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Poverty and Low Carbon Development Strategies

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Country Study (India)

Poverty and Low Carbon Development Strategies

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Abbreviations and acronyms

BAU	Business as usual scenario
BPL	People below poverty line
CSO	Central statistical organization
ET	Transfer for electricity
LPR	Low urban rural parity ratio
MGNAREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MPCE	Monthly per capita consumption expenditure
NAS	National sample survey organization of India
NEM	National enhanced energy efficiency mission
PAMA	Poverty alleviating mitigation actions
PCTC	Per capita total annual consumption expenditure
PDS	Public distribution system for providing subsidised food to poor
PT	Partial cash transfer

Executive summary

India faces many development challenges. It has to lift 340 million people out of poverty, reduce the rural-urban disparities, address energy poverty and solve many other development issues. But India also needs to contribute in solving the climate change problem and take mitigation actions.

Thus there is need to establish the impact of development initiatives in general and poverty alleviation measures in particular on the CO_2 emissions of the country and the extent to which they affect CO_2 emissions compared to a business-as-usual situation. Furthermore, mitigation actions should also be assessed from the point of view of their impact on poverty. Mitigation actions in India require increased investments in the energy sector, as renewable sources of energy are expensive compared to fossil fuels and so tend to reduce non-energy sector investments unless these are then funded by foreign capital. Non-energy sector investments include development initiatives like poverty alleviation, food security, investments in health and education etc., which directly affect the well being of everyone but especially the poor. Hence, it is important to study this impact of poverty alleviation on mitigation and vice versa, before formulating any low-carbon development strategies and poverty-alleviating mitigation actions (PAMAs) at the country level. More so, because PAMAs might work at specific action level but might yield smaller results at macro level.

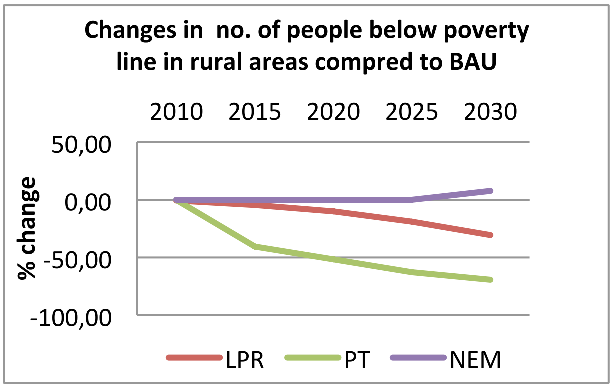
IRADe (Integrated Research and Action for Development) was commissioned by MAPS to undertake this study on poverty and low carbon development strategies.

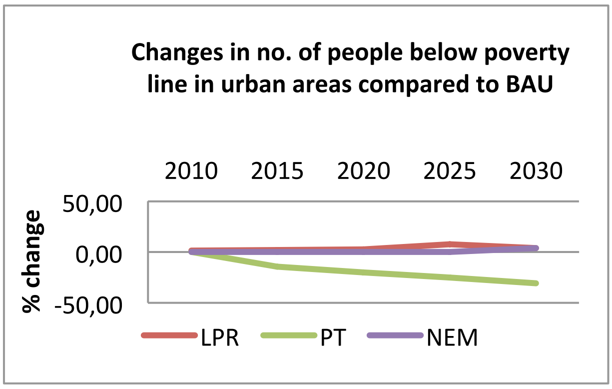
Four scenarios are created taking into account current Indian situation and policies:

1. Partial cash transfer to the poor households till they come out of poverty – PT (partial transfer).
2. Lowered urban to rural consumption expenditure parity ratio – LPR (low parity ratio).
3. Providing subsidised electricity to poor households – ET (electricity transfer).
4. National energy mission which provides targets for solar and wind based power generation in India – NEM (national energy mission).

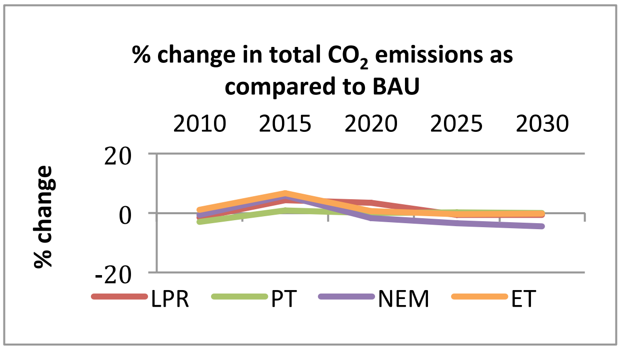
All the scenarios are compared with the business-as-usual (BAU) scenario in the model, and results are reported for the period of 2010 to 2030. The results discuss in detail the impact of various scenarios on a whole range of macro-level parameters like GDP, per capita consumption, poverty levels, poverty head count ratio, urban rural disparity, electricity consumption by poor, as well as carbon emissions, CO_2 intensity of GDP, energy intensity of GDP, etc. These results are shown graphically on the following page

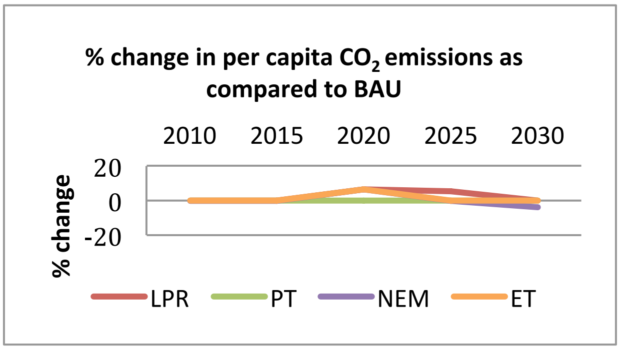
Poverty alleviation can be achieved through both the partial transfer (PT) and lowering urban rural disparity (LPR) scenarios. Subsidising electricity to poor households (ET) does not appear to reduce poverty. Mitigation action (enhancing energy efficiency) (NEM) does not increase poverty. (See graphs a and b).



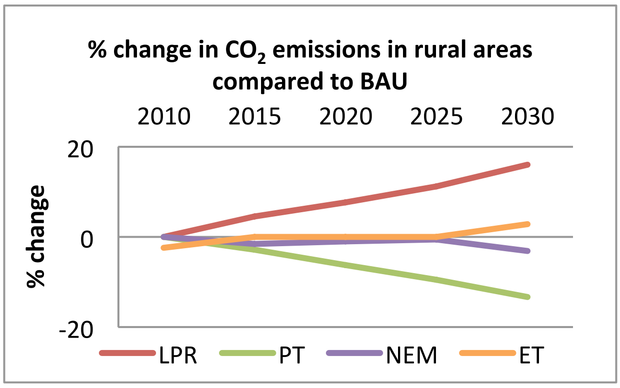


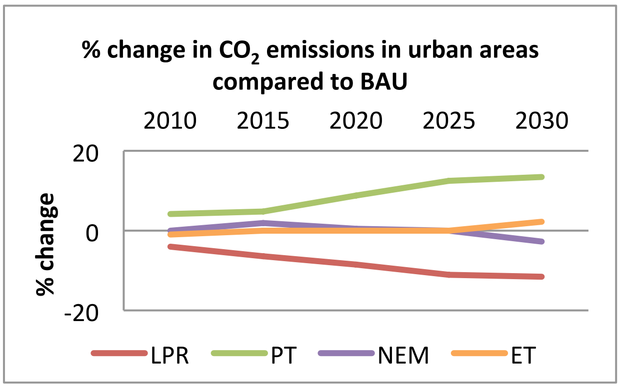
CO_2 emissions can be reduced by mitigation actions like national energy mission. Also, poverty alleviating measures increase CO_2 emissions in short term, but tend to come back to BAU levels in the longer term. See graphs c and d.





The model also predicts CO_2 emissions at household level. Rural and urban CO_2 emissions are found separately across scenarios and graphs e and f.





The results indicate that development goals like poverty alleviation, providing energy access to poor, and reducing urban-rural disparities can be achieved without increasing carbon emissions compared to BAU. Also, certain mitigation actions can be taken without increasing poverty.

1. Introduction

For developing countries like India the meaning of development is quite different from what it is for developed countries. India needs not just to sustain a high rate of growth and achieve higher and higher per capita income for its people, but must also solve enormous problems of poverty, inequality, a widening rural-urban disparity, lack of access to basic necessities of life for large number of its population ,and so on.

Traditional economic theory suggests that, in a land-scarce country like India, when incomes grow people shift from agriculture to industry to the service sector. Hence, if India has to lift its 340 million poor out of poverty, a structural change in the economy is essential. The number of people dependent on agriculture has to reduce. Rapid industrialization is required to provide productive employment to people moving out of agriculture and the service sector may have to grow even faster. Such structural change invariably implies growing urbanization. Also, people will move from lower- to higher-income classes, and when this will happen their consumption will increase and their consumption pattern will change.

This kind of development seen in the developed countries is fossil fuel energy-intensive. Rapid industrialization means higher demand for fossil fuels and changes in the consumption pattern imply more people using energy-intensive goods like electric appliances, motor cars, etc. Such higher energy consumption leads to higher CO_2 emissions (all things being equal). If India's per capita emissions keep on rising on account of a fossil fuel energy-intensive development path, it will become a major contributor to CO_2 emissions in the future given its population size, since India is already third-largest in total CO_2 emissions per year (IEA Key World Energy statistics, 2011).Following a low-carbon development path is therefore a necessity for India.

India, however, faces a unique problem. It has to lift around 340 million people out of poverty - the largest number of poor in any single country in the world. India needs to bring them into mainstream of development and provide them with sustainable livelihood opportunities. But once this many people come out of poverty and start consuming more and more fossil fuel energy-intensive goods, per capita and total country emissions will increase, thus adding to the climate change problem. Further, it is extremely difficult to lift people out of poverty without at the same time adding to the incomes of richer people– who contribute to emissions much more than poor. In short, there seems to be a tradeoff between achieving development and addressing climate change issues.

A PAMA or "poverty alleviating mitigation action" is a possible way out of this dilemma (Wlokas et al 2012). If mitigation actions can help in reducing poverty and provide livelihood opportunities to the people, both mitigation and poverty can be addressed simultaneously. Though this is quite true in case of individual mitigation actions, it might prove otherwise when analyzed in the macro-economic framework of India. When resources are diverted from the non-energy sector to the energy sector to achieve energy efficiency and increase the use of relatively expensive renewable energy sources to reduce carbon emissions, it often means that fewer resources are available for development initiatives which directly affect poor people. In the case of India, the size of the poverty problem implies that lifting millions out of poverty without increasing carbon emissions compared to a business-as-usual (BAU) scenario would be a remarkable achievement. It is proposed, however, that there can be various scenarios which can reduce poverty while simultaneously following the path of reduced energy intensity and emissions intensity of GDP. Alternatively, undertaking mitigation actions which do not reduce non-energy sector investments and do not threaten to increase poverty are also PAMAs.

2. Literature review

Existing literature dealing with poverty and rural-urban disparity problems in India does not deal with climate change explicitly. On the other hand, mitigation action literature, occasionally addresses the issue of achieving poverty reduction along with mitigation but does not deal with poverty as a central theme or give clear programs to combine both. One may also consider the notion of Business-as-unUsual, i.e. a pathway including existing policy, as developed by Strachan (2011), but applied to include (sustainable) developmental policies. Nonetheless, it is important to look at the existing literature to review the current poverty indicators in India, the situation of rural urban disparity and current important poverty alleviating measures. Mitigation actions and relevant policies initiated by the Indian government in the recent period are also reviewed. The scenarios described later in the model should be specifically viewed in the light of this current Indian situation.

2.1. Poverty in India

According to UNDP, 29.8% of India's population was poor in 2009-10, with the absolute number of poor being 354.68 million.

Table 1: Poverty indicators for India

Indicator	Reference Year	Value
Poverty headcount ratio (%)	2009-10	29.8
Total number of poor (in millions)	2009-10	354.68
Multidimensional poverty index (MPI)	2005	0.283
Multidimensional poverty headcount (%)	2005	53.7
Number of multidimensional poor (in millions)	2005	612
Global hunger index (GHI)	2004-09	23.7
Proportion of undernourished in population (%)	2005-07	21
Prevalence of underweight children under 5 years of age (%)	2005-07	43.5

Source: UNDP India factsheet- economic and human development indicators

In India, the poverty line is decided by the Planning Commission of India by appointing an expert group, which decides on the criteria to be included in establishing the poverty line. According to the Tendulkar committee appointed by the Planning Commission in 2009, poverty is defined based on the consumption expenditure given by National Sample Survey of India. The committee decided that people having monthly per capita consumption expenditure below Rs672.8 in rural areas andRs859.6 in urban areas in 2009-10 will be regarded as below the poverty line. According to this committee's estimates, there were 354.68 million poor persons in 2009-10. The poverty head count ratio for India was 29.8–33.8% in rural areas and 20.9% in urban areas in that period.

Table 2: Poverty indicators as per Planning Commission of India

	Poverty ratio (%)			Number of poor (million)		
	Rural	Urban	Total	Rural	Urban	Total
Expert group 2009 (Tendulkar methodology)						
1993–94	50.1	31.8	45.3	328.60	74.50	403.70
2004–05	41.8	25.7	37.2	325.81	81.41	407.22
2009–10	33.8	20.9	29.8	278.21	76.47	354.68
Annual average decline from 1993-94 to 2009-10						
from 1993–94 to 2004–05	0.75	0.55	0.74	0.25	-0.63	-0.32
from 2004–05 to 2009–10	1.60	0.96	1.48	9.52	0.99	10.51

Source: India Planning Commission website

2.2. Rural-urban disparity

Along with poverty, India faces a problem of a widening rural-urban disparity. This is measured by the rural-urban income gap and the rural-urban consumption gap.

2.2.1. Calculating rural-urban disparity based on income data

Generally the rural-urban disparity is calculated in terms of differences in income distribution. The Central Statistical Organization (CSO) of India tries to give approximate rural and urban income levels based on net domestic product calculations for various sectors separately for rural and urban areas.

CSO has given rural per capita net value added (NVA) at Rs16 414 and urban per capita NVA at Rs44 172in 2004–05 (at current prices) (national account statistics: sources and methods, 2012,). Thus, urban per capita income is 169% higher than that of rural areas for 2004–05. The rural-urban disparity in per capita income has gone up sharply over the three and a half decades. The ratio of urban to rural per capita income was 2.45 in 1970–71 and remained at a low level of 2.30 during the 1980s and early 1990s but went up sharply to 2.7 and 2.8 in the early and mid years of the 2000–2010 decade (Kundu, 2010). The following graph clearly depicts the rising rural-urban disparities in income.

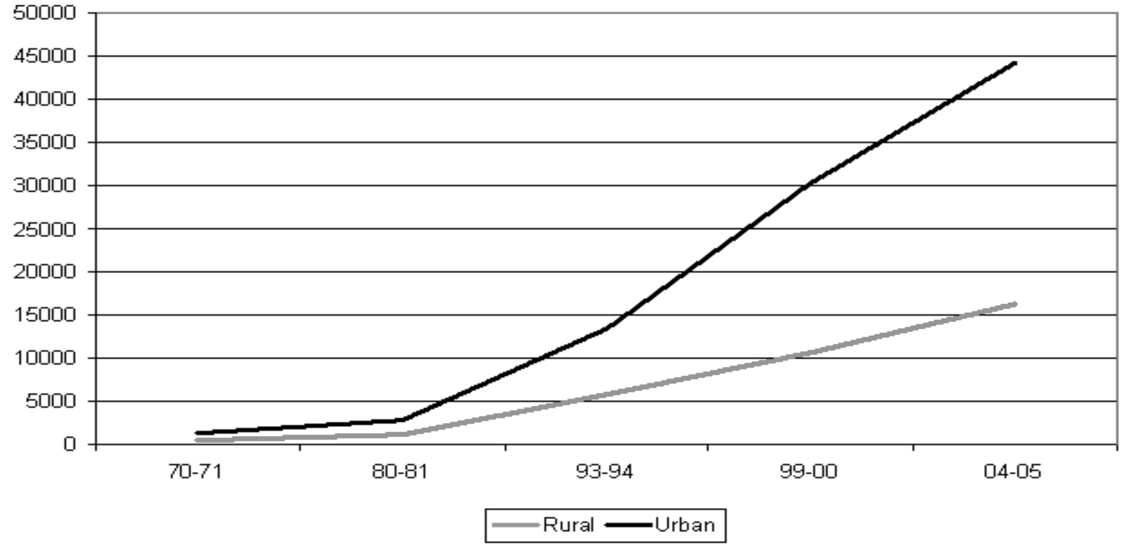


Figure 1: All-India average per capita income 1970-70 to 2004-2005
Source: Kundu A (2010)

2.2.2. Calculating the rural-urban disparity based on consumer expenditure data

Due to various problems attached with using CSO data for calculating the rural-urban disparity based on income data and lack of availability of continuous time series income data, it is common practice in India to use consumer expenditure data provided each year by a National Sample Survey (NSS) to calculate the disparity. According to NSS's 66th round for 2009–10, average rural monthly per capita consumer expenditure (MPCE) is Rs1, 053.64 and urban MPCE is Rs1, 984.46. Hence, urban MPCE is 88% higher than rural MPCE. The ratio of urban to rural MPCE is 1.88. Looking at the class-wise distribution of MPCE, it is clear that the rural-urban gap is widening at the higher decile classes.

Table 3: Average MPCE across decile classes

Rural India		Urban India		
Decile class of MPCE (MMRP)	**Average MPCE (MMRP) (Rs)**	**Decile class of MPCE (MMRP)**	**Average MPCE (MMRP) (Rs)**	**Ratio of urban to rural MPCE**
1st	452.98	1st	599.27	1.32
2nd	584.4	2nd	830.96	1.42
3rd	675.35	3rd	1011.84	1.50
4th	760.79	4th	1196.08	1.57
5th	848.07	5th	1397.99	1.65
6th	944.35	6th	1633.42	1.73
7th	1062.93	7th	1930.96	1.82
8th	1220.59	8th	2329.87	1.91
9th	1470.33	9th	3050.69	2.07
10th	2516.69	10th	5863.25	2.33
all classes	**1053.64**	**all classes**	**1984.46**	

*MMRP – modified mixed reference periods

Source: NSSO 66th round report, 2009-10

Table 3 shows that the difference between bottom decile classes in rural and urban areas is not much, rural MPCE for 1st decile being Rs452.98 and the figure in urban areas being Rs599.27 which is only 1.32 times the rural MPCE. But for the top decile the difference between urban and rural areas is clearly visible. Urban MPCE for the top decile is more than double that of rural areas (2.33 times)

There are also differences in the rural-urban gap across Indian states. Average urban MPCE was only 28% higher than average rural MPCE in Punjab, only 31% higher than average rural MPCE in Kerala, and only 41% higher in Rajasthan. In Maharashtra and Chhattisgarh, on the other hand, average urban MPCE was around 110% higher than average rural MPCE. In West Bengal and Karnataka, too, per capita expenditure in the urban sector was more than double that in the rural one.

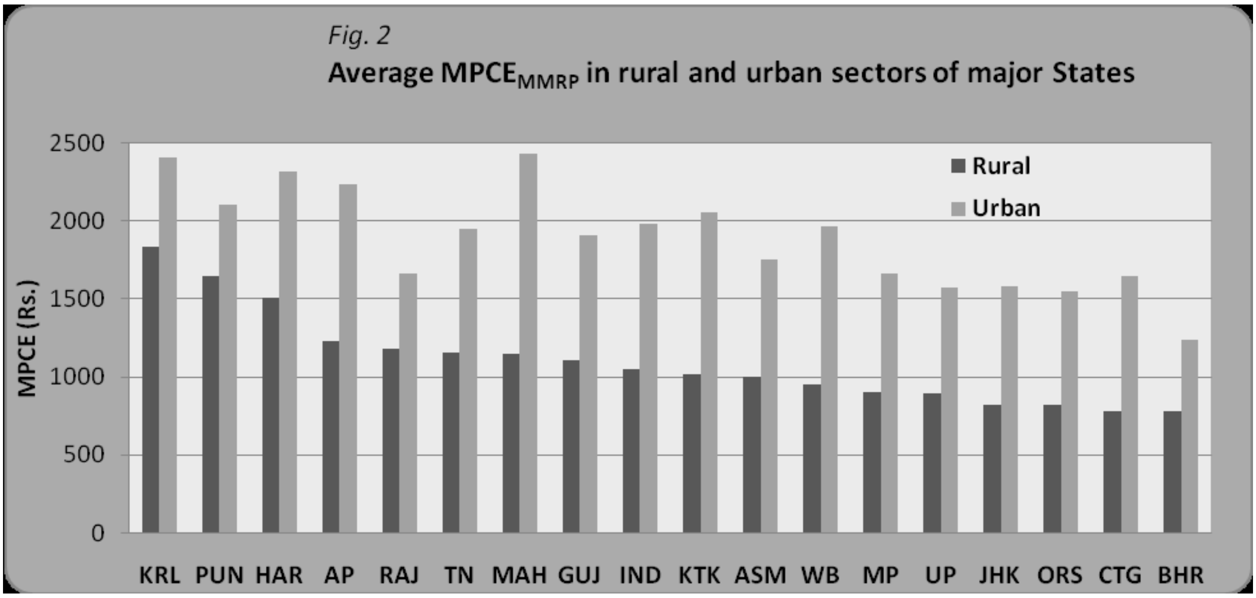


Figure 2: Average MPCE in rural and urban sectors of major states

Source: NSSO 66th round report, 2009-10

The rural-urban gap can also be seen with patterns of food expenditure. In Urban India the share of food in total monthly per capita expenditure is 40%, whereas in rural India the figure is 53%, and only 47% is available for non-food items – which are, in fact, highly valued durable items and “luxury items” important to standards of living.

The growth of MPCE over the period of 1987–88 to 2009–10 using mixed reference period (MRP)[1] also demonstrates that rural MPCE is growing at a slow pace compared to urban MPCE, thus widening the rural urban gap.

[1] Mixed reference period – MRP – refers to the use of different recall periods for different categories of items during the consumption expenditure survey carried out by National Sample Survey Organization of India. While reporting the consumption of goods by households, for the purchase of items like clothing, footwear, education, medical care (institutional) and durable goods a reference period of 365 days is used while for all other items (viz all food, pan, tobacco and intoxicants, fuel and light, miscellaneous goods and services including non institutional medical care, rents and taxes) a reference period of 30 days is taken.

Table 4: Growth of monthly per capita consumption expenditure from 1987–88 to 2009–10

Year	Urban average MPCE			Rural average MPCE		
	With current prices	With constant prices	Price deflator (with 1987-88 MPCE as 100)	With current prices	With constant prices	Price deflator (with 1987-88 MPCE as 100)
1987-88	250	250	100	158	158	100
1993-94	464	268	173	286	163	176
1999-00	855	306	279	486	179	271
2004-05	1105	327	338	579	182	319
2005-06	1171	330	355	625	187	334
2006-07	1313	345	380	695	192	362
2007-08	1472	366	402	772	199	389
2009-10	1856	369	503	953	193	494

Source: NSSO 66th round report, 2009-10

MPCE in rural India has grown from Rs158 in 1987–88 to Rs193 in 2009–10 at constant prices – that is, by about 22% in 23 years. But urban MPCE has grown from Rs250 in 1987–88 to Rs369 in 2009–10 – a growth of 47.6% over the 23-year period since1987–88.

Average figures are not sufficient to understand the actual differences in consumer expenditure across states. Urban MPCE is highest in the state of Maharashtra, at Rs2436.75 whereas rural MPCE is lowest in the state of Bihar at Rs681. Hence the highest MPCE level in urban areas is 258% that of the lowest in rural areas.

2.2.3. Increasing trend of rural-urban disparity

We have calculated the urban-rural MPCE ratio for various years from 1987–88 to 2009–10 using MPCE at current prices, constant prices and price deflator. The results give different ratios with different parameters but confirm the trend of increasing rural–urban disparity.

Table 5: Ratio of urban to rural monthly per capita consumption expenditure

	With current prices	With constant prices (base 1987-88	Price deflator (with 1987-88 MPCE as 100)
1987-88	1.58	1.58	1.00
1993-94	1.62	1.65	0.98
1999-2000	1.76	1.71	1.03
2004-05	1.91	1.80	1.06
2005-06	1.87	1.76	1.06
2006-07	1.89	1.80	1.05
2007-08	1.91	1.84	1.03
2009-10	1.95	1.91	1.02

Source: computed by author

Using constant prices is a better indicator to show changes in consumption expenditure across time and thus to show changes in the urban: rural ratio of consumption expenditure.

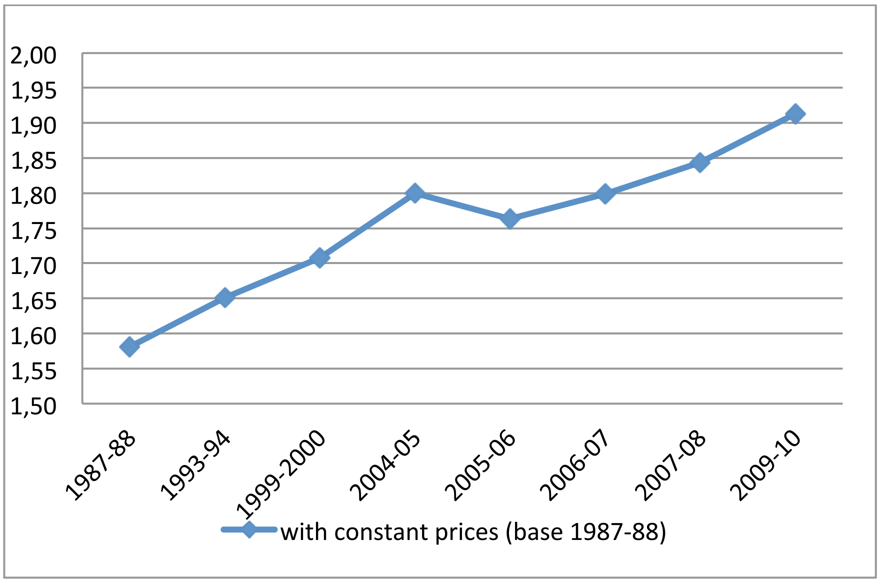


***Figure 3**: Ratio of urban to rural monthly per capita consumption expenditure*

2.3. Review of poverty-alleviating and disparity-reducing measures

For tackling the issue of poverty and rural-urban disparity, the government of India has started several programs. We review here two of the most important –one providing subsidised food to the poor, one providing guaranteed employment for rural households.

2.3.1. Public distribution system for providing subsidised food to poor

Broad framework of the public distribution system

The public distribution system (PDS) in India providing subsidised food to poor households is the largest welfare programme in India, with a budget corresponding to about 1% of the net national product. The fair-price shops under the PDS provide food grains (which include rice and wheat) for Below Poverty Line (BPL) people. A total of 35kg of food grains is provided per family per month. According to the economic survey for 2009-10, there are 65.2 million families receiving subsidised food under the PDS. Whether a particular household will be eligible for a BPL card or not depends on two different processes. Firstly, the numbers of BPL households is determined based on the Planning Commission of India estimates of poverty, superimposed on the number of households from census data. Secondly, an independent exercise of identification is conducted based on a household census using criteria determined by the Ministry of Rural Development, with the restriction that the number of poor to be identified by this process should be within the number estimated by the Planning Commission of India. Currently, government uses a 13-point criterion to identify poor people. It has proxy indicators like ownership of house, land, toilets etc, but the method has proved to be problematic so far.

Problems with the public distribution system

1. There are many problems associated with the identification of poor and subsequent distribution of BPL cards. The data from the 61st round of the National Sample Survey shows that only 44% of the households in the poorest quintile have BPL cards, while 17% of the households in the richest quintile also have them, which means there are large exclusion and inclusion errors in the identification of the poor. The exclusion errors are lower in states that have a higher coverage of the PDS.
2. One study found the PDS rarely meets the full requirement of cereals of the poor households. They have to depend on the market for remaining supplies. As a result, these households spend around 60% of their income on food items. For achieving food security, market price stabilization is also important and mere PDS reform will not be sufficient.
3. The cost of income transfer to the poor is very high in PDS. On average, the subsidy received by the poor is Rs11–17 per person per month, or Rs132–204 per person per year. The Planning Commission, in its report on the performance evaluation of PDS (2005), has considered whether the real income gain to the beneficiary (BPL households) is equal to (or more or less than) the amount of budgetary subsidy on food grains. For most states, the income gain to a BPL family is less compared to the budgetary

income transfer per BPL family. Hence, PDS is proving inefficient in providing effective income transfer to the poor and alternatives need to be implemented.

Instead of providing subsidized food through Public Distribution System, one alternative to providing subsidised food through the PDS could be direct cash transfer to the poor.

Concept of cash transfer

Cash transfers can be conditional (subject to the households meeting certain demands) or unconditional targeted (given only to households or individuals meeting particular criteria) or universal. If PDS is replaced with cash transfer, direct cash subsidies will be given to poor households, whereby a fixed amount will be transferred into people's bank accounts each month.

Case for replacing PDS with cash transfer

Many researchers have pointed out that nutrition status is not directly related to the consumption of cereals (Sharma, 2006; Deaton and Dreze, 2009; Headey et al, 2011); hence it is not very compelling to continue supplying food grains through PDS from the food security point of view. A cash transfer would let the family spend the money as it wishes - say on milk, or on sending the child to a better school (Parikh, 2011). As Dr Parikh suggests, any transfer should be made in the name of the woman of the household to empower her and to minimize its misuse. There is also need to minimize the inclusion and exclusion errors in the selection of poor people who would benefit. Parikh suggests that, instead of selecting poor people, the schemes should eliminate the rich who are easier to identify. For example, if all those who pay income tax, those who own motorized vehicles and all those in the organized sector, including government, with monthly emoluments of more than Rs15000 are excluded, the inclusion error could be reduced. A rough estimate of the number of households which would be thus excluded is some 30–40 million. Further, a reduction can be achieved through self-selection, as observed by Kotwal et al (2011). Better-off households would not perceive the gains from cash transfer as high and might ignore the scheme.

2.3.2. Employment guarantee scheme as a method of effective cash transfer

The second most important poverty alleviation program in the recent years is the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), the flagship programme of the Indian Central government, started in 2006. It aims to enhance the livelihood security of people in rural areas by guaranteeing100 days of wage-employment in a financial year to a rural household whose adult members are willing to do unskilled manual work.

Rationale behind MGNEGA

In rural areas in India 38% of male workers and 40% of female workers are casual labourers. Out of this, 63% of male workers and 79% of female workers are engaged in agricultural work (key indicators of employment & unemployment in India, 2009-2010) Due to the seasonal nature of agricultural work, these workers do not find year-round employment. Males are unemployed for 46 days on an average each year and women for around 40(report on wages & earnings of rural labour households, 2004-05)). Due to this chronic unemployment in rural areas, an effective employment guarantee scheme is needed. Also, rural areas are particularly behind in infrastructure like all-weather road connectivity, irrigation facilities, land development etc. MGNREGA responds to the dual needs for employment and rural infrastructure.

Salient features of MGNREGA

1. *Coverage*

   Since the third year of its implementation in 2008-09, MGNREGA covers the entire rural area in 619 districts in India.

2. *Hundred days job as a legal right*

   The Act has made supplementary livelihood in rural areas through unskilled manual work a legal right. Any rural household seeking unskilled manual work can register its family in the Gram Panchayat (village level authority) and obtain a job card. That household can then apply for work for at least 100 days in the Gram Panchayat, which is entrusted with the duty of providing work to the applicant within 15 days of the receipt of the application, failing which an unemployment allowance becomes payable to the household. The employment guarantee is for only one person per household – which decides itself on the person, and can change the person during the employment period.

3. *Payment of wages*

   The law prescribes payment of wages every week and not later than a fortnight after the work is done. In the event of delay in payment of wages, workers are entitled to compensation under the Payment of Wages Act, 1938. The average daily wage earned in 2011 was Rs100. Wages are deposited in bank or office accounts.

4. *Female participation*

   At least one-third of those given work must be women. As of 2011, the female participation rate has already reached 40-45% in many states.

5. *Types of work done under MGNREGA*

   - water conservation and water harvesting;
   - drought proofing, including plantation and afforestation;

- irrigation canals, including micro and minor irrigation works;
- renovation of traditional water bodies, including desilting of tanks;
- land development;
- flood control and protection works including drainage in waterlogged areas;
- Rural connectivity to provide all-weather access.

6. *Ensuring unskilled nature of work*

   The cost of the material component of projects, including the wages of the skilled and semi-skilled workers taken up under the scheme, must not exceed 40% of total project costs. Contractors and labour-displacing machinery are prohibited.

7. *Ensuring proper work conditions*

   Work should ordinarily be provided within a five-kilometer radius of the village, or a wage supplement of 10% is payable. Worksite facilities such as crèches, drinking water and shade have to be provided. A social audit has to be done by the Gram Sabha at least once in every six months.

8. *Funding*

   Central government pays:

   - the entire cost of wages of unskilled manual workers;
   - 75% of the cost of materials and the wages of skilled and semi-skilled workers.

   The state government pays the remaining 25% of the cost of materials and wages of skilled and semi-skilled workers.

Achievements of MGNREGA

Since its inception in 2006, MGNREGA has performed impressively in creating rural gainful employment and thus alleviating rural poverty and reducing rural inequality.

Table 6: Performance overview of the Mahatma Gandhi National Rural Employment Guarantee Act

	(2006-07) 200 Districts	(2007-08) 330 Districts	(2008-09) 615 Districts	(2009-10) 619 Districts	(2010-11) 626 Districts
Total job cards issued (in millions)	37.8	64.8	101.1	112.5	119.8
Employment provided to households: (in millions)	21	33.9	45.1	52.6	54.9
Total person days work provided (in billions)	0.9	1.4	2.1	2.8	2.5
Person days worked per household	43 days	42 days	48 days	54 days	47 days
Total available fund- (in Rs billions)	120.73	193.05	373.97	495.79	541.72
Expenditure (In Rs billions) [percentage against available funds]	88.23[73%]	158.56 [82%]	272.50 [73%]	379.05 [76%]	393.77 [73%]
Expenditure on wages (In Rs billions)	58.42 [66%]	107.38 [68%]	182.00 [67%]	255.79 [70%]	256.86 [68%]
Total works taken up (In millions)	0.835	1.788	2.775	4.617	5.099

Source: Report to the people 2011-12, MGNREGA

Employment generation

By 2011-12, 127 million job cards had been issued to rural households. Not all cardholders seek employment each year so it is important to look at actual employment provided. Since its inception, the Act has generated 11.1 billion person days. In the current financial year up to December, 2011 MGNREGA has provided employment to 37.7 million households generating 1.2 billion person days.

Enhanced wage earnings

Almost 70% of the expenditure is on wages. Over the last six years (Up to December, 2011) Rs1004.52 billion has been spent on the wages of MGNREGA labor. The average wage earned has risen from Rs65 per person day in 2006 to Rs100 by 2011 (Report to the people, 2011-12, MGNREGA)

Cash transfer

In 2009-10, average wages earned per household per day were Rs89.03 (National Sample survey, 2009-10). Also, average person days employed per household were 54 days for 2009-10. Hence, average income transfer stands to be Rs4807 per household in 2009-10.

Natural resource regeneration and impact on agricultural productivity

The works undertaken through MGNREGA give priority to activities related to water harvesting, groundwater recharge, drought proofing, and flood protection. Its focus on eco-restoration and sustainable livelihoods will lead over time to an increase in land productivity and aid the workers in moving from wage employment to sustainable employment outside MGNAREGA in agriculture and allied activities. Almost 53% of works relate to soil and water conservation. MGNREGA works by their very nature place stress on increasing land productivity, recharging ground water and increasing water availability. Various studies yield evidence of the usefulness and productivity of the assets created indicate that MGNREGA projects have lead to increases in groundwater levels, in water percolation, in agricultural productivity, and in cropping intensity. MGNREGA has helped in livelihood diversification and supplementing employment in lean seasons in rural areas.

2.4. Review mitigation actions and policies in India

After reviewing the poverty issue and poverty alleviating measures in India, we turn to the climate change problem. Before reviewing the mitigation actions taken by India to address the problem of climate change, it is important to review India's carbon footprint. It should be borne in mind that India's economy is growing fast, but historically its carbon emissions have been amongst the lowest, as indicated in the table below.

Table 7: Emissions data for selected countries

Country / Region	Population (million)	GDP ppp (billion 2000 US$)	Energy cons. (MTOE)	Per capita energy cons. (kgOE)	Energy intensity (KgOE/$GDPppp)	Per capita electricity Cons. (kwh)	CO_2 emissions (MT CO_2)	Per-capita CO_2 emission (tonnes)	Kg CO_2/$GDPppp
World	6,609	61,428	12,029	1.82	0.2	2,752	28,962	4.38	0.47
China	1,327	10,156	1,970	1.48	0.19	2,346	6,071	4.58	0.6
USA	302	11,468	2,340	7.75	0.2	13,616	5,769	19.1	0.5
Russia	141	1,651	786	5.54	0.48	6,443	1,593	11.24	0.97
Japan	128	3,620	513.5	4.02	0.14	8,475	1,236	9.68	0.34
India	**1123**	**4,025**	**421**	**0.53**	**0.1**	**543**	**1,146**	**1.18**	**0.28**
Germany	82	2,315	331	4.03	0.14	7,185	798	9.71	0.34
UK	61	1,833	211	3.48	0.12	6,142	523	8.6	0.29
France	64	1,738	264	4.15	0.15	7,573	369	5.81	0.21
Brazil	192	1,561	235	1.23	0.15	2,154	347	1.8	0.22
S. Africa	48	517	134.3	2.82	0.26	5,013	346	7.27	0.67

Source – IEA Gielen et al. "Energy Transition for Indian Industry", 2009

India's CO_2 emissions (1146 MT) are less than one fifth that of USA and China. In per capita terms India emits 1.18 tonnes of CO_2, China emits four times as much and the USA 16 times as much. India's emission intensity is 0.28 kg of CO_2/$ of GDP in purchasing power parity (PPP) terms, China's is more than twice as high, and the USA's is higher than the world average and 1.8 times of India. Per capita energy consumption and emissions for India are amongst the lowest in the world.

But India is committed to contribute to combating the climate change problem, and determined that her per capita emissions level will never exceed the average per capita carbon emissions level of developed countries. This declaration, made by India's Prime Minister on June 8, 2007 at Heiligendamm, Germany continues to guide India's stand towards energy consumption and places a self-imposed restraint. It is a voluntary commitment made by India towards the international community. In December 2009, India announced that it would aim to reduce the emissions intensity of its GDP by 20–25% from 2005 levels by 2020. This is a further articulation of India's voluntary commitment to mitigation.

2.4.1. National action plan on climate change

The Indian government formulated a national action plan for climate change in 2009, initiating eight missions as a part of its climate change efforts. They are as follows:

- National Solar Mission
- National Mission for Enhanced Energy Efficiency
- National Mission on Sustainable Habitat
- National Water Mission
- National Mission for Sustaining the Himalayan Ecosystem
- National Mission for a Green India
- National Mission for Sustainable Agriculture
- National Mission on Strategic Knowledge for Climate Change

2.4.2. National Solar Mission

Of the eight national action plans on climate change mentioned above, the national Solar Mission is considered in the paper as the basis for a scenario. It is specifically considered because increased use of solar will reduce dependability on fossil fuels in the long term as well as leading to job creation.

The mission targets are as follows:

- To create an enabling policy framework for the deployment of 20,000 MW of solar power by 2022.
- To ramp up the capacity of grid-connected solar power generation to 1000 MW by 2013, with an additional 3000 MW by 2017 through the mandatory use of the renewable purchase obligation by utilities backed with a preferential tariff. This capacity can be more than doubled – reaching 10,000MW installed power by 2017 or more, based on the enhanced and enabled international finance and technology transfer. Reaching the ambitious target for 2022 of 20,000 MW or more will depend on the 'learning' of the first two phases, which, if successful, could lead to conditions of grid-competitive solar power. The transition could be appropriately up scaled, based on the availability of international finance and technology.
- To create favourable conditions for solar manufacturing capability, particularly solar thermal for indigenous production and market leadership.
- To promote programmes for off-grid applications, reaching 1000 MW by 2017 and 2000 MW by 2022.
- To achieve 15 million $m^2$of solar thermal collector area by 2017 and 20 million by 2022.
- To deploy 20 million solar lighting systems for rural areas by 2022.

2.4.3. Expert group on low-carbon strategies for inclusive growth

An expert group on low-carbon strategies for inclusive growth submitted its report to the government in May 2011. According to it, India's approach to low-carbon inclusive growth recognizes that policies for climate change mitigation differentially affect the objectives of development. These objectives include poverty alleviation, improvement in quality of life, distributional justice, job creation, competitiveness, industrial growth, and improving the quality of the local environment. Improvement in quality of life goes beyond simple poverty alleviation.

The expert group considered options for low-carbon pathways in the power, transport, industry, buildings and forestry sectors, which are major emitting sectors in the Indian economy. In the power sector, reducing electricity demand through more efficient appliances, the introduction of more fuel-efficient power plants and changes in the mix of power plants are considered. In the transport sector, promoting goods transport by railways, mass transport for passenger movement, facilitating non-motorized transport and increasing fuel efficiency of vehicles are explored. Among industries, the possibilities of reducing emissions through change in technology in the steel, cement, oil and gas sectors are considered. The scope for reducing energy needs of commercial buildings is assessed. In the forestry sector, the Green India Mission is briefly outlined. The options considered suggest that, with "Determined efforts", India can bring down emission intensity of its GDP by 23–25% over the 2005 levels, and with “Aggressive efforts”, the figure could be 33–35%.However, the expert group has not worked out the costs associated with these measures, nor the feedback effect they would have in a macro-framework.

After the literature review of poverty-alleviating measures and mitigation actions in India, we are in a position to find out potential PAMAs in India. The following table shows the potential PAMA typology from the Indian point of view, although this list is only indicative.

Table 8: PAMA in the Indian context

Typology		**Poverty alleviation potential**	
CO_2reduction potential		High	Low
	High	*Type 1: Poverty alleviating mitigation action* Poverty driven mitigation action- **Electricity access to poor households through energy efficient CFL bulbs (Bachat Lamp Yojana)**	*Type 2: Conventional mitigation action* With no explicit focus on poverty (and possible opportunity cost) Climate driven mitigation action- **Increase in share of wind and solar power in total energy mix , energy efficiency measures (National Solar mission)**
	Low	*Type 3: Conventional action for poverty alleviation* With no explicit focus on reducing emissions (and possible increase in emissions) Non-climate driven poverty action- **Food security, employment guarantee schemes (PDS, National rural employment guarantee act)**	*Type 4: Failed/low impact mitigation action, failed poverty action* Conventional industrial/economic/ environmental policy without explicit focus on mitigation and poverty **Subsidizing fuel use which does not necessarily benefit only poor (policy of subsidizing diesel, LPG)**

2.5. Literature review of energy models

Models that assess the economic impact of climate change in the literature can be classified as bottom-up, top-down, or integrated. The bottom-up models bring technological knowledge and specificity, but often techno-economic evaluations are incomplete and overtly optimistic, in that policy and institutional obstacles are not fully accounted for. Top-down models bring macro-consistency but simplify the sectoral details by judgments and assumptions. Among them are econometric models which use reduced form equations for which structural relationships behind them remain unclear and implicitly constant. Another approach of top-down modeling is the computable general equilibrium (CGE) approach where a sequence of single period equilibrium is worked out. In econometric and CGE models, often high elasticity of substitution is assumed which makes it easy and relatively costless to adjust to CO_2 constraints. The problem is thus assumed away. An activity analysis approach permits macro-consistency, dynamic behavior, new and specific technological options and thus limited substitution. It can constitute a truly integrated top-down-bottom-up approach.

A few modeling studies have explored India's options. Weyant and Parikh (2004) analysed how various global models have projected India's emissions. In recent years, Shukla et. al. (2009) have studied low carbon pathway for India. It uses a combination of the ANSWER-MARKAL model and the AIM End use model to obtain the low-carbon pathway for India.

Integrated Research and Action for Development (IRADe), The Energy and Resource Institute (TERI), and the National Council of Applied Economic Research (NCAER) created models for the Ministry of Environment and Forests in 2009 to study the CO_2 emissions profile of India. The IRADe model optimizes consumer welfare, states explicit technological choices, provides energy-economy-Investment-consumption feedback, dynamically optimal investment, resource constraints, endogenous income distribution and separate consumer demand system for each consumer class. The TERI model is a MARKAL model with pre-determined energy demand, explicit technological choices and least cost energy solution. The model from NCAER is a year-by-year simulation model with endogenously determined prices, energy-economy-investment-consumption feedback, demand determined by demand system, myopic market economy, no resource constraints and non explicit technological choices.

The McKinsey report (2009) provides a global greenhouse gas abatement cost curve for 21 world regions. IIASA (Austria) has made a global energy assessment (GEA, 2011) and provided low-carbon pathways for different regions of the world, including South Asia, which can be applied to India.

All these models analyse low-carbon technology alternatives for India but do not necessarily deal with its impact on the macro economic variables like national income, energy and non-energy investments required, consumption levels in rural and urban areas from a long-term perspective. Thus an assessment of low-carbon alternatives from the macroeconomic point of view remains unexplored and choice among different technologies is not well informed. Similarly, none of the models take into account the impact of various poverty alleviation measures and development initiatives on carbon emissions, which is important for a developing country like India when making national commitments in climate change negotiations at International level.

3. IRADe model

The literature review shows that there is no specific way to assess either the impact of poverty alleviation measures on carbon emissions or the impact of mitigation action on poverty. As mentioned earlier, if there is a tradeoff involved between development and climate change concerns, it becomes of utmost important to measure both development indicators and carbon emissions simultaneously in one macro-economic framework. Only then is one in a position to measure how much various poverty alleviation measures lead to increasing energy consumption and carbon emissions and, alternatively, how much mitigation actions actually reduce non-energy sector investments and whether they increase poverty at the country level as a whole. The IRADe model essentially fills this knowledge gap and provides a tool to combine development indicators, energy consumption and resulting CO_2 emissions for India.

3.1. Introduction to the IRADe model

Parikh et.al. (2009) have estimated CO_2 emissions for India by major sectors for the year 2003-04 based on a social accounting matrix (SAM) for India, which incorporates the input-output flows for that year. We use a similar framework and formulate a macro economic activity analysis model. It is a multi sector and multi period optimization model. The IRADe model connects economic activities to the energy demand required for it to the carbon emissions resulting from it.

The model has 34 production activities producing 25 commodities. The highlight of the model is the endogenous income distribution with 20 expenditure classes, 10 rural and 10 urban and the feedback of energy and environment policies to the economy. The model allows for inter-sectoral linkages and hence the two-way interdependence between energy sector and the economy. The consequences of shift in energy sources on the other sectors of the economy can be examined. The model calculates CO_2 emissions from production and consumption activities using emission coefficients as a follow up of various energy strategies. The model has been upgraded to project up to 2030.

The model maximizes the present discounted value of private consumption over the planning period (in our case 20 years (2010- 2030)) subject to various demand and supply constraints.

Objective function: $MaxU = \sum_{t=0}^{T} \frac{POP_t * PC_t}{(1+r)^t} + \overline{PC}$

Where POP_t and PC_t are the total population and total per capita consumption at time t. T is the planning horizon.

The model is solved using the GAMS programming tool developed by Brooke et al (1988). For endogenous income distribution consistency, we iterate over optimal solutions changing distribution parameters between iterations till they converge.

3.2. Assumptions about important control parameters in the model

AEEI: The concept of autonomous energy efficiency improvement (AEEI) is used in energy models (Sanstad et al. 2006, Boeters, 2007).This is an annual reduction in energy inputs like coal, oil, natural gas and power. This in reality captures for a long period technological progress every year. The AEEI assumption in the IRADe model is given in Table 9 below.

TFPG: Total factor productivity growth rate is assumed to be zero in the model.

Maximum savings rate (S): Most developing countries have constrained resources. . The model imposes a limitation on maximum domestic savings available for investments. In our model it has been assumed to be 35% of GDP.

Minimum consumption rate: The minimum consumption rate is used as a monotonicity constraint on per capita total consumption. It ensures that in the optimal solution, since we are maximizing a discounted sum of total consumptions, this increase in the per capita consumption is within some expected and rational limits (maximum 7%).

Government consumption rate: The government's role is assumed to be exogenous. The government consumption growth rate is assumed to be a uniform 9% for all commodities and over all time points.

Table 9: Assumptions of exogenous parameters in the IRADe model

Parameter	Assumption	
AEEI	Coal	1.5% per year
	Petroleum products	1.5% per year
	Natural gas	1.5% per year
	Electricity	1% per year
Maximum savings rate (S)	35% of GDP	
Government consumption growth rate	9% per annum	
Minimum per capita private consumption	2% per annum	
Discount rate	3% per annum	

The model uses constant prices. Capital coefficients used in the model are illustrated in the diagram below. For reference, the coefficients are compared with international model developed by IIASA for creating GEA (Global Energy Pathways).

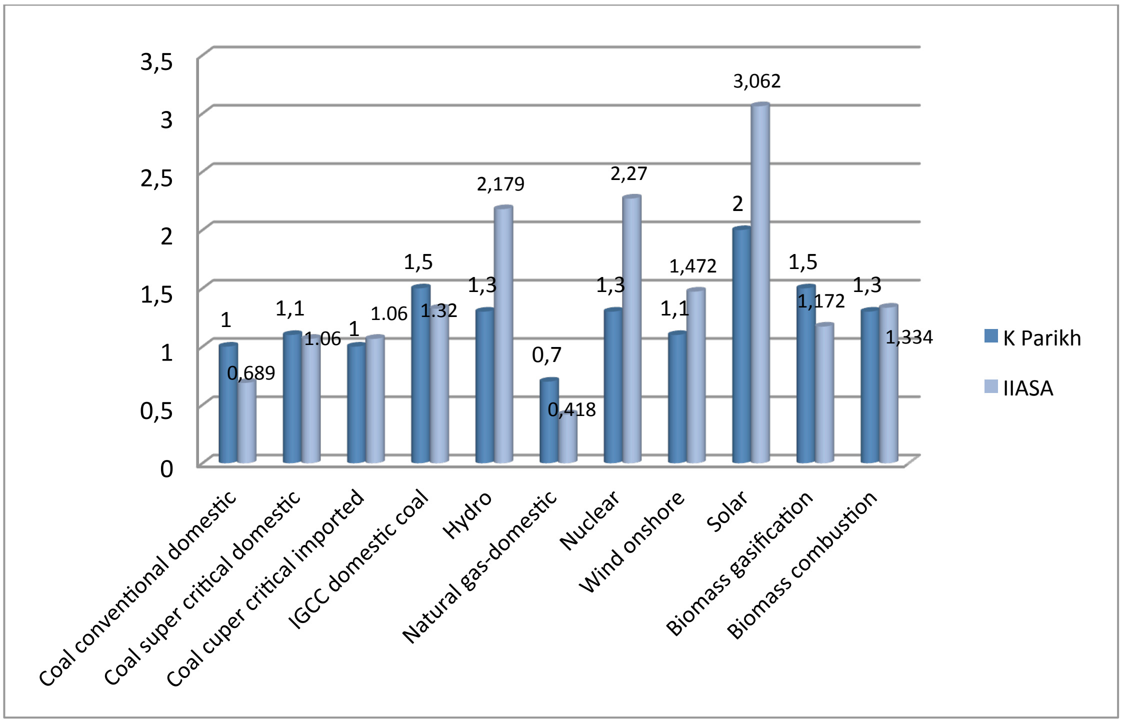


Figure 4: Capital coefficient comparison (million $/ MW)

3.3. Major features of the model

We discuss below the features of the model and sub-models and what we have achieved from the detailed analysis.

3.3.1 Data

We have used the recent data for India to estimate the various parameters and initial values of different variables to be included in the model structure. Input output coefficients and production functions for various activities form an important element of the model. The latest input-output table, published by the CSO (1998-99) and updated by Saluja to 2003-04 prices, has been used (Saluja & Yadav, 2006).

3.3.2 Production side in the model

The input-output table provided by CSO consists of information on 115 sectors/activities. These have been aggregated to 34 sectors for better interpretation of results. We have constructed four broad groups consisting of 34 production sectors as follow:

- Energy sectors: Coal and lignite, crude oil, electricity and gas, electricity hydro, wind, solar photo voltaic, solar thermal, electricity from wood, electricity from low-emission coal based technology.
- Non-energy sectors:
    - Agriculture and allied activities: food grains, oil seeds, sugarcane, other crops, animal husbandry, forestry and fishing.
    - Industry: Agro processing, textiles, petroleum products, fertilizer, cement, steel, manufacturing, mining and quarrying, non-metallic minerals, construction and water supply and gas.
    - Services sector: Transportation (railway and other), and other services. This sector is the largest chunk of the economy. It comprises trade, hotels and restaurant, banking services, insurance services, real estate services, business services, communications, storage, and public administration service

Our main focus has been on the agriculture and industrial sectors, since these are energy-intensive and CO_2 emissions are common in them.

3.3.3 Assumptions of energy resource constraints

To make the model more realistic, resource constraints have also been introduced into the model particularly for primary energy sources like coal, crude and natural gas. Apart from these, constraints have also been imposed on power generation capacities of newer technologies like nuclear, wind, wood and also on hydro and gas based power (see Table 11). These constraints are based on realistic beliefs about India's energy resources and production.

3.3.4 Consumption side in the model

Energy is required for production as well as consumption. To model consumption, data from the National Sample Survey of the 50th round to the 64th round has been used. LES demand systems have been arrived at for 20 consumer classes, 10 in rural areas and 10 in urban areas, programmed as a sub-model and embedded in the system. Each class has a separate consumption pattern derived from the marginal budget share of the given 25 commodities for each class. Rural and urban areas have separate consumption pattern and class boundaries.

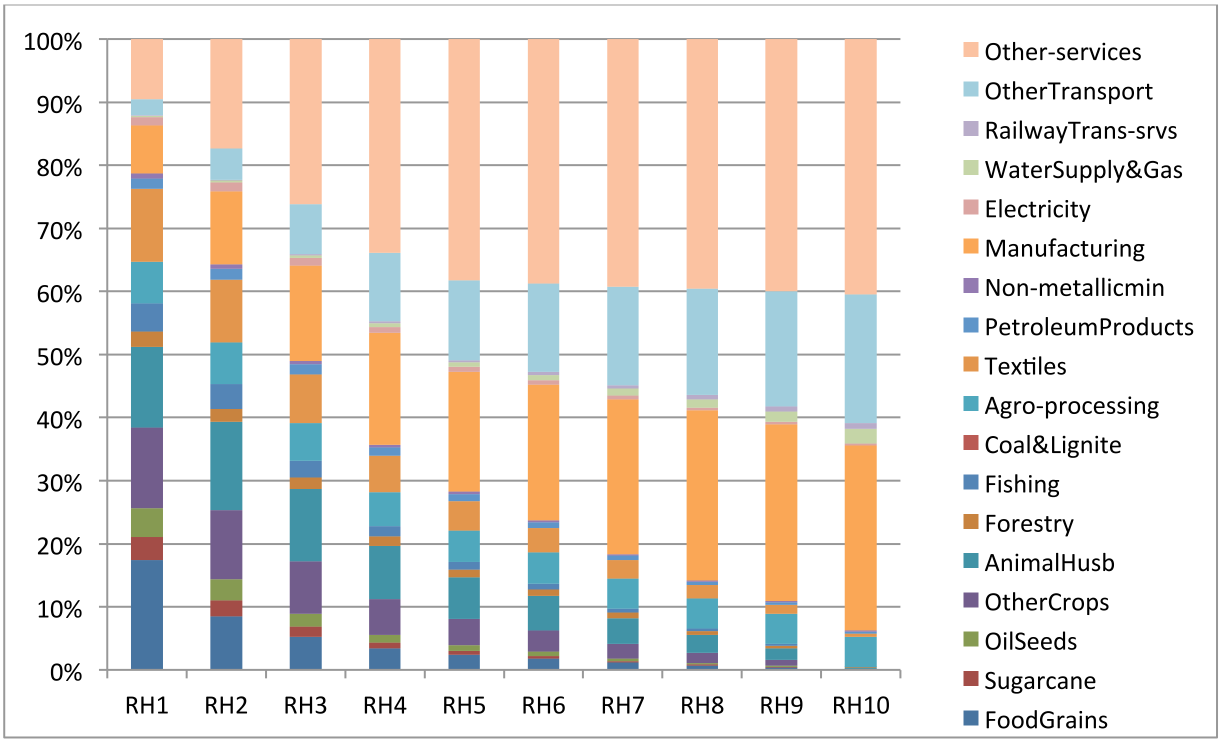


Figure 5: Marginal budget shares for different commodities across different expenditure classes for rural areas

Figure 5 shows that RH1 (Rural household class 1), which is the poorest class in rural areas, has a consumption pattern such that more than 55% of their consumption is food (food consumption basket comprises food grains, sugarcane, oil seeds, other crops, animal husbandry, fishing), whereas just 10% of their consumption expenditure goes on health, education and such “other services”. On the other hand, for the richest class in rural areas, around 40% of their consumption expenditure goes on those services.

The population in each class also gets endogenously determined in the model. The class boundaries remain constant over a period of time so that we can capture the movement of people from one class to another as the economy grows and analyze the changes in the consumption pattern of the people.

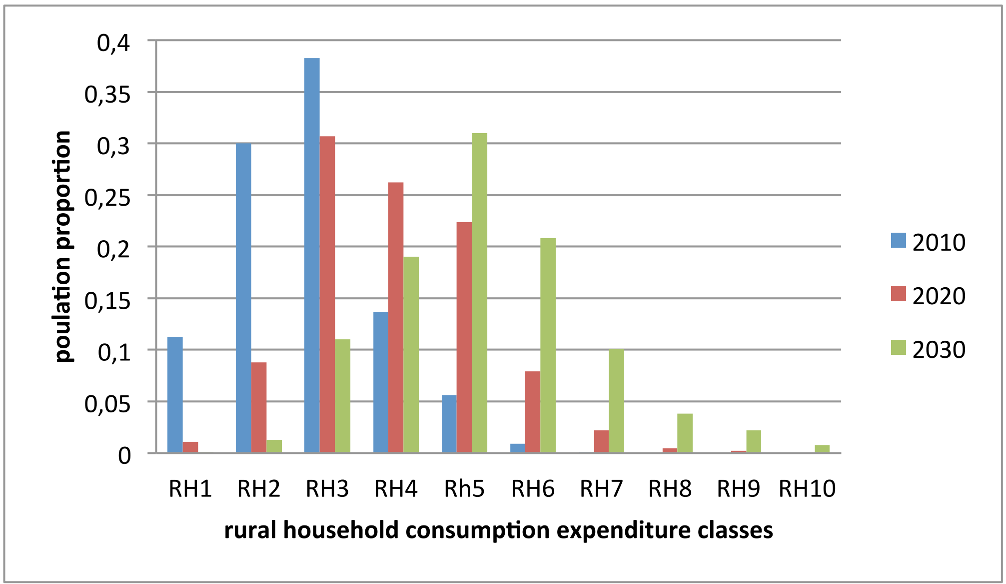


Figure 6: Rural population proportion across classes

The graph above shows that in 2010 the rural areas have most people in the poorer classes (RH1, RH2, RH3) and most people earn below Rs25,000 per annum (class boundary of RH3). By 2020, the population shifts to higher classes and the proportion of population in classes RH1 and RH2 declines. By 2030, most of the rural population falls into higher consumption expenditure classes (RH5, RH6 and RH7). Similar graphs are depicted below for urban areas.

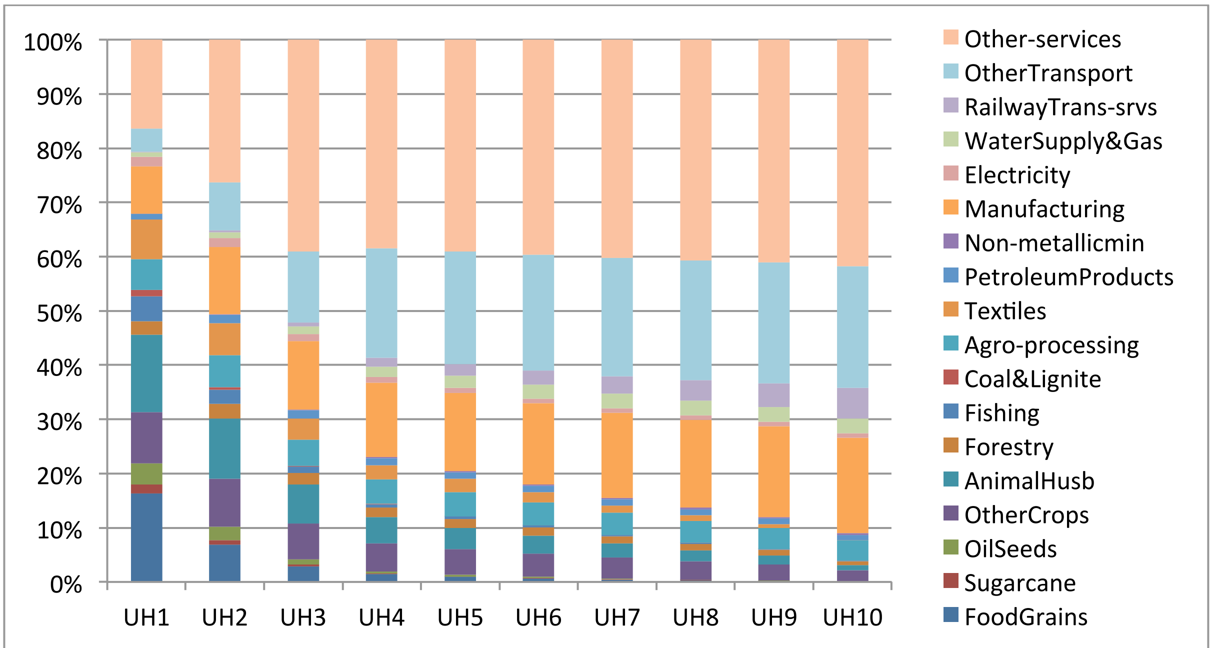


Figure 7: Marginal budget shares for different commodities across different expenditure classes for urban areas

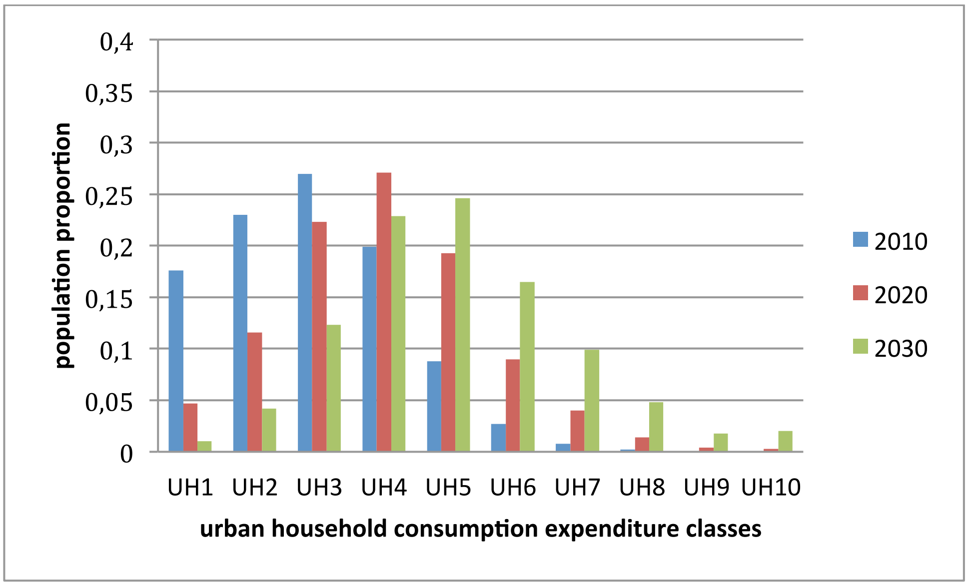


Figure 8: Urban population across classes

The above two graphs show that when most people in urban area are in poorer classes (UH1, UH2, UH3) and they spend more on food and less on manufactured products (as shown by marginal budget shares in Figure 7), the overall urban consumption has less carbon-intensive goods. As most people move to higher classes (UH5, UH6, UH7) by 2030, their consumption pattern change to include more manufactured goods, other services (as shown by marginal budget shares in UH5, UH6, UH7 classes in Figure 7) and is thus more energy and carbon intensive.

3.3.5 Measurement of poverty in the model

The number of people below the poverty line is endogenously determined in the model. Instead of defining a hypothetical poverty line to determine poverty incidence, the first two classes in rural and urban areas are considered as poor classes and people falling in these classes are considered as poor. The advantage of such an exercise is that it indicates not just income poverty or multidimensional poverty based on indicators of only food, health, education etc. Rather, it is based on people's total consumption and they are considered to be moving out of poverty only when they move to higher class where their overall consumption pattern changes. It also indicates that people are earning sufficiently above the minimum to afford higher consumption. This transition is sustainable over a period of time and people will not fall back to poverty, as the model is dynamic and optimizes taking into account the entire period of time under consideration. The constant class boundaries are helpful in tracing the movement of people to higher classes over a period of time, so poverty is reducing when the proportion of the population in the poorest two classes in rural and urban areas is diminishing. Thus the poverty line is defined in terms of the class boundary of the second-poorest class in rural and urban areas respectively. A poverty line in rural area is the upper class limit of RH2, Rs12, 000 per annum or Rs1, 000 per month per person. In urban areas, the poverty line is defined in terms of the class boundary of class UH2, which is Rs20, 000 per annum or Rs 1,666.67 per month per person.

The Consumption basket is linked to the energy use embodied in the commodities and thus to resulting carbon emissions. Hence, when people move out of poverty and their consumption pattern changes, we can also track the increased energy use and carbon emissions. Any poverty-alleviating measure can thus be traced to its impact on carbon emissions.

Similarly, when mitigation actions are taken (such as using less fossil fuel and relying more on renewable energy sources), this affects the production side, while the consumption level also changes and it impacts the population distribution in various classes. Hence, the number of people in the poorest two classes changes. This way, we are able to track the impact of mitigation action on poverty. Another important point is that, since the model is dynamic and optimizes over the span of the entire time period, we can find out mitigation actions which are financially feasible over a long run and unfeasible solutions are set aside.

4. Description of scenarios

Keeping in view both the objectives of poverty alleviation and mitigation action, four scenarios are built and are compared with Business as usual (BAU) in the model. Three scenarios start from a poverty-alleviation objective and assess the impact of the measures taken on the level of carbon emissions; the fourth has an initial objective of mitigation and assesses its impact on the poverty levels.

4.1. Business as Usual

Business As Usual (BAU) is the base run scenario and no poverty alleviation measures or mitigation actions are considered. It is an indication of where India would be positioned in terms of growth and development if climate concerns were ignored and with continued reliance on its current technological mix. Energy intensity and CO_2intensity of GDP declines in BAU, however, due to the assumption of AEEI (autonomous energy efficiency improvement). BAU assumes urban rural consumption parity ratio of 2.34. It provides the base run up to 2030.

The following parameters are considered in the BAU:

1. Macroeconomic indicators: value of GDP, growth rate of GDP, per capita consumption expenditure- total as well as separately for rural and urban, consumption expenditure class wise population in rural and urban areas.
2. Poverty indicators: total population below the poverty line, as well as separately for rural and urban areas, poverty head count ratio – total, rural and urban.
3. Energy sector: energy portfolio up to 2030 – energy intensity changes, primary commercial energy supply, domestic production, imports of coal, natural gas, crude petroleum, power generation using coal, natural gas, super critical coal, wood, solar, wind, nuclear, etc.
4. Environmental indicators: total, per capita, cumulative CO_2 emissions up to 2030, CO_2 intensity of GDP and CO_2 emissions from households in rural and urban areas, CO_2 emissions according to different activities in the model.

4.2. Poverty alleviation through targeted transfers

India has around 340 million poor people. The scenario is built to project poverty alleviation till 2030. The ideal (most efficient) social welfare policy for providing goods and services that are offered in a competitive market would be a direct transfer of income to the poor through a negative income tax if it can be effectively targeted (Virmani, 2006).Many have proposed that such direct transfer can be done by setting up a modern smart card system that delivers cash and/or subsidies to the poor based on their entitlements as per specified parameters and norms. Such a smart card could be programmed with identity (photo and biometric fingerprint), and have information on personal/household characteristics. Each person's/households' entitlements could be in the form of specified per unit subsidy for prescribed units for the purchase of all items in a set of items. This set of items could include food/cereals, kerosene, midday meals, nutrition supplements, drinking water, toilet/sanitation services, basic drugs, schooling (primary/secondary), internet access, electricity, and a host of other items reflecting the dozens of subsidies and programmes currently available. The entitlement could be varied, depending on economic and social handicaps such as age (infant or aged), mental handicap, physical disability, female head of household, lactating mother, chronic illness. In this way all the current stakeholders, special interest groups and social policies could be accommodated within a single integrated system (Virmani, 2006). However one has to recognize that a smart card only eliminates ghost cards and duplicate cards. It does not eliminate problems of identifying the poor or ensuring no inclusion or exclusion error.

Keeping in view such a smart card system that can effectively transfer cash to the poor; a cash transfer scenario is built to assess its impact on poverty alleviation compared to BAU. From 2015 onwards, each person in the poorest three household classes in rural areas and urban areas (RH1 to RH3 and UH1 to UH3) is provided with Rs3,000 per annum till his/her consumption increases and the person permanently moves to the higher classes and comes out of poverty. This cash transfer can be taken as the sum of all kinds of cash transfers received by the poor, for example in the form of cash transfer for food (as discussed above in the literature review), guaranteed wages received for unskilled labour under an employment guarantee scheme (like MGNAREGA), or all other subsidies. It is assumed that the government is able to levy additional tax on the richer classes so that investment is not affected, and is able to target it effectively. Even though targeting effectiveness is very questionable, we have used this scenario to get maximum impact on poverty reduction at minimum cost. A universal transfer or transfer to a larger group excluding clearly identifiable rich would have a smaller impact on the poor.

This scenario is henceforth referred to as Partial transfer (PT).

4.3. Reducing rural urban disparity

As discussed in the literature review, India experiences widening rural-urban disparity. Since around 70% of population still resides in rural areas, and in the future, too, the rural population will be much more than the urban one, widening the rural-urban disparity implies disproportionately less share of rural population in the total national income and increasing distress migration of rural population to urban areas.

The urban-rural parity ratio is exogenously prescribed in the model. The BAU scenario has constant rural urban consumption parity (constant ratio of rural to urban consumption over a period of time), but the share of rural consumption in total consumption goes down in later years because of higher urbanization and higher per capita income in the urban areas. In the alternative scenario, a lower urban-rural parity ratio is prescribed. Urban-rural parity is reduced by 6.7% per year. The reduction in parity would lead to lower migration from rural to urban areas and hence a higher rural to urban population ratio. This is calculated and exogenously specified in the model. The scenario is used to assess the impact of reduced inequality between rural and urban areas on rural and urban consumption levels, rural-urban population proportions, migration and poverty. The underlying assumption in this scenario is that a higher proportion of investment will be made in rural areas to create more jobs there. It is also assumed that this does not increase capital-output ratios. It is also assumed that sufficient skills exist in rural areas to benefit from the opportunities created. The methodology used to design this scenario is explained in the annexure. The implication is that migration to urban areas will reduce.

This scenario is henceforth referred to as Low rural-urban parity ratio (LPR).

4.4. Energy access to poor households

Apart from rural-urban income disparity, there are wide differences between the lifestyles and consumption patterns in rural and urban areas as well as between poor and rich people. One important factor in such differences is the varied access to energy. This can be defined in terms of lack of access to clean cooking fuels (like LPG) as well as lack of reliable electricity supply. Lack of energy access acts as a barrier for poverty alleviation as the livelihood opportunities of poor remain restricted. According to the expert group on low-carbon strategies for inclusive growth, “if growth is to be inclusive, demand for energy must necessarily increase. At the minimum, inclusive growth means all households have access to clean and convenient means of modern energy. This means all households are electrified and that all have access to clean cooking fuels such as natural gas or LPG.” If reliable electricity supply is provided to the poor, there are many lifestyle benefits. For example, they can use more electricity-based appliances and some machinery in income-generating activities, small farmers can increase productivity of the land, children can study for longer hours, reliable water supply can be provided, etc. All these benefits are longer-term and may not necessarily be captured immediately in the form of increased consumption level but definitely prove to be a part of poverty alleviation programme in the long run.

Hence, a scenario is built where a cash transfer is provided to fund electricity consumption in the classes that have below 1KWh electricity consumption per family per day. Each class is assumed to consume 1 KWh per family per day. The poorer classes consume 1KWh of electricity without spending any more money on electricity than they do otherwise –The assumption is that the government subsidises the additional cost of electricity, a move financed through an additional tax on consumers. The poorest three rural classes and poorest two urban classes will benefit most from this cash transfer.

The scenario is henceforth referred to as cash transfer for electricity (ET).

4.5. The impact of the National Energy Mission on poverty alleviation

The first three scenarios deal with poverty alleviation and the impact of such measures on emissions level is assessed. Equally important is to assess the impact of mitigation actions on the poverty alleviation efforts in the country. Depending on the outcome, one can consider some stated mitigation policies as NAMAs (Nationally Appropriate Mitigation Actions). Some mitigation actions can positively contribute to reducing poverty whereas some very stringent mitigation actions can actually divert resources from development funds to the energy sector, in turn increasing the poverty and vulnerability of the poor. Here a scenario is built on the lines of National Energy Mission (NEM) which considers the policies of the government's Ministry of New Renewable Energy (MNRE). The ministry has announced targets for solar and wind up to 2022. The growth rates from these targets are used to project targets up to 2030. This implies that the current policy is also followed up to 2030 for renewable energy sector. Here the model is required to attain government targets for solar and wind up to 2030.The impact of such mitigation action on the macro economy, including opportunity costs for other sectors and impact on poverty alleviation is assessed.

This is henceforth referred to as the NEM scenario. The construction of the NEM scenario is explained by using the tables below.

Table 10: MNRE projections in MW

	2010	2012	2017	2022
Wind	12,809	16,100	27,300	38,500
Solar	18	200	4,000	20,000

Table 11: Growth rate in MNRE targets from the wind and solar missions

Growth rates	2015	2020	2025
Wind	11.12	8.68	3.19
Solar PV	159.05	41.71	10.76
Solar thermal	159.05	41.71	10.76

The growth rates in Table 11 are used to then project beyond 2025 the targets for wind and solar as shown in Table 12 below. The table shows the constraint on how much power should be produced by 2030 through wind, solar PV & solar thermal.

Table 12: Assumptions on power production constraint for Wind and Solar in NEW scenario

	2010	2015	2020	2025	2030
Wind	22.44	38.02	57.64	67.45	78.93
Solar PV	0.02	2.21	12.61	21.02	35.04
Solar Thermal	0.02	2.45	14.02	23.36	38.93

5. Discussion of results

5.1. Impact on the macro economy

Four scenarios regarding poverty alleviation and mitigation action are assessed on the basis of their impact on macro economic variables like GDP, per capita consumption, etc. All four show that poverty alleviation and mitigation action can be achieved without much affecting national income and consumption levels compared to BAU.

Table 13: GDP across scenarios (Rs billion)

Year	BAU	LPR	PT	NEM	ET
2010	50,221	49,785	50,613	50,349	50,855
2015	68,836	70,157	69,274	71,734	68,659
2020	100,952	100,917	101,553	101,673	100,531
2025	151,427	151,032	152,523	151,200	151,438
2030	209,810	210,180	210,062	206,322	209,423

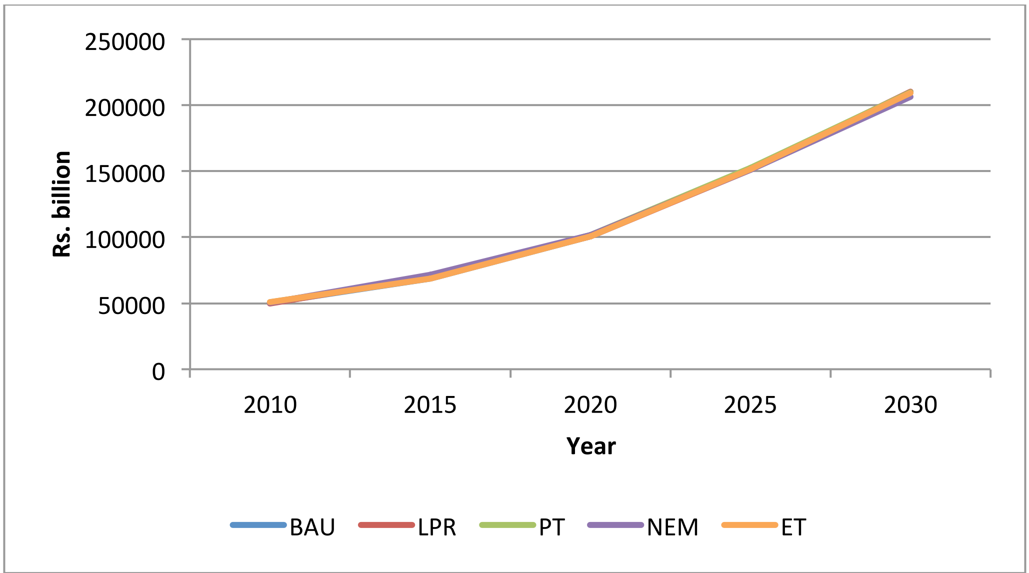


Figure 9: GDP across scenarios

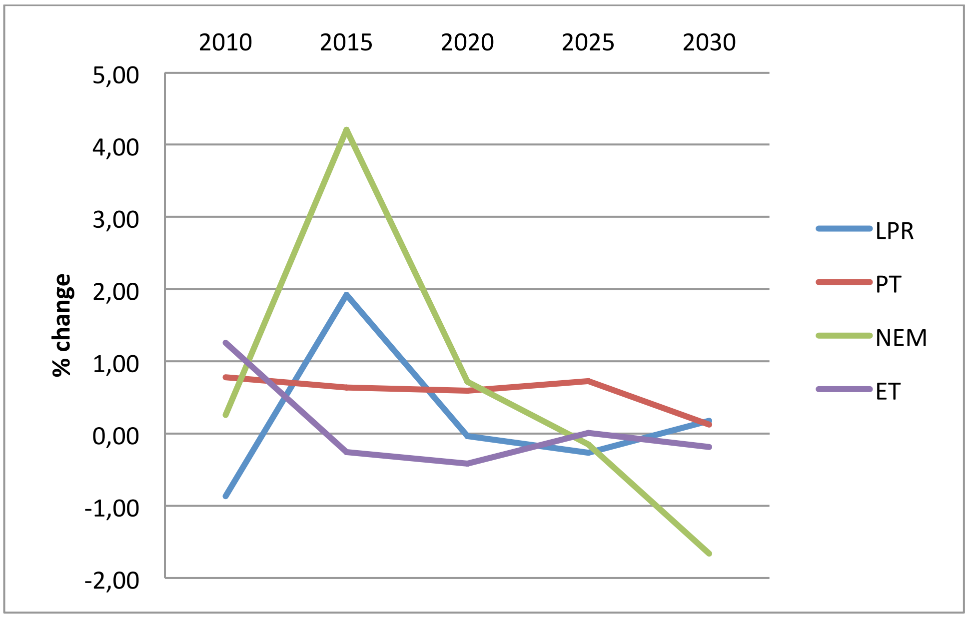


Figure 10: Changes in GDP compared to BAU

Table 14: Per capita consumption across scenarios (Rs/Person)

Year	BAU	LPR	PT	NEM	ET
2010	25,000	24,697	25,000	25,000	25,000
2015	36,733	36,288	36,733	36,733	36,733
2020	53,973	53,319	53,973	53,973	53,973
2025	79,304	78,343	79,304	79,304	79,304
2030	104,933	105,290	105,060	102,294	104,743

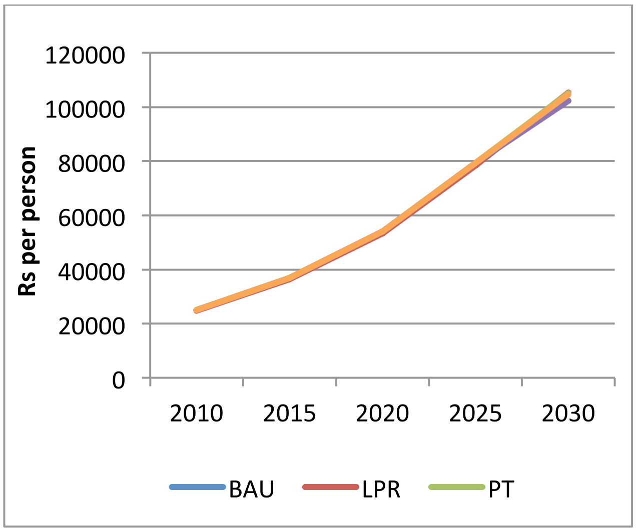


Figure 11: Per capita consumption across scenarios

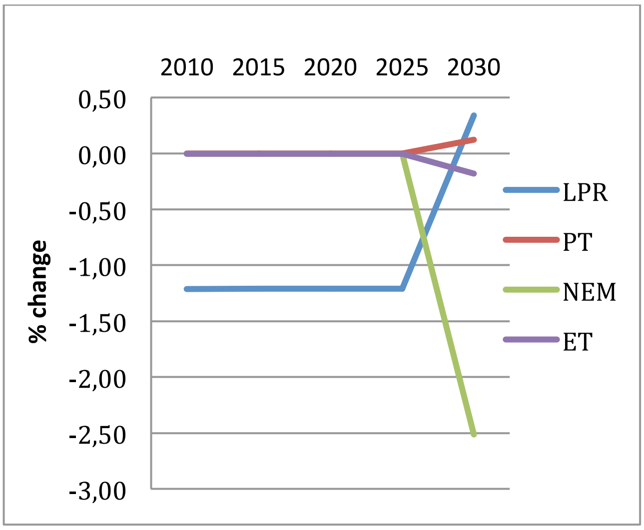


Figure 12: Changes in per capita consumption across scenarios

These scenarios show negligible impact on GDP and per capita consumption at the national level, but the absolute changes are not insignificant. The small impact on GDP could have been expected as the size of interventions in different scenarios is small compared to the size of the economy and also because the model is an optimizing one that adapts to the interventions. Of course, we expect changes in income distribution and levels of poverty and we look at these next.

5.2. Impact on poverty

As discussed earlier in the model description, poverty is defined in terms of people in the first two consumption classes in rural and urban areas (people falling in RH1, RH2, UH1, and UH2 are classified as poor). As discussed earlier, the model measures poverty with a fixed poverty line over a period of time. It is defined in terms of the class boundary of the second poorest class in each rural and urban area respectively. Hence, a poverty line in rural area is the upper class limit of RH2, Rs. 12,000 per annum or Rs1000 per month per person. In urban areas, the poverty line is defined in terms of the class boundary of second urban class UH2 which is Rs20, 000 per annum or Rs1666.67 per month per person.

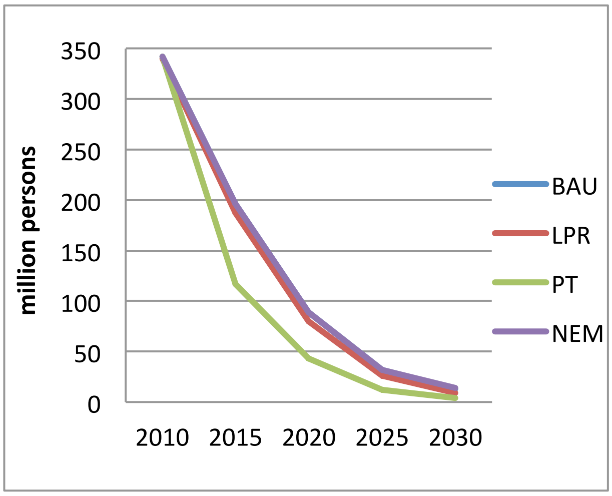
Poverty alleviating mechanisms like cash transfer (PT scenario), reducing rural urban disparity (LPR scenario) show that poverty can be reduced faster compared to BAU with these measures.

It is also important to note that mitigation action taken in the NEM scenario does not impact rural or urban poverty in a negative way and it is comparable to BAU in most years. In 2030, however, NEM increases rural poverty by one million compared to BAU, as the investments in energy sector increase.

5.2.1. Rural poverty

Table 15: Comparison of people below poverty line in rural areas across scenarios (million)

Year	BAU	LPR	PT	NEM
Year	BAU	LPR	PT	NEM
2010	342	340	342	342
2015	196	187	117	196
2020	89	80	43	89
2025	32	26	12	32
2030	**13**	**9**	**4**	**14**



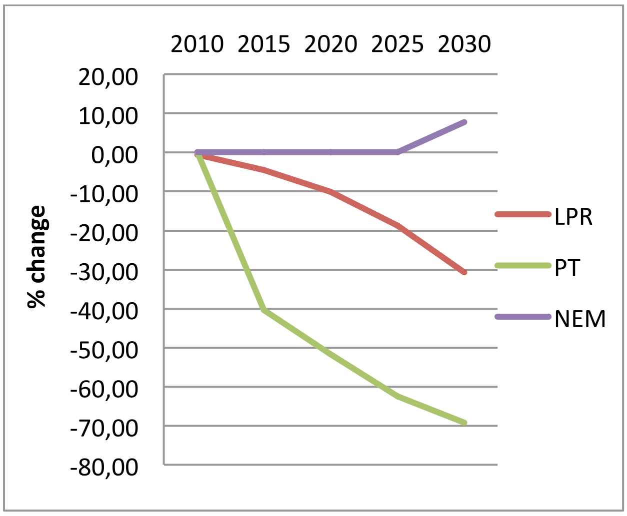


Figure 12: Comparison of people below poverty line across scenario

Figure 14: Changes in rural poverty compared to BAU

The graph above shows that partial transfer can reduce poverty by 60% points by 2030 compared to BAU. Reducing urban rural parity also affects poverty alleviation in rural areas and can reduce poverty up to 40% points.

Rural head count ratio

Table 16: Comparison of rural head count ratio across scenarios (%)

Year	BAU	LPR	PT	NEM
2010	342	340	342	342
2015	196	187	117	196
2020	89	80	43	89
2025	32	26	12	32
2030	**13**	**9**	**4**	**14**

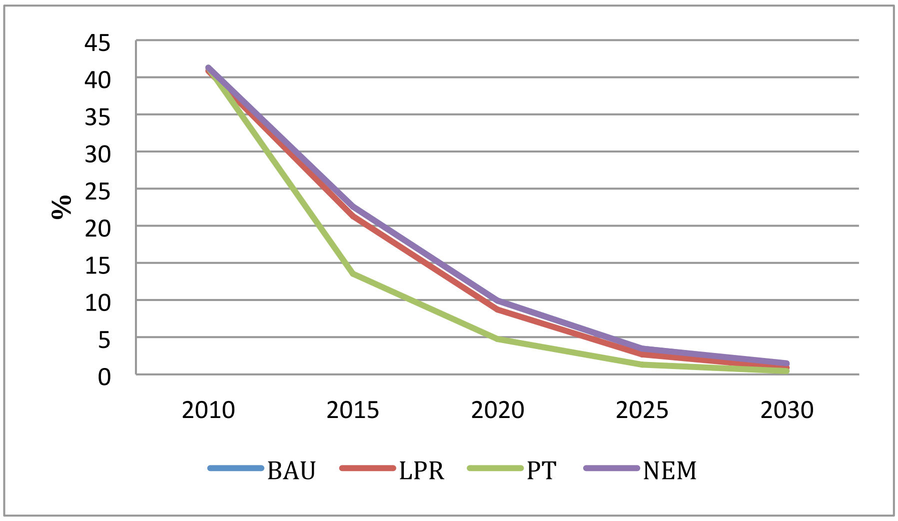


Figure 13: Comparison of rural head count ratio across scenarios

The graph above shows that consistent and effective cash transfer (PT scenario) can reduce poverty incidence in rural areas to less than 5% of rural population by 2020 only.

5.2.2. Urban poverty

Table 17: Comparison of people below poverty line in urban areas across scenarios

Year	BAU	LPR	PT	NEM
2010	142	144	142	142
2015	105	107	90	105
2020	69	71	55	69
2025	40	43	30	40
2030	**26**	**27**	**18**	**27**

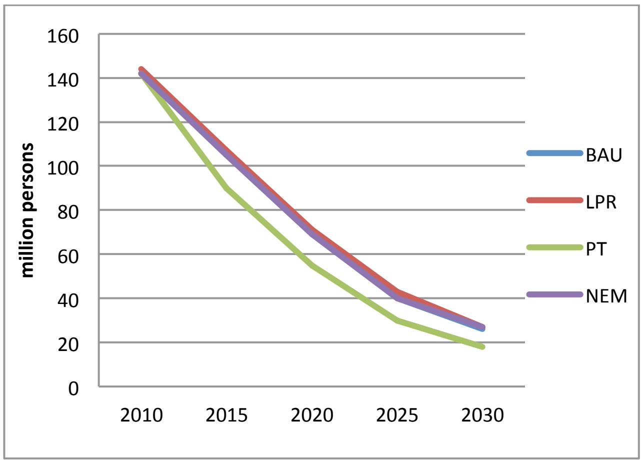


Figure 14: Comparison of people below poverty line in urban areas across scenarios

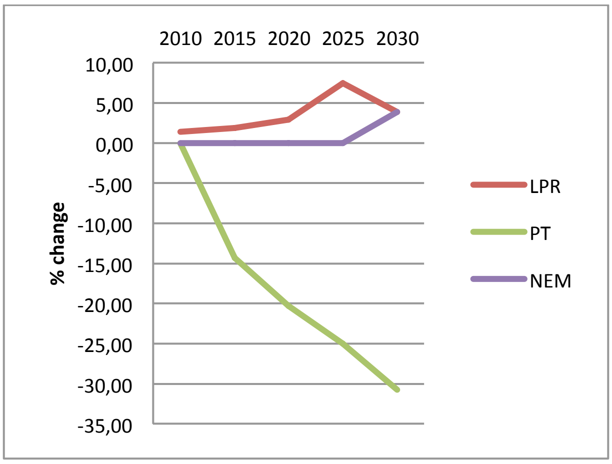


Figure 15: Changes in no of people below poverty line in urban areas compared to BAU

The graph above shows that partial transfer (PT) can reduce poverty in urban areas up to 30% compared to BAU by 2030, whereas efforts aimed at reducing urban rural parity (LPR scenario) can increase urban poverty by 10% by 2030.

Urban head count ratio

Table 18: Comparison of urban head count ratio across scenarios (%)

Year	BAU	LPR	PT	NEM
2010	40.62	41.6	40.62	40.62
2015	27.05	28.32	23.26	27.05
2020	16.22	17.5	12.92	16.22
2025	8.7	9.74	6.48	8.7
2030	5.17	5.83	3.67	5.44

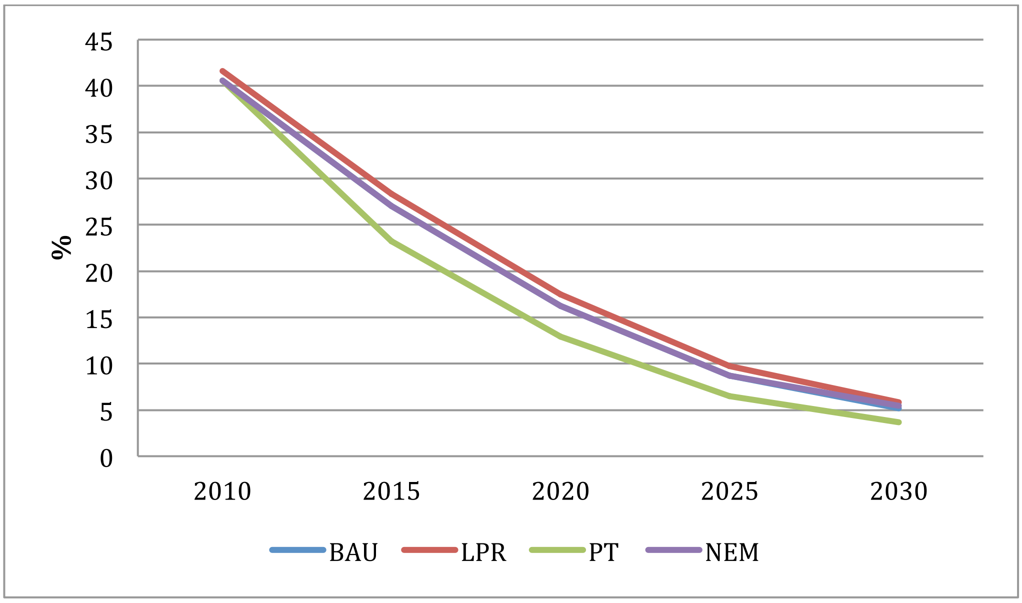


Figure 16: Comparison of urban head count ratio across scenarios

The graph above shows that urban poverty incidence can come down to less than 4% of urban population with effective cash transfer.

5.3. Impact of low rural urban disparity

Rural and urban per capita consumption levels are affected when the urban-rural parity ratio is lowered by 6.7% per year in the LPR scenario. When the rural urban disparity is reduced, the consumption in rural areas becomes comparable to consumption in urban areas. As shown in the table 12, in LPR scenario in 2010 urban consumption is more than twice that of rural consumption.

Table 19: Comparison of ratio of urban per capita consumption to rural per capita consumption under BAU and LPR scenario

Year	BAU	LPR
2010	2.34	2.26
2015	2.33	2.18
2020	2.34	2.11
2025	2.34	2.04
2030	2.33	1.97

As income opportunities in rural areas improve, there is higher income generation in rural areas compared to BAU. Hence, by 2030, urban per capita consumption is only 1.97 times that of rural. It impacts the migration of people from rural areas as and the migration slows down due to increased availability of opportunities in rural areas. It can be seen by the rural to urban population ratio in LPR as compared to BAU.

Table 20: Comparison of ratio of rural to urban population

Year	BAU	LPR
2010	2.35	2.40
2015	2.23	2.32
2020	2.12	2.25
2025	2.01	2.17
2030	1.90	2.10

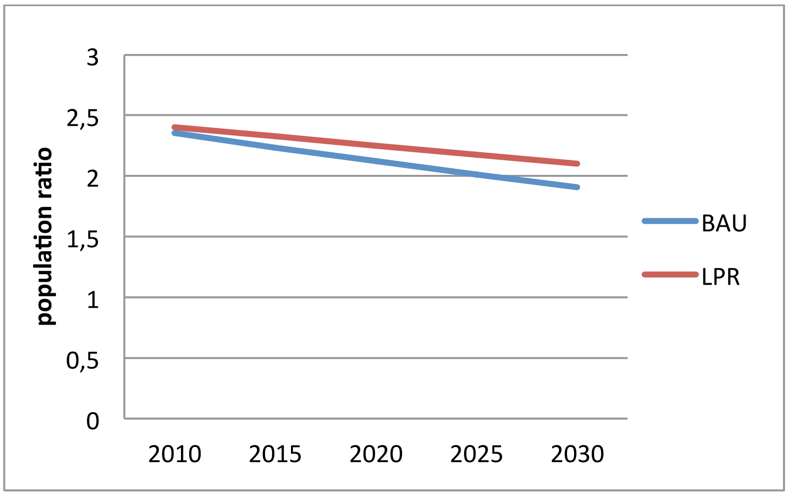


Figure 17: Comparison of ratio of rural to urban population

As a result of narrowing the gap between rural and urban income and changes in proportion of rural and urban populations, the rural areas' share of total consumption remains nearly constant as compared to the declining share seen in BAU. As a result, rural per capita consumption increases in the LPR scenario as shown in Figure 21.

Table 21: Comparison of ratio of rural consumption to total consumption

YEAR	BAU	LPR
2010	0.50	0.51
2015	0.48	0.51
2020	0.47	0.51
2025	0.46	0.51
2030	0.44	0.51

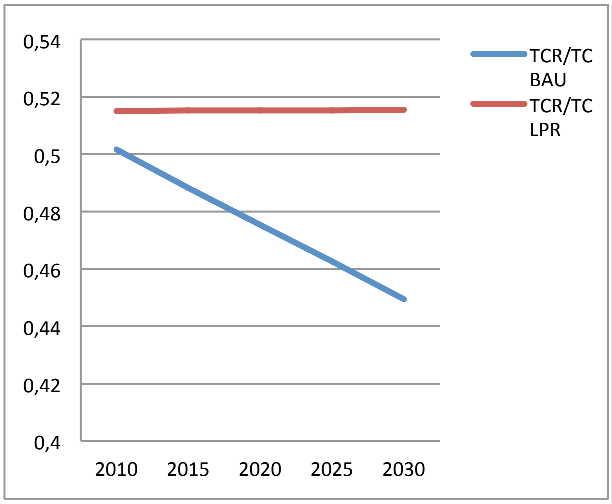


Figure 18: Rural per capita consumption across scenarios

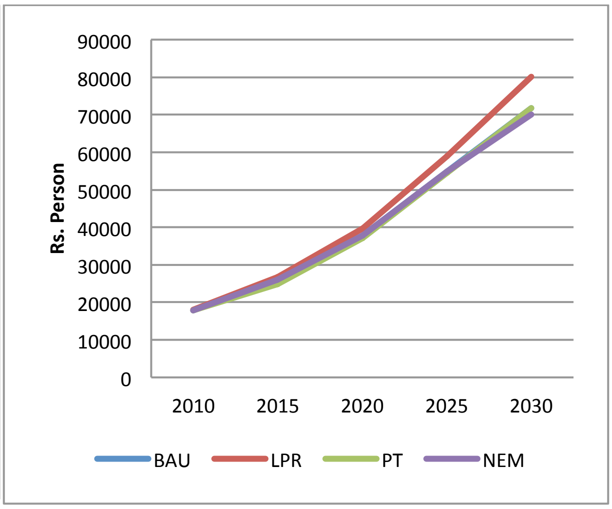


Figure 19: Comparison of ratio of rural consumption to total consumption

5.4. Impact of subsidised electricity on electricity consumption

When subsidised electricity is provided in the classes that have below 1KWh electricity consumption per family per day, it benefits rural and urban poorest class households (RH1, RH2, RH3, UH1 and UH2). Electricity consumption in these classes goes up compared to BAU and, as described earlier, it has longer-term benefits such as increases in the standard of living and increased livelihood opportunities. Here, comparison is made between only the BAU and ET scenarios which provide subsidised electricity, as other scenarios have similar situations to BAU's in regard to electricity.

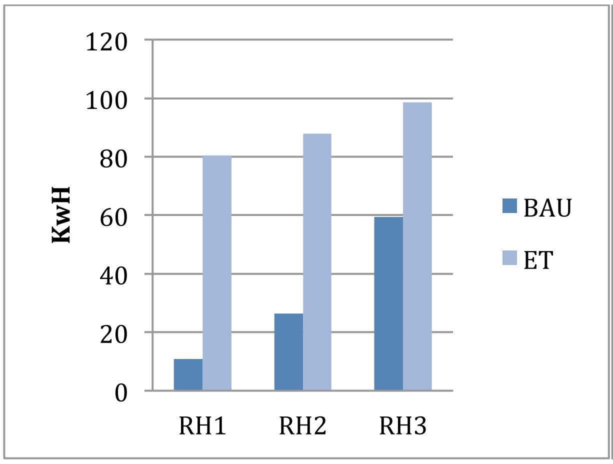


Figure 21: Increased electricity consumption in ET scenario compared to BAU in 2010 in rural households

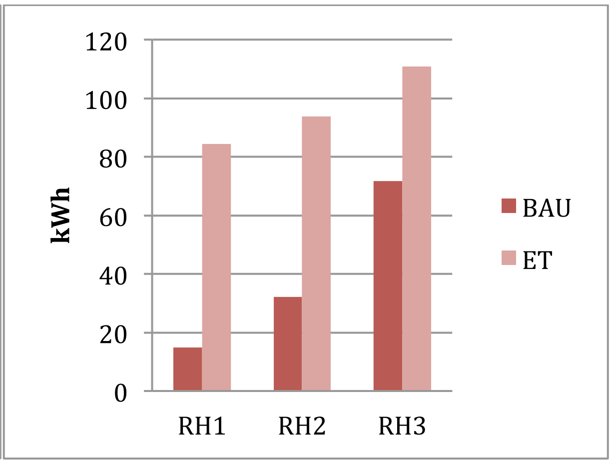


Figure 20: Increased electricity consumption in ET scenario compared to BAU in 2030 in rural households

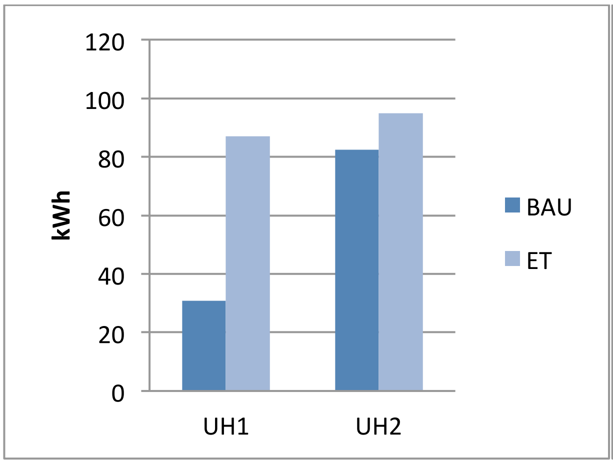


Figure 23: Increased electricity consumption in ET compared to BAU in 2010 in urban households

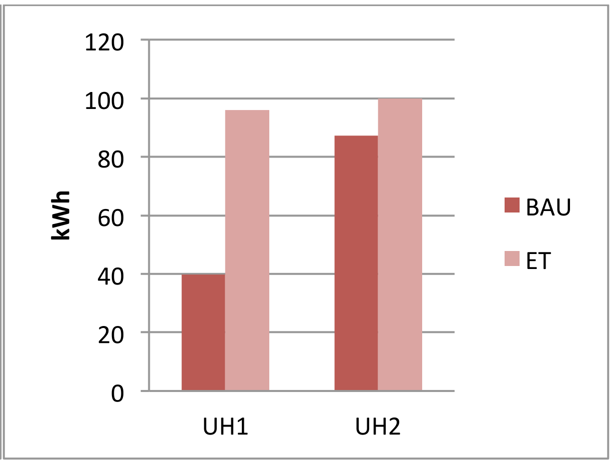


Figure 22: Increased electricity consumption in ET compared to BAU in 2030 in urban households

5.5. Impact on carbon emissions

Mitigation action designed in NEM scenario (BAU constrained for attaining government targets for solar and wind up to 2022) achieves lower emissions compared to BAU. It can also be noted that poverty-alleviating mechanisms in PT and LPR, although increasing CO_2 emissions in the initial period, result in a decrease of emissions to BAU level by 2030. In addition, provision of electricity access to poor people in ET scenario does not actually increase CO_2 emissions much, as the emissions are comparable to BAU level by 2030, the reason being that the economy makes adjustments to all such changes by 2030 and poverty alleviation and energy access is achieved without increasing carbon emissions after a period.

Table 22: Comparison of CO_2 emissions across scenarios (million tonnes)

Year	BAU	LPR	PT	NEM	ET
2005	1,324	1,323	1,324	1,323	1,323
2010	1,645	1,620	1,597	1,635	1,664
2015	1,915	1,999	1,931	2,029	2,043
2020	2,555	2,644	2,557	2,511	2,572
2025	3,632	3,613	3,640	3,510	3,620

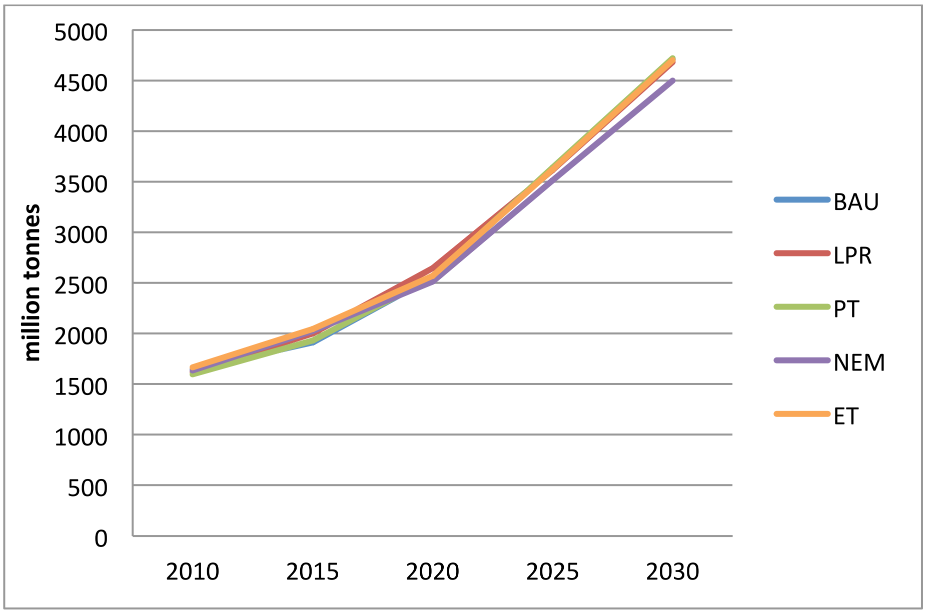


Figure 24: Comparison of CO_2 emissions across scenarios

Table 23: Comparison of relative total CO_2 emissions reductions across scenarios

Year	LPR	PT	NEM	ET
2005	-1.52	-2.92	-0.61	1.16
2010	4.39	0.84	5.95	6.68
2015	3.48	0.08	-1.72	0.67
2020	-0.52	0.22	-3.36	-0.33
2025	-0.57	0.17	-4.42	-0.13

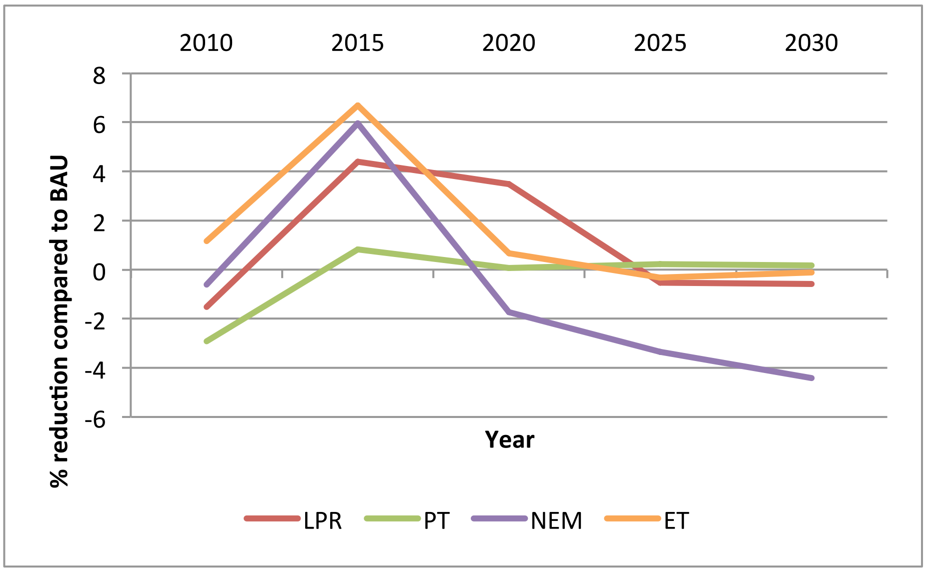


Figure 25: Comparison of relative total CO_2 emissions reductions across scenarios

Table 24: Comparison of per capita CO_2 emissions across scenarios

Year	BAU	LPR	PT	NEM	ET
2005	1.2	1.2	1.2	1.2	1.2
2010	1.4	1.4	1.4	1.4	1.4
2015	1.5	1.6	1.5	1.6	1.6
2020	1.9	2	1.9	1.9	1.9
2025	2.6	2.6	2.6	2.5	2.6
2030	3.3	3.2	3.3	3.1	3.3

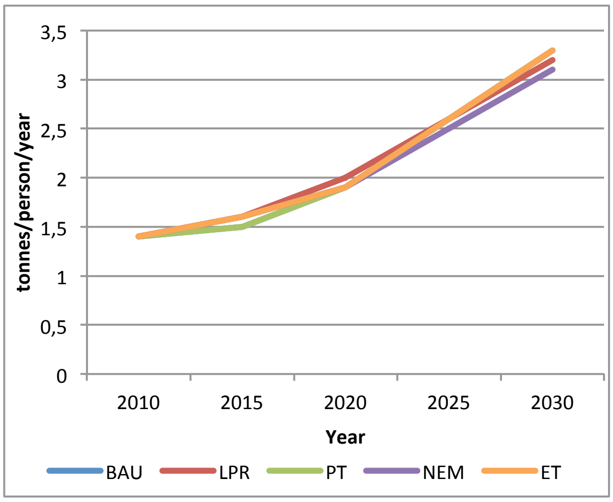


Figure 27: Comparison of per capita CO_2 emissions across scenarios

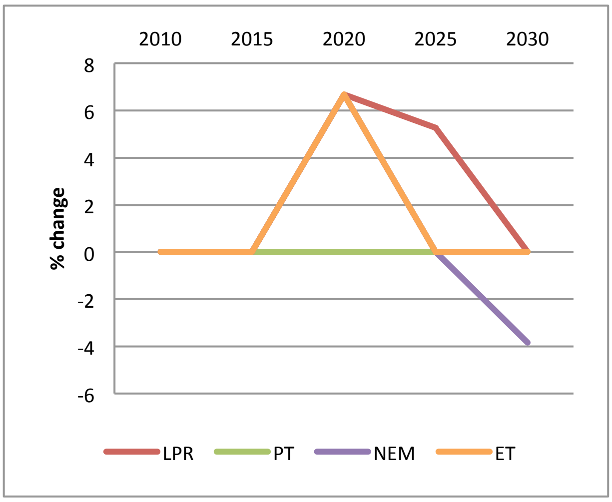


Figure 26: Reduction of per capita CO_2emissions compared to BAU

The following graph shows the different pathway of each scenario more clearly.

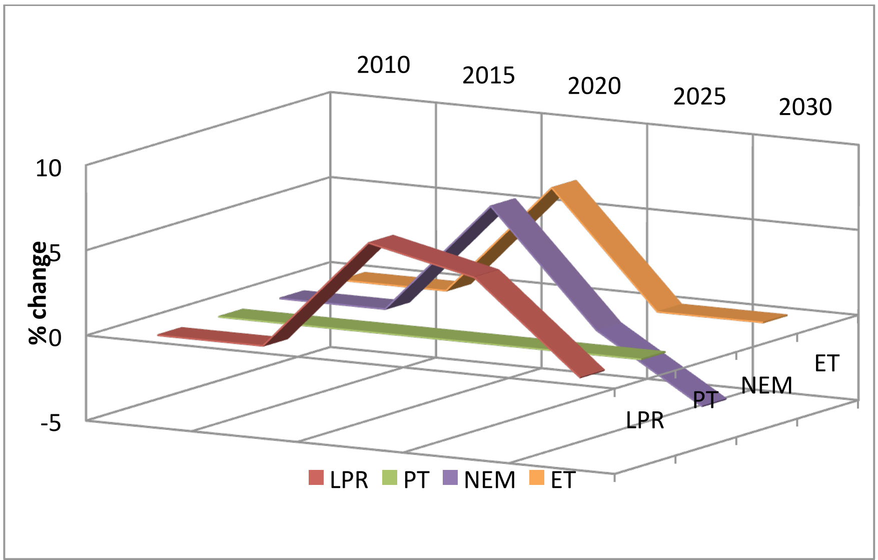


Figure 28: Reduction in per capita CO_2 emissions compared to BAU

Per capita emissions increase compared to BAU till 2020, but thereafter the economy accommodates the changes and CO_2 emissions reduce. NEM scenario achieves 4% reduction in CO_2 emissions compared to BAU. NEM and ET follow similar pathways until they diverge in 2025.

5.5.1. CO_2 emissions from household sector

Different scenarios show different impact on CO_2 emissions in rural and urban household sector.

CO_2 emissions for rural households

Table 25: Total $CO_{2\ emissions}$ for rural households

Year	BAU	LPR	PT	NEM	ET
2005	41	41	41	41	40
2010	66	69	67	66	66
2015	104	112	105	104	104
2020	161	179	162	161	161
2025	219	254	220	213	219
2030	41	41	41	41	40

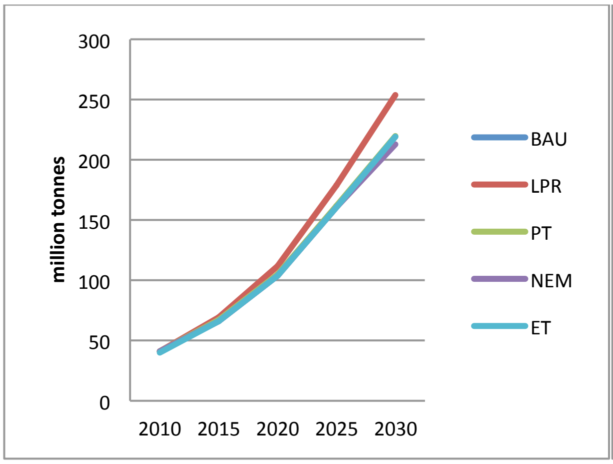


Figure 30: CO_2 emissions for rural households

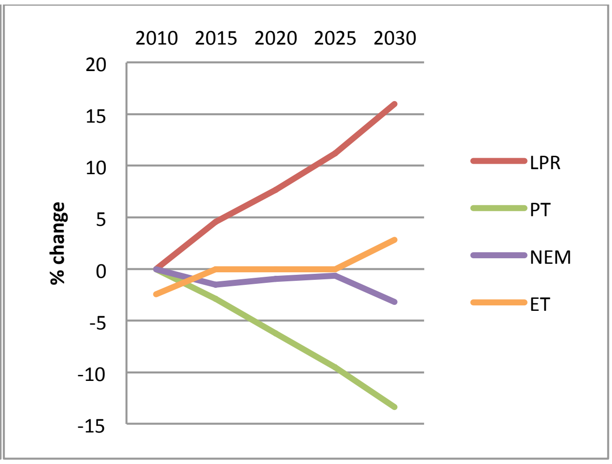


Figure 29: Percentage change in CO_2 emissions in rural areas compared to BAU

CO_2 emissions in rural areas increase with LPR scenario because LPR increases rural consumption whereas CO_2 emissions reduce in partial transfer scenario compared to BAU which is also poverty-alleviating. NEM and ET scenarios have less impact on CO_2 emissions at household level.

CO_2 emissions for urban households

Table 26: Total CO_2 emissions for urban households

Year	BAU	LPR	PT	NEM	ET
2005	100	96	100	100	99
2010	157	147	154	157	157
2015	247	226	246	247	247
2020	389	346	389	389	389
2025	544	481	546	531	543
2030	100	96	100	100	99

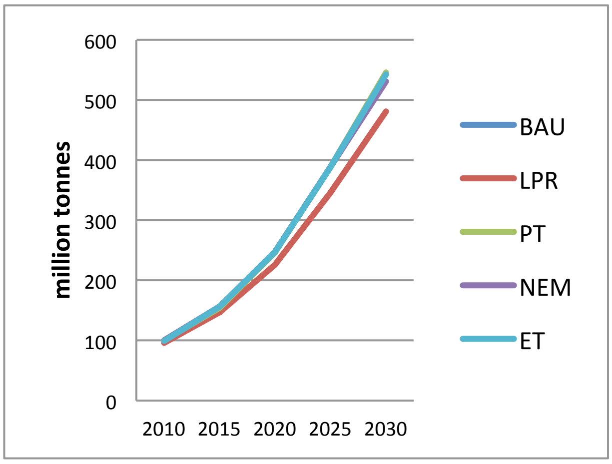


Figure 32:CO_2 emissions for urban households

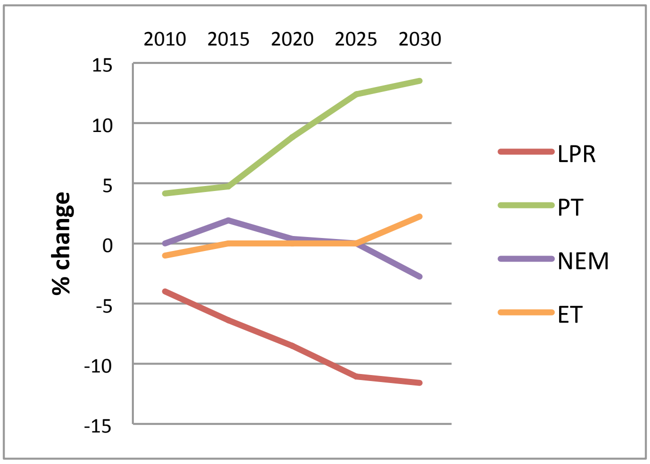


Figure 31: Percentage change in CO_2 emissions in urban areas compared to BAU

CO_2 emissions in urban areas decrease compared to BAU in LPR scenario but increase with PT scenario.

CO_2 intensity of GDP

The CO_2 intensity of GDP reduces successively across all scenarios as shown in the table below.

Table 27: Comparison of CO_2 intensity of GDP across scenarios (malt/_billion_$GDP (PPP))

Year	BAU	LPR	PT	NEM	ET
2010	0.295	0.293	0.284	0.292	0.294
2015	0.25	0.256	0.251	0.254	0.268
2020	0.228	0.236	0.227	0.222	0.23
2025	0.216	0.215	0.215	0.209	0.215
2030	0.202	0.2	0.202	0.196	0.202

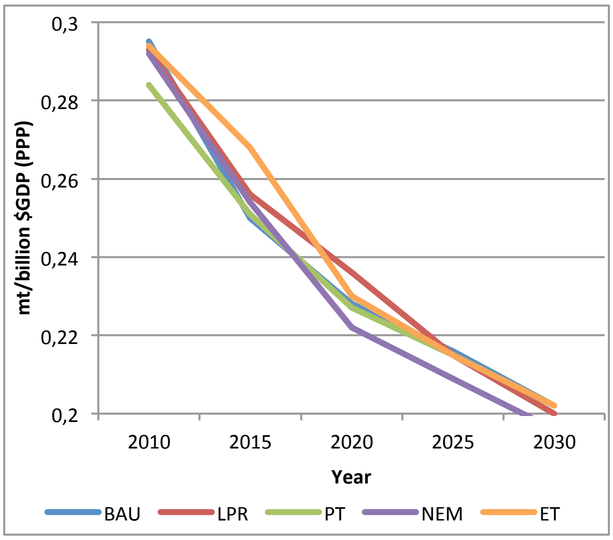


Figure 34: Comparison of CO_2 intensity of GDP across scenarios

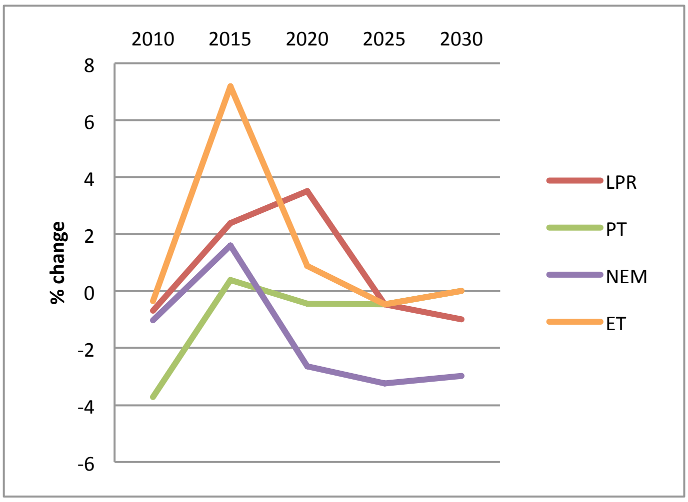


Figure 33: Percentage changes in CO_2 intensity compared to BAU

India has already announced that it will reduce the emissions intensity of its GDP by 20-25 percent from 2005 levels by the year 2020. In 2005, the CO2 emissions intensity of GDP was 0.362 according to the model. By 2020, it will come down to 0.228 in BAU and 0.222 in NEM which is more than 37% reduction. Hence, India is well poised to meet its announced target of 25% reduction in CO2 intensity of GDP.

5.6. Impact on energy intensity

The energy intensity of GDP is very low in India and it reduces further across all scenarios, as shown in the table below.

Table 28: Comparison of energy intensity of GDP across scenarios (KGOE/$GDP (PPP) LAKHS)

Year	BAU	LPR	PT	NEM
2010	0.086	0.084	0.082	0.084
2015	0.07	0.074	0.072	0.074
2020	0.064	0.064	0.061	0.061
2025	0.058	0.058	0.057	0.056
2030	0.054	0.054	0.054	0.053

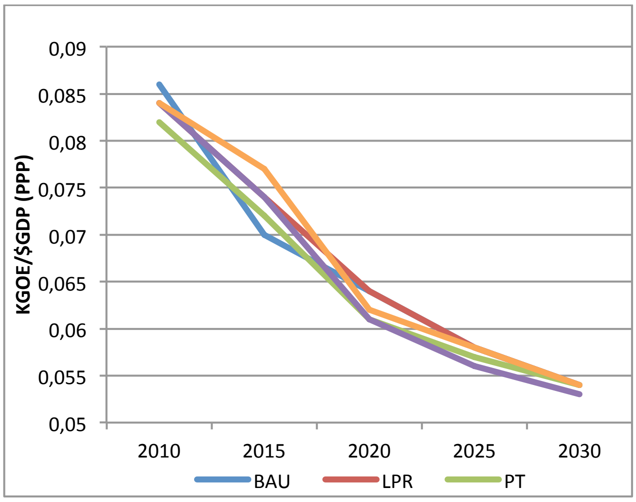


Figure 35: Comparison of energy intensity of GDP across scenarios

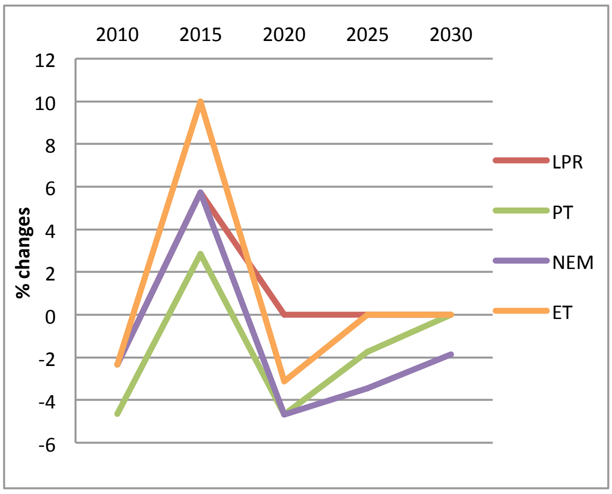


Figure 36: Reduction in energy intensity of GDP in scenarios compared to BAU

Since the model optimises over the entire period, the energy intensity of the GDP increases in first period (up to 2015) in NEM, as the fossil fuels are used first and then the model chooses renewable sources of energy. Ultimately energy intensity reduces by 2%, in the NEM scenario. This might seem to be a negligible change, but India already has one of the lowest energy intensities reduced by 2%, in NEM scenario. This might seem to be a negligible change, but India already has one of the lowest energy intensity of GDP in the world, so there is not much scope to reduce it further. With other poverty-alleviating scenarios, energy intensity increases first but the model accommodates the changes in the later period and again the energy intensity is comparable to BAU by 2030.

5.7. Comparing results for poverty and mitigation

All scenarios can be assessed together to find out the best strategy for India to address the issue of poverty and carbon emissions simultaneously. In the following figure, the log of the total number of people below the poverty line is plotted on the X axis and total CO_2 emissions from 2010 to 2030 are plotted on Y axis. The figure clearly indicates that PT achieves poverty alleviation much faster compared to other strategies while keeping CO_2 emissions comparable to BAU.

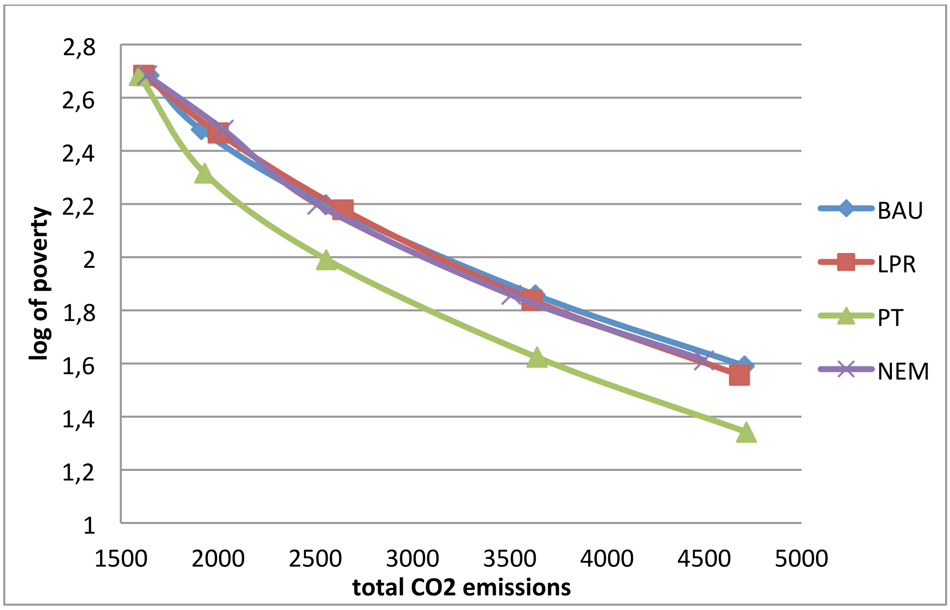


Figure 37: Comparison of scenarios for poverty and mitigation

6. Conclusion

The results of the modelling and the discussion above show that low-carbon development is a realizable strategy for India. Poverty alleviation, reducing rural urban disparity and providing energy access to poor are all achievable developmental goals and can be achieved without adding to the CO_2 emissions burden. CO_2 emissions will increase substantially only if the current fossil fuel energy-intensive growth path is continued by the time poor people shift into the middle class.

Also, India can further explore mitigation actions, which can reduce carbon emissions compared to BAU. But a balance needs to be maintained while designing mitigation actions so that they do not increase poverty.

7. Future work

Further study can be conducted by including more mitigation actions. More low-carbon technology options can be analysed according to their impact on poverty. Some potential PAMAs can be explored in the macro-economic framework.

8. References

Boeters, S 2007. Autonomous energy efficiency increases and the MAC curve in long-term energy-economy scenarios. CPB Netherlands Bureau for Economic Policy Analysis. Den Haag

Deaton, A and Dre'ze, J 2009. Nutrition In India: Facts and Interpretations. Economic & Political Weekly, Volume xliv No 7

Gielen, D 2009. Energy transition for industry. International Energy Agency

Headey D, Chiu, A, Kadiyala, S 2011. Agriculture's role in the Indian enigma: help or hindrance to the under nutrition crisis? International Food Policy Research Institute (IFPRI). New Delhi

India Central Statistical Organization 2012. Sources & methods of National Account Statistics. Government of India

India Ministry of Labour and Employment 2010. Report on wages and earnings on rural labour households, 61st round of national sample survey, rural labour enquiry. Government of India

India Ministry of Rural Development 2012. Report to the people. Mahatma Gandhi National Rural Employment Guarantee Act of 2005. Government of India

India Ministry of Statistics & Programme Implementation 2011. National Sample Survey: Key indicators of employment & unemployment in India, 2009-2011, 66th round of national sample survey. Government of India.

India Planning Commission. Data and statistics. http://planningcommission.nic.in/ . Government of India

India Planning Commission 2011. Interim report of the expert group on low carbon strategies for inclusive growth. Government of India

International Energy Agency 2011. Key World Energy Statistics.

Kotwal, A, Murugkar, M, Ramaswamy, B 2011. PDS Forever? Economic & Political Weekly. Vol. xlvi No 21.

Kundu, A 2010. Rural Urban Economic Disparities in India: Database and Trends. India Policy Forum. National Council of Applied Economic Research.

Parikh, J. and Ghosh, P 2009. Energy Technology Alternatives for India till 2030, International Journal of Energy Sector Management, 3(3), 233–250.

Parikh, K 2011. Food grain policy. Working paper. Integrated Research and Action for Development (IRADe).

Saluja, M R, and Yadav, B 2006. Social accounting matrix for India 2003-04. India Development Forum. Retrieved from http://planningcommission.nic.in/reports/sereport/ser/sr_sam.pdf

Sanstad, A, Jayashree, R, Jayant, S 2006. Estimating energy-augmenting technological change in developing country industries. Science Direct. Energy Economics 28: 720–729

Sharma, R 2006. Quantifying malnutrition in India. PhD Thesis, School of Economics, University of Delhi.

Shukla, P R 2009. Low carbon society vision 2050. Indian Institute of Management. Ahemadabad National Institute for Environmental Studies. Kyoto University . Mizuho Information & Research Institute

Strachan, N 2011. Business-as-Unusual: Existing policies in energy model baselines. Energy Economics 33:153-160

Tendulkar, S, Radhakrishna, R, Sengupta, S, 2009. Report of the expert group to review the methodology for estimation of poverty. Planning Commission. Government of India.

United Nations Development Programme. India factsheet: economic and human development indicators. http://www.undp.org/content/dam/india/docs/india_factsheet_economic_n_hdi.pdf

Virmani, A 2006. Poverty and Hunger in India: what is needed to eliminate them. India Planning Commission. Working paper No. 1/2006-PC . Government of India.

Wlokas, H L, Rennkamp, B, Torres Gunfaus, M , Winkler, H, Boyd, A, Tyler, E and Fedorsky, C 2012. Low Carbon Development and Poverty: Exploring poverty alleviating mitigation action in developing countries. Research Report for MAPS (Mitigation Action Plans and Scenarios). Energy Research Centre, University of Cape Town. http://www.mapsprogramme.org/knowledge-sharing/research_lce-and-poverty-paper_120330/ accessed 4 May 2011

9. Annexure

Technical details of the low urban rural parity ratio (LPR) scenario -

Let

$$\frac{POPR}{POPU} = GAMMA$$

and

$$\frac{PCU}{PCR} = URIP$$

Consider

$$\frac{PCR}{PC} = \frac{PCR}{\frac{POPR.PCR+POPU.PCU}{POP}}$$

Or

$$\frac{PCR}{PC} = \frac{POP.PCR}{POPR.PCR.\left[1 + \frac{URIP}{GAMMA}\right]}$$

Or

$$\frac{PCR}{PC} = \frac{\frac{POP}{POPR}}{\left[1 + \frac{URIP}{GAMMA}\right]}$$

Implies that

$$\frac{PCR}{PC} . \frac{POPR}{POP} = \frac{1}{\left[1 + \frac{URIP}{GAMMA}\right]}$$

Or

$$\frac{TCR}{TC} = \frac{1}{\left[1 + \frac{URIP}{GAMMA}\right]}$$

Implies

$$\theta_R = \frac{TCR}{TC} = \frac{1}{\left[1 + \frac{URIP}{GAMMA}\right]}$$

Or

$$1 + \frac{URIP}{GAMMA} = \frac{1}{\theta_R}$$

Or

$$\frac{URIP}{GAMMA} = \frac{1}{\theta_R} - 1$$

Or

$$GAMMA = \frac{URIP}{\frac{1}{\theta_R} - 1}$$

Assuming θ_R to be constant at the base year level the Gamma is computed for the assumed decrease in URIP. The URIP, GAMMA and θ_R are given in the table below:

	BAU				LPR					
YEAR	TCR/TC	URIP	GAMMA	YEAR	TCR/TC	URIP	GAMMA	GAMMA grt	POPR	POPU
2005	0.51	2.34	2.49	2005	0.51	2.34	2.48		781	315
2010	0.5	2.34	2.35	2010	.0.51	2.26	2.4	-0.67	831	346
2015	0.49	2.34	2.23	2015	0.51	2.19	2.32	-0.67	876	378
2020	0.48	2.34	2.12	2020	0.51	2.12	2.24	-0.67	917	409
2025	0.46	2.34	2.01	2025	0.51	2.05	2.17	-0.67	952	438
2030	0.45	2.34	1.91	2030	0.51	1.98	2.1	-0.67	978	466
2035	0.44	2.34	1.81	2035	0.51	1.91	2.03	-0.67	995	491
2040	0.42	2.34	1.72	2040	0.51	1.85	1.96	-0.67	1003	512
2045	0.41	2.34	1.64	2045	0.51	1.79	1.9	-0.67	1002	528
2050	0.4	2.34	1.56	2050	0.51	1.73	1.83	-0.67	991	540
2055	0.39	2.34	1.48	2055	0.51	1.67	1.77	-0.67	971	547
2060	0.38	2.34	1.41	2060	0.51	1.62	1.72	-0.67	942	549
2065	0.36	2.34	1.34	2065	0.51	1.56	1.66	-0.67	905	545