Using the App

This section covers what you need to know in order to use the app to build and solve nodal electricity market models. This is "how to use the app". You can start the tutorials without reading this section; each tutorial will tell you what to do as you go along, but if you want an overview of how to use the app then read this section first.

For a full description of all the controls and displays, see the next section, Controls and Displays, which is more for reference purposes.

Build an electricity market model

Starting a new model

The "new model" button shown in Figure 3 removes the existing model (if any) from the display.

Figure 3: The "new model" button

If the existing model has not been saved then it will be lost. Hence, if there is a model currently displayed then the alert shown in Figure 4 is raised.

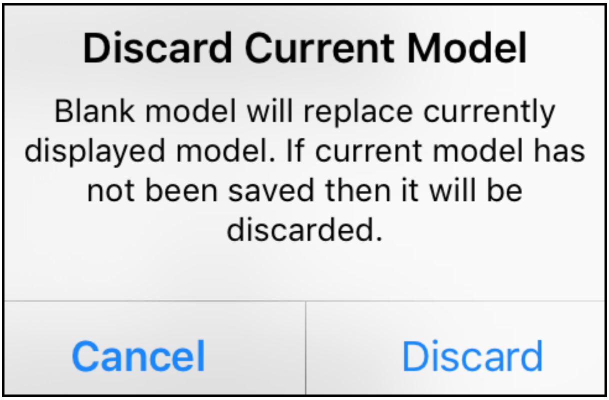


Figure 4: Warning when "new model" is actioned

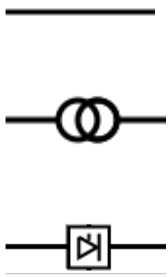
In the interests of getting started we will assume that you don't have a model that needs to be saved. How to save and load a model is covered in the Controls and Displays section.

Components of the network model

The first step in creating an electricity market model is to build the model of the electricity network. This network model is built using the components shown in Table 1.

Table 1: Components of the network model

Button	Visual	Description
Bus		A busbar that provides a common connection point at a substation. Effectively a node on the network.

Branch		Transmits electricity between buses. Represents either a transmission line, a cable, a transformer, or an HVDC link. Display options: line/cable, transformer, or HVDC link
Gen		An electricity generator
Load		An electricity consumer

Toolbars

Use the toolbar buttons to add components to the network model. On the iPad the toolbar looks like this:

On the iPhone, because it is smaller, there are two toolbars; the Main toolbar:

...and the Build toolbar:

On the iPhone the Main toolbar includes a button that takes you to the Build toolbar and vice-versa.

Adding components

To build the model shown in Figure 5 tap the toolbar buttons: Bus-Bus-Gen-Load-Branch.

The default placement of the components automatically builds this model, however the components can be moved and re-sized as necessary to build more complex models.

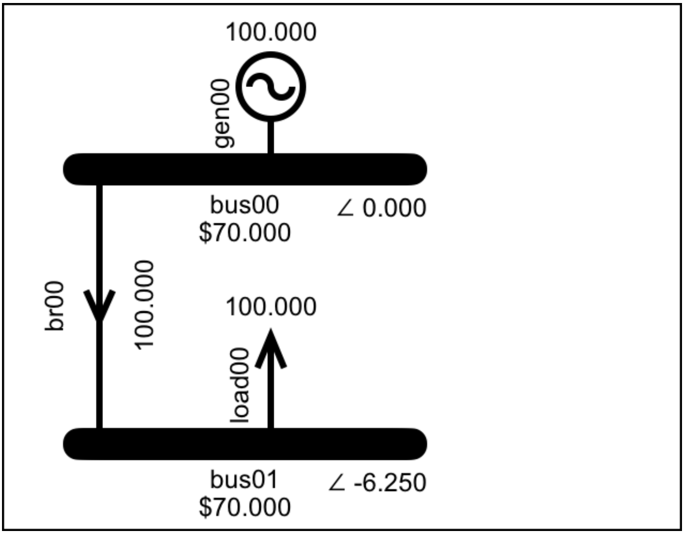


Figure 5: Simple model incorporating all component types

Viable components

Components that are connected together create electrical islands. Components that are not capable of making a valid contribution to the solution are assigned to island 0; these components are coloured green and excluded from the solve.

A component that is not fully connected is assigned to island 0; a generator or load is only fully connected if it is connected to a bus; a branch is only fully connected if both ends are connected.

A bus is only fully connected if it has two or more different components connected to it, or two branches connected to it, or it is connected to another bus that is fully connected. This reflects the fact that a bus that has only a load or a generator connected to it is not capable of making a meaningful contribution to the result.

Figure 6 shows examples of viable components and non-viable (island 0) components. In the case where the bus has two branches that connect to another bus that also only has the same two branches connected, this is not actually a viable island… the assessment is not intended to be foolproof, it is a screening; the important thing is that it removes most non-viable components, and it won't accidentally exclude viable components.

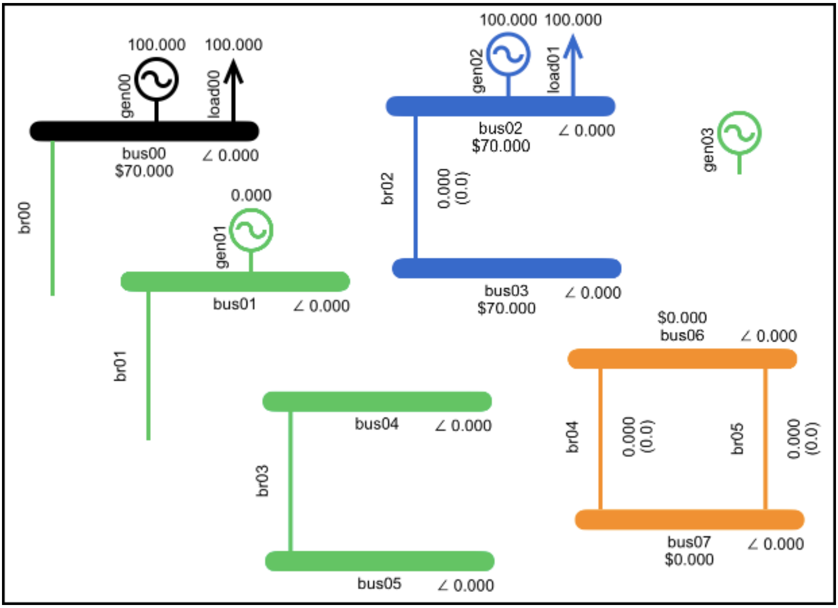


Figure 6: Island 0 components are coloured green and are excluded from the solve

Note also that the term "island 0" is somewhat misleading. Viable islands consist of components that are connected together, and all the components in the island have the same island number. Components that are assigned to island 0 are not necessarily connected… the only thing they have in common is that they are not able to make a meaningful contribution to the result.

Parameters

Once a component is added to the network model you can double-tap it to edit its parameters. The components and their parameters are listed in Table 2.

Table 2: The components and their parameters

Component	Parameter(s)
Bus	Has an editable parameter that indicates if it is the reference bus. (Each electrical island has one reference bus, which by default is the first bus added)
Branch	1) Resistance, susceptance and maximum flow. Reactance can also be entered instead of susceptance, in which case the susceptance is calculated from the resistance and reactance. 2) An option to display the branch as a circuit, a transformer, or an HVDC link. 3) An associated Losses display has parameters that determine how many loss segments there are and how the segments are calculated.

Gen	1) Energy offers, which have a price and quantity. 2) An associated Reserves display has reserve offers that have a price and quantity. The Reserves display also has parameters for total capacity, PLSR% and whether or not this gen can be a risk setter. 3) An associated Ramp display has an initial MW parameter and an up-ramp-rate parameter.
Load	Energy bids, which have a price and quantity. There is also the option to use the bid price entered for block 1 as the bid price for all other block 1 bids in the model.

Default parameters

The parameters *can* be edited, but the first few tutorials use the default parameters.

The default parameters can be changed by tapping the Data Display's eyedropper button, indicated in Figure 7, and then tapping OK on the alert shown in Figure 8.

The default values for reserves and ramp-rates cannot be changed.

Figure 7: Eyedropper button updates the default parameters

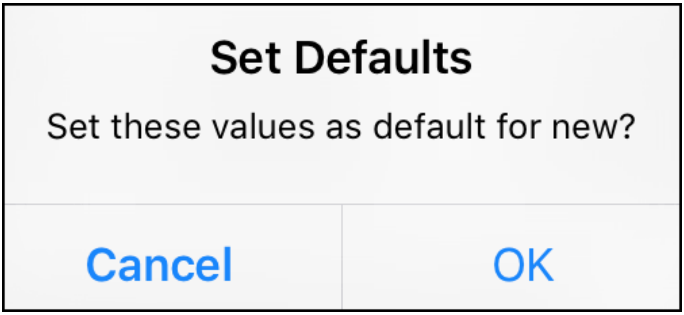


Figure 8: Alert to confirm changing the defaults

Solving the model

Having built the model shown in Figure 5, tap the Solve button to open the Solve Settings display. Select the solver options shown in Figure 9 and then tap the Solve Now button.

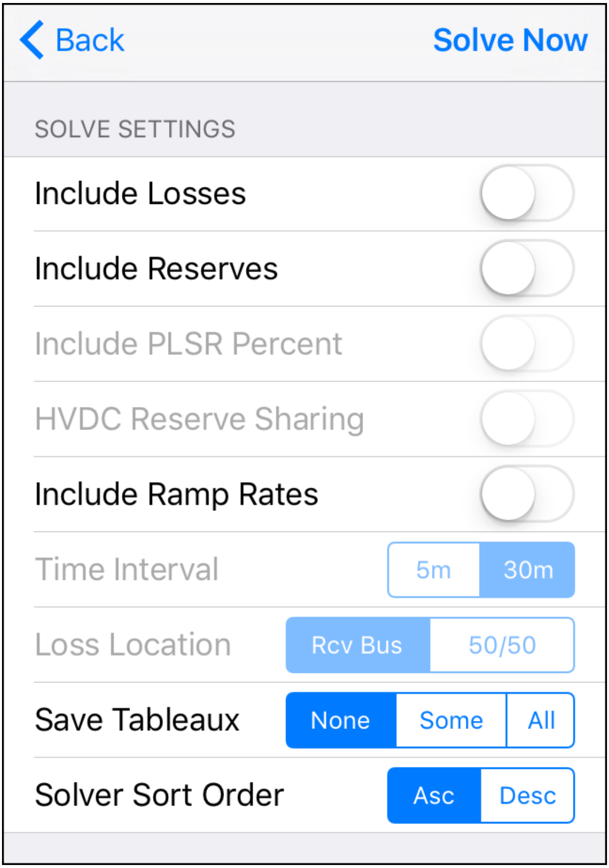


Figure 9: The Solve Settings display

Solver progress

As the model is solved, the simplex algorithm performs iterations that improve the objective value. The solve is complete when the objective value cannot be improved any further; this is explained in Tutorial 1: Explaining Prices, and also in Tutorial 9: Simplex Explained.

A plot of the objective value vs the iteration count is displayed as an overlay while the model is solving. For a large model such as the Hawkes Bay sample (see Tutorial 8: Actual Market Data) the solve takes a noticeable amount of time on older devices, e.g., iPhone 4S, and the chart serves to show that something is happening.

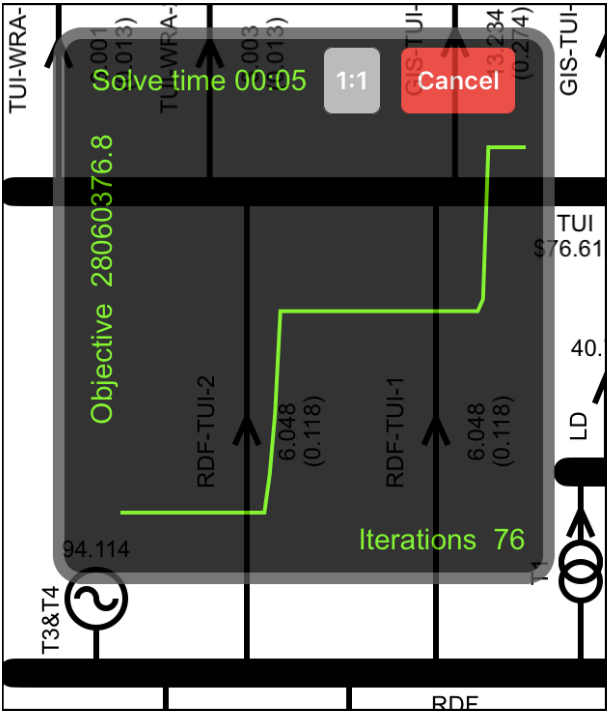


Figure 10: Objective vs iterations as overlay during solve

While the solve is in progress the chart displays a "Cancel" button, as shown in Figure 10. When the solve is complete this changes to a "Done" button, as shown in Figure 11. The Done button is used to dismiss the chart.

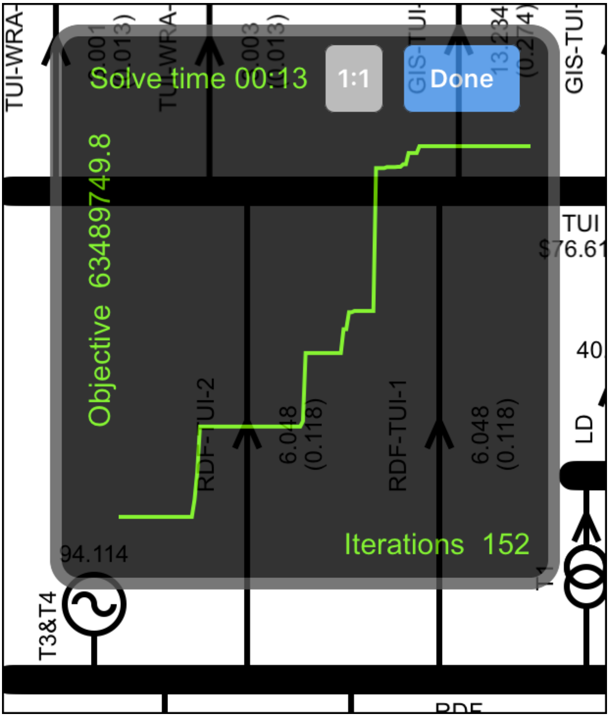


Figure 11: Objective vs iteration count as overlay during solve

For a small model the chart will be far less interesting, as shown in Figure 12, and will be completed almost immediately.

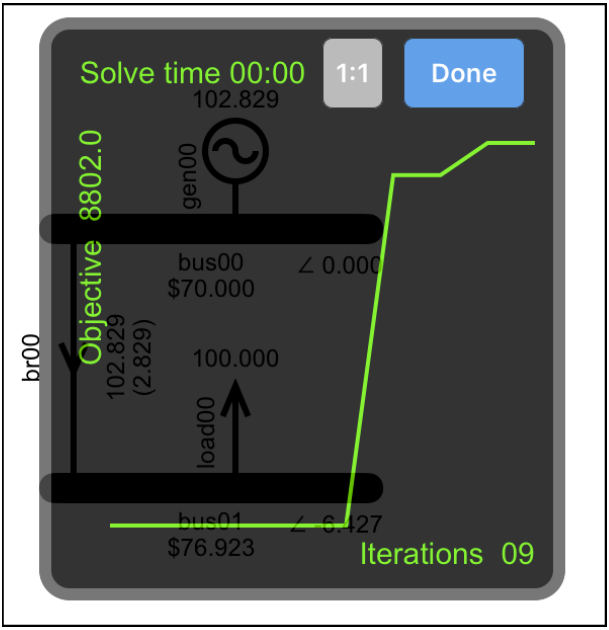


Figure 12: Objective vs iteration count for a smaller model

You can zoom into the plot to see the individual iteration points and tap them to see their details. The 1:1 button is available to make it easy to zoom back to 1:1 scale.

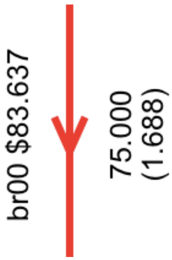
Viewing the results

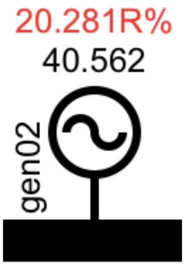
Results are displayed on the network model alongside the associated component. As shown in Figure 5 the cleared generation is displayed above the generator, the branch flow is displayed beside the branch, etc. More detailed results can be viewed via a component's Data Display, which is accessed by double-tapping the component. System level results can be viewed via the Results display.

Results on the network model

The network model display includes colours that identify binding constraints, as shown in Table 3.

Table 3: Colours used to indicate results

	Load bid not fully cleared
	Branch flow at max flow, i.e., binding branch
	Generator binding on capacity limit

	Generator with reserve constrained by PLSR%
	Generator constrained by a binding up-ramp-rate
	Generator is risk-setter
	HVDC link is binding on capacity (energy + reserves) constraint. Capacity is 50MW… 5MW of energy transfer and 45MW of reserve shared in same direction, 50MW of reserve in the opposite direction.

<table>
<tr>
<td>
</td>
<td>HVDC link is risk setter</td>
</tr>
</table>

Results on the Results display

The Results display is accessed via the toolbar button labelled “Results”. As shown in Figure 13, the Results display is divided into two sections; metrics relating to the simplex algorithm’s solving of the model, and aggregate quantities relating to the system being modelled.

All results include a △ column, which shows the change from the previous solve.

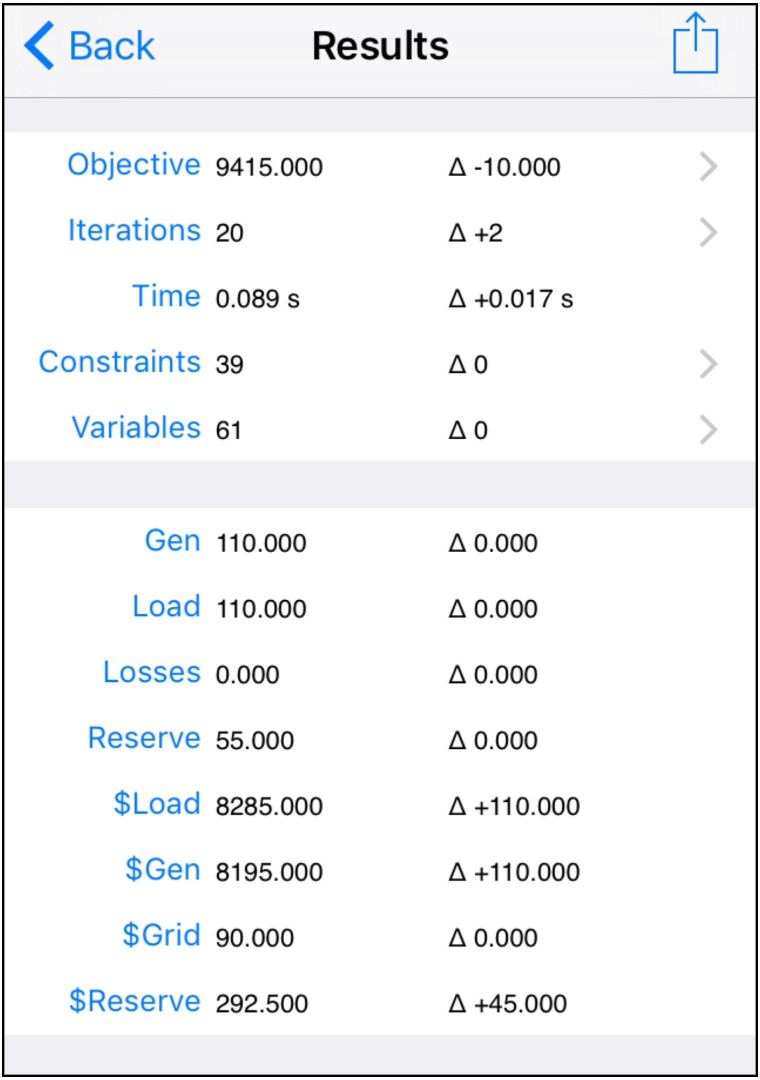


Figure 13: The Results display

If a row has the detail icon > then tapping that row leads to a details display as described in Table 4.

Table 4: Result rows that lead to detail displays

Results Row	Leads to detail…
Objective	Calculation of the objective value
Iterations	Details of all actions taken by the simplex algorithm and a link to a plot of objective value vs iteration count
Constraints	All the constraints in the LP model and their shadow price
Variables	All the variables in the LP model, their value and whether they are basic or non-basic

Shadow prices are explained in Tutorial 1: Explaining Prices. Basic and non-basic variables are explained in Tutorial 9: Simplex Explained.

The Import/Export button on the Results display

The toolbar on the Results display includes the import/export button indicated in Figure 14.

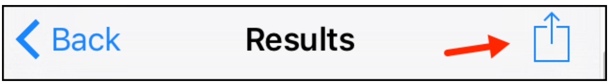


Figure 14: The Import/Export button

The import/export button leads to the Import Export display, which allows for the export of the following data via email: the simplex tableaux as a csv file, the results as a csv file, a screenshot of the network model, the complete model as a csv file (which can also be re-imported via email or iTunes), and the complete model as a GAMS file. See the Controls and Displays section for more details on exporting and importing.

Adjusting components

When we built the model shown in Figure 5 we left the components where they landed. However, components can be moved, re-sized or deleted.

The selected component

Before a component can be adjusted, i.e., moved or re-sized, it must be selected. A component is selected by tapping it once.

There is only one selected component at any one time. The selected component has a red or green box around it; the box is green if the component is fully connected, red if it is not.

Gen and load components are fully connected if they are connected to a bus; a branch is only fully connected if both ends are connected to a bus, a bus is always fully connected. Figure 15 shows an example of a branch that is the selected component, but is not fully connected.

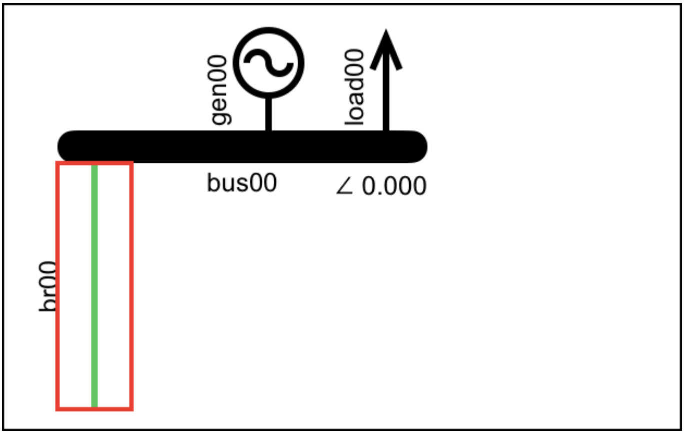


Figure 15: Branch that is selected, but not fully connected

Moving or resizing a component

The selected component is moved by dragging its centre. Buses and branches can also be re-sized, by dragging from the end. Figure 16 shows where to touch buses and branches in order to re-size or move them (these delineations are not normally visible).

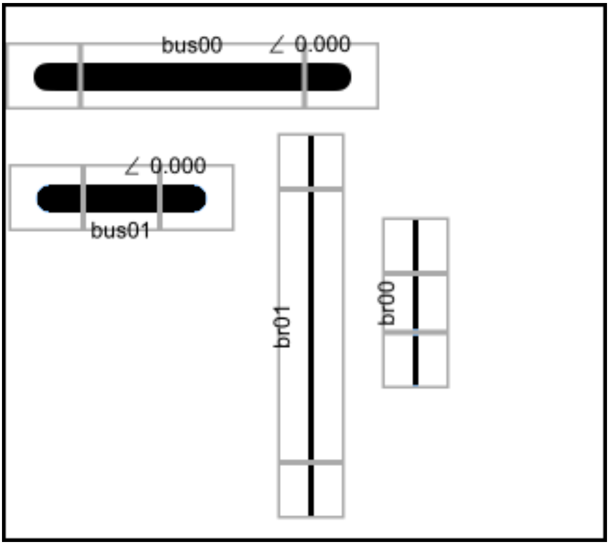


Figure 16: Drag from the middle to move, drag from the end to resize

When a bus is moved, the gen, load and branch components that are connected to the bus move with it.

Deleting a component

To delete a component, press and hold it; a cross will appear, as shown in Figure 17, and the component will wobble. Tap the component to delete it. Tap anywhere else to cancel the delete.

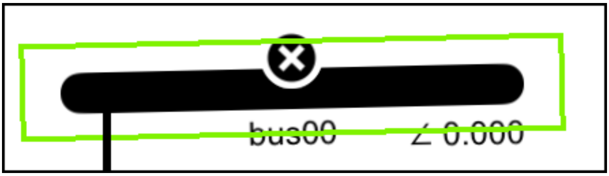


Figure 17: Select a component for deletion by press and hold

Zoom and scroll

Zoom and scroll enable the iPhone to edit an iPad-sized model. The extents of the large model are accessed by scrolling to move around, or by zooming in and out using the pinch gesture.

For models that fit on the iPhone screen without zooming, it is easier to work if zoom/scroll is switched off. Zoom/scroll is switched on and off via the Settings menu.

On the iPad there is no zoom, but scrolling is available when you operate in landscape mode.

Colours

Viable islands

Components connected to a bus will be in the same island as that bus.

If the bus does not have enough components connected to it to form a viable result then it will be in island 0, as described above.

When there are enough connected components then a viable island is formed. The first viable island is assigned island number 1. In most of the worked examples we will only have one island. Multiple islands appear in Tutorial 7: HVDC Link.

Reference Bus

The first bus that forms a viable island becomes the reference bus for that island. When the model it solved the reference bus has its bus angle set to zero, while all other bus angles in the island are variables that the solver can modify. Bus angles are explained in Tutorial 2: Modelling Transmission.

Connectivity colours

All components that are connected together are in the same island and have the same colour. The exception to this is the non-viable components, which are all in island 0 even if they are not connected. Components in island 0 are always green.

Changing colours

Island colours, except for island 0, can be changed via the Settings display, see the Controls and Displays section for details.