The Regulatory Assistance Project

The E3-India Model

Quick Start Guide

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Authorisation and Version History

Version	Date	Authorised for release by	Description
		Hector Pollitt	Abridged manual

1 Guide to Running E3-India

1.1 Getting started

This chapter describes the steps required to install and run the model. We start with a general overview in this section and then describe how to run the model using the graphical interface. The model itself and the graphical interface come as a single package and are designed specifically to work together.

Installation

E3-India is set up to run on a PC running Windows version 8 or higher[1]. There are otherwise no specific computer requirements but the software works best in Google Chrome, and we highly recommend using Chrome as a platform for the software. The model has also been tested in Microsoft Edge but it does not operate in older versions of Internet Explorer. The model works in Windows but at present it does not work on Mac computers.

The Manager software is provided as part of a package for the E3-India model. It collates all E3-India model inputs into one place, enabling users to make changes directly to the input files or to load files that have been edited elsewhere (e.g. using other text editor software) and viewing the model results.

Getting started

To get started:

1. Download the software to the directory C:\E3-India on your local drive.
2. In the C:\E3-India\ directory, launch the shortcut *manager.exe* (full path C:\E3-India\Manager\).

This will launch the E3-India Model Manager software in your default internet browser. The link may be copied into another browser window, so it is not necessary to set Chrome as your default browser.

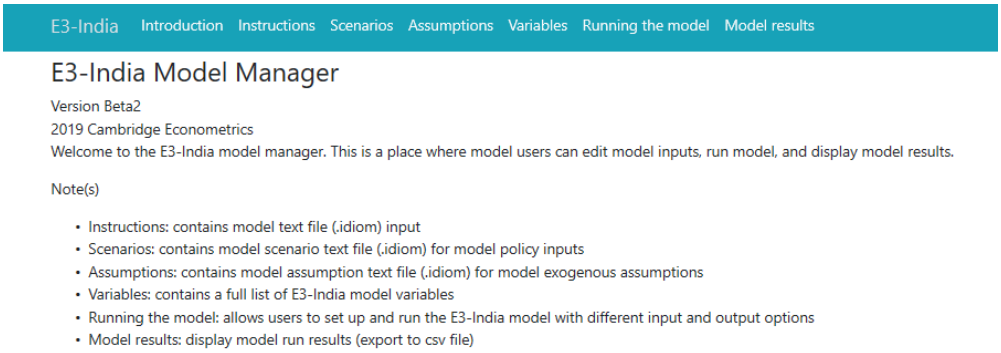
1.2 The E3-India Manager interface

The Manager software collates all E3-India model inputs into one place, enabling users to make changes directly to the input files or to load files that have been edited elsewhere. It is also used for viewing the model results.

[1] Most of the testing has been carried out using Windows 10.

Figure 1.1 shows an image of the software on start-up.

Figure 1.1: Image of the software on start-up



The software contains seven main tabs, which are described in Table 1.1. Many of the tabs link to other files that are installed on your local drive.

Table 1.1: The main tabs in the Manager

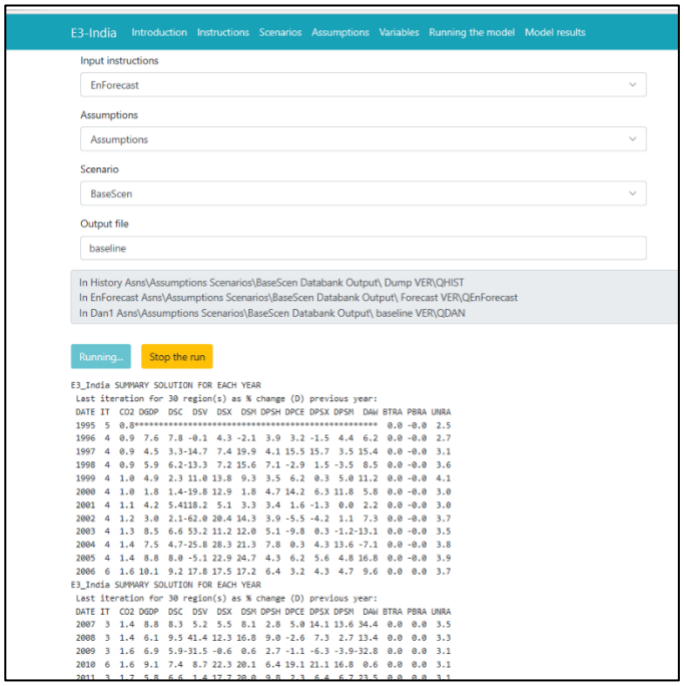
Tab:	Description:
Instructions (original files in c:\e3-india\In\)	The instructions files include the commands to set up and run the model (see below). More complex scenarios can be assessed by modifying the instructions files. On installation, E3-India has a pre-loaded set of files. There are further options to modify, duplicate and delete files.
Scenarios (original files in c:\e3-india\In\Scenario\)	The scenario files include a set of policy options that can be entered directly in the Manager. On installation, there is a baseline option and some test cases. Modifications can be made here.
Assumptions (original files in c:\e3-india\In\Asns\)	The assumptions file includes a set of forward-looking assumptions that are necessary for the model to run. These assumptions can be modified here.
Variables	A list of the main E3-India variables for reference.
Running the model	Here the user can set up and run the model, entering the choice of scenario and assumption input files and choosing a name for the output file.
Model results	This tab allows the user to view and compare model results, and to produce charts and tables with the option to export model results for further analysis.

There are three input files that are used every time the model is run:

- Instruction file: This file contains the code that sets up and operates the model. It offers a much wider range of options for potential scenarios but does require a basic knowledge of the IDIOM scripting language that is used. Advanced users typically work extensively with the instruction file.
- Scenario file: This contains a set of policy inputs, including carbon taxes and energy taxes, that can be modified easily without any programming.
- Assumptions file: This contains exogenous assumptions such as commodity prices, world growth rates, state tax rates and government spending. These can also be modified easily without any programming required.

A set of baseline inputs is provided: EnForecast.idiom (instruction file), Assumptions.idiom (assumption file) and BaseScen.idiom (scenario file).

Figure 1.2: Image of the model baseline using the provided inputs



It is recommended not to delete the baseline input files, but to instead duplicate these files, make changes to the duplicates and save them under different names for scenario analysis.

Running the model for the first time

It is recommended to have a set of baseline results first for comparison with future scenario results. To run the baseline:

1. Go to Running the model tab.
2. Select the default baseline inputs from the list: EnForecast.idiom (instruction file), Assumptions.idiom (assumption file) and BaseScen.idiom (scenario file).
3. Type in a name to be given to the output of this run e.g. ‘baseline’.

4. Click ‘run the model’ button and wait until it finishes.

Setting up scenarios

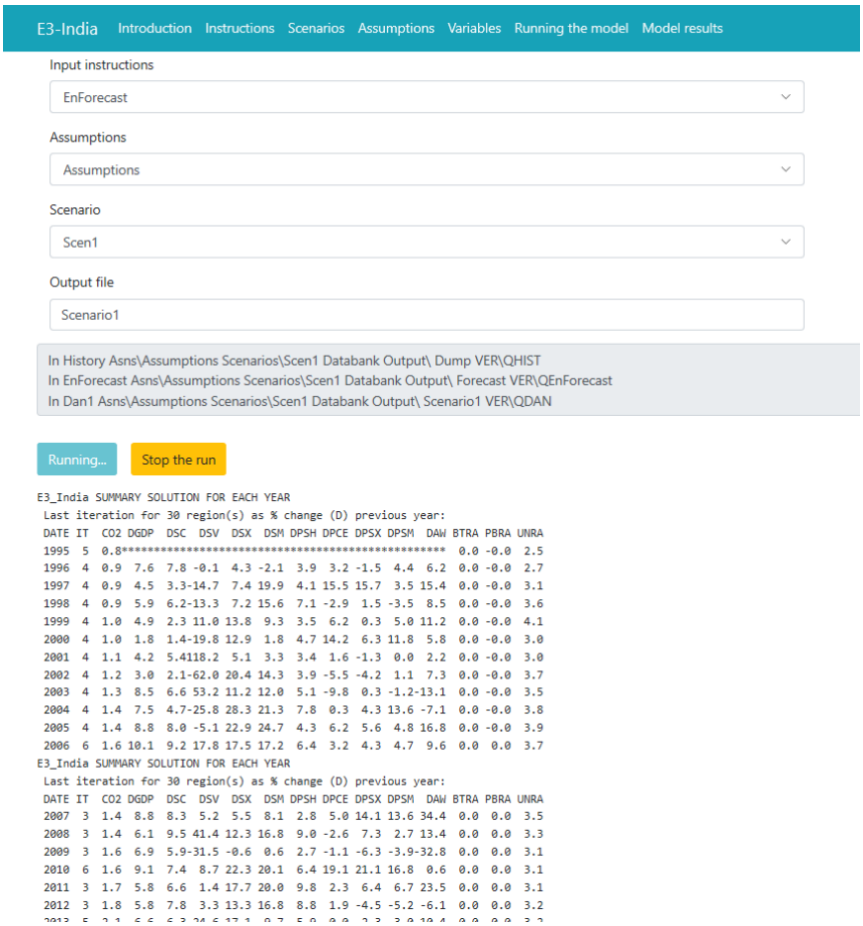
To set up and run scenarios after the baseline:

1. Go to the relevant tab to make the change (assumptions, scenarios or instructions)
2. Make a copy of the default input file by pressing the duplicate button and entering a new file name for it.
3. Make changes to the new file.
4. Click save once finished.
5. Follow step 1-4 of running the baseline above but make sure to select the relevant input files and provide a different name for results file.

Alternatively, steps 2 to 4 can be carried out outside the Manager by making a copy of the original input files and editing them manually using a standard text editor software package (e.g. Windows Notepad).

Note: output files are automatically saved to the C:\e3-india\output folder.

Figure 1.3: Image of a model scenario



Every time the user runs the model, three run sequences are automatically called (see command lines below). These lines are the model executables. The model runs over history first (to e.g. generate lagged variables), the forecast period (from the EnForecast script) and in a separate routine to print out the results (from the Dan1 script).

Figure 1.4: The three stages of running the model

```
In History Asns\Assumptions Scenarios\BaseScen Databank Output\ Dump VER\QHIST
In EnForecast Asns\Assumptions Scenarios\BaseScen Databank Output\ Forecast VER\QEnForecast
In Dan1 Asns\Assumptions Scenarios\BaseScen Databank Output\ Baseline VER\QDAN
```

The display box summarises key model variables as the model solves for each year of solution. It provides a quick overview of the model solution for all Indian states while the model is running. A full set of the model results can be accessed once the model has finished running.

Figure 1.5: Display when the model is running

```
E3_India SUMMARY SOLUTION FOR EACH YEAR
 Last iteration for 30 region(s) as % change (D) previous year:
 DATE IT  CO2 DGDP  DSC  DSV  DSX  DSM DPSH DPCE DPSX DPSM  DAW BTRA PBRA UNRA
 1995  5  0.8************************************************  0.0 -0.0  2.5
 1996  4  0.9  7.6  7.8 -0.1  4.3 -2.1  3.9  3.2 -1.5  4.4  6.2  0.0 -0.0  2.7
 1997  4  0.9  4.5  3.3-14.7  7.4 19.9  4.1 15.5 15.7  3.5 15.4  0.0 -0.0  3.1
 1998  4  0.9  5.9  6.2-13.3  7.2 15.6  7.1 -2.9  1.5 -3.5  8.5  0.0 -0.0  3.6
 1999  4  1.0  4.9  2.3 11.0 13.8  9.3  3.5  6.2  0.3  5.0 11.2  0.0 -0.0  4.1
 2000  4  1.0  1.8  1.4-19.8 12.9  1.8  4.7 14.2  6.3 11.8  5.8  0.0 -0.0  3.0
 2001  4  1.1  4.2  5.4118.2  5.1  3.3  3.4  1.6 -1.3  0.0  2.2  0.0 -0.0  3.0
 2002  4  1.2  3.0  2.1-62.0 20.4 14.3  3.9 -5.5 -4.2  1.1  7.3  0.0 -0.0  3.7
 2003  4  1.3  8.5  6.6 53.2 11.2 12.0  5.1 -9.8  0.3 -1.2-13.1  0.0 -0.0  3.5
 2004  4  1.4  7.5  4.7-25.8 28.3 21.3  7.8  0.3  4.3 13.6 -7.1  0.0 -0.0  3.8
 2005  4  1.4  8.8  8.0 -5.1 22.9 24.7  4.3  6.2  5.6  4.8 16.8  0.0 -0.0  3.9
 2006  6  1.6 10.1  9.2 17.8 17.5 17.2  6.4  3.2  4.3  4.7  9.6  0.0  0.0  3.7
E3_India SUMMARY SOLUTION FOR EACH YEAR
 Last iteration for 30 region(s) as % change (D) previous year:
 DATE IT  CO2 DGDP  DSC  DSV  DSX  DSM DPSH DPCE DPSX DPSM  DAW BTRA PBRA UNRA
 2007  3  1.4  8.8  8.3  5.2  5.5  8.1  2.8  5.0 14.1 13.6 34.4  0.0  0.0  3.5
 2008  3  1.4  6.1  9.5 41.4 12.3 16.8  9.0 -2.6  7.3  2.7 13.4  0.0  0.0  3.3
 2009  3  1.6  6.9  5.9-31.5 -0.6  0.6  2.7 -1.1 -6.3 -3.9-32.8  0.0  0.0  3.1
 2010  6  1.6  9.1  7.4  8.7 22.3 20.1  6.4 19.1 21.1 16.8  0.6  0.0  0.0  3.1
 2011  3  1.7  5.8  6.6  1.4 17.7 20.0  9.8  2.3  6.4  6.7 23.5  0.0  0.0  3.1
 2012  3  1.8  5.8  7.8  3.3 13.3 16.8  8.8  1.9 -4.5 -5.2 -6.1  0.0  0.0  3.2
 2013  5  2.1  6.6  6.3 24.6 17.1  9.7  5.9  0.0 -2.3 -3.0 10.4  0.0  0.0  3.2
 2014  5  2.2  6.9  6.1  1.8  3.3  5.3  0.3  0.0  1.7  1.7 36.6  0.0  0.0  3.2
 2015  7  2.3  7.7  6.2  6.8  6.3  6.2 -7.1  0.5  1.7  1.7 -8.2  0.0  0.0  2.8
 2016 38  2.4  6.1  6.1  3.4  5.6  5.5  1.1  1.2  2.0  1.9  1.0  0.0  0.7  2.8
 2017 50  2.5  6.1  6.0  3.4  5.4  5.3  1.4  1.3  2.0  1.9  1.0  0.0  0.7  2.8
 2018 41  2.7  6.1  6.0  3.3  5.7  5.6  1.0  1.3  2.0  1.9  1.0  0.0  0.8  2.8
 2019 50  2.8  6.0  6.1  3.2  5.6  5.6  1.2  1.3  2.0  1.9  1.0  0.0  0.8  2.8
 2020 50  3.0  6.1  6.1  3.2  5.8  5.8  1.2  1.3  2.0  1.9  0.9  0.0  0.8  2.8
 2021 50  3.1  6.7  7.1  4.3  6.1  6.0  1.2  1.2  1.8  1.8  1.2  0.0  0.8  2.8
 2022 50  3.3  6.7  7.1  4.3  6.1  6.0  1.2  1.2  1.8  1.8  1.2  0.0  0.8  2.8
 2023 50  3.5  6.6  7.1  4.2  6.1  6.1  1.2  1.2  1.9  1.8  1.2  0.0  0.8  2.8
 2024 50  3.7  6.6  7.0  4.1  6.1  6.1  1.2  1.3  1.9  1.9  1.2  0.0  0.8  2.8
 2025 50  3.9  6.6  7.0  4.0  6.1  6.1  1.2  1.3  1.9  1.9  1.2  0.0  0.8  2.7
 2026 50  4.1  6.6  7.0  3.9  6.1  6.1  1.3  1.6  2.0  1.9  1.1  0.0  0.7  2.7
 2027 50  4.3  6.6  7.0  3.9  6.1  6.1  1.3  1.4  2.0  1.9  1.1  0.0  0.7  2.7
 2028 50  4.6  6.6  6.9  3.8  6.1  6.1  1.4  1.4  2.1  1.9  1.1  0.0  0.8  2.7
```

Table 1.2: The variables displayed while the model is running

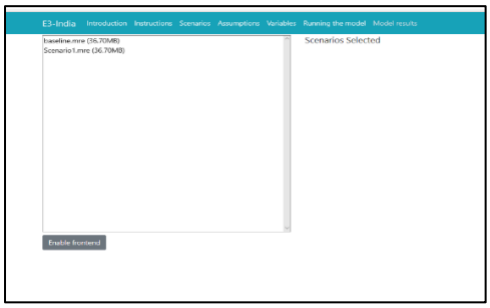
Code	Description	Unit
CO2	CO_2	CO_2 equivalent billion tonnes of carbon
DGDP	GDP	Year on year growth
DSC	Consumption	Year on year growth
DSV	Investment	Year on year growth
DSX	Exports	Year on year growth
DSM	Import	Year on year growth
DPSH	Industrial prices	Year on year growth
DPCE	Consumer prices	Year on year growth
DPSX	Export prices	Year on year growth
DPSM	Import prices	Year on year growth
DAW	Average Wage Rates	Year on year growth
BTRA	Trade balance	Percent
PBRA	Public balance	Percent
UNRA	Unemployment rate	Rate

Once the model finishes running, the output from the model run is saved in the C:\E3-India\Output folder. The output file is saved under a text (.mre) format which the Manager software translates into graphical format, allowing the user to inspect the model results in detail.

The Manager software automatically lists all the files with a .mre extension in the C:\E3-India\Output folder and users can select which sets of results to display.

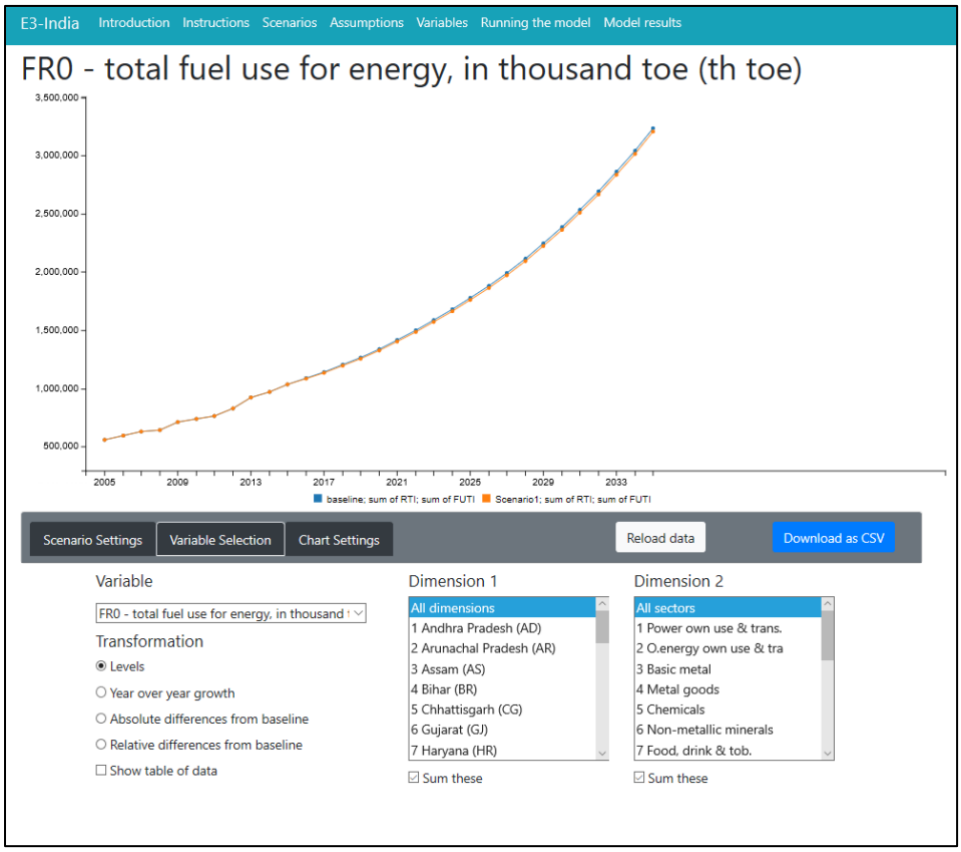
To select the results to display go to the Model Results tab. If the latest model run does not appear in the list, refresh the page as you would normally do in the internet browser. Select the results from the model runs that you wish to inspect and click on the 'Enable frontend' button.

Figure 1.6: Selecting sets of model results



To view the model results, select the relevant scenario(s), variable and dimensions to display.

Figure 1.7: Example of model output

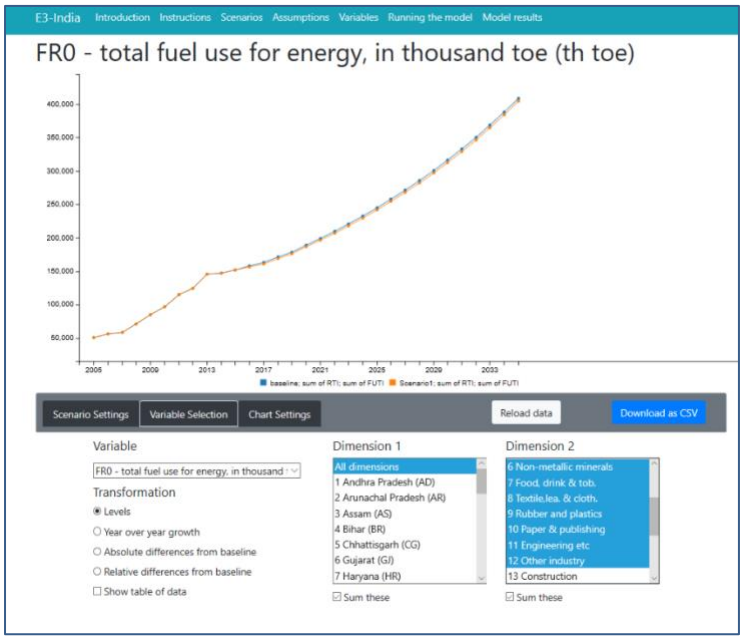


To compare scenario results against a baseline, select the baseline in the baseline drop down list (this can be any file). Choose the scenario, variable and dimensions to display.

Users can choose whether to view results in levels, absolute differences from baseline, relative difference from baseline, or year-on-year growth by selecting the relevant options in the bottom-left corner.

Additionally, users can select more than one sector or state to display simultaneously on the chart (by shift-clicking or control-clicking). There is an option to sum the dimensions selected, which is useful for checking aggregate results.

Figure 1.8: Example of comparing results against baseline



To export results, select '*Show a table of data'* and a table containing data will appear at the bottom of the page. Click '*download data as csv'* to export this table to .csv file. Alternatively, users can copy and paste the table to a spreadsheet package manually.

Users can browse through the full set of results from a model run. To rerun the model, return to the previous tabs. To look at the results from a different set of model runs, click on '*reload data'* button.

2 Model Inputs and Outputs

2.1 Introduction

This chapter describes E3-India's main model inputs and outputs. The following sections describe the main inputs that the model relies on, including data and econometric parameters. The final part of this chapter describes the format of the main model outputs.

2.2 Data inputs

Introduction to the model databanks

The data are the most important single input to E3-India. A lot of effort is put into ensuring that the model data are accurate and consistent to the maximum degree possible.

The following databanks are used to store the data:

- T – historical time-series data
- F – processed baseline forecast (see Section 4)
- X – cross-section data, including input-output tables and equation parameters
- E – energy balances, prices and emissions
- U – classification titles

One other databank is used for model operation:

- S – holds the calibration factors to match the baseline forecast (see section 4 of this chapter)

E3-India's data requirements are extensive and specific. All data must be processed so that they are in the correct classifications and units. Gaps in the data must be filled (see below). All data processing is carried out using the Oxmetrics software package.

Time-series economic data

It is a substantial exercise to create and maintain the time series of economic data. The main dimensions involved are:

- indicator
- states
- sector
- time period (annually from 1993)

In addition, indicators that are expressed in monetary units have constant and current price versions. Cambridge Econometrics therefore puts a large amount of resources into processing the time-series data.

The raw data are gathered from the sources described below and stored on the T databank. The model uses official sources as much as possible. It is often necessary to combine data sets to fill out gaps in the data and to estimate remaining missing values (see below).

The main indicators

A 'V' at the start of the name indicates a current price value; otherwise the indicator is expressed in constant prices (2011 rupees). The main indicators with full sectoral disaggregation are:

- QR/VQR – output (constant and current price bases)
- YVM/VYVM, YVF/VYVF – GVA at market prices and factor cost
- KR/VKR – investment
- CR/VCR – household expenditure (by product)
- GR/VGR – government final consumption (by category)
- QRX/VQRX – exports
- QRM/VQRM – imports
- YRE – employment
- YRLC – labour costs (current prices)

There are also time series for population (DPOP) and labour force (LGR), disaggregated by age and gender.

In addition, there are several macro-level time series that are used in the modelling. These include GDP, household incomes, tax and interest rates and the unemployment rate. They are also collected on an annual basis, starting from 1993.

Data sources for E3-India's economic data

Table 2.1 gives a summary of the data sources for economic variables used in the E3-India model. Most data are collected from original sources and processed by Indian national account data experts. Database construction was a major task. Full detailed data documentation is given in Appendix C.

The data must be consistent across states and in the same units. For monetary data, the rupee is used.

Table 2.1: E3-India data sources for economic variables

Variable	Source
Population	2001 Census of India - For State wise Rural and Urban Population 2011 Census of India - For State wise Rural and Urban Population
Unemployment and labour participation rates	NSSO Employment and Unemployment in India Surveys NSSO Employment and Unemployment Situation in India Surveys NSSO Household expenditure and Employment Situation in India Surveys
National Accounts and employment • Total Inputs • Gross Value Added	**Agriculture**: State-wise And Item-wise Estimates of Value of Output from Agriculture and Allied Sectors, Central Statistics Office, MOSPI, Government of India"

• Gross Fixed Capital Formation • Change in Stock • Profits • Employment • Compensation to Employees	**Mining**: Indian Mineral Year Book 2012, Indian Bureau of Mines, Government of India. **Services:** National Accounts Statistics, Ministry of Statistics and Programme Implementation. **Manufacturing:** Annual Survey of Industries reports (1993-2016), Ministry of Statistics and Programme Implementation.
Consumer expenditure	NSSO Household Consumer Expenditure in India NSSO Household Consumer Expenditure and Employment situation NSSO Key Indicators of Household Consumer Expenditure in India NSSO Level and Pattern of Consumer Expenditure E3 India state rural and urban population Level and Pattern of Consumer Expenditure in India, 1999-2000 NSS 55th Round (July 1999- June 2000) Household Consumption of Various Goods and Services in India 2011-12 (NSS 68th Round)
Government spending	Reserve Bank of India State Finances: A Study of Budgets India Ministry of Finance Union Budgets E3 India Population Own estimation using information from national total
External trade	Own estimation using information from national total (share of trade in national accounts)
Total gross disposable income	Own estimation using information from national total (ratio of gross disposable income and total wages and salaries in national accounts)
MOSPI – Indian Ministry of Statistics and Programme Implementation NSSO – Indian National Sample survey reports	

Values and price indices in E3-India

The general principle adopted in E3-India is that variables are defined in the currency unit appropriate for the use of the variable. This usually means that the units of measurement follow those in the data source. The principle of comparability is taken to imply that most current values are measured in millions of rupees and most constant values in millions of rupees at 2011 prices.

The price indices are calculated by dividing current by constant values in rupees.

Cross-sectional data

By cross-sectional data we mean data that are not usually available in time-series format. Historically, this has meant input-output tables. Other cross-sectional data include converters between model classifications that do not normally change over time.

Input-output tables in E3-India

There are no input-output data publicly available at state levels. However, state level input-output is crucial in the E3-India model as it is used to distinguish different economic characteristic between states and provide linkages between local industries. Our Indian national account expert spent great effort in putting together input-output flows information at state level from raw data sources. For full documentation on how the IO tables at state level were constructed, including sources, please see Appendix C.

Input-output flows are converted to coefficients by dividing the columns by industry output. These coefficients give the number of units of input required to produce one unit of output.

Energy and emissions data

State-level energy and emissions data for E3-India come from various sources. Where state-level data are not available, national data are used as proxies.

Table 2.2: E3-India data sources for energy variables

Variable	Source
Coal consumption	MOSPI Installed capacity, generation and consumption 2007-2013
Oil consumption	Indian Petroleum and Natural Gas statistics (Ministry of Petroleum & Natural Gas)
Gas consumption	MOSPI Installed capacity, generation and consumption 2007-2013
Electricity consumption	MOSPI Electricity sold to ultimate consumer: 2007-2013
Biomass Consumption	MOSPI renewable generation capacity data
Energy Prices	IEA national fuel price
MOSPI – Indian Ministry of Statistics and Programme Implementation	

Energy price data in E3-India

Energy price data

State-level energy prices for each fuel are also not available. Instead, energy prices for each state are assumed to match the national Indian prices obtained from the IEA Energy Statistics which provide prices (before and after taxes) in USD per tonne of oil equivalent by country and by fuel. Global fossil fuel price data for oil, coal and gas also come from the IEA.

CO_2 emissions in E3-India

Time-series data for CO_2 emissions, disaggregated by energy user, are calculated using national emission coefficients.

Correcting for missing data points

The team at Cambridge Econometrics has developed a software package to fill in gaps in any of the E3-India time series. The approach uses growth rates and shares between sectors and variables to estimate missing data points, both in cases of interpolation and extrapolation. Some time series have specific rules for filling gaps in the data, but the general procedures are described here.

The most straightforward case is when the growth rates of a variable are known and so the level can be estimated from these growth rates, as long as the initial level is known. Sharing is used when the time-series data of an aggregation of sectors are available but the individual time series is not. In this case, the sectoral time series can be calculated by sharing the total, using either actual or estimated shares.

In the case of extrapolation, it is often the case that aggregate data are available but sectoral data are not; for example, government expenditure is a good proxy for the total growth in education, health and defence spending. A special procedure has been put in place to estimate the growth in more disaggregated sectors so that the sum of these matches the known total, while the individual sectoral growth follows the characteristics of each sector. Interpolation is used when no external source is available, to estimate the path of change during an interval, at the beginning and end of which data are available.

Under different assumptions, time-series forecasts are created for each country and each aggregated variable: consumption, employment, GDP, trade and investment.

Naming conventions

E3-India's software limits model variables to four character names. These characters are typically used to identify first the dimensions of the variable (excluding time, which is a dimension for all the variables) and then the indicator. In particular, Q indicates disaggregation by product, Y by industry, F by energy (fuel) user and R by region. If a variable name starts with P then it usually indicates a price. S and 0 can be used to identify sums.

These conventions are used in the data processing and in the model itself. Some examples of common variables names are provided below:

- QR: (Gross) output by product and by region
- YR: (Gross) output by industry and region
- YRE: Employment by industry and region
- YRW: Wage rates by industry and region
- YRVA: Gross value added by industry and region
- CR: Consumption by consumption category and region
- PCR: Consumption prices by category and region
- RSC: Total consumption by region
- PRSC: Aggregate consumer price by region
- KR: Investment by investment category and region
- FR0: Total energy consumption by energy user and region
- FRET: Electricity consumption by energy user and region
- FCO2: CO_2 emissions by energy user and region
- RCO2: CO_2 emissions by region

2.3 Econometric parameters

The econometric techniques used to specify the functional form of the equations are the concepts of cointegration and error-correction methodology, particularly as promoted by Engle and Granger (1987) and Hendry et al (1984).

In brief, the process involves two stages. The first stage is a levels relationship, whereby an attempt is made to identify the existence of a cointegrating relationship between the chosen variables, selected on the basis of economic theory and a priori reasoning, e.g. for employment demand the list of variables contains real output, real wage costs, hours-worked, energy prices and the two measures of technological progress.

If a cointegrating relationship exists then the second stage regression is known as the error-correction representation, and involves a dynamic, first-difference, regression of all the variables from the first stage, along with lags of the dependent variable, lagged differences of the exogenous variables, and the error-correction term (the lagged residual from the first stage regression). Due to limitations of data size, however, only one lag of each variable is included in the second stage.

Stationarity tests on the residual from the levels equation are performed to check whether a cointegrating set is obtained. Due to the size of the model, the equations are estimated individually rather than through a cointegrating VAR. For both regressions, the estimation technique used is instrumental variables, principally because of the simultaneous nature of many of the relationships, e.g. wage, employment and price determination.

Software used

E3-India's parameter estimation is carried out using a customised set of software routines based in the Ox programming language (Doornik, 2007). The main advantage of using this approach is that parameters for all sectors and countries may be estimated using an automated approach.

The estimation produces a full set of standard econometric diagnostics, including standard errors and tests for endogeneity.

Estimation results

A list of equation results can be made available on request and parameters are stored on the X databank. For each equation, the following information is given:

- summary of results
- full list of parameter results
- full list of standard deviations

2.4 Baseline forecast

Overview

The E3-India model can be used for forming a set of projections, but it is usually used only for policy analysis. Policy analysis is carried out in the form of a baseline with additional policy scenarios, with the differences in results between the scenarios and the baseline being attributed to the policy being assessed.

This section describes how the baseline is formed.

Role of the baseline

Usually results from E3-India scenarios are presented as (percentage) difference from base, so at first it may appear that the actual levels in the baseline are not important. However, analysis has shown that the values used in the baseline can be very important in determining the outcomes from the analysis. For example:

- If a scenario has a fixed emission target (e.g. 20% below 2005 levels) then the baseline determines the amount of work that must be done in the scenario to meet the target.
- If a scenario adds a fixed amount on to energy prices, then baseline energy prices determine the relative (percentage) impact of that increase.

It is therefore important to have a baseline that does not introduce bias into the scenario results. A common requirement of E3-India analysis is that the baseline is made to be consistent with official published forecasts. Since we do not have access to state-level economic and energy projections, the E3-India baseline is calibrated to national projections from the World Energy Outlook (IEA, 2015). State-level projections have been set to match.

Methodology for calibrating

The first stage in matching the E3-India projections to a published forecast is to process these figures into a suitable format. This means that the various dimensions of the model must be matched, including:

- geographical coverage (i.e. each state and territory)
- annual time periods
- sectoral coverage (including fuels and fuel users)
- National Accounts entries

CE uses the Ox software for carrying out this process, and saves the results on to the forecast databank, F.db1.

The next stage is to solve the model to match the results on the forecast databank. This is referred to as the ‘calibrated forecast’. In this forecast, the model solves its equations and compares differences in results to the figures that are saved on the databank. The model results are replaced with the databank values but, crucially, the differences are stored and saved to another databank, S.db1. These are referred to as ‘residuals’ although the meaning is slightly different to the definition used in econometric estimation.

Endogenous baseline and scenarios

The final stage is the ‘endogenous solution’ in which the model equations are solved but the residuals are added on to these results. In theory, the final outcome should be the same as for the calibrated forecast, although in practice there are calibration errors so it is not an exact match.

The key difference, however, is that inputs to the endogenous baseline may be changed in order to produce a different outcome (as opposed to the calibrated forecast where the model would still match databank values). The final outcome

is thus a baseline forecast that matches the published projections, but which can also be used for comparison with scenarios.

Operational example

Consider an example for the aggregate consumption equation. If in the first year of forecast, E3-India predicts a value of 100bn rupees, but the published forecast suggests 101bn rupees then the calibrated forecast will estimate a residual of 1.01 (i.e. 101/100).

If we then test a scenario in which consumption increases by 2% in this year, the model results will be 100bn rupees (endogenous baseline) and 102bn rupees (scenario). These will be adjusted (multiplied) by the residual to become 101bn rupees and 103.02bn rupees.

When these results are presented as percentage difference from base, the figure that is reported is still 2% (103.02/101), so the calibration does not affect directly the conclusions from the model results.

When are results influenced by calibration?

In this example, there is no impact on the results relative to baseline from the calibration exercise. This is typically true for any log-linear relationship within the model structure, as the calibration factors are cancelled out when calculating differences from base.

However, there are relationships in the model that are not log-linear, most commonly simple linear factors. These include the construction of energy prices but also identities for GDP and for (gross) output, and the calculation for unemployment (as labour supply minus demand).

For example, if the calibration results in higher trade ratios in a certain country, then the effects that trade impacts have on GDP will increase in the scenarios.

It is therefore important that the baseline provides a reasonable representation of reality, otherwise it is possible to introduce bias into the results.

2.5 Other model data inputs

In the current version of the model there are two additional text files that are used as inputs (asides from the instruction file, see Chapter 2). These are the assumptions file and the scenario file, both of which can be modified by the model user.

The reason for having these inputs as text files rather than databank entries is that it allows easy manipulation, including through the Manager software (see Section 1.2). No programming expertise is therefore required to make the changes.

Assumptions file

The assumptions file contains basic economic information that is necessary for any model run. It consists mainly of exogenous model variables that are set by the model user.

The nature of the Fortran read commands means that the structure of the assumptions text files is very rigid, for example with the right number of white spaces (not tabs) and decimal places required for each entry.

The assumptions files cover the period 2000 to 2050 although historical values will get overwritten by the data stored on the model databanks and the last year of the model is 2035.

Commodity prices

At the top of the assumption file is a set of global commodity prices, with a focus on the energy groups that are covered by the model classifications. The figures are annual growth rates, in percentage terms.

Other world economies

Also at the top of the assumption file there is a set of twelve other countries' GDP assumptions that form demand for Indian exports. The E3-India model assumes that rates of growth in the rest of the world are exogenous, matching the numbers in the assumptions file. The figures are annual growth rates, in percentage terms.

National and regional assumptions

This is followed by a set of assumptions that are specific to each state. They are:

- Market exchange rate (not used)
- Long-run interest rate (same as national rate)
- Short-run interest rate (same as national rate, only used for comparative purposes)
- Change in government final consumption, year on year
- % of government consumption spent on defence, education and health
- Standard VAT rate
- Aggregate rate of direct taxes
- Average indirect tax rates
- Ratio of benefits to wages (giving implicit rate)
- Employees' social security rate
- Employers' social security rate

Scenarios file

The scenario file contains a set of policy inputs that relate to basic model scenarios (see examples in Chapter 3). It can also be modified through the model Manager. Most of the policies in the scenario files are absent in the baseline. Policy inputs in the scenario file are categorised to three main groups: CO_2 emissions policies, energy policies and options to recycle the revenue generated from market-based instruments.

CO_2 emissions policies

The following CO_2 emissions policies are available in the scenarios file:

- annual CO_2 tax rate, rupees per tonne of carbon
- switches to include different energy users in the policies
- switches to include different fuel types in the policies

Energy policies

The following energy policies are available in the scenario file:

- annual energy tax rate, rupees per toe
- switches to include different users in policies
- switch to include different fuel types in policies
- households implied price of electricity subsidies

Revenue recycling options

The scenario file includes options to recycle automatically the revenues generated from carbon taxes and energy taxes (so that government balances

remain unchanged). There are three options in the scenario file for how the revenues are recycled:

- to lower employers' social security contributions, switch 0<X<1: 1=all, 0= none
- to lower income tax rates, switch 0<X<1: 1=all, 0=none
- to lower VAT rates, switch 0<X<1: 1=all, 0= none

These revenue recycling options do not differentiate sources of revenues. The model automatically sets the revenues to be recycled from the policies so that they are overall 'revenue neutral'. Specific values for offsetting tax reductions can be entered through the assumption file discussed above.

2.6 Model outputs

Overview

The model produces relatively few results automatically. It instead stores results internally so that they can be accessed separately. The separation of model solution, (1) writing the results year by year to a large file (the 'dump'), and then (2) accessing this file to generate time series of results, is necessary because of software constraints and the logic of the model.

Because of the scale of the solution, the model does not hold all the time series of each variable, but only the current and past values necessary for the current year's solution; this reduces the storage requirements dramatically (one year plus lags instead of up to 50 years of values). At the completion of each year's solution, the solved values of most variables are written to the dump where they may be later accessed.

Data analysis files

The files that access the model results are called data analysis files. They are instruction files that are run after the model has finished solving (see Chapter 2).

The file produced contains matrix output. These files are designed as inputs to further processing, for example by other programming languages, or interpretation by the model manager software. They appear in the output directory with a '.MRE' extension.

The data analysis files must start with a RESTART command with a year that matches the PUT ALL statement in the IDIOM instruction file (usually the first year of solution). A SELECT command then determines the output stream and format:

- SELECT OUTPUT 7 CARDS – MRE output

The syntax is then relatively straight forward. The VALUE command is followed by the variable name, start year and end year to give a table in time series format. The CHANGE command gives the equivalent output as annual growth rates. For variables with two dimensions (excluding time) it is necessary to say which column is required. So, for example, the command:

- VALUE CR(?:03) 2013 2020

would give a time series for household consumption in Assam (region 3) between 2013 and 2020. The following command will print out results for all states:

- VALA CR(?:01) 2013 2020

Other model outputs

The other model outputs are created for diagnostic purposes. A small text file (diagnostics.mre) is created automatically, which contains summary information about whether the model has solved and, if not, which equation caused the breakdown in solution. A longer 'verification' text file contains automatically generated outputs from the model, including warnings and possible non-convergences in the solution (see Section **Error! Reference source not found.**), which can be returned to Cambridge Econometrics to assist with problems in solution. The verification files are by convention given names that start with the letter Q and are stored in the verification folder in the output directory.

3 The E3-India Test Scenarios

3.1 Introduction

We provide a set of pre-loaded model input files that were used in testing the E3-India. Table 3.1 provides an overview.

Table 3.1: Overview of example scenarios

Run	Description	Instruction file	Assumptions file	Scenario file
Baseline	E3-India baseline	EnForecast	Assumptions	BaseScen
S1	Exogenous investment	EnTest1	Assumptions	BaseScen
S2	Income tax	EnForecast	Assump1	BaseScen
S3	Energy tax	EnForecast	Assumptions	Scen1
S4	Carbon tax	EnForecast	Assumptions	Scen2
S5	S4+ revenue recycling (employers' SSC)	EnForecast	Assumptions	Scen3
S6	S4+ revenue recycling (income tax)	EnForecast	Assumptions	Scen4
S7	S4+ revenue recycling (VAT)	EnForecast	Assumptions	Scen5
S8	Energy efficiency	EnTest4	Assumptions	BaseScen
S9	Feeds-in-Tariff	EnTest2	Assumptions	BaseScen
S10	Renewable subsidies	EnTest3	Assumptions	BaseScen
S11	Exogenous oil price	EnForecast	Assump2	BaseScen
S12	Removing Electricity Price Subsidies to households	EnForecast	Assumptions	Scen6

To run the scenarios, select the pre-loaded input files accordingly in the options in **Running the model** tab. Then give the output file names for each run (e.g. S1,S2,… S11,S12). Click the run model button.

Please refer to main E3-India -Testing Scenarios document for more information.

Note making use of text editors

The input files that appear in the E3-India Manager software are text files that can be edited outside the E3-India Manager software environment using any text editor software. This may be preferred if the input requirements are complex. Another useful tip is to use some text editor software to highlight the differences of the two input files.

However it must be noted that, if editing these files outside the Manager software, the model input.idiom files require text formatting to be exactly the same as the default file provided.

3.2 Test scenario 1: Investment

Scenario description

Exogenous investment in 18. Other business Services sector from 2016 onward (10% of existing investment)

Model inputs

Variable	Description	Unit	Input file
KRX(18,all)	Exogenous investment by sector and by region	2011 million rupees	EnTest1 (Idiom instruction file)

Scenario main impacts

Variable	Description	Impacts (compared to BAU)
RSK (KR*)	Investment	Increase
RSQ (QR*)	Industry output	Increase
REMP (YRE*)	Industry employment	Increase overall but some decrease (substitution effect between capital and labour)
RSX (QRX*)	Industry export	Increase (demand from other regions + technology impacts)
RSM (QRM*)	Industry import	Increase (demand for other region goods/services)
* denotes sectoral variable		

3.3 Test scenario 2: Income tax

Scenario description

Increase average income tax rate in region 1 Andhra Paresh from 23% to 30% from 2017 onward (note further income tax testing for all regions are included in another test scenario – using revenues from carbon tax to reduce income tax in all regions).

Model inputs

Variable	Description	Unit	Input file
RDTX (11 TAX_DIRECT)	Average direct income tax rate	% of wages and salaries	Assump1 (assumption file)

Scenario main impacts

Variable	Description	Impacts (compared to BAU)
RRPD	Gross real disposable income (i.e. income after tax)	Decrease
RSC	Consumer spending	Decrease
GDP	GDP	Decrease
REMP (YRE*)	Employment	Decrease
RSQ (QR*)	Industry output	Decrease (especially services sector which are highly related to consumer spending)
* denotes sectoral variable		

3.4 Test scenario 3: Energy tax

Scenario description

Tax of 400 rupees per tonne of oil equivalent to all energy users of all fuels.

Model inputs

Variable	Description	Unit	Input file
RTEA	Energy tax rate 2001-2035	Rupees/toe	Scen1 (scenario)
FEDS	Switch for fuel user coverage	1 = full coverage	Scen1 (scenario)
JEDS	Switch for fuel type coverage	1 = full coverage	Scen1 (scenario)

Scenario main impacts

Variable	Description	Impacts (compared to BAU)
RFU (FR0*)	Total fuel demand	Decrease
FRET*	Electricity demand	Decrease (substitution with other fuels)
FRCT*	Coal demand	Decrease (substitution with other fuels)
FROT*	Oil demand	Decrease (substitution with other fuels)
FRGT*	Gas demand	Decrease (substitution with other fuels)
RCO2 (FCO2)	CO2 emissions	Decrease
PRSC (PCR*)	Average consumer price index	Increase (due to tax)
RSC (CR*)	Consumer spending	Decrease (less disposable income)
RSX (QRX*)	Export	Mostly decrease (from higher energy price but relative to other states so there are competitiveness effects from internal trade)
RSM (QRM*)	Import	Mostly decrease from lowered domestic demand and imports of energy
RGDP	GDP	+/- depending on scale of import reduction (improvement to GDP)
* denotes sectoral variable		

3.5 Test scenario 4: Carbon tax

Scenario description

Tax of 400 rupees per tonne of carbon (note not CO_2) to all energy users of all fuels. Note assuming no revenue recycling. All revenues are used to reduce government deficit.

Model inputs

Variable	Description	Unit	Input file
RTCA	Carbon tax rate, 2001-2035	Rupees/tonne of carbon	Scen2 (scenario)
FEDS	Switch for fuel user coverage	1 = full coverage	Scen2 (scenario)
JEDS	Switch for fuel type coverage	1 = full coverage	Scen2 (scenario)

Scenario main impacts

Variable	Description	Impacts (compared to BAU)
RCO2 (FCO2)	CO2 emissions	Decrease
RFU (FR0*)	Total fuel demand	Decrease
FRET*	Electricity demand	+/- (substitution with other fuels)
FRCT*	Coal demand	Decrease (substitution with other fuels)
FROT*	Oil demand	Decrease (substitution with other fuels)
FRGT*	Gas demand	Decrease (substitution with other fuels e.g. coal to gas)
MJEF*	Fuels demand by PG	Fossil fuels decrease
MEWG*	Power sector generation by technologies	Fossil fuels decrease/ possibly small increase in renewable shares but not drastic due to small CO_2 tax
METC*	Localised costs of electricity as seen by investors by technologies (including carbon costs + policies)	Fossil fuels costs increase
PYH(9,all)*	Electricity price (sector 9)	Increase
PRSC (PCR*)	Average consumer price index	Increase (due to tax and higher electricity price)
RSC (CR*)	Consumer spending	Decrease (less disposable income)
RSX (QRX*)	Export	Mostly decrease (from higher energy price but relative to other states so there are competitiveness effects from internal trade)

RSM (QRM*)	Import	Mostly decrease from lowered domestic demand and imports of energy
RGDP	GDP	+/- depending on scale of import reduction (improvement to GDP)
* denotes sectoral variable		

Figure 3.1: The impact of the carbon/energy tax on prices and wage rates

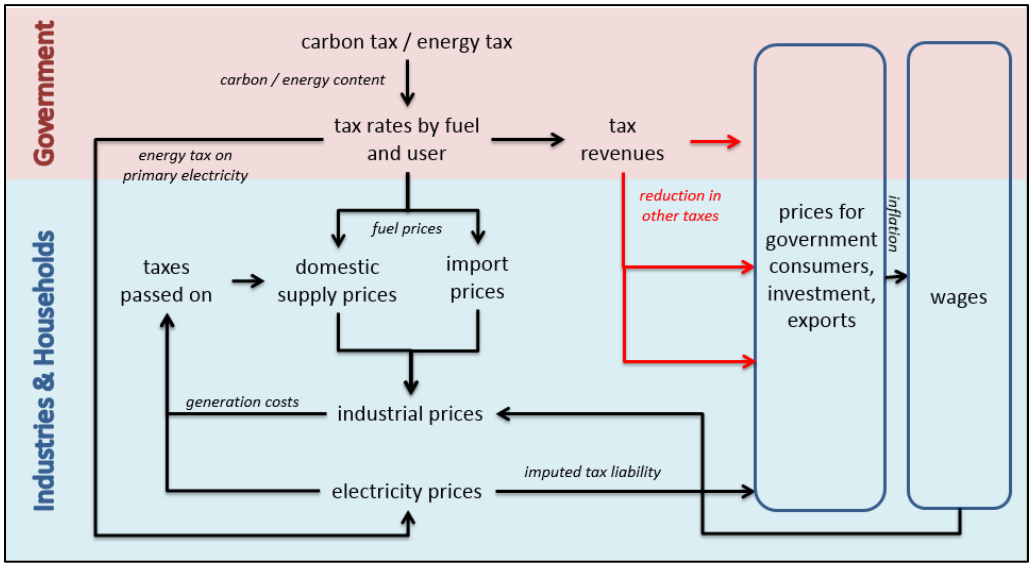
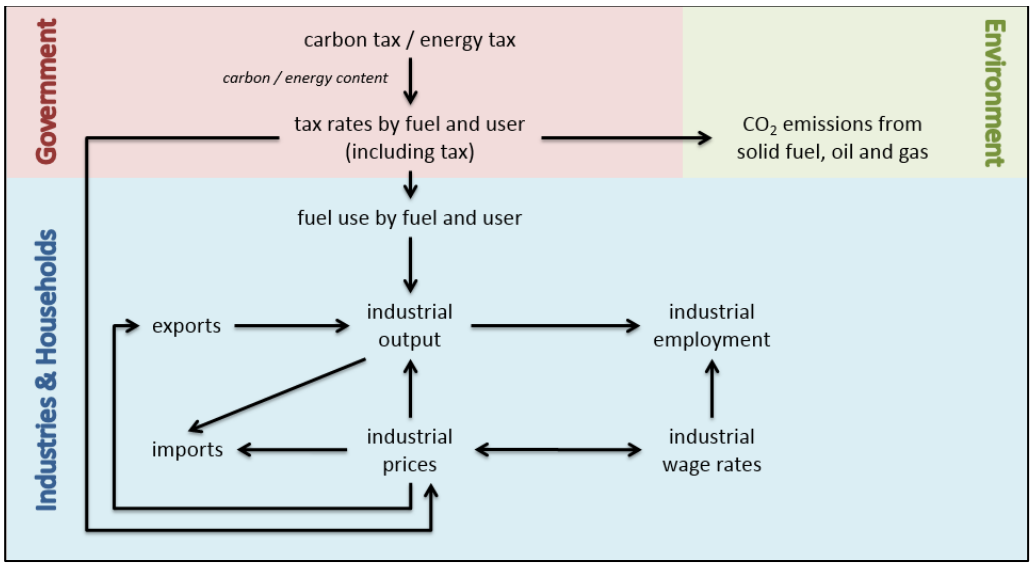


Figure 3.2: The impact of the carbon/energy tax on fuel use, CO_2 emissions and industrial employent



9.5 Test scenario 5: Carbon tax+revenue recycling (employers' social security contribution)

Scenario description

Same tax as previously (400 rupees per tonne of carbon) to all energy users of all fuels. All revenues from carbon tax used to reduce employers' social security contribution within the region.

Model inputs

Variable	Description	Unit	Input file
RTCA	Carbon tax rate, 2001-2035	Rupees/tonne of carbon	Scen3(scenario)
FEDS	Switch for fuel user coverage	1 = full coverage	Scen3 (scenario)
JEDS	Switch for fuel type coverage	1 = full coverage	Scen3 (scenario)
RRTE	Proportion of energy tax and carbon tax to reduce employers'SSC by	1 = 100%	Scen3 (scenario)

Scenario main impacts

In addition to the carbon tax scenario.

Variable	Description	Impacts (compared to the carbon tax with no revenue recycling scenario)
RCTT	Total revenues from carbon tax (m rupees)	Increase (tax rate x CO2 emissions)
RERR	Employers social security contribution rates	Decrease
REMP (YRE*)	Employment	Increase (direct impact from lowering labour costs to firms)
RGDP	GDP	Increase
RSC (CR*)	Consumer spending	Increase
RWS (YRWS*)	Total wages and salaries	Increase
RRDP	Real disposable income	Increase
PYH	Industry prices	Decrease (reduction in labour unit cost) but not all costs will pass through to final price
* denotes sectoral variable		

3.6 Test scenario 6: Carbon tax+revenue recycling (income tax)

Scenario description

Same tax as previously (400 rupees per tonne of carbon) to all energy users of all fuels. All revenues from carbon tax used to reduce direct tax (income tax) within the region.

Model inputs

Variable	Description	Unit	Input file
RTCA	Carbon tax rate, 2001-2035	Rupees/tonne of carbon	Scen4(scenario)
FEDS	Switch for fuel user coverage	1 = full coverage	Scen4 (scenario)
JEDS	Switch for fuel type coverage	1 = full coverage	Scen4 (scenario)
RRTR	Proportion of energy tax and carbon tax to reduce direct tax by	1 = 100%	Scen4 (scenario)

Scenario main impacts

In addition to the carbon tax scenario.

Variable	Description	Impacts (compared to the carbon tax with no revenue recycling scenario)
RCTT	Total revenues from carbon tax (m rupees)	Increase (tax rate x CO2 emissions)
RDTR	Direct tax rates	Decrease
RRDP	Real disposable income (income after tax)	Increase
RSC (CR*)	Consumer spending	Increase
RGDP	GDP	Increase
REMP (YRE*)	Employment	Increase (secondary impact from higher GDP)
* denotes sectoral variable		

3.7 Test scenario 7: Carbon tax+revenue recycling (VAT)

Scenario description

Same tax as previously (400 rupees per tonne of carbon) to all energy users of all fuels. All revenues from carbon tax used to reduce VAT within the region.

Model inputs

Variable	Description	Unit	Input file
RTCA	Carbon tax rate, 2001-2035	Rupees/tonne of carbon	Scen5(scenario)
FEDS	Switch for fuel user coverage	1 = full coverage	Scen5 (scenario)
JEDS	Switch for fuel type coverage	1 = full coverage	Scen5 (scenario)
RRVT	Proportion of energy tax and carbon tax to reduce VAT by	1 = 100%	Scen5 (scenario)

Scenario main impacts

In addition to the carbon tax scenario.

Variable	Description	Impacts (compared to the carbon tax with no revenue recycling scenario)
RCTT	Total revenues from carbon tax (m rupees)	Increase (tax rate x CO2 emissions)
RSVT	VAT rates	Decrease
PRSC (PCR*)	Consumer price index	Decrease
RSC (CR*)	Consumer spending	Increase
RGDP	GDP	Increase
REMP (YRE*)	Employment	Increase (secondary impact from higher GDP)
* denotes sectoral variable		

3.8 Test scenario 8: Energy efficiency (savings + investment)

Scenario description

10% energy savings in the use of coal by manufacturing sector in all regions. Manufacturing investment increase approximately $1m (60 m rupees) per 6,000 toe (source: estimated from IEA WEIO and WEO publications). Investment paid for by manufacturing (increase in cost to the sector).

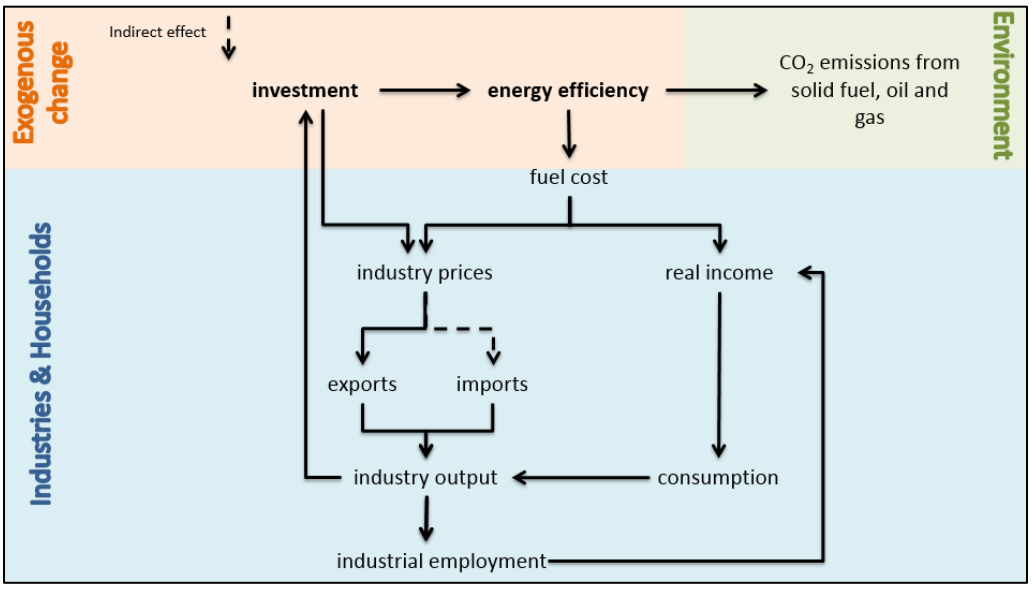
Model inputs

Variable	Description	Unit	Input file
FRCH(3,all)	Exogenous change in coal demand by manufacturing (fuel user 3)	Thousand TOE	EnTest4.idiom (IDIOM Instruction file)
KRX(8,all)	Exogenous change in investment by manufacturing sector (industry 8)	2011 m rupees	EnTest4.idiom (IDIOM Instruction file)
YRUX(8,all)	Exogenous increase in costs to manufacturing (get added to total unit cost)	Entered as m rupees and get converted to unit cost in model	EnTest4.idiom (IDIOM Instruction file)

Scenario main impacts

Variable	Description	Impacts (compared to BAU)
FRCT	Coal demand	Decrease
FR0	Total energy demand	Decrease
FCO2	CO2	Decrease
RSK (KR*)	Investment	Increase
RGDP	GDP	Increase
YRUC*	Unit costs of industry	Increase
PYH*	Industry price	Increase by less than costs
Other++		
* denotes sectoral variable		

Figure 3.3: The main economic interactions of energy efficiency



3.9 Test scenario 9: Feeds-in-tariff

Scenario description

Feed-in-tariff for renewables technologies in FTT-power: -110% difference between levelized costs and electricity price.
Technology included: Tidal (15), Large Hydro(16), Onshore(17) , Offshore(18), CSP(20) note Solar PV (19) already have FIT in the baseline.

Example

LCOE of solar is $140/MWh, Electricity price is around $50/MWh
FIT is (140-50) *-1.1 = - $99/MWh
Cost to investor become 140-99 = $41/MWh
making small profit ($50-$41 = $9/MWh).

Note that FIT rate of -110% doesn't make all technologies profitable depending on difference between costs and price of that technology

Model inputs

Variable	Description	Unit	Input file
MEFI	Feed-in-tariff by power technology by region	% difference between levelised cost and electricity price	EnTest2.idiom (IDIOM Instruction file)

Scenario main impacts

Variable	Description	Impacts (compared to BAU)
METC*	Localised costs of electricity as seen by investors by technologies (including carbon costs + policies)	Decrease in technologies with FIT
MEWK*	Power sector capacities by technologies by region	Renewable shares increase (but there will be substitution due to differences in final LCOE)
MEWG*	Power sector generations by technologies by region	Renewable shares increase (but there will be substitution due to differences in final LCOE)
MWIY	Power sector investment in new capacity	Renewable increase (but fossil fuels could decrease)
MJEP*/PFRE*	Price of energy/Price of electricity	Electricity price increase to pay for FIT
FRET*	Electricity demand	Reduce from higher electricity price

PRSC	Consumer price index	Increase from higher electricity price
RSC (CR*)	Consumer spending	Decrease
RSK (KR*)	Investment	Higher investment by electricity sector (feedback from FTT)
RGDP	GDP	+/- depending on scale of RSC and RSK impacts
Other++		
* denotes sectoral variable		

3.10 Test scenario 10: Renewable subsidies

Scenario description

Subsidies for renewables technologies in FTT-power: 50% of investment costs of technologies
Technology included: Tidal (15), Large Hydro(16), Onshore(17) , Offshore(18), Geothermal(21)

Note(s): we assumed government paid for the subsidies but not raise taxes in response (i.e. through bigger budget deficit). This assumption can easily be change to achieve revenue neutrality.

Model inputs

Variable	Description	Unit	Input file
MEWT	FTT subsidies by power technology by region	% of investment cost of technology	EnTest3.idiom (IDIOM Instruction file)

Scenario main impacts

Variable	Description	Impacts (compared to BAU)
METC*	Localised costs of electricity as seen by investors by technologies (including carbon costs + policies)	Decrease in technologies with subsidies
MEWK*	Power sector capacities by technologies by region	Renewable shares increase (but there will be substitution due to differences in final LCOE)
MEWG*	Power sector generations by technologies by region	Renewable shares increase (but there will be substitution due to differences in final LCOE)
MWIY	Power sector investment in new capacity	Renewable increase (but fossil fuels could decrease)
MJEP*/ PFRE*	Price of energy /Price of electricity	Electricity price decrease because of subsidies
FRET*	Electricity demand	Higher from lower electricity price
PRSC (PCR*)	Consumer price index	Decrease from lower electricity price (although average could be positive due to higher economic activity)
RSC (CR*)	Consumer spending	Increase
RSK (KR*)	Investment	Higher investment by electricity sector (feedback from FTT)
RGDP	GDP	Increase from investment and possibly lower price

		(but could be negative once we start changing assumption about revenue neutrality)
* denotes sectoral variable		

3.11 Test scenario 11: Exogenous oil price

Scenario description

Increase exogenous global oil price assumption – instead of growing at 3% pa between 2016-2020 let assume it is growing at 4% pa instead.
Note(s): Global energy price assumptions are in pa growth rate and derived from the latest IEA World Energy Outlook publication (current policies scenario).

Model inputs

Variable	Description	Unit	Input file
PMF (CPRICE_BRENT_OIL)	Price of import groups in $ (2005 =1.00)	Index	Assump2.idiom (assumption file)

Scenario main impacts

Variable	Description	Impacts (compared to BAU)
PFRO*	Oil price by fuel users	Increase from higher Brent oil price assumption
PFR0*	Average price of energy by users	Increase as oil price increases
RFU (FR0*)	Total fuel demand	Decrease
FROT*	Oil demand	Decrease
RCO2 (FCO2*)	CO2 emissions	Decrease
RGDP	GDP	Increase or decrease depending on which impacts are larger – reduction in oil imports or impacts from higher price on consumption
RSM (QRM)	Imports	Oil import decrease
RSC (CR)	Consumer spending	Decrease due to higher price lead to reduction in real disposable income
* denotes sectoral variable		

3.12 Test scenario 12: Removing Electricity Price Subsidies to households

Scenario description

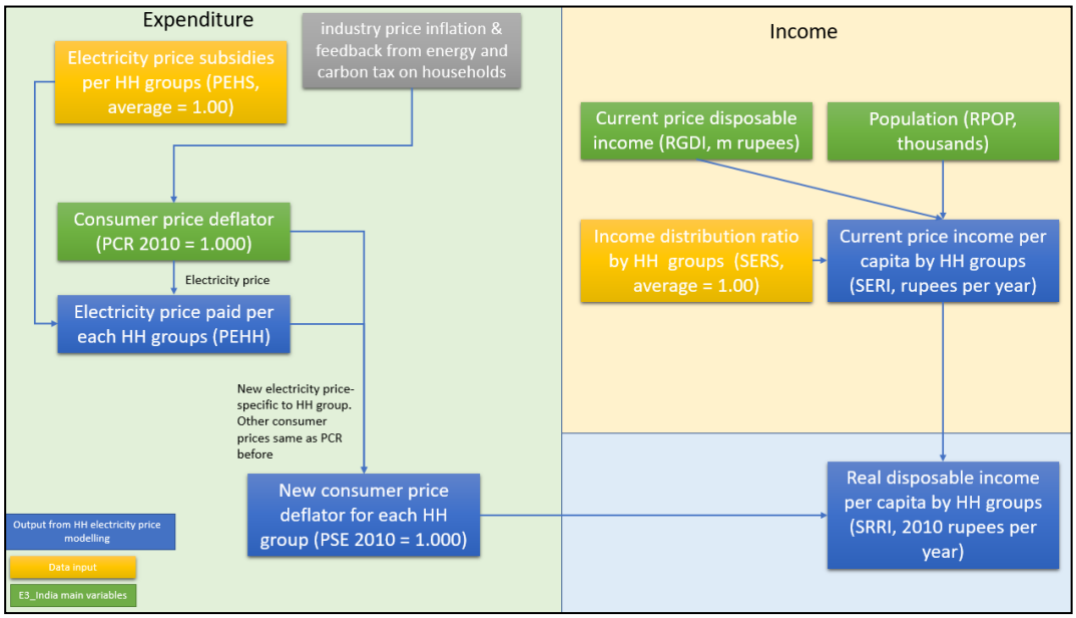
Removing electricity price subsidies for each State to look at impacts on various types of households.

Note- subsidy is treated as negative tax in E3_India so a scenario to remove electricity subsidies implies a positive electricity tax on household's consumption of electricity.

The E3_India's energy users' classification is

- 1 Power generation
- 2 Other transformation
- 3 Manufacturing
- 4 Transport
- 5 Households
- 6 Services
- 7 Agriculture
- 8 Non-energy used

For electricity use, the model includes modelling of electricity price subsidies to different household types. This provides results on household's income distribution from changes in electricity taxation and subsidies. The figure below demonstrates how income distributions, measured by changes in real disposable income by household groups, are affected from changes in electricity prices.



It should be noted that due to lack of time series data, the model doesn't include price-elasticity of electricity demand for each group types of households. Users need to work out the equivalent average electricity price increase for the whole households group and use these values as electricity tax on the household groups. The variable PEHS[2], electricity price subsidies by households, enables

[2] Baseline PEHS is estimated from a) electricity price per consumption unit by state https://www.bijlibachao.com/news/domestic-electricity-lt-tariff-slabs-and-rates-for-all-states-in-india-in-

users to adjust the subsidy rates to provide distributional impacts (no feedback to the rest of the model).

Model inputs

Variable	Description	Unit	Input file
RTEA	Energy tax rate 2001-2035 (5000 rupees/toe)	Rupees/toe	Scen6 (scenario)
FEDS	Switch for fuel user coverage (only households)	1 = full coverage	Scen6 (scenario)
JEDS	Switch for fuel type coverage (only electricity)	1 = full coverage	Scen6 (scenario)
PESH	Households implied price of electricity subsidies (removed all subsidies in the baseline – set to 1 for all groups)	1.00 = no subsidies, 0.8 = 20% subsidies	Scen6 (scenario)

Scenario main impacts

Variable	Description	Impacts (compared to BAU)
FRET*	Electricity demand from households	Decrease
RFU (FR0*)	Total fuel demand	Decrease or there might be substitution between fuels
PRSC (PCR*)	Average consumer price index	Increase (due to electricity tax)
RSC (CR*)	Consumer spending	Decrease (less disposable income)
RGDP	GDP	Small decrease from reduction in consumer demand
SRRI*	Real disposable income by households	Household groups that are more vulnerable (e.g. low income) are worse off than other groups
* denotes sectoral variable		

2016.html and b) household electricity consumption by states, quintiles and rural/urban https://openknowledge.worldbank.org/bitstream/handle/10986/20538/926480PUB0978100Box385381B00PUBLIC0.pdf?sequence=1&isAllowed=y

Appendix A Model Assumption and Scenario Inputs

Appendix B Model Classifications

E3-India Classifications

Regions

1 Andhra Pradesh (AD)
2 Arunachal Pradesh (AR)
3 Assam (AS)
4 Bihar (BR)
5 Chhattisgarh (CG)
6 Gujarat (GJ)
7 Haryana (HR)
8 Himachal Pradesh (HP)
9 Goa (GA)
10 Jammu & Kashmir (JK)
11 Jharkhand (JH)
12 Karnataka (KA)
13 Kerala (KL)
14 Madhya Pradesh (MP)
15 Maharashtra (MH)
16 Manipur (MN)
17 Meghalaya (ML)
18 Mizoram (MZ)
19 Nagaland (NL)
20 Odisha (OD)
21 Punjab (PB)
22 Rajasthan (RJ)
23 Sikkim (SK)
24 Tamil Nadu (TN)
25 Tripura (TR)
26 Uttar Pradesh (UP)
27 Uttarakhand (UK)
28 West Bengal (WB)
29 Andaman & Nicobar (AN)
30 Chandigarh (CH)
31 Delhi (DL)
32 Pondicherry (PY)

Sectors

1 Agriculture etc
2 Forestry
3 Coal
4 Oil & Gas etc
5 Other Mining
6 Food, Drink & Tobacco
7 Textiles & Clothing
8 Leather
9 Wood
10 Paper, Print. & Pub.
11 Manuf. Fuels
12 Pharmaceuticals
13 Chemicals
14 Rubber & Plastics
15 Non-Met. Min. Prods.
16 Basic Metals
17 Metal Goods
18 Electronics
19 Electrical Engineer & Inst
20 Motor Vehicles
21 Other Transport Equip.
22 Other Manufacturing
23 Electricity Supply
24 Gas Supply
25 Water Supply
26 Construction
27 Trade and logistics
28 Hotels & Catering
29 Land Transport etc
30 Water Transport
31 Air Transport
32 Communications
33 Banking & insurance
34 Other Business Services
35 Public Admin. & Defence
36 Education
37 Health & Social Work
38 Misc. Services
39 Unallocated

Fuels

1 Coal
2 Oil
3 Natural Gas
4 Electricity
5 Biomass

Power sector Technologies

1 Nuclear
2 Oil
3 Coal
4 Coal + CCS
5 IGCC
6 IGCC + CCS
7 CCGT
8 CCGT + CCS
9 Solid Biomass
10 S Biomass CCS
11 BIGCC
12 BIGCC + CCS
13 Biogas
14 Biogas + CCS
15 Tidal
16 Large Hydro
17 Onshore
18 Offshore
19 Solar PV
20 CSP
21 Geothermal
22 Wave
23 Fuel Cells
24 CHP

Fuel Users

1 Power own use & trans.
2 Other energy own use & transformation
3 Basic metal
4 Metal goods
5 Chemicals
6 Non-metallic minerals
7 Food, drink & tobacco
8 Textile, leather & clothing
9 Rubber and plastics
10 Paper & publishing
11 Engineering etc
12 Other industry
13 Construction
14 Rail transport
15 Road transport
16 Air transport
17 Water transport
18 Households
19 Services
20 Agriculture & fishing
21 Non-energy use

E3-India Classifications

Consumers' Expenditure

1 Food
2 Drink
3 Tobacco
4 Clothing etc.
5 Rent
6 Water etc.
7 Electricity
8 Gas
9 Liquid fuels
10 Other fuels
11 Durable goods
12 Other consumables
13 Medical
14 Transport services
15 Other services
16 Recreational
17 Unallocated

Government sectors

1 Defence
2 Education
3 Health
4 Other
5 Unallocated

Labour Groups

1 Male 15-19
2 Male 20-24
3 Male 25-29
4 Male 30-34
5 Male 35-39
6 Male 40-44
7 Male 44-49
8 Male 50-54
9 Male 55-59
10 Male 60-64
11 Male 65+
12 Female 15-19
13 Female 20-24
14 Female 25-29
15 Female 30-34
16 Female 35-39
17 Female 40-44
18 Female 45-49
19 Female 50-54
20 Female 55-59
21 Female 60-64
22 Female 65+
23 Total 15-19
24 Total 20-24
25 Total 25-29
26 Total 30-34
27 Total 35-39
28 Total 40-44
29 Total 45-49
30 Total 50-54
31 Total 55-59
32 Total 60-64
33 Total 65+

Population groups

1 Male Children
2 Male 15-19
3 Male 20-24
4 Male 25-29
5 Male 30-34
6 Male 35-39
7 Male 40-44
8 Male 44-49
9 Male 50-54
10 Male 55-59
11 Male 60-64
12 Male OAPs
13 Female Children
14 Female 15-19
15 Female 20-24
16 Female 25-29
17 Female 30-34
18 Female 35-39
19 Female 40-44
20 Female 45-49
21 Female 50-54
22 Female 55-59
23 Female 60-64
24 Female OAPs

B.1 Assumption file

In the assumptions file there are two types of inputs, commodity prices and GDP in other parts of the world. Both are expressed as annual growth rates. The categories are:

- 02 CPRICE_FOOD_FEED – prices for food and animal feed
- 03 CPRICE_WOOD – prices for wood as a raw material
- 04 CPRICE_CONS_MIN – prices for aggregates and other construction minerals
- 05 CPRICE_IND_MIN – prices for minerals used for industrial purposes
- 06 CPRICE_FER_ORES – prices for ferrous ores
- 07 CPRICE_NFER_ORES – prices for non-ferrous ores
- 08 CPRICE_COAL – coal prices
- 09 CPRICE_BRENT_OIL – oil prices
- 10 CPRICE_GAS – natural gas prices
- 11 CPRICE_OTHERS – prices for other commodities

The countries for which GDP growth can be adjusted are India's main trading partners. Other countries are included in the final rest of world category.

B.2 Scenario file

The inputs in the scenarios file are:

Input	Units	Dimensions	Definition
RTEA	Rup/toe	State x Year	Energy tax levied on energy consumption
RTCA	Rup/tC	State x Year	Carbon tax levied on CO2 emissions
FEDS	Share	Fuel User x State	Exemptions from RTCA and RTEA, 0 = exempt
JEDS	Share	Fuel x State	Exemptions from RTCA and RTEA, 0 = exempt
RRTE	%	State x Year	Carbon/energy tax revenues used to reduce employers' social contributions
RRTR	%	State x Year	Carbon/energy tax revenues used to reduce income taxes
RRVT	%	State x Year	Carbon/energy tax revenues used to reduce VAT
PESH	Share	Income Group x State	Implied subsidies to each group (1 = none)

Other inputs (through the instructions files)

Additional flexibility is added when using the instructions files. Some of the most commonly used inputs here are shown below.

- FRCH (fuel user by state) – exogenous reduction in coal consumption, in thousands of tonnes of oil equivalent.
- FROH, FRGH, FREH – exogenous reductions in oil, gas and electricity consumptions (same dimensions and units).
- KRX (sector by state) – exogenous increase in investment, millions of rupees at 2011 prices.

Almost all the variables in E3-India can be shocked exogenously. For further information on this please contact the modelling team.