TWO PATHS TO EMISSION REDUCTIONS: ENERGY EFFICIENCY AND RENEWABLE

Alternative title: Energy, Emissions and Economy-wide impacts of adopting appliance efficiency measures

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ABSTRACT

As India moves towards meeting its Intended Nationally Determined Contributions (INDCs) to emissions reduction, policy makers have to choose among available alternatives. Investment in renewable energy continues to be the primary choice. Energy efficiency is relegated to the second place as savings are not obvious to track and its economy wide impacts are difficult to estimate. The debate on the choice between energy efficiency and renewable energy is far from settled and decisions continue to be made void of empirical evidence.

This paper estimates the reduction in energy consumption, emissions and economy wide impacts over time from promotion of efficient light bulbs appliances in the Indian context. We then estimate the investment (and associated emissions) required to meet the equivalent energy demand through conventional and renewable sources if the energy efficiency measures were not deployed.

This method helps to quantify the additional monetary and environmental benefits of efficiency improvement programs (the efficient light bulb program in this case). The impacts of these alternative policy scenarios are estimated using a coupled input-output econometric framework of the newly developed E3-India model. The model captures the relationship between Economy, Energy and Emissions, covering 20 economic sectors, 8 energy users and five income quintiles for India's 32 states and union territories.

INTRODUCTION

As India moves towards meeting its Intended Nationally Determined Contributions (INDCs) to emissions reduction, policy makers have to choose among available alternatives. Investment in renewable energy continues to be the primary choice. Energy efficiency is relegated to the second place as savings are not obvious to track and its economy wide impacts are difficult to estimate. The debate on the choice between energy efficiency and renewable energy is far from settled and decisions continue to be made void of empirical evidence.

EMISSIONS

India's Intended Nationally Determined Contribution include a reduction in the emissions intensity of its GDP by 20-25% reduction in Emission intensity of GDP by 2020 and, 33 to 35 per cent by 2030 from 2005 level. It also pledges to create a carbon sink of 2.5 to 3 b tonne of CO_2 equivalent through additional forest and tree cover by 2030 (MoEF, 2015).

Economy

ELECTRICITY

Total electricity generation capacity in 2016 was 322 GW (CEA 2016). The consumption was 1,031 TWh of which 23% (or 237 TWh) was in the domestic sector. Deficit xx. About 81% of the households[1] use electricity as the main source of lighting. Lighting accounts for 28% of the residential electricity use. It is believed that promoting efficient lighting in domestic sector will save 50 b kWh in electricity every year which is equivalent to about 19 GW of avoided generation capacity (EESL, 2014).

Bulbs: LED share and change over time

DEMAND SIDE MANAGEMENT BASED EFFICIENT LIGHTING PROGRAM

Ministry of Power, Government of India launched the Demand side management based Efficient Lighting Program (DELP). DELP was relaunched

[1] NSSO, 2016

as Unnat Jyoti by Affordable LEDs for All (UJALA, meaning light in Hindi) in 2014. It is being executed by Energy Efficiency Services Limited (EESL)[2] as possibly the world largest zero subsidy LED program for domestic consumers. The aim of the program is to replace the inefficient 60 W ICL bulbs with energy efficient 8 W LED bulbs. The LED bulbs consume about 85% less energy, gives same amount of light and last 20 times longer.

Under this program, EESL negotiated bulk purchase from LED manufactures and brought the cost down from about Rs. 310 to Rs. 38 /bulb to make it affordable to households. The corresponding retail prices of these bulbs were Rs. 400 and Rs. 65 respectively. EESL participates in distributing these bulbs to households. The program aims to replace 770 m bulbs during 2014-2019 (EESL, 2014). About 758 m ICL bulbs were sold in 2012 alone (ELCOMA in EESL, 2014) and hence, the overall replacement potential is huge.

Households buy these LED light bulbs as a replacement for their conventional ICL bulbs at the cost of Rs. 50 / bulb under the program. Assuming a usage of 3.5 hours per day for 300 days a year (EESL, 2014), the LED bulbs completely pay for itself in little over 2 months.

EXPECTED IMPACTS

EESL 2014, IEA, 2017

RESEARCH QUESTION AND METHODOLOY

This paper estimates the reduction in energy consumption, emissions and economy wide impacts on employment and income over time from promotion of efficient household appliances in the Indian context. The current focus is on the domestic efficient light bulbs program. We then estimate the investment (and associated emissions) required to meet the equivalent energy demand through conventional and renewable sources if the energy efficiency measures were not deployed.

The impacts of these alternative policy scenarios are estimated based on their economy wide impacts using a coupled input-output econometric framework and the future technology transitions (Mercure, 2012) module of the newly developed E3-India model. The model captures the relationship between Economy, Energy and Emissions, covering 20 economic sectors, 8 energy users and five income quintiles-for India's 32 states and union territories.

SIGNIFICANCE OF RESEARCH

This method helps to quantify the additional monetary and environmental benefits of efficiency improvement programs beyond their direct impacts. It also helps to identify any negative impacts in the process which may deserve to be addressed for policy implementation. Finally, the approach provides empirical evidence to policy makers to aid in decision-making taking into account the economic, environment and energy related impacts of any given policy.

THE E3 MODEL[3]

E3-India is a simulation model built using the coupled input-output econometric approach linked with the national accounting framework. It is based on globally accepted E3ME model (Cambridge Econometrics, 2014) which has been in existence since the mid-1990's and builds on the UK MDM-E3 model that has existed since the 1970s. It has been used for official policy analysis in Europe (e.g. Pollitt et al, 2014).

ECONOMIC MODULE

It is a demand based post Keynesian, non-equilibrium model which neither assumes perfectly competitive market nor optimized use of capital and labor. The behavior is instead estimated using historic data. It is based on real-world relationships, rather than an optimization based tool (see discussion in European Commission, 2016). This approach sets it apart from more traditional CGE approach to economic modeling which is heavily reliant on assumptions about optimizing behavior and perfectly available information (Pollitt, 2017).

<<insert Figure 1 here>>

ENERGY MODULE

The energy system is fully integrated with the economy within the modelling framework. Five of

[2] A super Energy Service Company (ESCO) under the Ministry of Power, Government of India

[3] Cambridge Econometrics (2014, 2017). This section needs to be compressed and paraphrased

the economic sectors in the model (coal, oil extraction, gas extraction, electricity distribution, gas distribution) are defined specifically to support these linkages. Their demand by other industrial sectors as part of the production process is econometrically estimated in the model.

The five carriers are energy in the model are Coal, Oil, Natural gas, Electricity, Biomass. There are 8 users of energy in the model namely Power generation, Other transformation, Manufacturing, Transport, Households, Services, Agriculture, Non-energy use

POWER GENERATION MODULE

The power generation sector is modelled using a 'bottom-up' approach. The FTT (Future Technology Transitions) tool, which is based on evolutionary theory, is used for this purpose (Mercure, 2012). FTT defines 24 energy technologies, which are adopted on the basis of existing market structure and relative technology costs. The model is one of diffusion, which takes into account rates of learning and declining costs of development over time. However, it also recognizes limitations in the energy system, for example maximum shares of intermittent generation, or limitations on available sites for certain renewable technologies.

EMISSIONS MODULE

xx

E3 INDIA

E3-India provides a representation of the Indian economy using the E3M framework. The model has the following dimensions- 32 Indian states and territories, 20 economic sectors, 5 income quintiles, 8 users of 5 different energy carriers, 24 power sector technologies, 10 types of atmospheric emission and annual projections out to 2035. While the general structure of the model allows it to assess general economic policies, the integrated economy-energy linkages make the model an ideal tool for assessing various energy policies (e.g. efficiency programs, energy or carbon taxation).

The model data are derived from official and publicly available sources wherever possible. For most model variables the data are sourced from state-level statistical offices. Limitations in the data are recognized and gaps are filled out using specialized software algorithms. Time series data are collected for all economic, energy and emission related variables (annually from 1995) so that econometric estimation may be carried out.

The estimation approach used is a two-stage least squares error correction model. The exact specification is derived from Hendry et al (1984) and Engle and Granger (1987). It provides both a long-term 'steady-state' outcome as well as looking at the transition period to get to long-term outcomes.

The model can be run for a single state or for India as a whole. The states are linked together through trade linkages and the sectors are linked through input-output relationships. Energy-economy relationships are modelled by combining physical and economic data. Outputs from the model include a full set of national accounts indicators, covering macro-level indicators such as GDP and inflation, but also sectoral output, trade and prices. The sectoral dimension of the model is particularly important for assessing the effects of energy policy as the ways in which sectors use (or provide) energy vary considerably.

SCENARIO DEFINITION

We make the following simplifying assumptions to model the impact of the bulb replacement program on economy, energy and emissions using the E3 India framework-

- Total of 770 m LED bulbs are replaced equally over the 6 years of the program. The number of bulbs replaced in each state is proportional to the household expense on electricity in that state[4]
- Households pay for the efficient LED bulbs from their savings without altering their expenditure on other goods
- As of now we are not aware of study on how LED bulbs may change the usage pattern in the Indian context, and hence the usage patterns under the program are assumed to be same as that of the baseline.
- No market transformation is assumed at the end of the program period. Households revert to their original preferences for bulbs once the program is over. However, they continue to save on electricity bills due to replacements made well beyond the program period as LED bulbs have very long product life

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- [4] Currently we assume that all LED bulbs are replacing ICL bulbs, while it is possible that some of the replacements may be happening for CFL bulbs.

- The manufacturing sector makes a one-time investment of about Rs. 30 b (source) in 2013 i.e., one year before the start of the program to meet the increased demand of LED bulbs from 2014. The investment in manufacturing at the national level is prorated to states based on the number of workers in manufacturing sector in respective states
- EESL creates a total of 35,000 temporary jobs (EESL, 2014) during the program period to distribute LED bulbs to households via electricity distribution company

<<insert Figure 2 here>>

The lifecycle cost and benefits of using LED bulbs, program implementation cost (negligible), intra-year monetary transactions that happen as part of program implementation, and indirect benefits accrued to power distribution companies are currently ignored in the scenario analysis.

DIRECT IMPACTS

The direct impacts of the program include household savings in electricity bills, investment in manufacturing to increase domestic production of LED bulbs, reduction in need for new power generation capacity and associated emissions (Table 1). These are estimated using simple multipliers for conversions among energy, emissions and savings. Households spend about Rs. 6.4 m/yr. during the program period on purchase of replacement LED bulbs. By the end of the program period they start saving 42 TWh/yr. of electricity and Rs. 218 b/yr. in corresponding bills. The direct impacts of the program is equivalent to avoidance of about 12 numbers of new 500 MW coal plant and removal of 34 m tonne of CO_2 every year after 2019.

<<insert Table 1 here>>

MODEL RESULTS

The results presented in this paper are work in progress. The section describes the modeled impact of the efficient bulb replacement program at the end of the program period i.e., 2019 unless otherwise mentioned. The % change values are over the respective business as usual scenario (baseline). All monetary values are specified in Rs. (INR) in 2010 prices.

ECONOMY

There is a reduction of Rs. 256 billion (0.2%) over the baseline in GDP by the end of the program (Table 2). The decline is largely due to reduction in investments and household consumption and is marginally offset by reduction in imports. There is negligible change in exports.

<<insert Table 2 , Figure 3 here>>

The impact on GDP is described below.

GDP = Investment + Consumption by households + Government expenditure + (Exports – Imports)

A heavy reduction in electricity demand by households leads to avoidance of new power generation capacity. This translates to a reduction of Rs. 344 b investments in the electricity generation sector in 2019 alone. An overall reduction in **investment** of Rs. 353 billion (1%) is observed. The reduction in investment is the largest contributor to short run reduction in GDP. The cumulative reduction in investment in power generation during the program period is Rs 1,776 b.

The overall reduction in **consumption by households is** of Rs. 113 b, of which there is a reduction of Rs. 287 b (17.4%) on electricity bills, and about Rs. 174 b in increased spending on goods and services including purchase of LED bulbs. The total household consumption dropped even when households saved a considerable amount from electricity bills which they could have spent on other goods. This was due to an overall decrease in real personal disposable income to the tune of Rs. 172 b. This drop in personal disposable income is primarily associated with decreased employment in the power generation and the construction industry.

Part of the reduction in GDP is offset by decrease in **imports** by Rs. 174 b. This was spurred by investment in manufacturing at the beginning of the program period leading a decrease in imports of Rs. 118 b. There was no change in the government expenditure component of GDP as it is exogenously derived in the model.

The total number of jobs marginally decreased by around 261,000 (0.05%). There was 9 % reduction in jobs in the electricity generation (71,000) sector and about 50,000 each in the construction and trade sectors. The reduction in the construction and trade sector can be attributed partly to decrease in construction of new power plants and its spill over impacts on other sectors.

<<insert Figure 4 here>>

In the long run, there is marginal negative impact on the GDP. This reduction is less than the household's reduced expenditure on electricity bills, even beyond 2035 due to sustained savings. LED bulbs have a very long life of around 35,000-50,000 hour (or 20 or more years) and low failure rates, leading to sustained savings over long term. There is no noticeable[5] negative impact on investment, imports, exports or employment. (Table 2).

ENERGY, ELECTRICITY AND EMISSIONS

The impact on energy, electricity and emissions are summarized in Table 3. They are as follows.

Energy

The total fuel use for energy (by 8 users of energy across 5 carriers) is reduced by 2.6% or about 31 m TOE/yr. in 2019. Maximum reduction in fuel use happens in power generation (5%) and households (2%). The cumulative reduction during the program period is of 110 m TOE. In the long run, there is an overall sustained reduction of about 28 m TOE/yr. of fuel use (Figure 5).

<<insert Figure 5 here>>

Electricity consumption

The change in total electricity consumption is almost completely led by savings due to households' use of efficient bulbs (Table 4). Electricity consumption by households is reduced by 17.5% or 3.4 m TOE/yr. (~39.5 TWh/yr.) (Figure 6) at the end of the program period. The cumulative savings in electricity during the program periods is about 142 TWh. The impact of LED bulb replacement is visible in the long run and households continued to save 2.6 m TOE/yr. (~32 TWh/yr.) of electricity even beyond 2035.

<insert Figure 6 here>>

[5] >0.05%

Electricity generation

There is a reduction of 40 TWh (4.2%) in electricity generation in 2019 alone. The investment in new generation capacity drops by 11% or Rs. 344 b by the end of the program period. The total reduction in investment during this period is about Rs 1,722 b. The reduction of investments happens mainly in large hydro, coal and CCGT based plants. The investment returns to the baseline situation after the program ends. New construction of electricity capacity is reduced by 10% every year and cumulatively by 9 GW between 2014 and 2019 (Figure 7).

<<insert Figure 7 here>>

Emissions

The program leads to a CO_2 reduction of 13.9 m tonne of Carbon/yr. (51 m tonne of CO_2/yr.) at its peak in 2019. Almost all of this reduction comes from power generation sector of which two-thirds is from coal fired power plants and one-third from natural gas (Figure 8). The cumulative reduction in emissions during the program period is equivalent to 182 m tonne of CO_2. The program leads to sustained reduction of about 47 m tonne of CO_2/yr. beyond 2035.

<<insert Figure 8 here>>

SUMMARY OF FINDINGS

In the short-run, there is a minor reduction of 0.2% in GDP by the end of the program period. The decline is largely due to reduction in investments and household consumption, and is marginally offset by reduction in imports. There is negligible change in exports.

The program will lead to cumulative savings of 110 m TOE in fuel use, 142 TWh in electricity consumption, a staggering Rs. 1,722 b in investment during 2014-2019. It will lead to avoided new generation capacity of 9 GW along with a reduction of 182 m tonne of emissions of CO_2 during the same period.

In the long run, there is a negligible reduction in GDP except for the part contributed by the sustained decrease in spending by the household on electricity bills. No other noticeable impacts are there on imports, exports or employment. There is sustained reduction in fuel use of 28 m TOE/yr., 32

TWh/yr. in electricity consumption and 47 m tonne of CO_2/yr. even beyond 2035.

This summarizes the long term benefits of the program with little private investment of Rs. 30 b in the manufacturing sector and a proactive policy to facilitate adoption of efficient bulbs without subsidies or tax incentives.

CONCLUSION

MAIN CLAIM

The single most important contribution of program like UJALA, India's domestic efficient lighting program is the sustained reduction in emissions without any adverse impact on the economy in the long run and the need of tax or subsidies.

Using the E3 India model, we find that India will save at least 28 m TOE/yr. in fuels in the long run. This is equivalent to reduction of 47 million tonne of CO_2 every year. And it happens with the government just acting as a catalyst to promote energy efficient lighting without any investment, taxes or subsidies and an initial one time investment of Rs. 30 b in the manufacturing sector. The program will also lead to avoidance of the new generation capacity of 9 GW and save Rs. 1,776 b in investment in power generation.

If the same reduction in emissions is to be achieved using renewable option, India will need an investment of about Rs. 10 b every year during the program period, or Rs. 59 b cumulatively between 2014 and 2019. This is twice the investment required in the manufacturing sector under the efficient lighting policy scenario. Further, the efficient light bulb program frees up investment of Rs 1,776 b for other economic sectors and welfare. Thus, while both energy efficiency program (like the efficient light program) and renewable energy reduces emissions, EE based measures requires half the investment to achieve the same.

The estimated benefits of the efficient lighting program in this paper are on the conservative side, given that the model currently does not account for market transformation. Currently, we have estimated the impact of replacing 770 m bulbs over 6 years, while 758 m ICL bulbs were sold alone in 2012 (ELCOMA, EESL 2014). Hence the overall potential for transition to efficient lighting is huge. As LED bulbs become widely used beyond the stipulations of the program and in applications such as streetlights, commercial and industrial buildings, the benefits will be many times of what is currently estimated in this paper.

Contribution to INDC: This program alone contributes to a cumulative reduction of 0.7 b tonne of CO2 till 2030

SIGNIFICANCE OF THE WORK

Use of E3-Indlia like models can estimate the economy, energy and environment benefits of efficient light bulb replacement programs well beyond their direct effects.

This is the first attempt to estimate coupled economy, energy and environment benefits of energy efficiency program for appliances in the Indian context to our knowledge. The results also cautions about some adverse impact of the program in short run (like reduction in investments and jobs, particularly in the power generation sector) to better plan for those contingencies and avoid any short term employment and welfare impacts that can derail the policy. These short term negative impacts predicted in the model can be overcome if the investments saved from power generation is used in other sectors or for welfare needs. The findings help provide additional empirical support to policy makers to confidently advocate and adopt energy efficiency as a tool to combat climate change without sacrificing economic growth, or needs of additional investment, taxes or subsidies.

Importantly, we also show that the energy efficiency route to emissions reduction (as in the case of efficient bulb replacement program) requires one-half the investment that is required to achieve the same benefits through a renewable energy technology like solar farms. The argument can be extended to promote other efficient appliance programs like air conditioners, motors and pumps, etc., though it should be noted that these have much higher costs, are less prevalent and provide comparatively lower reduction in consumption as compared to the bulb replacement program. However, to meet India's INDC goals, the option is not going to be a choice between energy efficiency or renewable energy, but both.

LIMITATIONS AND NEXT STEPS

This is 'work in progress' and is based on simplified version of the UJALA like DELP program. The model is also being continuously improved. Hence, the impacts and the results presented here should be used as preliminary estimates only. Currently aggregated national level results are shared here for brevity of presentation. The comparison with investment in RE is preliminary. We hope to perform comparable analysis of the renewable energy route to emission reduction.

It is important to note that the current estimates of benefits are on the conservative side. To estimate the full benefit of the program, the following will have to be considered-

- Market transformation and associated investments including the use of LED bulbs outside the program i.e., in industry, streetlights, commercial buildings; and their use as new fixtures
- Detailed modeling of renewable energy investments and associated impacts on economy and emissions
- Issues related to power supply constraint, shortage and access
- Alternate use of investment saved in power generation and its economy wide impacts
- Comparison of our results with other similar studies globally

We hope to address these in next iteration of the model. Some of the relatively more difficult, nonetheless important drivers include

- Impact on households in different income quintiles to understand the distributive impact of the policy
- Shifts in consumer preferences for LED bulbs
- Behavioral interventions (Allcott & Mullainathan, 2010)
- Associated health, education and productivity benefits

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ANNEXURE

Nomenclature

m	millions
b	billions
T	tonne
th	Thousand
Rs.	Rupees (INR)
yr	Year
TOE	tonne of Oil Equivalent
MW	Megawatts
GW	Gigawatts
DELP	Demand side management based Efficient Lighting Program

Assumptions

LED use per year	300	days
LED use per day	3.5	hours
8 W LED bulb cost	50	Rs
LED wattage	8	W
Conventional ICL bulb wattage	60	W
1 tonne of Oil Equivalent (TOE)	11,630	kWh
1 th tonne of Carbon	3.67	th tonne of CO_2
Unit cost of electricity*	5.2	Rs / kWh
Power plant capacity factor*	75%	
Transmission and distribution losses*	23%[6]	
Energy produced by 1MW coal plant*	6,570	MWh
Emissions from 1MW coal plant*	0.81	T CO_2/MWh
Cost of RE plant*	2.025[7]	m Rs / MW
RE annual output*	1,500	kwh/kW plant

*these simple conversion metrics are not part of the main model

[6] CEA, 2016
[7] http://mnre.gov.in/file-manager/grid-solar/Scheme-for%20development-of-Solar-Park-&-Ultra-Mega-Solar-Power-Project-2014-2019.pdf

FIGURES AND TABLES

Model structure

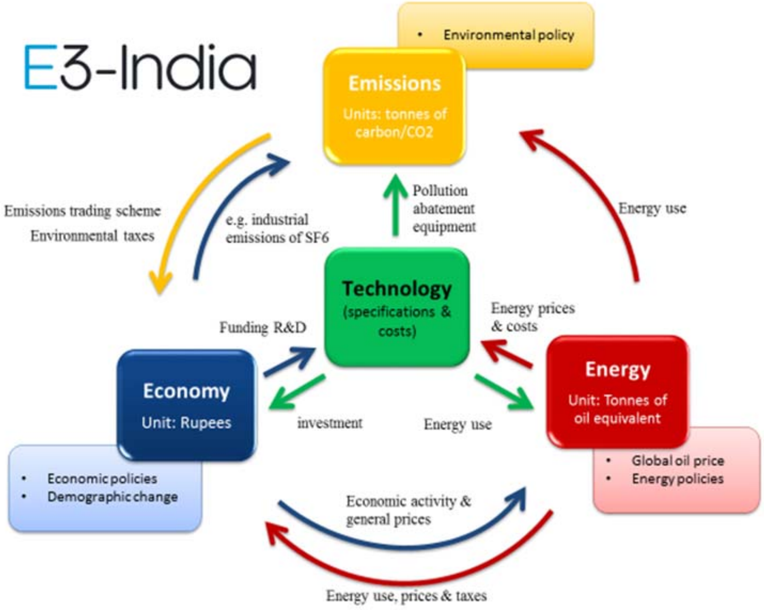
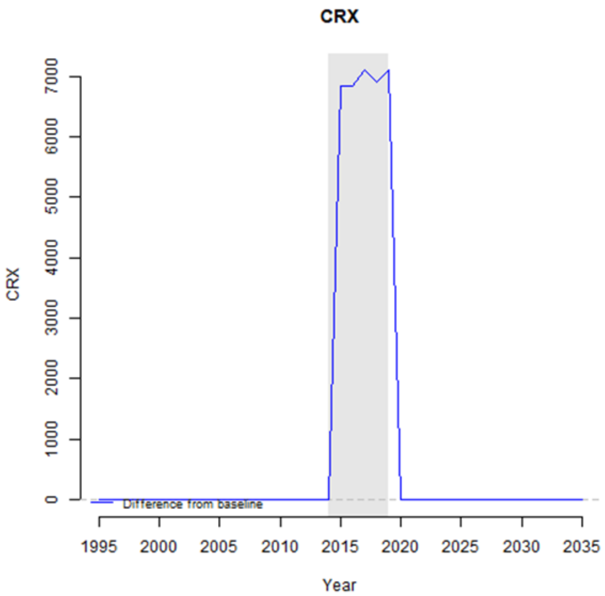
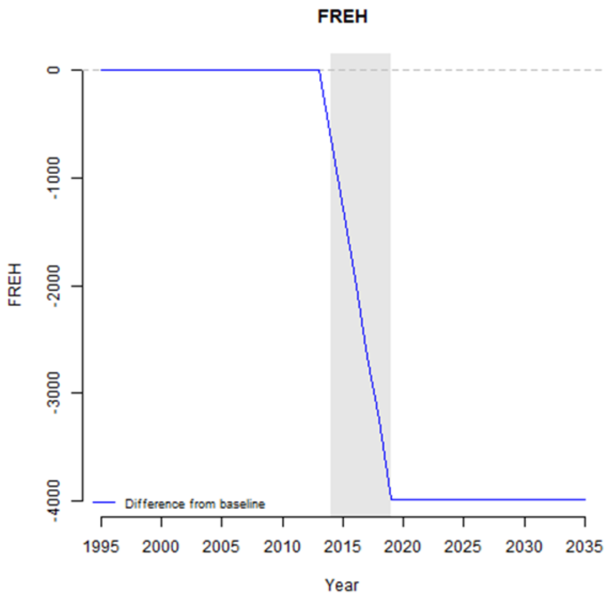


Figure 1: E3 India model structure (Cambridge Econometrics, 2017)

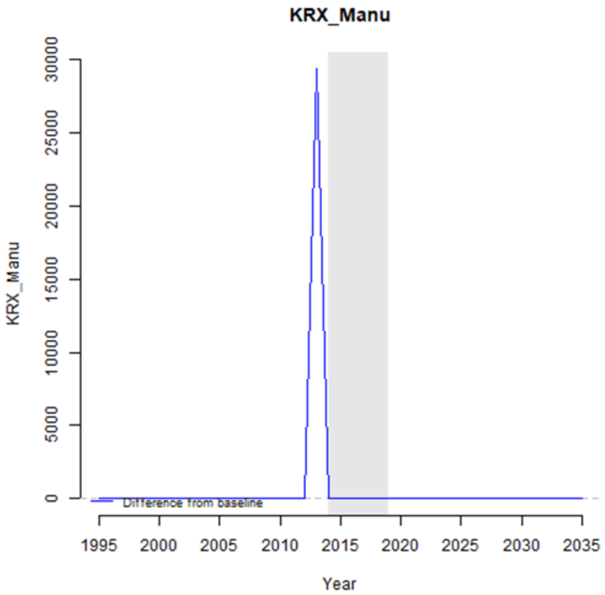
Scenario definition



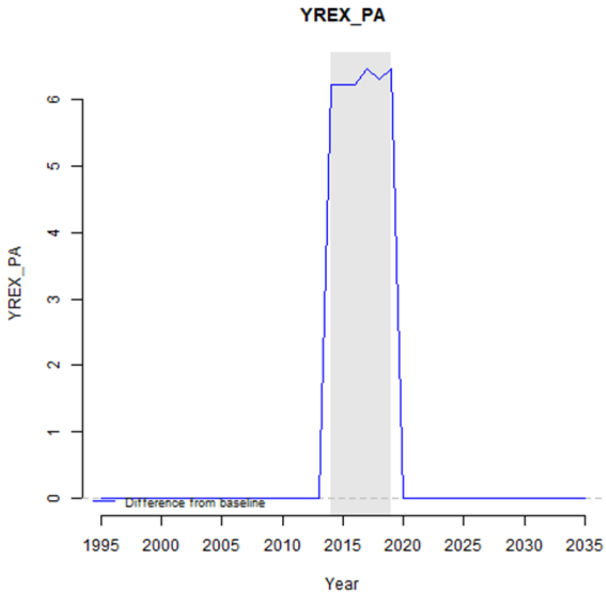
a. Household's exogenous expenditure on bulbs (m Rs): Households buy LED bulbs during the program period. This expenditure is program induced and hence, applied exogenously to their expenditure.



b. Household's exogenous expenditure on electricity (m Rs): Households expenditure on electricity falls linearly during the program period. After 2019, households continue to save from replaced bulbs but the scenario assumes that no new replacements takes place



c. Investment in Manufacturing (m Rs): The scenario includes one-time exogenous investment in the manufacturing sector just before the start of the program to meet the increased demand for LED bulbs



d. Temporary jobs for bulb distribution (thousands): EESL creates temporary jobs during the program period to facilitate the distribution of LED bulbs across different states

Figure 2: Scenario definition / Model inputs for policy intervention (refer to Table 1 for details)

Direct impacts

Year	Number of bulbs purchased (m)	Total HH expenditure on bulbs (m Rs)	Reduction in electricity consumption (GWh)	Reduction in electricity consumption (th TOE)	Reduction in HH expenditure on electricity bill (m Rs)	Reduction in new plant capacity (MW)	Emissions Reduction in Carbon (th tonne)	Emissions Reduction in C02 (th tonne)
2014	128.33	6,417	7,007	602	36,436	1,067	1,547	5,676
2015	128.33	6,417	14,014	1,205	72,873	1,067	3,093	11,351
2016	128.33	6,417	21,021	1,807	109,309	1,067	4,640	17,027
2017	128.33	6,417	28,028	2,410	145,746	1,067	6,186	22,703
2018	128.33	6,417	35,035	3,012	182,182	1,067	7,733	28,378
2019	**128.33**	**6,417**	**42,042**	**3,615**	**218,618**	**1,067**	**9,279**	**34,054**
Sum	770	38,500	147,147	12,652	765,164	6,399	32,477	119,189
2035		-	42,042	3,615	218,618	-	9,279	34,054

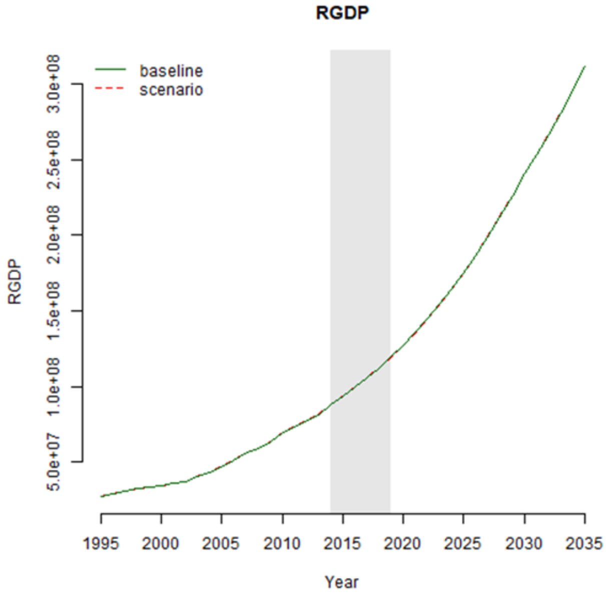
Table 1: Direct impacts

Economic impacts

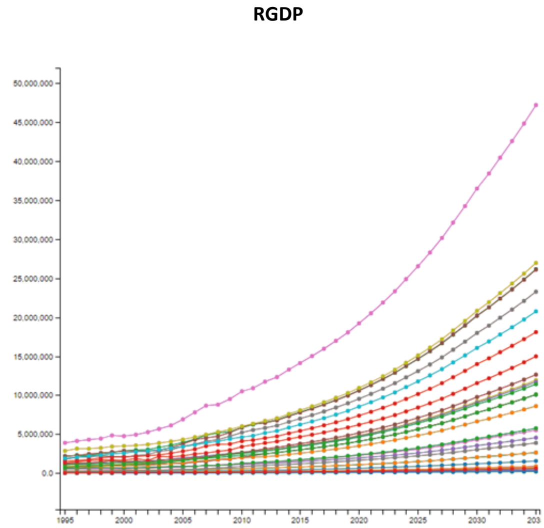
Model variable			RGDP	RSK	RSC	RSG	QEX	QEM	RRPD	REMP
			GDP (m Rs)	Investment (m Rs)	HH Consumption (m Rs)	Government expenditure (m Rs)	Exports (m Rs)	Imports (m Rs)	Real personal disposable income (m Rs)	Total employment '000s
Baseline	2,014	annual	87,964,925	26,981,811	56,623,800	16,552,779	52,023,051	54,860,436	56,642,014	437,801
Baseline	2,019	annual	119,576,099	36,590,017	77,566,905	21,126,002	68,632,031	72,624,543	81,275,028	499,465
Scenario	2,019	annual	119,320,043	36,236,358	77,453,778	21,126,002	68,615,748	72,450,438	81,102,782	499,204
Short run model impacts	2019 Scenario - 2019 Baseline	**value**	**-256,056**	**-353,660**	**-113,127**		**-16,283**	**-174,104**	**-172,246**	**-261**
		% over baseline	**-0.21**	**-0.97**	**-0.15**		**-0.02**	**-0.24**	**-0.21**	**-0.05**
		cumulative change 2014:19	-1,037,844	-1,776,173	-370,694		-33,069	-893,199	-587,859	-1,714
Long run baseline	2035	annual	311,625,280	95,125,339	192,734,830	46,115,382	165,932,187	175,214,093	247,349,150	743468.977
Long run scenario	2035	annual	311,449,026	95,099,982	192,581,579	46,115,382	165,899,510	175,199,138	247,135,707	743356.681
Long run model impacts	2035 Scenario - 2035 Baseline	**value**	**-176,254**	**-25,358**	**-153,251**		**-32,677**	**-14,955**	**-213,442**	**-112**
		% over baseline	**-0.06**	**-0.03**	**-0.08**		**-0.02**	**-0.01**	**-0.09**	**-0.02**

Table 2: Impact on the economy (2010 prices)

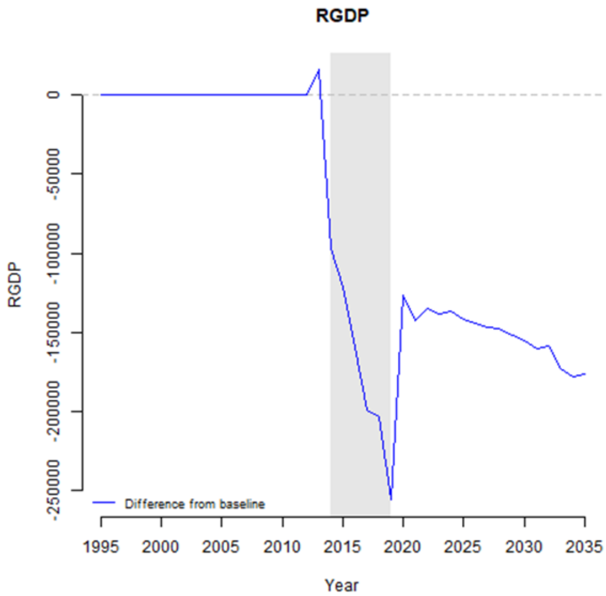
GDP figures



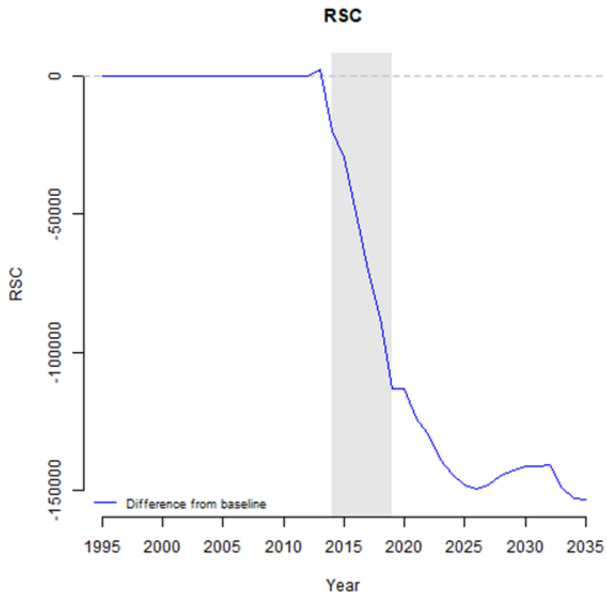
a. GDP



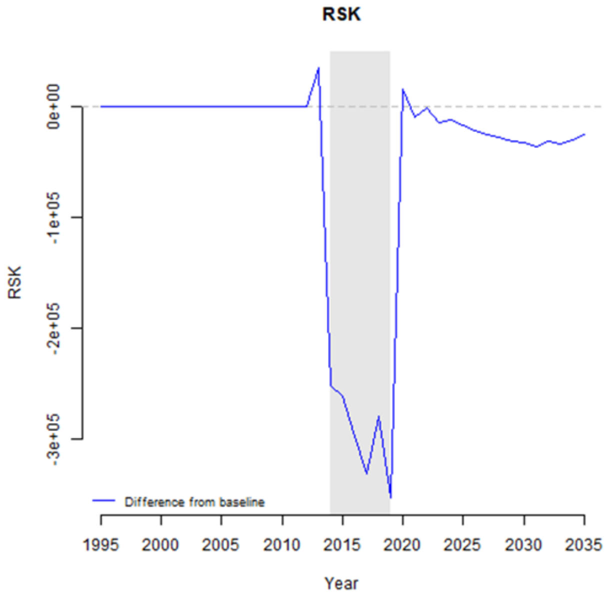
b. GDP for different states and UTs



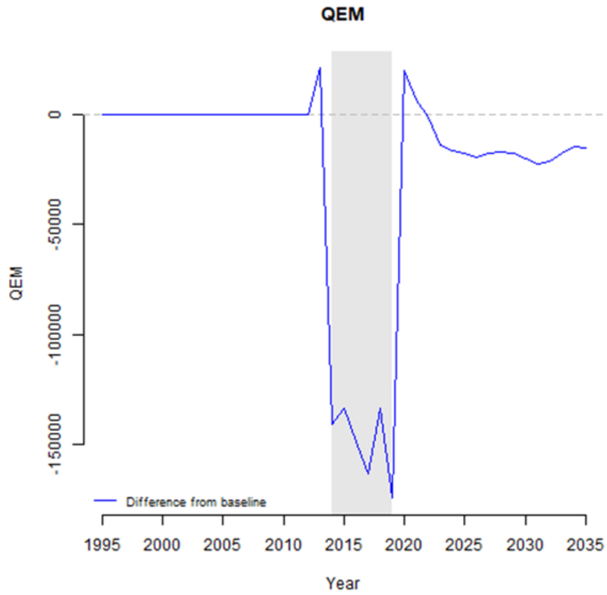
c. Change in GDP



d. Total household expenditure

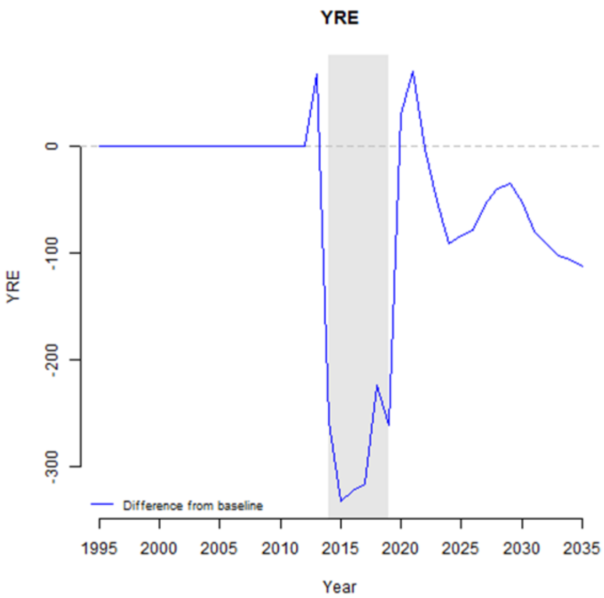


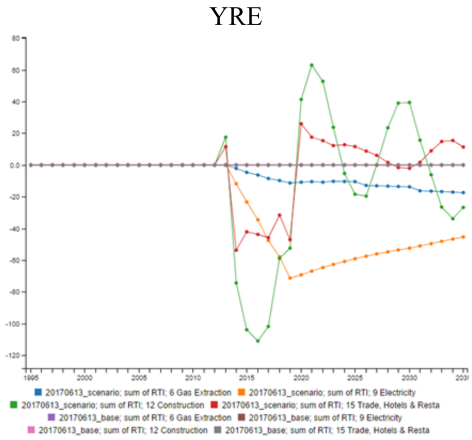
d. Investment



f. Imports

Figure 3: Impact on GDP (m Rs 2010 prices)





a. Change in total employment

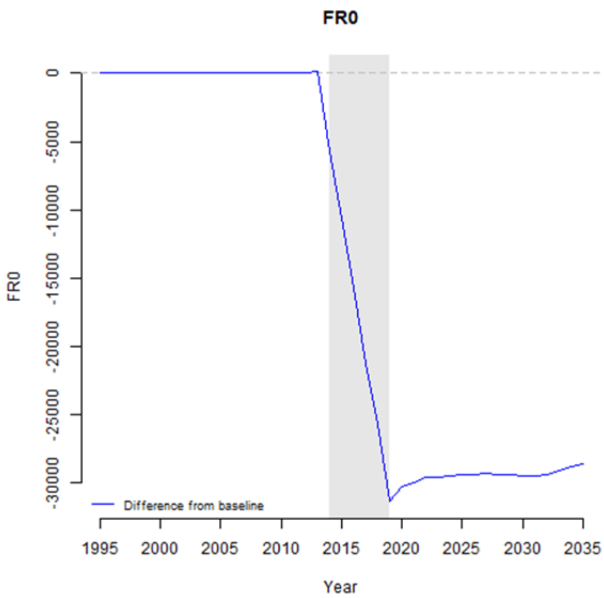
Change in total employment

Figure 4: Impact on employment (thousands)

Energy, Electricity, Emissions

Model variable			FRET		MEWG	KR (electricity)	MEWI	RCO2		JCO2	FCO2	FR0
			Total electricity consumption (th TOE)	Total electricity consumption (GWh)	Electricity generation (GWh)	Investment in new generation capacity (m Rs)	New construction of electricity capacity (GW)	Emissions, Carbon (th tonne)	Emissions, C02 (th tonne)			Total fuel use (th TOE)
Baseline	2,014	annual	64,629	751,638	751,638	2,266,645	15	646,182	2,371,488	658,311	646,182	1,015,979
Baseline	2,019	annual	83,436	970,361	970,361	3,056,989	17	789,634	2,897,958	812,936	789,634	1,211,329
Scenario	2,019	annual	79,963	929,964	929,964	2,712,259	15	775,731	2,846,932	794,654	775,731	1,179,911
Short run model impacts	2019 Scenario - 2019 Baseline	**value**	**-3,473**	**-40,397**	**-40,397**	**-344,730**	**-2**	**-13,904**	**-51,026**	**-18,281**	**-13,904**	**-31,418**
		% over baseline	**-4.16**	**-4.16**	**-4.16**	**-11.28**	**-10.00**	**-1.76**		**-2.25**	**-1.76**	**-2.59**
		cumulative change 2014:19	-12,274	-142,748	-142,748	-1,722,370	-9	-49,729	-182,504	-64,450	-49,729	-110,596
Long run baseline	2035	annual	192,269	2,236,093	2,236,093	7,614,389	33.8	1,638,895		1,689,766	1,638,895	2335468
Long run scenario	2035	annual	189,470	2,203,541	2,203,541	7,597,398	33.7	1,626,163		1,673,153	1,626,163	2306857
Long run model impacts	2035 Scenario - 2035 Baseline	**value**	-2,799	-32,551	-32,551	-16,991	0	-12,732	-46,728	-16,613	-12,732	-28,610
		% over baseline	**-1.46**	**-1.46**	**-1.46**	**-0.22**	**-0.25**	**-0.78**		**-0.98**	**-0.78**	

Table 3: Energy, electricity and emissions



a. Total reduction in fuel use

b. Energy by users

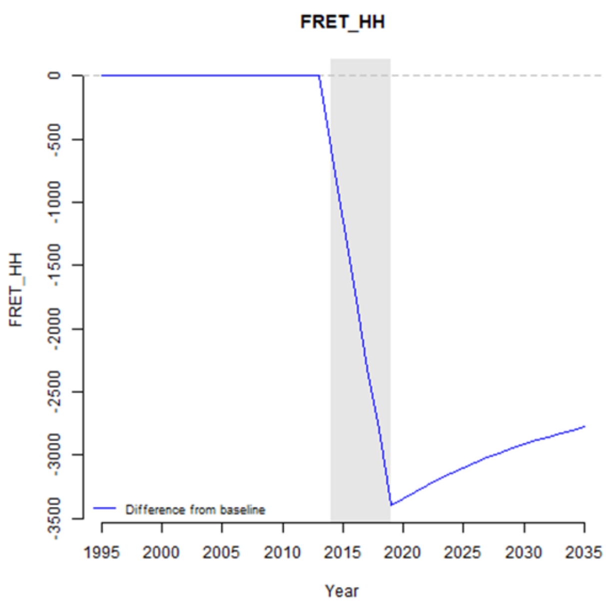
Figure 5: Fuel use for energy (th TOE)

Impact on households

Model variable			CR (Elec)	FR0 (HH)		FRET(HH)	
			HH expenditure on electricity bill (m Rs)	Total Fuel use by HH (th TOE)	Total Fuel use by HH (GWh)	Electricity consumption by HH (th TOE)	Electricity consumption by HH (GWh)
Baseline	2,014	annual	1,397,925	181,647		16,331	189,924
Baseline	2,019	annual	1,657,702	190,726		19,412	225,757
Scenario	2,019	annual	1,370,087	186,998		16,011	186,205
Short run model impacts	2019 Scenario - 2019 Baseline	**value**	**-287,615**	**-3,728**	**-43,356**	**-3,401**	**-39,552**
		% over baseline	**-17.35**	**-1.95**		**-17.52**	**-17.52**
		cumulative change 2014:19	-1,011,777	-12,832	-149,232	-11,954	-139,022
Long run baseline	2035	annual	3,265,168	222329.208		38,475	447,464
Long run scenario	2035	annual	3,031,301	218146.882		35,697	415,157
Long run model impacts	2035 Scenario - 2035 Baseline	**value**	**-233,868**	**-4,182**		**-2,778**	**-32,307**
		% over baseline	**-7.16**	**-1.88**		**-7.22**	**-7.22**

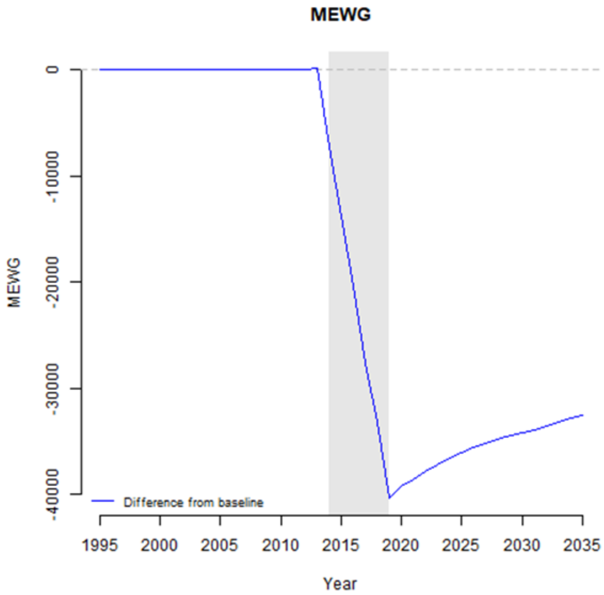
Table 4: Impact on Households

a. Electricity use by households

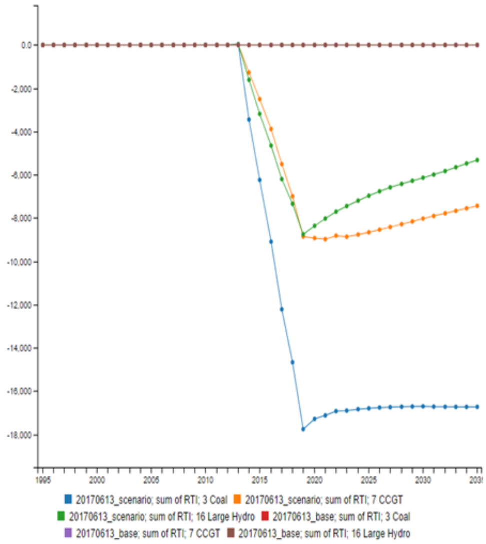


b. Reduction in electricity use by households

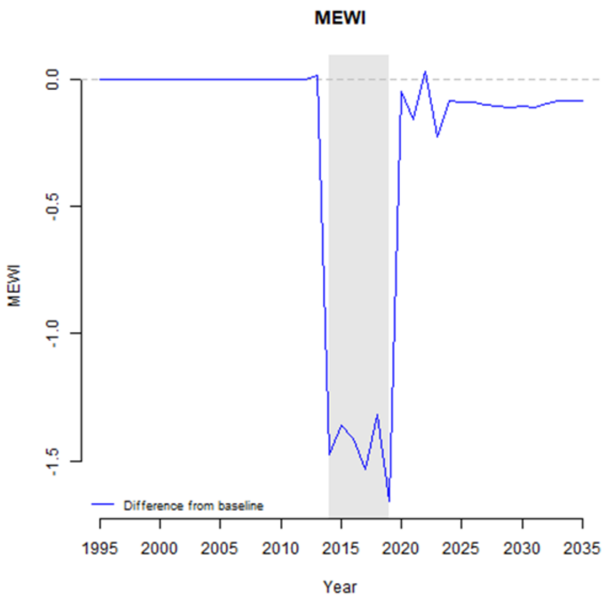
Figure 6: Electricity used by households (th TOE)



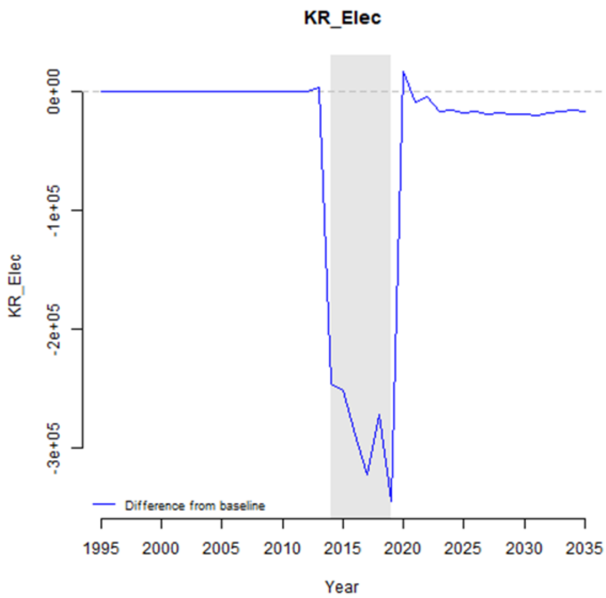
a. Reduction in electricity generation capacity (GWh)



b. Reduction in electricity generation capacity (GWh)

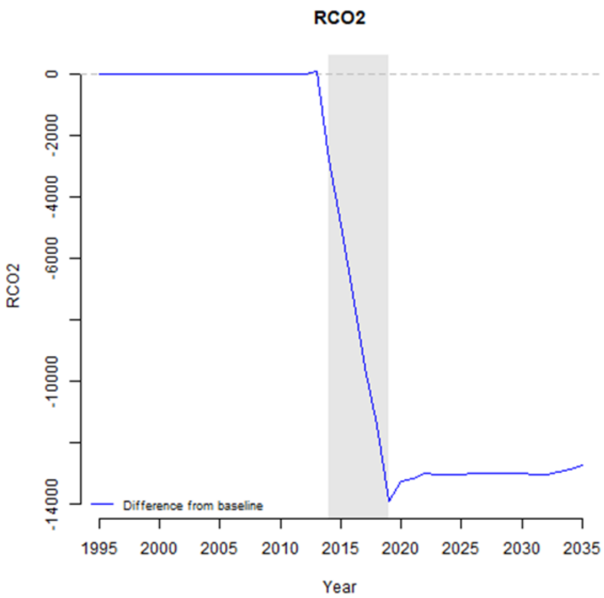


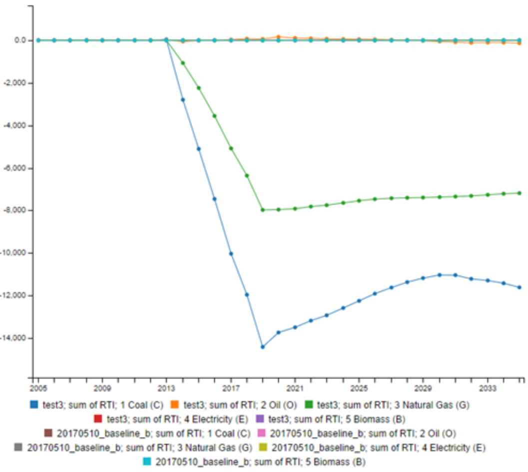
c. Reduction in New construction of electricity capacity (GW)



d. Investment in power generation (m Rs. 2010 prices)

Figure 7: Power generation





a. Total reduction in CO_2 over baseline

b. Reduction in CO_2 from coal and natural gas based plants

Figure 8: Emissions (th tonne of Carbon)