Getting Started with Granta EduPack

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1: Getting Started with Granta EduPack

These Getting Started exercises provide an overview of the key tools and features in Ansys Granta EduPack, and form a set of tutorials to help you familiarize yourself with the software.

You can choose whether to work through them in order, or complete only the exercises relevant to you.

This set of exercises covers the main tools and features available in Granta EduPack and Granta EduPack Introductory 2025 R2 or later. Earlier versions may give different results, or not include all features.

2: Granta EduPack tools and features

Granta EduPack contains a number of tools and features designed to support the teaching of materials and processes.

The main tools in Granta EduPack and Granta EduPack Introductory are:

Select:	The central hub of Granta EduPack, used to apply the systematic material selection methodology. A powerful selection engine that identifies records that meet an array of design criteria and enables trade-offs between competing objectives.
Chart:	Create charts and add formatting and labels to illustrate your point.
Eco Audit:	Quickly estimate the energy usage and climate change (CO_2-eq) of a product over its entire lifecycle, and study *What If* design scenarios.

The following tools and features are enabled in all advanced Level 3 databases included in Granta EduPack (for example, Level 3 Aerospace and Level 3 Eco Design, but not Level 3):

Enhanced Eco Audit:	The enhanced version of the tool also accounts for Secondary, Joining, and Finishing processes, and includes a cost analysis.
Synthesizer:	Estimate performance of materials by modeling new hybrid materials, battery packs, or the part cost of a design; and compare these results with existing records.
Engineering Solver:	Quickly calculate the required strength, stiffness or Shape Factor for a given design, and include them in a Limit Stage.
Find Similar:	Select materials based on how similar their properties are to a Reference record.
Comparison Tables:	Compare up to 20 records side-by-side, and highlight the differences in their material properties from a Reference record.
Selection Reports:	Easily record and summarise your complex selection project with an automatically generated report.

The exercises for these advanced features are designed so that Introductory users can simply skip them. You will also be prompted to change databases to one that supports the feature.

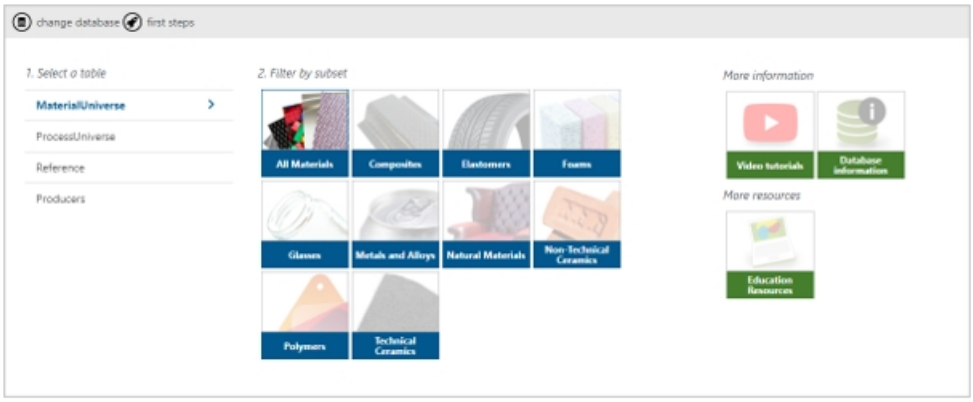
3: Browsing and Searching

Find material and process records in Granta EduPack using the Browse and Search tools.

3.1. Exercise 1: Opening a database

Explore the databases in Granta EduPack and browse the tables and subsets within them.

On starting Granta EduPack, the **Databases** window will appear, showing all installed databases. The following exercises use the *MaterialUniverse* and *ProcessUniverse* tables, which are found within all Granta material databases. After clicking on a database name in the **Databases** window to select it, the Homepage then opens to show a list of the available tables and a graphic for each subset.

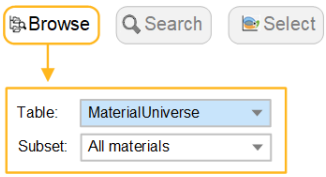


From the homepage you can view more information on the database, select a subset, and access online resources for students and educators.

1. Select the **Level 2** database

   If a feature used in an exercise is not enabled in the **Level 2** database, you are asked to change to one that does as part of the exercise. Results and images may differ if you complete an exercise using a different database.

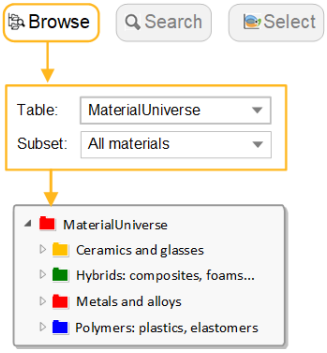
2. Read about the available data and applications
   a) Click **Database information** to view a detailed description of the database.
   b) Click the **Back** arrow to return to the homepage.
3. Select a material subset
   a) Click one of the subset icons, and notice that the **Browse** panel appears.
4. Change to the **ProcessUniverse** table
   a) Click **ProcessUniverse** and notice that the Browse tree in the left panel updates.
5. Close the Homepage tab
   a) Click the cross at the top of the Homepage tab. This page can be reopened at any time by clicking **Home** on the main toolbar.
6. Change to the **MaterialUniverse** table
   a) With the Homepage closed, navigate to different tables using the **Table** list in the **Browse** panel.



3.2. Exercise 2: Browse material records

Navigate the Browse tree to search for material folders and records.

1. Select the **MaterialUniverse** table and the **All Materials** subset



2. Find the record for *Stainless Steel*
   a) Double-click a folder in the Browse tree to view the records and folders below it.
3. Open the folder-level record for **Polymers**

   Folder-level records provide a general overview of a material family, rather than containing data on a specific material. They have their own icon: .
4. Open the **Polypropylene (PP)** record
   a) Double-click the record name in the tree to view the datasheet.
   b) Click ⓘ to view Science Notes for more information on the property and underlying science.
   c) Right-click the datasheet to see a menu with further actions, for example: **Locate in Browse tree**, **Copy** or **Print** the datasheet, and **Duplicate Record**.
5. Find processes that can shape *Polypropylene*, by clicking the **ProcessUniverse** link at the bottom of the datasheet

Polymers and elastomers > Polymers > Thermoplastics >

DESCRIPTION

Image

Caption

1. Polypropylene samples showing texture and transparency. © Chris Lefteri 2. Polypropylene glasses. © Thinkstock

The material

Polypropylene, PP, first produced commercially in 1958, is the younger brother of polyethylene - a very similar molecule with similar price, processing methods and application. Like PE it is produced in very large quantities (more than 30 million tons per year in 2000), growing at nearly 10% per year, and like PE its molecule-lengths and side-branches can be tailored by clever catalysis, giving precise control of impact strength, and of the properties that influence molding and drawing. In its pure form polypropylene is flammable and degrades in sunlight. Fire retardants make it slow to burn and stabilizers give it extreme stability, both to UV radiation and to fresh and salt water and most aqueous solutions.

Compositional summary

(CH2-CH(CH3))n

GENERAL PROPERTIES

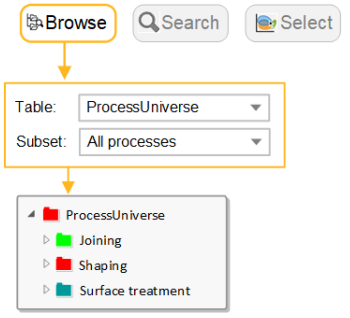
Density		-		kg/m^3
Price		-		GBP/kg

Part of the Polypropylene Level 2 datasheet

3.3. Exercise 3: Browse process records

You can also use the Browse tree to search for process records.

1. Browse **ProcessUniverse: All Processes**



2. Find the record for the shaping process *Injection molding, thermoplastics*

3. Find the record for the surface treatment process *Vapor metallizing (PVD)*
4. Find the record for the joining process *Friction welding (metals)*
5. Find materials that can be die cast, using the link to **MaterialUniverse** at the bottom of the datasheet for *Gravity die casting*

3.4. Exercise 4: Searching

Use keyword searches to find materials and processing methods.

1. Find the material `Polylactide`

2. Find the process *Vacuum assisted resin transfer molding (VARTM)*
3. Find materials used for `"cutting tools"`

   The search matches text on a datasheet. For example, a search for `"cutting tools"` would return all records with the phrase "cutting tools" in the record description or supporting information.
4. Find the material **Concrete**

   The search matches the record's folder name. If the search term appears in a folder name, all records under that folder will be returned. For example, a search for concrete would return all records in the folder named Cement and concrete e.g. *Plaster of Paris*.
5. Enter the search term `alum*`

   Records containing the terms *Alumina*, *Aluminum* or *Alumino* are returned.

3.5. Advanced searches

You can perform more advanced queries using search operators.

The following search operators are available:

Operator	Description
AND	Finds records containing both the search terms, so `steel AND alloy` returns only records containing both the words **steel** and **alloy**
OR	Finds records containing either search term, so `steel OR alloy` returns all records that contain **steel**, **alloy**, or **both**
NOT	Finds records containing the first search term, but not the second, so `steel NOT alloy` returns only records with the word **steel** but without the word **alloy**
Phrase Search	Finds the exact search term, so `"steel alloy"` will return only records containing the exact phrase **steel alloy**
Parentheses	Used to group search terms, so `iron AND (ore OR cast)` will return the records containing **iron** and containing either **ore**, **cast**, or **both**

Operator	Description
Wildcards	Use ? as a wildcard single character, or * as a wildcard representing any number of characters (these cannot be used as the first character in a search string)

Note: AND operators are automatically added when a search has two or more terms and no other operators have been entered.

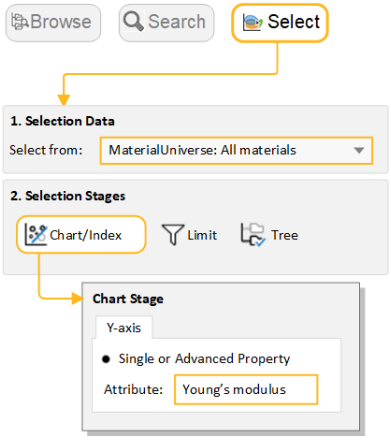
4: Creating property charts

Bar charts and bubble charts are a great way to visualize and communicate material properties, as well as being a key tool to support systematic materials selection.

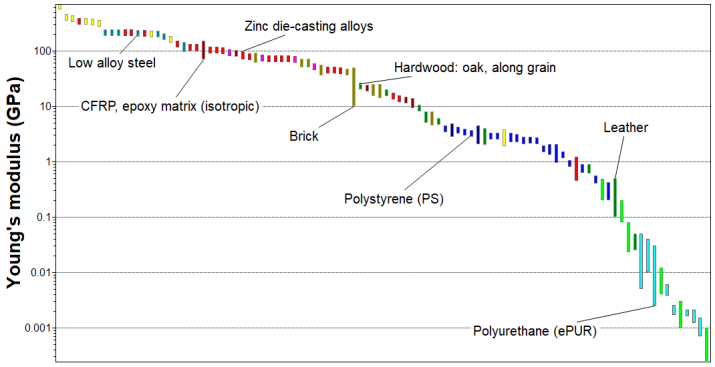
4.1. Exercise 5: Create a bar chart

Plot materials data on a bar chart using the Chart/Index Stage.

1. Select **MaterialUniverse: All materials** on the **Chart/Select** tab
   a) Click **Chart/Select**, and then select **MaterialUniverse: All materials**.
2. Create a bar chart of *Young's modulus (E)*
   a) Under **Selection Stages**, click **Chart/Index**.
   b) Set the Y-axis attribute to **Young's modulus**, and click **OK**.
   c) For a bar chart, you do not set an X-axis: leave its attribute set to <None>.



3. Explore the chart
   a) Click **Zoom in** and then drag to zoom in on an area of the chart.
   b) Click **Zoom out** to zoom out.
   c) Click **Autoscale** to zoom back to view the whole chart again.
4. Label records on the chart
   a) Click a record on the chart and then drag to add and position a new data label.
   b) To delete a data label, select it and press `DELETE`. To delete all labels in the chart, press `CTRL+A` and then press `DELETE`.

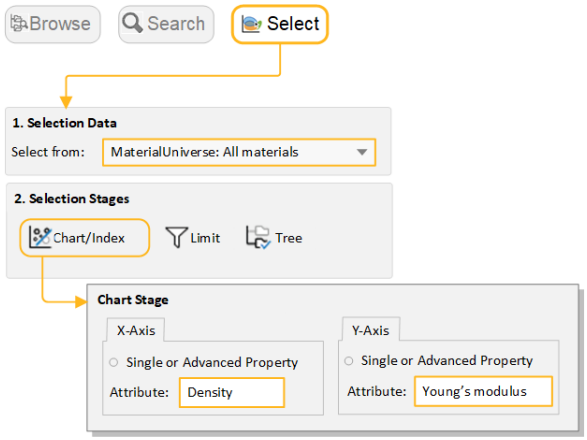


4.2. Exercise 6: Create a bubble chart

Add attributes to both axes to create a bubble chart.

1. Make a bubble chart plotting *Young's modulus (E)* against *Density (ρ)*

a) Under **Selection Stages**, click **Chart/Index**.
b) Set the Y-axis to **Young's modulus** and set the X-axis to **Density**.
c) Leave the **Axis Settings** as default values to create a log-log plot.

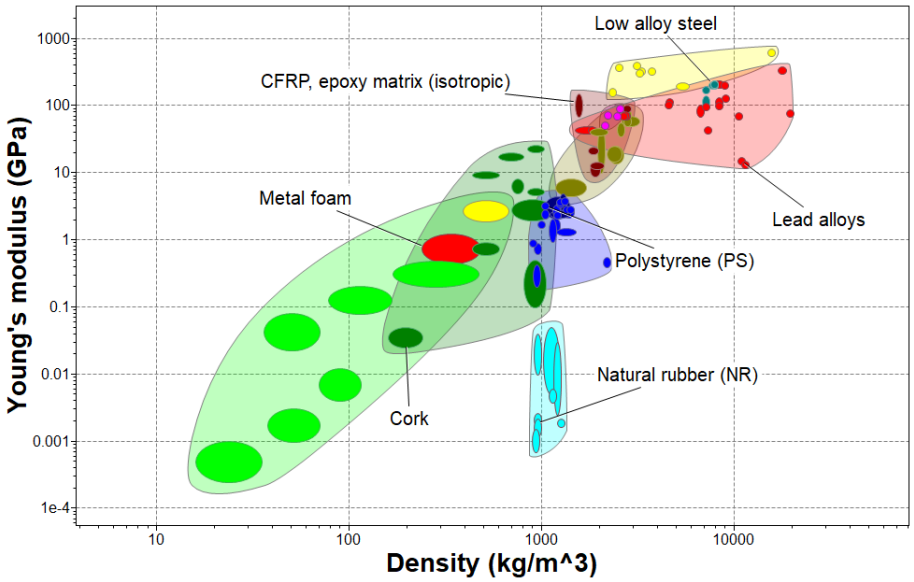


2. Display family envelopes

a) Click **Show Family Envelopes** to look at how data for a given family of materials cluster together.

3. Label records on the chart

a) Hover the cursor over the record bubble to see the record name, and then label some records (click over a record and drag).
b) Try adding labels from the **Results** list: right-click a record in the list, and select **Label** on the shortcut menu, then drag the label where you want it on the chart.
c) If the new label isn't visible at the current zoom, click **Autoscale** to display the whole chart again.



4. Delete this stage

a) Select the stage in the Selection Stages list and press `DELETE`.

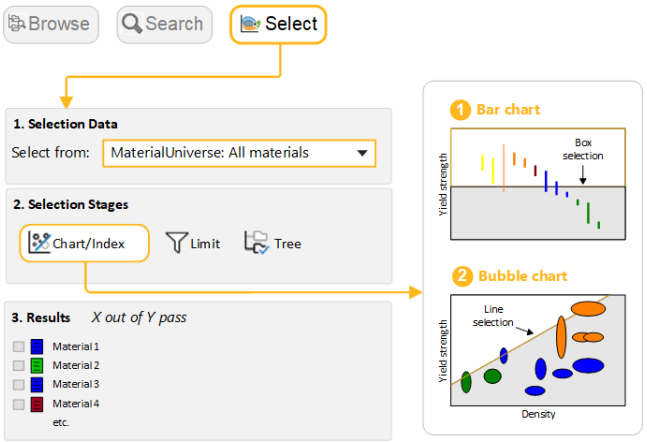
5: Filtering and screening

You can filter records based on their attribute values using the Chart, Limit and Tree Stages.

5.1. Exercise 7: Selection using a Chart Stage

Use the Index line and Box selection tools to select materials based on their attribute values.

When plotted on a Chart, records can also be filtered using the **Index line** and **Box selection** tools.



1. Create a bar chart of *Yield strength (σ_y)*
   a) Set the Y-axis to **Yield strength (elastic limit)**.
2. Use a **Box selection** to identify materials with high values of *Yield strength*
   a) Click **Box selection** , then drag to define the selection box.

3. Add **Density (ρ)** to the X-axis
   a) Click **Chart Settings** , then go to the X-Axis tab and select Density as the X-axis attribute. You can also double-click the chart axis to open the dialog.
4. Use an Index line to identify materials with high values of specific strength, σ_y / ρ

a) Click **Index and display lines** .
b) Use the default **Slope** value of 1.
c) The objective of the line is set to **Maximize the index** by default, which will result in selection of materials above the line, for high values of σ_y / ρ.
d) Click **OK**, then click the chart to position the line through a particular point.
e) Drag the line upwards to refine the selection to fewer materials.

5. Add a **Box selection** to the chart to identify materials with low *Density* that maximize the index.

6. Rank the Results list by specific strength (*Yield strength / Density*)

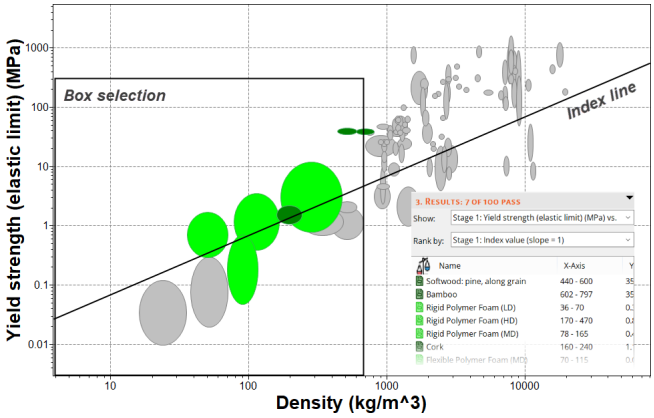
Show: *Stage 1: Yield strength v. Density*

Rank by: *Stage 1: Index value*.

Example results: *Bamboo, Cork, Rigid Polymer Foam (MD)*.

7. Delete this stage

a) Select the stage in the Selection Stages list and press `DELETE`.



5.2. Exercise 8: Selection using a Limit Stage

Filter records by applying limits to one or more attributes.

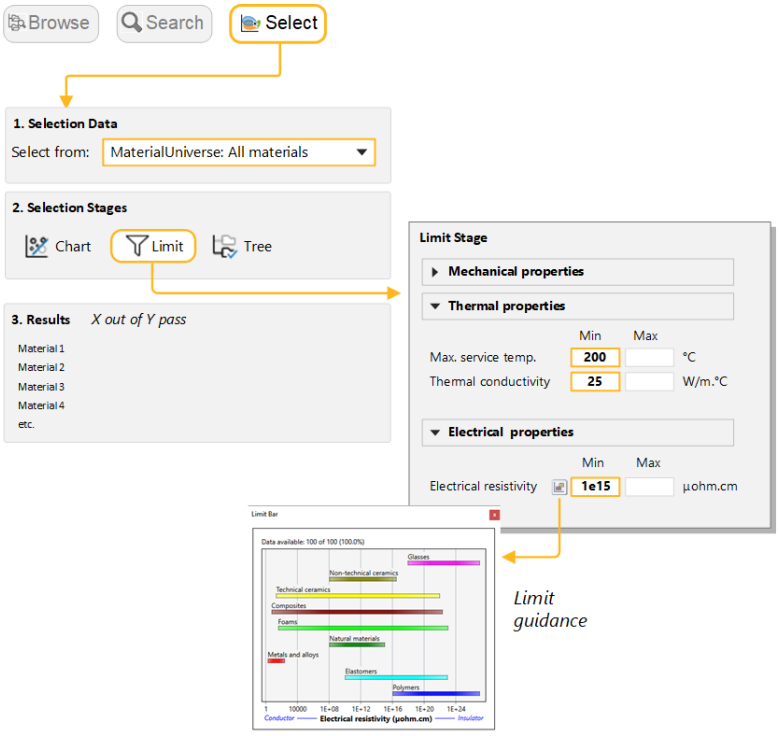
1. Select materials with specific thermal and electrical properties.

a) Create a new **Limit Stage** with the following criteria:

Maximum service temperature	> 200 °C
Thermal conductivity	> 25 W/m.°C
Electrical resistivity	> 1e15 µohm.cm

b) Use the limit bars for guidance on suitable values, and keep AND logic selected. Enter the limits – minimum or maximum as appropriate – and click **Apply**.
c) You can change the units on the datasheet by going to the **Units** tab under **Settings**.

Example results: *Aluminum nitride, Alumina, Silicon nitride*.



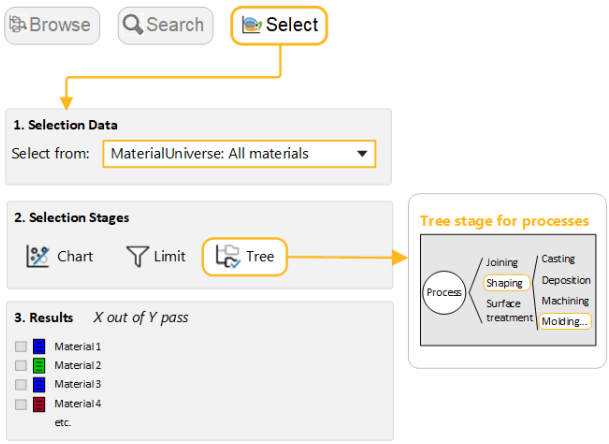
2. Filter the results further to select only materials which are resistant to *Hydrofluoric Acid (40%)*.
   a) Under **Durability: Acids**, select **Acceptable** and **Excellent** for *Hydrofluoric Acid (40%)*.
   b) Click **Apply**. *Silicon nitride* should be the only passing record.

5.3. Exercise 9: Selection using a Tree Stage

Use a Tree Stage to filter records by category based on their links to records in other data tables, or based on the database hierarchy (tree).

For example, you can filter for records that are linked to a specific process record.

1. Find materials that can be molded
   a) Under **Selection Stage**, click **Tree**. In the Tree Stage dialog, select **ProcessUniverse** and navigate to *Molding*.
   b) Select the folder, click **Insert**, then click **OK**.
2. Click **Show** to view a list of *MaterialUniverse* records to which this process folder is linked.
   a) Double-click a record name to view its datasheet.



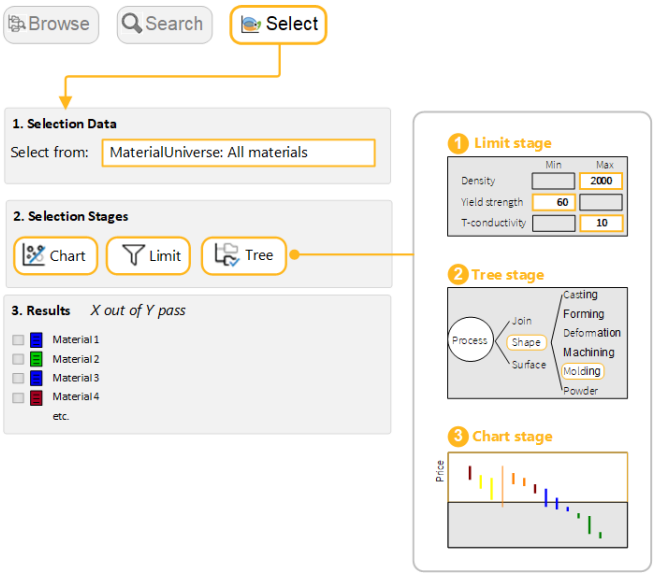
3. Delete this stage.
4. Find processes which can join *Ferrous Metals* and *alloys*
   a) In the **Selection Project** panel, under **Selection Data**, select **ProcessUniverse: Joining**.
   b) In the Tree Stage dialog, select **MaterialUniverse**, expand **Metals and alloys**, select **Ferrous**, and then click **Insert** followed by **OK**.
   c) Click **Show** to view the linked records.
5. Delete this stage.

6: Putting it all together

Now you have learned how to create Charts and use Selection Stages, you can combine selection stages to filter records based on design constraints.

6.1. Exercise 10: Combining filtering and charting tools

You can identify materials which meet mutlitple selection criteria by combining selection stages.



1. Choose the data table
   a) **Select from**: **MaterialUniverse: All materials**.
2. Select materials with specific physical, mechanical, and thermal properties.
   a) Create a **Limit Stage** with the following criteria:

Density	< 2000 kg/m^3
Yield strength (elastic limit)	> 60 MPa
Thermal conductivity	< 10 W/m.°C

3. Filter the results to find those that can be *Thermoformed*
   a) Create a **Tree Stage** and **Insert** *ProcessUniverse > Shaping > Molding > Thermoplastic molding > Thermoforming*.
4. Rank the results by *Price* and find the three cheapest materials
   a) Create a **Chart Stage** with a bar chart of **Price** on the Y-Axis. On the chart, all materials that fail one or more stages are grayed out. The **Results** panel lists the materials that pass all stages by default.
   b) In the **Rank by** menu, select **Stage 3: Price**.

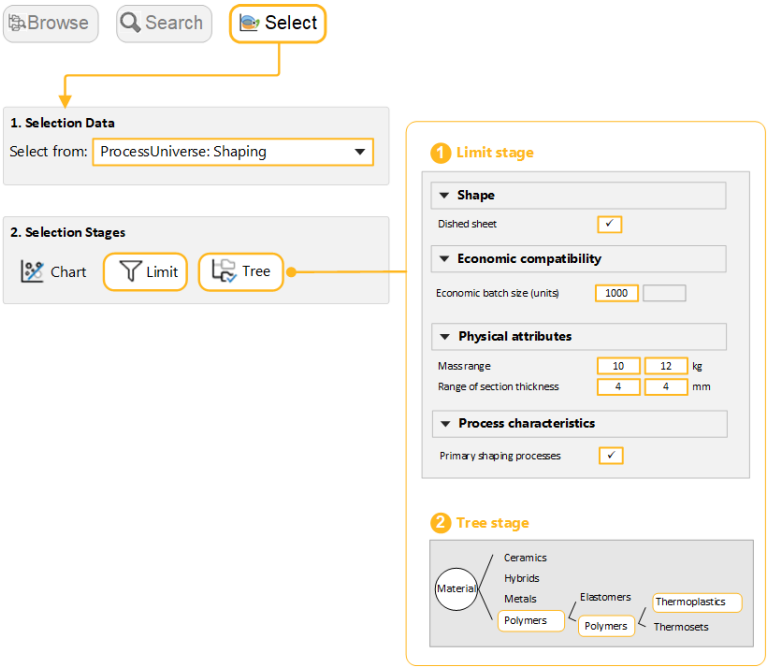
6.2. Exercise 11: Process selection

You can also filter *ProcessUniverse* records in the same way as for *MaterialUniverse* by combining selection stages.

1. Select the data table
   a) **Select from**: **ProcessUniverse: Shaping**.
2. Find *Primary shaping processes* to make a component with specific shape, physical, and economic properties.
   a) Add a **Limit Stage** with five criteria:

Shape	**Dished sheet**
Mass range	`10 - 12 kg`
Range of section thickness	`4 mm`
Process characteristics	**Primary shaping process**
Economic batch size	`> 1000`

3. Filter the results to only include *Thermoplastic* materials
   a) Add a **Tree Stage** and **Insert** *MaterialUniverse > Polymers and Elastomers > Polymers > Thermoplastic*.
   Example results: *Rotational molding, Compression molding, Thermoforming*



6.3. Exercise 12: Advanced selection using the Performance Index Finder

The Performance Index Finder lets you plot a performance index on a chart as a combined property.

> **Note:** The Performance Index Finder is only enabled in Level 3 databases.

In this exercise, you will use the Performance Index Finder to find the materials best suited for a beam, loaded in bending, that is part of a low cost, lightweight, strength-limited design.

1. Select a Level 3 database and data table
   a) Click **Change...** under **Selection Data** to change the database to **Level 3**.
   b) **Select from**: **MaterialUniverse: All bulk materials**.
2. Create a chart using the Performance Index Finder
   a) Click **Chart/Index**, then select the **Performance Index Finder** radio button.
3. Enter the **Component Definition** for the Y-Axis

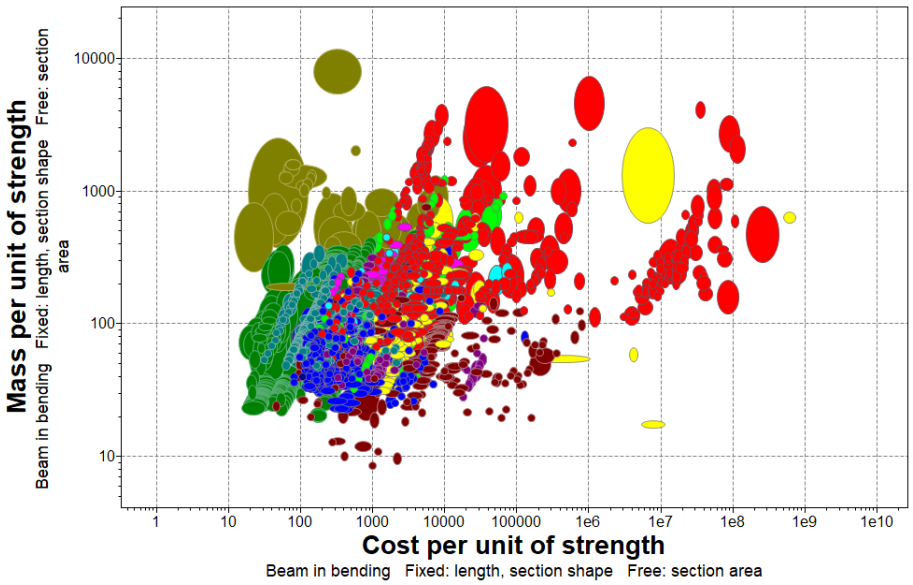
Function and Loading:	**Beam in bending**
Limiting Constraint:	**Strength**
Optimize	**Mass**

   Keep the default values for **Free** and **Fixed Variables**, and **Axis Settings**.
4. Enter the **Component Definition** for the X-Axis
   a) Go to the X-Axis tab and select **Performance Index Finder**. Set the following values:

Function and Loading:	**Beam in bending**
Limiting Constraint:	**Strength**
Optimize	**Cost**

   Keep the default values for **Free** and **Fixed Variables**, and **Axis Settings**.
5. View the chart
   a) Click **OK** to view the chart.

   Materials in the bottom-left corner are best suited for a lightweight, low cost, strength-limited design.



6. Delete this stage.

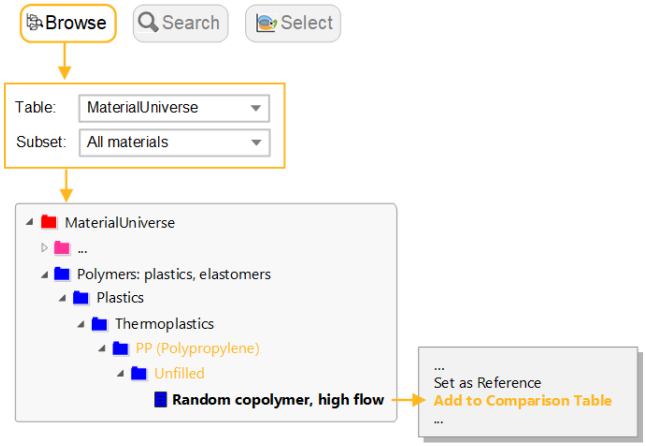
6.4. Exercise 13: Advanced selection with Comparison Tables

Comparison Tables allow you to compare several different records at once, and highlight differences between them.

> **Note:** **Comparison Tables** are only enabled in the advanced Level 3 databases. The option will be grayed out or not appear at all if you have opened any of the databases available in Granta EduPack Introductory, including Level 3.

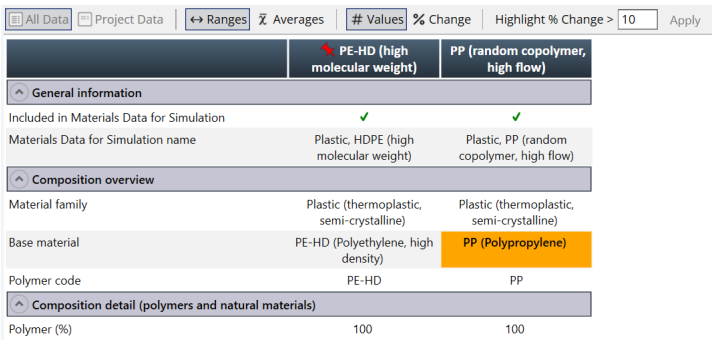
In industry, materials selection projects are often required to find a replacement for an existing material, due to changes in the design or manufacture of the component, or because of supply chain issues. **Comparison Tables** allow you to compare several different records at once, and highlight differences between them.

1. Change the database to one where **Comparison Tables** are enabled
   a) Change the database and table to **Level 3 Polymer, MaterialUniverse: All materials**.
2. Add an *unfilled PP (Polypropylene)* and an *unfilled high-density PE (Polyethylene)* record to a **Comparison Table**.
   a) Find an example of each in the Browse tree, then right-click and select **Add to Comparison Table**.



3. Set the high-density PE as the **Reference record**
   a) Hover over the record name in the comparison table header and click **Set as Reference** .

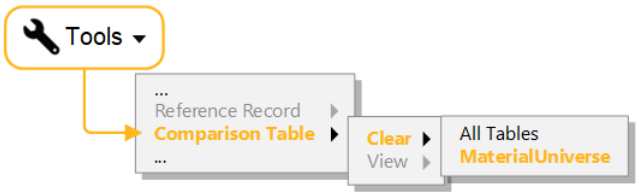
> **Note:** **Reference record** is another feature enabled in the advanced Level 3 databases. Setting a **Reference record** allows you to easily identify it in the browse tree and on charts, and compare other records to it using **Comparison Tables** and **Find Similar** (see the next exercise and the software Help for more information).



4. Show the differences relative to the **Reference record** as percentages
   a) Click % **Change** in the **Comparison Table** toolbar.

> **Note:** These are differences in the range values, not the averages.

5. Clear the **Comparison Table** and **Reference record**
   a) Click **Tools** on the main toolbar, then select **Comparison Table** > **Clear** > **MaterialUniverse**. Repeat for the Reference record.

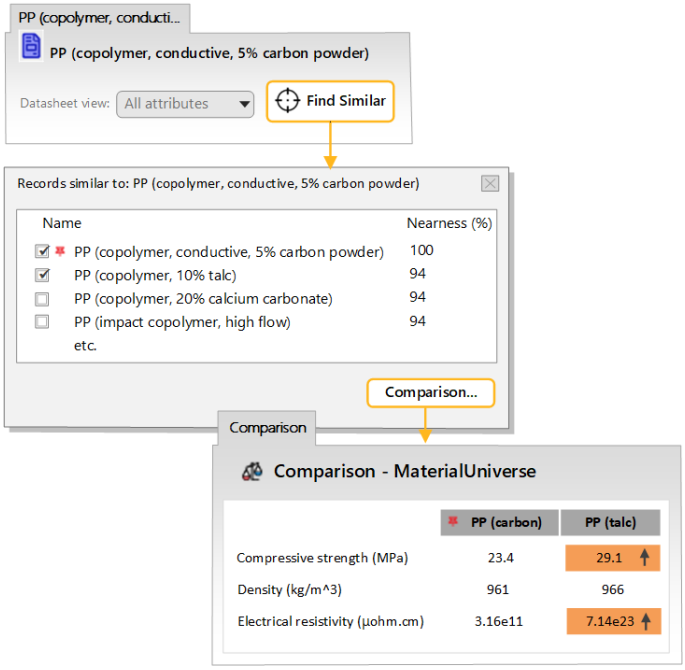


6.5. Exercise 14: Advanced selection with Find Similar and Limit Stage

Find similar materials to your record, and then filter additonal attributes to identify materials which have the required properties for your design requirements.

> **Note:**
>
> **Find Similar** is only enabled in the advanced Level 3 databases. This exercise assumes you are using the *Level 3 Polymer* database from the last exercise.

1. Open the record for *Polypropylene (Copolymer, Conductive, 5% Carbon powder)*
2. Find records similar to it
   a) Click **Find Similar** at the top of the datasheet tab. *Polypropylene (Copolymer, Conductive, 5% Carbon powder)* will become the Reference record.
   b) Use the default weightings to calculate nearness - do not open **Nearness Settings**.
3. Compare the current material with the nearest alternative
   a) Select one of the closest records from the list of results, *PP (copolymer, 10% talc)*, and open a comparison table by clicking **Comparison...**



The **Comparison Table** is highlighted where there is a difference between the original (reference) and alternative materials. The nearest materials in the results have similar physical properties to the reference material (density, yield strength, Young's modulus). However, the original material may have been chosen for its other characteristics. In this case, the polymer is conductive (has a low electrical resistivity).

To find materials which have all the properties we need, we can proceed in one of two ways:

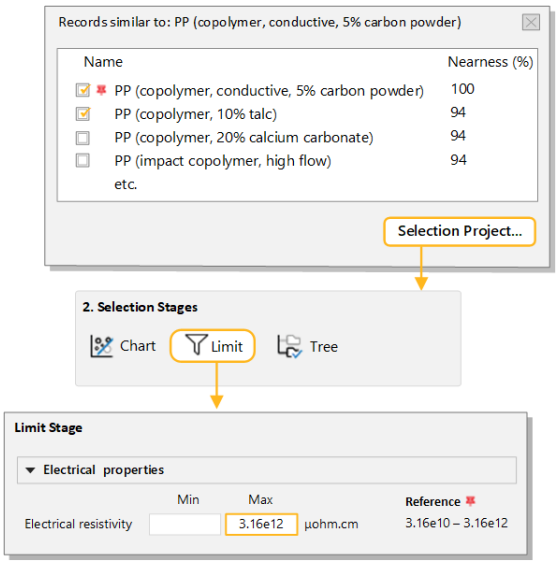
- Adjust the **Nearness Settings** to prioritise the material properties most important to our application (see Exercise 15).
- Use the results from **Find Similar** as the basis of a Selection Project. In this case, you can use a **Limit Stage** to filter on the additional requirement for conductivity.

4. Create a Selection Project using the results

a) In the **Records similar to** dialog, click **Selection Project**. The results are loaded into a new project, ranked by nearness.

5. Filter the results for an *Electrical resistivity* that is equal to or lower than that of the reference material

a) Create a **Limit Stage**, and set the maximum value for **Electrical resistivity** to `3.16e12`, which is the maximum value for the reference record. **Apply** the stage.



Example results, with Nearness (%):

- *PP (10-12%, stainless steel fiber)* - **86%**
- *PP (10% carbon fiber)* - **82%**
- *ABS (40% aluminum flake)* - **81%**

6. Delete this stage.

6.6. Exercise 15: Advanced selection with Find Similar and Nearness Settings

Instead of filtering on additional attributes, you can change the criteria used for calculating nearness to take account of different requirements.

> **Note:** **Find Similar** is only enabled in the advanced Level 3 databases. This exercise assumes you are using the *Level 3 Polymer* database from the last exercise.

1. Find records similar to *Polypropylene (Copolymer, Conductive, 5% Carbon powder)*

a) Open the datasheet and click **Find Similar**.

2. Re-calculate the list of alternative materials, taking *Electrical resistivity* into account and prioritizing results with a resistivity that is the same or lower than the reference material

a) Click the **Nearness settings** link on the **Records Similar to** dialog.
b) Under **Electrical Properties**, select **Electrical resistivity**. Set it to **100% when Same or lower**, and increase the **Weighting factor** to 2.
c) Click **OK** to generate the new results.

> **Note:** These results are conceptually different to those from the previous exercise. We have ranked similar materials, taking into account the resistivity, but there is not a fixed upper limit as

there was when filtering using the **Limit Stage**. Materials with a higher resistivity than the reference will still be included in these results.

6.7. Exercise 16: Calculate values for a Limit Stage using Engineering Solver

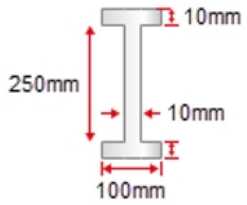
Use the Engineering Solver to convert engineering requirements into material properties, and then use these properties to filter materials in a Limit Stage.

Design requirements are often specified in terms of geometry, loading, and maximum deflections. The **Engineering Solver** tool converts these engineering requirements into material properties, which can then be applied in a **Limit Stage** to screen for suitable materials.

Note: Engineering Solver is only enabled in the advanced Level 3 databases. This exercise assumes you are using the *Level 3 Polymer* database from the last exercise.

1. Open the **Engineering Solver**.
   a) Click **Solver** on the main toolbar.
2. Select the loading geometry **Beam in Bending**

   This model estimates the minimum strength, stiffness and *Shape Factor* values required for a beam with the specified geometry and load conditions.
3. Enter the geometry for an I-beam with the following dimensions:



   Use the **Cross-section** list to select *I-section*. Enter the following dimensions and use the drop-down lists at the end of each line to select the correct units:

   Breadth, b = 100 mm; *Depth, d* = 250 mm; *Thickness, t* = 10 mm; *Web thickness,* t_w= 10 mm; *Length, l* = 5 m.

4. Enter the design parameters for a cantilever with an end load of 5 kN

   Load condition = *Cantilever End load*; *Load* = 5 kN; *Safety factor* = 1.5; *Maximum deflection* = 50 mm.

   The results are populated automatically. You should see that the minimum required *Young's Modulus* is 133 GPa and the minimum *Yield Strength* is 108 MPa.

   Keep the **Engineering Solver** dialog open.
5. Select materials based on the results from **Engineering Solver**
   a) Create a new **Limit stage** using **MaterialUniverse: All bulk materials**, and enter the minimum *Young's modulus* and *Yield strength (elastic limit)* estimated by the **Solver**. You can copy and paste from the dialog using `CTRL+C` and `CTRL+V`.
   b) Make sure the units in the **Engineering Solver** and **Limit Stage** match. Change the results units in the **Engineering Solver** dialog if they do not.

Over a third of the materials in the database meet the requirements. Typically, you would apply more constraints and selection stages to narrow the list further.

6. Delete this stage, and **Change** database back to *Level 2*

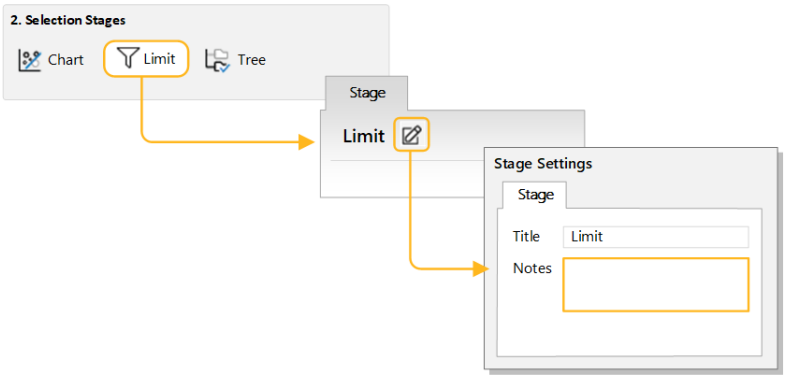
7: Saving, copying, and report writing

Selection Projects can be saved and revisited at a later date, or copied and exported in to other applications.

7.1. Exercise 17: Adding comments and saving a project

You can add Notes to a selection project as a reminder of why you have applied certain constraints and objectives.

Notes can be added to each selection stage, or to the overall project (in **Project Settings**), and are displayed on mouse-over in the stage tab, and are saved in the project



1. Click **Notes** in the stage window heading to open the **Stage Settings** dialog, then enter some comments in the Notes box.
2. Save your project

   Select **File** > **Save Project**. Give the project a filename and folder location; the project will be saved with the file extension `.ces`.

7.2. Exercise 18: Copying charts, data and results lists

You can copy and paste Charts, records, and results lists into a document in another application such as Microsoft® Word, Microsoft Excel, Microsoft Powerpoint, or Notepad.

1. Copy a chart into a document
   a) To copy a chart to the clipboard: in the chart window, right-click the chart and select **Copy** on the shortcut menu, or press `CTRL+C`.
   b) You can then paste the chart image from your clipboard into the document as a device-independent bitmap.
2. Copy a datasheet into a document
   a) To copy a datasheet to the clipboard: display the datasheet, then right-click the datasheet and select **Copy** on the shortcut menu, or press `CTRL+C`.
   b) You can then paste the data from your clipboard into the document.
3. Copy results into a document

a) To copy results to the clipboard, use `SHIFT+click` or `CTRL+click` to highlight the records you want, then right-click and select **Copy** on the shortcut menu, or press `CTRL+C`.
b) To select all results in the list, right-click and select **Select All** on the shortcut menu, or press `CTRL+A`.
c) You can then paste the results from your clipboard into the document.

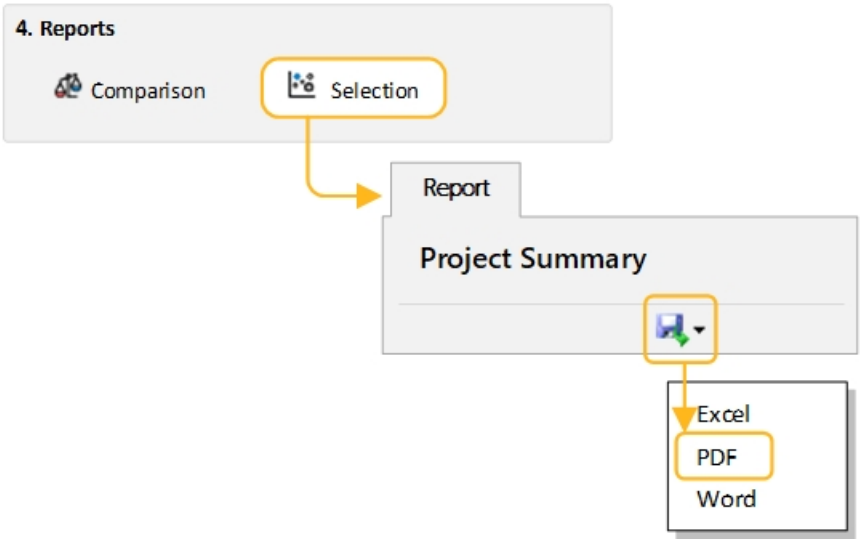
4. Edit the document you have created

7.3. Exercise 19: Exporting Selection Reports

You can export Selection Reports as a PDF, a Microsoft® Word document, or a Microsoft Excel spreadsheet.

> **Note: Selection Reports** are only enabled in the advanced Level 3 databases (for example, Level 3 Sustainability). The option will not appear if you have opened any of the databases available in Granta EduPack Introductory, including Level 3.

1. Generate a Selection Report
   a) Click **Selection** at the bottom of the **Chart/Select** pane.
2. Export the report as a PDF
   a) Click **Export** and select **PDF**. Selection Reports can be exported as a PDF, a Microsoft® Word document, or a Microsoft Excel spreadsheet.



8: Eco Audit tool

The Eco Audit tool estimates the energy used and CO_2 produced during the key life phases of a product (material, manufacture, transport, use, and end of life), and identifies which phase has the dominant contribution.

This is the starting point for eco-aware product design, as it identifies which parameters need to be targeted to reduce the eco-footprint of the product.

The next few exercises will take you through a case study for a brand of bottled mineral water. It is sold in 1 liter PET bottles with polypropylene caps. A bottle weighs 40 grams, the cap weighs 1 gram. Bottles and caps are molded, filled, and transported 550 km from the French Alps to England by a 7.5-16 tonne truck, refrigerated for 2 days and then sold. The overall life of the bottle is one year.

An example product file for this case study is installed with *Granta EduPack* in the *Samples* folder, with the filename *Level 2 - Bottle PET.prd*. Eco Audit .prd files can only be opened and saved from the Eco Audit tab, and are saved separately from selection project files (*.ces*).

> **Note:** The **Enhanced Eco Audit** tool contains warnings about restricted substances, and options to include a cost analysis or a secondary process in the audit. For more information on these advanced features, see the **Help** or the teaching resources for EduPack on the Ansys Education Resources site.

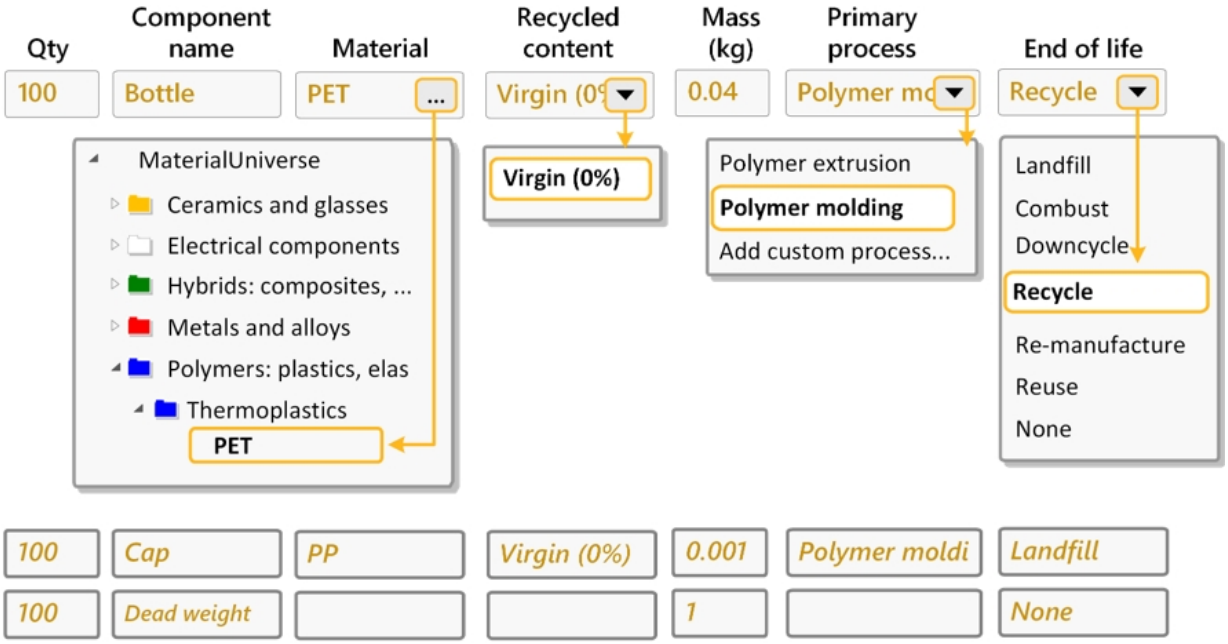
8.1. Exercise 20: Define and audit a product

Enter data for each of your product's components and life phases, then run an Eco Audit Report to analyze each life phase.

To view an explanation of the calculations used at each stage, click the Help icon in the header.

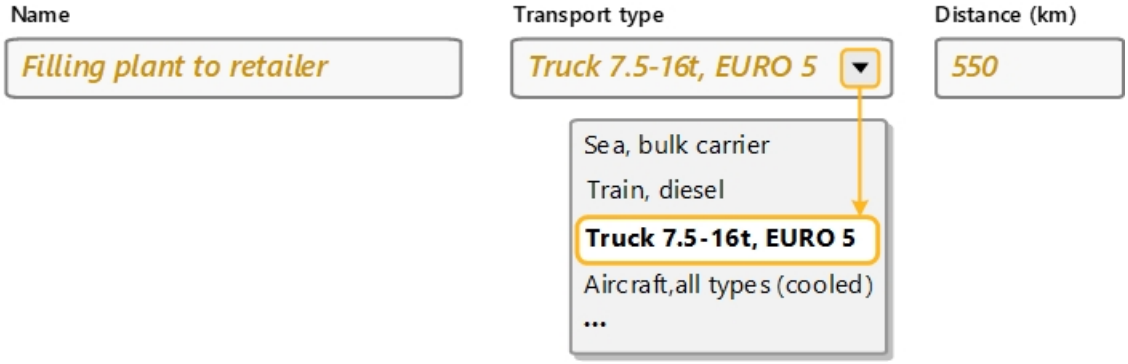
1. Enter material, manufacture, and end of life details

   Bill of materials (BoM) and primary processing method.



2. Enter transport details

Transportation from site of manufacture to point of sale.



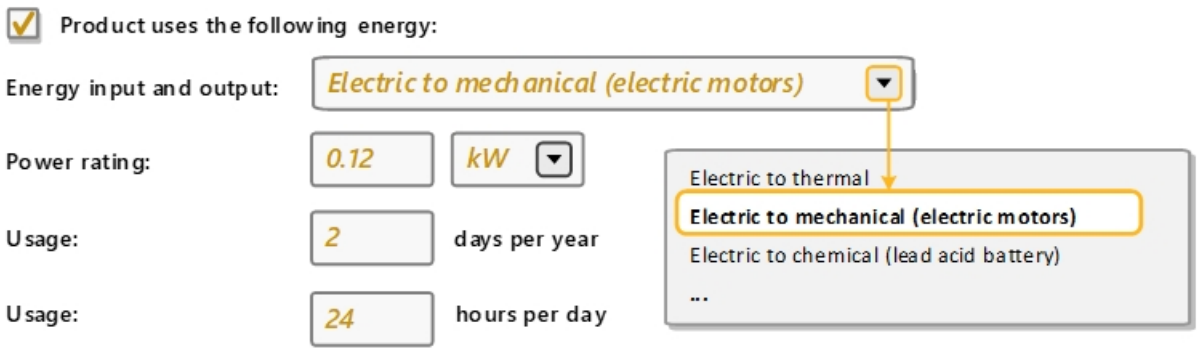
3. Enter **Product life** and **Country of use**

Expected product lifetime and geographic region where it will be used.

4. Enter details of energy consumption during product use

Energy is used to refrigerate the product at point of sale (average energy required to refrigerate 100 bottles at 4°C = 0.12kW). Enter this under **Static Mode**.

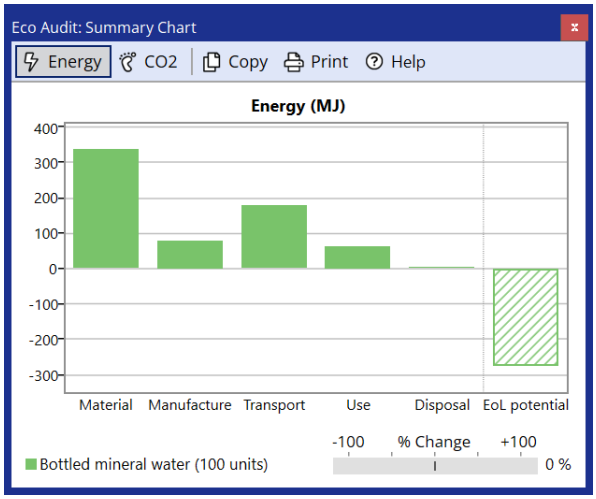
(This product is not part of a vehicle, so there is no **Mobile Mode** entry.)



5. View the **Summary Chart** and **Eco Audit Report**

   Click **Summary chart**. The chart enables rapid identification of the dominant life phase. Toggle between plots of energy usage or Climate change (CO_2-eq).

   For this product, *Material* is the dominant life phase. Each life phase can be clicked to show guidance on strategies to reduce its impact.



   Click **Detailed report** to view a component-by-component breakdown of each life phase. The Report can be saved as a PDF or Word document.

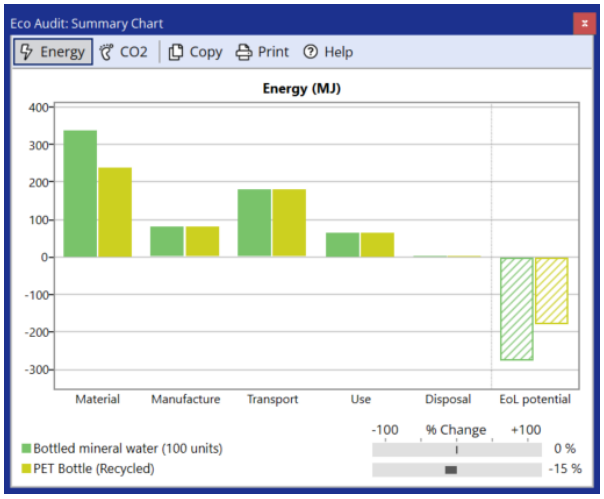
8.2. Exercise 21: Compare products with Eco Audit

You can assess the impact of modifying a product's life phase by comparing products.

This exercise assumes you have completed Exercise 20: Define and audit a product on page 30.

1. Create a copy of your product for comparison
   a) Click **Compare with** on the Product Definition tab and select **Copy of current product**.

2. Change the **Product name** to `PET Bottle (Recycled)`
3. Change the **Recycled content** value for PET to `35%`
   a) Click in the box to manually type in a value.
4. Generate the **Summary chart**.



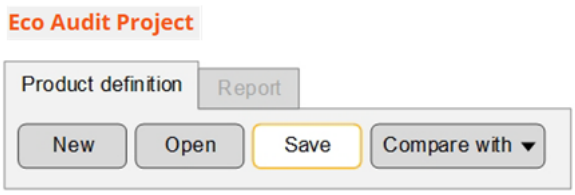
The first life energy (not including EoL potential) is reduced by 15%.

> **Note:** The Summary chart can be copied into a document or printed using **Copy** and **Print** at the top of the chart window.

8.3. Exercise 22: Saving and exporting

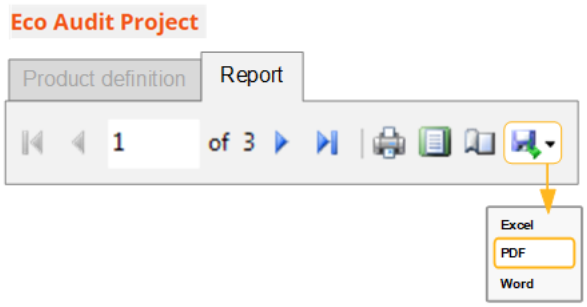
Eco Audit product definitions and reports do not form part of a selection project, and need to be saved separately.

1. **Save** your product definition



2. Generate an Eco Audit Report
   a) Click the **Report** tab (or click **Detailed Report** on the Product definition tab).
3. **Export** the report as a PDF
   a) Click the disk icon at the top of the **Report** tab, and select **PDF**.

   You will require a PDF reader such as Adobe Reader to view the exported report.



9: Synthesizer tool

You can use the Synthesizer Tool to predict the performance of hybrid materials and structures, and compare them with more conventional materials.

> **Note: Synthesizer** is only enabled in the advanced Level 3 databases (for example, Level 3 Sustainability). The toolbar icon will be grayed out if you have opened any of the databases available in Granta EduPack Introductory, including Level 3.

The **Synthesizer** tool is designed for use in the early stage of product development. It consists of three types of model: *hybrid models*, for estimating the performance of novel materials and structures, *Part Cost Estimator*, for calculating the cost of a component based on the materials and processes used, and *Battery Designer*, for comparing early-stage battery module and pack designs.

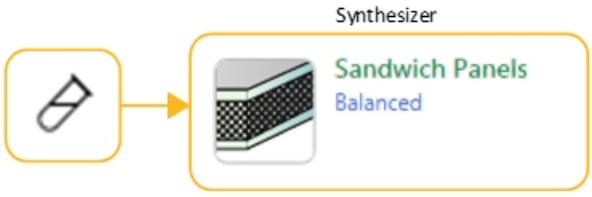
Synthesized records produced using the **Synthesizer** tool can then be compared with existing records in the *MaterialUniverse* database using selection stages.

9.1. Exercise 23: Model hybrid materials with the Sandwich Panels model

Hybrid materials and structures combine the benefits of two or more materials to produce new materials that exhibit unique combinations of properties.

For example, both composite materials and sandwich panels are commonly used to create strong, lightweight structures.

1. You will need to use an advanced Level 3 database for this exercise.
   a) Change the database to **Level 3 Polymer**.
2. Plot *Young's modulus (E)* against *Density (ρ)* using the *MaterialUniverse: All bulk materials* subset
   As in Exercise 6: Create a bubble chart on page 13.
3. Use the *Sandwich Panels* model to create synthesized records for a family of hybrid materials
   a) Click **Synthesizer** on the toolbar (or click **Tools** > **Synthesizer** on the menu bar).
   b) Select the **Sandwich Panels – Balanced** model.



4. Set the **Source Record** values

Face-sheet	*Aluminum, 6061, T6 (wrought)*
Core	*Polymethacrylimide foam (rigid, 0.200)*

Click **Browse** and locate the records in the browse tree.

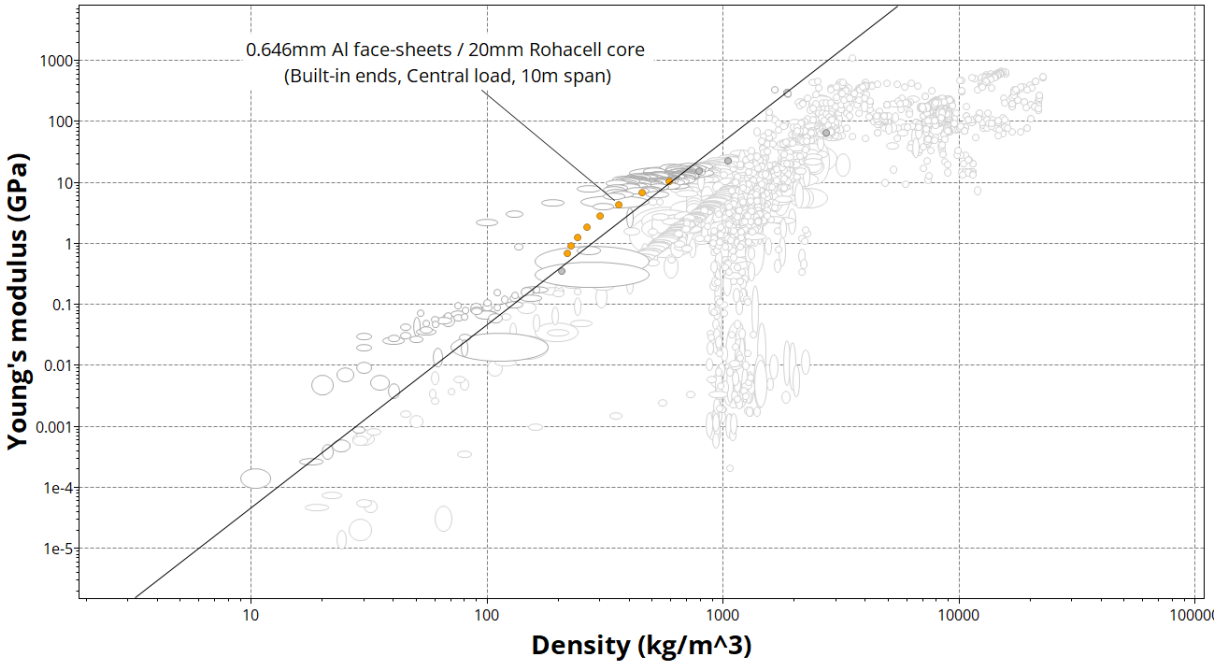
5. Keep the default values for **Model Variables** and **Model Parameters**, and set the following **Record Naming** values:

Face-sheet	`Al`
Core	`Rohacell`

6. Create the synthesized records
   a) Click **Create** and then **Finish**. The new synthesized records are shown in the Results list and on the Chart Stage.

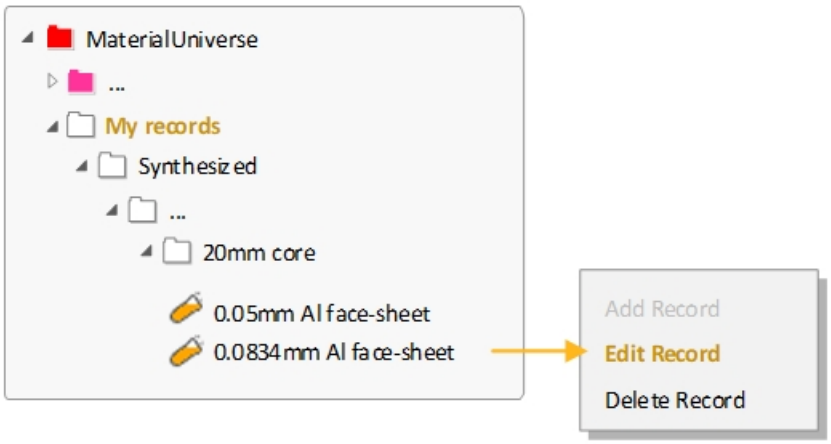
> **Note:** Click the blue Help icon or press F1 in the Synthesizer tool dialog to view further information about the current model type, including details of the calculations used.

7. Plot an **Index line** corresponding to a lightweight, stiff panel in bending: $E^{1/3}/\rho$
   a) Click **Index and display lines**, enter a slope value of 3, and select **maximize the index**. Click the plot area to place the index line, then click and drag to change its position.
8. Add labels to the source records and some of the synthesized records
   a) You can click individual records on the chart and drag to place a label.
   b) You can also add labels from the **Results** list: select one or more records in the list, right-click and select **Label** on the shortcut menu, then drag the labels where you want them on the chart.
   c) Click **Highlight synthesized records** to help you identify the synthesized records on the chart.
   d) Use the Zoom controls and to zoom in to the area of interest on the chart.



9. Navigate to your synthesized records in the **Browse** panel

   Synthesized records appear on the browse tree under **My Records** and may be edited or deleted in a similar way to **User Defined records**.



10. Delete the Chart Stage

9.2. Exercise 24: Part Cost Estimator

The Part Cost Estimator is a Synthesizer model that calculates the total cost of a component based on the material and processing costs.

> **Note:** You will need to use an advanced Level 3 database for this exercise

1. Use the *Part Cost Estimator* to compare the cost of a component when manufactured as an injection-molded polymer, or a rolled and pressed metal

   a) Click **Synthesizer** on the toolbar. In the dialog, select **Cost – Part cost estimator**.

2. Enter the **Component Details** for the first component

Material	*PP (copolymer, 20% talc)*
Value of scrap material	`10%`
Part mass	`6.4`
Part length	`10`
Batch size	`1000 - 1E6`
Number of values	`10`

   For this exercise, the units of part mass and part length do not matter.

3. Enter the **Primary Shaping Process** values

Primary process	*Injection molding (thermoplastics)*
Availability	**Custom form**
Part complexity	**Standard**

   Use the default values for **Load factor**, **Overhead rate**, and **Capital write-off time**.

4. Set the **Record Naming** values

Material	`PP`

Primary process	`molded`

5. **Create** the new records
   a) Click **Create**. Keep the **Part Cost Estimator** dialog open.
6. Enter **Component Details** for the second component
   a) In the **Part Cost Estimator** dialog, click **Previous** and change the **Component Details**:

Material	*YS170 hot rolled* (a high strength, drawing quality steel)
Part mass	`10`

   Use the existing values for **scrap material value**, **part length**, **batch size**, and **number of values** (these are retained from the first material processing chain input).
7. Enter **Primary Shaping Process** values

Primary process	*Hot shape rolling*

   Use the existing values for the remaining properties.
8. Enter details for the **Secondary Shaping Process**
   a) Select **Include secondary process**, and enter the following value:

Secondary process	*Press forming*

   Use the default values for **Part complexity**, **Amount of scrap**, and **Scrap recycled**.
9. Enter the **Record Naming** values:

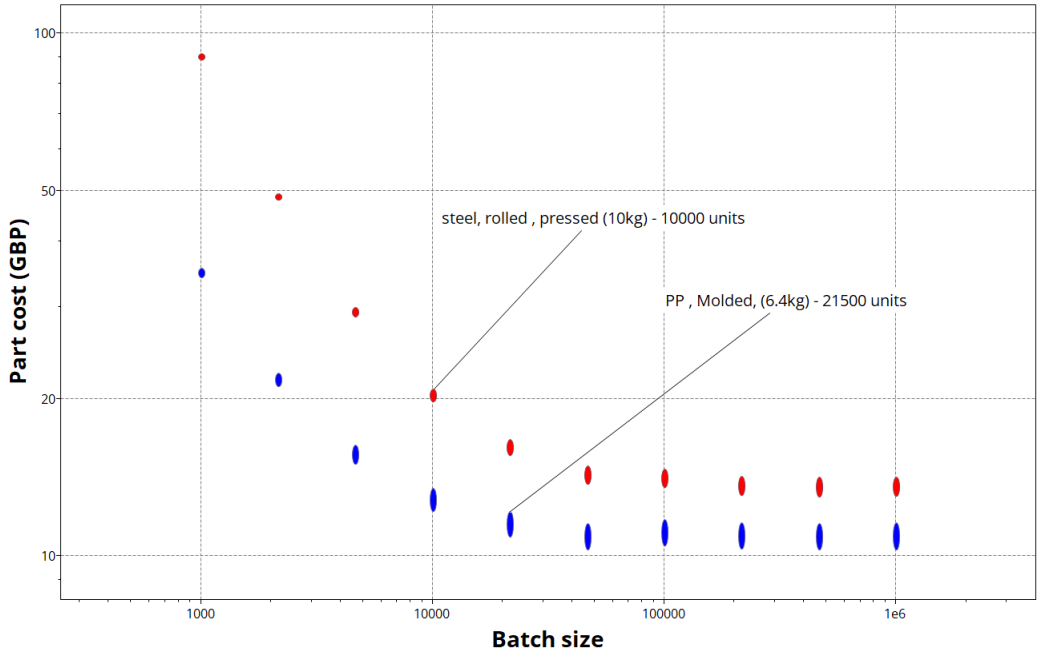
Material	`Steel`
Primary process	`rolled`
Secondary process	`pressed`

10. Click **Create** and then **Finish** to create the records and close the *Part Cost Estimator*

    Synthesized records created using *Part Cost Estimator* are appended to the *MaterialUniverse* browse tree under **My records** > **Synthesized** > **Part cost estimator**.
11. Create a bubble chart to compare the two material processing chains
    a) Select **MaterialUniverse: All bulk materials**, click **Chart/Index**, and set the following x- and y-axis values:

Category	**Part cost estimator**
X-Axis Attribute	**Batch size**
Y-Axis Attribute	**Part cost**

12. Change the **Record color** for easy comparison of the two processing chains
    a) Navigate to **My records** > **Synthesized** > **Part cost estimator**. Right-click the *PP*, *molded* subfolder, click **Record color**, and click a color to change the record color for all records in that folder.



13. Delete the Chart Stage

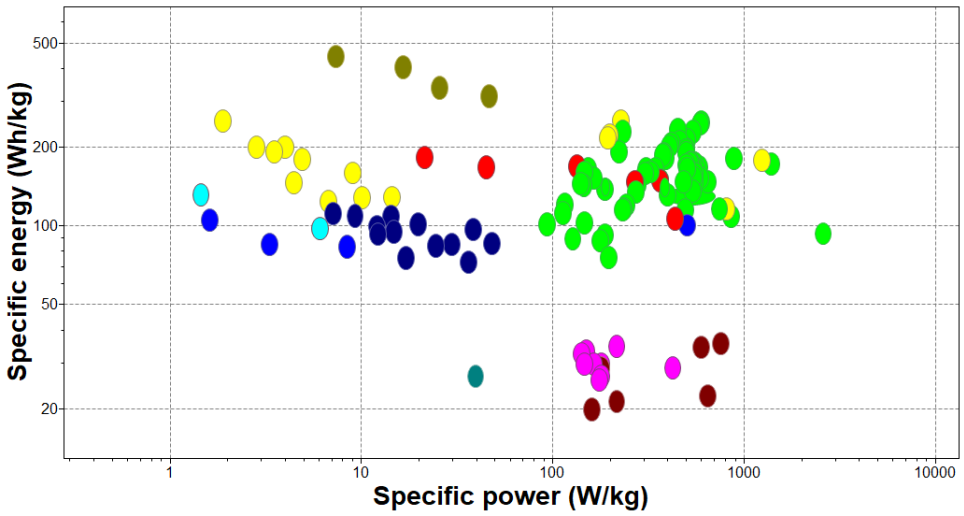
9.3. Exercise 25: Battery Designer

Battery Designer is a Synthesizer model that estimates the performance of battery module and pack designs based on the materials, battery cell type, and thermal management system used.

> **Note:** You will need to use an advanced Level 3 database for this exercise

1. Create a bubble chart to compare individual battery cells.
   a) On the **Chart/Select** panel, **Select from: Battery Cells: All Cells**.
   b) Click **Chart/Index** and set the following x- and y-axis values:

Category	**General**
X-Axis Attribute	**Specific power**
Y-Axis Attribute	**Specific energy**



Charts of *Specific energy* against *Specific power* are also known as Ragone plots.

By default, this will display all cells in the *Battery Cells* table, as well as any synthesized Module and Pack records in the Selection Project.

2. Use the *Battery Designer* to estimate the performance of an example multi-cell module configuration

a) Click **Synthesizer** on the toolbar. In the dialog, select **Battery Designer - Cell to Module (by number of cells)**.

3. Under **Module**, enter the name and battery cell type

Name	`Test Module 1`
Battery Cell	*Lithium-ion (NCA) Cylindrical 3500 mAh*

4. Set the **Number of cells** and target **Discharge Current**

Number of cells in series	`10`
Number of cells in parallel	`2`
Discharge current	`7A`

5. Select a custom **Configuration**

a) Check the **Custom configuration** check box.

b) Make sure the **Or pre-defined module** check box is not selected.

6. Set **Packaging** materials and dimensions:

Casing material	*PC (high viscosity, molding and extrusion)*
Wall thickness	`3 mm`
Insulation material	*PC foam (rigid, closed cell, 0.65)*
Insulation thickness	`3 mm`
Cell spacing	`1 mm`

7. Select a **Thermal management system (TMS)**

Cooling system type	**Passive air cooling**

8. Click **Create** and then **Finish** to create the synthesized record and close the Battery Designer

Synthesized records created using Battery Designer are appended to the Battery Cells table under **My records** > **Synthesized** > **Modules**.

9. Go back to the bubble chart

   The new Module record is now displayed on the Ragone plot.

10. Now create some Module records based on desired performance, and compare them to the existing Module

    a) Click **Synthesizer** and in the dialog, select **Battery Designer - Cell to Module (by performance)**.

11. Enter the **Module details**:

Name	`Test Module 2`
Battery Cell	*Lithium-ion (NCA) Cylindrical 3500 mAh*

12. Set the target **Performance**:

Should last for at least	`60-240 min`
Number of values	`10`
with Current	`7 A`
and Voltage	`36 V`

13. Select custom **Configuration**
14. Set the **Packaging** materials and dimensions:

Casing material	*PC (high viscosity, molding and extrusion)*
Wall thickness	`3 mm`
Insulation material	*PC foam (rigid, closed cell, 0.65)*
Insulation thickness	`3 mm`
Cell spacing	`1 mm`

15. Set the **Thermal management system (TMS)**

Cooling system type	**Passive air cooling**

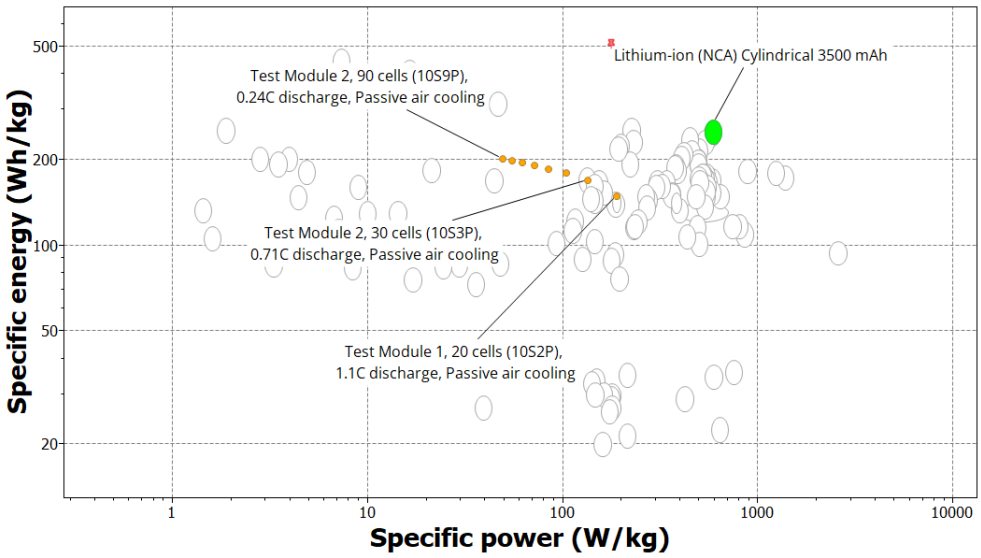
16. Create Module records

    a) Click **Create** and then **Finish**.

17. Compare Module records using the bubble chart

    All the synthesized Modules can now be compared with each other and with individual cells.

    You can also open Module datasheets to view other calculated properties associated with that module, for example predicted operating temperature and discharge time.



To reproduce this chart:

- Set *Lithium-ion (NCA) Cylindrical 3500 mAh* as the Reference record.
- Select **Highlight Synthesized Records** and **Highlight Reference Record** on the Chart toolbar.