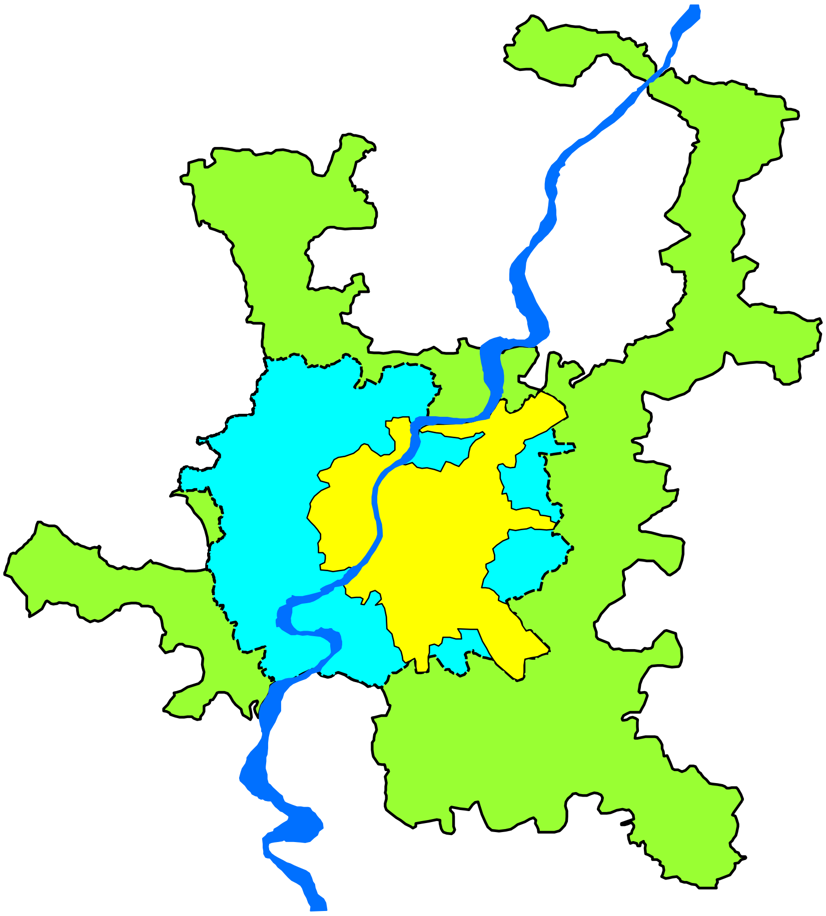
Low Carbon Society Vision 2035

AHMEDABAD



October, 2009

Indian Institute of Management Ahmedabad
Kyoto University
Mizuho Information & Research Institute
National Institute for Environmental Studies

Preface

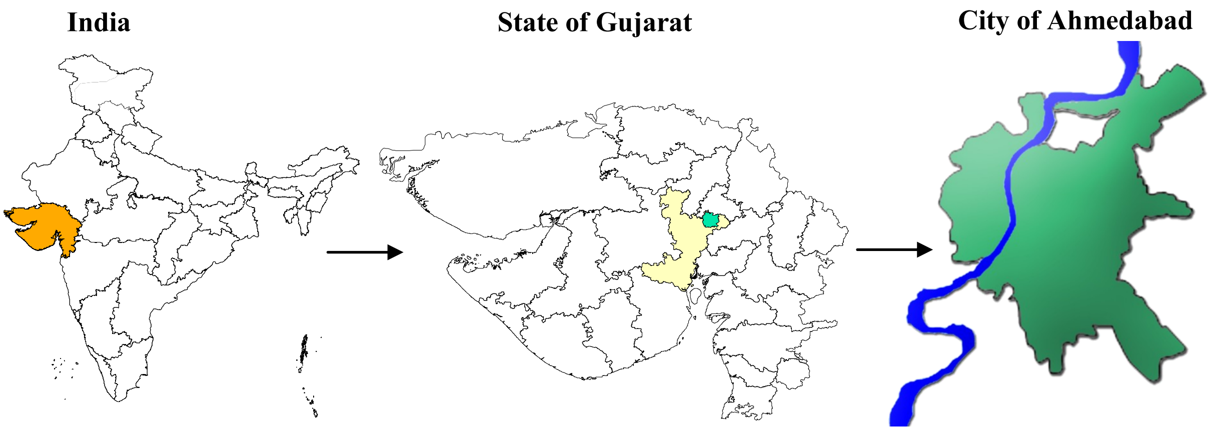
This project is the outcome of support from government agencies and collaboration among various academic and research institutions - namely Indian Institute of Management Ahmedabad, India, Kyoto University, National Institute for Environmental Studies (NIES) and Mizuho Information & Research Institute from Japan.

We thank Ahmedabad Municipal Corporation (AMC), and other planning & development agencies - the Ahmedabad Urban Development Authority (AUDA), and City Managers Association for their cooperation in providing data, information and perspectives which were essential for meaningful modeling of Ahmedabad Low Carbon Society (LCS) scenario.

This LCS scenario document is intended to communicate to city level policy makers - how to effectively integrate climate change actions in the development plans of the city. The actions outlined in the document, we believe, would guide effective transition towards a Low Carbon Ahmedabad. The proposed LCS is in line with national position articulated in India's National Climate Change Action Plan and official Government position in various high level declarations such as the "Major Economies Forum on Energy and Climate".

We hope that our research approach and findings shall contribute to assisting in sustainable transition of Ahmedabad - India's seventh largest and a highly dynamic city - to a Low Carbon Society, in one of the World's fastest growing economy.

- P. R. Shukla



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Executive summary

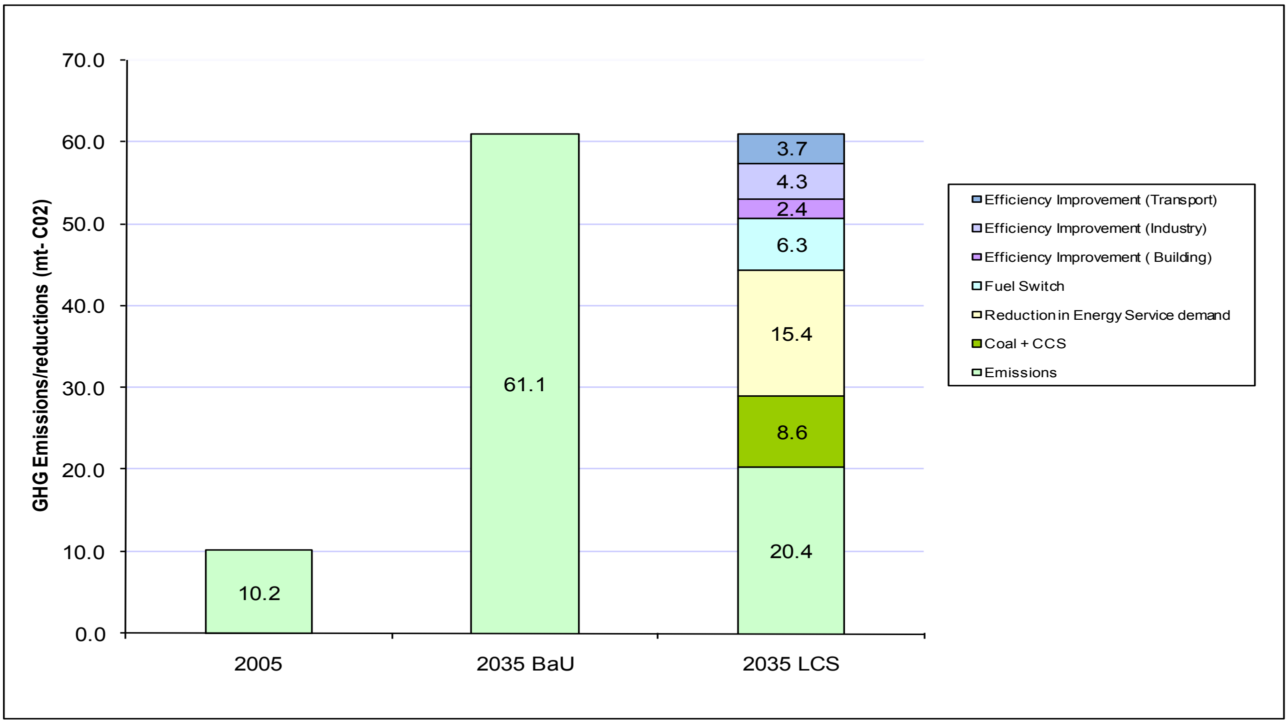
This report articulates a low carbon vision for the city of Ahmedabad. The methodology involves deducing current socio economic, energy and emission parameters for the city using the base year (2005) data . These parameters are used in conjunction with the future energy service demands, energy technology assumptions, and socio economic assumptions for Ahmedabad (population, etc) from the City Development Plan (CDP) ,to obtain the target year (2035) energy, emission and economic details. The ExSS tool estimates energy consumption and GHG emissions increase under 2035 Business as Usual (BAU) scenario. The current per capita emission for Ahmedabad is 2.09 t-CO_2 (2005). In 2035, this figure will increase to 5.47 t-CO_2 under the BAU scenario .

The current GHG emissions of Ahmedabad are approximately 10.2 million ton CO_2, which increases to 61.1 million ton -CO_2, or around 6 times higher than the 2005 level under the BAU (2035) scenario. However, by adopting various countermeasures , the GHG emissions get reduced to 20.4 million ton - CO_2 (reduction by 66.67% over 2035 BAU level).

In order to transit to a low carbon society in Ahmedabad, several countermeasures are required. It is interestingly observed from the model output that for a LCS transition in Ahmedabad, decarbonization has a higher mitigation potential as compared to energy efficiency improvements in the LCS scenario for Ahmedabad. The major emission reduction potential is from improvements in energy intensity of economic activities, cleaner and greener power (coal with CCS, renewable like hydro, solar and biomass), reduction in energy service demand for industrial and commercial sector, fuel switch in power, transport and industrial sector; and measures promoting end-use device efficiency in the transport sector, industrial and residential sector.

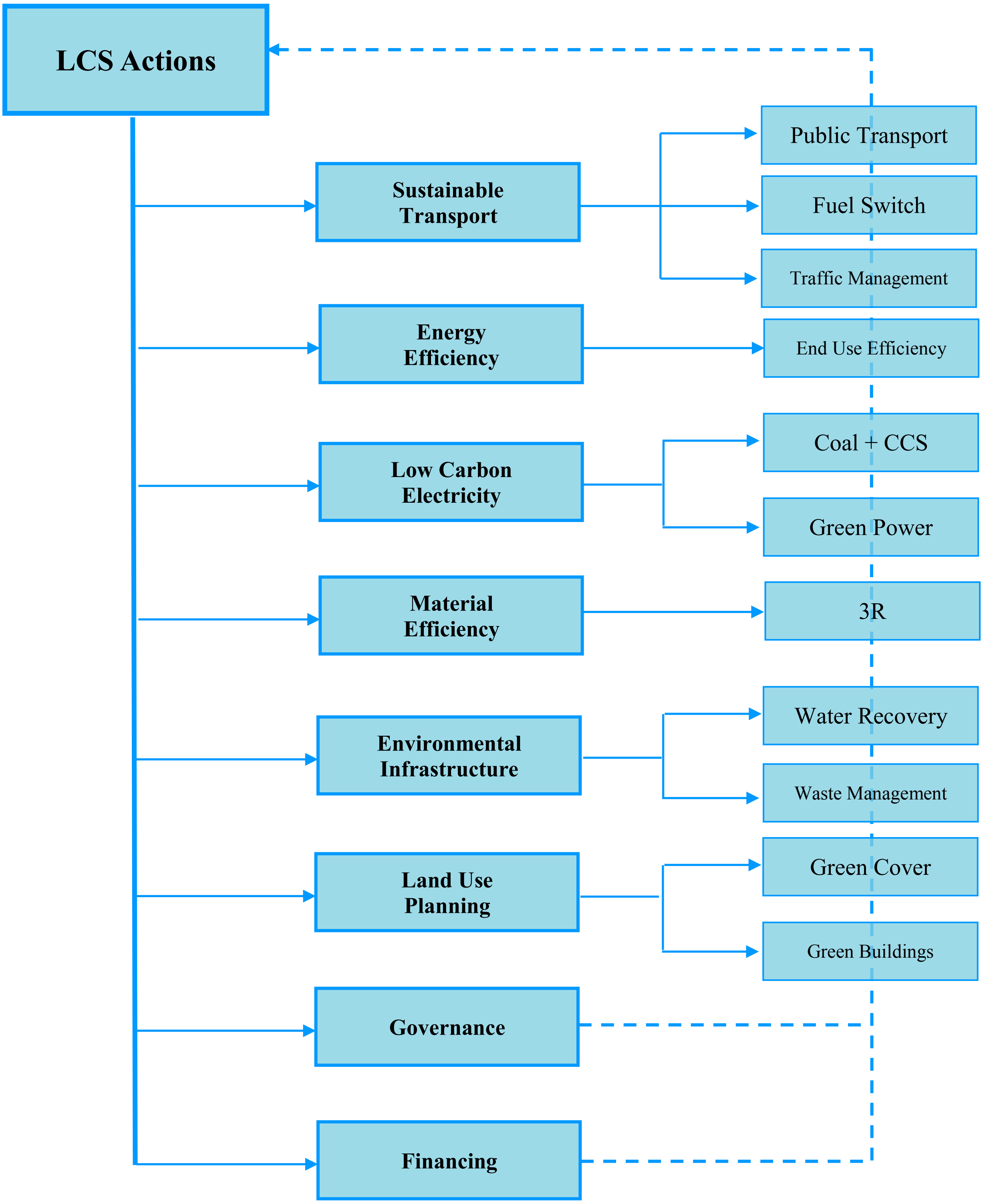
These countermeasures can be presented as a policy package of “Eight Actions” for Ahmedabad

Figure 1: GHG emissions and mitigations by means



Policy Package for Ahmedabad

For realizing the vision of a Low Carbon Society for Ahmedabad, a comprehensive list of policy options are required for implementation of the mitigation measures. The policy package suggested is a menu of recommended actions, that is needed to be integrated in the city development plan of Ahmedabad. Together, these set of actions would help in devising dedicated policies in the present and thus, helping in the realization of a low-carbon society vision for Ahmedabad.



Background

In the developed world context, the concept of a low-carbon society has the following attributes:

(1) Actions should be compatible with the principles of sustainable development, however not at the cost of the development needs of all groups in the society.

(2) Make an equitable contribution towards global efforts in stabilizing CO_2 concentration in the atmosphere and other GHG gases, through deep emission cuts.

(3) Use low-carbon energy sources and technologies and demonstrate a high level of energy efficiency at all levels of energy usage.

(4) Adopt certain behavioral and consumption styles that are consistent with low levels of greenhouse gas emissions.

However, the concept of a low-carbon society has a different meaning for the developing world. Countries, like India, still have low per capita emissions, are on an increasing economic growth trajectory and have priorities in meeting the development needs, like education, healthcare.

But, the LCS opportunity for developing countries arrives with a window of opportunity, as it gives a chance for such countries to avoid critical lock-ins; particularly in long-lived infrastructure assets. From the perspective of a city, like Ahmedabad, the LCS opportunity is a window to decide about the future flow of energy through infrastructure and other behavioral and lifestyle related choices and therefore the importance of such a study.

For setting priorities within the overall framework of an LCS society, it is imperative to understand the long-term goals for such a society. At the Ahmedabad city level, the overall aim of implementing actions within the LCS framework should aim at improving the "Quality of Life" (QOL) of the local residents. 'Quality of Life' should be embodied within the broader deliverables of providing a safe, secure and a comfortable city. Such a society would not emerge in the immediate future but decisions regarding key choices have to be taken now.

Such choices would be either resource/sector based or hard/soft type. While the former controls key energy service demands in certain sectors like residential, building, commercial, etc but the latter, provides an alternative option through either physical type decisions or management decisions. It is important to recognize that the concept of LCS from a city-level perspective should be planned within the jurisdictional levels of the local government. Specifically, only those activities or actions should be considered which the local government is capable of influencing like operationalisation of standards in building sector, promoting the concept of 3R etc.

At the next level, the LCS framework at the city level should look at opportunities which create various kinds of co-benefits apart from direct GHG emission reductions. Such co-benefits, like improved local air quality, provide an opportunity to minimize social costs of such a transition. The other advantage of such an approach would be in achieving "multiple dividends", at minimum social cost. It also helps in achieving various developmental goals of the city and therefore, is in line with the concept of sustainable development.

Extending the LCS framework further, the city would therefore be in conformance with a climate friendly regime. However at the same time the city would also be resilient to climatic variability. The LCS opportunity should therefore be looked at in terms of a platform for planning for climatic exigencies and therefore, minimize operational and other losses.

Target Setting and Timeline

The current selection of target year, 2035 is chosen to keep in mind two time periods:

(1) Period up to 2020 (the terminal year of Post-Kyoto global carbon architecture period) and;

(2) Period beyond 2020, which gives an opportunity to check the progress made towards the long-term commitment of GHG emission reductions by global leaders by 2050.

The time period is typically situated so as to assess the progress towards meeting GHG emission targets. Therefore actions taken now could be assessed by 2035 so as to get a realistic estimate about achieving deep cuts in GHG emissions by 2050; as envisaged by global leaders at (G8+5) summit in 2009. The targets in this study are in line with such global commitments as city level planning is a part of the larger national policy making in India. The immediate future, 2020 (terminal year of post-Kyoto period, to be agreed upon at Copenhagen in December 2009) and the long-term future, 2050; coincides well with the target year of 2035 chosen for this study.

Figure 2: "*Ellis Bridge*" connecting east and west Ahmedabad

In the recent (G8+5) summit, deep global reduction target of GHG emissions was agreed upon by nations coinciding with the maximum temperature rise of 2º Celsius (stabilization target) and the present LCS study is in line with the same targets. This scenario has also been endorsed at the 2009 declaration by the leaders of the "Major Economies Forum on Energy and Climate". As per our modeling analysis for India, using other global climate models, for the year 2035 this stabilization target of 2º Celsius translates into a 67% reduction in GHG emissions from BAU level. Thus, the countermeasures for a low carbon society scenario (2035 LCS) in Ahmedabad have also been designed to achieve a 67% reduction from 2035 BAU emissions.

The idea of LCS is not committing to the 2 deg C target, but an aspirational attempt being made by India. However, this target is subject to adequate financial and technological commitment as agreed upon under the Framework Convention on Climate Change and also, by the declaration of world leaders of major economies.

Figure 3: A glimpse of land use planning scenario in Ahmedabad

A city like Ahmedabad is also participatory to these global efforts but would need financial, technical and other (carbon finance) instruments, as agreed upon under the framework convention on climate change, to achieve these aspirational targets. These efforts do not under any circumstance, undermine the importance of various bilateral efforts in achieving the LCS targets.

About Ahmedabad

Ahmedabad is the largest city in Gujarat and also, its commercial capital. It is the seventh largest urban agglomeration (UA) in India. The city was founded in the year 1411 AD and is located on the banks of River Sabarmati. Ahmedabad gets its name from Sultan Ahmed Shah, who founded the city.

Historically Ahmedabad has been one of the most important centers of trade and commerce in western India. It was once known as the "Manchester of India" owing to its textile industry. Today some of the industrial activities that have flourished in the city include chemicals, pharmaceuticals, electronics, dyes and paints. Ahmedabad's status as an important centre of trade and commerce remains unchanged. The city also has a large market for consumer goods in the retailing sector.

Figure 4: East and West Ahmedabad separated by the Sabarmati River

The city of Ahmedabad developed in a cluster enclosed by a wall that was built in 1456 AD. In the late 19th century, development started spilling over towards the northeast and southeast of the walled city. With the establishment of the first textile mill in 1861, residences also developed across the western side of the Sabarmati river.

The city plays a significant role in the economy of the state of Gujarat. Ahmedabad accounts for almost 19 percent of main urban workers in the state and 60 percent in Ahmedabad District. Several key high-growth industries such as textiles, pharmaceuticals and natural gas are already firmly anchored in Ahmedabad. The industrial centers around Ahmedabad are continuously experiencing expansion on account of economic growth. Ahmedabad is also a major financial centre contributing about 14% of the total investments in stock exchanges in India. The economic base of the city is now shifting towards tertiary (service) sectors, which now account for more than 50% of total employment.

Ahmedabad and its surroundings are currently under the jurisdictional authority of two local bodies, namely the Ahmedabad Municipal Corporation (AMC) and the Ahmedabad Urban Development Authority (AUDA). Beyond the municipal limits; the development is managed by the AUDA.

Table 1: Ahmedabad Demographics

Parameter	**AMC**	**Urban Agglomeration**
Population (million) - *1991* - *2001* - *2006(estimated)*	 2.8 3.5 4.9	 3.3 4.5 5.1
Population Growth - *1991-2001*	 2.03%	 2.74%
Area (Km2) - *2001* - *2006*	 190.8 464.1	 485 485
Density (per sq. km.) *2001* *2006*	 18,445*	 9,290 10,609

**In 2006, the jurisdictional limit of AMC was increased to 464.16 sq. km. This new limit coincides with the limits of the Ahmedabad Urban Agglomeration. The density of AMC in 2006 has not been calculated since the area of AMC in 2006 was almost equal to the UA area and the new AMC limits now included the population formerly housed in UA limits.*

UA: It is a continuous urban spread constituting a town and its adjoining urban outgrowths

Some Initiatives Underway

Many initiatives are being undertaken currently by the city. The state government announced the township policy in 2006. This policy promotes townships to come up at growth nodes emerging around various industrial clusters. The policy sees the government as a facilitator providing 'trunk infrastructure' like access roads, bulk water supply and bulk power (electricity and gas). This would facilitate effective planning for city level infrastructure for future scenarios. Besides, there are various initiatives underway in the urban transport infrastructure sector, with the Bus Rapid Transit System (BRTS) under execution and the Mass Rapid Transit System (Metro) also being planned. These initiatives would also play a significant role in deciding about energy choices for the city.

The new regional plan submitted to the government envisages Ahmedabad into a much bigger Ahmedabad Metropolitan Area. It plans for a multi-modal transportation hub with Metro rail, BRTS, regional rail and the mass rapid transit systems in the next 7-10 years. This regional plan has been prepared for an area of 10,000 Km^2, which also comprises of 5 air strips within 65 km radius from the city and four multi-modal transport stations in the vicinity.

Figure 5: "*Janmarg*" - The BRTS Corridor under development

Reforms in the public transportation system includes low-floored CNG buses fitted with vehicle tracking system (GPS) and bus conductors with hand-held electronic ticketing machine. This has resulted in an increase of bus patronage, and improved collection. This has also resulted in an enhanced quality of service for passengers, mapping out loss making routes, reduces overlapping of routes and maximizing fleet usage by efficient management through constant monitoring of buses on various routes. The local government has also taken an initiative to develop the Sabarmati riverfront (Figure 6). This project also demonstrates governance initiative, since it is being managed by a special purpose vehicle (SPV), which is coordinating all the activities pertaining to this project.

Figure 6: Sabarmati River Front , being developed at Ahmedabad

Among the latest technological innovation, the AMC has developed Asia's largest landfill site to dispose 1.15 million tonne of waste, developed over a total area of 2.77 Km^2. It has been designed to meet city's requirements for the next 30 years. Solid waste will be segregated into biodegradable and non-biodegradable categories and dumped in a systematic manner, adhering to environmental standards. The waste would then be used to make pellets and fluff, to be used as fuel in local industries. The initiative of recycling waste to useful energy form by generation of methane (CH_4) is successfully being running under pilot phase for other existing solid waste management (SWM) treatment plant.

The creation of such an environmental infrastructure leads to multiple dividends. The area around the newly created SWM site has been planned to be developed as a "Green Zone", which would contribute in improving the ambient environment.

Socio Economic Scenario: 2035

Assumptions of the future society

The population of Ahmedabad has increased from 2.8 million in 1991 to 3.5 million in 2001. In response to rapid increase in population and development on the fringes, the jurisdictional limit of AMC was increased to 464.16 sq. km in 2006. The major portion of this extension of municipal borders has taken place on the western side of Ahmedabad. The western region is actually seen as the modern, dynamic and well-planned part of the city, offering world-famous educational institutions, most recent malls and entertainment facilities, and high-income residential areas. The new outgrowths have been in the western parts of the city, within the AUDA jurisdiction.

Using the growth rates from UN medium term population projections for India, it can be estimated that the population of Ahmedabad in 2035 would increase to 11.16 million. Using this assumption about population, and other assumptions (Table 2) about 2035 Ahmedabad, future socio-economic indicators in 2035 are estimated by the tool. Following are the important results of economy, households and transport sector scenario in 2035.

Economy: Modeling results show that the real GDP of Ahmedabad is expected to be approximately INR 7300 billion (12.9 times the 2005 level). An input-output framework has been used to determine the future structure of the economy. Model results show that the structure of the ecnomy is as follows: share of the primary sector changes from 3.1% in 2005 to 1.7% in 2035, for secondary sector it reduces to 61.7% and in

Figure 7: Road infrastructure around Ahmedabad

Table 2: Quantitative Assumptions of socio-economic indicators (2035)

Av. Number of people/household	3.1
Demographic composition	0-14 [30%], 15-64 [63%], 65+ [7%]
Primary Industry Exports	Growing @ 6.6%
Secondary Industry Exports	Growing @ 6.6%
Tertiary Industry Exports	Growing @ 6.5%
Private consumption	Increasing @ 12.0%
Government consumption	Increasing @ 11.9%
Fixed capital formation	Increasing @ 12.1%
Modal share	Rail [10%], Bus [35%], Car [20%], Two-wheelers [10%],Auto-rickshaw[10%],Walk & Cycle [15%]
% denotes CAGR; [%] denotes percentage share; $ corresponds to years 2005 US Dollar	

the tertiary sector, it changes from 27.7% in 2005 to 36.7% in 2035. Considering the trends, we can conclude that the primary sector has decreased by 1.4% , the secondary sector has decreased by 7.6% and the tertiary sector has correspondingly increased by 9.0% during the period (in absolute % terms).

Households: The number of houses of type 1 (detached or apartment, greater than 25 m^2 area) would increase from 0.89 million in 2005 to 3.27 million in 2035 while a decrease would happen in houses of type 2 (shanty, less than 25 m^2 area). Thus, with increased economic affluence, a major portion of the population will stay in type 1 houses.

Commercial: The total floor space for commercial activities has been assumed to increase from 103 sq. km in 2005 to 282 sq. km in 2035.

Transport: Passenger transport demand will increase from 21 billion passenger-km in 2005 to 33 billion passenger-km level in 2035 while the corresponding freight demand would be 126 million tonne-km in 2035 as compared to 7 million tonne-km in 2005 .

Figure 8: Indian Institute of Management Ahmedabad Campus

Table 3: Estimation result of scenario quantification in 2035 Ahmedabad

	2005	2035	2035/2005
Population (millions)	4.87	11.16	2.3
No. of households (millions)	1.18	3.62	3.1
GDP (billion INR)	273	3380	12.4
GDP per capita ('000 INR)	56	338	6.0
Gross output (billion INR)	567	7300	12.9
-Primary industry	*17*	*115*	*6.8*
-Secondary	*393*	*4506*	*11.5*
-Tertiary	*157*	*2679*	*17*
Floor space for commercial (sq. km)	103	282	2.7
Passenger Transport Demand (billion p-km)	21	33	1.6
Freight Transport Demand (million t-km)	7	126	18
BAU Energy Demand (million toe)	1.8	18	10
BAU CO_2 Emissions (million ton -CO_2)	10	61	6.1
BAU Emissions per capita (t-CO_2)	2.1	5.5	2.6

Energy & Emissions : 2035

The macroeconomic data is used to estimate future energy demand and the corresponding GHG emissions in 2035, based on scenario quantification. The estimated results about energy demand and GHG emissions are shown in Figures 9-12 below. Final energy demand in Ahmedabad is projected to increase from 1.8 million toe in 2005 to 18 million toe in 2035 (BAU scenario). Energy demand for industry is expected to be 12832.17 ktoe, having a share of 70.4%. However, the major source of energy demand is met by electricity in 2035 (in this case, gas based thermal power generation), closely followed by coal based generation (23.8%). Oil follows later with a percentage of 9.9% , with almost equal share in residential and industrial usage. It is also used in substantial quantities in the transport sector also. Renewable energy sources , particularly solar and biomass power show minor contribution in the energy mix.

In the 2035 LCS case, the energy profile has an interesting description. Gas penetration has decreased slightly but the electricity from coal is generated by coal + CCS (low carbon electricity). Another typical and interesting feature of the energy demand profile is the slight penetration of H2 energy in the transport sector in 2035 under the LCS scenario, a realization which is definitely possible.

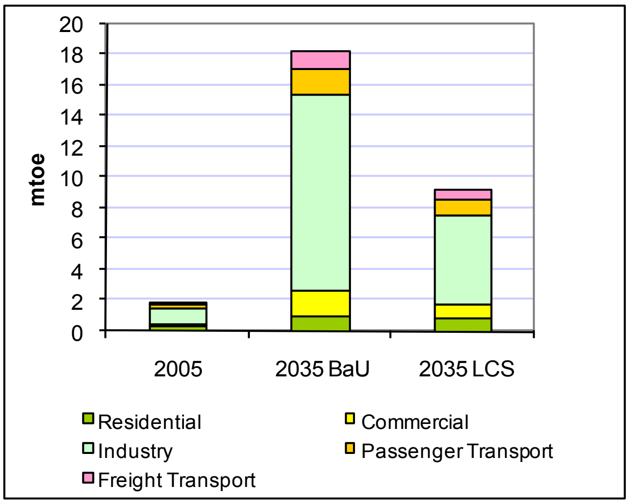


Figure 9: Final energy demand by sector

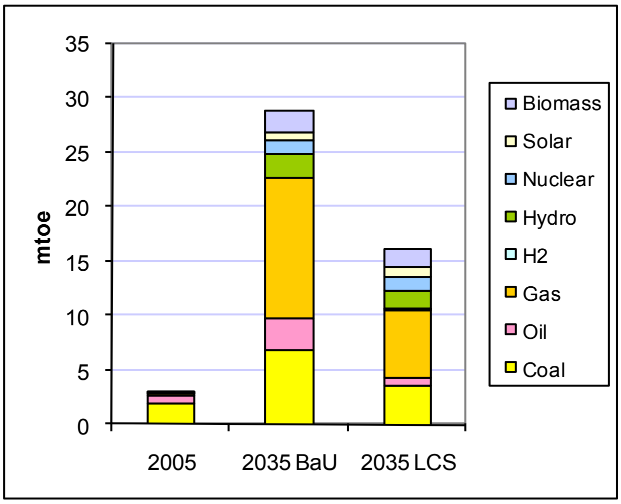


Figure 10: Energy demand by primary energy

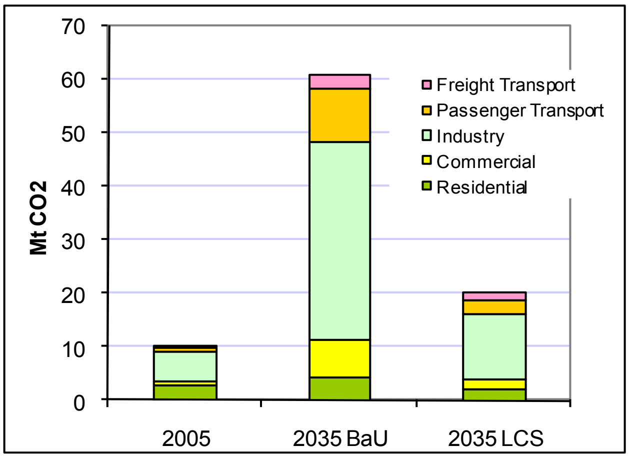


Figure 11: GHG emissions by sector

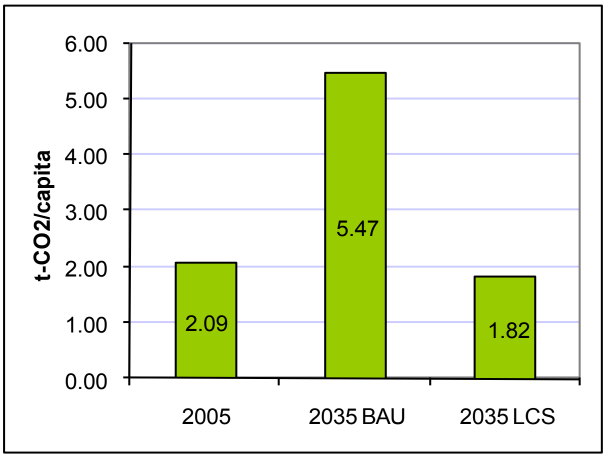


Figure 12: Per capita GHG emissions

Based on the energy demand by source, the GHG emissions in Ahmedabad are projected to increase from 10 million ton -CO_2 in 2005 to 61 million ton -CO_2 in 2035 under BAU scenario. A sectoral analysis of GHG emissions points that emission from the industry sector will be about 6.56 times than what it is in 2005. Similar results for the passenger transport is 14.68, freight transport is 7.74 , residential is 1.49 and commercial sector is 10.40.

In order to transit to a low carbon society in Ahmedabad, several countermeasures are required. It is interestingly observed from the output that for a LCS transition in Ahmedabad, decarbonization has a higher mitigation potential as compared to energy efficiency improvements in the LCS scenario for Ahmedabad. The major emission reduction potential is from improvements in energy intensity of economic activities, low carbon power (coal with CCS, more renewable like hydro, solar and biomass), reduction in energy service demand (for industrial and commercial sector), fuel switch in power, transport and industrial sector; and measures promoting end-use device efficiency (particularly, in the transport sector, industrial and residential sector).

Table 4: Final energy demand by sector (Unit: ktoe)

	Coal	*Oil*	*Gas*	*H2*	*Solar*	*Biomass*	*Electricity*	*Total*
2005 (ktoe)								
Residential	0.00	174.00	0.03	0.00	0.31	2.00	167.00	343.34
Commercial	0.00	35.00	0.03	0.00	0.00	0.00	42.00	77.03
Industry	579.00	145.00	124.00	0.00	0.00	15.00	194.00	1057.00
P- Transport	0.00	234.00	13.00	0.00	0.00	0.00	1.00	248.00
F- Transport	0.00	121.00	0.00	0.00	0.00	0.00	0.00	121.00
Total	**579.00**	**709.00**	**137.06**	**0.00**	**0.31**	**17.00**	**404.00**	**1846.37**
Share (%)	31.34%	38.37%	7.45%	0.00%	0.02%	0.92%	21.9%	100%
2035- BAU								
Residential	0.00	237.00	250.00	0.00	1.60	1.60	454.00	944.20
Commercial	0.00	0.00	805.00	0.00	25.00	0.00	832.00	1662.00
Industry	947.00	1332.00	8341.00	0.00	0.00	379.00	1833.00	12832.00
P- Transport	0.00	56.00	73.00	0.00	0.00	12.00	1484.00	1625.00
F- Transport	0.00	935.00	0.00	0.00	0.00	219.00	0.00	1154.00
Total	**947.00**	**2560.00**	**9469.00**	**0.00**	**26.60**	**611.60**	**4603.00**	**18217.20**
Share (%)	5.20%	14.05%	51.98%	0.00%	0.15%	3.36%	25.27%	100%
2035 - LCS								
Residential	0.00	117.33	191.19	0.00	3.20	0.00	492.31	804.03
Commercial	0.00	0.00	432.01	0.00	30.30	0.00	497.09	959.40
Industry	0.00	0.00	4227.88	0.00	0.00	103.14	1404.43	5735.45
P- Transport	0.00	38.67	29.12	3.05	0.00	6.52	1042.52	1119.88
F- Transport	0.00	579.75	0.00	0.00	0.00	64.42	0.00	644.17
Total	**0.0**	**735.75**	**4880.20**	**3.05**	**33.50**	**174.08**	**3436.35**	**9262.93**
Share (%)	0.00%	7.94%	52.68%	0.03%	0.36%	1.88%	37.10%	100%

P-Transport: Passenger Transport, F-Transport: Freight Transport

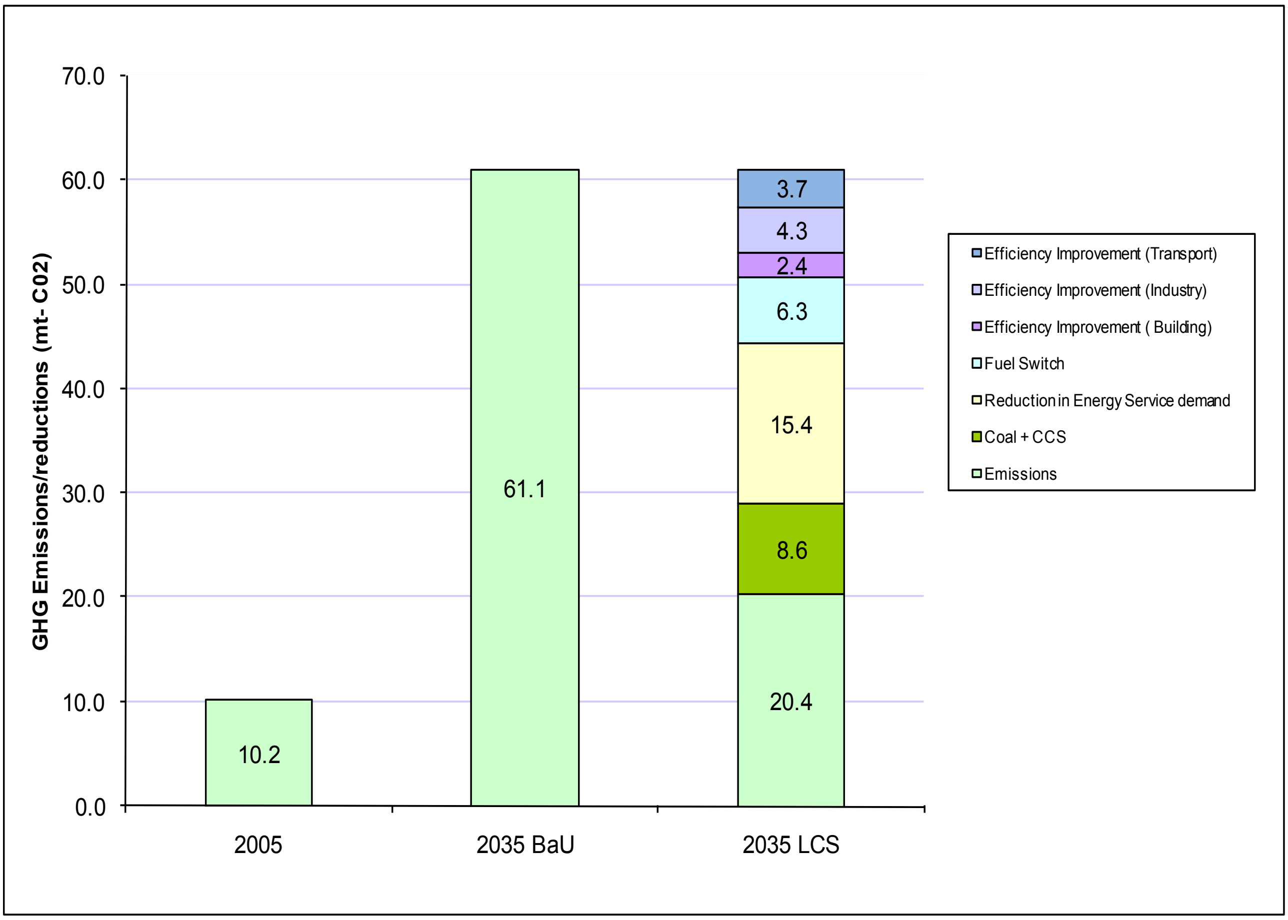
Mitigation potential in 2035

The current CO_2 emissions for Ahmedabad are 10.17 million ton -CO_2 (2005). In 2035, this figure will increase to 61.1 million ton CO_2 under the BAU scenario. However, under a 67% reduction countermeasure scenario, the emissions need to be reduced to 20.4 million ton -CO_2.

The largest reduction of 15.4 million ton CO_2 comes from reduction in energy service demand, primarily in the industrial sector. The second big chunk comes from low-carbon power (coal + CCS, in partial form and this option is proved to be available in and around Ahmedabad in abundance). The next big potential is in the form of fuel switching (to gas) - 6.3 million ton CO_2. Energy efficiency improvements provide the balance, which are in the transport sector (3.7 million ton CO_2), 4.3 million ton CO_2 in industry and 2.4 million ton CO_2 in the building sector. A cross cutting factor of fuel-switch (from oil to gas) is observed to be contributing a good portion of CO_2 cut. This happens primarily in the transport and industry sector.

In order to transit to a low carbon economy, several measures are required. The key measures include improving energy intensity (achieved through reducing energy service demand), providing low carbon power (coal with CCS), fuel switch in transport and industrial sector and measures promoting end-use device efficiency (particularly, in the transport sector, industrial and residential sector).

Figure 13 : Breakdown of emissions reduction potential



Eight “Actions” toward LCS

General introduction of actions

Broadly, the actions are enumerated in the following table. The actions can be broadly categorized into those that promotes improvements in efficiency, to those that encourages sustainable mode of transportation and finally, to clean forms of energy. However within these actions, the overarching action of governance and financing has been separately considered. The governance aspect ensures that the actions are implemented in the most non-conflicting manner and the financing action ensures that the actions are able to attract innovative financing mechanisms so that the actions are sustainable by itself.

However it must be noted that all the actions yield multiple co-benefits and build adaptive capacities of the local population.

	Actions	*Options*
1	*Sustainable Transport*	● Mass transit systems like train and bus ● Shift from oil to gas and electricity ● Promoting zero carbon transport, like bicycles ● Use ICT for better transport management ● Appropriate infrastructure that promotes transition to bicycle and walking
2	*Energy Efficiency*	● Energy labeling program implementation ● Device efficiency standardization in all sectors
3	*Low -Carbon Electricity*	● Option of CCS in the present electricity supply system ● Promoting transition towards procuring “green” power ● Promoting new power infrastructure based on advanced renewable energy technologies
4	*Material Efficiency*	● Using 3R principle to promote resource conservation, dematerialization, and recycling ● Use of sustainable, less energy intensive , local and renewable materials ● Promotion of efficiency at building level
5	*Environmental Infrastructure*	● Water resource management ● Waste Management (Solid, Liquid)
6	*Land Use Planning*	● Improving built environment (reducing urban heat island effect) ● Increasing Green Cover
7	*Governance*	● Coordination, planning and implementation of LCS actions
8	*Financing*	● Filling the viability gap, for new LCS infrastructure

Description of “Actions”

The action on **Sustainable transport** comprises of focus on vehicle efficiency improvements, fuel switch from oil to gas (private vehicles and buses) and electricity (train and buses), better traffic management and shift from private vehicles to public vehicles (bus and train). However to achieve such a scenario, certain indirect actions would be required. Some of these actions will be standardization of vehicle efficiencies, gas supply infrastructure and appropriate institutional mechanisms to ensure transition to mass based transit systems. From the developing countries view-point, such an action would yield multiple benefits. On the co-benefits side, there would be improvement in local air quality due to reduced pollution and reduction in use of natural resources. Sustainable transport will lead to various adaptation benefits as well, by enhancing health security (owing to improved air quality) and energy security (due to reduced energy usage, specially oil).

The action on **Energy Efficiency (EE)** is focused on efficiency improvements achieved through device improvements. These efficiency impacts are realized in residential, commercial, industrial and transport sectors. It is believed that due to technological innovations and improvements, such high efficiency factors are realizable. These efficiency improvements can be consistently achieved through implementation of uniform building codes (efficiency in residential sector), promotion of local and less carbon intensive material for construction and designing an appropriate institutional mechanism to facilitate such a transition.

The action on **Low Carbon Electricity** aims at decoupling the carbon intensity of power sector by using more renewable sources of energy for power generation or by using coal with CCS option. Another aspect in low carbon electricity is generating electricity from waste (solid waste management). Such possibilities have already been explored for Ahmedabad, and are realistic. Such shifts in energy technology would yield multiple benefits, such as improvement in local air quality and effective waste management. On the adaptation side, investments in low carbon electricity would generate livelihood and build capacity in low carbon energy technologies. Besides, it would also enhance health security (owing to improved air quality) and energy security (due to reduced usage of fossil fuels, specially coal).

The action on **Material Efficiency** aims at promoting resource conservation, dematerialization, and recycling . This will also provide significant co-benefits in terms of promoting a sustainable lifestyle, better control of energy service flows and resource conservation. These measures would also result in improving livelihood security (generation of employment through local industries) and enhance energy security by the overall reduction in energy demand.

The action on **Environmental Infrastructure** comprises of creating various infrastructures such as solid waste management facilities and sewage treatment plants. Apart from direct mitigation benefits, these are important in realizing other co-benefits such as promotion of 3R and enhancing the quality of life. For example, a modern landfill can also be a source of fuels in the form of land fill gas (LFG), pellets and fluff, which can be used in the local industries.

The action on **Land Use planning,** targets at increasing the green cover and improving the built environment so as to reduce the urban heat island effect. This will also offer the co-benefits of enhancing the quality of life, controlling energy flows, and better adaptation to extreme weather events.

The larger framework of **Governance** comprises of how to govern the city. Local government executes at the interface of the state and the centre and therefore has to plan, implement and coordinate a host of activities. To facilitate a smooth transition to a low carbon city, the local government of Ahmedabad would need an effective governance and institutional mechanism. Governance initiatives will have an overlapping influence in ensuring sustained sectoral emission reductions. In the residential and commercial sector, effective governance would comprise of implementing uniform building codes, ensuring faster penetration of energy labeling programs and greater public awareness about reducing energy consumption. In the transport sector, governance initiatives should focus on better city planning (to reduce congestion, and encourage shorter movements) and standardizing vehicle efficiency norms. And in the industry and power sector, it comprises of implementing energy efficiency standards and ensuring mandatory fuel switch to cleaner fuels.

In the context of developing nations, **Financing** plays a key role in any low carbon initiative over and above the business as usual transition. Thus, the deep emission cuts would involve substantial investments in low-carbon infrastructure. Besides, these infrastructure and technology choices would also lead to some economic losses (GDP), which would translate into developmental loss and would have to be compensated through international investments and technology transfer. For ensuring a transition to a low carbon society, various financial initiatives would be necessary at the local level. In the building sector, financial incentives are needed for energy efficiency improvements (advance technologies in end use devices), and initiatives like green buildings. In the transport sector, financial support is needed for huge investments in public transport infrastructure, modern transport technology (traffic management), and incentives to promote efficient vehicles. Industry sector needs to be supported with financial initiatives such as tax benefits for investments in efficient and low carbon technology equipments. For the power sector, investments in CCS and renewable energy technologies need to be appropriately supported financially.

MUNICIPAL BONDS FOR FINANCING INFRASTRUCTURE PROJECTS IN AHMEDABAD

Before 1993-94, Ahmedabad Municipal Corporation was a loss-making urban local body with accumulated cash losses of Rs. 350 million. The Ahmedabad Municipal Corporation (AMC) improved its fiscal profile from 1993 to 1996 by introducing several significant fiscal and management reforms. These innovations laid the groundwork for issuing a municipal bond.. In 1998, the Ahmedabad Municipal Corporation issued its first municipal bonds for Rs. 1000 million. The issue was designed to partially finance a Rs. 4890 million water supply and sewerage program. This was a remarkable achievement as it was the first municipal bond issue in India without a state government guarantee and it represented the first step towards fully market-based system of local government finance. Ahmedabad emerges in the top ten cities category, whose corporation is the most credit worthy. After the first bond was issued in 1998, which was placed publicly ; the other three bonds of total value of 258 crore was privately placed. Expert opinion suggest that the Indian capital markets are hugely under-developed and municipal bonds are a good way to tap into this fast growing funds market. Ahmedabad has been traditionally a safe haven for investors, owing to the reforms in accounting practices and consistently generating good income.

Governance

At the outset, governance structure is a hierarchical web of interactions at various levels. These interactions, popularly termed as organization structure, help in delineating responsibilities and setting up jurisdictional boundaries. For e.g., AMC is divided into various zones and each zone has Deputy Municipal Commissioner with the overall responsibility of the zone. However many common and overlapping functions are aggregated at the AMC level, like water supply and production. These departments have to ensure coordination at all levels to facilitate implementation of any initiative. This becomes an onerous task for a large area, and therefore manifests itself in various inefficiencies. The local government has thus embarked upon various initiatives so as to solve this problem. One of the initiative is the Continuous Monitoring System – to bring more accountability and transparency （at all levels of governance）.

Another aspect in the governance structure is the form of governing arrangement. AMC has come up with innovative forms of local governance, like Public-Private Partnership （implemented in Solid Waste Management Projects）, Special Purpose Vehicle （like the BRTS project, and the Sabarmati Riverfront Development Project）, among others. These forms help in managing policy implementation in a viable and effective framework.

Key function of the local government lies in coordinating, planning and implementing policies. However with a number of policy initiatives, and with overlapping governance structures; it becomes extremely difficult in achieving the desired results. For example, BRTS （Bus Rapid System） project is implemented via a Special Purpose Vehicle （SPV）, a typical project structure which is run on commercial principles, but local implementation overlaps with jurisdictional responsibilities of various state departments like the traffic police, regional transport office. These offices come under the control of the state government and therefore, it is a challenge for the local authorities to remove the multifarious effects of coordination failure.

Financing

The options at the local level comprise of innovative financial mechanisms, like through ‘municipal bond market’ and through innovative institutional arrangements. On the institutional front, for example; the Sabarmati River Front Project is a Special Purpose Vehicle, aimed at reclaiming land on the sides of the river Sabarmati. Not only improving the built environment through this initiative of an environmentally initiated infrastructure, this initiative aims to sell a part of the land claimed back on commercial basis. This improves the viability of the project and ensures speedy pay-back.

Thus in the overall framework of governance and financing, the set of activities like form, finance and structure; help in connecting with the framework of sustainability for the LCS society （from the resources side as well as from the consumption side）. It also looks at the redistribution justice aspect, as people participate at the lowest levels and concern about the common citizen in the policy making process helps in ensuring equity in the decision making progress.

Most of the cities in the current context exhibit voluntary participation in various activities. However, these voluntary participations predicate upon various inputs like information, capacity and support from stake holders. As of now, most of these initiatives are achieved through private channels only and are in isolation. And therefore, effective governance structures is a fundamental aspect in ensuring implementation of various LCS actions. Uniform sustainability frameworks can only be implemented through effective governance structures backed by policies, laws and regulations.

Energy and Environment Policies in India

There have been numerous policy initiatives, legislations and acts enacted and introduced in the environment and energy domain in India. These policies, legislations and acts have focused either individually on an environmental sector like water, air or they have targeted broadly the entire value chain of the energy sector. For example, the latest policy document adopted by the Government of India - the Integrated Energy Policy Roadmap, 2006. This policy road-map has been accepted by the Government of India (GoI) in 2009, and which broadly links energy sector to the goals of Sustainable Development by developing policies that promote 'efficiency' and reflect externalities associated with energy consumption.

Further in June, 2008; the Prime Minister of India released India's first National Action Plan on Climate Change (NAPCC) outlining existing and future policies and programs addressing climate mitigation and adaptation. The plan identifies eight core "national missions" running through 2017 and directed ministries to submit detailed implementation plans to the Prime Minister's Council on Climate Change by December 2008.

Emphasizing the importance of high economic growth rates, the plan "identifies measures that promote our development objectives while also yielding co-benefits for addressing climate change effectively." It says "these national measures would be more successful with assistance from developed countries", and pledges that India's per capita greenhouse gas emissions "will at no point exceed that of developed countries even as we pursue our development objectives."

The eight National Missions and their related targets are elucidated below in the table. These targets are in line with the mitigation of GHG emissions across many sectors, and therefore are important from the perspective of an LCS study.

No.	National Mission	Targets
1	National Solar Mission	Specific targets for increasing use of solar thermal technologies in urban areas, industry, and commercial establishments
2	National Mission for Enhanced Energy Efficiency	Building on the Energy Conservation Act 2001
3	National Mission on Sustainable Habitat	Extending the existing Energy Conservation Building Code; Emphasis on urban waste management and recycling, including power production from waste (3R)
4	National Water Mission	20% improvement in water use efficiency through pricing and other measures
5	National Mission for Sustaining the Himalayan Ecosystem	Conservation of biodiversity, forest cover, and other ecological values in the Himalayan region, where glaciers are projected to recede
6	National Mission for a "Green India"	Expanding forest cover from 23% to 33%
7	National Mission for Sustainable Agriculture	Promotion of sustainable agricultural practices
8	National Mission on Strategic Knowledge for Climate Change:	The plan envisions a new Climate Science Research Fund that supports activities like climate modeling, and increased international collaboration; It also encourage private sector initiatives to develop adaptation and mitigation technologies

Moreover, there are other specific programs identified for implementation, within the National Action Plan from the mitigation perspective. It mandates the retirement of old inefficient coal-fired power plants and supports R&D in making IGCC and supercritical technologies to be used as power plant technology. It also envisages initiatives like renewable portfolio standard for all states and mandatory energy audits for energy intensive industries. The plan also advocates for aggressive implementation of the energy labeling program.

Buildings (Residential & Commercial sector)

Residential Sector

The number of households in Ahmedabad is assumed to increase from 1.18 million in 2005 to 3.6 million in 2035 (BAU). This increase is on account of expanding population and reduction in persons per household due to increasing urbanization. Since the number of households is a major driver for energy demand, the final energy consumption increases from 343 ktoe in 2005 to 944 ktoe in 2035 (BAU), which is reduced to 804 ktoe under the LCS scenario. The corresponding CO_2 emissions changes from 4.21 million ton -CO_2 in 2035 (BAU) to 1.90 million ton -CO_2 in 2035 LCS scenario. The largest mitigation potential is change in the nature of centralized power supply and end use device efficiency.

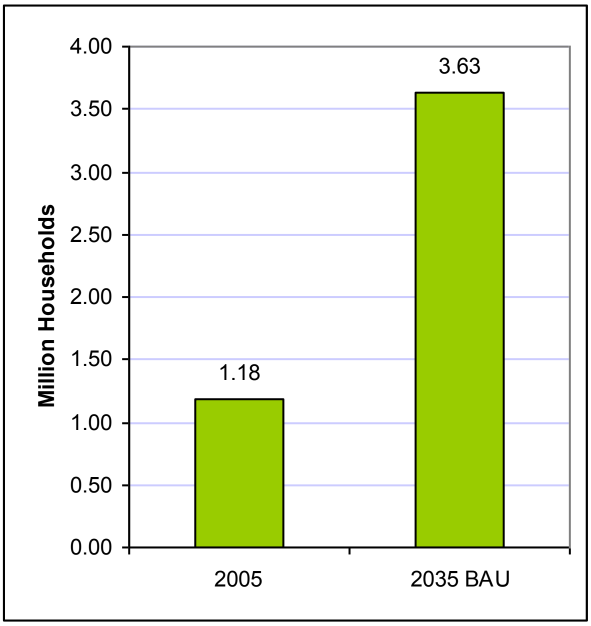


Figure 14: Number of households

Commercial Sector

The commercial floor space area is assumed to increase from 103 sq. km in 2005 to 282 sq. km in 2035, on account of increased commercial activities in the economy. Commercial floor space area is the major driver for energy demand. By changing the nature of centralized power supply and end use device efficiency , final energy consumption reduces from 1662 ktoe (BAU-2035) to 959 ktoe (BAU-LCS). The corresponding emission reduction is from 7.22 million ton -CO_2 to 2.08 million ton -CO_2 in 2035 LCS scenario.

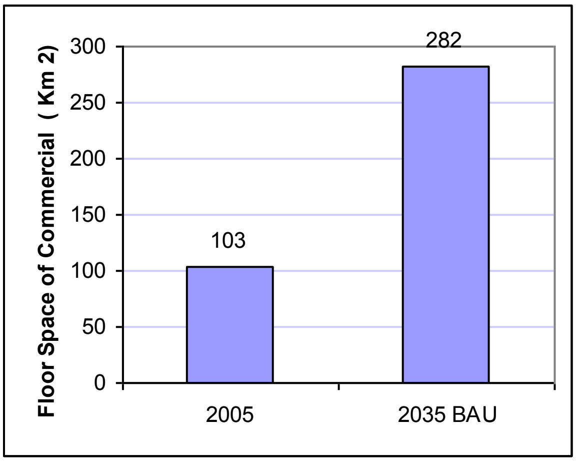


Figure 15: Floor space of commercial

Policy package for buildings and commercial sector

The policy package for mitigation of GHG emissions in the building and commercial sector comprises of energy efficiency, fuel switch (end use and centralized power supply) and reduction in energy service demand. The energy efficiency improvements are achieved through end-use device efficiency as well as material efficiency. These measures can be implemented by appropriate policies such as providing financial incentives, implementation of uniform building codes, energy labeling programs, public awareness building and financial & technical support for implementing coal with CCS and also, financial incentives for promotion of renewable.

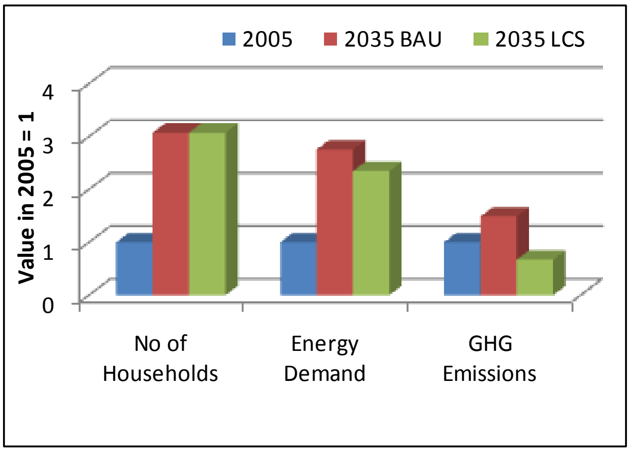


Figure 16: Change from base year : Residential Sector

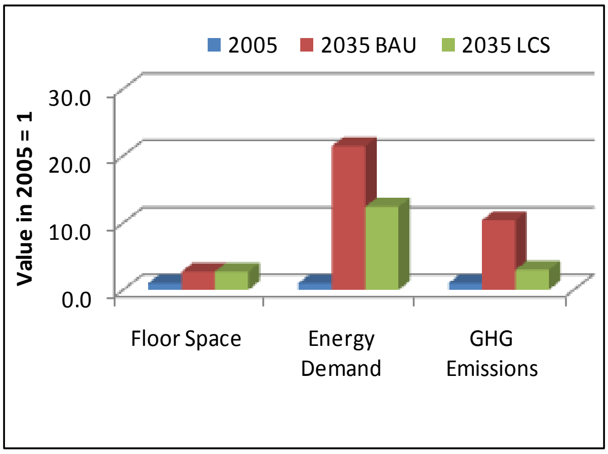


Figure 17: Change from base year : Commercial Sector

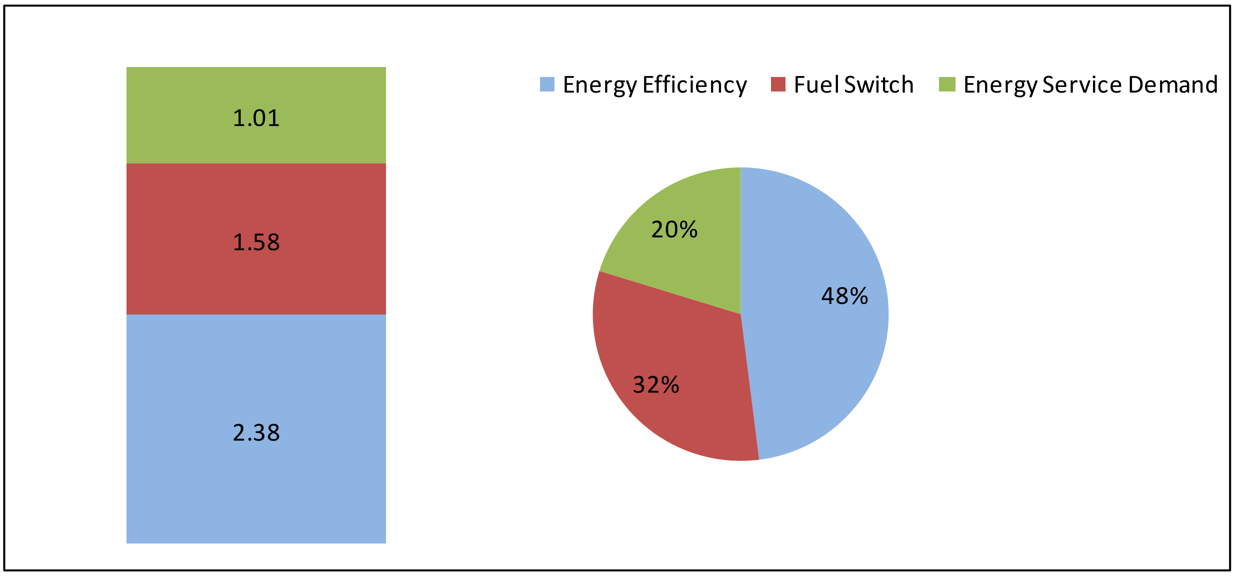


Figure 18: Action wise mitigation potential in building sector (million tonne CO2)

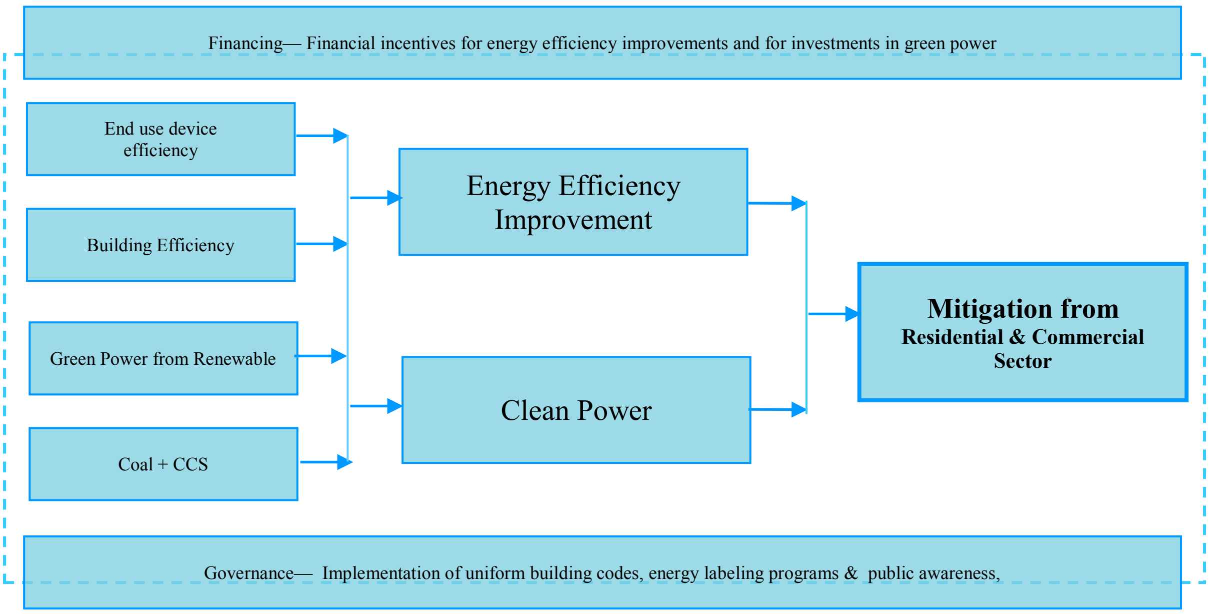


Figure 19: Mitigation policy package for residential and commercial sector

Transport (Passenger & Freight)

Passenger Transport Sector

In 2035 (BAU), the passenger transport demand is assumed to be 33 billion p- km, which has been assumed to remain the same in the 2035 LCS case. However the final energy consumption reduces from 1625 ktoe to 1120 ktoe, under the LCS scenario. Correspondingly the emissions reduce from 10.21 million ton -CO_2 to 2.66 million ton -CO_2. The largest mitigation is achieved from vehicle efficiency and improved traffic management. Moreover, there is a major share of this demand serviced by electric buses and trains. This shift provides the multiple benefit of reduction in energy demand on account of modal shift, and reduction in emissions due to fuel switch from Oil/Gas to low carbon electricity.

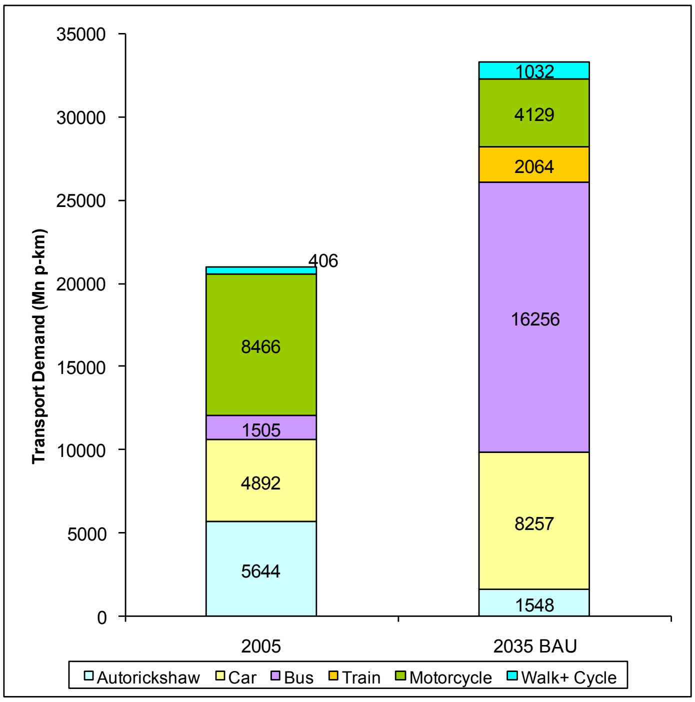


Figure 20: Passenger transport demand (Million p– km)

Freight Transport Sector

The freight demand in Ahmedabad is serviced by trucks, and the energy demand from freight transport increases substantially in the BAU scenario to 1154 ktoe. This increase is on account of manufacturing activities in the economy. Under the LCS scenario, the energy demand reduces to 644.17 ktoe, due to vehicle efficiency improvement and travel demand management. The corresponding reduction in GHG emissions is from 2.61 million ton -CO_2 to 1.62 million ton -CO_2.

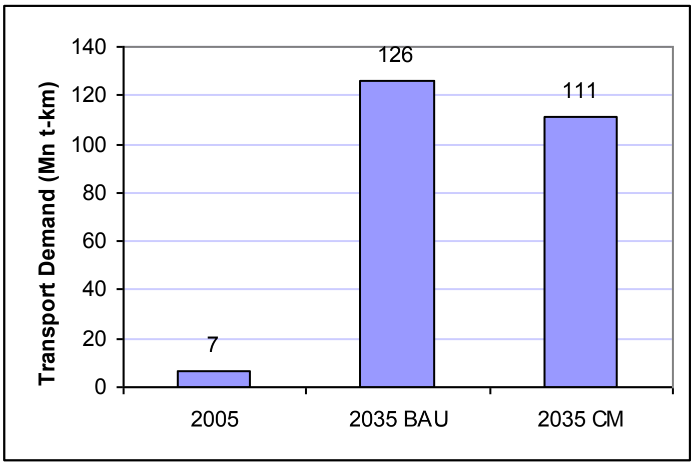


Figure 21: Freight transport demand (Million t– km)

Policy package for transport sector

The policy package of the transport sector primarily comprises of focus on energy efficiency (Vehicle efficiency, traffic management and shift form private vehicles to public vehicles), fuel switch (oil to gas, oil to electricity), and reduction in freight transport demand. There should be an increased thrust on electric vehicles, for both private vehicles and public transport buses. In order to promote such a transition, efforts have to be focused on better city planning, investments in public transport systems, standardization of vehicle efficiency norms, financial incentives to promote vehicles with better efficiency.

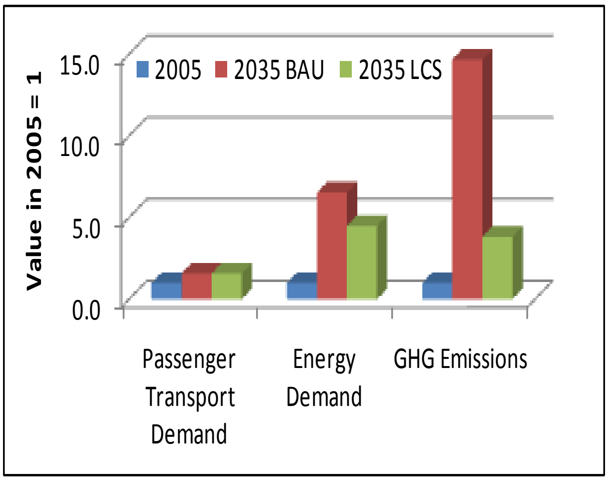


Figure 22: Change from base year: Passenger Transport

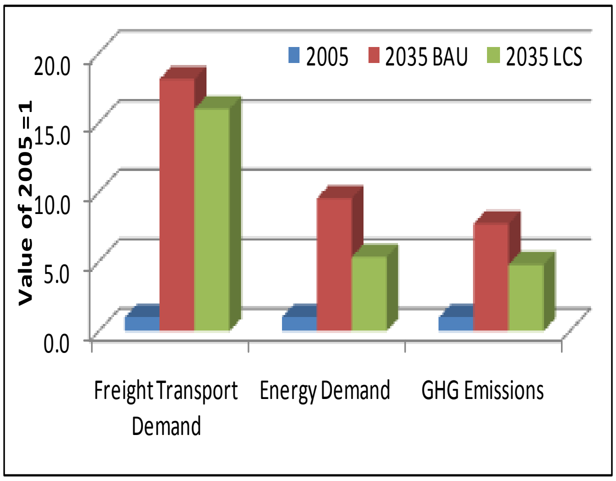


Figure 23: Change from base year: Freight Transport

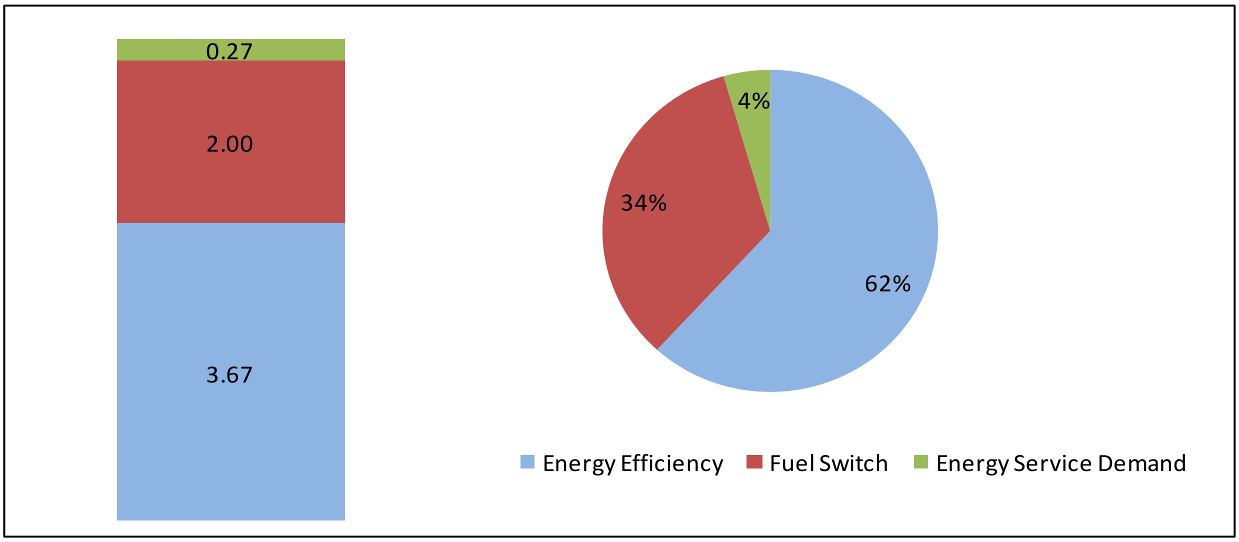


Figure 24: Action wise mitigation potential in the transport sector (million tonne CO2)

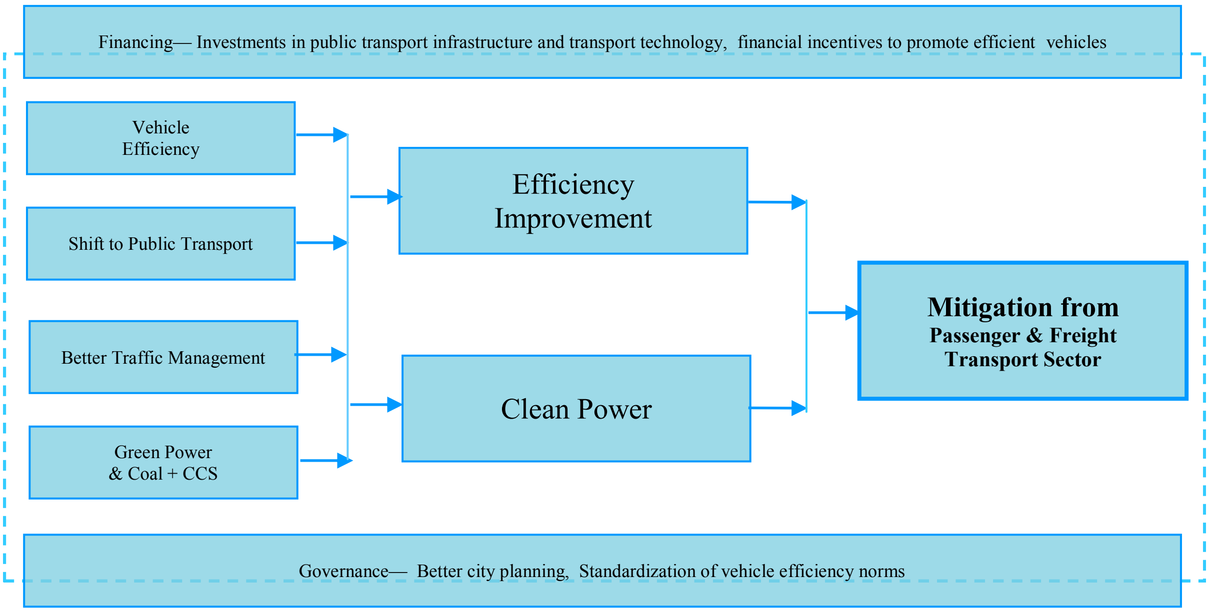


Figure 25: Mitigation policy package for passenger and freight transport sector

Industry & Power Sector

Mitigation measures in the Industrial sector

The industrial sector for this analysis comprises of the manufacturing, construction, electricity & water, transport equipments and agriculture. The output of these sectors increases to 7300 billion INR in 2035 BAU from 567 billion INR in 2005. The composition of industry in Ahmedabad would remain the same, with a change in the structure.The energy consumption in the industrial sector is 12.8 million toe in 2035 BAU. The emissions from the sector reduce to 12.10 million ton CO_2 in 2035 LCS case, as against 36.84 million ton CO_2 in 2035 BAU. This reduction is achieved by energy efficiency improvements in end-use devises like boilers and furnaces, fuel switch from coal & oil to gas and clean electricity. Moreover the electricity is from cleaner centralized power, generated from renewable and coal + CCS.

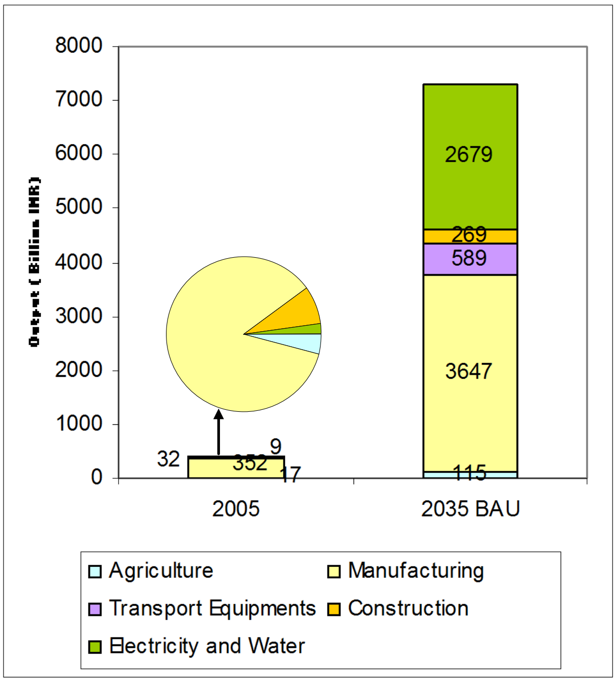


Figure 26: Output by industry (Billion INR)

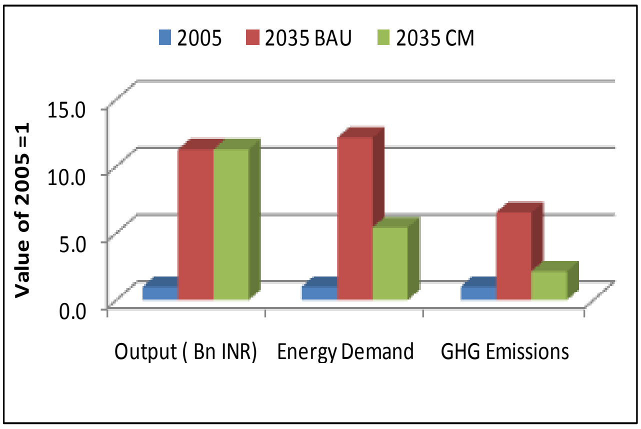


Figure 27: Change from base year in Industry sector

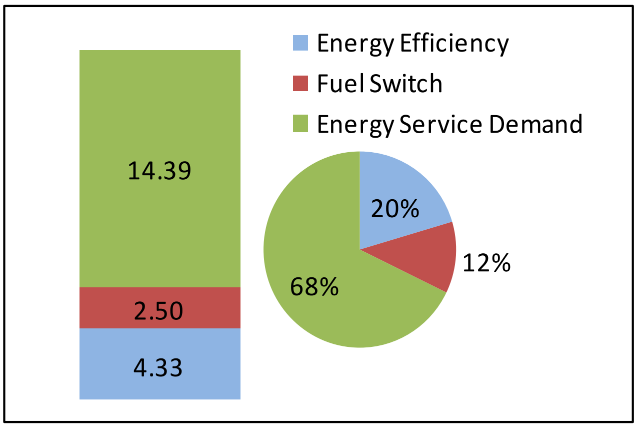


Figure 28 : Action wise mitigation potential in Industry sector (million tonne CO2)

Policy package for Industry sector

The policy package for the industrial sector comprises of measures that promotes reduction in energy service demand (decoupling energy and industrial output) , energy efficiency improvements in end-use devices (boilers and other industrial equipments), and fuel switch to cleaner fuels like gas and electricity. Financial incentives, and appropriate mandates for using energy efficient devices in the industry sector is essential. In order to achieve this, adequate investment incentives are to be provided either in the form of subsidies or accelerated depreciation for new investment in energy efficient technologies.

Mitigation measures in the Power sector

The power sector in Ahmedabad comprises of two power plants, one a 400 MW coal-based power plant and another 100 MW gas-based power plant. Besides, electricity is also imported from the grid, which is predominantly coal based. Therefore the power sector emits the maximum amount of GHGs on account of coal usage in huge quantities. The mitigation potential in the power sector emerges from efficiency improvements , fuel switch to gas or renewable energy like solar and biomass, clean energy in the form of nuclear (major part of this energy is to be procured from the grid) and also, by using the option of coal + CCS .

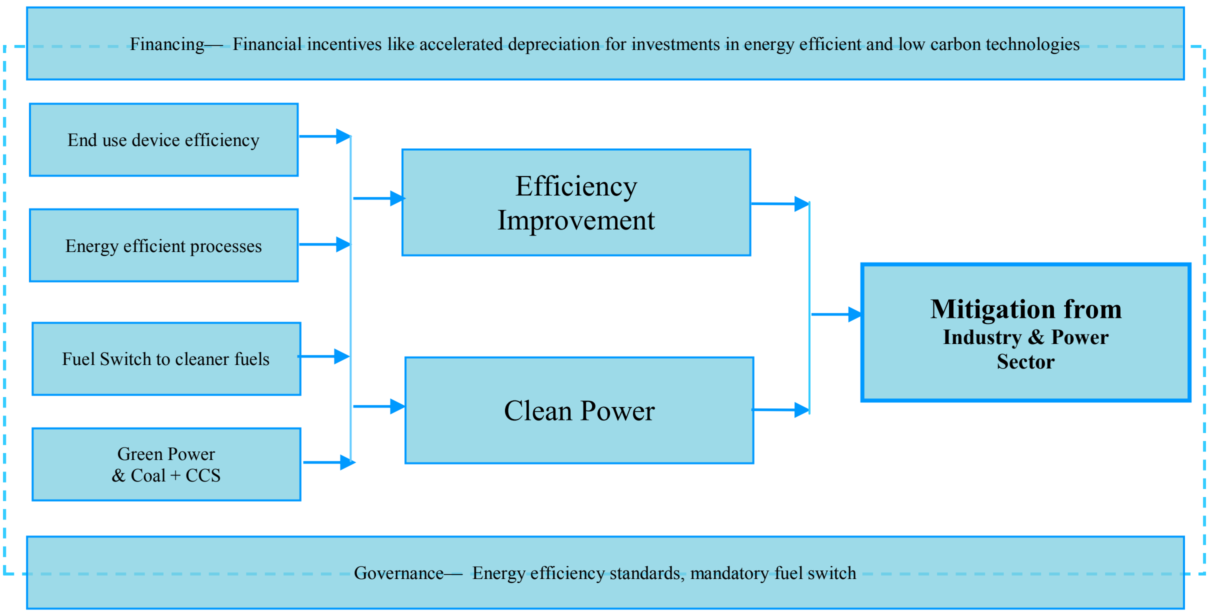
The total emission reduction of 41 million ton -CO_2 in Ahmedabad in the 2035 LCS case has a major contribution of 26.2 million ton -CO_2 (64%of total) from the power sector. Out of this reduction from Power Sector, majority (67% or 17.6 million ton -CO_2) is on account of energy efficiency and fuel switch in the power sector, and the remaining 33 % (8.6 million ton -CO_2) is contributed from using coal with CCS. Following table shows the contribution of various primary energy sources to the electricity sector under 2005 (Base), 2035 (BaU) and 2035 (LCS) Scenarios:

Table 5: Fuel wise composition of power sector (%)

%	*Coal*	*Oil*	*Gas*	*Hydro*	*Nuclear*	*Solar*	*Biomass*	*Total*
2005	91.74	1.95	6.16	0.00	0.00	0.15	0.00	100.00
2035 BAU	38.90	1.90	22.40	14.50	8.20	5.20	8.90	100.00
2035 LCS	33.82*	0.94	15.03	16.11	12.21	7.65	14.24	100.00

* 64.4 % of this is Coal + CCS

Figure 29: Mitigation policy package for Industry and Power Sector



Methodology

A Procedure to create a local LCS scenario

In order to create a local low-carbon society scenario, we developed a method based on the idea of "back casting", which sets a desirable goal first, and then seek the way to achieve it. Figure 27 shows overview of the method.

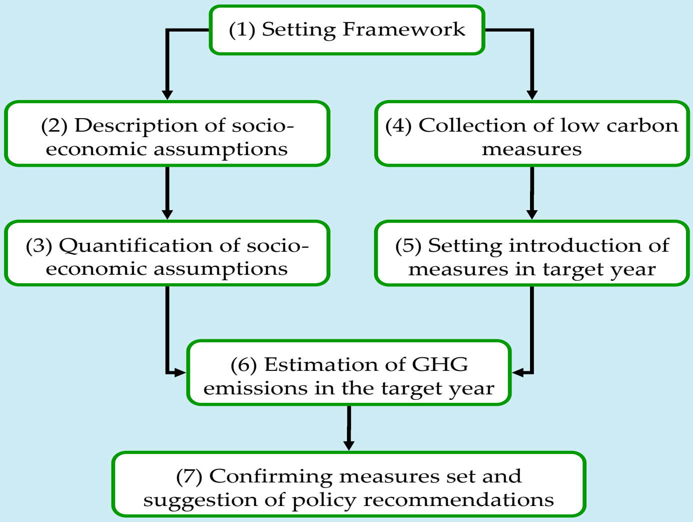


Figure 27. Procedure to create a local LCS scenario

(1) Setting framework

Framework of an LCS scenario includes; target area, base year, target year, environmental target, number of scenarios. Among them, the base year is compared with target year. The target year should be far enough to realize required change, and near enough to image the vision for the people in the region. In this study, we set the target year of Ahmedabad as 2035. This is also a suitable time span for an LCS study for the reasons above and also, in line with the explanation given earlier (p 4). As an environmental target, we targeted CO_2 from energy use because it will be a main source of GHG emissions from Ahmedabad in 2035.

(2)Assumptions of socio-economic situations

Before conducting quantitative estimation, qualitative future image should be written. It is an image of lifestyle, economy and industry, land use and so on. For this, we made assumptions about the future in Ahmedabad on various dimensions; such as economy, population, land use, etc. These assumptions were either based on the city CDP, or other government estimates about socio-economic conditions.

(3)Quantification of socio-economic assumptions

To estimate Snapshot based on future image of (2), values of exogenous variables and parameters are set. Using those input, ExSS calculates socio-economic indices of the target year such as GDP, output by industry, transport demand, and so on.

(4)Collection of low-carbon measures

To collect counter measures which are thought to be available in the target year. For example, high energy-efficiency devices, transport structure change such as public transport, use of renewable energy, energy saving behavior and carbon sink. Technical data is required to estimate their effect to reduce GHG emissions. In this research we employed those assumptions which are in line with a developing economy and also, considering the fact that in 2035 quite a number of advanced technologies and systems would penetrate into India, and thus Ahmedabad.

(5)Setting introduction of counter measures

Technological parameters related to energy efficiencies are defined with respect to current efficiency levels and also, its acceptance. In future estimates, such consideration as more penetration due to cost decrease is taken into account in specifying estimates about certain technologies.

(6)Estimation of GHG emission in the target year

Based on socio-economic indices and assumption of measures' introduction, GHG emissions are calculated.

(7)Proposal of policies

Propose policy set to introduce the measures defined. Available policies depend on the local situation of Ahmedabad. ExSS can calculate emission reduction of each counter measure.

Therefore, it can show reduction potential of measures which especially needs local policy. It can also identify measures which have high reduction potential and therefore important.

Quantitative estimation tool "Extended Snapshot Tool"

Figure 28 shows the structure of the Extended Snapshot Tool (ExSS); seven blocks with input parameters, exogenous variables and variables between modules. ExSS is a system of simultaneous equations. Given a set of exogenous variables and parameters, solution is uniquely defined. In this simulation model, only CO_2 emission from energy consumption is calculated, even though, ESS can be used to estimate other GHG and environmental loads such as air quality. In many LCS scenarios, exogenously fixed population data are used. However, people migrate more easily, when the target region is relatively a smaller area such as a state, district, city or town. Population is decided by demand from outside of the region, labor participation ratio, demographic composition and relationship of commuting with outside of the region. To determine output of industries, input-output approach with "export-base approach" is combined in line with the theory of regional economics.

Industries producing export goods are called "basic industry". Production of basic industries induces other industries i.e. non-basic industries, through demand of intermediate input and consumption of their employees. Number of workers must fulfill labor demand of those productions. Given assumptions of where those workers live and labor participation ratio, population living in the region is computed. This model enables us to consider viewpoints of regional economic development to estimate energy demand and CO2 emissions. For future estimation, assumption of export value is especially important if the target region is thought to (or, desired to) develop led by particular industry.

Passenger transport demand is estimated from the population and freight transport demand is a function of output by industries. Floor area of commerce is determined as the driving force for commercial sector. Other than these driving forces, activity level of each sector (energy demand by fuels) is determined from three parameters. One is energy service demand per driving force, energy efficiency and fuel share. Diffusion of counter measures changes the value of these parameters, and so GHG emissions.

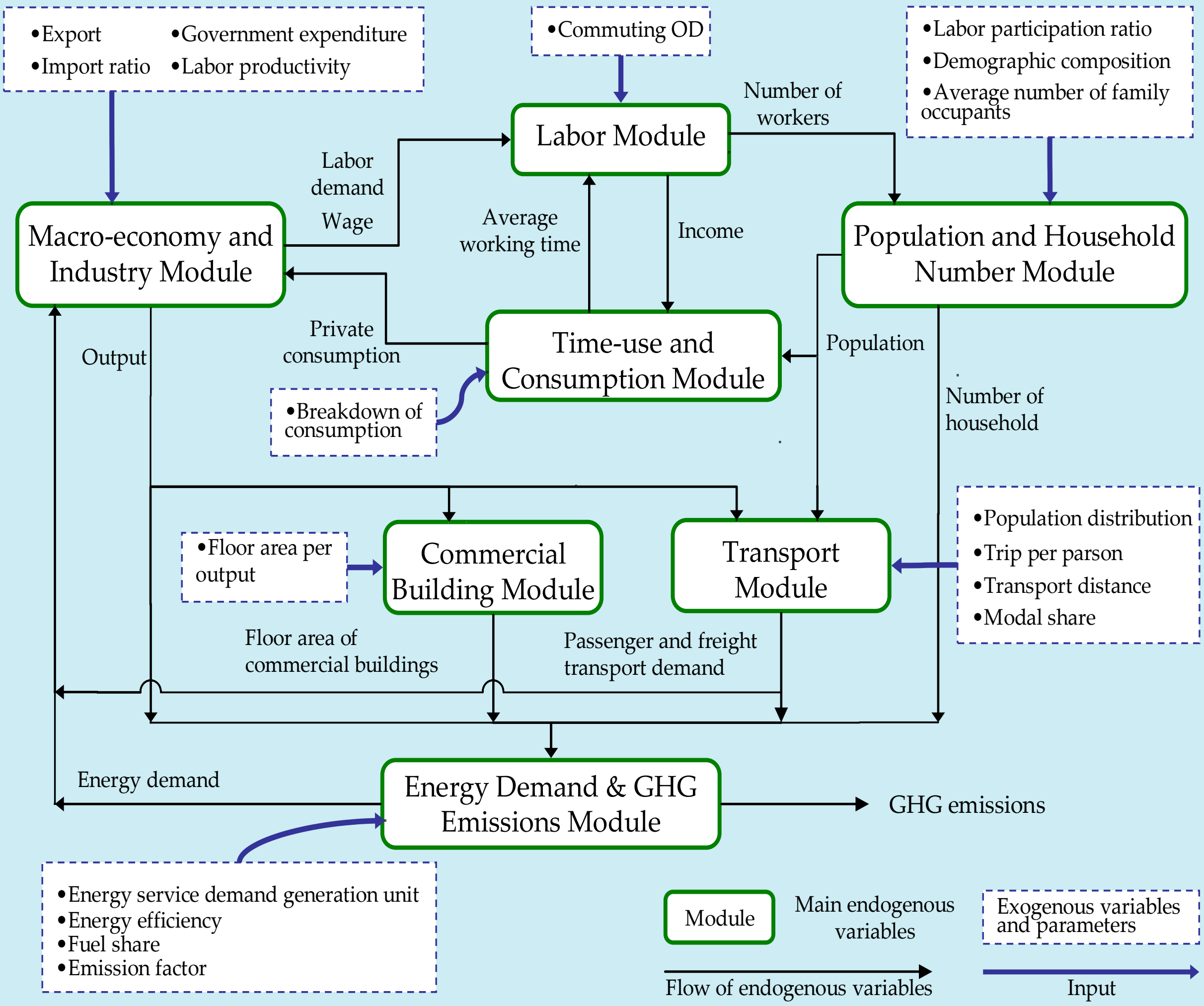


Figure 28. Overview of calculation system of Extended Snapshot Tool

Data Tables

Input-Output table in 2005 (Base year)

Unit: Billion INR	Agriculture	Manufacturing	Construction	Electricity and Water	Services	Total Intermediate Use	Private Consumption	Government Consumption	Private Investment	Government Investment	Export	Import	Total
Agriculture	2.88	56.77	1.53	1.10	3.48	65.76	19.46	0.12	0.22		6.62	-75.17	17.02
Manufacturing	1.31	116.27	9.07	1.37	10.10	138.11	21.03	1.01	11.90		206.65	-26.51	352.20
Transport Equipments	0.03	0.38	0.01	0.01	0.49	0.91	0.93	0.16	2.05			-4.05	0.00
Construction	0.14	7.77	0.94	0.18	2.46	11.49	0.10	0.86	21.33	2.78		-4.89	31.66
Electricity and Water	0.20	8.03	0.62	2.28	1.56	12.70	0.65	0.20			4.77	-9.23	9.09
Services	1.29	72.13	5.27	1.65	20.25	100.60	47.19	14.45	1.00	1.22	33.70	-41.24	156.93
Total Input	5.85	261.36	17.45	6.58	38.33	329.57							
Value Add -Wage	9.30	51.44	11.32	2.66	94.95								
Value Add - Capital	2.32	12.86	2.83	0.66	23.74								
Tax & Subsidy	-0.46	26.54	0.06	-0.81	-0.10								
Total Output	17.02	352.20	31.66	9.09	156.93								

Energy Balance Table in 2005 (Base Year)

Unit: Ktoe	Coal	Oil	Gas	Solar	Biomass	Electricity	Total
Passenger Transport	0.00	234.00	13.00	0.00	0.00	1.00	248.00
Freight Transport	0.00	121.00	0.00	0.00	0.00	0.00	121.00
Residential	0.00	174.00	0.03	0.31	2.00	167.00	343.34
Commercial	0.00	35.00	0.03	0.00	0.00	42.00	77.03
Industry	579.00	145.00	124.00	0.00	15.00	194.00	1057.00
Total	579.00	709.00	137.06	0.31	17.00	404.00	1846.37

Input-Output table in 2035 BAU (Target Year)

Unit: Billion INR	Agriculture	Manufacturing	Construction	Electricity and Water	Services	Total Interme-diate Use	Private Con-sumption	Government Consumption	Private Invest-ment	Government Investment	Export	Import	Total
Agriculture	19.47	587.91	28.47	32.49	59.45	727.78	269.62	3.50	6.74		44.42	-937.11	114.95
Manufacturing	8.82	1203.99	168.85	40.44	172.40	1594.50	828.24	30.60	220.24		1385.49	-411.91	3647.16
Transport Equip-ments	0.18	3.93	0.19	0.31	8.32	12.92	42.72	4.79	61.76			-122.18	0.00
Construction	0.96	80.47	17.55	5.29	41.97	146.23	4.44	25.85	440.47	63.41		-90.99	589.41
Electricity and Water	1.37	83.20	11.59	67.51	26.63	190.30	29.90	5.98	341.81	24.73	32.01	-355.63	269.09
Services	8.74	746.99	98.20	48.71	345.73	1248.37	1521.30	436.00	30.17	38.68	225.95	-821.21	2679.27
Total Input	39.54	2706.48	324.83	194.75	654.51	3920.11							
Value Add -Wage	62.82	532.66	210.73	78.68	1621.16								
Value Add - Capital	15.70	133.17	52.68	19.67	405.29								
Tax & Subsidy	-3.11	274.85	1.16	-24.00	-1.69								
Total Output	114.95	3647.16	589.41	269.09	2679.27								

Energy Balance Table in 2035 BAU (Target Year)

Unit: Ktoe	Coal	Oil	Gas	Solar	Biomass	Electricity	Total
Passenger Transport	0.00	56.00	73.00	0.00	12.00	1484.00	1625.00
Freight Transport	0.00	935.00	0.00	0.00	219.00	0.00	1154.00
Residential	0.00	237.00	250.00	1.60	1.60	454.00	944.20
Commercial	0.00	0.00	805.00	25.00	0.00	832.00	1662.00
Industry	947.00	1332.00	8341.00	0.00	379.00	1833.00	12832.00
Total	947.00	2560.00	9469.00	26.60	611.60	4603.00	18217.20

Ahmedabad Low Carbon Society Vision 2035
October 2009

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