iGrid Project 4 -
Institutional Barriers, Economic Modelling and Stakeholder Engagement

D-CODE User Manual

Supplements the D-CODE model released in December 2011.

Chris Cooper

Institute for Sustainable Futures

D-CODE enquiries:

chris.cooper@uts.edu.au

+61 2 9514 4946

Contents

1 Access and compatibility

To promote maximum accessibility, the D-CODE model has been formulated to run on Microsoft Office Excel®. It is currently available for free download from the Intelligent Grid website, http://www.igrid.net.au.

To use the model, the user will require Microsoft Excel 2007 or later. The model is not compatible with Microsoft Excel for Apple systems.

Before running the user must:

Enable macros - Go to the Microsoft dropdown menu; click 'Excel options' then 'Popular'. Check the 'Show Developer tab in the ribbon' box. At the developer tab, open 'Macro security' and click 'enable all macros'.

Install the Solver add-in: The Solver Add-in must be installed to enable the running of the Optimal Mix Analysis. To install, go to the Microsoft dropdown menu and click 'Excel options' then 'Add-ins'. Select the Solver add-in from the list, the click 'Go' to install. To ensure it has been properly installed, make sure 'Solver' button features in the 'Data' tab in the ribbon

2 Setting up the model

Both the cost curve generator and the OMA can be processed simultaneously as they both draw from the same input data and assumptions. Below is the flow of tabs the user must follow to set up and run the model.

Flow of input spreadsheets:

⇒ **Control Panel** - Select model parameters and create a scenario

⇒ **Select technologies** – Choose technologies and demand reduction opportunities to feature

⇒ **Input datasheet –** review and adjust input data for each technology. Here the user can review the original source and methodology used to formulate each piece of input data

⇒ **Run model**–click 'run model' to iterate

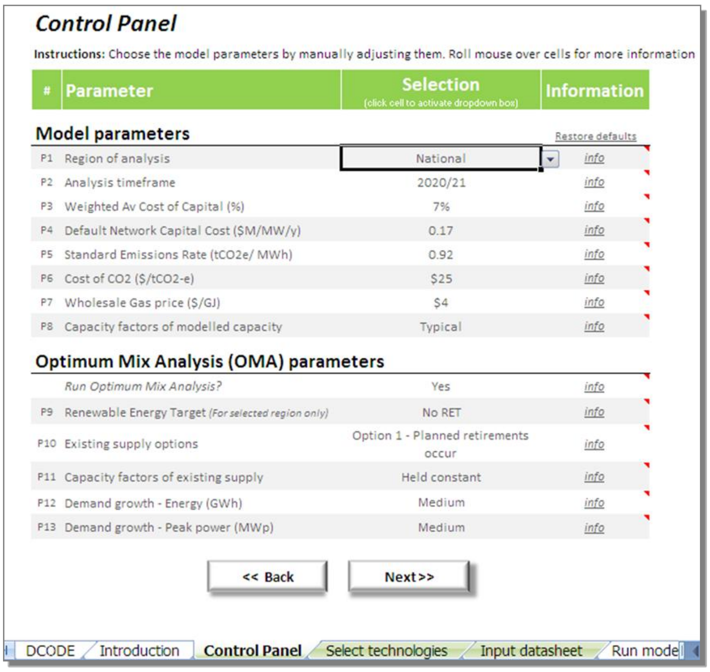
The input data for the model is contained within two sheets in the model, the 'Control Panel' worksheet and the 'Input Datasheet' worksheet.

2.1 The Control Panel tab

The ‘Control Panel’ tab is where the user enters the market-wide model parameters. **Error! Reference source not found.** below shows a screenshot of the ‘Control Panel’. The user can select the parameters by either drop-down box selection or by overriding the default data built into the model. Full explanations of each parameter can be viewed by scrolling the cursor over ‘info’. In addition, the definition and role of each parameter is summarised in Section 8.

Note that P10 through to P14 are parameters specific to the optimal mix analysis and are hidden if the user chooses not to run the OMA from the dropdown box in P9.

Figure 1 - Screenshot of Control Panel tab



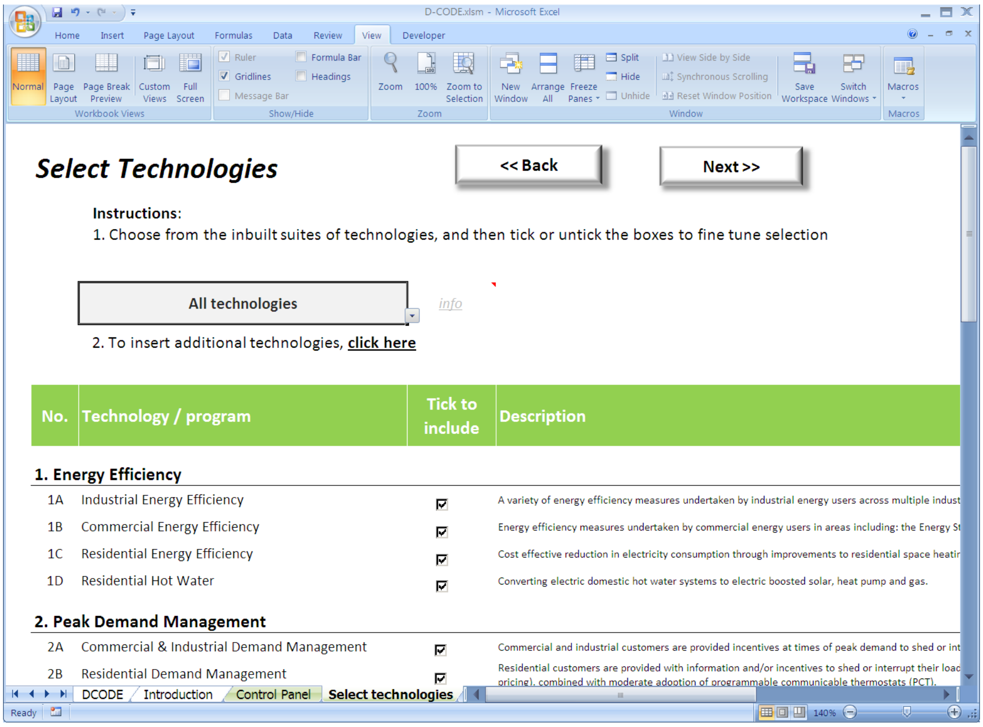
2.2 Select technologies tab

Here the user can select the technologies to be included in the analysis. Data for 33 technologies are already included within the model.

2.2.1 Selecting technologies

Using the grey dropdown box, the user can select a suite of technologies grouped by categories, and/or can then check or uncheck the boxes to include or exclude technologies.

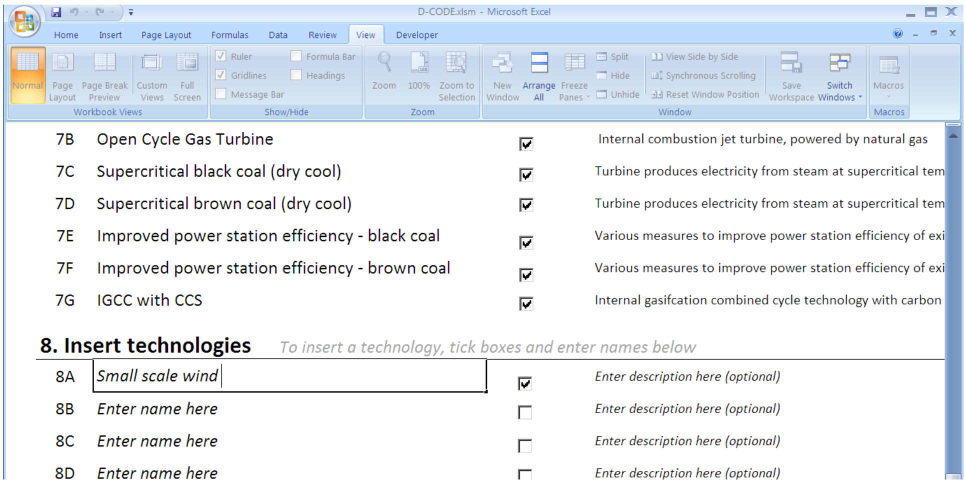
Figure 2 - the Select Technologies tab in D-CODE



2.2.2 Entering additional technologies

To add additional technologies, scroll down to '8. Insert Technologies', tick the box and enter the technology name as shown in Figure 3. Up to nine additional technologies can be entered.

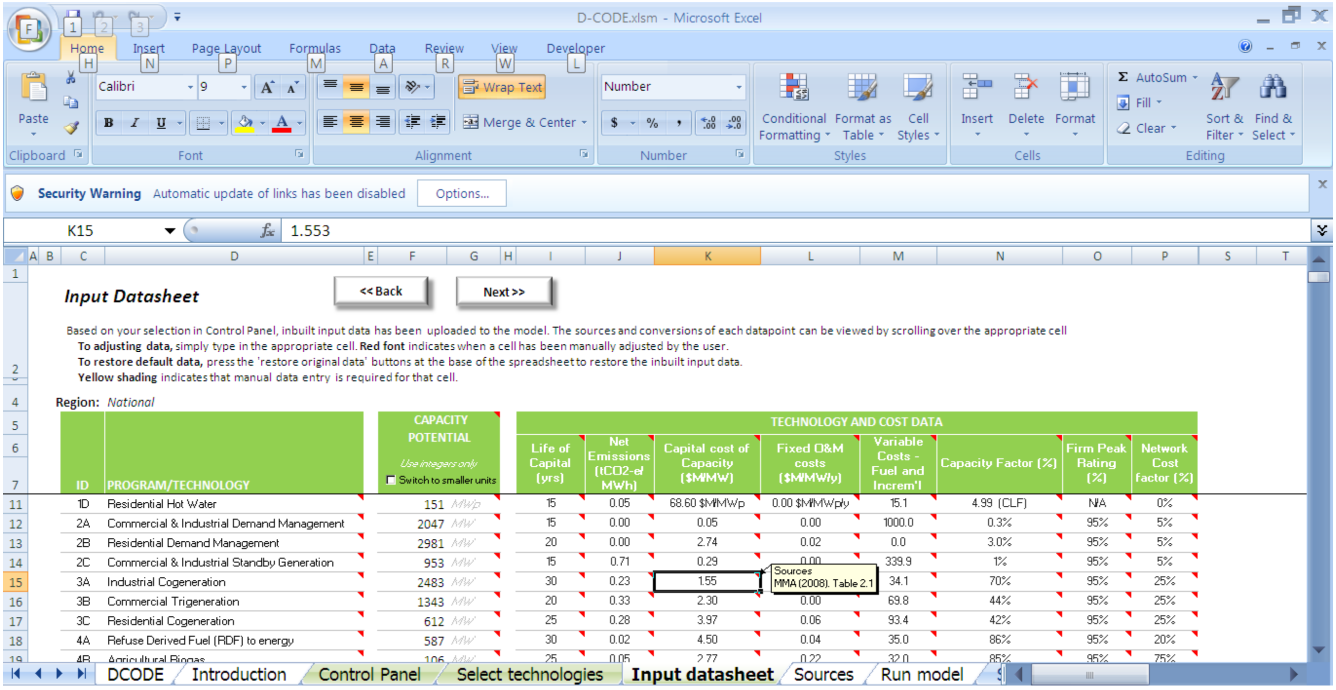
Figure 3 - Inserting additional technologies



2.3 Input datasheet tab

The 'Input Datasheet' contains all of the technology specific input data used to generate cost curves and run the Optimal Mix Analysis. A screenshot of the Input Datasheet is contained in Figure 4 below.

Figure 4 – The input datasheet tab



2.3.1 Viewing the input variable definition

Roll the cursor over the variable name at the top of the column to see the variable definition

2.3.2 Viewing the data source and conversion notes

Roll the cursor over the relevant cell to see the data source (the data compendium also contains full data reference).

2.3.3 Adjusting the input data

Simply click on the cell and enter the preferred data. To remind you of the changes you have made to the defaults, the data becomes red if changed.

2.3.4 Restoring the default data

To restore the default data (and hence override any adjustments you have made) simply click either the 'restore inbuilt capacity potential data' (restores that column only) or 'restore inbuilt technology and cost data' (restores all columns except capacity potential) hyperlinks at the bottom of the input datasheet.

2.3.5 Entering data for additional technologies

If additional technologies were specified in the 'Select Technologies' tab, the user must enter appropriate input data for that technology. Scroll to the base of the 'Input datasheet' page, and enter data in the relevant row for the additional technology. The cells requiring manual data entry will be highlighted yellow and contain the text "ENTER DATA". All data must be entered to ensure the technology features in the D-CODE outputs.

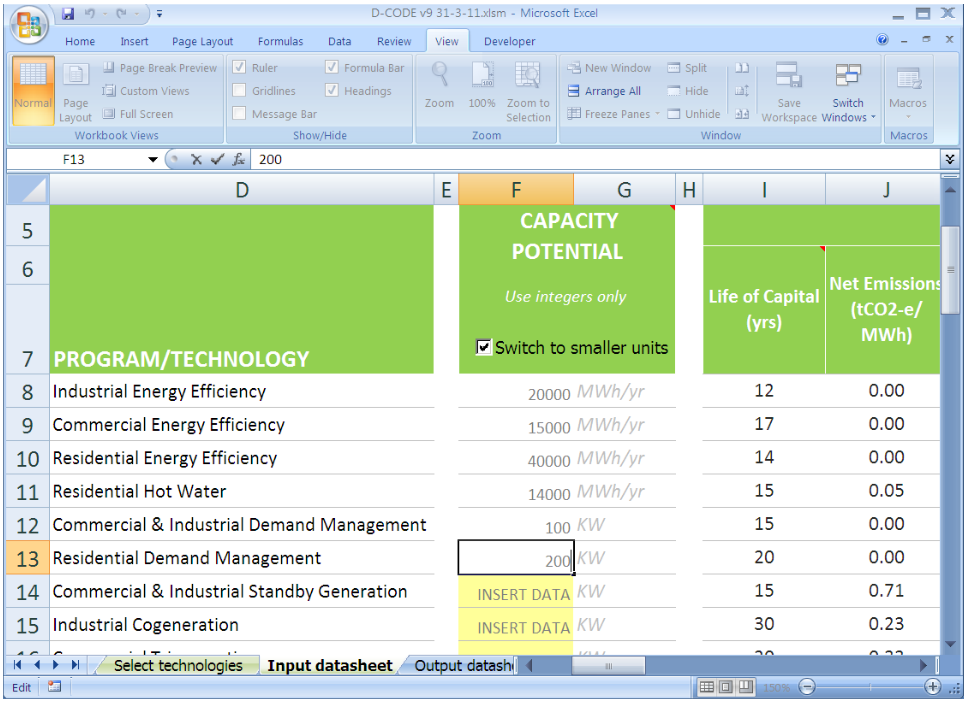
2.3.6 Custom region selection

If the Region of Analysis ('Control Panel', P1) is selected as 'Custom', the user must manually enter the capacity potential of each technology within the 'Input datasheet'. The cells requiring manual data entry will be highlighted yellow and contain the text “ENTER DATA” as displayed in Figure 5 below.

If the custom region in question is relatively small compared to the inbuilt jurisdictions, then it may be necessary for the model user switch to smaller units when entering the capacity development potential, by checking the box in the capacity potential column as shown in Figure 5. The units will changes from MW to kW, and MWp to MWh for energy efficiency measures.[1]

Note: D-CODE does not run the Optimal Mix Analysis if custom scale is selected, due to excessive manual data requirements.

Figure 5 - Switching to smaller unit when entering a custom region



3 Running the model

Once the inputs have been finalised, the model is ready to run. At the ‘Run Model’ spreadsheet, simply click the Run Model button.

If you have selected to run the OMA analysis, you will receive two notification boxes that should tell you that ‘Solver found a solution’, to which you should click ‘keep Solver Solution’ and then OK.

If the model fails to properly run, refer to Troubleshooting at the end of the manual.

[1] Energy saved per year is a more at-hand data measure for smaller scale energy efficiency compared

4 Viewing the outputs

Once the model has successfully run, you can browse through the outputs by clicking the Next and Back buttons.

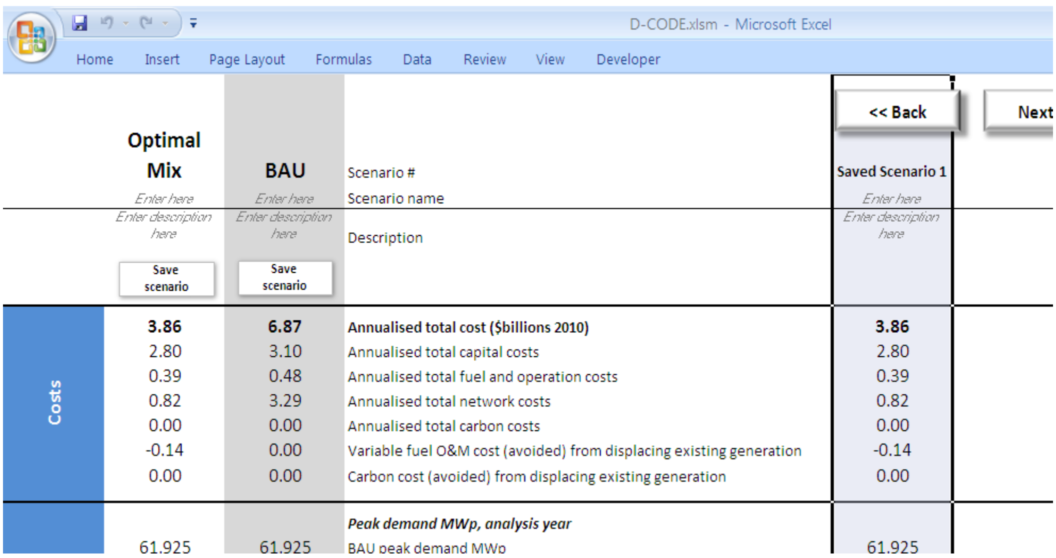
Flow of output spreadsheets:

- ⇒ **Scenario Output data**- full numerical output of OMA and BAU cases. Includes model performance parameters. Allows scenario saving.
- ⇒ **Costs - OMA v BAU** – graphical cost comparison of optimal mix v BAU case
- ⇒ **Emissions - OMA v BAU –** graphical emissions comparison of optimal mix v BAU case
- ⇒ **Optimal mix technologies –** graphical analysis of deployed optimal mix technologies
- ⇒ **BAU technologies -** graphical analysis of deployed BAU technologies
- ⇒ **Output calculations** – complete calculations of each output variable and technology
- ⇒ **Cost curves** – Graphical representation of levelised cost curves

5 Saving scenarios

To save a scenario, simply click the "Save scenario" button at the top of the relevant column within the 'Scenario output data' spreadsheet. The scenario will automatically paste itself on the right hand side as displayed in Figure 6 below. The user can then change the name so to recognise the saved scenario. All input parameters and output data are included in the column to enable complete analysis. To save any of the graphical outputs, the user must manually copy and paste the graph (pasting as picture) within a separate worksheet.

Figure 6 – Saving a scenario



6 Troubleshooting

The D-CODE is still very much a new working model. If you experience any difficulties with the model, or have any suggested improvements, please email the author to enable the model and this document to be updated. Some identified issues are troubleshot below.

1. **Message box "There are insufficient resources to run the Optimal mix/BAU model..." appear on running D-CODE.**

   The message box will specify which constraint has insufficient resource. This can be resolved by increasing the number of technologies included in the model (if they are restricted) or increasing the of capacity potential of certain technologies with the first data column in the Input datasheet.

2. **The VBA dialogue box opens and the model fails to run.**
   Ensure that all macros are enabled and Solver add-in is properly installed. Stop the VBA debugger and attempt to run the model again.

3. **Outputs do not seem to change when modelling different parameters.**

   If the outputs are clearly not responding to changes in the model constraints it may be that Solver has uninstalled itself. Reinstall the Solver add-in and try running the model again.

4. **Default formula is overridden in the Control Panel.**
   Download D-CODE again and cut and paste the original formulas back into the cells. Alternatively, simply use the re-downloaded model.

5. **A certain technology does not feature in the cost curves.**
   For graph formatting purposes, D-CODE cost curves include formatting thresholds which may lead to certain technologies being omitted based on up to two factors:
   a. Insufficient capacity (the width is too small for clear graphical display)
   b. Too high cost (the cost is too high for clear graphical display)

   If a) is the reason for the exclusion, try increasing the capacity potential of the technology within the input datasheet.

   Common examples of b) include peaking technologies (i.e. open cycle gas) which have a very high $/MWh cost (but a low $M/MWp cost) and therefore often do not feature on the energy cost curves, or energy generators with a low firm peak rating (i.e. wind) which have a very high $M/MWp cost and therefore often do no feature on the peak power cost curves. Such exclusions are expected and are not necessary a bad thing. Other technologies may simply be too expensive for both curves.

7 D-CODE files

The D-CODE model is available at www.igrid.net.au

D-CODE Working Paper 4.3, which explains the rationale and outputs of the model, is available at www.igrid.net.au and is downloadable with the D-CODE model.

D-CODE Data Compendium, downloadable with the D-CODE model.

8 Glossary

The tables below provide a definition of each parameter and input data contained in the model. The first two tables represent each data from the input spreadsheets and the third table explains the function of each of the hidden spreadsheets within the model.

Table 1 – Glossary of parameters from the 'Control Panel' spreadsheet in D-CODE (in order of display)

#	Parameter	Selection options • ***Indicates dropdown Selection***	Explanation
P1	**Region of analysis**	• National • NEM • NSW (inc. ACT) • Victoria • Queensland • South Australia • Tasmania • Western Australia • Northern Territory • Custom	User selects the region of analysis. The model data is updated to reflect how much capacity of each technology/program could reasonably be installed in each region over the specified time frame. **Note:** a) If 'custom' is selected the user must be prepared to enter capacity development potential data for each selected technology over the specified time period. b) The OMA feature is disabled if 'custom' is selected, as manual data requirements are too cumbersome.
P2	**Analysis year**	• Any year between 2012/13 and 2020/21	User selects the year of analysis. D-CODE models future energy supply from the year 2010/11 up until the year selected by the user in this category. The selected year will determine the calculation of capacity development potential of each technology or program in the cost curve analysis, as well as the scale of the energy constraints (i.e. the capacity shortfall) that must be met, based on plant retirements.
P3	**Weighted Average Cost of Capital (WACC)**	Default provided, user can override.	The WACC is the expected rate of return on capital, used to determine cost of using capital/money at an earlier rather than later point in time (%). This is used to annualise the fixed capital and network costs in order to compare technologies of different life spans.
P4	**Default Network Capital Cost ($M/MW/y)**	Automatically generated based on the region selected. User can override.	Default network cost is the average business as usual cost to deliver centralised energy supply based on figures updated from Langham et al. (2010, Table 35). It is based on the average per megawatt (MW) transmission and distribution costs of upgrading and maintaining capacity in the electricity network to meet additional demand (See D-CODE Working Paper Section for more information)
P5	**Standard Emissions Rate (tCO2e/MWh)**	Automatically generated based on the region	The average expected GHG emissions rate for producing one unit of energy in the modelled market in 2010. These emissions include only Scope 2 emissions i.e. does not

		selected. User can override.	include emissions from fuel extraction, transmission and distribution. (DCCEE, 2010, National Greenhouse Accounts Factors)
P6	**Cost of CO2 ($/tCO2-e)**	Default of $23 provided, user can override.	The expected cost for emitting one metric tonne of CO2-e ('carbon dioxide equivalent'), the international accepted form for comparing greenhouse gases, through either a carbon tax or emissions trading scheme
P7	**Wholesale Gas price ($/GJ)**	• $4 • $6 • $8	Select the wholesale gas price to best suit your region or to test the sensitivity of different gas prices on costs of gas fuelled supply options. (AUD$2010).
P8	**Capacity factors of modelled generation mix**	• Typical • Maximum	The user can select the capacity factors of the newly installed technologies. By choosing 'typical' the typical (average) expected capacity factor for each technology will be used in model calculations. By choosing 'maximum', the maximum capacity factor for each technology will be used in the model. **Note**: capacity factors, along with other cost data, can be manually adjusted for each technology at the 'Input datasheet'.
	Run OMA?	• Yes • No	Select 'yes' to runOMA and display the parameters P10 to P14 (which relate solely to the OMA model). Selecting 'no' will only display the cost curves in the outputs section. **Note**: If 'Custom' is selected as the region in P1, this will automatically set to 'no' as D-CODE does not feature the OMA for custom regions due to excessive manual data requirements.
	Renewable Energy Target *(OMA only)*	• No RET • 10% • 20% • 30%	**For states:** the selected target will force x% of total system generation in the selected region to come from renewable energy generation in the analysis year. **For national and NEM:** the RET is based on the actual incremental targets set by the Office of the Renewable Energy Regulator (ORER 2011) and outlined in the data compendium. In these instances the x % target selected is the target for year 2020/21; the RET for earlier years (as specified in P2) is based on the incremental targets. As the actual incremental targets are based on a 20% by 2020 RET, D-CODE weights the incremental target accordingly if 10% or 30% is selected.
	Existing supply retirements *(OMA only)*	• Option 1 – Planned retirements occur • Option 2 – Coal plants retire after 40 years operation • Option 3 – Coal plant retire after 30 years operation	Select from the various coal retirement option options. D-CODE uses plant level data to calculate the impact of different coal-generator retirement policies on the energy shortfall at the specified year. The greater the plant retirements, the greater the capacity shortfall and hence more capacity will be included in the OMA. *Option 1 – Planned retirements occur* (as specified in the AEMO Statement of Opportunities, 2010) *Option 2 – Coal plants retire after 40 years operation.* Plant age data obtained from ESAA (2010). *Option 3 – Coal plants retire after 30 years operation* (accelerated retirement). Plant age data obtained from ESAA (2010).
	Capacity factors of existing supply *(OMA only)*	• Held constant • Ramped up in response to energy demand growth (where	The existing supply may have the ability to increase annual energy supply by generating at a higher capacity factor. The user can choose whether to: *Hold capacity factors constant* or *Increase capacity factors in response to increasing energy demand growth (where possible).*

		possible)	
	Demand growth - Energy (GWh) *(OMA only)*	• High • Medium • Low	The demand projections for each region are based on AEMO Statement of Opportunities (2010) demand projection at 10% probability of exceedance. They are based on population and economic growth forecasts, the introduction of carbon pricing in 2013/14, business-as-usual energy efficiency programs, and an increase in the use of solar hot water and small-scale photovoltaic generation and the adoption of plug-in electric vehicles.
	Demand growth - Peak power (MWp) *(OMA only)*	• High • Medium • Low	As above (P13).

Table 2 – Glossary of technology specific inputs, contained in the 'Input Datasheet' in D-CODE (in order of display).

Input field	Units	Definition
Capacity potential	MW (MW of peak demand reduction, or "MWp", in the case of energy efficiency, due to its indistinct capacity)	Potential increased capacity estimates are based on the economic potential of installed capacity until 2020-21, assuming optimum policy settings and market conditions for each technology. Where specific jurisdiction level data is not available, a number of methods have been used to estimate the capacity potential: • Extrapolating projections from other jurisdictions with similar contextual settings • Applying data on technology uptake in jurisdictions with favourable policy conditions for those technologies. When transferring from to the local context appropriate scale weights have been used to adjust for factors such as population or electricity demand. The specific assumptions used in each calculation are fully disclosed within the model within the data compendium.
Life of Capital	Yrs	The number of years the technology/project will be in service
Net Emissions	t CO_2-e/MWh	The amount of greenhouse gases in tonnes emitted by a technology per unit of energy. Calculated by measuring the impact of various GHG equivalent to that of carbon dioxide. These emissions include only Scope 2 emissions i.e. does not include emissions from fuel extraction and distribution. (DCCEE, 2010, National Greenhouse Accounts Factors)
Capital cost of capacity	$M/MW	Estimated capital cost of a technology/program in millions of dollars per unit of capacity. For plants where there is a wide range of capital costs, data is selected from the most reputable source that reflects the median.
Fixed O&M costs	$M/MW/yr	Estimated fixed operation and maintenance cost of the plant/program in millions of dollars per unit of capacity.
Variable Fuel & O&M costs	$/MWh	Estimated variable costs per unit of energy generated. Includes fuel and incremental operation and maintenance costs.
Capacity factor	%	The ratio of the actual output of a power plant over an annual cycle and its output if it had operated at full capacity the entire time. D-CODE can select from either an average (default) capacity factor or a maximum capacity factor. **Note:** for energy efficiency measures, capacity factor has been replaced with a Conservation Load Factor (CLF) because it enables calculation of firm peak capacity (MWp) and energy saved (GWh) without using non-representational measures such as capacity (MW), capacity factor and firm peak rating. Refer to Langham et al. (2010, p27) for information on the CLF concept.

Firm peak rating	%	Also known as Firm Peak Capacity Factor. The proportion of the maximum possible power that can reliably contribute towards meeting peak power demand when needed.
Network Cost factor	%	The transmission and distribution (T&D) costs relative to the Default network capital cost. Range from 0% for technologies with no network cost (such as energy efficiency), to 100% (implying the same network cost as a centralized fossil fuel generator.

Table 3 – Description of spreadsheets (hidden in D-CODE) used to calculate the constraint levels.

Spreadsheet name	Spreadsheet function	Relevant parameters
Demand data	Using data from AEMO (2010), the projected demand for annual generation and peak is calculated	• P1 Region of analysis • P2 Analysis year • P13 Demand growth (GWh) • P14 Demand Growth (MWp)
Plant retirements	Inbuilt data tables display the plant retirements by selected region, year and plant retirement scenario. Scheduled retirements are from AEMO (2010) and plant age data is from ESAA (2010).	
Peak supply data	Calculation of peak supply from existing generators (2011 and previous). Takes into account figures from 'Plant Retirements' spreadsheet. Constraint #1: MWpR= Peak demand minus peak supply from existing generators plus plant retirements	• P1 Region of analysis • P2 Analysis year • P11 Existing supply retirements
Generation data	Calculation of generation from existing generators (2011 and previous). Takes into account peak supply (from previous spreadsheet) and also the potential to ramp up capacity factors of existing schedulable generators (not including hydro). Constraint #2: GWhR= Annual Energy generation minus annual energy generation from existing generators plus generation from plant retirements	• P1 Region of analysis • P2 Analysis year • P11 Existing supply retirements • P12 Capacity factors of existing supply
Renewable generation data	Calculation of renewable energy target based on pre-existing level of renewable energy, and total electricity generation in the analysis year. Constraint #3:RenewableGenR= Total generation multiplied by RET level selected (P10) minus pre-existing renewable energy generation (States only). Note:RenewableGenR for National and NEM is based on predetermined level set by ORER (2011)	• P1 Region of analysis • P2 Analysis year • P10 Renewable Energy Target