Two paths to emission reduction: Energy efficiency and Renewable

2017 IIOC, Atlantic City

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Notes

- Work in progress, acknowledge co-author
- Thanks for RAP for funding this project
- Take points from the flash presentation

Motivation

- Understand the **magnitude of emissions reduction** that can come from energy efficiency measure

- How does Energy Efficiency based policy **compare to Renewable Energy based projects**

Background: India

- Elec total
- Elec HH
- Emissions

The two paths to emission reduction

- Efficiency
  - **Appliances**: Efficient appliances
  - **Buildings**: Energy conservation Building Code
  - **Industry**: Perform, Achieve and Trade (PAT)

- Renewable
  - **Solar and Wind**

Domestic Efficient Light bulb replacement Program (DELP)

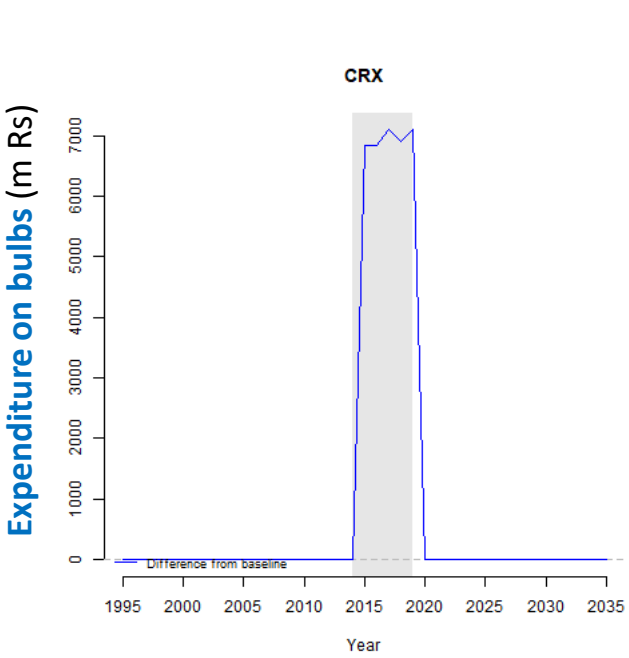
- 60 W ICL
  - Rs 10 / bulb
- 8 W LED
  - 85% more efficient
  - 20 times longer life
  - Rs. 50 /bulb (reduced from Rs 310)

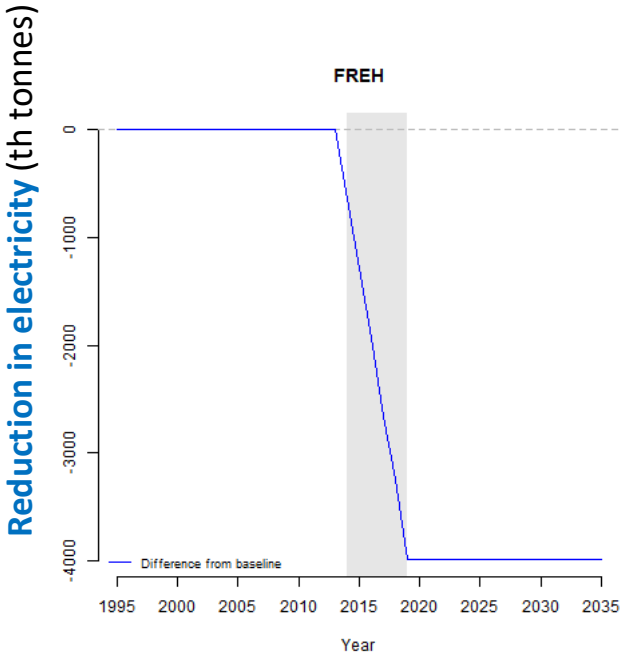
- The program targets replacement on 770m bulbs over 6 year period.
  - 758 m ICL bulbs were sold alone in 2018 (ELCOMA)

Questions

- What is the **impact** of DELP on economy, energy and emissions?
- What are some of the **unintended** impacts?
- What investments in **renewable energy** would result in similar emission reduction?

Scenario

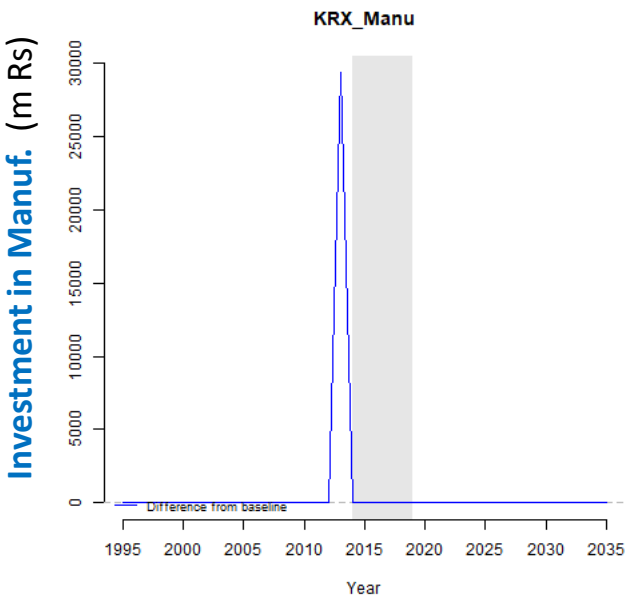


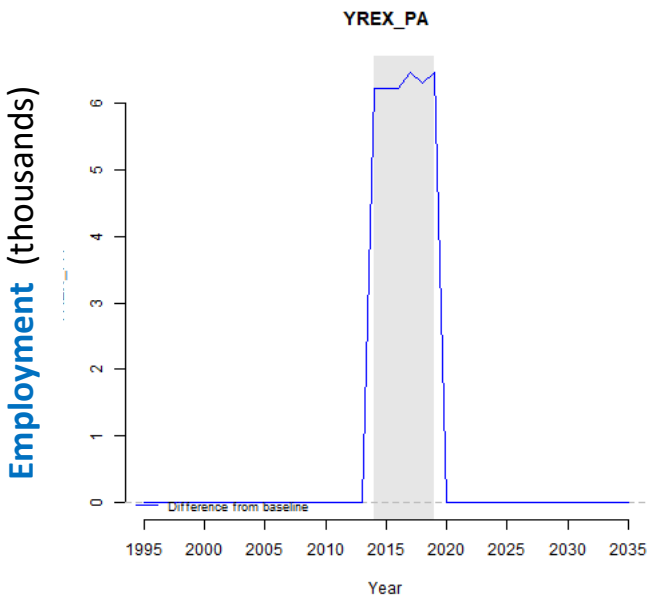


- **770 m LED bulbs, 2014-19**
  - The number of bulbs replaced in each state is proportional to the household expense on electricity in that state

- **No market transformation**
  - 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

Scenario



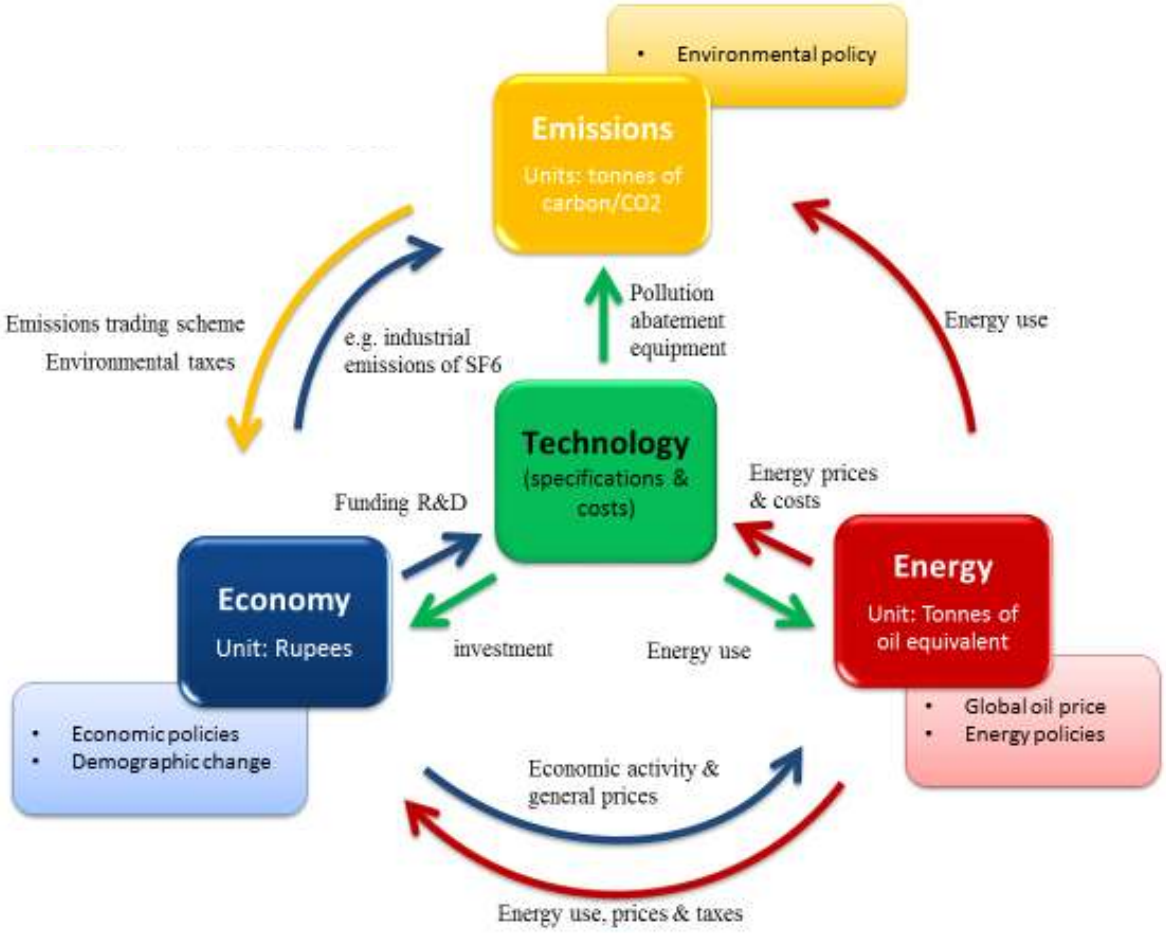


- **One-time investment of Rs. 30 b in 2013 in the manufacturing sector**
  - i.e., one year before the start of the program to meet the increased demand of LED bulbs from 2014
- **35,000 temporary jobs during the program period**
  - Distribution of LED bulbs to households via electricity distribution company

Direct impacts

Year	Reduction in res. electricity consumption (GWh)	Reduction in new plant capacity (MW)	Emissions Reduction in C02 (th tonne)
2014	7,007	1,067	5,676
2015	14,014	1,067	11,351
2016	21,021	1,067	17,027
2017	28,028	1,067	22,703
2018	35,035	1,067	28,378
2019	42,042	1,067	34,054
2019 (% of baseline)	**19**	**6.4**	**1.2**
Sum (2014-2019)	147,147	6,399	119,189
(% cumulative impact)	**12**	**7.0**	**0.8**

E3 India Model



Scenario assumptions

- 100 % replacement
  - All LED bulbs are replacing ICL bulbs (some of the replacements may be happening for CFL bulbs)
- Households pay for the efficient LED bulbs from their savings without altering their expenditure on other goods
- The lifecycle cost and benefits of using LED bulbs are ignored
- Program implementation cost are negligible
- Intra-year monetary transactions are ignored

IMPACTS

Unnada's suggestion

1. GDP impacts for India – time series
2. employment impacts for India – time series
3. CO2 impacts for India – time series
4. Impacts on various component of GDP of India (consumer, investment, imports and exports) in 2014, 2020,2030 as % from baseline
5. GDP impacts for all states in 2014, 2020,2030 as % from baseline
6. CO2 impacts by users – India as % from baseline
7. Energy demand impacts by users – India as % from baseline
8. FTT variables?

Impacts

Bulb replacement

-> Investment in manufacturing

-> Reduction in HH consumption of electricity

-> Avoided power generation capacity

-> Investment in power generation

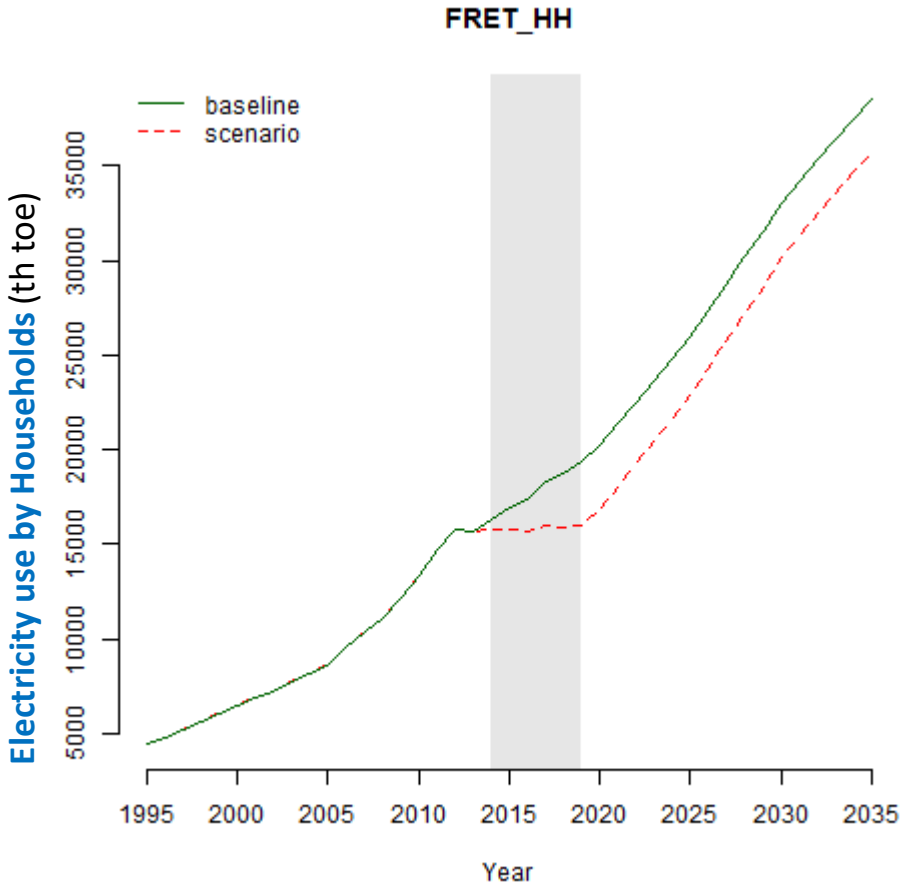
-> Other sectors: Investments, Employment, Wages

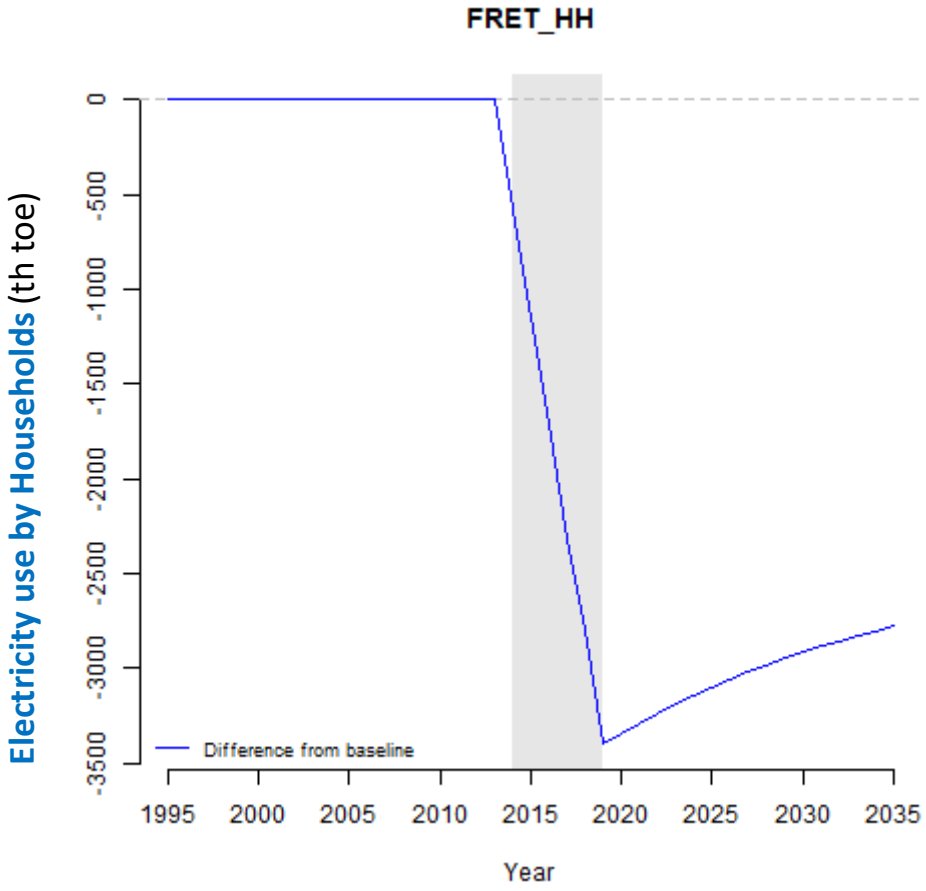
-> GDP (investment, consumption, imports)

-> Energy use and Emissions

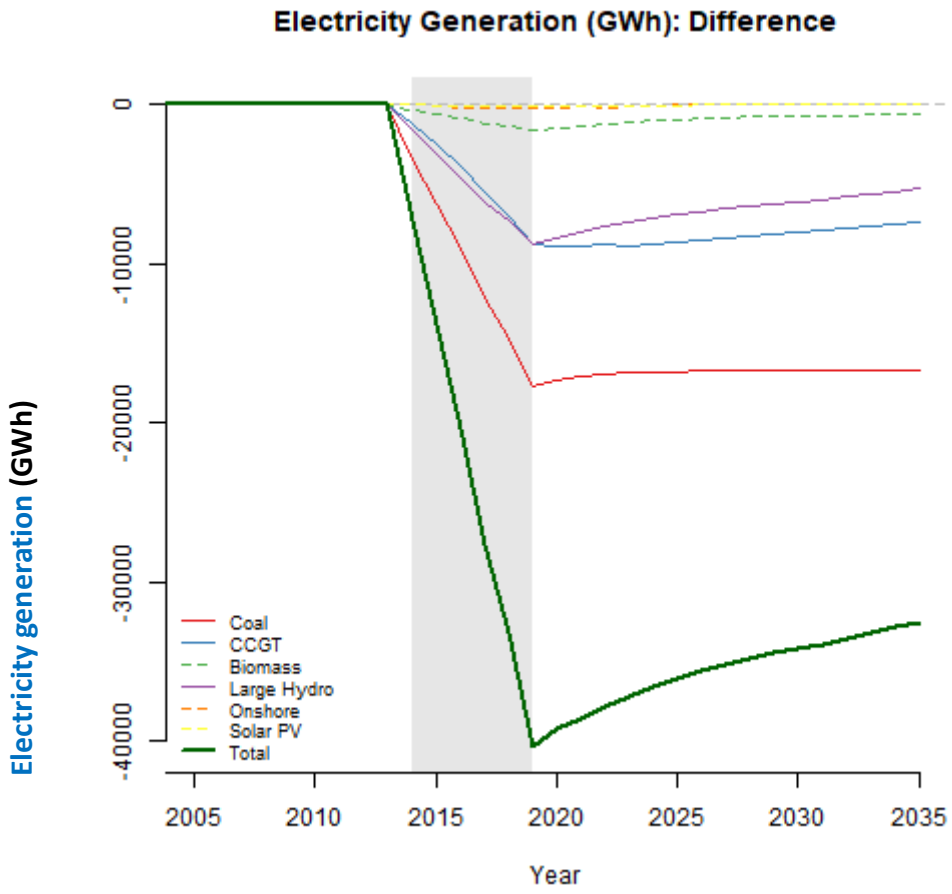
-> Regional impacts

Electricity use by Households

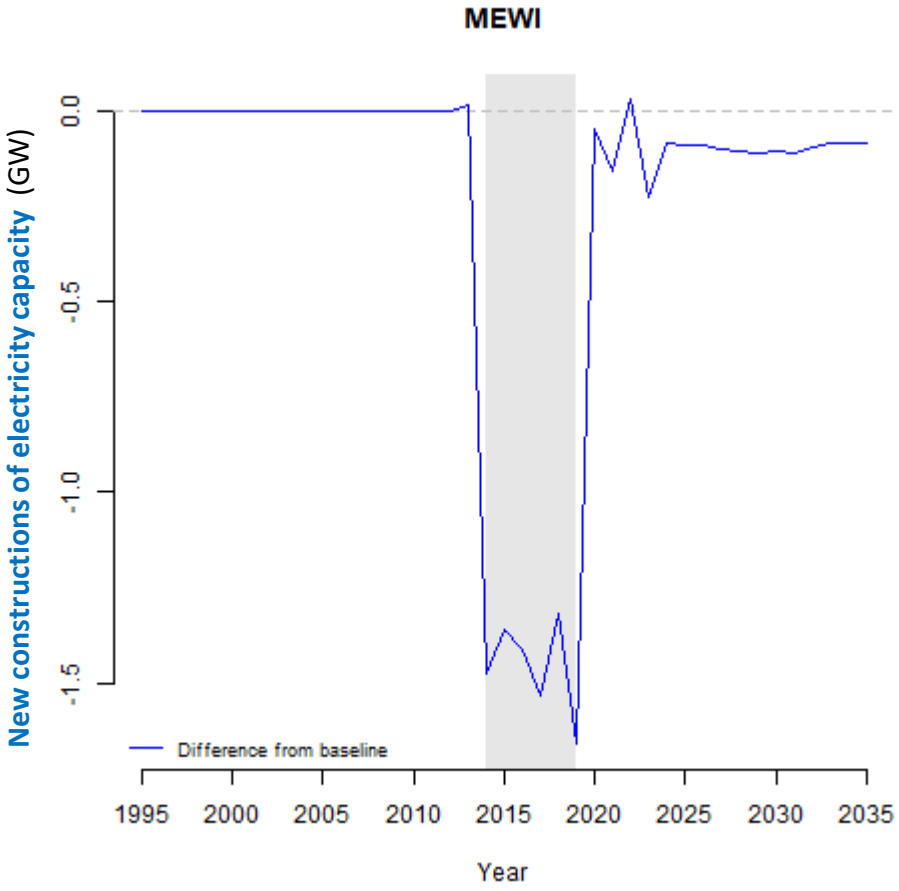


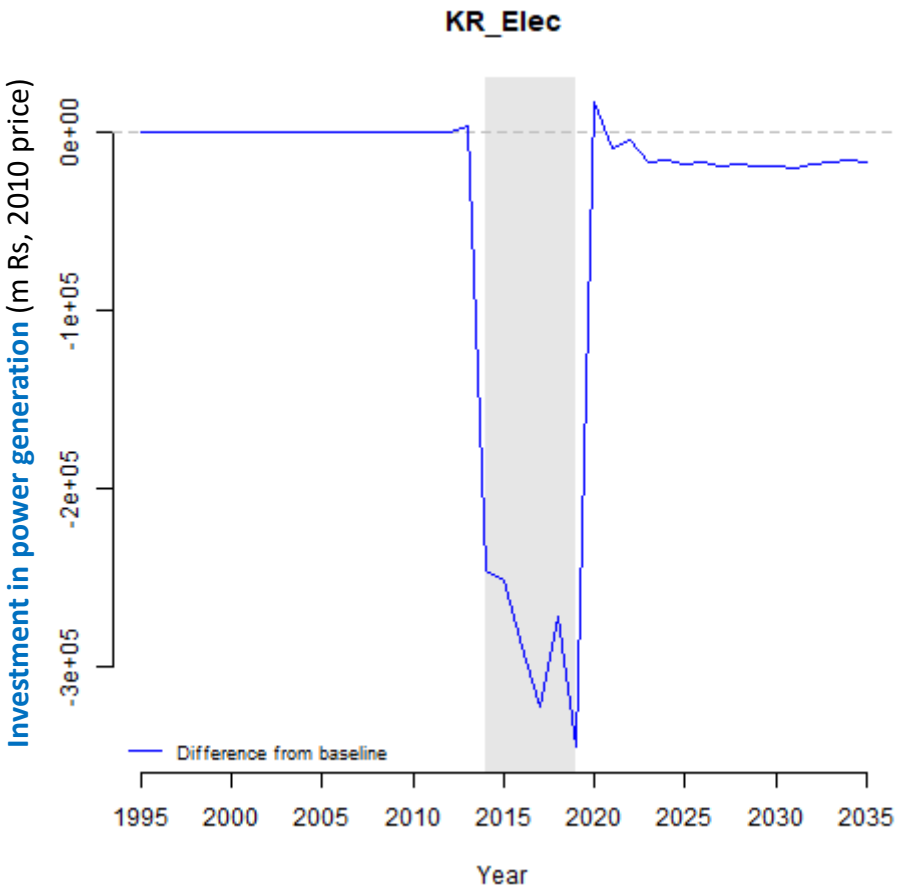


Power generation



Power generation capacity

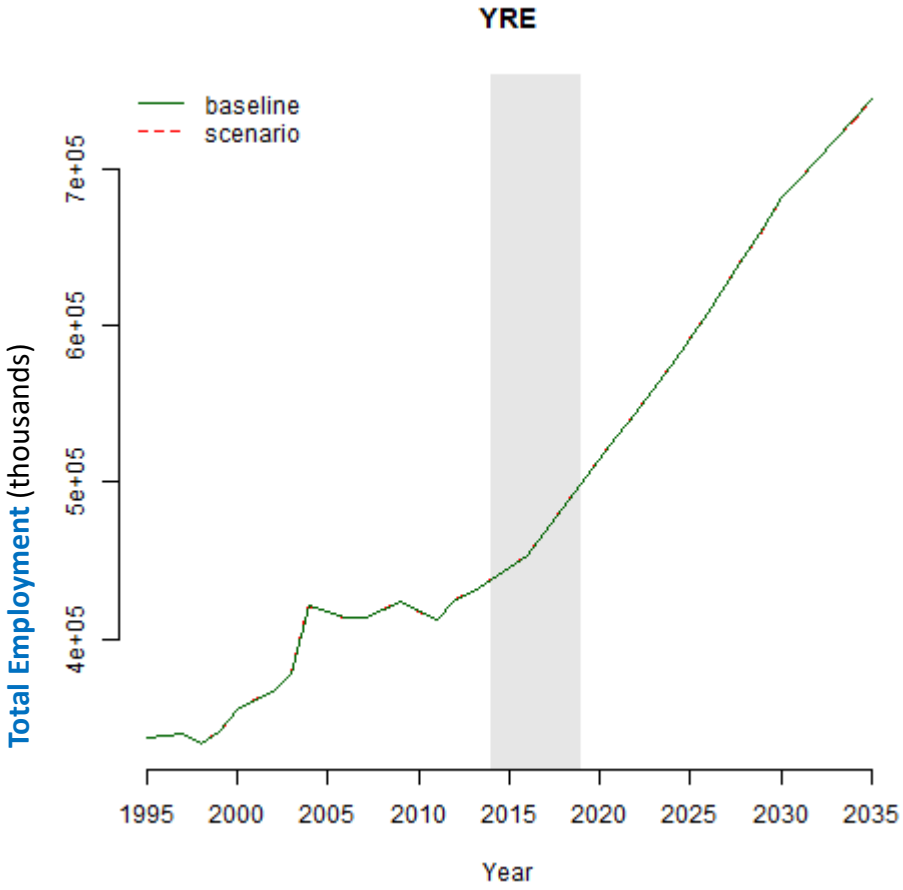


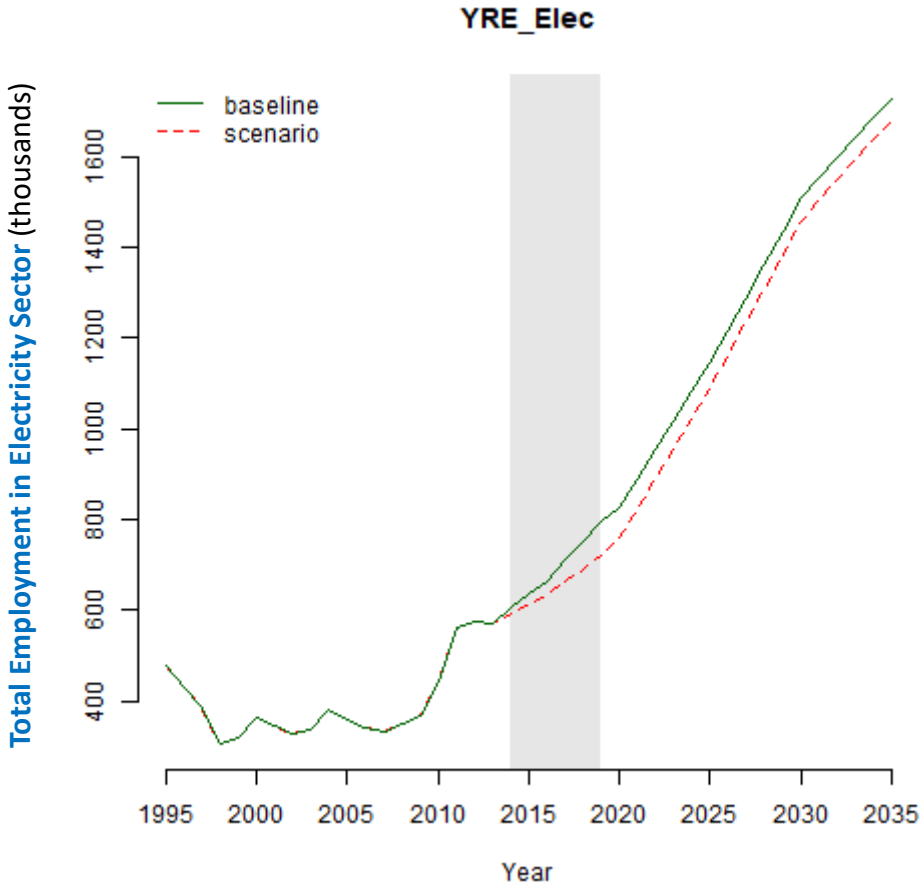


Power generation

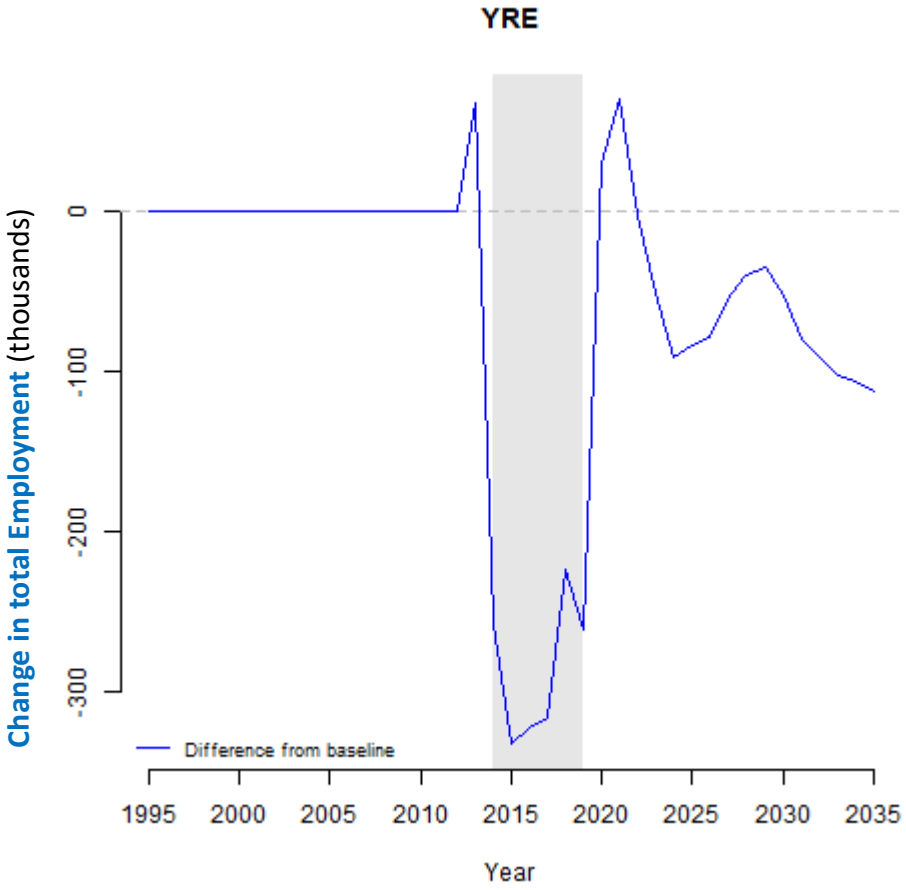
Model variable			MEWG	KR (electricity)	MEWI
			Electricity generation (GWh)	**Investment in new generation capacity (m Rs)**	**New construction of electricity capacity (GW)**
Baseline	2,014	annual	751,638	2,266,645	14.7
Baseline	2,019	annual	970,361	3,056,989	16.6
Scenario	2,019	annual	929,964	2,712,259	14.9
Short run model impacts	**2019 Scenario - 2019 Baseline**	**value**	**-40,397**	**-344,730**	**-1.7**
		% over baseline	**-4.16**	**-11.28**	**-10.00**
		cumulative change 2014:19	**-142,748**	**-1,722,370**	**-8.8**
Long run baseline	2035	annual	2,236,093	7,614,389	33.8
Long run scenario	2035	annual	2,203,541	7,597,398	33.7
Long run model impacts	2035 Scenario - 2035 Baseline	value	-32,551	-16,991	-0.1
		% over baseline	-1.46	-0.22	-0.25

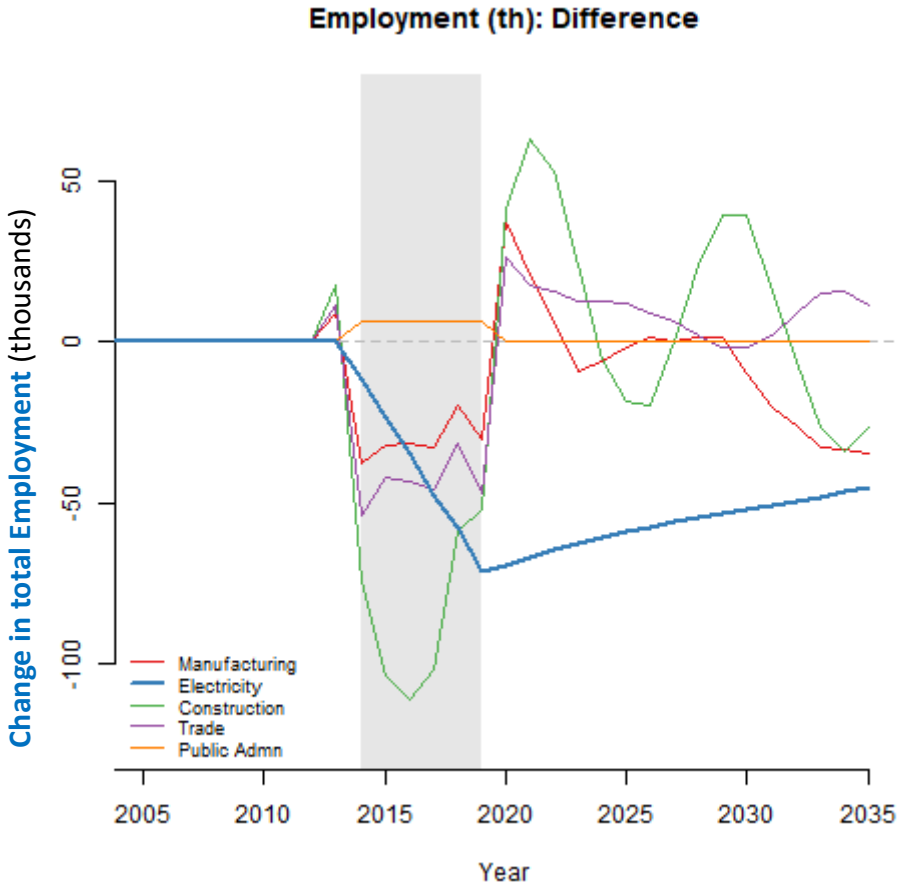
Employment


YRE
baseline
scenario
Total Employment (thousands)
4e+05
5e+05
6e+05
7e+05
1995
2000
2005
2010
2015
2020
2025
2030
2035
Year


YRE_Elec
baseline
scenario
Total Employment in Electricity Sector (thousands)
400
600
800
1000
1200
1400
1600
1995
2000
2005
2010
2015
2020
2025
2030
2035
Year

Employment


YRE
Change in total Employment (thousands)
0
-100
-200
-300
Difference from baseline
1995
2000
2005
2010
2015
2020
2025
2030
2035
Year


Employment (th): Difference
Change in total Employment (thousands)
50
0
-50
-100
Manufacturing
Electricity
Construction
Trade
Public Admn
2005
2010
2015
2020
2025
2030
2035
Year

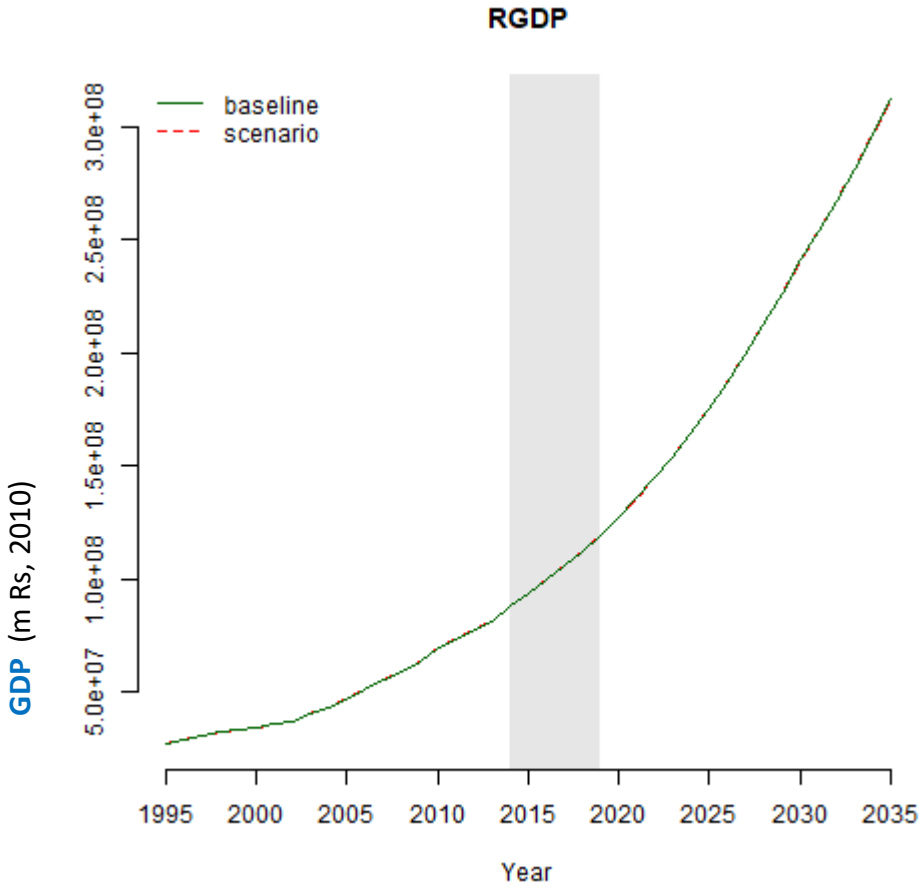
Impact on other sectors

- wages

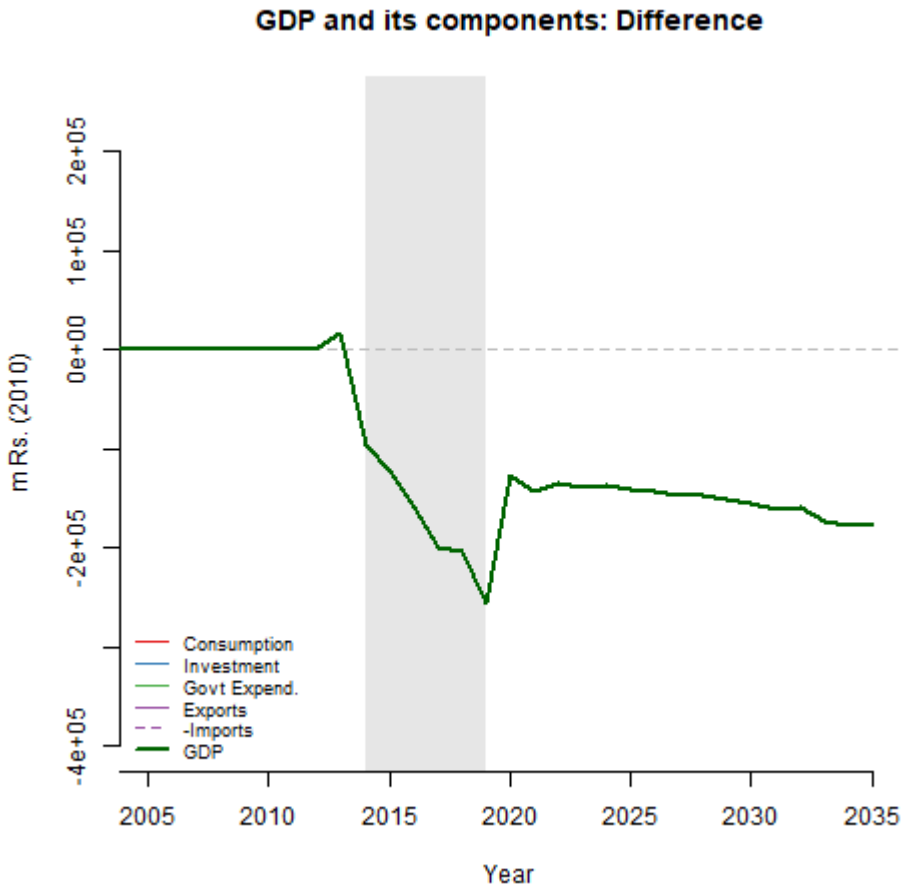
Income and employment

			Real personal disposable income (m Rs)	Total employment '000s
Baseline	2,014	annual	56,642,014	437,801
Baseline	2,019	annual	81,275,028	499,465
Scenario	2,019	annual	81,102,782	499,204
Short run model impacts	**2019 Scenario - 2019 Baseline**	**value**	**-172,246**	**-261**
		% over baseline	**-0.21**	**-0.05**
		cumulative change 2014:19	-587,859	-1,714
Long run baseline	2035	annual	247,349,150	743468
Long run scenario	2035	annual	247,135,707	743356
Long run model impacts	**2035 Scenario - 2035 Baseline**	**value**	**-213,442**	**-112**
		% over baseline	**-0.09**	**-0.02**

GDP


RGDP
baseline
scenario
GDP (m Rs, 2010)
5.0e+07
1.0e+08
1.5e+08
2.0e+08
2.5e+08
3.0e+08
1995
2000
2005
2010
2015
2020
2025
2030
2035
Year

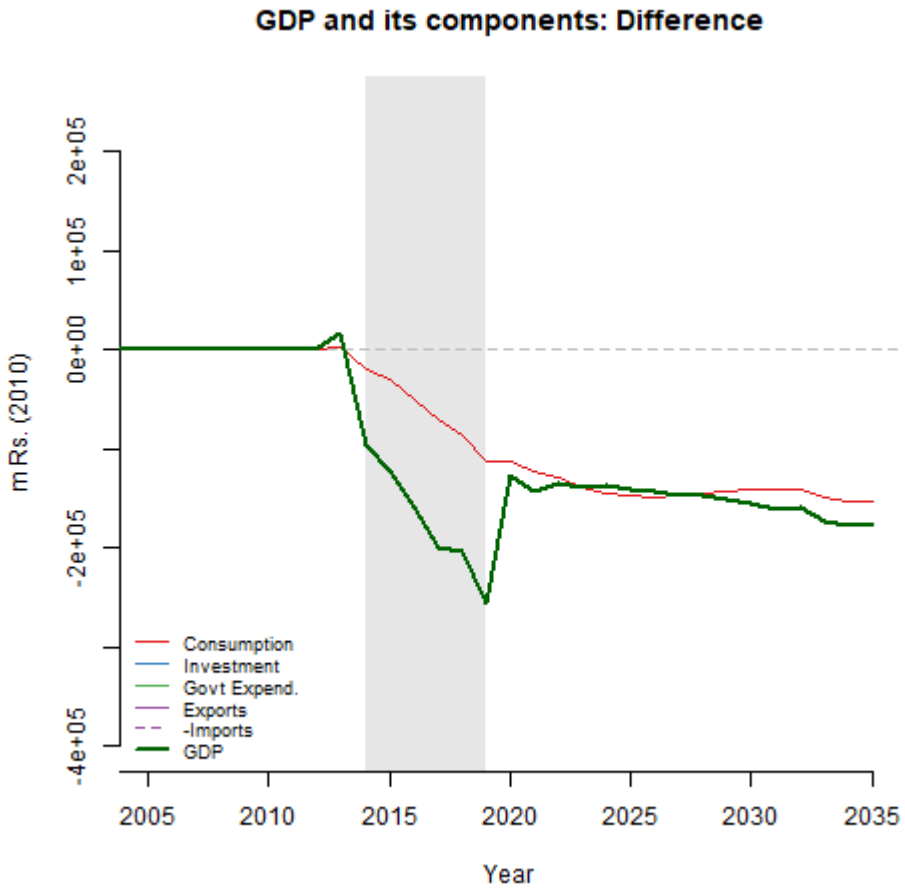
GDP



Consumption
+ Investment
+ Govt Exp.
+ Exports
- Imports

Difference over baseline

GDP



Consumption

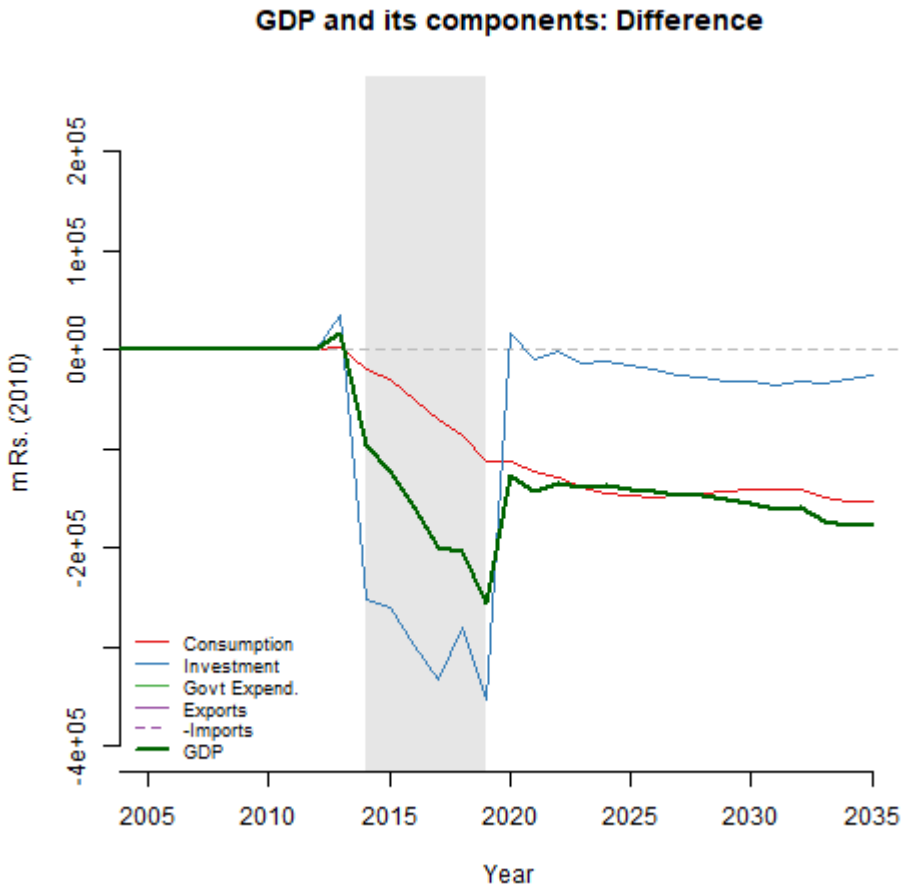
+ Investment
+ Govt Exp.
+ Exports
- Imports

Difference over baseline

Consumption details

- Total, Elec (model, direct), other sectors
- Regional impact?

GDP



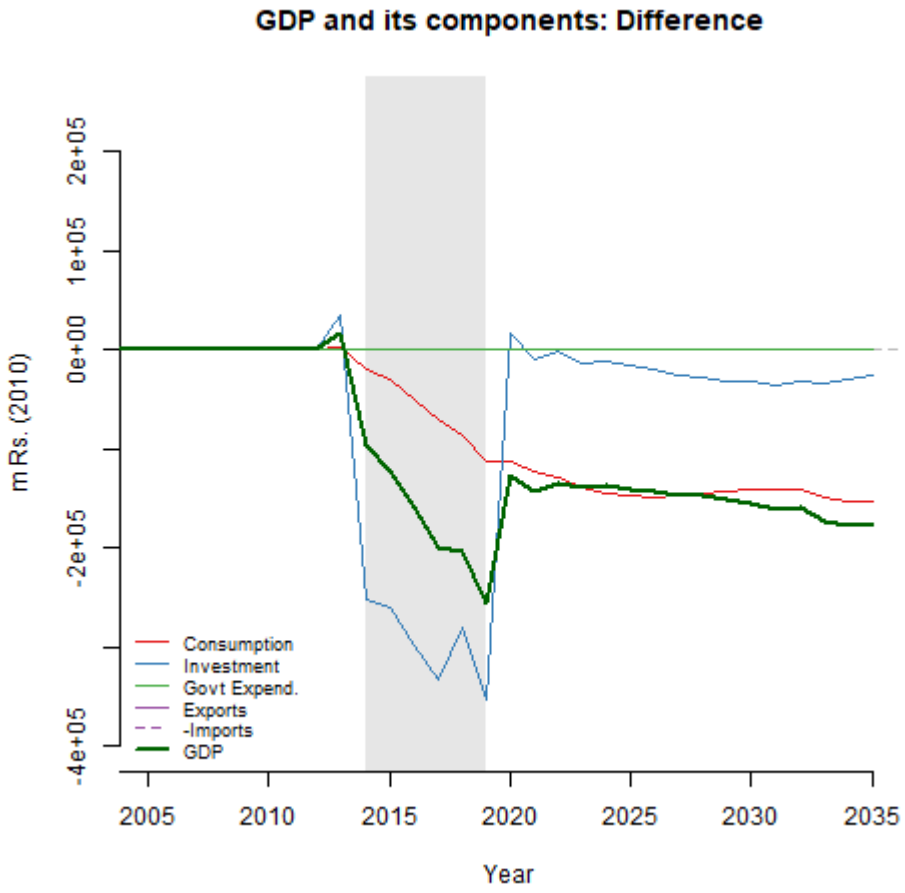
Consumption
+ Investment
+ Govt Exp.
+ Exports
- Imports

Difference over baseline

Investment details

- Elec, Manuf (model, shock), other sectors
- Regional impact?

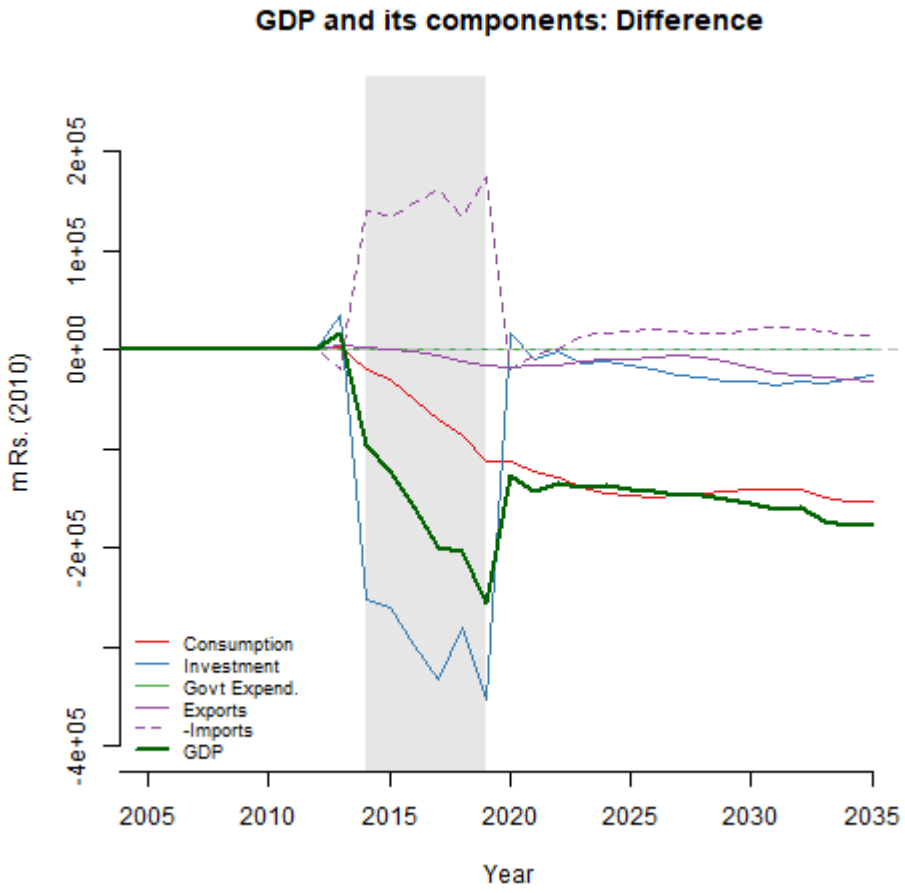
GDP



Consumption
+ Investment
+ Govt Exp.
+ Exports
- Imports

Difference over baseline

GDP



Consumption
+ Investment
+ Govt Exp.
+ Exports
- Imports

Difference over baseline

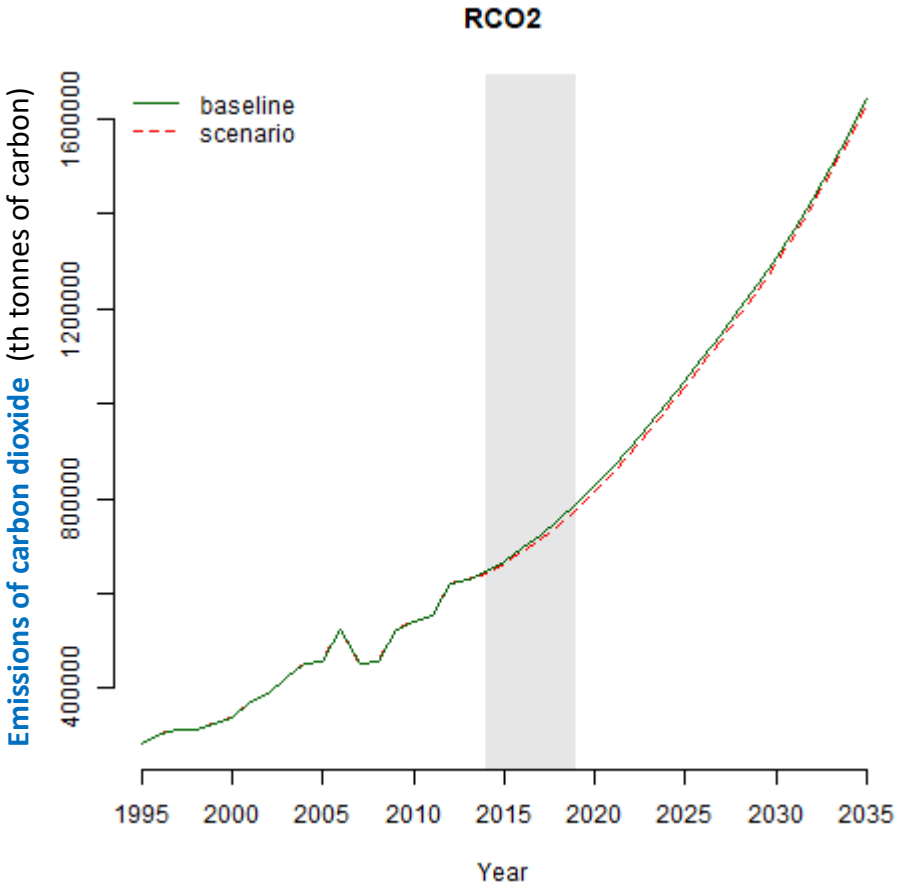
Import details

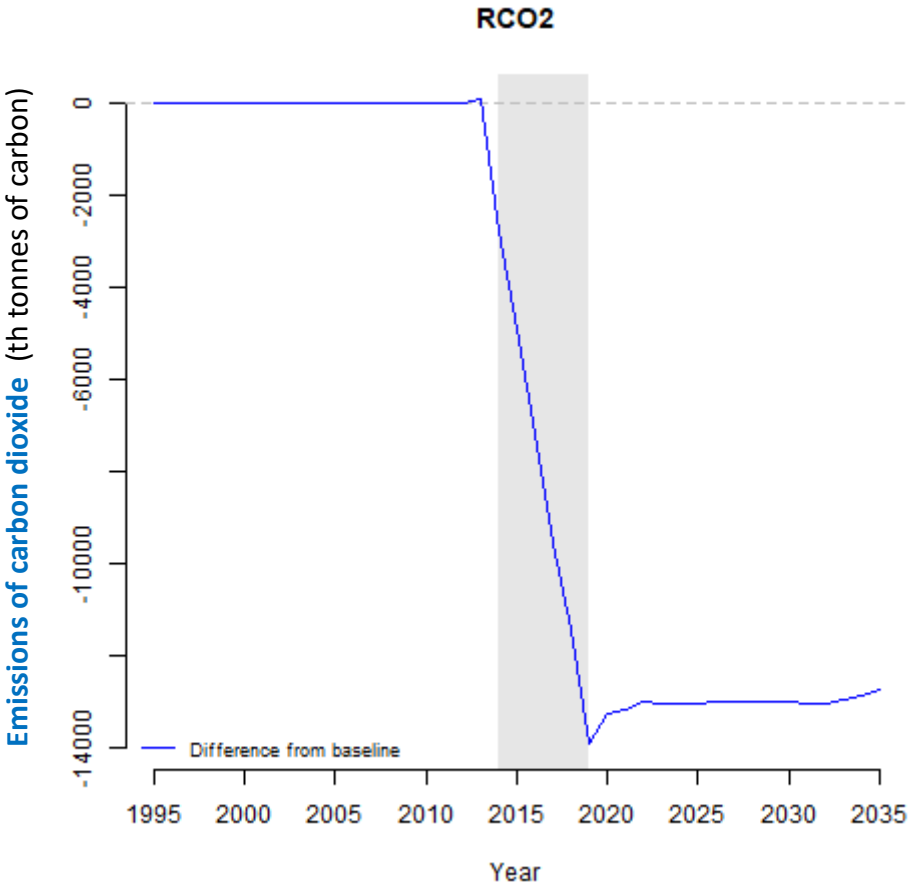
- Manuf, other sectors

GDP

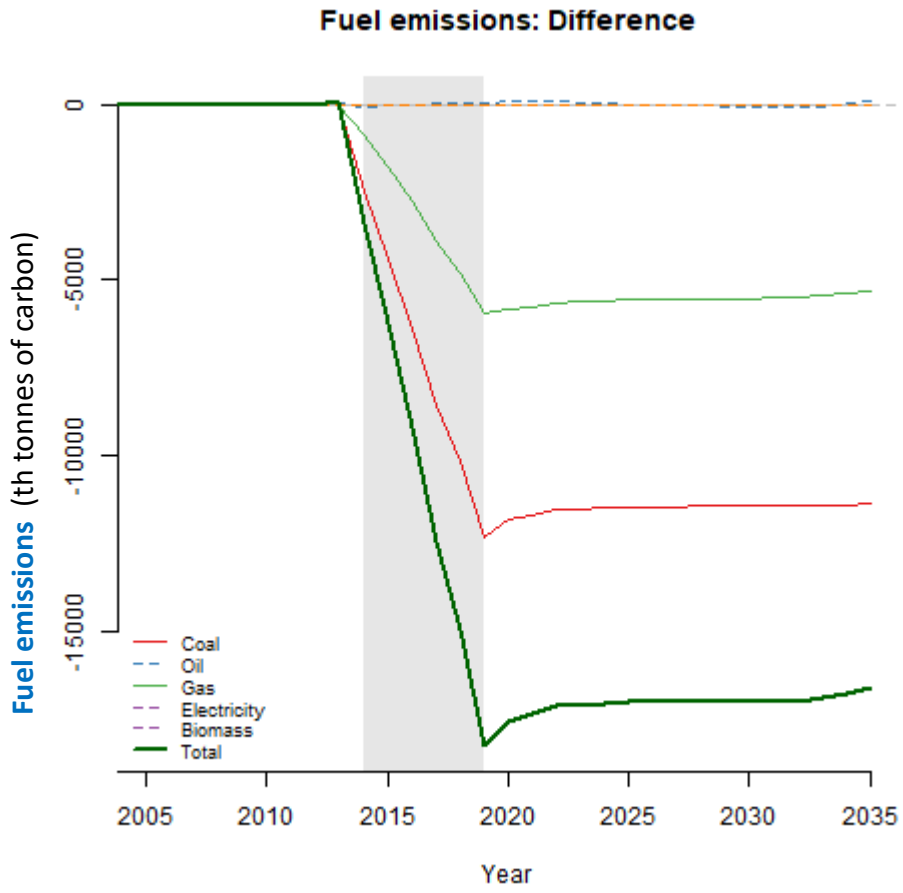
	RGDP	RSK	RSC	RSG	QEX	QEM
	GDP (m Rs)	Investment (m Rs)	HH Consumption (m Rs)	Government expenditure (m Rs)	Exports (m Rs)	Imports (m Rs)
2,014	87,964,925	26,981,811	56,623,800	16,552,779	52,023,051	54,860,436
2,019	119,576,099	36,590,017	77,566,905	21,126,002	68,632,031	72,624,543
2,019	119,320,043	36,236,358	77,453,778	21,126,002	68,615,748	72,450,438
2019 Scenario - 2019 Baseline	-256,056	-353,660	-113,127		-16,283	-174,104
% over baseline	**-0.21**	**-0.97**	**-0.15**		**-0.02**	**-0.24**
cumulative change 2014:19	**-1,037,844**	**-1,776,173**	**-370,694**		**-33,069**	**-893,199**
2035	311,625,280	95,125,339	192,734,830	46,115,382	165,932,187	175,214,093
2035	311,449,026	95,099,982	192,581,579	46,115,382	165,899,510	175,199,138
2035 Scenario - 2035 Baseline	**-176,254**	**-25,358**	**-153,251**		**-32,677**	**-14,955**
% over baseline	**-0.06**	**-0.03**	**-0.08**		**-0.02**	**-0.01**

Emissions

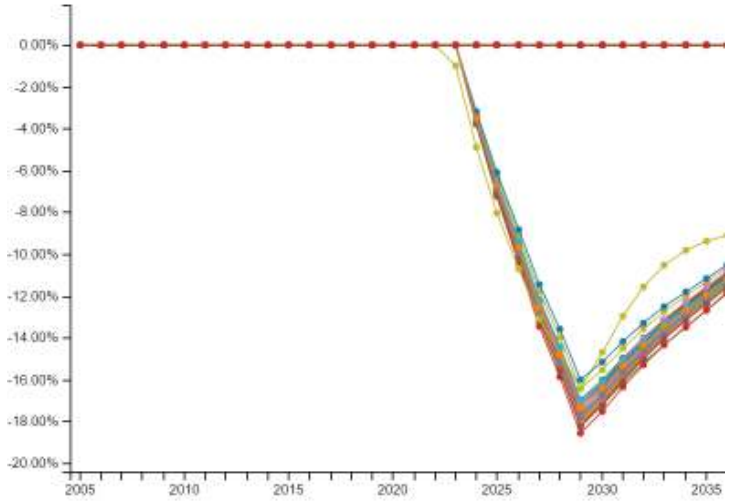

RCO2
baseline
scenario
Emissions of carbon dioxide (th tonnes of carbon)
400000
800000
1200000
1600000
1995
2000
2005
2010
2015
2020
2025
2030
2035
Year


RCO2
Difference from baseline
Emissions of carbon dioxide (th tonnes of carbon)
0
-2000
-4000
-6000
-10000
-14000
1995
2000
2005
2010
2015
2020
2025
2030
2035
Year

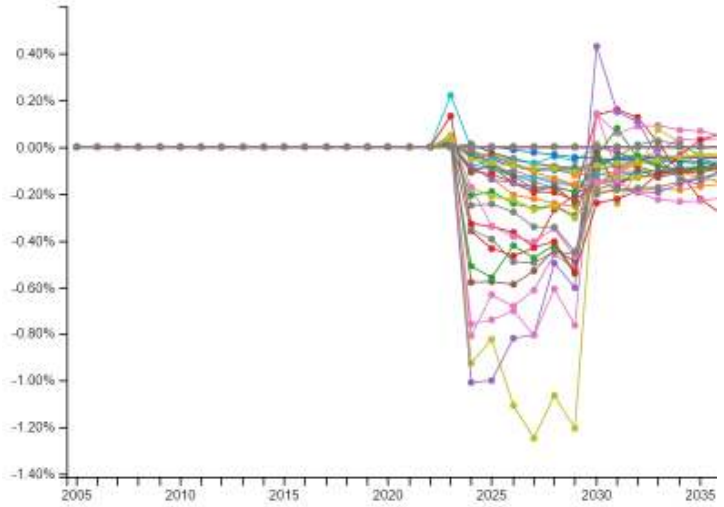
Emissions


Fuel emissions: Difference
Fuel emissions (th tonnes of carbon)
0
-5000
-10000
-15000
Coal
Oil
Gas
Electricity
Biomass
Total
2005
2010
2015
2020
2025
2030
2035
Year

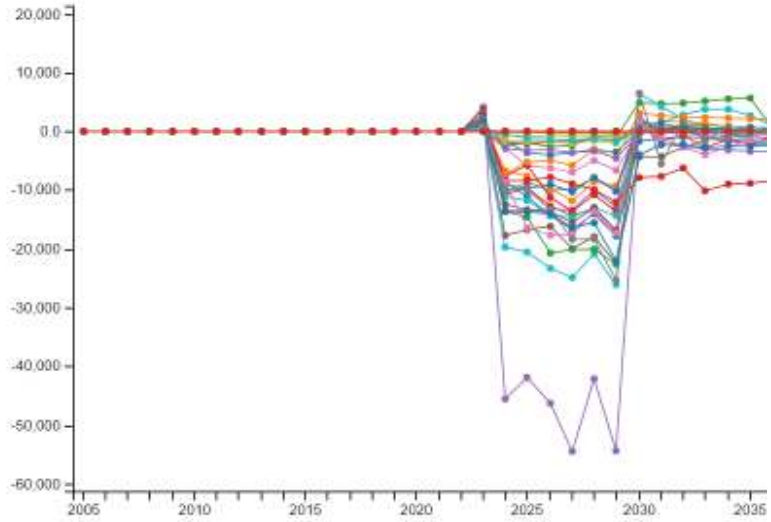
Regional impacts (work in progress)



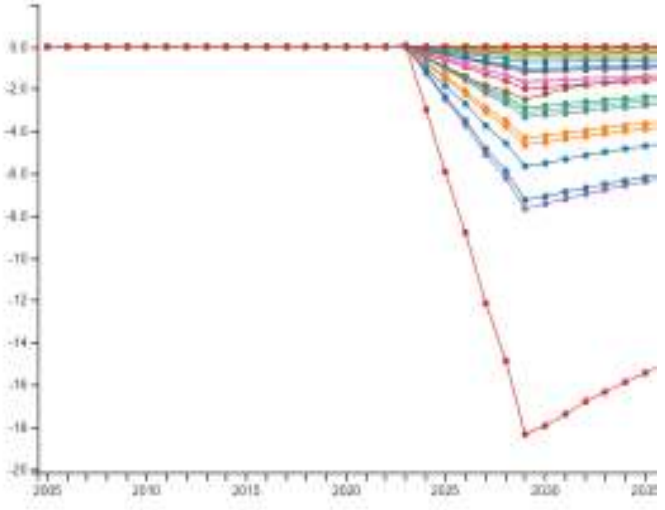
% change in HH electricity consumption



GDP



Investments



Employment in electricity sector

Comparison with renewable energy (work in progress)

Energy Efficiency

- **Rs 30 b of investment**
- No additional resource required
- Reduces employment in short run
- No additional environmental externalities
- Bottoms up, people involvement required, behavioral change
- Invisible, politically less preferred
- Continuous technology upgrade

Renewable Energy

- **Rs 59 b of investment**
- Demand of additional resource (land)
- May generates employment in short run
- Additional environmental externalities
- Top down, people involvement not required
- Visible, politically preferred
- Technological lock in

Conclusion

- Minor adverse impact on GDP in short run
- Avoided generation capacity of 9 GW (11%), investment of Rs 1,772 b in power generation
- Reduction of 182 th tonnes of CO2 during the program period
- Sustained emission reduction (47 m tonne of CO2/yr in the long run)

without public investment, taxes or subsidies

Significance of the work

- Coupled Economics, Environment and Energy model helps to estimate long term feedback among these systems

- Helps identify potential unintended impacts
  - short run negative impacts (e.g. investment, jobs)
  - regional imbalances (e.g. winners vs losers)

- Comparison with alternative options like RE

Next steps

- Market transformation
- Power supply constraint, shortage and access, indirect benefits accrued to power distribution companies
- Impact on households in different income quintiles (distributive impact)
- Detailed modeling of renewable energy investments and associated impacts on economy and emissions
- Study of regional impacts
- Comparison of results with other similar studies globally

Next next steps!

- Modeling potential remedial policies, including alternate use of investment saved in power generation and its impacts
- Shifts in consumer preferences for LED bulbs
- Rebound effects
- Behavioral impacts on bulb usage
- Health, education and productivity benefits

THANKS

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Maithili Iyer, Lawrence Berkeley National Lab, USA

NOTES

Tasks

- Regional imbalance, RE
- Text edits, messaging

- Ensure that all points in the paper are covered (limitations, next steps,…)
- Ensure all points from flash ppt are covered

- Add units to all graphs

- Impacts
  - Direct
  - Short term diff and Cumulative
  - Long term diff and cumulative

Changes in next iteration

- Move investment to 2014
- Make replacement from ICL and CFL 50-50%
- Agriculture/Construction jobs?

Households

Income / Employment

Energy