Co-benefits of Low Carbon Pathway on Air Quality, Human Health and Agricultural Productivity in India

An initiative supported by

SHAKTI
SUSTAINABLE ENERGY FOUNDATION

teri

teri school of advanced studies

Suggested format for citation

T E R I [The Energy and Resources Institute]. 2018
Assess the human health and agricultural co-benefits of a low carbon pathway for India, New Delhi: The Energy and Resources Institute. 121 pp.
[Project Report No. 2015EE06]

For more information

Project Monitoring Cell
The Energy and Resources Institute
Darbari Seth Block
IHC Complex, Lodhi Road
New Delhi – 110 003
India

Tel. 2468 2100 or 2468 2111
E-mail pmc@teri.res.in
Fax 2468 2144 or 2468 2145
Web www.teriin.org
India +91 • Delhi (0)11

Shakti Sustainable Energy Foundation works to strengthen the energy security of the country by aiding the design and implementation of policies that encourage energy efficiency, renewable energy and sustainable transport solutions, with an emphasis on sub sectors with the most energy saving potential. Working together with policy makers, civil society, academia, industry and other partners, they take concerted action to help chart out a sustainable energy future for India (www.shaktifoundation.in).

Project Team

Project Advisors

Dr. Prodipto Ghosh, Distinguished Fellow, TERI

Dr. Atul Kumar, Associate Professor, TERI School of Advanced Studies

Project Investigator

Dr. Sumit Sharma, Associate Director and Fellow, TERI

Co-Project Investigator

Dr. Ritu Mathur, Director & Senior Fellow, TERI

Prof. Suresh Jain, Head of Department, TERI School of Advanced Studies

Team Members

Dr. Arindam Datta, Fellow, TERI

Mr. Swapnil Shekhar , Research Associate TERI

Mr. Jai Kishan Malik, Research Associate, TERI

Ms. Anju Goel, Associate Fellow, TERI

Dr. Chuba Jamir, Assistant Professor, TERI School of Advanced Studies

Ms. Ilika Mohan, Research Associate, TERI

Mr. Kabir Sharma, Research Associate, TERI

Ms. Sugandha , Research Associate, TERI

Ms. Seema Kundu, Associate Fellow, TERI

India has demonstrated its commitment to fast-track greenhouse gas (GHG) mitigation measures that align well with its development priorities. The National Action Plan on Climate Change (NAPCC) was launched in 2008, and a concerted effort was put in place to draw strategies that would help India in aligning its development with low-carbon actions. Moreover, the NAPCC also ensured that there was a broad spectrum of initiatives built-in towards such a goal. The intended nationally determined contribution (INDC) submitted by India to the **United Nations Framework Convention on Climate Change** (UNFCCC) in October 2015, is ambitious given that India has already been incorporating several low-carbon solutions and strategies across sectors. India has committed to reduce the GHG emissions intensity of its economy by 33–35% by 2030 as compared to the 2005 level. A consideration of co-benefits, such as improvement of air quality, expected reductions in human health impacts, increase in agricultural yields etc. against a business-as-usual (BAU) pathway, can significantly strengthen the case for proposed climate actions by tilting the overall cost-to-benefit ratio favourably towards the latter. Furthermore, as elucidated in the NAPCC's approach of simultaneous advancement of India's development and climate objectives, co-benefits are viewed as more meaningful objectives to pursue rather than outright climate mitigation. Therefore, it is extremely relevant that while assessing the implications of a low carbon growth trajectory for India, the co-benefits to be derived from proposed policy measures designed to mitigate climate change are also evaluated and quantified. Additionally, consideration of co-benefits will support more informed prioritization among available policy options.

In this context, TERI has conducted this study which is supported by the Shakti Sustainable Energy Foundation. The main objectives of the study were to carry out a co-benefits assessment of various energy policy scenarios. Four different alternative scenarios modelled within the energy (MARKAL) model, depicting varying levels of GHG mitigation options are considered to assess not only the CO_2 emission reduction potential, but to also identify and examine the possible co-benefits of the alternative options. The co-benefits that are assessed and quantified include reductions in emissions of air pollutants, change in concentration of air pollutants, impacts on human health, and agricultural yields. The whole of India's landmass is chosen as the study domain for the assessment. This study assesses the air quality improvement co-benefits of various energy development and mitigation pathways using integrated modelling techniques to convert energy use information under different scenarios to air pollutant emission and its corresponding impacts on human health and agriculture.

The MARKAL model was used to depict the possible energy use under BAU and three different scenarios which focus on different levels of uptake of options, such as clean energy alternatives and energy efficient technologies. The BAU scenario represents climate policies in India that were already implemented before 2016, and an ambitious high GDP growth as envisaged necessary for sustainable development by the Indian Government. Other three scenarios are: i) INDC—takes into account various climate policies and targets formulated in India's INDC submission; ii) ambition (AMBI)—higher GHG mitigation ambition than those formulated in INDC submission by India while keeping development in India at the forefront; and iii) low growth (LG)—takes into account lower growth rate than the BAU.

The Energy scenario modelling and analysis show that while the total primary energy consumption increases over the years in all scenarios, it declines across the Reference (BAU), INDC, and Ambition (the High Growth scenarios) as the stringency of mitigation actions increases. The capacity of coal based power plants successively declines across the three high growth scenarios, increasingly being replaced by renewables like solar and wind electricity. The key mitigation strategy in the demand sectors is efficiency improvement- either by shifting to better and more efficient and cleaner technologies (like electric pumpsets in agricultural sector, more efficient appliances in the residential sector, energy efficient buildings in the commercial sector, processes with lower SECs in industrial sector, etc.) or by fuel switching (electric vehicles in transport sector, shift from traditional biomass to LPG in cooking etc.). The industrial sector shows significant dependence on coal while the transport sector shows dependence on petroleum even in the Ambition Scenario. However, improvement in SEC in the former and engine efficiency and fuel switching (to EVs) in the latter lead to significant reduction in energy consumption in both INDC and Ambition Scenarios. The Low Growth Scenario on the other hand brings forth an interesting energy consumption pathway. The energy consumption in 2031 in this scenario is close to that of the Ambition Scenario which increases to slightly more than that in INDC Scenario by 2051.

Energy use numbers from the MARKAL model under different scenarios were fed into the GAINS-ASIA emission model and estimates of emissions were derived for pollutants, such as PM_{10}, NOx, SO_2, CO, and non-methane volatile organic compounds (NMVOCs) for the year 2016, 2030, and 2050. The emission sources have been broadly classified into five major sectors, that is, a) Power, b) Transport, c) Domestic, d) Industry, and e) Others. The estimated emissions of air pollutants from the GAINS-ASIA were further fed into an air quality model (CMAQ) to assess the impacts on air quality, human health, and agricultural productivity in 2030 and 2050, under different scenarios.

The estimated PM_{10} emission from different sectors indicates 49.9% and 8.5% increase during 2030 and 2050 respectively, compared to the emission in 2016 under the BAU scenario. However, the estimated PM_{10} emissions were projected to decrease during 2050 compared to 2030, due to penetration of LPG in residential sector, BS-VI vehicles in transport, and introduction of stringent standards for industries and power plants. On the other side, estimated annual NOx emission under the AMBI scenario suggests an increase of 30% to 60% during 2030 and 2050, respectively compared to 2016. Study indicates, in spite of reduction in total energy consumption, the AMBI scenario doesn't suggest decrease in the emission of pollutants over the INDC scenario—this might be attributed to the shifts in the type and quality of fuels used in the energy sector. The study suggests that the emission of NMVOCs is expected to grow at a much faster rate compared to other pollutants due to absence of adequate standards for control.

Emissions were fed into an air quality model to predict $PM_{2.5}$ and ozone concentrations for the year 2016. The modelled values were compared with actual observation of pollutants for model validation purpose. High pollutant concentrations were observed in the Indo-Gangetic plains mainly due to high population densities, vehicular movement, and presence of power plants. Higher concentrations are also observed in the western part of the country which is attributed to industries and boundary conditions showing contributions from outside the borders of India. While the INDC scenario shows a significant decrease in $PM_{2.5}$ concentrations as compared to the Reference (BAU) scenario, the AMBI scenario does not show further decrease in $PM_{2.5}$ concentrations indicating that CO_2 emission reduction need not necessarily be synergistic with decreasing local air pollutants, and may need specific and concerted action to address the latter. Also, different air pollutants may vary differently as is noticed in the Ambition scenario which does not indicate a decrease in PM_{10} levels, but reflects a significant decrease in ozone concentration as compared to the INDC scenario. The Low Growth scenario shows lower $PM_{2.5}$ concentrations in 2030 than all the other scenarios, while it shows higher $PM_{2.5}$ concentrations than the INDC scenario in 2050. The Low Growth scenario in 2050 assumes lower penetration of efficient technologies with low growth across sectors and hence shows lower $PM_{2.5}$ concentrations than the BAU (on account of lower growth), but higher concentrations than INDC (on account of lower penetration of efficient technologies). Ozone concentrations are expected to increase significantly in future in the BAU scenario due to projected increase in emissions of both of its precursors—NOx and VOCs. The INDC scenario shows some decrease in emissions of precursors and a decrease is also observed in the ozone concentrations. Ambition scenario shows the greatest decrease in ozone concentrations in India due to uptake of efficient technologies, which lead to reduction in emissions of ozone precursors.

The predicted pollutant concentrations are fed into the impact models. A significant decline in the total respiratory and cardiovascular mortality is expected during 2030 and 2050, under different alternative scenarios. The AMBI and INDC scenario shows a decline of 9%–11% in mortalities which can be attributed to improvement in air quality. The loss of wheat is expected to increase from 27 Mt (in 2016) to 55 Mt and 153 Mt during 2030 and 2050, respectively under the BAU scenario. However, the wheat loss is expected to decrease by 10 Mt, 15 Mt, and 6 Mt during 2050 under the INDC, AMBI, and LG scenarios, with respect to the BAU scenario. The energy, emissions, concentrations of $PM_{2.5}$ and ozone, and their impacts over human health and wheat productivity, in various scenarios are shown in Table E.1.

Table E.1 Energy consumption, emissions, concentrations of $PM_{2.5}$ and ozone, and their impacts over human health and wheat productivity, under various scenarios

	2016	2030				2050			
	Base	BAU	INDC	AMBI	LG	BAU	INDC	AMBI	LG
Energy (PJ)									
Total consumption	28,626	54,720	52,147	49,895	50,996	110,231	95,388	85,612	90,383
Emissions									
CO_2 (Mt)	2,053	4,734	4,519	4,232	4,001	10,373	9,209	8,080	8,317
PM_{10} (Kt)	13,619	20,425	18,734	18,759	19,088	16,536	13,790	14,887	16,307
SO_2 (Kt)	8,417	10,144	10,047	10,154	8,883	14,408	13,411	13,157	11,605
NOx (Kt)	6,988	9,164	8,739	8,442	8,664	15,365	11,850	11,271	11,956
Emission intensity (gCO_2/Re)									

	2016	2030				2050			
CO_2	27.62	18.07	17.25	16.16	23.14	10.18	9.04	7.93	14.14
Air quality									
$PM_{2.5}$ ($\mu g/m^3$)	51.7	69.5	66.5	66.4	66.3	69.6	60.3	62.1	64.8
Ozone (ppb)	51.9	53.5	53.1	52.8	53.3	57.4	55.7	55.0	55.9
Health									
Mortalities (million)	0.79	1.05	1.02	1.02	1.02	1.22	1.09	1.11	1.16
Agriculture									
Wheat loss (million t)	26.9	55	54	53.1	54.7	152.3	141.7	137.2	143.9

The percentage change in energy, emissions, concentrations of $PM_{2.5}$ and ozone, and their impacts over human health and wheat productivity, in various scenarios is shown in Table E.2.

Table E.2 Percentage change in energy, emissions, concentrations of $PM_{2.5}$ and ozone, and their impacts over human health and wheat productivity, in various scenarios

	2016	2030				2050			
	Base	BAU*	INDC**	AMBI**	LG**	BAU*	INDC**	AMBI**	LG**
Energy									
Total consumption		91%	-5%	-9%	-7%	285%	-13%	-22%	-18%
Emissions									
CO_2		131%	-5%	-11%	-15%	405%	-11%	-22%	-20%
PM_{10}		50%	-8%	-8%	-7%	21%	-17%	-10%	-1%
SO_2		21%	-1%	0%	-12%	71%	-7%	-9%	-19%
NOx		31%	-5%	-8%	-5%	120%	-23%	-27%	-22%
Emission Intensity									
CO_2		-35%	-5%	-11%	28%	-63%	-11%	-22%	39%
Air quality									
$PM_{2.5}$		34%	-4%	-4%	-5%	35%	-13%	-11%	-7%
Ozone		3%	-1%	-1%	0%	11%	-3%	-4%	-3%
Health									
Mortalities		33%	-3%	-3%	-3%	54%	-11%	-9%	-5%
Agriculture									
Wheat loss		104%	-2%	-3%	-1%	466%	-7%	-10%	-6%

* change with respect to Base-2016

** change with respect to BAU in respective years (2030/2050)

Study suggests that the decrease in the consumption of energy in different sectors does not necessarily lead to a proportionate decrease in the associated emission of air pollutants and their effects on human health and agriculture. However, there are significant co-benefits of low carbon energy policies on air quality, human health, and agricultural productivity. Evidently, there is a need for drafting integrated and synergistic strategies to control emission of both GHG and air pollutants. This will have reduced impacts of warming, and air pollution, at global, regional, and local scales.