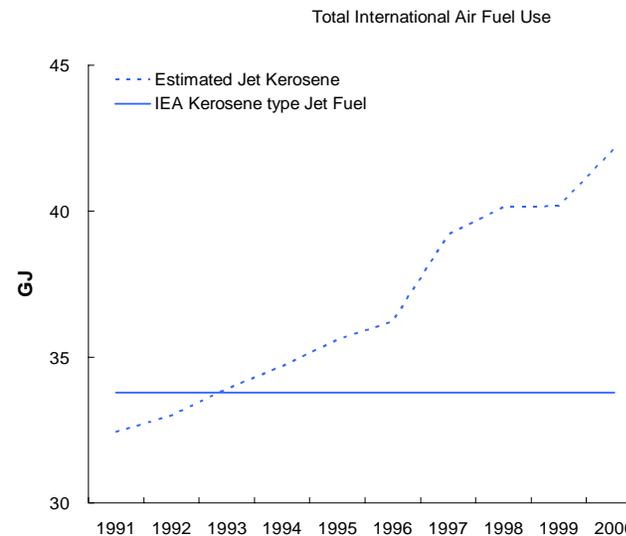
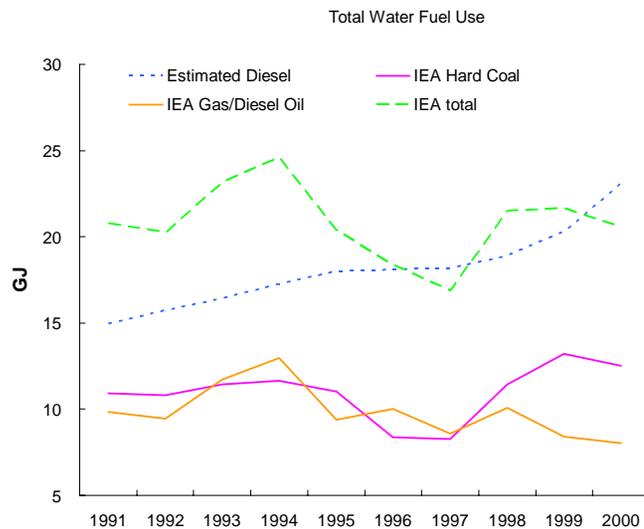
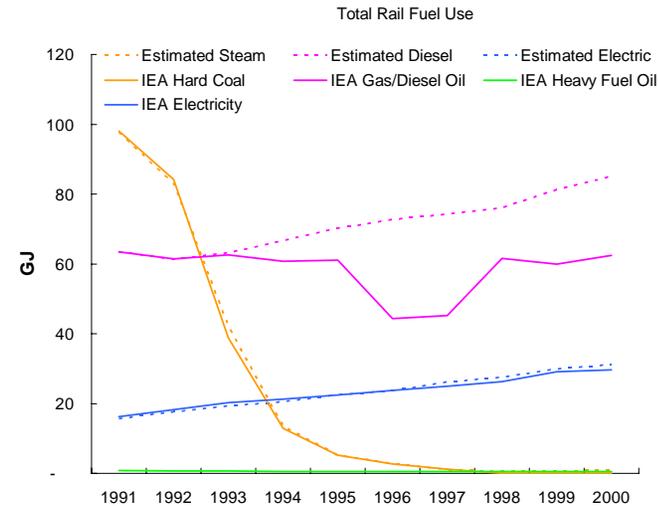
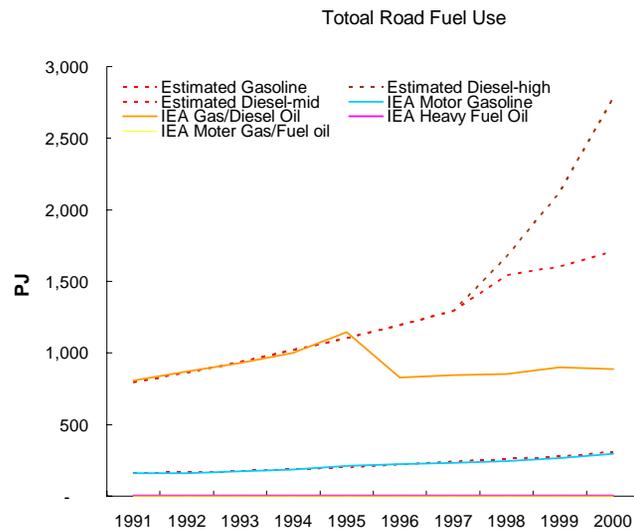
India Transportation Energy Consumption by Fuel in 1991-2000

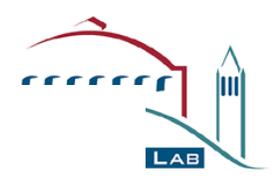


IndiaTransport Energy Consumption by Mode

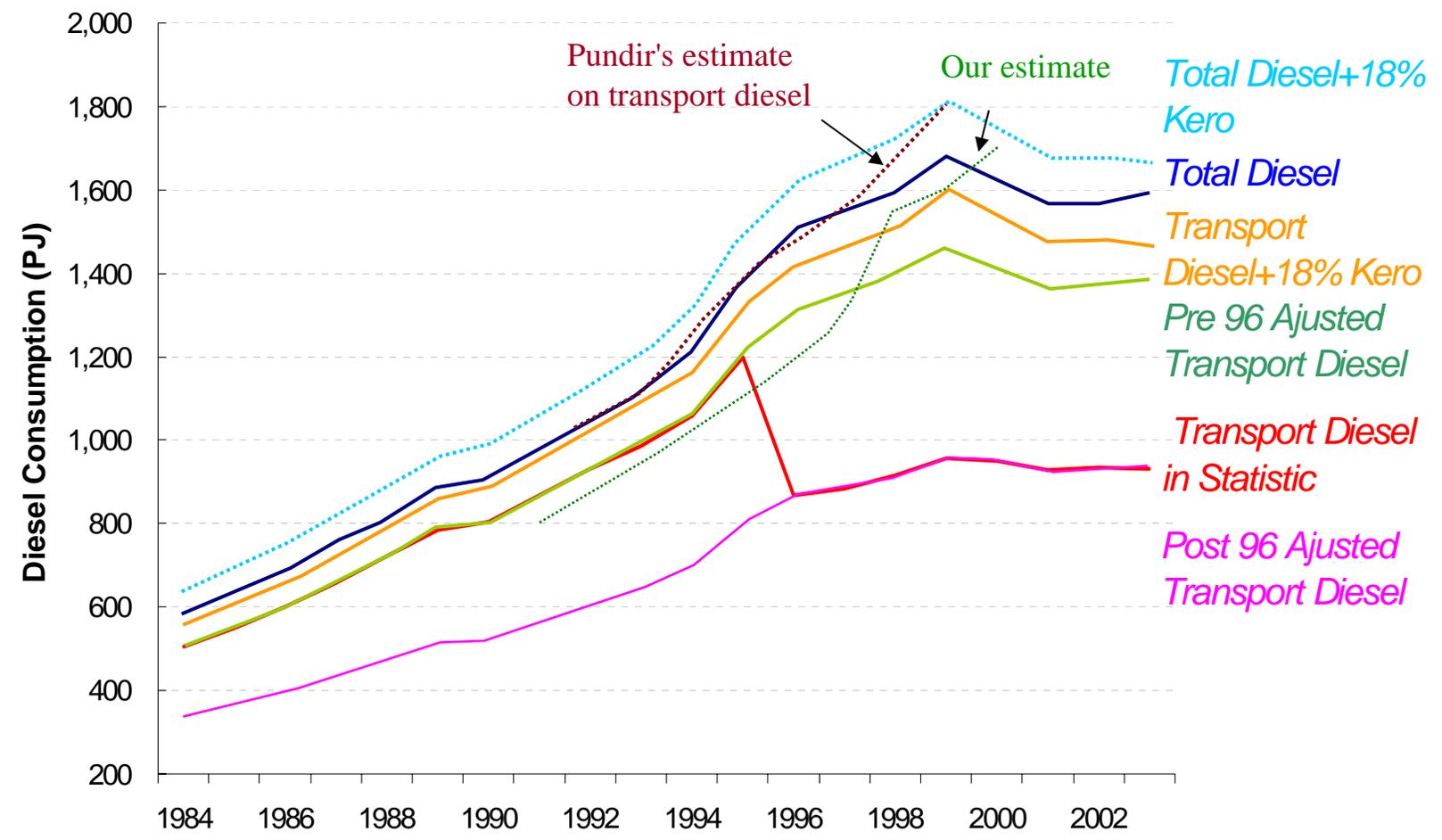


Comparison of the Estimated and IEA Transport Energy Use in India





transport diesel



Future work



- **the bottom-up approach points to possible inaccuracies in the top-down data, particularly in terms of diesel fuel consumption.**
- **further research is required to determine if there are not also errors in our assumptions, but the decrease and flattening of diesel fuel consumption on roads— by far the largest component of the sector – seems difficult to explain with reasonable assumptions of driver behavior.**
- **In presenting this analysis, we hope not only to say something about a particular sector in India, but to demonstrate an approach that we hope will provide insights into other sectors and countries as well.**
- **In terms of India, we hope to continue this effort towards building a more complete and detailed database which will be useful to policymakers there, as well as to the international community of researchers, for whom India is likely to continue to gain attention**

THE END

