Blueprint

Railway NAMA

MRV Blueprint based on India Railways NAMA

DRAFT

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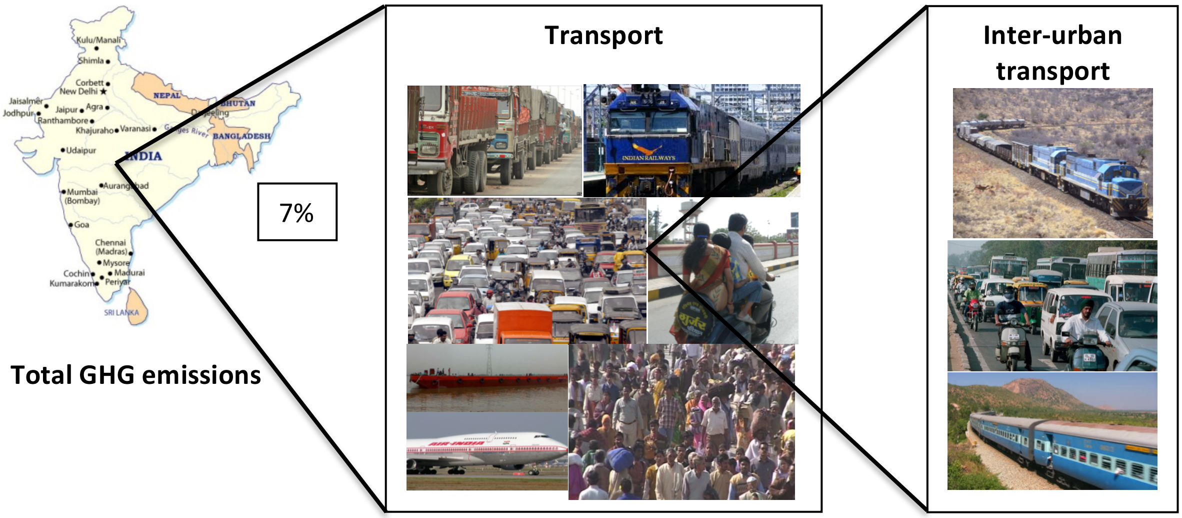
1. Nama Background

1.1. NAMA Scope

The scope of the NAMA is inter-urban rail transport in India. It includes the GHG reductions achieved by moving passenger and freight from modes such as road or plane towards rail. Within the framework of avoid, shift and improve the NAMA is basically a shift project (road and air to rail) with improvement components (rail efficiency). Traffic avoidance is not targeted. The NAMA includes as GHG gases CO_2 and CH_4 due to the nature of transport emissions. The starting date of the NAMA is January 2012 in line with the XII 5-year plan of the Government of India (GOI) which includes a shift towards green growth and emphasizes rail investment as a means to reduce the carbon footprint of transport.

Figure 1: NAMA Scope



The NAMA was developed by Grütter Consulting (www.transport-ghg.com) on behalf of India Railways (IR) with finance from the Asian Development Bank (ADB).

1.2. GHG Emissions of Transport in India

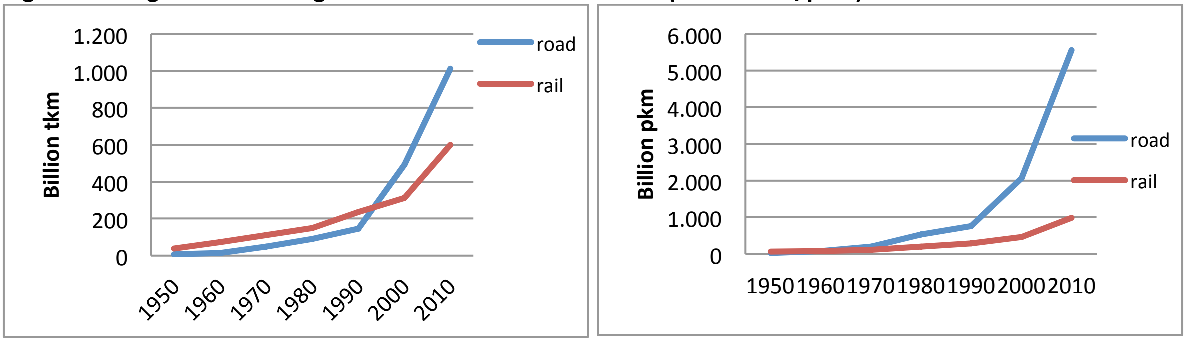
Fuel combustion in the transport sector including road, aviation, navigation and railways resulted in 142 million tons of CO_{2e} emissions accounting for 7% of the total GHG emissions of India in 2007 and around 9% if including electricity production related GHG emissions in the transport sector. Amongst all modes of transport, road transport alone emitted 87% of the total transport-related GHG emissions. It is expected that GHG emissions from transport will triple or quadruple until 2020. The transport sector emissions have increased over the time period 1994 to 2007 with a compound annual growth rate of 4.5% which is in line with Indian CO_2 emissions growth (excluding LULUCF and agriculture)[1].

[1] GOI, Interim Report of the Expert Group on Low Carbon Strategies for Inclusive Growth, 2011, table 2.2

1.3. The Rail Sector in India

In the year 2011, transport in India had a GDP share of 6.5% with a declining share of rail and an increasing share of road. Road has become over the last 2 decades the predominant mode of transporting freight and passengers in India. The following figure shows the growth of freight on the road and by rail for the last 6 decades.

Figure 2: Freight and Passenger Movement India 1950-2010 (Billion tkm/pkm)



Source: GOI, XI 5-year Plan Working Group Transport 1950-2005 and GOI, Road Transport Yearbook 2011

The share of rail in respect to road in freight transport in terms of ton-kilometres has declined from 86% rail in the year 1950 to 36% in the year 2012. The share of rail in passenger transport in terms of passenger-kilometres has declined from 74% rail in the year 1950 to 15% in the year 2012.

1.4. Policies

On June 30, 2008, India announced and launched its National Action Plan on Climate Change (NAPCC). The NAPCC proposes as one of its core actions to encourage mode shift from road to rail for long-distance trips. In December 2009, India announced its target to reduce the emission intensity of its GDP by 20-25% from 2005 levels by 2020, through pursuit of proactive policies. The Expert Group on Low Carbon Strategies for Inclusive Growth[2] provides a menu of options that can reduce India's emission intensity over the time frame. It concludes that reducing GHG emissions from the transport sector would broadly require a shift away from road and air towards rail and water and therefore suggests increasing the share of freight and passenger transport of rail.

The Government of India set up the National Transport Development Policy Committee (NTDPC) as a High Level Committee on February 02, 2010 to provide guidance on long term transport policy for the country. The Working Group on Rail of the NTDPC has identified the necessity to foster efficient rail transport. The Working Group set up ambitious targets on increasing the capacity and modernizing IR. It explicitly states that tools like NAMAs for technology transfer and financing shall be used. The NAMA has been structured around the NTDPC plan on how to foster rail in India.

1.5. NAMA Objectives

The NAMA objective is to reduce GHG emissions through low-carbon inter-urban passenger and freight transport. The NAMA is in accordance with the targets and the core actions as identified in the NAPCC, the Low Carbon Strategies for Inclusive Growth, and the NTDPC. The core action taken is

[2] Set up by the Planning Commission of the Government of India

infrastructure investment in tracks of India railway therefore increasing the supply of passenger and freight services thus allowing for a mode shift from road to rail.

1.6. NAMA Actions

The NAMA starting date is 01/01/2012 commensurate with the XIIth-5 Year Plan of the GOI for the period 2012-2017 and the 2011 report on Low Carbon Strategy for Inclusive Growth[3] which provide the steps to reduce India's emission intensity over the time frame in line with India's December 2009 announced target to reduce the emissions intensity of its GDP by 20-25% from 2005 levels by 2020, through pursuit of proactive policies.

The following concrete actions are anticipated from 2012 until 2030[4]:

- Six Dedicated Freight Corridors (DFC) totalling around 9,500 km of rails tracks. The first two DFCs are currently under construction whilst pre-feasibility studies have been carried out for the remaining. The investment amount estimated for this part is around 2,400 billion INR.
- Construct 14,500 km of 3rd and 4th lines on saturated track routes. Lines approaching major metropolises would also require additional 5th and 6th lines to effectively segregate commuter lines from non-commuter lines (around 300 km). The investment amount estimated for this part is around 2,900 billion INR.
- Double tracking of around 24,000 km of single lines. The investment amount estimated for this part is around 2,400 billion INR.
- 30,000 km of new lines including national projects and projects required for strategic regions and international corridors. Of this, projects for around 14,000 km have been sanctioned at the moment. The investment amount estimated for this part is around 3,000 billion INR.
- Upgrading of speed on segregated passenger corridors to 100 km/h implying advanced signalling technology, elimination of level crossings, fencing of tracks etc. The investment amount estimated for this part is around 1,000 billion INR.
- Electrification of around 20,000 km of tracks. The investment amount estimated for this part is around 250 billion INR.
- Investment in new rolling stock including 1.1 million new freight wagons, 28,000 additional electric locomotives, 15,000 new diesel locomotives, 210,000 new passenger coaches plus upgrading of production units and workshops for the maintenance of the rolling stock. The investment amount estimated for this part is around 17,300 billion INR.
- Development of railway stations, freight terminals and coaching maintenance terminals with an investment of 4,000 billion INR.
- Technological upgrading and modernization of tracks, bridges, signals and telecom, information technology and other with an investment of around 8,000 billion INR.

In total the required investment for all components[5] is roughly 45,000 billion INR or around 800 billion USD[6] ramping up rail investment from currently 0.6% of GDP to around 1.3%. Rail freight transport shall thereby increase by 10% annually reversing the mode trend and reaching a mode

[3] GOI, Interim Report of the Expert Group on Low Carbon Strategies for Inclusive Growth, 2011
[4] NTDPC, Working Group on Railways, 06/2012
[5] Excludes urban transport
[6] Exchange rate of 56 INR to USD 8/2012 i.e. at times of the Working Group Report

share of 50%. Rail passenger transport shall also increase by 10% annually. This is not sufficient to reverse but will slower the trend of losing mode share to the road.

2. The Baseline

2.1. Boundaries

The boundary is a territorial boundary including all inter-urban rail operations in India. International services are only accounted for until the border. Urban services including metro and suburban rail is not included as baseline mode alternatives, trip distances, and baseline mode emissions are very different from inter-urban services. IR separates these types of services in their annual statistics.

The NAMA thus looks at the entire rail sector including freight as well as passenger transport and not just at a new line. This is different from a CDM project based approach where a new line or investment is looked at. It reflects more a sectoral approach. This is justified as numerous synergy effects occur e.g. freight may be transported entirely by rail over longer distances if new tracks are built and not only for the new track lines. The same holds true for passengers. On the other hand some new tracks might divert traffic from existing tracks. Therefore it is more appropriate to make an overall country wide assessment. Whilst this does not allow for reporting with precision the impact of a singular isolated measure e.g. double tracking of Line “Y” it does allow to determine with a good level of confidence the GHG impact of combined rail measures thereby also including important synergy effects e.g. due to having a larger network or the combined effect of higher speed plus new destinations. Stand-alone project approaches also have a methodological complexity in separating cause-impact effects from other on-going activities. Scaling up your NAMA to a sectoral or sub-sectoral approach such as nationwide inter-urban transport simplifies baseline and monitoring, requires less assumptions concerning separation of impacts, and is less complicated and questionable concerning system boundary definition.

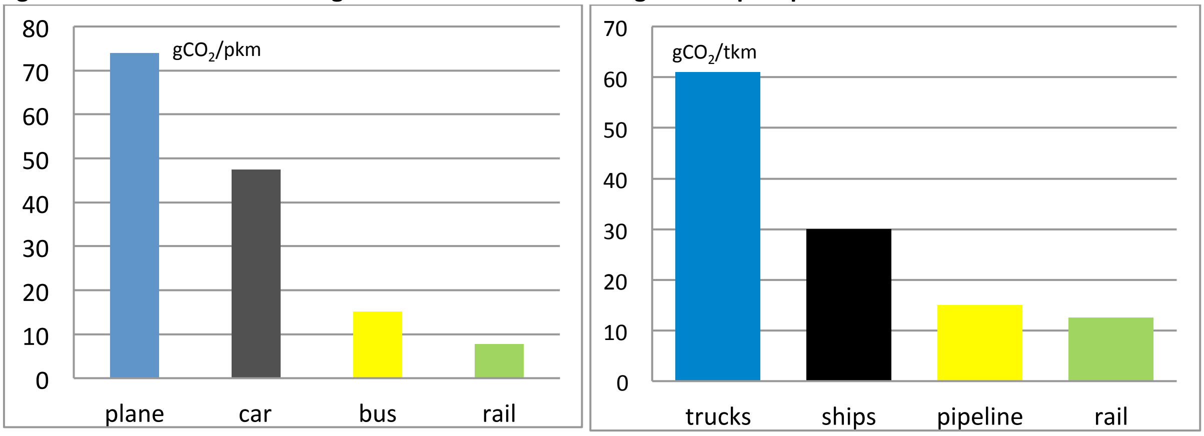
From a GHG perspective the focus is on direct emissions. Upstream and downstream emissions and such under no direct control of IR (leakage emissions) are not included. However for matter of transparency a specific section has been included in the NAMA on indirect or leakage emissions sources including an estimation of their potential GHG impact. Electricity generation based emissions are included as direct emission source.

2.2. Impact Chain

The NAMA activity is basically infrastructure investment in increasing the supply of transport capacity of rail in freight and passenger transport. The increased supply leads to freight and passengers using rail instead of other modes due to rail being competitive in terms of price and reliability. Rail participates in a growing market whilst only increasing slightly its market share. The services of rail are offered at competitive prices so that the additional supply offer is matched with an additional demand of rail services. The impact of the NAMA is thus on “shift” within the Avoid-Shift-Improve-Fuels (ASIF) framework. To a minor extent investments are also made in improving rail efficiency through electrification and more efficient locomotives. This results in lower emissions per tkm and pkm of rail transport and thus also in emission reductions.

The GHG reductions are basically due to efficiency differences in modes of transport as shown in the figures below. A shift of modes towards rail thus reduces GHG emissions. It is expected that over time the efficiency differences in absolute terms will rather increase than decrease, especially for cars and buses due to a drop in occupation rates[7].

Figure 3: Emission Factors Freight and Inter-Urban Passenger Transport per Mode in India 2012



Source: Grütter Consulting, 2013

The table below includes the direct and indirect effects of the NAMA as well as the calculated absolute and relative impacts (relative to the projected emission reductions).

Table 1: Effects and Impacts of Rail NAMA

Effects		Impact annual average emissions 2012-2030	Impact as % of emission reductions
Direct effects	Increased rail tkm increasing rail freight emissions	12.6 $MtCO_2$	Total emission reductions 152 $MtCO_2$ per annum (freezed baseline)
	Increased rail pkm increasing rail passenger emissions	10.3 $MtCO_2$	
	Mode shift road to rail freight reducing road based freight emissions (baseline)	- 123.7 $MtCO_2$	
	Mode shift road (bus, car) and plane to rail reducing passenger road/plane emissions (baseline)	- 51.5 $MtCO_2$ (avoided)	
Indirect effects	Rail construction[8]	5.7 $MtCO_2$	4%
	Rail carriage production[9]	0.9 $MtCO_2$	<1%
	Upstream well-to-tank (WTT) diesel fuel emissions increased rail activity	2.0 $MtCO_2$	1%
	Road construction without mode shift to accommodate trucks, buses, cars which shift to rail (baseline)[10]	- 0.5 $MtCO_2$ (avoided)	<1%
	Vehicle production emissions without mode shift (baseline)[11]	- 7.4 $MtCO_2$ (avoided)	5%
	Upstream well-to-tank (WTT) diesel and gasoline emissions of fuel without mode shift (baseline)	- 33.0 $MtCO_2$ (avoided)	22%
	Congestion impact and induced traffic	n.d.	<1%

Source: Grütter Consulting, 2014

[7] The drop in occupation rate is not related to the NAMA activity but due to increased comfort levels in buses and a trend towards dropping occupation rates in cars with increasing income levels observed in many countries.
[8] Includes tracks, overhead lines, stations, bridges, tunnels annualized for 30-year life-span without discounting
[9] Includes locos and carriages annualized for 40-year life-span without discounting
[10] Includes construction, maintenance and operation over 40-year life-span; annualized without discounting
[11] Based on average lifetime distance driven per vehicle (production emissions per km) separated for bus, truck and car

The following points need to be taken into account:

- The comparison base is a freezed baseline i.e. constant absolute tkm and pkm levels of 2011. For a discussion of baseline approaches see section 2.2. The NAMA itself also calculates the impacts of a dynamic BAU baseline.
- The observation period for impacts is 2012-2030. The one-off impacts (e.g. construction) have been annualized based on their commercial life span.
- The impact is based on the simple annual average of the observation period 2012-2030.
- Electricity based emissions are included as direct emissions (in contrast to WRI definitions in the Greenhouse Gas Protocol[12] but in accordance with CDM procedures[13]).
- Direct and indirect effects and emissions are determined for the NAMA case as well as for the baseline case.

The congestion impact on roads is considered to be of minor nature due to:

- pkm and tkm are expected to grow independent of the NAMA by 8-10% annually. For 2030 it is expected that 13 billion tkm more are transported (primarily by road and rail) compared to 2010. Around 7 billion tkm of this traffic growth would be by rail. It is also expected that in 2030 around 50 billion pkm more are transported (by road, rail, plane) compared to 2010 of which around 5 billion pkm would be by rail. The rail capacity increase is thus only around 10% of the growth increase. Overall the relative share of the rail impact on inter-urban road traffic, even under a freezed baseline, will therefore be in the order of 10-15% in terms of passenger car units (PCU).
- It is assumed and integrated in the road construction emissions that new roads are built upon reaching the carrying capacity per lane (defined as PCU/h); therefore the congestion effect is only of temporary nature and fluctuating according to lane capacity.
- Induced traffic for freight is considered as marginal as prices of IR are in line with road prices therefore not provoking large changes of logistics networks. In passenger transport induced traffic is recorded with monitoring (the passenger is asked if he/she would not have realized the trip in absence of rail transport) and such passengers are included as 0 baseline emission passengers. According to the realized pre-survey the induced traffic is around 1%.

Two conclusions can be drawn:

- The major indirect impact is from upstream fuel usage (WTT).
- The sum of indirect impacts increases emission reductions i.e. baseline indirect impacts are stronger than NAMA activity based indirect impacts. Non-inclusion of indirect effects is therefore conservative.

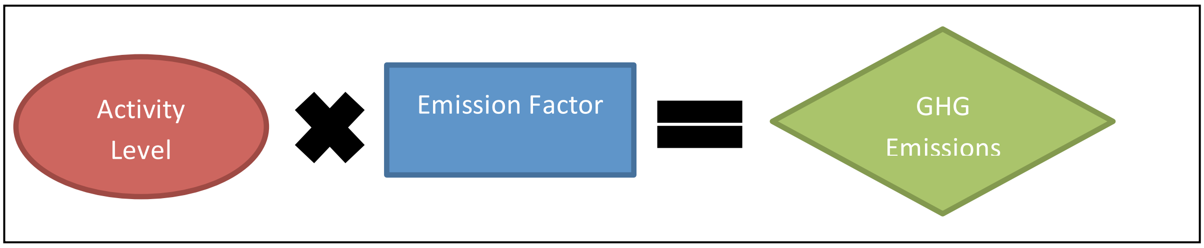
2.3. Baseline Approach

GHG emission reductions are based on the difference between rail based emissions relative to emissions of alternative transport modes for inter-urban freight and passenger transport. This

[12] http://www.ghgprotocol.org/
[13] http://cdm.unfccc.int/methodologies/DB/EY2CL7RTEHRC9V6YQHLAR6MJ6VEU83

includes an activity level (amount of freight and passengers transported) and an emission factor component, both of which change over time.

Figure 4: Elements of GHG Determination



A separation is made between passenger transport and freight transport as both have distinct activity indicators as well as distinct emission factors. The activity indicator for freight is tkm i.e. amount of freight in tons transported over distance and for passengers pkm i.e. amount of passengers transported over distance in km. GHG emission reductions are thereafter the difference in emissions for freight and passengers per tkm and pkm between rail and alternative modes of transport multiplied with the difference of the activity level as actually monitored against a BAU (Business As Usual) scenario.

Baseline construction involves therefore basically two elements:

- The activity level in absence of the NAMA i.e. passenger and freight movement expressed in ton-kilometres (tkm) and passenger-kilometres (pkm).
- The emission factor in absence of the NAMA per pkm and tkm which is influenced by the mode of transit chosen in absence of rail and the emission factor for each mode.

Different baseline approaches are used to determine GHG reductions all of which have their justification and give a certain information. The approaches included are no rail service, a freezed baseline, and a projected BAU development.

Baseline 1: No Rail Service

This baseline describes the future situation in absence of any rail transport in India. Whilst not realistic under a concept of BAU this baseline is useful to assess the GHG impact of rail in India. The information given with this baseline is what emissions India would have in inter-urban transport in the years 2030 if no rail system would operate. It thus gives an indication of the carbon footprint and the sustainable development benefits in operational terms of IR i.e. of the GHG reductions caused by IR operations. This is not a requirement of a NAMA but gives interesting additional information on the impact of rail services.

Baseline 2: Freezed Baseline

The passenger and freight activity in terms of pkm and tkm are freezed at their current level (in absolute terms). This again might not be considered as a realistic scenario under a BAU concept as in the past IR has increased its passenger and freight movement. However this baseline allows to determine and separate the impact of expansion investments from such required to maintain current performance levels. The GHG reductions and the sustainable development benefits calculated under a freezed baseline are the impact of all new investments and improvements realized by IR since

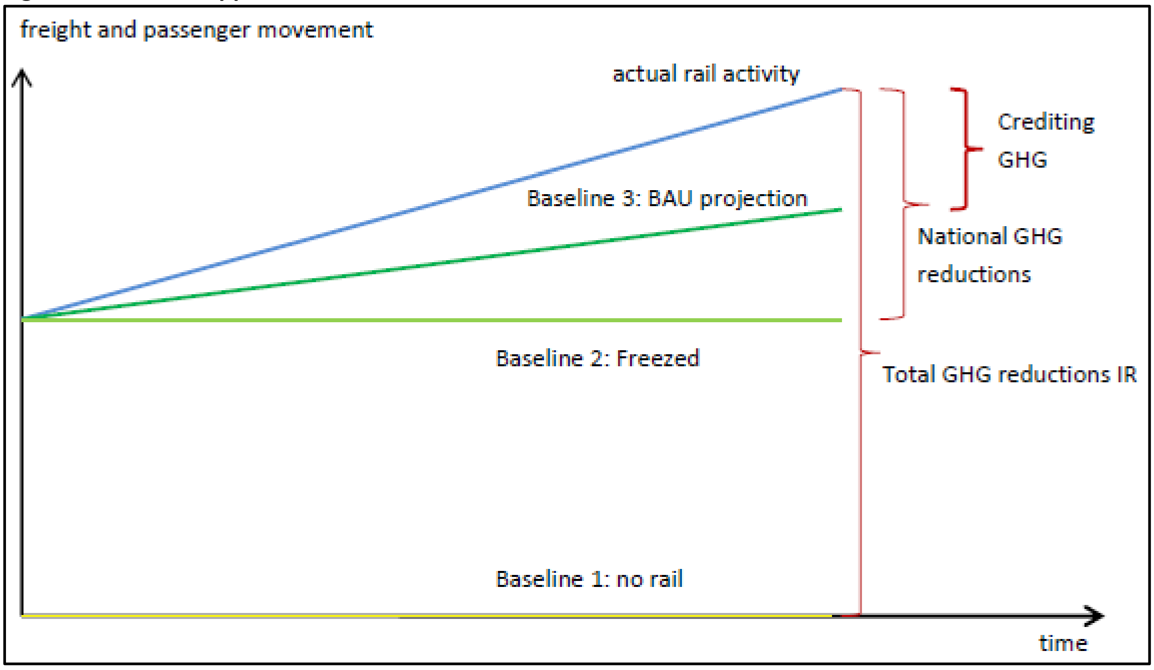
January 2012 resulting in increased freight and passenger movement. They can therefore be considered as India's contribution towards reducing GHGs under a NAMA.

Baseline 3: BAU Projection

This baseline models the expected future movement of passengers and freight. This can be based on historic trends (historic data of passenger and freight movement a trend extrapolation into the future) or it can be based on a correlation/regression baseline which projects rail freight and passenger movement based on observed relations with core parameters to determine supply of pkm and tkm. These observed parameters and relations are again based on past trends and data. Therefore a BAU projection will be related with past development (directly or through explanatory parameters) and projects from their future levels of freight and passenger movement. This baseline is surpassed if interventions go beyond such historic observed trends e.g. investment in rail goes beyond the past relation to GDP therefore resulting in additional freight and passenger movement.

The following graph shows in an exemplary manner the three baseline approaches.

Figure 5: Baseline Approaches



Source: Grütter Consulting, 2014

2.4. Baseline Steps

The following graph shows the steps followed to determine the baseline emissions of passenger transport. A comparable approach is used for freight transport.

Figure 6: Steps to Determine Baseline Passenger Emissions

Step 1 Activity Level

- BAU pkm rail is determined (3 baseline approaches)
- The baseline emissions are determined based on the difference of the real activity level (actual monitored pkm) and the (calculated) BAU pkm.

Step 2 Mode Split Baseline

- The mode split of the baseline passenger (equivalent to the mode rail passengers would have used in absence of rail) is determined.

Step 3 EF per Mode

- For each baseline mode the EF per pkm is determined

$$BE_{P,y} = (ALP_{NAMA,y} - ALP_{BAU,y}) \times \left[\sum_{i=1..n} MS_{i,y} \times EF_{i,y}\right] \quad (1)$$

Where:

$BE_{P,y}$	Baseline emissions of passenger transport in the year y (tCO_{2e})
$ALP_{NAMA,y}$	NAMA activity level (idem to actual level) passenger movement in the year y (million pkm)
$ALP_{BAU,y}$	BAU activity level passenger movement in the year y (million pkm)
$MS_{i,y}$	Distance weighted mode share of mode i of rail users in absence of rail in the year y (%)
$EF_{i,y}$	Emission factor of mode i in the year y (gCO_2/pkm)

$$EF_{i,y} = \frac{SFC_{i,y} \times NCV \times EF_{CO2}}{OC_{i,y}} \quad (2)$$

Where:

$EF_{i,y}$	Emission factor of mode i in the year y (gCO_2/pkm)
$SFC_{i,y}$	Specific fuel consumption of mode i in the year y (g/km)
NCV	Net Calorific Value of fuel x (MJ/g)
EF_{CO2}	CO_2 Emission factor of fuel x (gCO_2/MJ)
$OC_{i,y}$	Occupation rate of mode i (passengers)

As mentioned for the **baseline activity level of rail pkm and tkm** different scenarios exist including taking the value 0 (no rail), taking the value of 2011 (freezed baseline), making ex-ante a historic projection or a correlation baseline. Correlating GDP with inter-urban pkm gives a very good correlation with a correlation number K of 0.998 which is very strong. The best matching factor or elasticity rate of inter-urban passenger pkm to GDP growth rate is 1.008 for the case of India[14]. The BAU activity level can therefore be determined annually based on the measured GDP growth rate and applying the determined elasticity factor. The same method can be applied to freight transport with a resultant elasticity factor of 0.994.

The approach used to determine the **baseline mode share** differentiates freight and passenger movement. For freight this is straightforward and can be based on historical or observed mode shares in absence of rail. In the case of India for freight transport the baseline mode in absence of rail is road as shipping is only used marginally and pipelines only for petroleum products. For passenger

[14] Meaning that a 1% increase in GDP results in a 1.008% increase in pkm rail

movement surveys of rail users are conducted, in which passengers are asked what mode they would have used in absence of rail. This approach is also used in the approved CDM methodologies for mode shift in transport being AM0031, ACM0016 and AM0101[15]. This approach allows the user of rail to identify potential alternative transport modes under a hypothetic scenario i.e. a survey of rail users is conducted which asks passengers what mode of transport (if any) they would have used to perform this trip in absence of rail. An alternative approach would be to use the historic or observed motorized mode split excluding rail potentially eventually combined with a distance-related factor. However in practice inter-urban mode split data is in general not available. Also this approach has a methodological flaw as it implicitly assumes that rail users have the same mode preferences as non-rail users. This is questionable as rail users might belong to a different socio-economic strata and might not have access to passenger cars whilst having a preference for bus transport. Taking the observed inter-urban mode split will therefore over-estimate emission reductions. This has been confirmed by comparing e.g. observed mode-shares in urban settings with mode preferences uttered by public transport users in metro or BRT projects. The baseline mode share is thus basically fixed for freight and dynamically determined i.e. monitored in regular intervals for passenger transport.

For the **baseline emission factor per mode** (i.e. emissions per pkm of buses, cars, planes and per tkm of trucks) the approach followed is in accordance with approved CDM methodologies such as ACM0016. The baseline emission factor per mode is based on monitored or default parameters (see monitoring section) and updated in regular intervals to take into account vehicle technology changes, traffic conditions as well as changes in transport efficiency related to occupation rates or load factors.

2.5. Parameters for Baseline Determination

The core parameters required to determine the baseline are related to the activity level, the mode share and the emission factor per mode of transport.

Concerning the activity level the data required is basically historic data on pkm and tkm of rail and GDP data. IR registers through ticketing and invoices the trip distance of passengers and the lead distance of freight and annually publishes pkm and net tkm.

Concerning baseline mode shares for freight this can be based on historic data readily available as alternatives are limited (shipping, pipeline, road). For road rough estimates based on the registered number of trucks, average load factor (default 50%) and average annual distance driven can be used. For passenger transport this is an observed variable using e.g. a survey. A pilot survey can be realized on the existing rail system. See the monitoring section for further information.

Concerning baseline emission factors per mode the following table lists required data as well as potential information sources. This component will require substantial data collection efforts and investment as data in this form is in general not available in most countries. Using estimated, old, non-robust and default values is not considered appropriate for core elements as they will greatly affect emission reduction calculations. The approach proposed is to update all baseline emission factors every 5 years i.e. the baseline values used in the NAMA are not static and constant but adapted based on monitored values. This is possible as baseline modes are only substituted partially

[15] http://cdm.unfccc.int/methodologies/PAmethodologies/approved

and still continue to exist widely. Also, baseline parameters such as specific fuel consumption or occupation rate are not directly influenced or altered through the NAMA activity. The baseline parameters collected in this manner cannot only be used for rail NAMAs but for many other sustainable transport interventions such as green freight programs, vehicle efficiency programs, or fuel efficiency norms. Data collection could thus be coordinated and managed through the Ministry of Transport and be regularly reported in the national Biannual Update Reports (BURs) to the UNFCCC, thus also making data consistent over different NAMAs and allowing for bottom-up calculations of transport emissions.

Table 2: Parameters Required for Determination of Baseline Emission Factors per Mode of Transport

ID	Parameter	Information Sources
1	Net Calorific Values of fuels	IPCC; Default values can be used as national values will only differ marginally from defaults
2	CO_2 emission factors of fuels	IPCC; Default values can be used as national values will only differ marginally from defaults
3	Biofuel share per fuel type	Government data sources or petroleum companies
4	Specific fuel consumption (km/l or l/km) for inter-urban buses, trucks, passenger cars. The fuel consumption needs to be known for different vehicle sub-categories which require a break-down in fuel type and vehicle size (e.g. trucks >32t). The average value then needs to be adjusted based on the relative share in pkm or tkm	For buses and trucks this can be based on company records. Vehicle registration data can be used to determine the relative share of vehicle sub-categories[16] (e.g. truck weight, bus size). For passenger cars default values based on manufacturers and norms can be used as these will be conservative (understating fuel consumption). If manufacturer data is separated in total/urban/highway the highway part needs to be taken. If based on studies latter need to be representative for inter-urban travel.
5	Average occupation rates for buses and passenger cars; For trucks the average load factor in tons needs to be determined. This requires information on capacity utilization (this requires again information on empty trip factor) and the average payload capacity.	Load factor trucks and occupation rates of buses can often be obtained from companies. Visual observation studies can be realized for these components. They must be realized for inter-urban transport as occupation rates of urban transport differ considerably. It is not recommended to use international default values as these can be hugely wrong and will influence the result strongly.
6	Emission factor per pkm of air transport	ICAO; the ICAO calculator is regularly updated and is conservative (lower end of estimates); Also the approved CDM methodology for High Speed Rail (AM0101) uses this data source. Important is that the average distance of air trips needs to be monitored (with the passenger survey) to use the appropriate distance related ICAO factor.

3. The Impact

The impact in terms of GHG reduction as well as sustainable development (SD) impact is based on the baseline minus the NAMA activity emissions. As discussed under section 2 different baseline approaches are used and therefore different impact levels are determined.

Concerning SD, the following parameters are monitored:

[16] Other factors such as engine size, model, average mileage inter-urban, age etc. of course also influence this parameter. If such disaggregated data is available it should of course be used, but in practice this is not a realistic assumption.

- Job creation: The job creation impact has two levels of assessment: 1) The relative impact: Relative to the baseline rail transport requires overall less jobs when comparing the number of bus and truck related jobs versus rail jobs under BAU; 2) the absolute impact: The amount of new jobs created in the railway system due to its expansion.
- Energy security incl. conservation of energy sources and reduced dependency on imports. This is calculated based on the net fuel savings of the NAMA.
- The social benefits of a shift from road to rail are basically less accidents and an improved air quality resulting in a positive health impact. The former is quantified based on national levels of accidentality rates per vehicle-km per mode.
- The air quality improvement is determined based on avoided NO_x and PM emissions. Data used are default emission factors per vehicle-km based on the average vehicle population age per mode and the avoided vehicle-km per mode based on the mode-shift with the NAMA activity.

The following table shows core results of the NAMA in terms of GHG and SD impact.

Table 3: GHG and SD Impact of NAMA 2020 and 2030

Parameter	Scenario	Impact 2020	Impact 2030	Average 2012-2030	Cumulative 2012-2030
GHG reductions in million tCO_2 excluding leakage[17]	No rail	130	550	210	3,940
	Freezed 2011	80	490	150	2,890
	Dynamic BAU	20	290	70	1,390
Job creation (number of regular employees)	No rail	2,250,000	5,400,000	Not expressed as jobs are not created each year	
	Dynamic BAU	240,00	2,100,00		
Reduced number of deaths on the road	No rail	20,000	80,000	60,000	600,000
	Freezed 2011	7,500	62,000	33,500	335,000
	Dynamic BAU	500	4,500	2,500	25,000
PM reductions in tons	No rail	50,000	220,000	80,000	1,600,000
	Freezed 2011	30,000	200,000	60,000	1,200,000
	Dynamic BAU	4,000	50,000	15,000	300,000
NO_x reductions in tons	No rail	1,200,000	4,900,000	1,900,000	36,000,000
	Freezed 2011	700,000	4,400,000	1,400,000	26,000,000
	Dynamic BAU	100,000	600,000	240,000	4,500,000

As can be seen the NAMA can have a very significant impact on GHG reduction as well as on sustainable development. Annual emission reductions of the NAMA under a dynamic baseline (most conservative) represent total GHG emissions of countries like Sweden. In 2030, the NAMA could reduce emissions by nearly 300 million tons which represents around 5% of India's expected BAU emissions for that year i.e. could provide a substantial reduction. In terms of transport emissions the NAMA represents a 20% reduction compared to BAU transport emissions by the year 2030 i.e. the NAMA has a significant impact on India's transport emissions.[18]

The sustainable development benefit of the NAMA includes a significantly reduced air pollution in particle matter as well as NO_x, less road deaths and fuel savings over the period until 2030 worth

[17] With leakage around 20% additional emission reductions
[18] By 2020 the impact is of much smaller magnitude as rail investments require a long lead time.

more than 400 billion USD. This represents around 50% of the total investment value thus also visualizing the positive economic impact for society as a whole of the NAMA implementation.

The magnitude of the emission reductions are due to three related aspects:

- Large distances driven of passengers as well as of freight due also to the size of the country.
- Large population and economy of India leading to very high passenger and freight numbers.
- The high investment in rail, considerably expanding its service level.

4. Monitoring

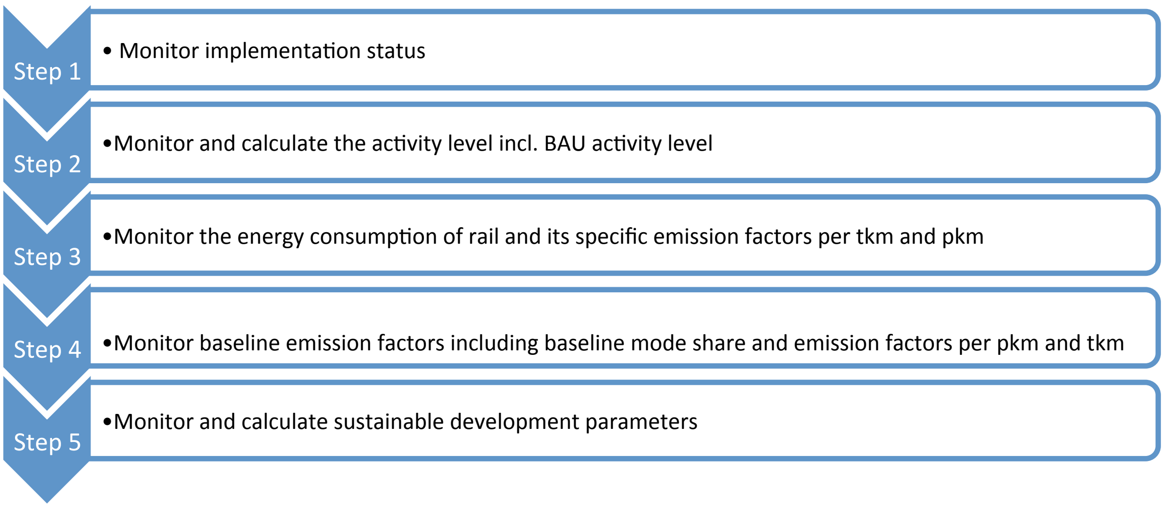
4.1. Institutional Setting

The NAMA is embedded in IR which is part of the Ministry of Railways. IR has a department for climate change which tracks and monitors required data and performs the surveys. This entity also realizes carbon footprint calculations for IR. The department in charge was trained during NAMA development including the realization of a full monitoring process, including reporting. At the moment, the Ministry of Environment of India has not yet defined how data shall be processed and registered for the realization of the BUR.

4.2. Monitoring Approach

The MRV is based on bottom-up calculations. Sustainable development impacts as well as GHGs are monitored.

Figure 7: Steps/Elements of Monitoring



Step 1 Implementation status: The physical implementation of the NAMA is monitored and compared to projections. Core parameters include distance of new tracks built, distance of new double tracking rails and number of newly acquired coaches, carriages and trains. This data is not required for emission reduction calculations but shows the progress of the NAMA and can be used for plausibility of the monitored activity levels and emission reductions.

Step 2 Activity level: The activity level in terms of pkm and tkm is monitored and together with the monitored GDP growth rate and the elasticity factor the BAU activity level is calculated. The BAU activity level can then be compared with the actual recorded level to determine additional rail transport levels.

Step 3 Energy consumption rail: The electricity and diesel fuel consumption for freight and for passenger transport is monitored. Together with the tkm and pkm of rail and the emission factor of diesel and electricity this allows to calculate the specific emission factor per tkm and per pkm of rail.

Step 4 Baseline emission factors: Factors which are revised in regular intervals include the passenger mode split used by rail passengers, the specific fuel consumption of different vehicles (basically trucks, buses and passenger cars) and the occupation rate of different vehicle categories being basically cars and inter-urban buses. These factors together with the emission factor per fuel allow to determine the emissions per pkm and tkm for different modes of transit.

Step 5 Sustainable development parameters: The parameters looked at are job creation, accidentality and local air pollutants.

Monitoring of baseline emission factors and the mode shares would only be made every 5th year as no large changes from year to year are expected.

The most demanding task in terms of finance and due to not being a regular activity of IR is the regular passenger survey (see below for further details) and the update of emission factors per mode of transit (trucks and buses basically). However these components are not only useful for a rail NAMA but for virtually any transport intervention with the goal of low carbon transport and should thus be collected in a regular form by the country within a general monitoring framework for transport in the country.

4.3. Monitoring Parameters

The following table gives an overview of all parameters monitored including also data source and a comment indicating if this data needs to be monitored specifically for the NAMA or is parameter which is monitored anyway.

Table 4: Annually Monitored Parameters

ID	Parameter Description	Source	Comment
1	New lines built incl. doubling lines in km and USD investment	IR	Parameter recorded by IR also without NAMA
2	New freight waggons, passenger coaches and locos in units and USD investment[19]	IR	Parameter recorded by IR also without NAMA
3	Real GDP at constant prices in India	GOI	Parameter reported by 3rd Party
4	Rail nter-urban passenger transport movement in pkm	IR	Parameter recorded by IR also without NAMA
5	Rail freight transport movement in tkm	IR	Parameter recorded by IR also without NAMA
6	Total fuel consumed by rail for freight and for passenger movement of fuel type x in liters	IR	Parameter recorded by IR also without NAMA

[19] ID 1 and 2 monitor the implementation of planned investments and thus provide information about supply expansion

7	Total electricity consumed by rail for freight and for passenger movement in MWh	IR	Parameter recorded by IR also without NAMA
8	Emission factor of electricity based on weighted average emissions in tCO_2/MWh	GOI	Parameter reported by 3rd Party
9	Transmission and distribution losses of the grid in %	GOI	Parameter reported by 3rd Party
10	Net calorific value of fuel type x in MJ/kg	IPCC	Parameter reported by 3rd Party
11	CO_2 emission factor of fuel type x in gCO_2/MJ	IPCC	Parameter reported by 3rd Party
12	Staff (regular employees) of IR	IR	Parameter recorded by IR also without NAMA
13	Number of persons killed/injured in road accidents per tsd vehicles and number of persons killed/injured in rail accidents	GOI and IR	Data is available and reported by 3rd parties
14	NO_X emission factor of vehicle category i in g/km	GOI	Data is available and reported by 3rd parties based on emission regulations
15	PM emission factor of vehicle category i in g/km	GOI	Data is available and reported by 3rd parties based on emission regulations

The interesting fact is that all parameters which need to be monitored annually are part of the regular reporting of IR or of 3rd Parties. Thus no additional data collection effort and no additional data collection cost needs occurs every year. The additional effort required is to collect the data from the different institutions, realize a quality control of the data, to make all relevant calculations and to realize a monitoring report.

Consequently, on an annual base no additional data needs to be collected. However in intervals of five years other parameters need to be monitored. These do require additional data collection efforts. The following table shows the parameters required every five years. The interval of five years is thereby based upon slow and only minor annual changes of the parameters thus not making it necessary to measure them annually.

Table 5: Parameters Monitored Every Five Years

ID	Parameter Description	Source	Comment
16	Specific fuel consumption of mode i	Various	This might entail measurements; in general data for this can however be collected based on national reports or company data
17	Share of fuel type x used per mode i	GOI	Registration statistics might not be conclusive enough for certain vehicle categories and would thus require data research at company level
18	Biofuel share of fuel type x	GOI	Data is available and reported by 3rd parties
19	Occupation rate of mode i	Various	This will require data research at company level (buses) or specific occupation rate studies
20	Distance weighted mode share of mode i of rail users	Survey	This will require a specific representative survey to be performed of IR users
21	Load factor of trucks[20]	Companies	This can be based on road surveys, company data or Commodity Flow Surveys
22	Emission factor per PKM for plane flights	ICAO	ICAO Carbon Emission Calculator has the data per origin-destination.

[20] Defined as capacity utilization multiplied with payload capacity

Of the parameters which need to be monitored every five years core parameters require a significant collection effort.

Specific fuel consumption, occupation rate of vehicles and the load factor require substantial efforts. With new technologies like telematics tracking of vehicles (for load factor/occupation rates and specific fuel consumption) or using big-data from cell-phones this data collection might become less cumbersome in the future than currently. The optimal case would be, if this data is collected on a national level also for other NAMAs and for the national bottom-up inventory in order to guarantee consistency.

The largest monitoring effort is the survey of rail passengers. This cannot be made automatically and is not an observable parameter which means that e.g. cell-phone tracking cannot be applied. The reason is that passengers are asked a counterfactual question namely what mode of transit they would have used in absence of rail i.e. it is a hypothetical trip and not the one they actually perform. The survey also requires efforts in statistical design to ensure robustness and reliability. The initial survey was realized at rail-stations in India. This is a relatively simple approach requiring daily or hourly passenger numbers per station to fix the sample size and sample distribution per station and to calculate the expansion factors thereafter. However, in the case of India with a total of more than 8,000 railway stations distributed all over the country the survey cost is significant even if working with a sample (to ensure comparable surveys over stations and for quality control the same survey supervisor is used nationwide). Surveys can also be based on phone interviews taking as base cell phone registration data. The widespread usage of rail in India as well as the cell-phone distribution make this a statistically valid and less costly alternative. The third alternative applied since 2015 in the case of IR is the usage of regular customer satisfaction surveys introduced recently by IR. These will be performed 2015 at around 200 rail stations on a random base. The questions related to the NAMA have been added on the customer satisfaction survey thus minimizing additional effort and cost while including the monitoring in a sustainable manner in normal business procedures of IR. The table below shows the core parameters of the survey.

Table 6: Main Features of Passenger Survey

Feature	Details
Survey objective	Determine the baseline mode passengers of inter-urban rail would have used and determine the trip length. Latter is used to weight the mode used
Parameter	Main parameter: Mode used in absence of rail Secondary parameter: Distance travelled per mode
Target population	Passengers over 12 years of age using India Railways for inter-urban trips. Smaller children are excluded due to problems in answering the questions.
Sample frame	Based on average passengers transported per day on inter-urban rail trips entire India.
Relative error level (CV)	A global desired level of precision (CV) of 10% for the parameters of interest with a precision level of 90/10 is required.
Coverage	India: national trips of IR all over India
Size of Universe	Generally in one day IR mobilizes around 10 million inter-urban passengers per day
Sample size	Estimated at 10,000 completed surveys.
Sample frequency	Every 5 years. No seasonality is expected[21].
Method of information collection	Basically two options exist: 1. Face-to-face surveys conducted e.g. a railway stations surveying passengers. Railway stations as well as passengers questioned need to be randomized. The random distribution allows that the sample mirrors the total population in any other non-

[21] Exception holiday season

	observed variables such as age, gender, religion, personal preferences etc. This approach (albeit not randomizing stations) has been used for the initial survey. 2. Phone-based interviews nationwide asking persons which have recently used railways for inter-urban trips. This approach also allows for randomization and has potentially significantly lower costs due to the large IR network entailing high travel and collection costs of face-to-face surveys.
Trip distance calculation	Based on entry-exit station of the passenger. For road modes based on road maps and for plane based on ICAO distance calculator.
Pilot survey	For projection purposes and for survey questionnaire design a pilot survey was conducted of 3,000 passengers with random sampling during an entire week at 2 of the most popular IR stations in Bangalore and Delhi during 10/2013.

Source: Grütter Consulting, 2014

The estimated cost of monitoring the parameters which require additional efforts is around USD 50,000 per annum depending on which data is already available. If a passenger survey would be required the cost of latter would be, for the case of India, in the order of 100,000 USD. This cost will depend on factors such as the size of the country, the size of the rail network, the unit cost of surveys, and the survey approach used.