The Regulatory Assistance Project

The E3-India Model

Technical model manual, Volume 8: Case studies

This volume (8) is part of a 9-volume series covering the E3-India model

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Authorisation and Version History

Version	Date	Authorised for release by	Description
1.1	18/08/17	Hector Pollitt	Updates for initial case studies.
1.0	17/06/17	Hector Pollitt	First version, Volume 8.

Contents

1 Introduction

1.1 Introduction

This volume gives so examples of scenarios that have been assessed with E3-India. It is designed to be used as a guide for other model users. It is anticipated that the volume is updated over time so that researchers can share their work with other potential modellers.

2 Case studies

2.1 Initial testing

Overview

This section highlights three exercises that were carried out by Surabhi Joshi and Riley Allen in 2016/17. The scenarios were used as part of the testing for the original version of E3-India, and presented at several workshops in India.

Three themes were tested, these are described below. The following paragraphs introduce the exercise.

Introduction

The E3-India is a macroeconomic policy impact model developed by Cambridge Econometrics to help foster effective engagement around policy at the state level in India. The model is being developed as a tool and at present is at an advanced stage of development, sufficient for us to demonstrate its potential for simulation and analysis of policy impacts. Data gaps will be filled, and we hope that as local knowledge grows over time, that will help the model realize its full potential.

The analysis presented below helps to demonstrate the flexibility and use of the model in three ways. First, the model is flexible with respect to geographic scale. It can be used to demonstrate policy impacts at different geographic resolutions (regions) that span one or more states and territories. Second, the model is flexible with respect to technology. It can be used to reveal the impacts of policy scenarios that are differentiated by energy technology (like feed-in tariffs, or FiTs, for example, to demonstrate impacts on GHG emissions) by region. Third, the model is tightly woven among energy, environment, and the economy (the Es in "E3"). Consequently, the model permits its users to understand impacts of policy both within the sector and beyond. We can, for example, use the model to understand the impacts of technology transition scenarios with key economic parameters such as state-level GDP, investments, and consumer expenditure for state-level or economy-wide E3 simulations.

The latest version of the E3-India model, the Beta 3 (B3) version, is now available. This version of the model incorporates certain default "scenario" and "assumption" files along with "idiom" files that provide users flexible tools to run policy simulations. All three of these text file groupings are in text files that can be manipulated by the model user. The scenario and assumption files are preconstructed tables to allow for relatively simple policy simulations by users. The idiom files represent a tool for advanced users to simulate policies using a fairly basic programming language developed by Cambridge Econometrics for the model.

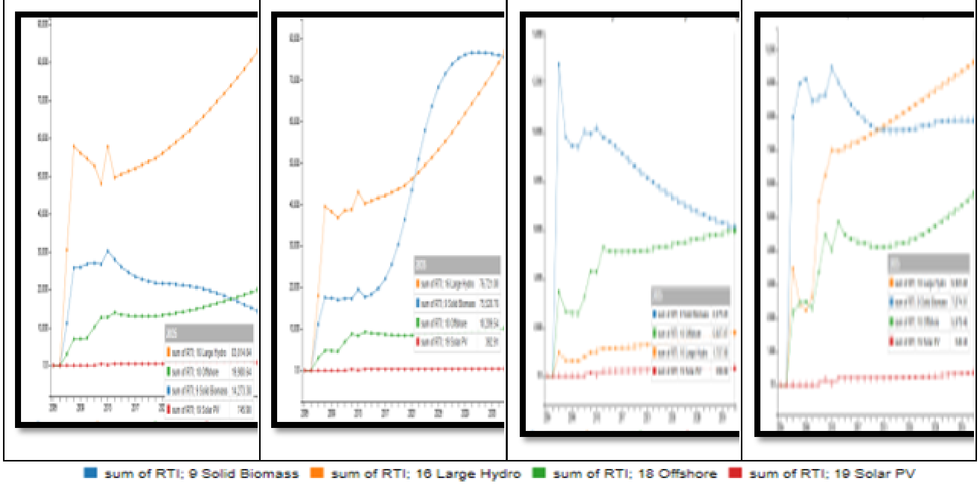
The modeling framework provides considerable flexibility for users to modify model input variables and then to view the impacts of those modifications on an extensive list of outputs. In order to manage the long list of variables, CE has created a high-level organizational structure that can be viewed through the model interface. There are three major groups of simulation variables: i) energy, environmental, and economic (E3) variables available by region, ii) E3 variables available by sector(within each region), and iii) energy technologies, referred to as future technology transition(FTT) variables. The requisite regional resolution for analysis is selected using either individual states or union territory or aggregates as demonstrated in Theme I.

Theme I: Applying the E3-India Model in Different Geographic Regions

The Renewable Energy Technology (RET) transition scenario is based on existing renewable capacities associated with individual states and trajectory of renewable growth as forecasted by the model. The RET transition scenario was studied among four different groups of Indian states categorized and aggregated as follows: i) high RET (i.e., “high” with respect to installed capacity) states; ii) low-RET states; iii) remote northeastern states; and iv) Union Territories. The growth trends for four renewable energy technologies (solid biomass, large hydro, onshore wind and solar photovoltaic technology (PV) from 2005 to 2035 were analyzed in terms of annual electricity generation (GWh/year). The results indicate that states with high RET capacity would be the forerunners in solar and wind installations until 2035. Solid biomass and large hydro would have significant share in renewables for all the categories. The promotion of solar PV would be more aggressive in Union Territories than in northeastern states or low-RET states. Thus, within the same national boundaries, the pathway of the Renewable Energy Transition would be significantly different for the four regional categories analyzed. The simulated trajectory of renewable generation for either individual states or aggregated groups can effectively inform policy choices, regulatory actions, and utility decisions for better management and infrastructure planning for energy capacity addition in each region. The vertical axis shows the trend of electricity generation by technology represented in Gwh/year.

Figure 2.1: Renewable penetration in different groups of states

High-RET states	Low-RET states	Remote northeastern states	Union Territories
1	2	3	4
Maharashtra, Madhya Pradesh, Gujarat, Rajasthan, Tamil Nadu, Karnataka, Chhattisgarh	Bihar, Jharkhand, Uttarakhand, Haryana, Odisha, Himachal Pradesh	Assam, Tripura, Meghalaya, Arunachal Pradesh, Manipur, Nagaland , Mizoram	Goa, Delhi, Chandigarh, Pondicherry, Andaman Nicobar

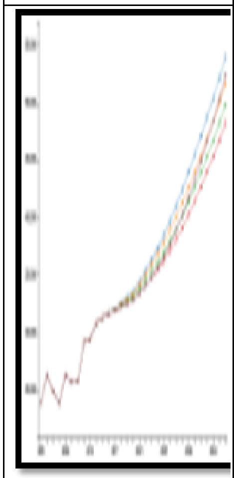
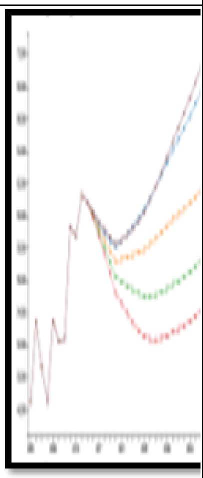
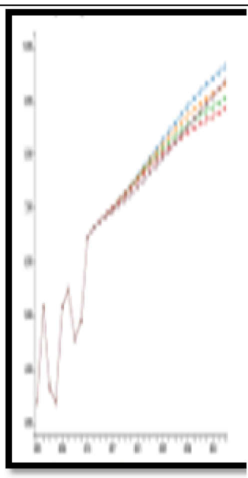
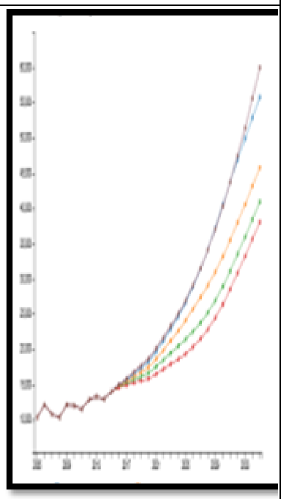


Theme II: Feed-in tariffs and assessment of low-GHG pathways

FiTs are wholesale price or “standard offer” prices that are awarded to technologies that meet the eligibility requirements for any given generation technology. FiTs typically include a price premium (above market-base or cost-based prices) to encourage the development of newer technologies.

The analysis performed required modifications to the “idiom” files described earlier. The code in the file was modified to establish greater FiT-based incentives for solid biomass, large hydro, offshore wind and solar PV. The analysis includes four different levels of FiTs in terms of the percentage premium above the electricity price to establish a new levelized wholesale FiT-base price available to the technologies listed. The baseline scenario (9) has FiT levels set at 1.1 (meaning that the FiT is 110 percent of the base price). New idiom scenario files named with changes to the code were modified and given new text file names: F1, F2, F3 and F4.The FiTs were setat1.6, 2.1, 2.6, and 3.1(to establish price premiums of 60 percent, 110 percent, 160 percent and 210 percent, respectively). An assessment of carbon emissions associated with above energy pathways of RETs for the four categories of Indian states was performed. The results are illustrated below.

Figure 2.2: CO_2 emissions in groups of states (thtC)

High RET states	Low RET states	Remote northeastern states	Union Territories
			
% Emission change (positive values reflect a reduction)			
5.18%	**21.80 %**	**5.47%**	**36.55%**

Fit1; sum of RTI; 1 Power generation   FIT2; sum of RTI; 1 Power generation
Fit3; sum of RTI; 1 Power generation   Fit4; sum of RTI; 1 Power generation
FITbase; sum of RTI; 1 Power generation   FIT; sum of RTI; 1 Power generation

The above analysis demonstrates that higher FiT rates in high RET states or remote northeastern states do not show a significant reduction in CO2 emissions. However, similar incentives for low-RET states or Union Territories such as Delhi and Chandigarh lead to a fairly large reduction in carbon intensity of 21.8 percent and 36.55 percent, respectively. This analysis is indicative of the role that RET policies for union territories or late movers states can play in GHG reductions for India. This type of analysis becomes critically important with India’s ratification of the Paris climate agreement, in which India has proactively committed to reductions in carbon emission intensity of its GDP of 33-35 percent below 2005 levels by 2030.

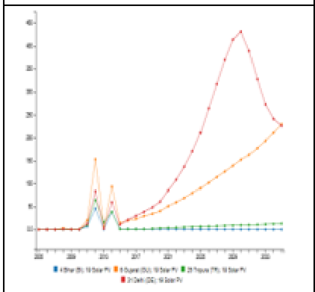
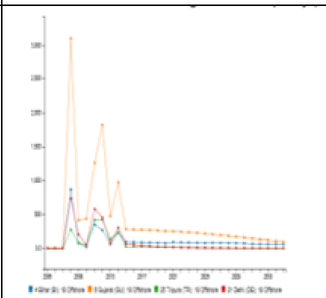
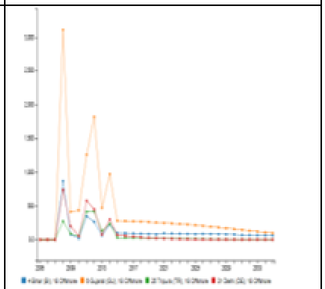
Of course, other dimensions of the impacts, including impacts on electric rates and the economy, should also be considered in such an analysis. Such analysis would allow policymakers to consider the alternative pathways and their respective impacts on carbon reduction, consumers, and the economy. The E3-India modeling framework provides a closed (self-consistent) framework for evaluating such the potential impacts. The third theme helps to demonstrate these capabilities within the E3-India model.

Theme III: Integration of the technology transition scenarios with key economic state level parameters

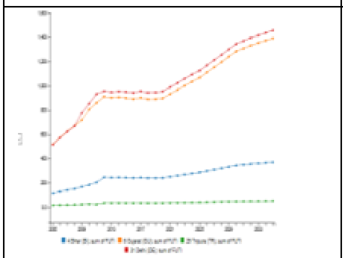
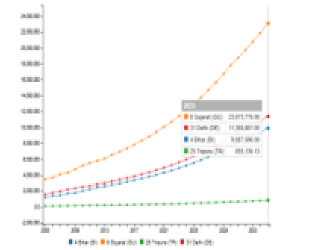
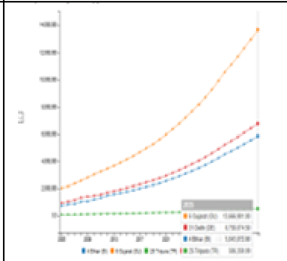
This section deals with using theE3-India model for analyzing some key state-level parameters, such as power sector investments, consumer spending, and total investments, and ascertaining their impact on key economic outcomes such as changes in GDP. The first set of graphics shows the investment categories and levels that are needed to meet the RET targets in different regions. The second set of graphics shows the impacts of these investments on key economic outputs, including GDP and consumer expenditures.

Figure 2.3: Investment and economic impacts

I) MWIY: Investment in new generation capacity (M2000$) for representative high and low-RET states, remote north eastern states and Union Territories

PV	Onshore wind	Solid biomass
		

II) Trends of GDP measure expenditure at market price, regional total consumption expenditure, and regional total investment spending are traced in the figure below for the four categories of states studied

GDP measure at market price (2005-2035)	Regional total consumption expenditure (2005-2035)	Regional total investment spending (2005-2035)
		

The trend indicates high investments in earlier years, followed by constant low investments for onshore wind and solid biomass. Investments for solar PV show a greater positive investment trajectory over time. The GDP trends for the four categories of states show higher GDP generation for high-RET states and Union Territories, followed by low-RET states and remote northeastern states. The regional consumption expenditure and investments increase with time but the trajectory differs among the categories of states, with high-RET states and Union Territories being the leaders.

2.2 Ongoing case studies

The following case studies are currently being assessed.

Towards Healthy Discoms: Mapping impacts of power sector efficiency improvement, subsidy phase out and tariff rationalisation articulated through UDAY across Indian states

Financial health of state DISCOMs in India have been snafued with huge accumulated debt (approximately Rs. 4.3 lakh crore as on March 2015). The financially stressed DISCOMs are not been able to supply adequate power at affordable rates, hampering quality of life and overall economic growth and development of many Indian states. A unique scheme launched by government of India's i.e Ujjwaal Discom Yojana (UDAY) aims at improving Discom performance plurilaterally through four initiatives (i) Improving operational efficiencies of DISCOMs; (ii) Reduction of cost of power; (iii) Reduction in interest cost of DISCOMs; (iv) Enforcing financial discipline on DISCOMs through alignment with State finances. This study simulates impacts associated with a synchronous effort to improve performance of DISCOM and shift of debt from dejure to defacto borrowing by states.

The study generates scenarios using information from state level tripariate MoUs executed under UDAY and uses E3-India modelling tool to simulate individual and combined impacts on indicators like state electricity tariff across consumption categories, GDP, employment , electricity price and emissions.

Evaluating green grid scenarios for triple bottom line of Economic, Social and environmental efficiencies

The feasibility of integrating targeted 175 GW of solar and wind capacities to the existing Indian grid have been recently established using production coast based modelling. This study provides an extension and wider dimension to existing studies by evaluating impacts of various probable scenarios for state level RE targets in India from a development perspective. This involves use of an array of economic, social and environmental performance indicators using E3-India model. The study maps energy transition impacts on state level sectoral multipliers along with employment and environmental impacts in terms of CO_2, SOx and NOx. The five prominent scenarios for RE integration i.e. 1) No new renewable 2) 20 GW wind (W) – 50 GW solar (S) 3) 100S-60W 4) 60S-100W 5) 150S-100W are analysed. This study provides an initial probe into possibility of structural change mediated in Indian economy by unprecedented renewable integration and its economy wide impacts for the economy.