Eskom

Corporate Services Division

Corporate Technical Audit Department

Contracted the North-West University to execute this project

The Measurement and Verification Guideline:
Geyser Insulation Distribution Projects (Draft)

Project Name:	M&V Guideline: Geyser Insulation Distribution
Project Number:	N/A
Report Type:	M&V Geyser Guideline
Reporting Period:	N/A

Report Issue Date: 30 APRIL 2008
Report Number: PM/M&V/NWU - 07/08 – M&V Geyser Guideline (Draft) v2r1
Revision Number: M&V Geyser Guideline (Draft) v1r11

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Nomenclature:

NWU	North-West University
M&V	Measurement and Verification
DSM	Demand Side Management
T_e	Environmental Temperature
T_s	Set Point Temperature
m	Slope
ID	Identification Number
CPUT	Cape Peninsula University of Technology

1 INTRODUCTION

NWU M&V team was requested by Eskom to develop a standard methodology and procedure to determine the impact of installing geyser and pipe insulation. This standard methodology and procedure will reduce the amount of work needed during a national roll-out campaign. This report is the draft geyser insulation guideline and needs to be approved by all the M&V teams before the finalisation of the guideline.

The guideline includes a description of the methodology and procedures followed to characterise the impact of geyser blankets on the standing losses, extension of the methodology to pipe insulation and a user manual for the application.

2 METERING PROCEDURES AND CHARACTERISATION

The NWU M&V team evaluated a sample set of geysers to characterise the influence of geyser blankets on standing losses. The methodology followed is described in this section. The results from this study formed the foundation for the application developed. The purpose of the application was to determine the impact of geyser blankets and pipe insulation, on standing losses.

In order to quantify and assess the savings, some measurements and calculations needs to be made. Expenditure on measurement and assessing of savings should be dependent on the amount the project will save on electricity. In other words; if a project will only save a little, it is not viable to spend huge amounts of money on the measuring equipment in order to verify the savings.

South Africa has a relatively warm climate and therefore much smaller temperature differences, (environmental versus geyser temperature), than areas with colder climates. The impact of installing geyser blankets on the standing losses of a geyser in South Africa, is therefore smaller. Another issue is that a sample of geysers are normally scattered over a large area, making the measuring of the impact expensive (one meter per geyser). If every geyser would have been measured, the savings resulting from the installation of geyser blankets will be lost in the cost of the metering equipment.

It was therefore a requirement to develop a methodology to determine the impact of geyser blankets without measurements. The following section will describe the methodology followed to determine the impact of geyser blankets on the standing loses.

2.1 METHODOLOGY

In order to determine the baseline (the electricity use of the geysers without DSM intervention) the following variables need to be taken into consideration:

- Geyser Set point (Temperature)
- Water usage

- Environmental temperature
- Size of geyser
- Geyser blanket characteristics

The electric power is therefore a function of several variables:

$$IP_{kW} = f\,(X_1, X_2, X_3, X_4, X_5, X_6)\ldots[1]$$

Where: IP_{kW} = Electric power
X_1 = Geyser Set point
X_2 = Water usage
X_3 = Environmental temperature
X_4 = Size of geyser
X_5 = Geyser blanket characteristics
X_6 = Maintenance on geyser blanket

A number of the above mentioned variables could be eliminated from the function:

- **Water usage:** It can be assumed that the water usage before and after implementation will remain the same because nothing was installed to change the water usage pattern.
- **Geyser Blanket characteristics:** Can be omitted from the equation because all the geysers were fitted with the same type of geyser blankets.
- **Maintenance:** Maintenance on the geyser is only a value 0 or 1 to verify if a geyser blanket is installed (1) or not (0).

Therefore the only things remaining that influence the standing losses are the following:

$$IP_{kW} = f\,(X_1, X_2, X_3)\ldots[2]$$

Where: IP_{kW} = Electric power
X_1 = Geyser Set point
X_2 = Environmental temperature
X_3 = Size of geyser

The methodology is based on finding a relation between geyser standing losses, set point water temperature (thermostat setting) and environmental temperature. This would simplify future projects because only the thermostat setting and the environmental temperature will be required to determine what the standing losses would be over a certain period. Impact of installing geyser blankets could be easily determined in current and future M&V projects.

2.2 SAMPLE USED TO DEVELOP METHODOLOGY

The sample (shown in Figure 1) comprises of nine identical geysers installed in a residential apartment complex in Potchefstroom. All the geysers are installed on an outside wall, have a 100-litre capacity and a 2kW heater element. The geysers have thermostats that can be manually adjusted so that the supplied water temperature can be regulated. The thermostats of the geysers were set to either 60℃ or 70℃ and were not change d for the rest of the metering period. These thermostat settings are typical for geysers in residential areas.

Figure 1: Sample used (bottom row) in determining the methodology (without geyser blankets)

Six of the nine geysers were fitted with geyser blankets after baseline determination. The geysers with the geysers blankets are shown in Figure 2. A “before” and “after” phase can clearly be distinguished. Using the “before” relations as the baseline and the “after” relations as the actual values, energy savings could be determined.

Figure 2: Geyser blankets installed

2.3 METERING

To find a relation between geyser standing losses, thermostat setting and environmental temperature the following measurements are needed (Measurement configuration shown in Figure 3):

1. Electricity consumption (measured in amps, assumed voltage to be 230V). This measurement is a direct indication whether the geyser used power or not.
2. Environmental temperature. Temperature data from the South African Weather Bureau can be used.
3. Hot water temperature. Installing flow meters is an intrusive process and therefore not viable. The quantity of water consumed is negligible, as only periods when no water was used were studied to determine geyser standing losses. Measuring the temperature of the hot water supply pipe is a direct, non-intrusive technique to determine when hot water was consumed. This measurement indicates whether the element of the geyser switched on to restore the water temperature, (the temperature dropped due to hot water consumption or standing losses).

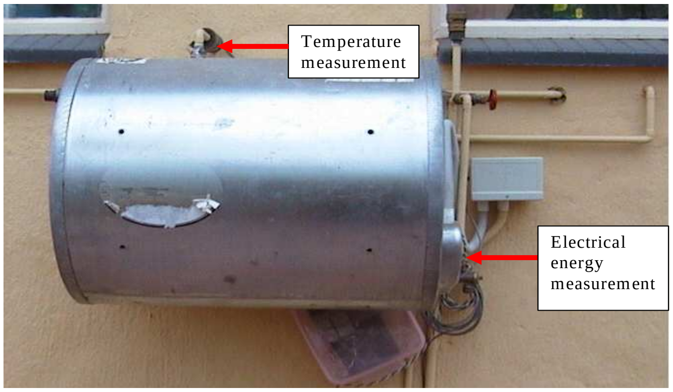


Figure 3: Geyser installation and metering points

A "before" case was developed in the period three months prior to the installation of geyser blankets. Logging intervals were 5 minutely.

2.4 FILTERING OF NON-STANDING LOSSES EVENTS

Only periods when no hot water was consumed would be considered to determine the geyser standing losses. It was therefore necessary to isolate events where hot water was consumed and the geyser switched on as a result.

Figure 4 indicates events of consumption of hot water from the geyser. The graph on the left shows the energy consumption. On the right hand side, the hot water supply pipe (top line) and the environment (bottom line) temperatures are shown.

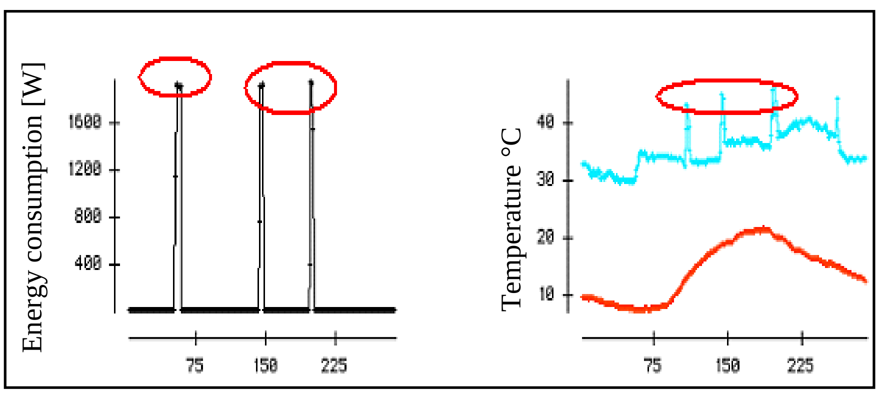


Figure 4: Temperatures of water supply pipe (top) and environment (bottom)

Three encircled peaks can be seen; these peaks indicate the events when the heating elements switched on. The temperature graph indicates the events when hot water was consumed from the geyser and consequently the heater element switched on to restore the temperature. The increase in electricity consumption as a result of hot water consumption; was disregarded.

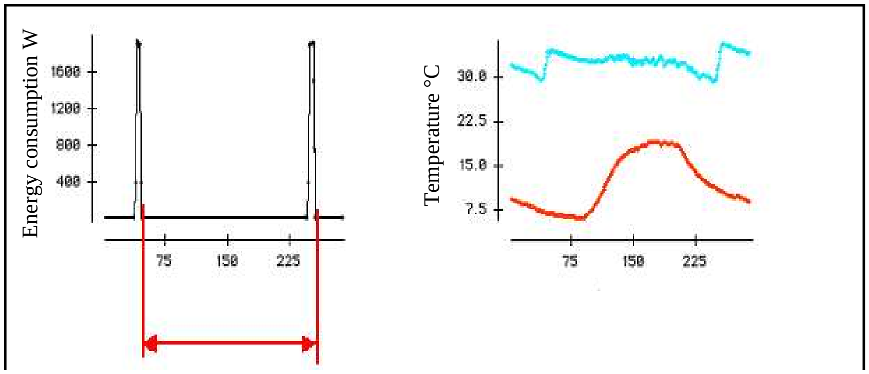


Figure 5: Example of a time period with no hot water consumption

Figure 5 shows a period where no hot water was consumed. The left hand graph shows electricity consumption and the right hand graph shows the temperature profile. At the top on the temperature graph, the hot water supply pipe temperature can be seen and at the bottom the environmental temperature. A slow decline in water temperature is observed and at a certain value, the heating element switches on and the water temperature in the supply pipe is restored.

The electricity consumption (Figure 5) is therefore due to the geyser standing losses. Installation of a geyser blanket will increase the intervals of element switching.

2.5 DETERMINING THE GENERIC EQUATION

2.5.1 *Determining a generic equation for an un-insulated geyser*

After the data isolation procedure was completed, the remaining data contained only information of geyser standing losses. A scatter of the electricity consumption (due to standing losses) versus the environmental temperature was drawn (Figure 6). A generic equation was developed by calculating the average value of the slope and y-intercept (shown in Figure 7). This equation was developed for temperatures between 0℃ and 23℃. The equation could be rewritten to include the geyser set point as an input to the equation.

Therefore:

$$\text{Losses} = -\ 1.9307 \times (T_e - T_s) \ldots[3]$$

with T_e environmental temperature and T_s the set point.

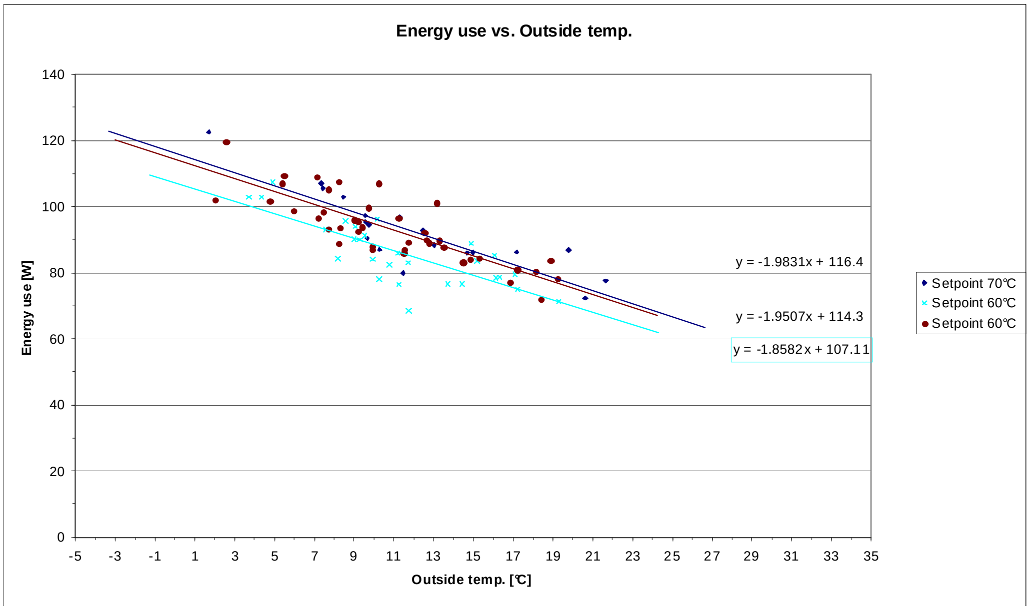


Figure 6: Geyser standing loses vs. environmental temperature for different set points

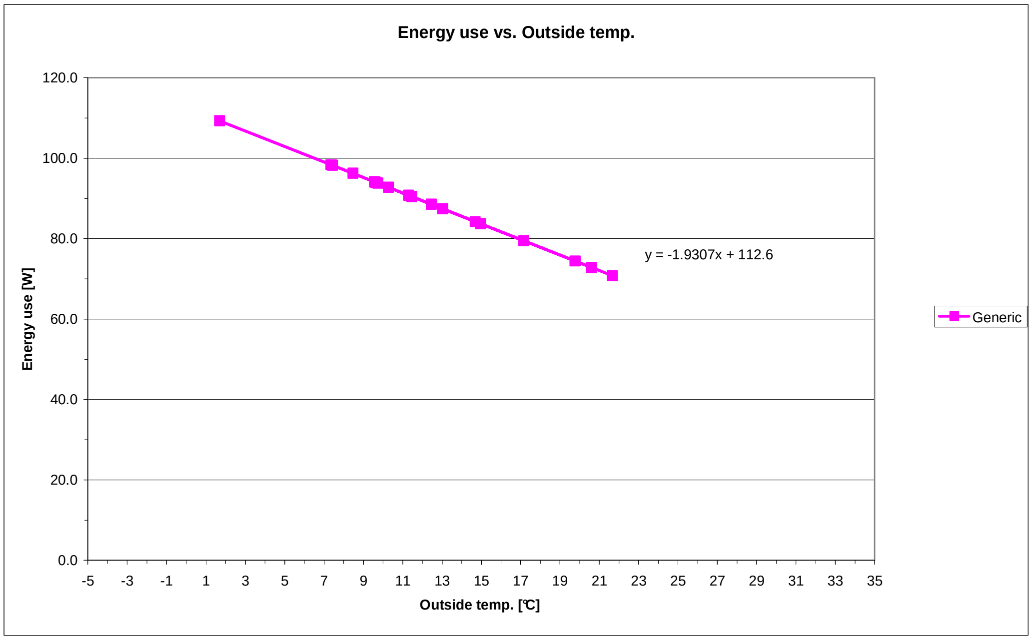


Figure 7: Geyser standing losses vs. environment temperature in the generic equation

2.5.2 *Determining a generic equation for insulated geysers*

Exactly the same methodology was followed for insulated geysers. The same three geysers were covered with geyser blankets (air gap with reflective coating) after 3 months. The generic equation and values for both insulated and un-insulated geysers are shown in Figure 8.

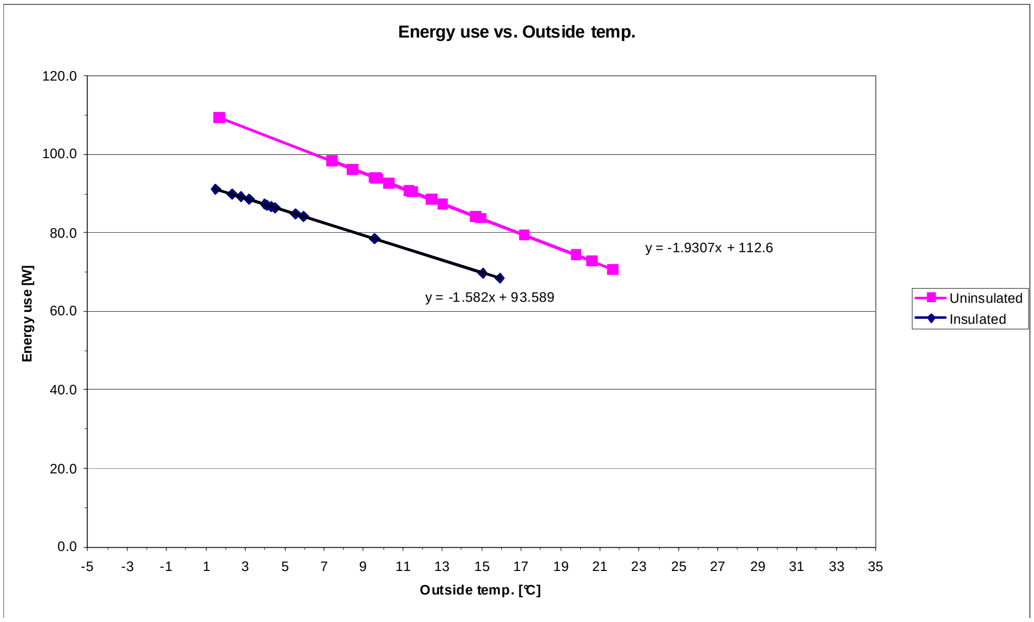


Figure 8: Generic equation for geyser standing losses, insulated and un-insulated

The calculations were performed to obtain an equation in the same form as the equation for the un-insulated geyser discussed in section 2.5.1. Therefore, the standing losses of an insulated 100 litre geyser are as follows:

$$\text{Losses} = -\,1.582 \times (T_e - T_s) \quad \ldots[4]$$

with T_e environmental temperature and T_s the set point.

2.6 SUMMARY

Equations [3] and [4] were developed using geysers in operation in a residential complex. With these equations the geyser standing losses for both insulated and un-insulated 100 litre geysers can be calculated; with the only inputs being the environmental temperature and the geyser set point temperature.

The equations are applicable to 100 litre geysers with air gap insulation with reflective coating.

The equation for standing loses on un-insulated geysers is as follows:

$$\text{Losses} = -\,1.9307 \times (T_e - T_s)$$

with T_e environmental temperature and T_s the set point.

The equation for standing loses on insulated geysers is as follows:

$$\text{Losses} = -\,1.582 \times (T_e - T_s)$$

with T_e environmental temperature and T_s the set point.

3 EVALUATION OF GEYSER AND PIPE INSULATION DISTRIBUTION PROJECTS

3.1 ISSUES TO CONSIDER

The issues to consider when evaluating geyser and pipe insulation distribution projects are the following:

- Amount of geyser to be fitted with geyser blankets and pipe insulation
- Set points of the geysers
- Size of geysers
- Type of geyser
- Ambient conditions of the geysers
- Location of the geysers
    - Inside
    - Outside
    - Ceiling void
- Type of insulation
- Percentage coverage of geyser with blanket
- Percentage coverage of pipe with insulation
- Decay rate (blankets and insulation becomes torn and tattered)

3.2 CHARACTERISATION AND METERING PROCEDURE

In order to characterise the standing losses the following need to be measured for a week:

- Set point of geyser (Ts) (Once of measurement)
- Environmental temperature (Ta)
- Power consumption (kWh)

From these measurements the standing losses, average environmental temperature and average standing loss in Watts can be calculated. These measurements and calculations needs to be repeated for the geyser:

- Without a blanket (will only be done once per type of geyser)
- With a blanket (will be repeated for every type of insulation)
- With a blanket and 3 meter pipe insulation (will be repeated for every type of insulation)

Figure 9 shows the characterisation procedure graphically. The loses can be determined using the following equation:

$$\text{Losses}_{1,2,3} = \text{m}_{1,2,3} * (Ta - Ts)$$

With:

m_1 = slope of the trend line of scatter drawn of data from geyser without insulation

m_2 = slope of the trend line drawn of data from geyser with insulation

m_3 = slope of the trend line drawn of data from geyser with insulation and 3 meter pipe insulation

T_a = environmental temperature

T_s = set point temperature

The m-values will be defined by detailed metering on the specified system. The ambient temperature will be dependent on the area where the geyser is installed and weather data for that city (available from the weather bureau). The application will have 20 cities' annual weather data in half-hourly format included. The application also has the ability to upload other weather data if the applicable city is not included in the 20 cities listed in the application. The lines in Figure 9 coincide at the set point temperature, where the ambient temperature is equal to the set point temperature.

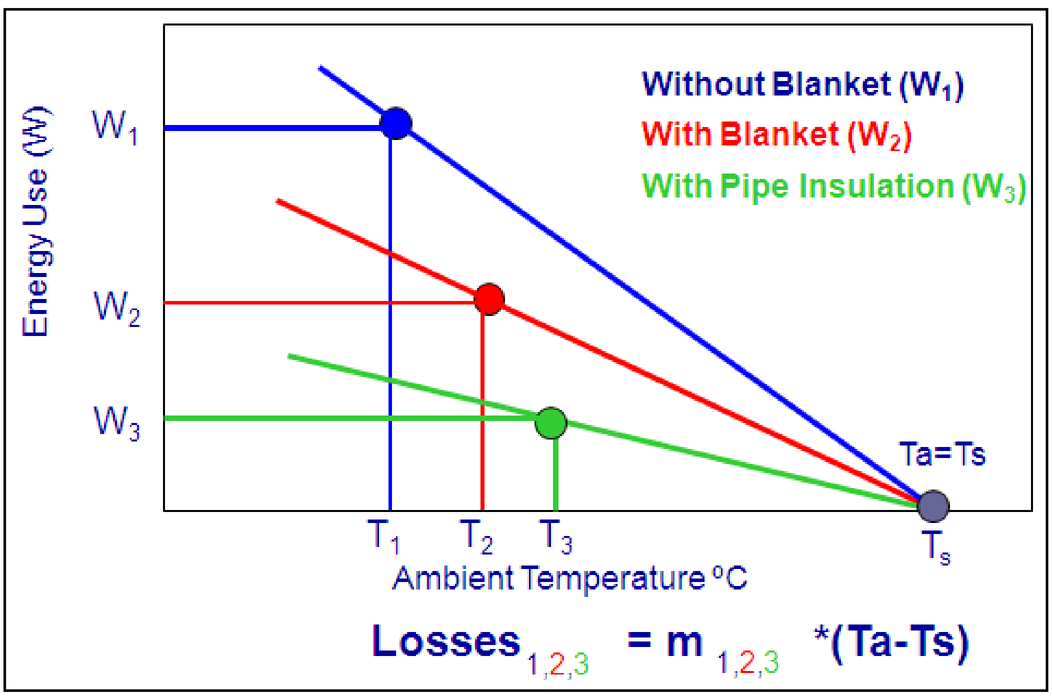


Figure 9: Characterisation procedure

In order to cater for different lengths of pipe and geyser insulated a percentage coverage factor will be used. As illustrated in Figure 10 if the geyser is covered with a blanket but only portion of the 3 meter pipe is insulated, the standing losses will be calculated between W_2 and W_3 according to the percentage coverage.

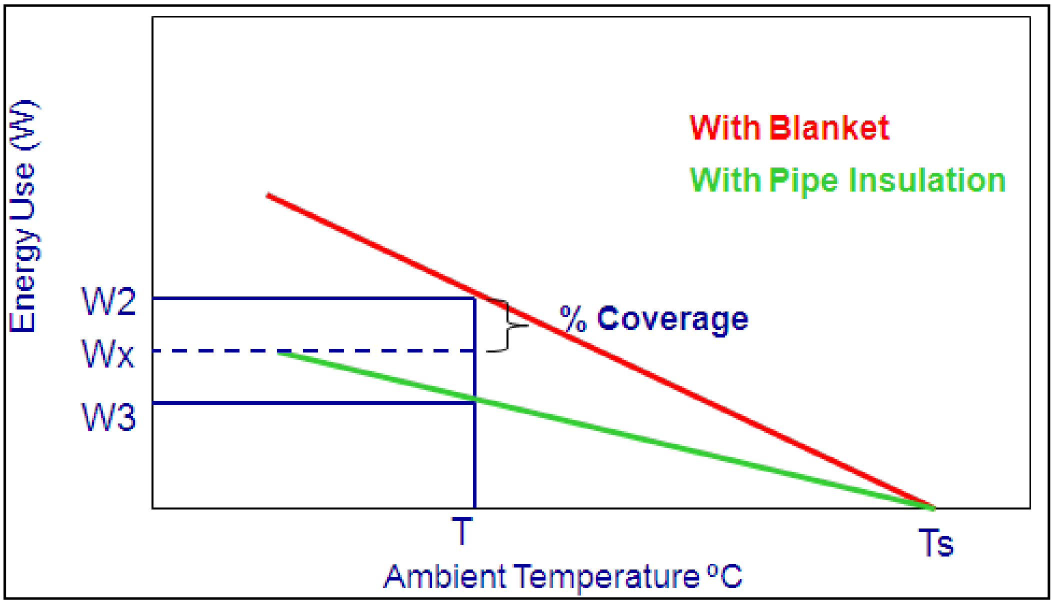


Figure 10: Percentage coverage illustration

The form that needs to be completed during the metering and characterisation phase can be found in Appendix A.

3.3 GEYSER BLANKET AND PIPE INSULATION STATISTICAL MODEL

- Inputs to the statistical model include (gathered through fieldworker form, Appendix B):
  - Number of geysers
  - Set point
  - Size of geyser
  - Type/make of geyser
  - Location of geyser
  - Ambient temperatures
  - Type of insulation
  - % Coverage of geyser with blanket
  - % Coverage of pipe with insulation
  - Decay rate
- The model contains the slope of the three lines. This is a specific value, characteristic to a certain geyser size, geyser type and insulation type
    - M_1 – Slope of the trend line for a geyser without insulation

        - M_2 – Slope of the line for a geyser with insulation
        - M_3 – Slope of the line for a geyser with blanket and pipe insulation
- Outputs of such a model will include:
    - Baseline - hourly Watt values
    - Actual - hourly Watt values

3.3.1 *Fieldworker Form (Installation visit)*

The fieldworker forms captures all the information required for the application. During installation phase a sample of the geysers need to be visited to capture all the relevant information. The information needed includes the geyser make and size which can only be gathered before the geyser blanket is installed.

Detailed description of the fieldworker form and all the relevant information is given in section 5.3. The fieldworker form (Installation visit) can be found in Appendix B.

3.3.2 *Fieldworker Form (Follow-up visit)*

A follow-up visit is necessary to determine if the geyser blankets and pipe insulation are still intact after three to six months. The same geysers that were visited during the installation visit needs to be revisited. The information gathered during the follow-up visit is captured in the fieldworker from (Follow-up visit), Appendix C.

This information will be incorporated to determine a decay rate. The decay rate will be dealt with in the same manner as percentage coverage that was described in Figure 10.

4 OVERVIEW OF GEYSER INSULATION DISTRIBUTION PROJECTS

Step 1: Complete fieldworker forms for a sample of geysers. The M&V team needs to accompany the ESCo to a sample of before installation of the geyser blankets. This is necessary because information on the un-insulated geyser must be gathered which would be difficult to obtain when the geyser are already insulated.

Step 2: The information gathered through the fieldworker forms needs to be entered into the application.

Step 3: Generate results using the Geyser Insulation M&V tool.

Step 4: Conduct a follow-up visit, (on the sample of geysers visited) to determine the decay rate of the insulation.

Step 5: The information gathered during the follow-up visit needs to be entered into the application.

Step 6: Generate results using the Geyser Insulation M&V tool.

5 GEYSER INSULATION M&V TOOL - USER MANUAL

To start a new project you need to do the following:

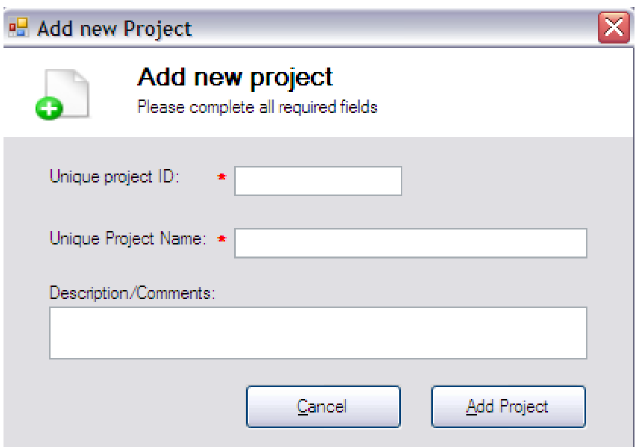
- Add a new project (Section 5.1)
- Fill in the fieldworker forms. Additional forms can be added later. (Appendix B)
- Fill in m-values if needed (Section 5.4)
- Import weather data if the applicable town is not listed (Section 5.4)
- Generate M&V results by using the user queries (Section 5.5)

If you want to generate results from a project that is already in the database you need to do the following:

- Open and existing project (Section 5.2)
- Generate M&V results by using the user queries (Section 5.5)

5.1 *Add new project*

On the main menu, click File and then click New Project. The following window will appear:



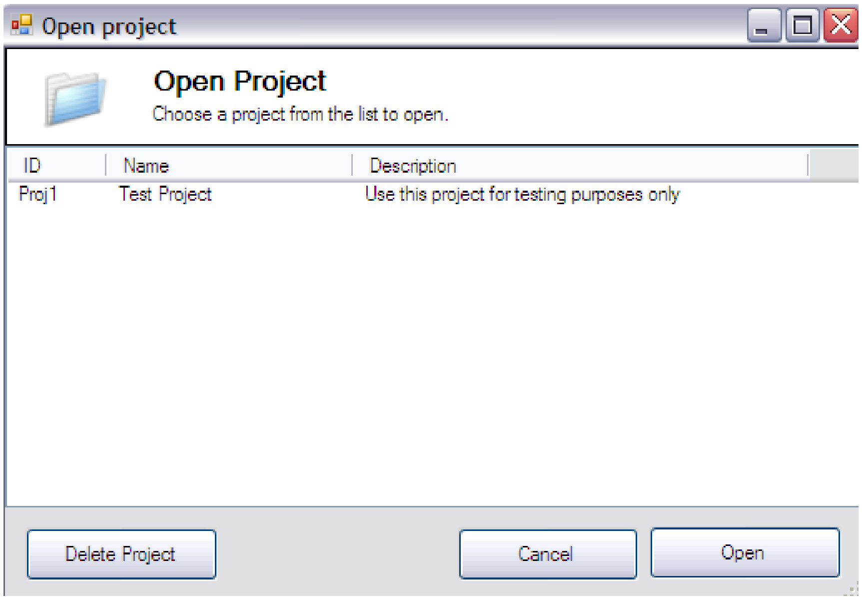
- Type in a unique project ID, preferably the DSM project number.
- Type in a unique project name, preferably the DSM project name.
- Click Add Project.

If the project is added successfully a confirmation message will be displayed:

The newly added project is not opened by default. If you want to use the newly added project you can open it from the file menu.

5.2 *Open existing project*

On the main menu, click File and then click Open Project. The following window will appear:

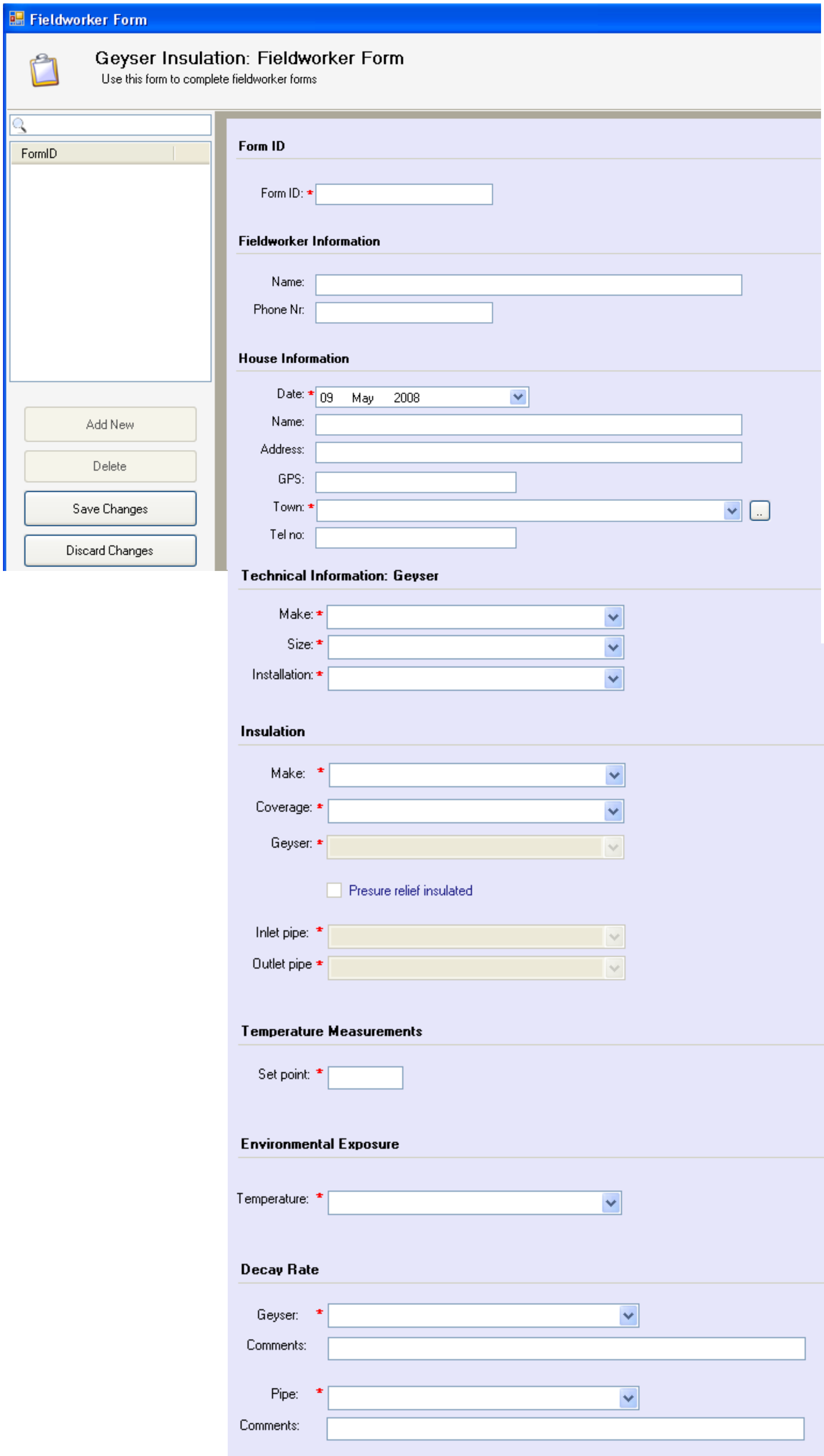


To open an existing project select the applicable project and click on Open. The project is now open and the name of the project will appear on the bottom left of your screen. The toolbar icons for the fieldworker forms and user queries will also be enabled now.

5.3 *Fieldworker form*

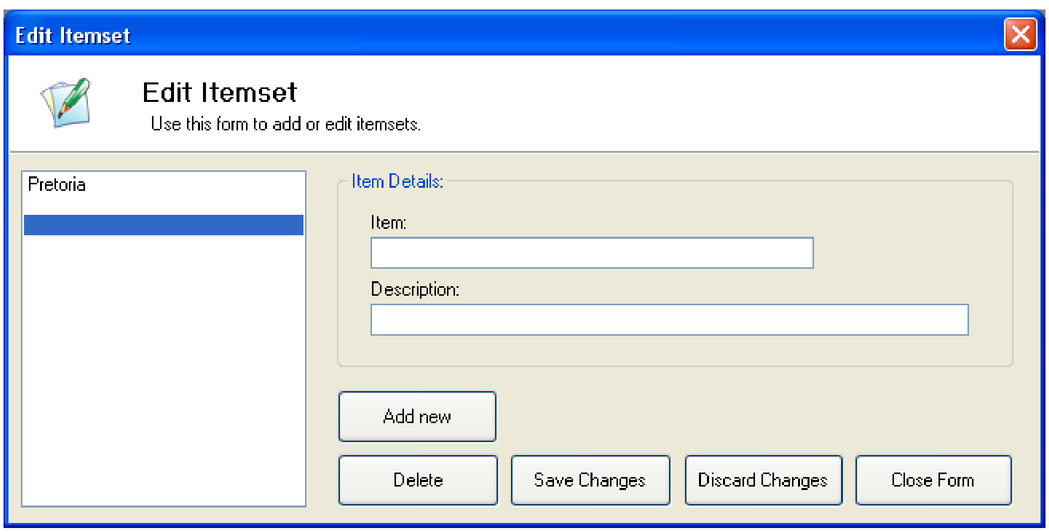
On the main menu, click Project and then click Fieldworker form. The window on the next page will appear.

Use the form below to insert the data gathered by the fieldworkers. Each fieldworker form in this particular project must be added using this window. As you complete entering the forms the application will update the averages calculate from all the fieldworker forms entered. For example if 3 geysers with set points of 60ºC and 2 with set points of 50ºC is entered, the average temperature for the sample will be 56ºC.


Fieldworker Form
Geyser Insulation: Fieldworker Form
Use this form to complete fieldworker forms
FormID
Add New
Delete
Save Changes
Discard Changes
Form ID
Form ID: *
Fieldworker Information
Name:
Phone Nr:
House Information
Date: * 09 May 2008
Name:
Address:
GPS:
Town: *
Tel no:
Technical Information: Geyser
Make: *
Size: *
Installation: *
Insulation
Make: *
Coverage: *
Geyser: *
Presure relief insulated
Inlet pipe: *
Outlet pipe *
Temperature Measurements
Set point: *
Environmental Exposure
Temperature: *
Decay Rate
Geyser: *
Comments:
Pipe: *
Comments:

Description of fields that need to be typed in is given in the following section. All the fields with (*) next to it is compulsory, the rest of the fields are for more detailed information:

- Form ID
  - Form ID: * *Type in from ID number as found on top of the field worker form*
- Fieldworker Information
  - Name: *Type in the fieldworker's name*
  - Phone Nr: *Type in fieldworker's phone nr.*
- House Information
  - Date: * *Select date on which the house was visited from the calendar or enter a date*
  - Name: *Enter the name of a person living in the house*
  - Address: * *Enter the address of the house*
  - GPS: *Enter the GPS coordinates of the house*
  - Tel nr: *Enter the telephone number of a person living in the house*
  - Town: * *Select a town from the list or type in the new town name by clicking on the*  *button. The following window will appear allowing you to edit the item set:*



Fill in the name of the town or installation set up under Item. Give a description if preferred. Save Changes and click on the Close Form button.

- Technical Information:
  - Geyser
    - Make: * *Select a make from the list. This version of the tool considers all makes to be the same because only one type of geyser has been tested thus far.*
    - Size: * *Select a size from the list.*
    - Installation: * *Select an installation arrangement from the list*
  - Insulation
    - Make: * *Select the applicable make of insulation from the list. This version of the tool considers all makes to be the same because only one type of geyser has been tested thus far.*
    - Coverage: * *Select the applicable coverage from the list. This selection is an indication whether only the geyser is insulated or if the geyser and pipes are insulated.*
    - Geyser: * *Select from the list according to how the geyser is insulated.*
    - Pressure relief insulated: *Select the tick box if the pressure relief is insulated.*
    - Inlet pipe: * *Select the amount of meters insulated or nearest amount*
    - Outlet pipe: * *Select the amount of meters insulated or nearest amount*
  - Temperature Measurements
    - Set point: * *Enter the set point temperature of the geyser*
  - Environmental Exposure
    - Temperature: * *Select the town where the geyser is installed. If the town is not listed you can do one of the following:*
      - *Select the town which environmental temperature best represents the environmental temperature of the applicable town.*

- *If the geyser is installed inside the house with a constant temperature environment you can select the applicable constant temperature.*

- *If the temperature to which the geyser is exposed is not listed, you can import your own set of weather data. The procedure is described in section 5.4.*

o Decay Rate

- Geyser: * *Select from the list the applicable description of the state of the insulation on the geyser at the time of the follow-up visit. If it is the first visit, select 'Insulation still intact'.*

- Comments: *If the state of the geyser insulation is not adequately described in the above mentioned list or if you want to elaborate then you can give a description here. Remember that you need to select a description next to* Geyser *that is closest to the applicable situation.*

- Pipe: * *Select from the list the applicable description of the state of the insulation on the pipe at the time of the follow-up visit. If it is the first visit, select 'Insulation still intact', or if there is no insulation on the pipe select 'No insulation on pipe'.*

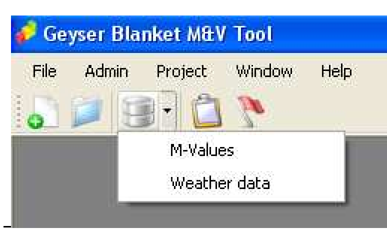
- Comments: *If the state of the pipe insulation is not adequately described in the above mentioned list you can formulate a description here. Remember that you need to select a description next to* Pipe *that best represents the applicable situation.*

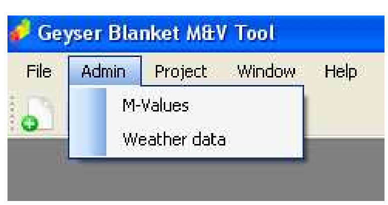
After all the changes have been made, you can save the changes by clicking on the

button.

If you want to edit a form that has already been entered/saved, you can double click on the name of the form and the data will appear. After you have edited the form, you need to save the changes.

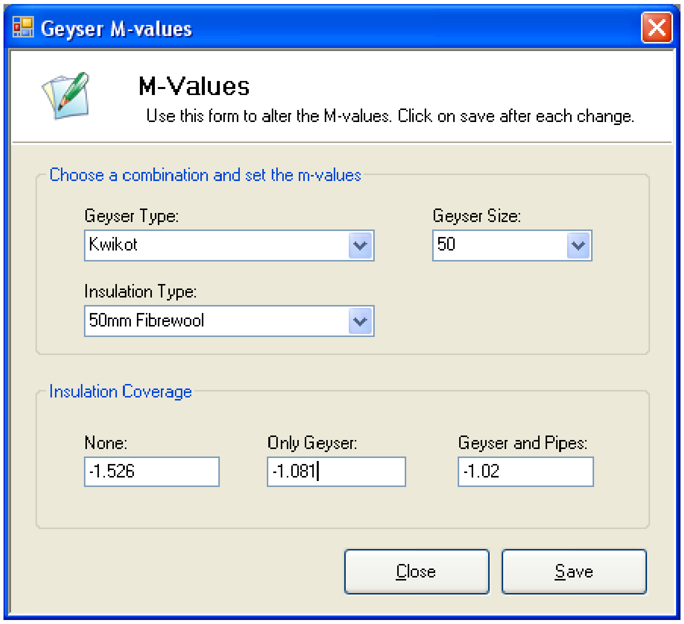
5.4 *Admin*





M-Values

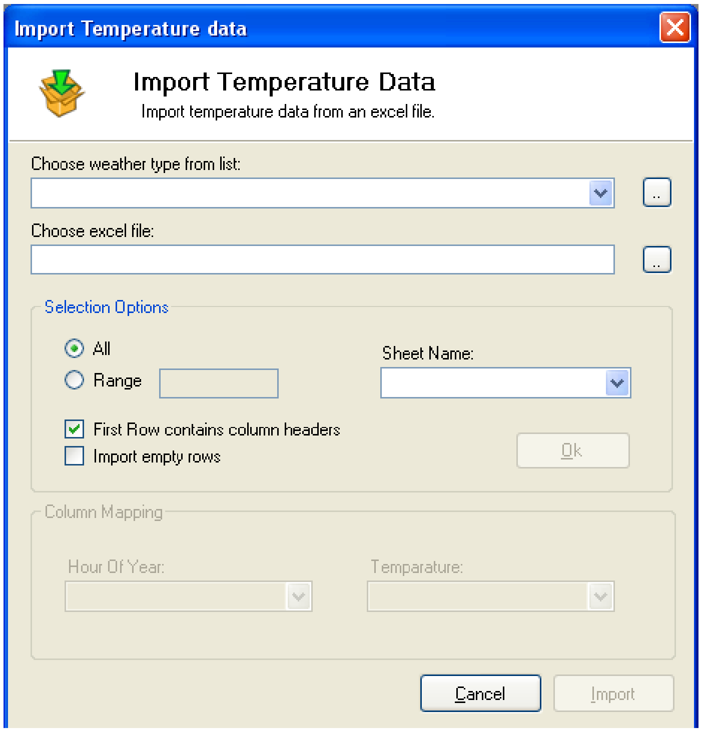
On the main menu, click Admin and then click M-Values, the following window will appear:



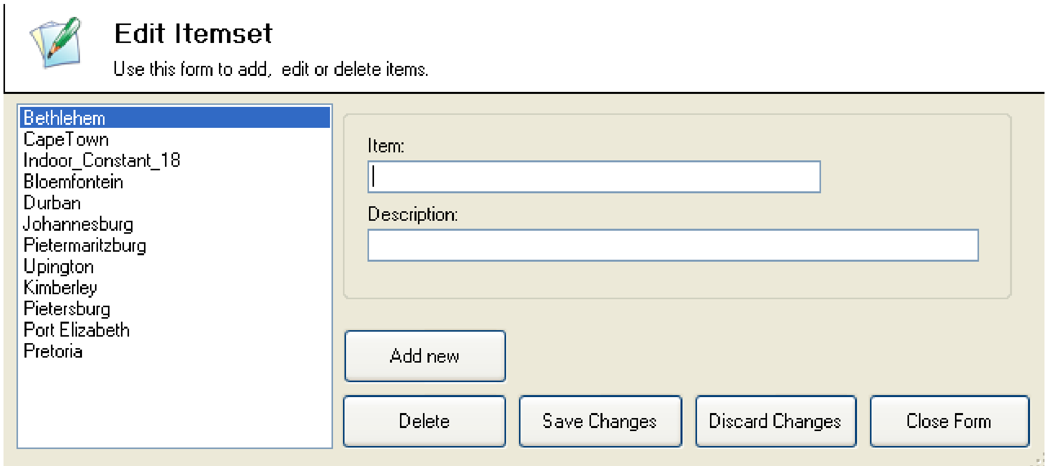
Additional M-values can be added using this form. The M-values are developed by CPUT. Editing of this form will only be allowed by NWU and after editing an upgraded version will be distributed.

Weather data

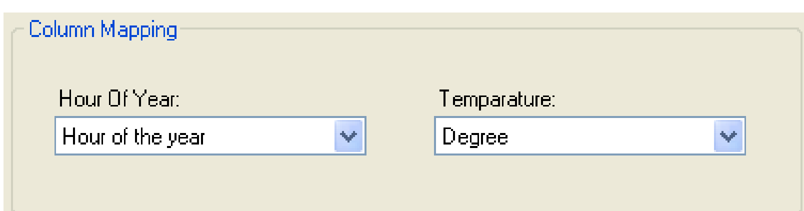
This section explains the steps that needs to be taken to import additional weather data if the existing temperature data set is not an addequate representation of your area. Appendix D contains an example of the format of the data to be included in the application. The data must be of hourly format for a full year.



- The next step is to choose the excel file that contains the temperature data.
- Select a weather type from the list. If it does not appear in the list, you can add additional weather types by clicking on the button. A window will appear allowing you to edit the item set.



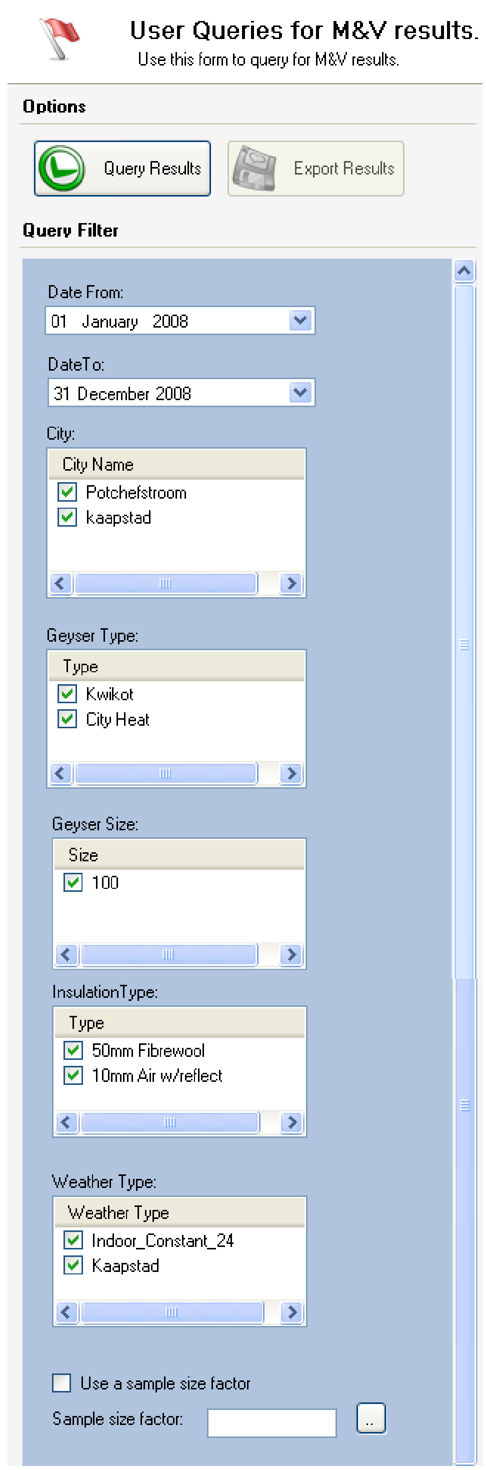
- Click on Add new to add a new temperature set. Fill in the name of the city or description of the data set under Item and click on Save Changes. You can now close this window by clicking on Close Form.
- To browse for the file click on .. and select the excel file from disk
- After selecting the file, select the 'sheet name' containing the data to import and click Ok.
- The Column Mapping section will now be active. The application will automatically detect all the column headings of the sheet selected. Select the column name where the hour of the year are situated and the column where the temperature data are situated.



Click on Import to import the data. Your temperature data has now been imported.

5.5 *User Queries*

After the fieldworker forms are completed and saved the user queries section can be used to generate the M&V results. When clicking on the user queries button the following window will appear:



The date from and to indicates the period when the field worker forms were entered.

Select the applicable city or cities for your results.

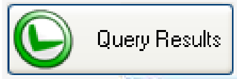
Select the type of geyser or geysers that should be included in your results.

Select the size or sizes of the geysers that you would like to include.

Select the type of insulation that you would want results from.

Select the weather type or types applicable.

Select a sample size factor according to the amount of geysers in the project ex. 200 000.

After all the selections are made, click on 

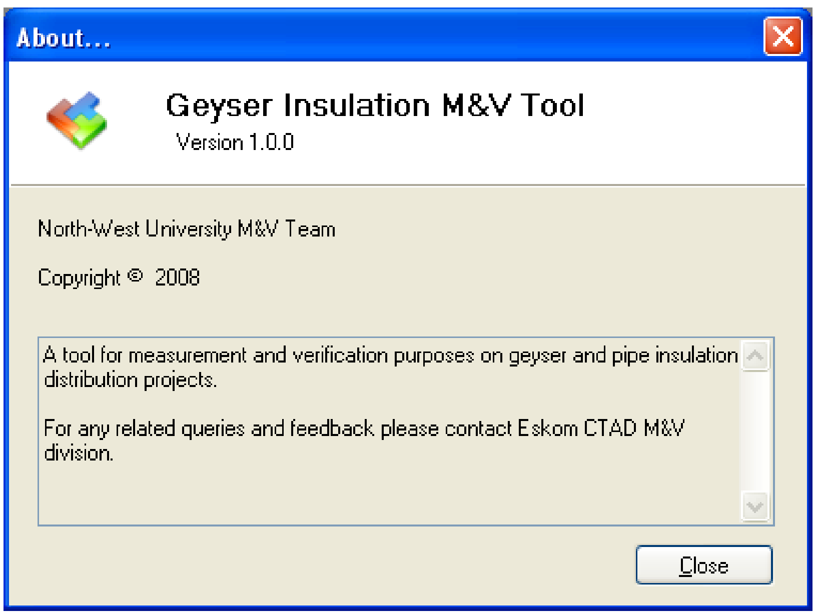
to generate the M&V results.

The results can be exported by clicking on the 

button. Choose a location and a csv or xml file will be exported.

5.6 *Help*

When selecting the About button, the following window will appear:



When selecting the Contents button, the Geyser Insulation M&V Tool's help file will appear, consisting of the user manual.

APPENDIX A

Metering Procedure & Characterisation Form

Geyser information

1	Make of geyser	
2	Size of geyser	

Type of insulation

3	Name of insulation used	
4	Type of insulation	
5	Thickness of the insulation [mm]	
6	Thermal conductivity value [k-value]	

Installation information

7	What percentage of the geyser is covered with insulation	
8	Is the pressure relief insulated	
9	Meters of pipe insulated at geyser inlet	
10	Meters of pipe insulated at geyser outlet	

A No Blanket

Measurements

Measure for a week the following:

11	Date started with metering	
12	Date ended with metering	
13	Set Point [C]	
14	Ambient Temperature [C]	
15	Power consumption [kWh]	

Calculations

Calculate the following:

16	Standing Losses	
17	Average Ambient [C]	
18	Average Standing Losses [W]	

B With Blanket (needs to be repeated for every type of insulation)

Measurements

Measure for a week the following:

19	Date started with metering	
20	Date ended with metering	
21	Set Point [C]	
22	Ambient Temperature [C]	
23	Power consumption [kWh]	

Calculations

Calculate the following:

24	Standing Losses	
25	Average Ambient [C]	
26	Average Standing Losses [W]	

C With Blanket & 1m pipe at inlet & 3m pipe at outlet (needs to be repeated for every type of insulation)

Measurements

Measure for a week the following:

27	Date started with metering	
28	Date ended with metering	
29	Set Point [C]	
30	Ambient Temperature [C]	
31	Power consumption [kWh]	

Calculations

Calculate the following:

32	Standing Losses	
33	Average Ambient [C]	

Name	
Signature	

APPENDIX B

From ID Nr:	

Geyser Insulation - Fieldworker Form

A Fieldworker Information

Name	
Phone no.	

B House Information

Date	
Name	
Tel no.	
Address	
GPS	
Town	

C Technical Information

Geyser	
Make	
Kwikot	
Sunbeam	
City Heat	
Other	
Size	
50 L	
100 L	
150 L	
200 L	
Other	
Geyser Installation	
Outside the building	
Inside in a room	
Air Conditioned	
Not Air Conditioned	
In the ceiling	
Corrugated iron roof	
Insulated	
Un-insulated	
Tile roof	
Insulated	
Un-insulated	

Geyser Blanket Insulation	
Make	
% Coverage	
Geyser	
Whole geyser covered	
All of geyser except part of fixture	
All of geyser except the rounded ends	
Other	
Pipe	
Pressure relief insulated	
Inlet pipe	
0m - 0.5m	
0.5m - 1m	
Other	
Outlet pipe	
0m - 1m	
1m - 2m	
2m - 3m	
Other	

D Temperature Measurements

True hot water set point at tap	

Name	
Signature	

APPENDIX C

Geyser Insulation - Decay Rate

A Fieldworker Information

Name	
Tel no.	

B House Information

Date	
Name	
Tel no.	
Address	
GPS	
Town	

C Technical Information

Geyser	
Make	
Size	
Geyser Installation	

Insulation	
Make	
% Coverage	
Geyser	
Pipe	

D Temperature Measurements

Set point	

E Decay Rate

Geyser		
Insulation still intact		
Tape broken		
Round ends open		
No insulation on geyser		
Comments		
Pipe		
Insulation still intact		
Tape broken		
No insulation on pipe		
Comments		

APPENDIX D

Month	Day	Hour	Hour of the year	Time	Degree
1	1	1	1	00:00	21.8
1	1	2	2	01:00	21.4
1	1	3	3	02:00	20.9
1	1	4	4	03:00	20.4
1	1	5	5	04:00	20
1	1	6	6	05:00	20.4
1	1	7	7	06:00	21.3
1	1	8	8	07:00	22.7
1	1	9	9	08:00	24.5
1	1	10	10	09:00	26.6
1	1	11	11	10:00	28.3
1	1	12	12	11:00	29.7
1	1	13	13	12:00	30.7
1	1	14	14	13:00	31.4
1	1	15	15	14:00	31.7
1	1	16	16	15:00	31.8
1	1	17	17	16:00	31.3
1	1	18	18	17:00	30.4
1	1	19	19	18:00	29
1	1	20	20	19:00	27.5
1	1	21	21	20:00	26
1	1	22	22	21:00	24.6
1	1	23	23	22:00	23.1
1	1	24	24	23:00	21.6
1	2	1	25	00:00	20.8
1	2	2	26	01:00	20
1	2	3	27	02:00	19.2
1	2	4	28	03:00	18.4
1	2	5	29	04:00	17.6
1	2	6	30	05:00	17.9
1	2	7	31	06:00	19
1	2	8	32	07:00	20.2
12	31	17	8753	16:00	25.4
12	31	18	8754	17:00	25
12	31	19	8755	18:00	24.1
12	31	20	8756	19:00	22.7
12	31	21	8757	20:00	21.2
12	31	22	8758	21:00	19.8
12	31	23	8759	22:00	18.3
12	31	24	8760	23:00	16.9