Dairy Greenhouse gas Abatement Strategy calculator (DGAS)

Farmer version User Manual

Version 1.2

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Dairy Greenhouse gas Abatement Strategies (DGAS) calculator

The Dairy Greenhouse gas Abatement Strategies (DGAS) calculator has been developed by the Tasmanian Institute of Agricultural Research (TIAR), through funding by the Department of Agriculture, Fisheries and Forestry and by Dairy Australia, to address the greenhouse gas emissions concerns of the Australian dairy industry. It draws upon the Department of Climate Change National Inventory Report 2006 submission to the UN Framework Convention on Climate Change and incorporates the most recent scientific knowledge in its modelling. This manual refers to DGAS version 1.2, October 2009. The model is constructed as a Microsoft Excel Workbook and incorporates MSForms for ease of use.

Purpose of Software

DGAS software is intended to give the User an understanding of the greenhouse gases emitted from their enterprise, both in absolute terms and relative to milksolids produced. The gases, carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are multiplied by 1, 21 and 310, respectively, so as to be expressed in tonnes of CO_2 equivalents. These are then totalled and compared to the tonnes of milksolids produced by the enterprise.

The software is specifically engineered to enable the User to vary the key inputs to the enterprise and compare the effects of changes on emission levels. Both baseline and a strategy data are processed and the outputs graphed for easy comparison. A report of inputs and results can be printed out or saved as an MSExcel spreadsheet.

Due to the detailed inputs required, this farmer version of DGAS has been simplified in terms of data entry. With this may come a degree of inaccuracy with the results? Therefore this must be kept in mind when reviewing the results and the potential changes that may occur with adopting an abatement strategy.

System Requirements

The system is constructed using the Microsoft Office environment and has been tested using MS Excel 2000, 2003 and 2007. The libraries used in the programming of the interface forms are compatible with Office 97 and 2007. All development has been done on Intel-based machines running Microsoft Windows XP. The software has not been tested on other operating systems or hardware, but should run on systems that support Microsoft Office 97 or later.

The security settings of Excel (Office2000: Tools/Macro/Security, Office2003: Tools/Options/Security) should be set to Medium. When you open the DGAS Excel workbook you will be asked whether or not to enable macros. You should do so (“Enable Macros”), for the interface forms to run. After a brief pause, the *Farm Inputs* form will appear and the spreadsheet will be minimised.

The security settings of Excel 2007 (Developer/ Macro Security/ Macro settings) needs to be set to enable all macros before DGAS will run. After a brief pause (approximately 10 seconds), the *farm inputs* form will appear and the spreadsheet will be minimised. You should not need to click the Restart button when opening up the calculator for the first time.

To exit the system, the Excel workbook must be closed. At this point any changes you have made can be saved. If you do not wish to overwrite previous data and still wish to save current data, then use “SaveAs” and save as a different DGAS Excel workbook. Please note the information located in the Save Results section in this report (page 10) pertaining to issues with various formats of MS Office Excel. DGAS should only be saved using the MS Excel 97-2003 format (*.xls), irrespective of which format is currently available to the User for saving (i.e. **Do not** save as MS Excel 2007 [*.xlsx, *.xlsm or *.xlsb] formats)).

At times when multiple copies of DGAS are open, the macros driving the calculator can become interfered with, thus making the calculator unworkable. Therefore we recommend two steps. Firstly when opening up DGAS for the first time, use the “SaveAs” option and only work from this working version; keep the original DGAS version filed separately. Secondly minimise having two or more copies of DGAS open concurrently. If a debug message does appear, there is little that can be done, so delete that file, reopen the original DGAS file and resave as the working version of DGAS.

Workbook View

The DGAS MSExcel file is editable, to enable further refinement of the model. There are three functional categories of worksheets in the workbook. In order to protect the workbook from inadvertent damage, all sheets except the "BackDrop" sheet are hidden by the macros driving the forms (Figure 1.). If the User closes the forms without deliberately navigating via "EXCEL" buttons, the other worksheets will remain hidden. The "EXCEL" buttons are found on the *Farm Inputs* form (the form that automatically opens when the DGAS file is opened) and the *Results* form.

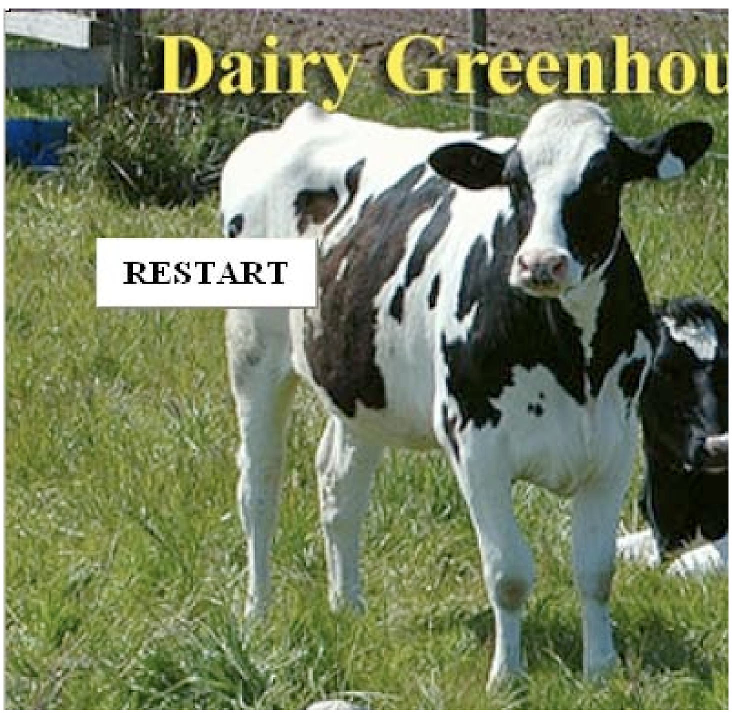


Figure 1. The BackDrop worksheet is the only sheet to be visible unless form-based navigation is used. The restart button will launch the userforms.

Once the Excel worksheets are visible, it is possible to swap freely between the forms and the worksheets via the restart button on the "BackDrop" sheet. The User must deliberately choose to open the worksheets with a view to editing. <u>Such a step is not to be taken lightly</u> and should be done using a copy of the DGAS file.

Introduction page

After DGAS is opened but before the input sheets appear, an introduction page will appear. On the page there are three areas of information with which a first-time user needs to become familiar. These are navigation between forms, saving DGAS and printing the results. To close the introduction page and proceed to the first input sheet, click the cross in the top right hand corner of the page. After the User has become familiar with these four issues, they can elect to not see the introduction any more by ticking the ‘Don’t show the introduction again’ box. Otherwise this page will appear each time that DGAS is opened.

Input Sheets

Two input worksheets are used to store the descriptions of the baseline scenario (“FarmSheet” and “HerdSheet”), two mirror sheets are used to store the descriptions of the abatement strategy scenario (“Farm_A_Sheet” and “Herd_A_Sheet”) and one worksheet is used to enter the economics (“EconomicsSheet”). Pre-farm emissions are calculated on the farm sheets.

Calculator Sheets

The models used for calculating the emissions resulting from the enterprise of dairying are divided into “Enteric Methane”, “Fecal Methane”, “Nitrous Oxide-Fecal”, “Nitrous Oxide – SoilsFerts”, “Trees” and “Electricity & Diesel”.

Output Sheets

The penultimate worksheet in the workbook is the “ResultsSheet” where the output for the two scenarios is separated and graphed. The 3rd last worksheet, “PrintSheet”, is a summary of both the inputs and the results. It can be saved separately and printed – both from worksheet view and, more easily from the *Results* userform. The last worksheet is the FeedQuality table referencing various feed type qualities.

Structure of Software

The software has, at its core, 15 “worksheets” in an MSExcel “workbook” and six “userforms”. The 15 “worksheets” sheets are the functional components of the software (Figure 2.). Five userforms are devoted to accepting the Baseline, Strategy and Economics inputs and one is used to access the results.

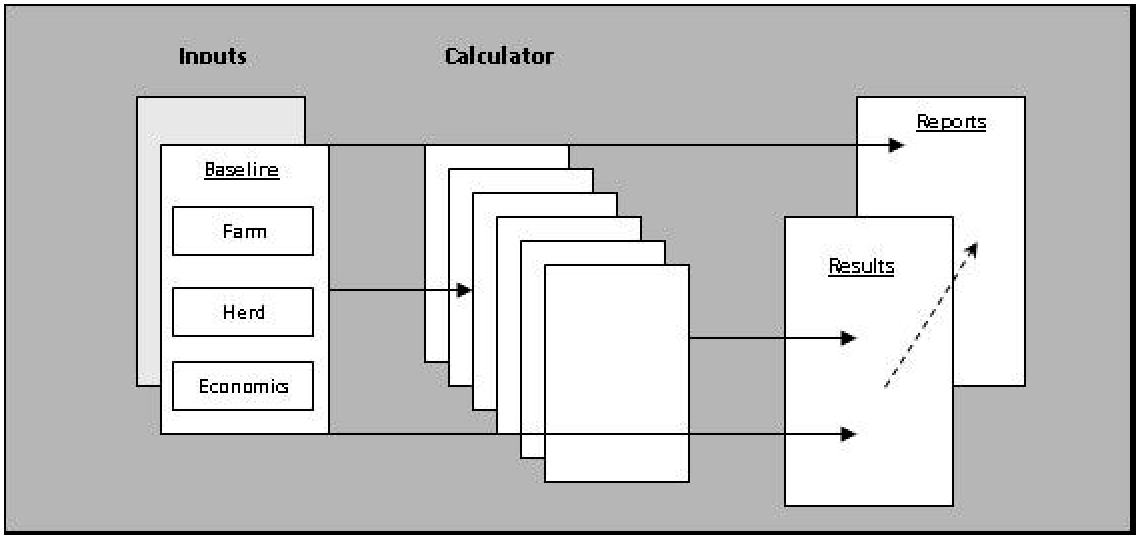


Figure 2. The functional operation of DGAS. Baseline and strategy inputs are passed to the calculator and to the results and report pages. The calculator applies transformations before passing that data to the results page. Results are included in the report.

Navigation

The software is designed to take the User through a specific path of data entry via six userforms. The User is asked to enter details of the current farm practices first. These are divided into *Farm Inputs* (the first form to open when the User chooses “Enable Macros”), *Herd Information* and *Economics*. The current farming practice data is referred to as the “Baseline” scenario and is associated with **green** navigation buttons (see Figure 3.).

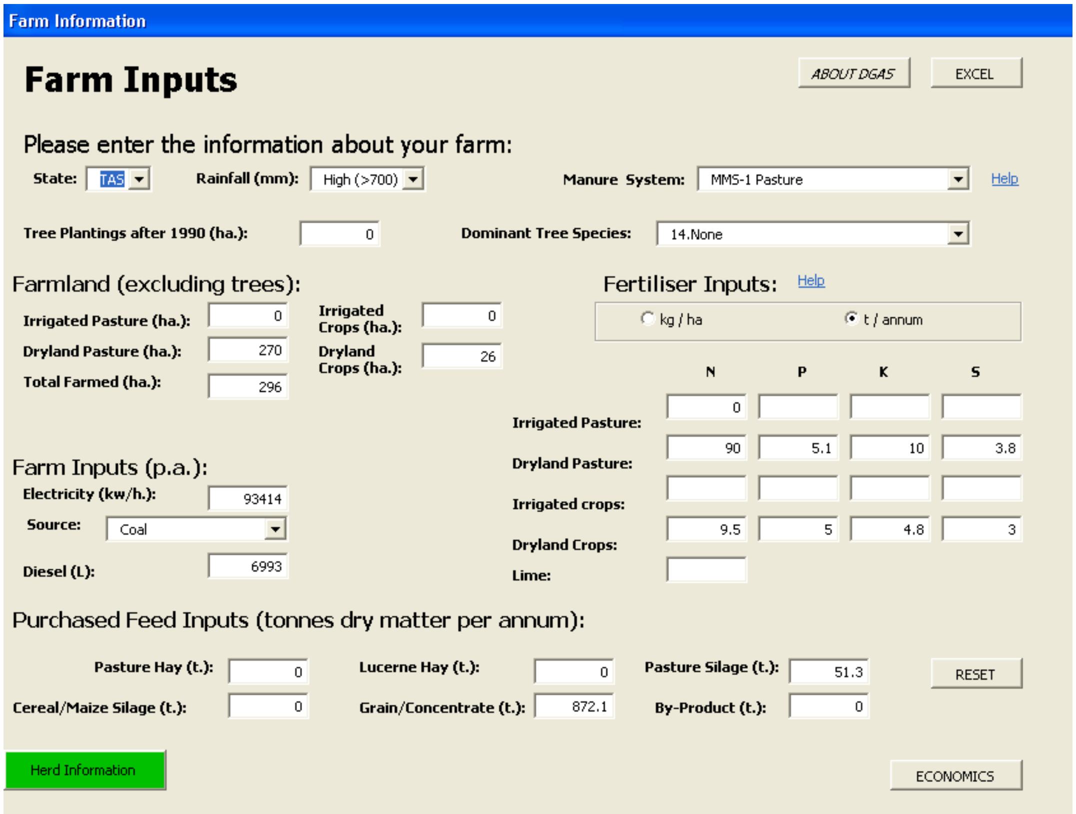


Figure 3. The first data input form – enter the current practices for the farm here. To enter the current herd information, click the green button.

After entering the farm information, selecting the **green** herd information button will open the herd information form. Having entered the herd information, it is possible to go back and edit the farm inputs or navigate to the *Results* form, associated with **red** navigation buttons. You can view the results and after reviewing, you can navigate back and edit the *Herd Information* form by selecting the back button or by closing the page by selecting the "X" in the top right corner of the userform. Once on the *Herd Information,* you can then navigate back to *Farm Inputs* form by selecting the **green** herd information button (Figure 4.).

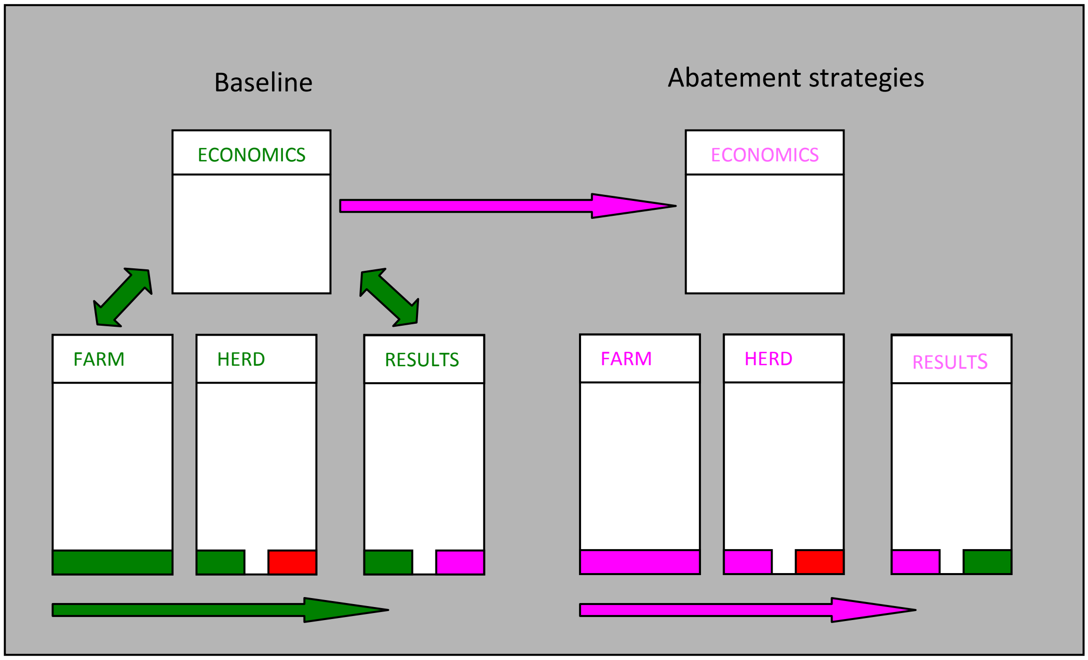


Figure 4. Navigation sequence of the userforms. Baseline information is entered before the User can enter an abatement strategy. Results are viewed after each scenario. The results form permits navigation between scenarios.

The User can enter their economics data from either the *Farm Inputs* form or the *Results* form. To enter the *Economics* form, click on the Economics navigation button at the bottom right hand corner of the *Farm Inputs* form. On the *Economics* form, you can enter the farms' annual financial information. This form can be cleared, closed to return to the *Farm inputs* form and the figures can be transferred to the *Economics Strategy* form. To navigate to the *Economics Strategy* form from the *Economics* form, select the **pink** navigation button. While the financial status of the farm could be of value in determining the effects of adopting abatement strategies and in the potential cost of an emissions trading scheme, it is not essential that the economic data is entered. More information regarding the *Economics* form will be discussed further in this manual.

Once the User is satisfied that the baseline farm data is accurate, the User is then able to enter a speculative scenario referred to as a "Strategy" or "Abatement Strategy" for both the farm inputs and herd information. These are associated with **pink** navigation buttons. The "Farm Strategy" button closes the *Results* form and takes the User to the *Farm Input Abatement Strategy* form. From there it is possible to move to the *Herd*

Abatement Strategy form and then forwards to the *Results* form where output from the baseline and the abatement scenario can be compared, printed or saved.

The User is able to navigate from the forms to the Excel workbook by clicking the "EXCEL" navigation button found on the *Farm Input, Farm Inputs Abatement Strategy* and *Results* forms. This allows the User to assess the equations and emission factors associated with calculating the GHG emissions.

Form Inputs and Controls

The baseline and the strategy *Farm Input* forms have identical data entry fields, with only a small difference in the two *Herd Information* and *Economics* forms. The baseline *Herd Information* form allows the User to copy baseline data for both the farm and herd to the strategy forms as a convenience. The *Economics* form can also be copied from the baseline to the strategy form by selecting the Copy to Strategy button. The *Herd Information Abatement Strategy* form allows the addition of fixed abatement strategies as well as altering herd and diet information. The *Economics Strategy* form has one farm income and two farm expenses boxes to allow the User to indicate the changes in finances associated with the abatement strategy assessed.

Validation

A series of dropdown lists allow the User to select options that require text. All other data requires the User to enter numbers. Text characters cannot be entered (Figure 5.).

Figure 5. Fields requiring numbers will not accept text characters. When the User clicks OK on the error message, the field is reset to zero.

If the User moves to a new form without adding all necessary data, they will be allowed to move, but will be shown a list of the missing data (Figure 6.). This warning is only generated if the User has filled in at least one of the essential fields. Otherwise the User is assumed to have reset the form.

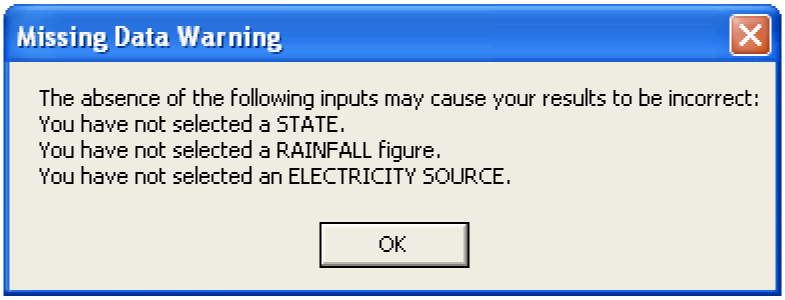


Figure 6. Leaving the farm input baseline and strategy forms will raise a warning if essential data is omitted.

Tips and help

Where appropriate, tips for data entry (such as unit conversions and expansion of abbreviations) will appear if the mouse hovers over an input field or label. More extensive assistance is also provided where complex decisions are required and can be obtained by clicking on the blue "Help" beside complex fields (Figure 7.).

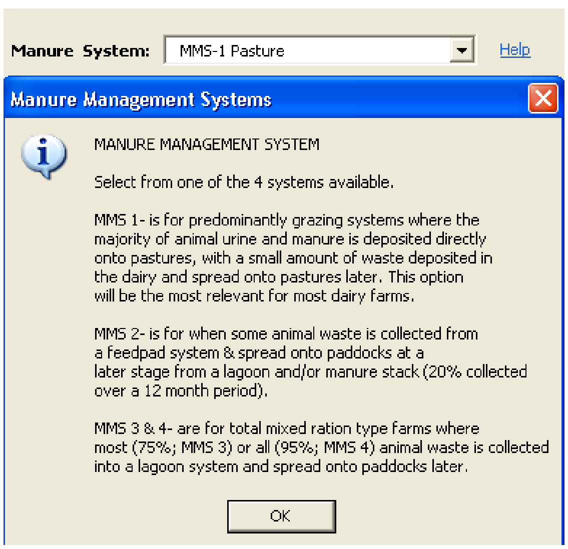


Figure 7. Help for selecting the Manure Management System from the dropdown list.

Reset button

If you wish to clear data from the entire form, click the "RESET" button. The User will be warned and able to cancel the action before data is deleted (Figure 8.).

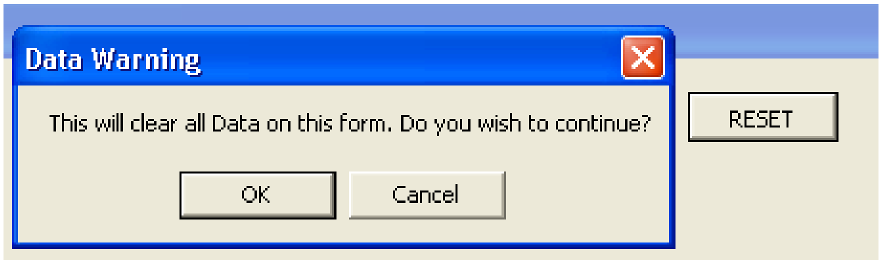


Figure 8. The User has an opportunity to reconsider when clicking the reset button.

Excel button

The “EXCEL” button allows the User to close the form interface and open the MSExcel workbook. All the usual menu items, formulas, format options, etc are available to the User. The sheets may be “protected” but can be unprotected via the Tools/Protection/ menu options.

WARNING: Changes to the workbook may destroy the calculator!

The calculator is highly dependent upon the values in specific cell locations. Even inserting or deleting a row is likely to cause damage that will be difficult to repair. It is best to experiment with a copy of the file first before making any long term alterations. The userforms have similar dependencies since data must be recorded in specific locations.

Print results

The “PRINT” button will compile a report on the “PrintSheet” worksheet and send a print instruction to the default printer. It uses the print setup and print configurations of the Excel program running the DGAS file, and thus of the computer running Excel. The report is set out to fit into 3 or 4 landscape A4 pages. The User is able to reconfigure all of this by altering the layout of the “PrintSheet” worksheet. The page set-up should be in landscape. The margins should be customised so that the top and bottom are 2.5 cm, the left and right are 1.0 cm and the header and footer are 1.3cm.

WARNING: It is suggested that the User only alter the formatting if they absolutely must and that they do so ***only on a copy*** of the file. The report draws on all the input values as well as a copy of the actual bar graph and pie chart. In particular, the nutrition details for the herd are copied to specific blocks of cells at the end of the sheet. Empty data is omitted.

Save DGAS As

The “Save DGAS As” button is found on the *Results* userform. Click on the “Save DGAS As” button and you will be directed to the standard Excel SaveAs dialog box. You can change the name and location of the file to be saved as desired (Figure 9.) .

Although the calculator has been tested on various MS Office Excel formats, including 2000, 2003 and 2007, there are issues relating to saving DGAS in the 2007 format. Therefore, irrespective of the format of Excel, **DGAS must be saved** as a MS Excel 97-2003 format with the xls extension (Figure 10.). **Do not** save it using the Excel 2007 Workbook (*.xlsx), Excel 2007 Macro-enabled Workbook (*.xlsm) or Excel 2007 Binary Workbook (*.xlsb) formats as this has the potential to corrupt the file.

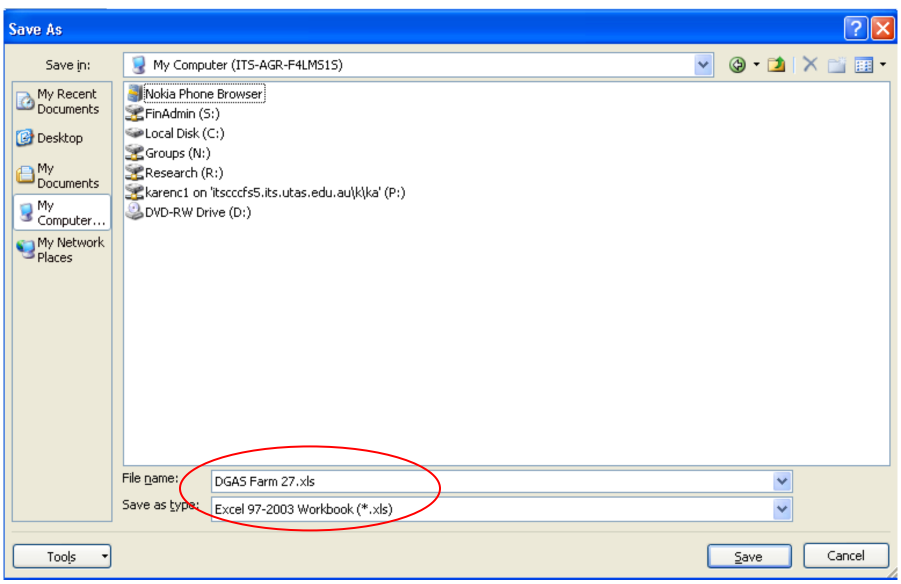


Figure 9. When saving DGAS, always check that the format used to save it is the Excel 97-2003 Workbook format as other formats can corrupt the calculator.

Save results

The “SAVE RESULTS” button allows the User to save the report worksheet “PrintSheet” to a separate workbook. ***It does not*** save the whole DGAS workbook. The default filename of this workbook is “Results.xls” but can be changed in the usual manner through the “SaveAs” dialogue box that is launched when you click the button (Figure 10.).

As the PrintSheet contains Excel charts without their data tables, the User will be asked if they wish to update the charts. Typically the User would choose “No” – especially if the original DGAS file has been moved.

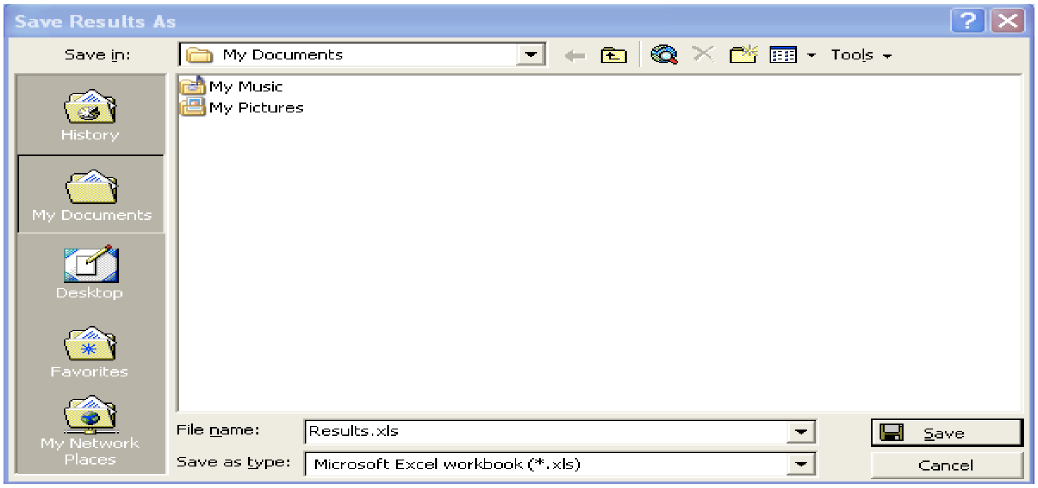


Figure 10. The “SAVE RESULTS” button will allow a report to be saved as a separate Excel workbook.

DGAS User forms

Farm Inputs

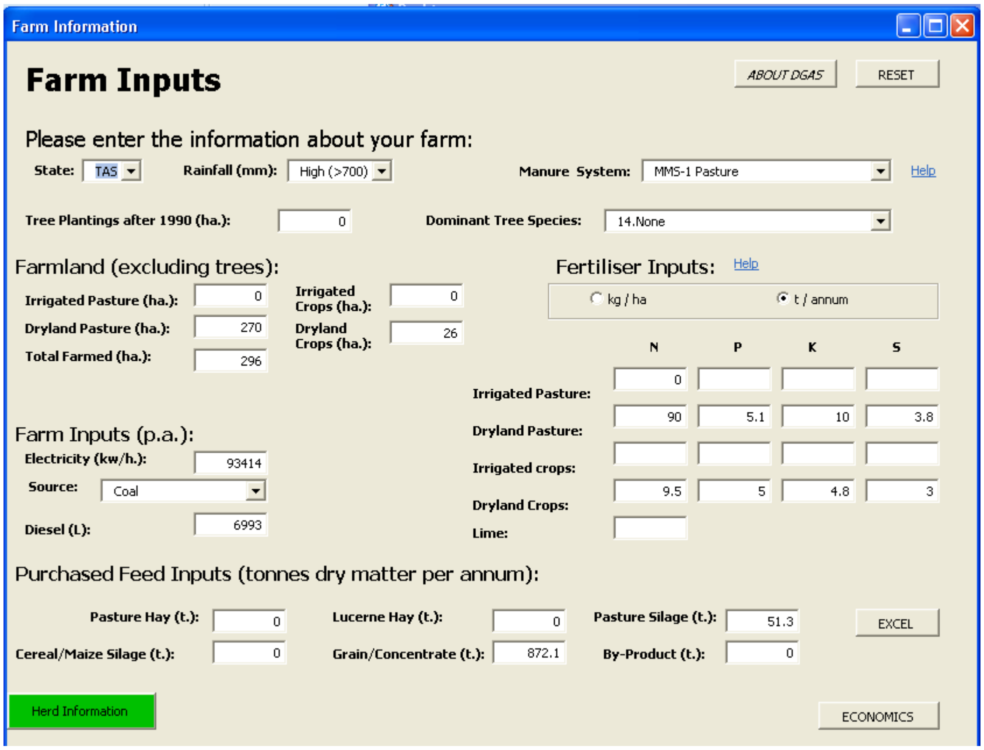


Figure 11. The Farm Inputs form. All text input is selected from dropdown lists. The only data entered using the keyboard is numeric. Data is logically grouped and can be navigated using both the tab and enter keys.

The *Farm Inputs* form contains all the information regarding the physical aspects of the farm (Figure 11.). The "pre-farm" emissions such as those from electricity, diesel, fertiliser and purchased feed inputs are calculated from the data entered on this form. The nitrogen fertiliser data is also used to determine total nitrous oxide- fertiliser emissions and partially determine the nitrous oxide- indirect emissions.

Manure system

The User has one of four options when selecting the manure management system. The proportion of manure that is spread daily onto pastures as the herd grazes determines the emission factor used to calculate the methane- effluent ponds and nitrous oxide- dung, urine & spread emissions. Most dairy farms would select the MMS 1 option, with the bulk of animal waste being directly deposited onto pastures during grazing time. If a farm operation includes using a feedpad area for part of the year, the MMS 2 option may be relevant. This option assumes that 80% of all manures from all stock classes is deposited directly onto pastures and the balance 20% will be stored in a lagoon system or a dry stack and applied to pastures at a later stage. The MMS 3 and 4 options are for farms that operate under a total mixed ration scenario whereby 75% (MMS 3) or 95% (MMS 4) of all manures are stored and applied at a later stage.

Trees

The potential rate of carbon sequestration can be calculated based on the area of land planted to plantation after 1990, the dominant species and the average rainfall range selected. The amount of sequestration is shown in the bar graphs as a positive number for ease of graphing the results only. It is deducted from the total farm GHG emissions and is not included in the ETS liability.

Farmland area

This section allows the User to indicate the area of farm that is considered as growing irrigated and dryland pastures and crops, with the calculator determining total area. The accuracy of this section is only important when selecting the fertiliser kg/ha option (see next section).

Fertiliser inputs

The fertiliser inputs section is important to record the amount of nitrogen fertiliser applied to determine nitrous oxide emissions associated with the fertiliser and to determine pre-farm GHG emissions associated with all fertiliser inputs. The User has one of two options when entering fertiliser inputs. The first fertiliser input option is kilograms per hectare (kg/ha). When this option is selected, the amount of nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) applied to each of the four classes (irrigated and dryland pasture and crops) is multiplied by the area of each class to determine the total amount of fertiliser applied. If this option is employed, accurate farmland area is important. Under some circumstances, farmland area may need to be greater than the actual farm area. For example, a 10ha irrigated crop during the spring to autumn seasons may have had 100kg N/ha applied over the growing period. After harvesting, this area may be oversown with a dryland perennial pasture for winter and fertilised with 155 kg N/ha. This fertiliser inputs option will cater for these different classes and fertiliser rates.

The second fertiliser input option is tonnes per annum (tonnes/annum; shown as selected in Figure 12.). Selecting this option is used when a total amount of nutrient is known and isn't reliant on the farmland area. If the User is unsure as to whether the fertiliser was applied to irrigated or dryland pastures/crops (i.e. just know that you purchased 100t N but unsure how much of it went onto irrigated pastures/crops and how much went onto dryland pastures/crops), just enter the information in the irrigated boxes. The overall emissions will only be marginally greater using the irrigated option compared to the dryland option. The help button will assist the User with calculating fertiliser inputs.

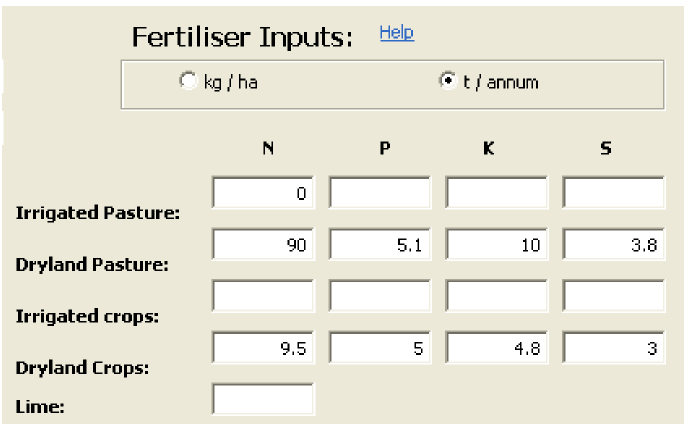


Figure 12. The fertiliser inputs section, highlighting that the tonnes per annum option was chosen and that there was fertiliser applied to irrigated and dryland pastures.

Farm inputs

There are three types of electricity source that can be selected; coal, natural gas and clean (hydro, wind, solar etc). As most of Australia is linked to a national grid, it may be difficult to know what the source of electricity is. To overcome this, there is a 4^{th} option, unknown, which can be selected. While most farms fuel usage would be predominantly diesel, if larger amounts of unleaded fuel is used, this can be included in the diesel usage. The GHG emission factors for diesel and unleaded fuel are similar so the outcome would not be too inaccurate.

Purchased feed inputs

The User can enter the amount of purchased feed inputs brought onto the farm. There are four forages, a grain/concentrate and a by-product section. These figures are reported as tonnes of dry matter per annum and are multiplied by an emission factor to determine the GHG emissions associated with the production of these feed types. Byproducts include feeds like canola meal, whole cottonseed, vegetable waste, brewers' grain etc. Select the section that is most appropriate to the feed types you purchase but do not be too concerned as these amounts are only important for the pre-farm GHG emissions calculations.

Herd Inputs

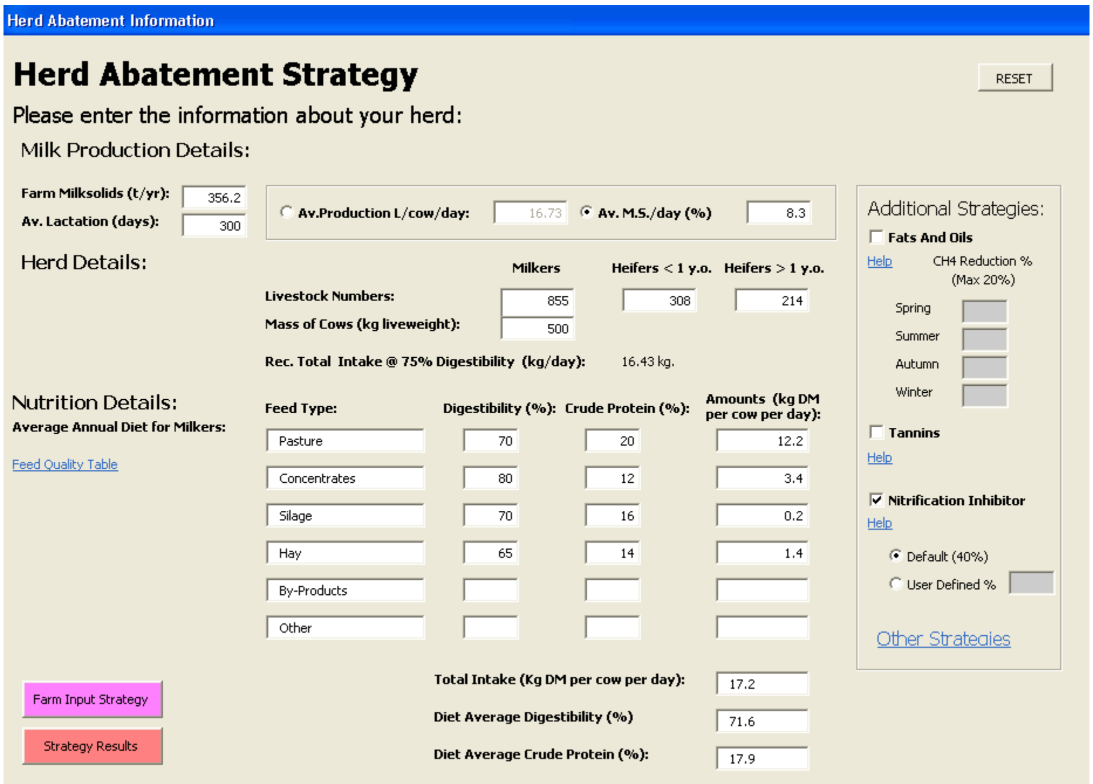


Figure 13. The Herd and Herd Abatement Strategy pages are identical with the exception of the additional strategies section and the colour of the navigation buttons. This allows for the inclusion of three fixed greenhouse gas abatement strategies: feeding fats and/or tannins and using a nitrification inhibitor. These strategies can be used in isolation or in combination by checking the appropriate boxes.

Milk production

Milk production details are needed to determine the level of energy from the diet that is available for methane production. Daily per cow milk production can be calculated by one of two methods. If daily per cow milk production is known, click on the Av. Production L/cow/day radio button and enter the litres. This figure is the average litres per day for the whole duration of the lactation, not the peak milk production. For example, if the average per cow milk production was 6,000 litres over 300 days, then production per day would be 20 litres.

The second option is by clicking on the Av. MS/day % radio button and entering the average milksolids percentage over the duration of the season. When using this second option, farm milksolids, average lactation length and number of milkers needs to be already entered. If any of these figures has not been entered prior to selecting the Av. MS button, an error message will prompt the User to this.

In Figure 13. above, the Av. MS/day % radio button was selected. Based on the herd size, annual milksolids production and quality, the calculator determined that each cow would have produced an average of 16.73 litres/day over the duration of the lactation (value is presented in the Av. Production L/cow/day box but can't be altered here). This gives the User an opportunity to review the various values if this milk production figure seems too high or low.

Herd details

To simplify the data required for the farmer version, the herd details section has been dramatically reduced compared to the adviser version of DGAS. In the farmer version, only the milking herd size and weight, and the number of replacements (0-1 yr old and 1-2 yr old) are required. Form these figures, DGAS calculates the weight of the replacements, based on a fraction of the mature cow weight, the daily weight gain of the replacements and the number and weight of bulls (all these calculations are hidden but can be seen in the excel spreadsheet).

If you milk year round the number of milkers needs to reflect the total number of cows that have calved and contributed to the total milk production for the year. For example if you milk 300 cows year round, there is generally 30 cows calving each month so the total number of milkers would be 360 over the 12-month period. Enter 360 in the herd size box.

Calculation of feed intake

The calculation of feed intake has also been simplified in the farmer version of DGAS, compared to the adviser version. Only an average annual diet for the milking herd is required. Five specific feed types are considered and a sixth category can be used to incorporate “Other” feed types. If you are feeding two types of silage but no hay, the second silage figures can be entered in the hay section to determine the diets’ digestibility and crude protein %.

The calculator has been programmed to automatically suggest likely dry matter digestibility and crude protein % for pasture, concentrates, silage and hay. While these figures are typical, the User may wish to alter these figures on the *Herd Inputs* form. If however, the User wants a more permanent change of the default figures, by clicking on any of the EXCEL buttons (assessed from the *Farm inputs* or *Results* forms), selecting the HerdSheet worksheet and scrolling down to cell A24 (Figure 14.), each of the feed types can be altered. Save this new version of DGAS with a new name, then open up and reset both the *Herd Information and Herd Abatement Strategy* forms. Save this new version again so that each time the calculator is opened, these altered values appear for the milking herd’s diet.

Default Feed Values.	
Pasture	
Digest.	70
Protein	20
Concentrate	
Digest.	80
Protein	12
Silage	
Digest.	70
Protein	16
Hay	
Digest.	65
Protein	14

Figure 14. Default feed values for digestibility and crude protein for pastures, concentrates, silage and hay.

All feed data needs to be entered on a dry matter basis, by converting all wet weights to dry weights. For example, grain is generally 90% dry and 10% moisture. If you feed 5 kg of grain (as fed), multiply this by 90% to get 4.5 kg DM. Likewise, if you feed 3 kg of silage (as fed) that is 33% dry, then by multiplying 3 kg by 33%, you are feeding 1 kg DM of silage.

Average dry matter %, dry matter digestibility % and crude protein % for an array of feed sources can be accessed by clicking on the Feed Quality Table button. This takes you to a list of common feed sources, sourced from a Victorian DPI website. To return to the *Herd Inputs* form, click on the close button in the top left hand corner.

Entering the daily intake of each feed source with their corresponding digestibility and crude protein % is essential to determine the annual diet quality figures for the milking herd. While these figures need to be fairly accurate, there is some room for variation. Therefore do not be too concerned if you are not sure if its 8 or 9 kg pasture/day, as long as the figures are relatively accurate (i.e. difference between 8 and 9 is minimal compared to 5 or 10 kg). These intake values determine the overall dry matter digestibility and crude protein figures and are used to determine methane and nitrous oxide emissions. The diet for the replacement herd and the bulls is assumed to be equivalent to the milking herds' pasture quality information.

A recommended daily feed intake is estimated for the milking herd to achieve their daily milk production average, based on the overall diet having a digestibility of 75%. This figure is intended as a convenience for the User, so that once the User has entered the milk production data and the amount of grain and other supplements, they can then have a realistic indication of the daily pasture intake required to achieve that level of milk production. The recommended daily intake can also assist if one abatement strategy involves an increase in milk production. The User is able to ascertain the level of feed intake required to achieve this increase in milk production and therefore increase feed intakes accordingly. The feed intake calculation assumes an average feed digestibility of 75% and will not be shown until milk production and herd weight are entered. For the example below (Figure 15.), the herd would need to be consuming a minimum of 17.3 kg DM/day over the duration of the lactation to achieve the milk production entered.

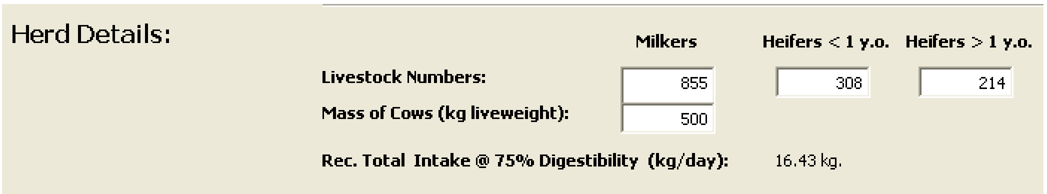
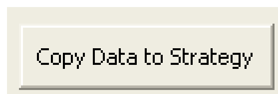


Figure 15. The daily feed intake to achieve this level of milk production is 16.43 kg DM/day over the duration of the lactation, when the diet is 75% digestible. If the mean digestibility is lower, this intake needs to be slightly higher.

<u>Copy baseline data</u>

Once farm and herd data is entered on their corresponding forms, all entered data can be transferred to their corresponding abatement forms. This is achieved by clicking on the “Copy Data to Strategy” button 

at the bottom left hand side of the page. This reduces the re-entry of the same data needed on the abatement strategy pages. When the User navigates to the strategy forms, they need only edit the particular inputs they wish to change.

Economics

Figure 16. The Economics page allows for a comparison of the EBIT (Earnings Before Interest and Taxes) for the baseline and strategy farms.

From the *Farm inputs* form, the User can navigate to the *Economics* form. While it is not necessary to enter any financial information into DGAS, the facility to enter data allows the calculator to have more power in illustrating the effect of adopting an abatement strategy on farm economics, especially in conjunction with an emissions trading scheme.

There are three help messages on the *Farm Economics* page to assist in entering the base farm economic information and how to use the calculator to determine the effects of an emissions trading scheme (ETS) on farm EBIT (Earnings Before Income and Taxes).

The *Economics* form allows the User to enter the annual total farm income, herd expenses, pasture and feed expenses and overhead expenses (Figure 16.). Total income, total expenses and EBIT are calculated on a total basis and on a per kilogram of milksolids basis.

The User can then assess the effects of an emissions trading scheme (ETS) on the baseline and abatement strategy farm EBIT. After entering the farm economic data and selecting a carbon price ($/t CO_2-e) and the percentage of GHG emissions the farmer is liable, by multiplying these two figures by the farms GHG emissions/t MS, the calculator determines how much the farms EBIT has decreased and the new EBIT (Covered EBIT) as a result of the ETS. In the example in Figure 16 above, the baseline farm EBIT was $1.30/kg MS before the ETS. Under an emissions trading scheme, with an emission of 12.16 t CO_2-e/t MS, a carbon price of $25 and a 10% liability, the EBIT was reduced by $0.03 to be a covered EBIT $1.27. This is the new farm EBIT after paying for the necessary credits for the farms GHG emissions.

Once an abatement strategy has been assessed in terms of its effect on the farms GHG emissions, the economic implications of this strategy can also be examined. In the current example, we assessed the effect of a nitrification inhibitor in reducing N_2O fertiliser emissions by 40% over a 12 month period. The abatement strategy reduced GHG emissions intensity from 12.16 to 11.69 t CO_2-e/t MS (Figure 17.). However there was an additional fertiliser costs of $15,000 associated with the strategy (Change to expenses box), increasing the total operating cost from $3.22 to $3.26/kg MS. With the same carbon price and farmer liability as the baseline farm system, the farm EBIT was reduced by a similar rate as the baseline farm system ($0.03/kg MS) to now be $1.23/kg MS.

Results

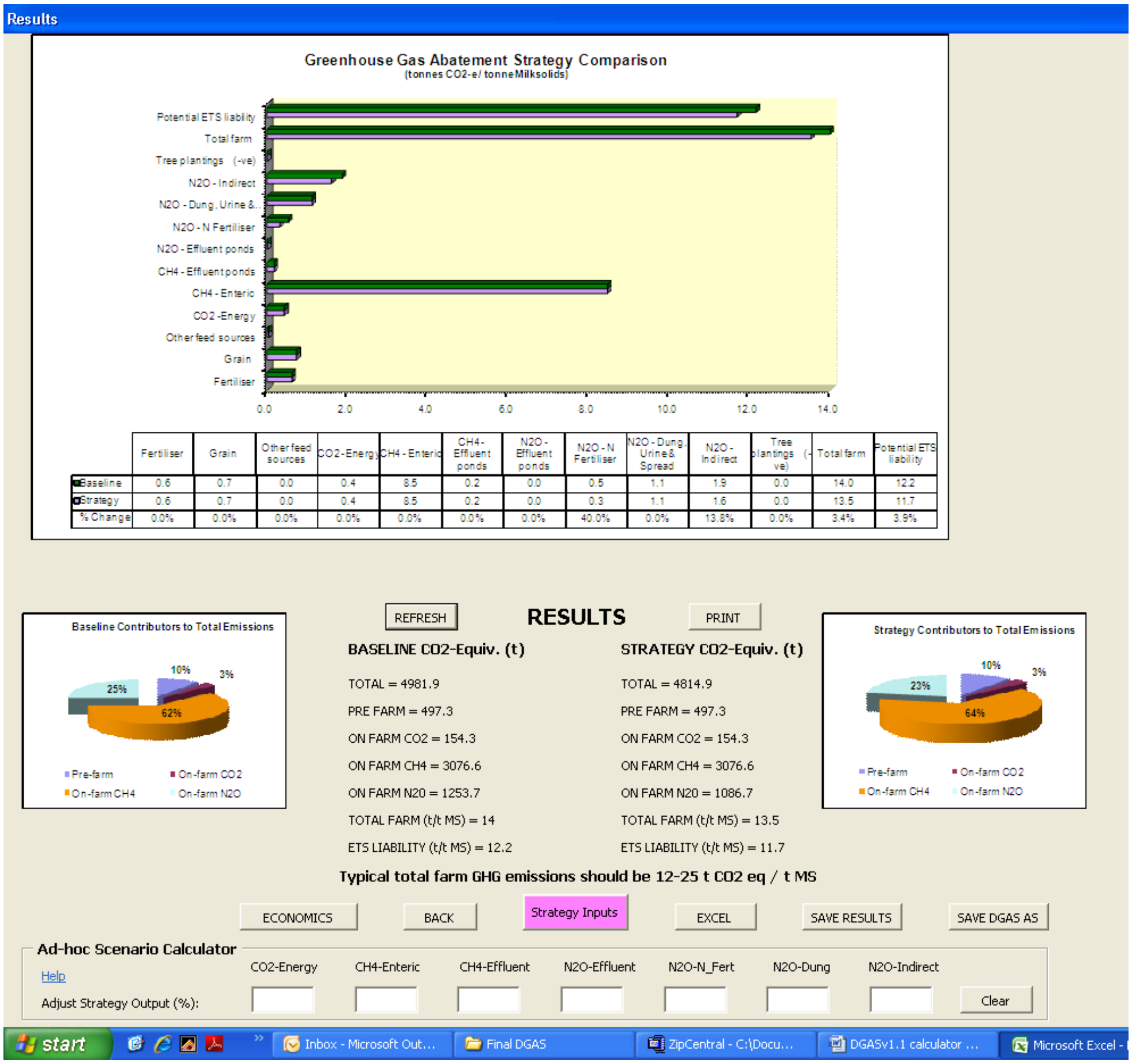


Figure 17. The results form shows the comparison of baseline and strategy greenhouse gas emissions. A summary of these results together with the two input scenarios can be printed or saved as a separate file from this form.

The graphs shown on the *Results* form are images copied from the ResultsSheet in the workbook (Figure 17.). Each time you make a change and return to the *Results* form, this image is updated. A refresh button is provided so that you can re-assure yourself that you are looking at the most up-to-date results from the calculator. If there appears to be an error in the data entry, the User can either scroll forwards through the forms by selecting the **green** Baseline Inputs navigation button if the error is in the baseline data or select the back navigation button if the error appears in the abatement strategy data.

Bar graph

The bar graph shows the contributing factors and total emissions for both the baseline farm system and for an abatement strategy system. The units of measurement are tonnes of carbon dioxide (CO_2) equivalent per tonne of milksolids produced.

The contribution of tree plantings in sequestering CO_2 is subtracted from the total emissions from the farm, but is shown on the graph as being a positive value. This is only for formatting reasons and has been identified on the axis label as “Tree Plantings (-ve)”.

The top two bars represent total farm emissions and emissions under an emissions trading scheme. Total farm emission is the sum of pre-farm embedded emissions, on-farm carbon dioxide emissions, on-farm methane emissions and on-farm nitrous oxide emissions minus any tree planting sequestration.

At the time of developing this model, an emissions trading scheme (ETS) titled the Carbon Pollution Reduction Scheme (CPRS) was in the process of being introduced and a decision on the inclusion of agricultural in a CPRS will not be made until 2013. The ETS liability used in this calculator is the sum of on-farm methane and on-farm nitrous oxide emissions minus any tree planting sequestration. Which emissions will be accounted for under a CPRS for dairy farms is currently unknown. We have used the above calculation as a guide only.

The data table below the bar graph indicates the actual values of each contributor and the percentage change in emissions achieved adopting an abatement strategy for each contributor. A positive ‘% better’ figure indicates that the GHG emissions/t MS for that source has decreased while a negative ‘% better’ figure indicates that the GHG emissions/t MS for that source has increased (e.g. increased grain feeding could result in a negative % better figure).

Pie chart

The Pie charts (one for the baseline and one for the strategy) show the proportional contributions of the pre-farm embedded emissions and the three on-farm gases associated with the enterprise.

Absolute values list

The absolute tonnage of greenhouse gases for the farm (as CO_2 equivalents) are listed in two tables between the pie charts. In addition there is a repeat baseline and abatement strategy total farm GHG emissions/t MS and the ETS liability GHG emissions/t MS from the line graph. Total farm GHG emissions (inc. pre-farm and on-farm CO_2) would be expected to be in the range of 12-25 t CO_2-e/t MS. Any figures vastly different to this would be due to incorrect data entry.

Ad-hoc strategy calculator

The User is able to enter values for a single strategy that is not included in the calculator (Figure 18.). The ad-hoc strategy allows for the User to define a percentage reduction in emission from the seven sources of GHG emissions. This can be used to provide an indication of the level of reduction in emissions required to meet a farm emission target. The User should enter a percentage for each type of emission affected by the strategy. Help is provided to assist with use of the ad-hoc strategy calculator. The strategy series on the graphs and absolute value lists change to reflect the new strategy, when the User moves to a new field or uses the tab key. Ad-hoc scenarios are only retained for the session. They are removed when the workbook is next opened. For the below example, the User has determined a strategy that reduces CO_2 emissions by 10% and a strategy that reduces CH_4- Enteric emissions by 15%. The calculator would then work out the new total farm and ETS emissions for this strategy.

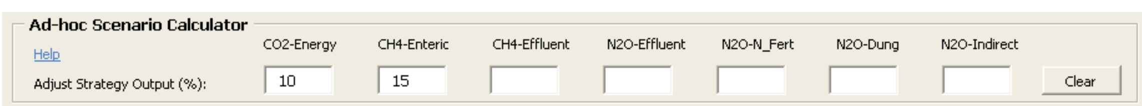


Figure 18. The Ad-hoc Scenario Calculator allows the User to alter DGAS's strategy output.

Additional Abatement Strategies

Three additional abatement strategies have been included on the *Herd Information Abatement Strategy* form. The User can select to feed Fats and Oils, Tannins and/or use a Nitrification Inhibitor to reduce emissions. The strategy of reducing emissions by using fats and/or tannins is only operational on the milking herd; we have not programmed DGAS to calculate the effects of these two strategies for the replacements and bulls in addition to the milking herd. The three approaches can be used concurrently (Figure

19.). Over time as new abatement strategies are available (e.g. a vaccine that reduces methane emissions by 10%), the list of additional abatement strategies can be increased.

Figure 19. The three current additional abatement strategies that are available to be implemented are feeding fats and oils and for any combination of seasons and percentage methane reduction, feeding tannins and using a nitrification inhibitor with ether the default 40% reduction or a user defined percentage. Other strategies can be selected to assist in understanding how to use the Ad-hoc Scenario calculator. Help is available to assist with each of these.

Fats and oils supplementation

Feeding fats and oil can reduce methane emissions. Only select this option if you know the fat content of the diet. Cows can be fed fats to a maximum of 6-7% of their diet. All feeds contain fats so by calculating the fat content of the diet, you can determine if this abatement strategy is suitable for your farming system. For each 1% additional fat in the diet, there is potentially a 5.6% reduction in methane. Therefore if your herd's current summer diet contains 3% fat, you could safely feed another 3%, with a 16.8% reduction in methane. Type 16.8 into the summer box and add the quantity and quality data of the fat into the summer nutritional details. Generally there is some scope to feed fats and oils over summer and autumn periods, especially under dryland conditions. Seek nutritional advice if you wish to adopt this abatement strategy, as feeding fats above 6-7% will decrease feed intakes and result in a depression in milk production.

Tannins supplementation

Tannins bind proteins so they are better digested. This assists in reducing methane and alters the nitrogen content of dung and urine. Selecting tannins will reduce methane by 10%, reduce urine N output by 33% and increase dung N output by 50%.

Nitrification Inhibitor

Nitrification Inhibitors can reduce the emission of nitrous oxide associated with the application of nitrogen fertilisers. Selecting the default strategy calculates a 40% reduction in nitrous oxide emissions. The User may select the default 40% reduction figure or can define their own reduction potential figure. Selecting this strategy will also result in a reduction in the indirect nitrous oxide emissions as approximately half of these are related to fertilisers and the other half to animal waste.

Acknowledgements and Licensing

DGAS is funded by The Department of Agriculture, Fisheries and Forestry (DAFF), Dairy Australia (DA) and the University of Tasmania; compiled by staff of the Tasmanian Institute of Agricultural Research (Robert Kildare, Karen Christie and Dr Richard Rawnsley) with the assistance of Dr Richard Eckard, University of Melbourne.
This calculator is a further development of the Dairy Greenhouse Framework calculator, compiled by Richard Eckard, Roger Hegarty and Geoff Thomas.

Note:

a) The calculator is subject to development at all times,

b) The methods are continually changing so we take no responsibility for the currency of the tool, and

c) Professional advice should be sought on the interpretation of the results and the consequences of adopting abatement strategies.

Table 1. Average dry matter %, dry matter digestibility and crude protein % figures for various feed sources (data sourced from the Diet Check program, referencing feed quality data from FEEDTEST, DPI Victoria (link at bottom of table)

	Dry matter %			Dry matter digestibility %			Crude protein %		
	Average	Range		Average	Range		Average	Range	
Barley grain	88.7	81.2	97.0	79.5	55.6	87.3	10.8	6.3	19.0
Barley hay	87.0	66.1	93.7	56.9	27.2	72.4	8.2	1.2	14.6
Barley silage	39.0	20.9	64.3	58.8	35.6	74.3	10.7	5.5	22.9
Barley straw	89.3	73.4	93.6	42.0	14.2	55.0	2.8	0.2	28.8
Brewer's grain	28.2	13.9	60.6	69.8	53.7	90.5	21.6	9.8	28.8
Canola meal	90.5	87.4	93.5	78.2	63.4	102.1	37.5	27.4	42.1
Carrot pulp	10.0	8.0	15.5	82.1	56.9	91.8	9.8	6.5	15.3
Citrus pulp	14.3	10.6	17.3	83.4	62.1	93.7	8.6	6.0	11.9
Cottonseed meal	89.8	87.5	95.3	71.8	62.1	82.1	43.5	39.5	48.0
Clover hay generic	86.6	61.3	93.2	57.5	40.1	72.4	17.6	6.3	26.1
Clover silage generic	41.9	20.9	79.5	62.1	52.4	68.5	19.3	12.4	27.2
Grape marc	55.1	19.6	93.9	40.7	14.9	78.2	12.1	5.4	17.2
Grass hay	86.3	51.9	94.0	51.7	31.7	67.9	8.0	0.7	17.7
Grass silage	43.2	17.1	89.3	60.1	31.0	77.6	13.2	5.1	26.6
Legume/grass silage (grass dom.)	86.4	45.2	95.9	56.9	33.6	73.7	14.5	4.1	25.4
Legume/grass silage (legume dom.)	42.1	13.7	68.3	60.8	38.1	73.7	16.0	7.3	28.6
Lucerne hay	87.8	36.0	96.1	60.1	34.3	73.1	18.9	5.7	29.7
Lucerne silage	49.5	15.8	87.7	60.8	31.0	70.5	20.0	5.3	32.1
Lucerne straw	86.1	68.2	93.4	36.9	27.8	44.0	8.9	5.9	14.1
Lupin seed	91.6	86.1	95.5	81.5	72.4	96.3	32.0	21.3	43.2
Maize grain	84.2	60.3	96.4	89.2	79.5	96.3	10.0	7.3	21.9
Maize silage	30.9	9.2	84.5	68.5	32.3	84.0	7.7	3.4	17.1
Oats	91.1	80.0	93.3	66.6	38.1	91.8	9.0	4.0	15.4
Oaten hay	88.9	40.2	96.4	54.3	29.1	73.1	6.9	1.1	16.3

	Dry matter %			Dry matter digestibility %			Crude protein %		
	Average	Range		Average	Range		Average	Range	
Oaten silage	40.9	18.1	82.2	56.2	38.1	72.4	9.8	3.8	19.4
Oaten straw	89.4	80.2	93.8	40.1	27.8	64.7	2.8	0.1	11.9
Pasture hay	86.2	48.6	95.5	54.3	34.3	72.4	10.8	1.7	30.0
Pasture silage	43.1	10.9	87.6	60.8	14.2	76.3	14.1	3.2	27.3
Persian clover hay	85.6	67.8	93.5	62.1	45.3	75.6	16.2	5.3	23.3
Persian clover silage	42.9	23.7	81.9	64.0	53.0	72.4	17.6	8.0	23.4
Rice bran	90.4	89.9	90.8	89.9	60.1	97.6	15.5	12.9	19.6
Rice straw	85.2	52.2	93.5	43.3	34.3	57.5	4.0	1.9	5.0
Sorghum grain	89.6	86.2	94.4	86.0	80.8	93.1	10.6	9.6	13.2
Soyabean meal	85.4	11.9	93.7	96.3	86.0	104.7	43.5	29.3	53.7
Sub clover hay	86.8	71.7	93.9	56.9	42.0	68.5	17.2	7.7	25.7
Sub clover silage	37.1	20.6	59.9	61.4	33.6	67.9	18.8	12.6	26.9
Sunflower meal	90.8	86.4	92.0	64.0	54.3	90.5	34.1	20.4	39.1
Tomato pulp	27.3	16.6	30.2	49.8	26.5	60.1	19.4	5.0	22.6
Triticale grain	89.4	80.3	96.9	84.0	75.0	87.3	11.4	6.6	18.8
Triticale hay	86.6	54.3	93.9	55.6	31.0	69.2	7.3	1.3	16.2
Triticale silage	42.9	20.1	71.0	58.8	45.9	72.4	10.8	4.0	24.0
Triticale straw	89.8	62.7	95.7	40.1	26.5	58.2	2.8	0.7	6.7
Turnip tops*	29.1	8.5	87.7	86.6	69.2	93.7	15.9	7.2	29.6
Turnip bulbs*	23.7	4.7	87.4	89.9	75.6	95.7	14.8	4.6	26.7
Wheat bran	34.0	15.1	89.6	77.6	70.5	85.3	17.9	8.4	29.8
Wheat grain	89.4	80.2	92.9	84.7	67.9	91.2	12.9	7.4	22.7
Wheat hay	87.9	46.8	95.1	56.2	31.7	71.1	8.2	0.1	17.4
Wheat silage	44.9	27.5	69.1	56.9	29.7	69.2	10.0	6.5	16.0

http://dpi.vic.gov.au/DPI/nrenfa.nsf/childdocs/-180715ADC627966E4A256B750004BDD5-339BEADDC806EC76CA256C85007F5276-3A6971B9781EF822CA256D86007EF25C?open