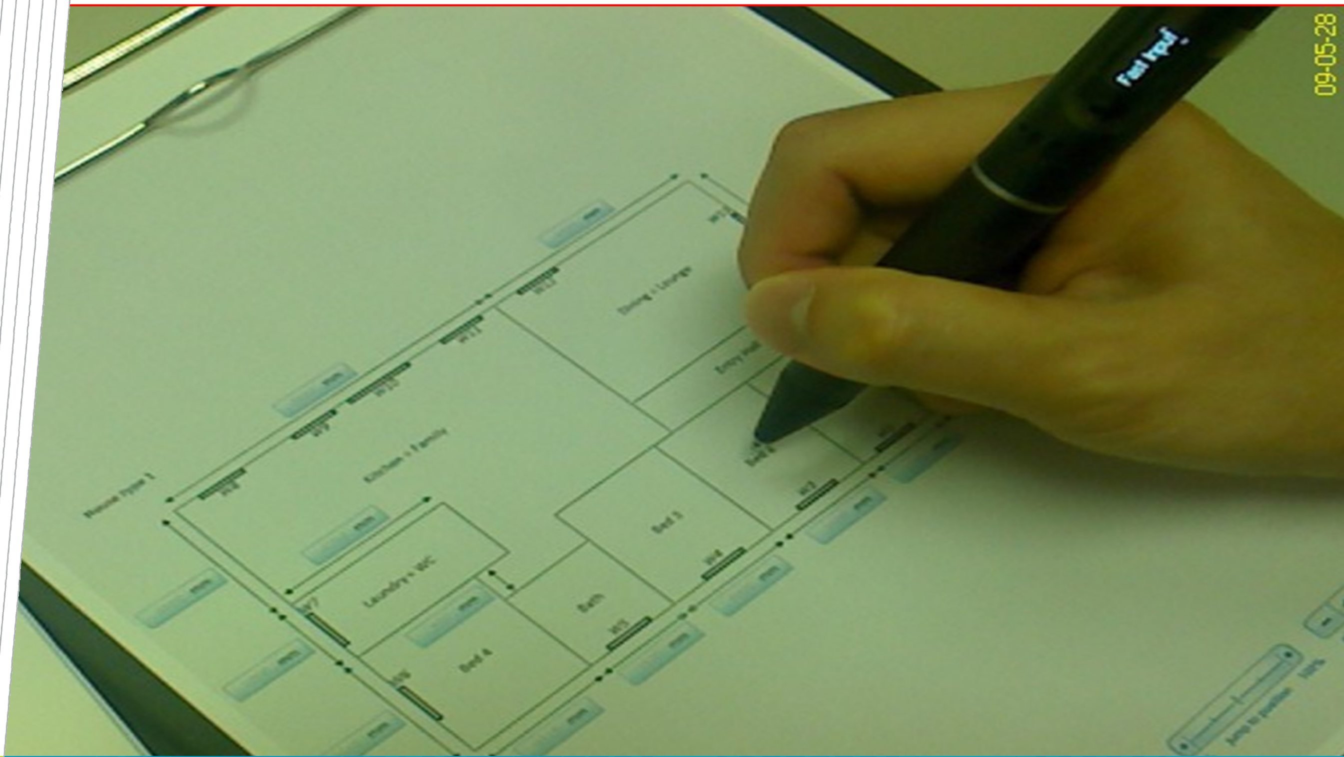
CSIRO

AccuRate Sustainability Tool

Green Loans Program
Fast Input Mechanism

CSIRO Climate Adaptation Flagship



www.csiro.au

Research report
Report number: R-555-49-7a

Yong Bing Khoo, Mingwei Zhou, Wan Yee Chan, Dong Chen, Melissa James

May 2009

Enquiries should be addressed to:

Yong Bing Khoo
CSIRO Sustainable Ecosystems
37 Graham Road
Highett VIC 3190, Australia
Email: yongbing.khoo@csiro.au
Telephone: +61 3 9252 6051

Copyright and Disclaimer

Important Disclaimer

Contents

List of Figures

List of Tables

1. INTRODUCTION

The 2008/2009 Federal Budget announced the provision of $300 million for the Green Loans Program (GLP) to assist families in the installation of solar, water, and energy efficient products. Green loan approvals will be subject to detailed sustainability assessments that will be conducted by accredited experts. These experts will determine the most appropriate actions that can improve the environmental performance of properties.

GLP requested a proposal for the development of Fast Input Mechanism to upgrade the data entry process for the current AccuRate Sustainability tool. This module allows the tool's data entry facility to improve the accuracy of the sustainability assessment data after using Fast Input Mechanism's input process.

Fast Input Mechanism covers basic design and construction features such as:

- Style/Era (e.g. federation, 60s, 70s, 80s, etc)
- Construction type (e.g. cavity brick, timber, brick veneer, concrete block)
- Roof type (e.g. flat, high pitch, low pitch)
- No. of floors
- Floor type (e.g. timber, concrete plus tile, concrete plus carpet)
- Shade type (e.g. eaves, permanent external blinds, seasonal external blinds)
- Insulation level ceiling (e.g. R0, R1, R2, R3, R4, Foil only, Foil plus R3)
- Insulation level wall (R0, R0.5, R1.0, Foil only)
- No. of bedrooms
- Floor plan (select from floor plans determined by above) + flip button
- Orientation (allows North arrow to be set)

Other factors that determine the range of house plans may be drawn from the initial input page, e.g. postcode.

The target outcome is the creation of a full 2nd Generation NatHERS house assessment file in significantly less time than the current data entry process of at least 2 to 6 hours (depending on complexity of the house and assessor's experience in using NatHERS). For those homes that are identified as typical building types in Fast Input Mechanism's library, the time required for data entry can be reduced to about 10 minutes.

1.1 Project objectives

CSIRO proposed to research and develop Fast Input Mechanism as part of the AccuRate Sustainability tool to deliver the requested GLP upgraded data entry process.

The proposed research and development work were carried out in three stages:

1. The research and design of a mapping mechanism that translated the selections of basic design and construction features that are found in the majority of existing homes into AccuRate's internal data structures. These basic design and construction features would be provided to the CSIRO project team via Association of Building Sustainability Assessors (ABSA) or other entities through separate activities that are managed by Department of the Environment, Water, Heritage and the Arts (DEWHA). The mapping mechanism was presented to key ABSA members and other stakeholders through a mock-up interface and a rapid prototype application as pre-cursors of the full implementation.
2. The implementation and integration of Fast Input Mechanism into the AccuRate Sustainability tool. An alpha version of the software was released for testing and validation by ABSA members.
3. The revision and fine tuning of Fast Input Mechanism through the beta release of the software for further testing and validation.

1.2 Project deliverables

This project delivers the following outcomes:

1. A software that builds 2nd Generation NatHERS files from selections that are available from a minimal number of drop-down boxes. These selections include basic design and construction features that are found in most existing homes.
2. A report that describes the research and development work that was conducted:
   - Technical explanations of the development of Fast Input Mechanism,
   - The discussion of consultations with DEWHA and ABSA on aspects of software development, and
   - Beta testing of the software against expert assessment using the full data entry process.

The Australian Federal Government commissioned another research project that was conducted by ABSA to investigate data input processes. The project identified improvements that were developed and reported separately from this Fast Input Mechanism project.

The automatic calculation of roof/ceiling zones based on the information that was already available from other data entry were included in a separate proposal (AccuRate New Release). As such, this feature was not included in Fast Input Mechanism.

The first deliverable will be suppled as a CD for beta-testing proof-of-concept and implementation of Fast Input Mechanism. The CD will include a user guide.

This report constitutes the fulfilment of the requirements of the second deliverable.

2. DATA INPUT FOR HOUSE SUSTAINABILITY ASSESSMENT

2.1 Requirements for data input

The Nationwide House Energy Rating Scheme (NatHERS) provides a framework that allows for the development of various software tools to rate the potential energy efficiency of Australian homes. NatHERS also defines the minimum set of information that is to be used by such tools.

The house rating process that is associated with existing dwellings requires assessors to inspect the house and input house details into a rating tool for assessment. The house details include the house's location, orientation, dimensions, shading, as well as various building elements and constructions. The details need to represent the house's characteristics precisely in order to achieve an accurate assessment. It also needs to be fast enough to achieve high productivity and therefore lower costs.

To facilitate a consistent interpretation of building plans and specification sheets, the NatHERS Scheme also defines how spaces or rooms must be defined by accredited software tools. As a result, comfort parameters and internal heat loads can be calculated.

The following section discusses the data input methods used in the current NatHERS rating tools. These methods provide a background for the template-based data input technology that will be discussed in later sections of this report.

2.2 Data input process in AccuRate Sustainability tool

The current operational version of AccuRate (v1.1.4.1) uses a form-based approach in its data input process. It categorises building data into five different pages: Project, Constructions, Zones, Elements, Shading and Ventilation. The latest upgrade of the AccuRate Sustainability Tool has three more pages: Lighting, Hot water, and Water use (Figure 1). Each page contains data forms and fields that are relevant to the page's main content. In addition, sub-pages and forms are used to gather more detailed information when needed.

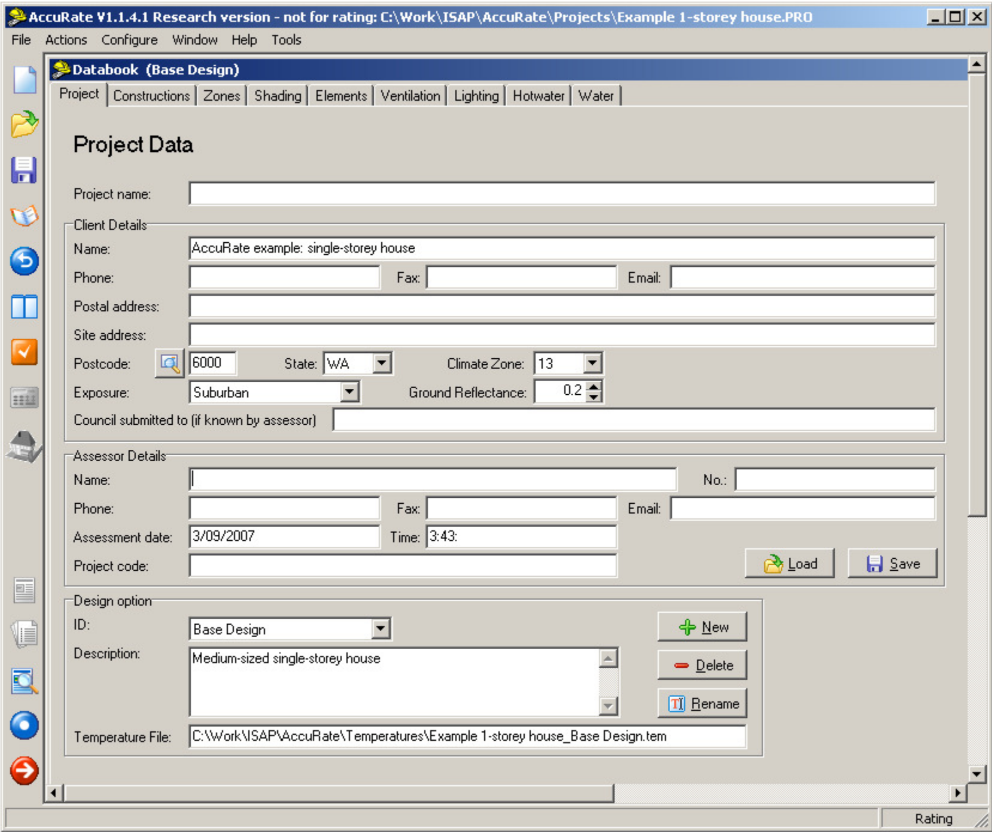


Figure 1 A screenshot of AccuRate Sustainability Tool.

2.3 Data input process in BERS Pro

Building Energy Rating Scheme (BERS Pro), developed by Solar Logic (2009), uses the same NatHERS engine as AccuRate. BERS Pro has a graphical data input process through which assessors perform assessments by drawing house plans visually instead of entering textual data only. As shown in Figure 2, most of the building data can be selected from icons displayed on the screen. There is a smaller range of constructions and material sets available.

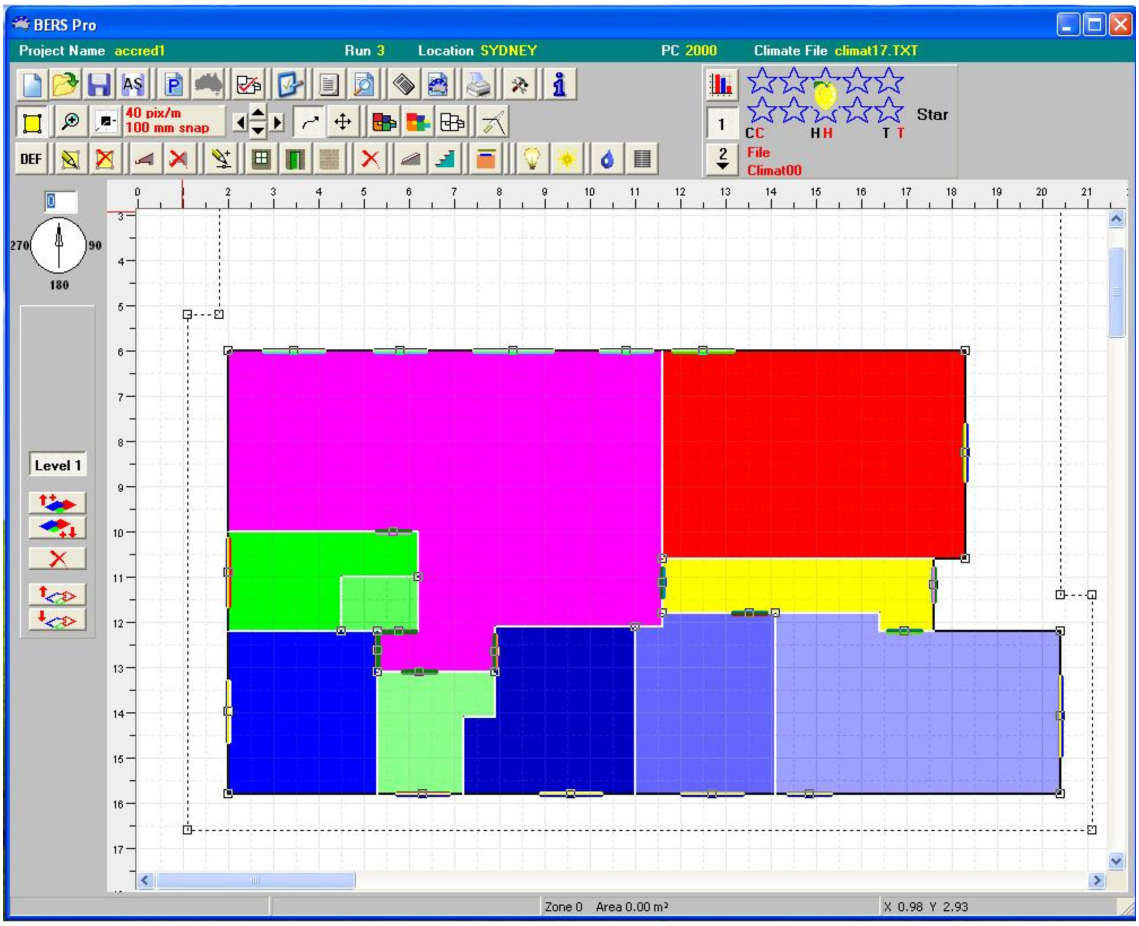


Figure 2 A screenshot of BERS Pro.

2.4 Data input process in FirstRate 5

FirstRate was developed by the Sustainability Victoria with the aim of reducing the time required in the rating process. FirstRate 5 incorporates the same NatHERS engine that is used by AccuRate and BERS Pro. As shown in Figure 3, FirstRate5 uses a graphical user interface to help assessors to input building data.

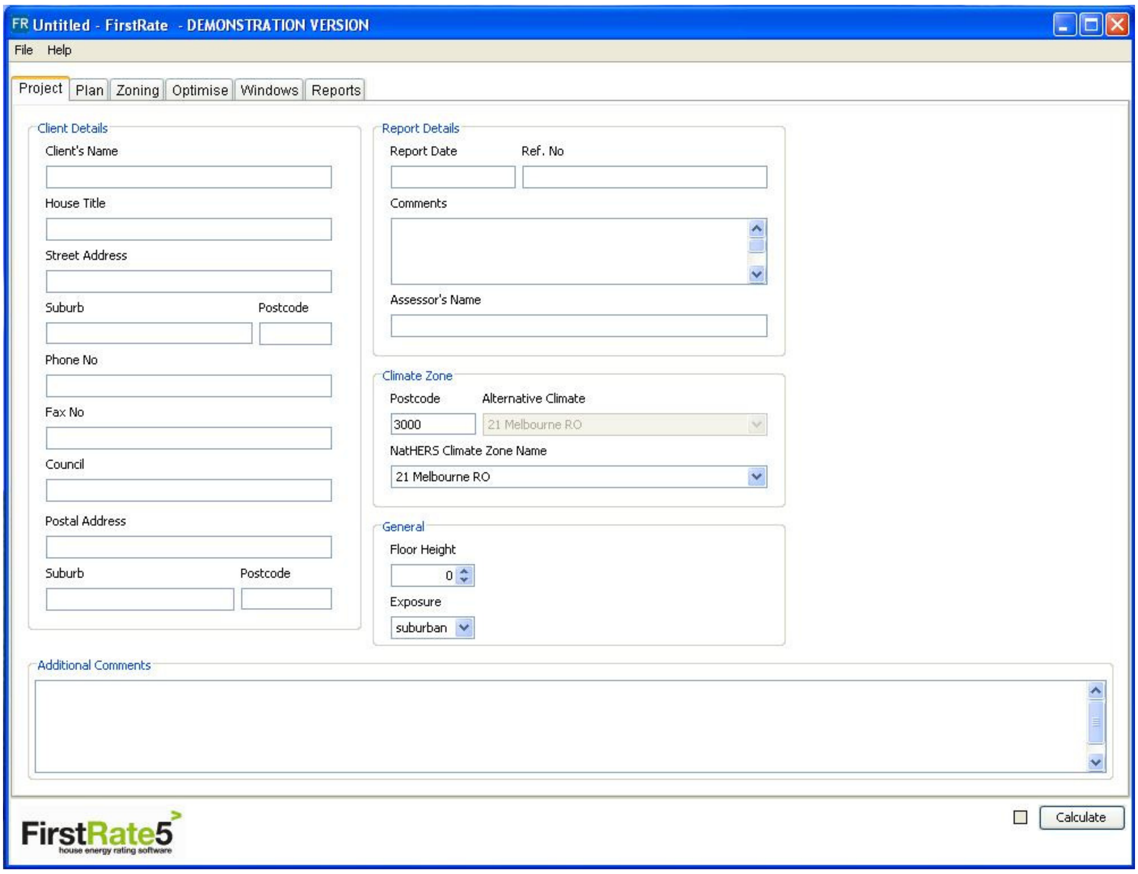


Figure 3 A screenshot of FirstRate 5.

2.5 A template-based approach to data input process

Australian residential houses have a rich diversity of design styles and construction materials. Nonetheless, there are periods in the Australian history during which some building types were more prevalent than others. These houses represent the building technologies, material availability, and life styles of the period in which they were constructed. It is estimated that 80% of Australian existing houses can be categorized as *typical houses* that were usually built by one of the major house builders (Boyd, 1952).

The underlying motivation for Fast Input Mechanism is to explore the use of the characteristics of typical houses in order to minimize the amount of data and time required for assessments. Key challenges of this project include the identification and generalisation of these house types to accommodate minor variations so that they can support wide-spread usage.

A template-based approach was investigated to address these challenges. The approach leverages house models created in AccuRate to provide the default layout and values of typical houses. Using this approach, many data calculations can be automated because the relationships between different parts of the houses are known. For instance, the lengths of adjacent rooms may be set by measuring the length in only one room when relevant conditions are met. A new data input process was also developed to support this approach.

ABSA provided the team with a set of house plans originally used for AccuRate Accreditation. These house plans represent some typical houses in Australia. House 1 was selected as the test case in the Fast Input Mechanism project because its plans have the most complete set of data. Furthermore, it is sufficiently complex to highlight the technical issues that need to be overcome when developing templates.

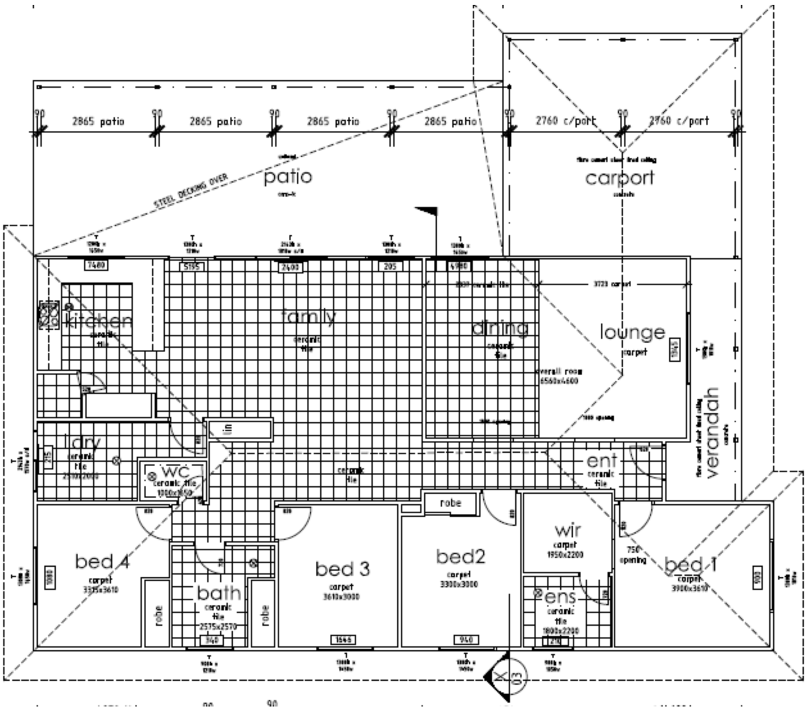


Figure 4 The floor plan of House 1.

The floor plan of House 1 is shown in Figure 4. According to its internal configuration, 12 thermal zones are identified:

1. Bed 1
2. Bed 2
3. Bed 3
4. Bed 4
5. WIR
6. Ensuite
7. Bath
8. Laundry
9. WC
10. Entry
11. Kitchen + Family
12. Dining + Lounge.

2.6 Technologies for developing the house templates

The template-based approach assumes that generic templates for typical houses, can be used to represent actual houses of those types in assessments through customization of key parameters. This assumption is valid because the internal partitioning and zoning contribute significantly lesser than the external buildings' envelopes. A sensitivity study was conducted to ascertain the degree to which floor plans can be generalized and simplified. The generalization and simplification process attempts to minimize the number of internal partitioning and thermal zones while maintaining acceptable levels of precision. At the same time, it is important for the templates to be sufficiently comprehensive to accurately represent the intended types of houses. Three streams of work were conducted to support the zone minimization process:

1. A sensitivity study was undertaken based on changes to internal partitioning and thermal zoning to determine the degree to which assessment results are affected when the number of thermal zones are reduced from the original 12 to 7, 5, and 2 zones. This sensitivity study provides a basis on which trade-offs between precision and speed can be made.

2. A geometric and topological model for the House 1 template was investigated to determine the relationships between external walls, internal walls, ceiling, roof space, and floor. Minor features (e.g. wardrobe and cupboards) were removed or simplified to allow assessors focus on key features of houses and increase their efficiency in entering data. An algorithm was developed to test these relationships so that dimensions can be derived from a minimal set of measurements.

3. A data output interface was established to generate a fully functional AccuRate project data file that can be imported into AccuRate for further assessment. This interface is necessary because AccuRate uses a proprietary file format (.pro) which cannot be accessed by other applications.

3. UNDERPINNING TECHNOLOGIES FOR FAST INPUT MECHANISM

3.1 A sensitivity study on thermal zones

AccuRate uses the concept of thermal zones to characterize the rooms/volumes within houses. Zone types can be set by assessors and reflect the purpose of the rooms/volumes. In the rating mode, AccuRate has a number of pre-defined zone types. Zones of types “Living”, “Living/Kitchen”, and “Bedroom” are automatically heated and cooled. In contrast, zones of types “Sub-floor” and “Roof-Space” are not heated or cooled. There are other zones that can be controlled or defined by assessors, such as “Other (daytime usage)”, “Other (night-time usage)”, and “Garage”.

Ballinger (2006) recommended some basic rules about zones. He suggested that each room or each discrete volume in a dwelling can be zoned according to the following guidelines:

- An individual room/volume that has one or more exterior walls and one or more windows or roof windows can be treated as a separate zone in AccuRate.
- A passage or any other internal space that connects a number of rooms/volumes together to provide through-ventilation can be treated as a separate zone.
- A room/volume can be combined with the room into which it opens when the following conditions are met:
  1. It does *not* have a window or roof window to the exterior (such as a wardrobe or small walk-I store room), and
  2. The floor area of the room/volume is not greater than $5m^2$ or 25% of the area of the room into which this room of volume opens (whichever is the greater).
- All kitchen pantries, wardrobes and shallow cupboards (less than 1.5m deep) can be combined with the room into which they open unless they represent more than $5m^2$ or 25% of the area of the room into which this room/volume opens (which ever is the greater).

In addition, Ballinger (2006) suggested that:

- Generally, only one or two zones should be selected as “Living”.
- Only one zone should be selected as “Living/Kitchen”. In the rating mode, an error will be generated if there is more than one “Living/Kitchen”.
- The zone types of all bedrooms should be set as “Bedroom”.
- The zone types of all other living or day-time usage rooms (e.g. study, home office, laundry, sewing rooms) should be set as “Other (daytime usage)”.
- The zone types of rooms that are associated with bedrooms (e.g. such as Bathrooms, ensuite bathrooms and other bedroom-related personal relaxation spaces) should be set as “Other (night-time usage)”.
- Generally, all zones whose types are set as “Other” with walls and windows to the exterior should be heated and cooled, unless specified otherwise below.
- Rooms/volumes which are nominated as utility rooms (e.g. bathrooms, laundries, stores) should be treated as separate zones. The zone types should be set as either “Other (daytime usage)” or “Other (night-time usage)”. These zones should not have heating and cooling enabled. Doors should be included as openings between those zones and the others.
- The zone types of non-habitable subfloor spaces should be set as “Sub-floor”.
- The zone types of non-habitable roof spaces or attics should be set as “Roof space”.
- The zone types of garages that are attached to the dwelling should be set as “Garage”. These zones should not be heated or cooled. Detached garages should not be included in the rating process.

According to these guidelines, House 1 can be divided into 12 thermal zones, as shown in Table 1. The floor plan of the fully-zoned house is shown in Figure 5.

Table 1 The 12 thermal zones in House 1.

Name	Type	Heated	Cooled	Conditioned	Comments
Bed 1	Bedroom	Y	Y	1600-0900	
Bed 2	Bedroom	Y	Y	1600-0900	
Bed 3	Bedroom	Y	Y	1600-0900	
Bed 4	Bedroom	Y	Y	1600-0900	
WIR	Night use	N	N		
Ensuite	Night use	N	N		
Kitchen	Living/Kitchen	Y	Y	0700-2400	Cooking heat gains included
Dining	Living	Y	Y	0700-2400	No cooking heat gains
Entry	Living	Y	Y	0700-2400	No cooking heat gains
WC	Day use	Y	Y	0700-2400	No cooking heat gains
Laundry	Day use	N	N		

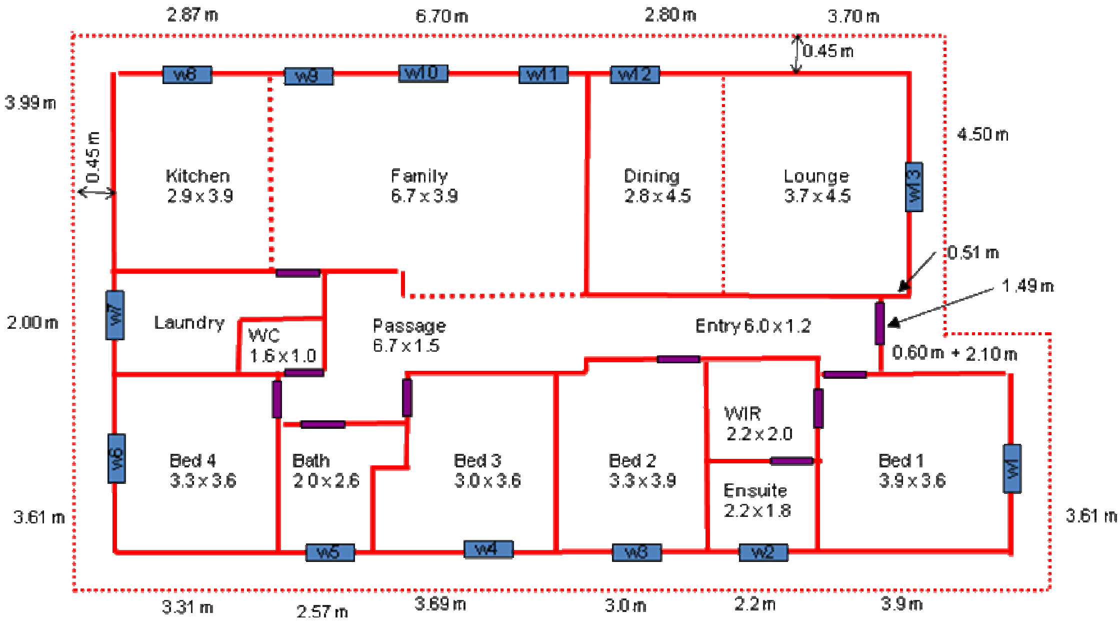


Figure 5 Fully-zoned House 1 with 12 thermal zones.

One way to accelerate the data input process is to reduce the number of zones as much as possible while maintaining acceptable levels of precision. Various approaches were investigated through merging zones of the same types systematically until the house is reduced to two zones – a day-time use living zone and a night-time use sleeping zone. The effects of these reductions were studied in this project.

Figure 6 shows the result of the first merging process. In this process, the following zones were merged to reduce House 1 to 7 zones:

- All bed rooms were merged into one “Sleeping” zone.
- WC and Laundry were merged into one “Utility” zone.
- WIR and Ensuite were merged into one “Night use” zone.

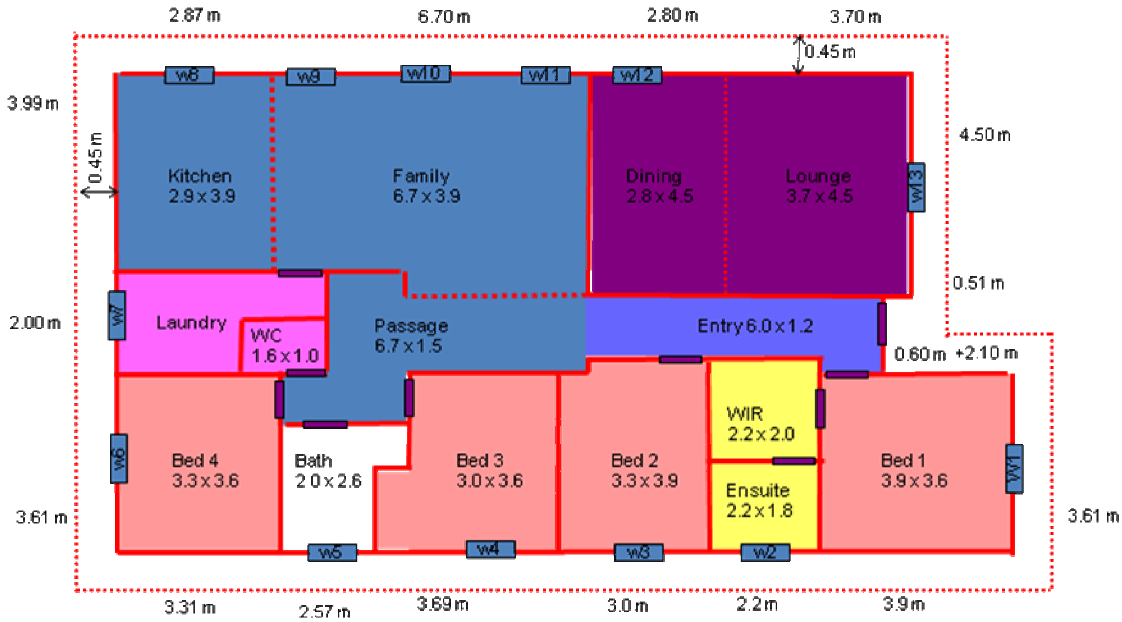


Figure 6 House 1 with 7 thermal zones.

Figure 7 shows the results of the second merging process. In this process, the following zones were merged to reduce House 1 to 5 zones:

- Kitchen/Family, Lounge/Dining, and Entry were merged into a single "Living" zone.

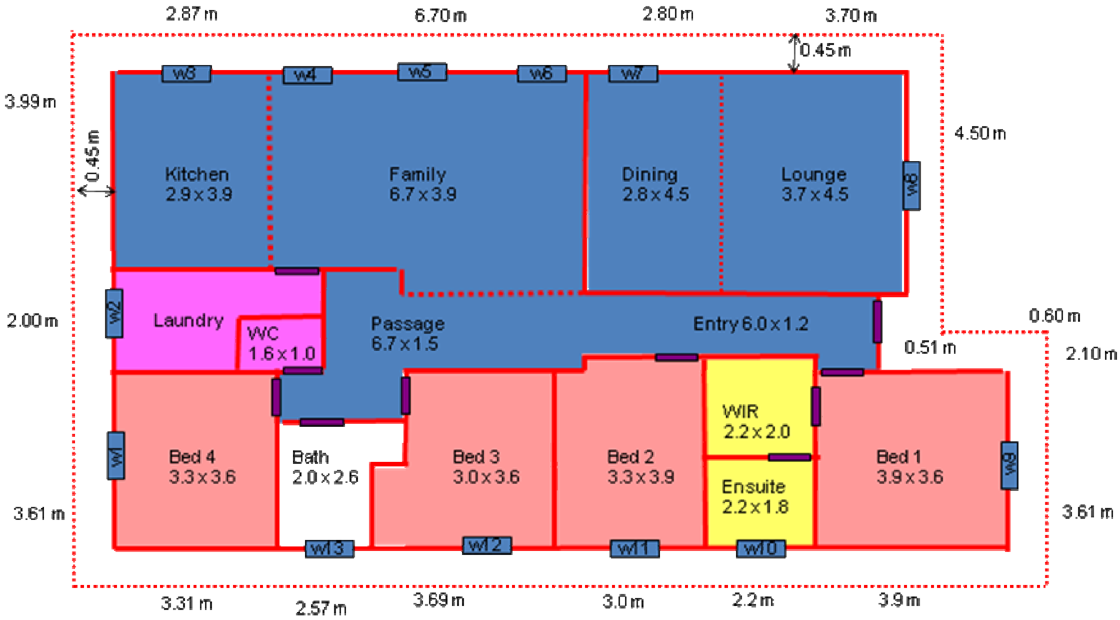


Figure 7 House 1 with 5 thermal zones.

Figure 8 shows the results of the third merging process. In this process, the following zones were merged to reduce House 1 to 2 zones:

- Bathroom and WIR/Ensuite were merged into "Sleeping" zone.
- The "Utility" zone was merged with the "Living" zone.

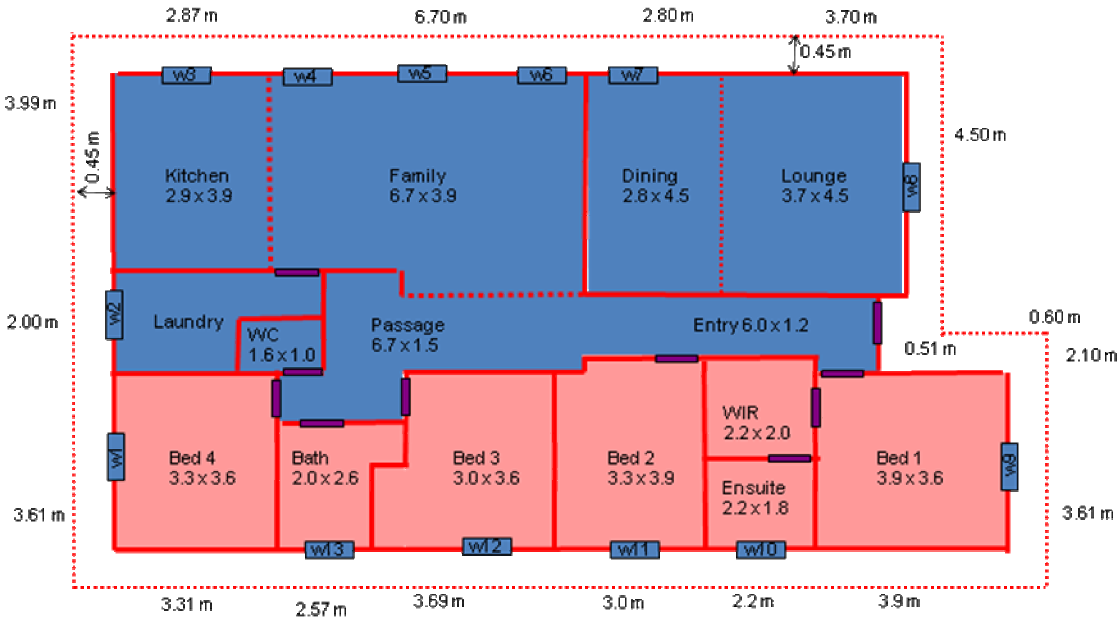


Figure 8 House 1 with 2 thermal zones.

The 12-zoned House 1 was used as the baseline comparison to assess the sensitivity of different zoning approaches. The location of House 1 is set to Climate Zone 62 (Highett, VIC 3190). The external building envelope was unchanged except for the eaves (450mm) and azimuth (North). The external wall is a colorbond wall with a vertical air gap (40 nominal), R1.0 batt, and plasterboard. The ceiling is plasterboard with R2.0 bulk insulation. The area-adjusted energy requirements and star ratings of the four combinations are presented in Table 2.

Table 2 Area-adjusted energy requirements (in MJ/m^2 annum) and star ratings for the different zoning approaches (based on Climate Zone 62).

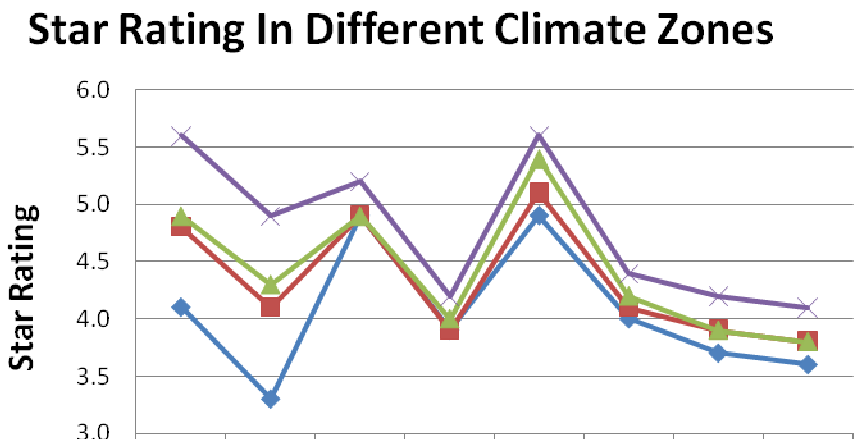
	12 Zones	7 Zones	5 Zones	2 Zones
Heating	202.0	194.5	190.4	173.8
Cooling (Sensible)	15.6	15.2	14.6	15.6
Cooling (latent)	1.8	1.7	1.5	1.5
Total Energy	219.3	211.4	206.5	190.9
Star Rating	4.0	4.1	4.2	4.4

The results in Table 2 show that the reduction of thermal zones has minor effects on the energy requirements. The results of the 7-zone and 5-zone approaches are relatively close to the 12-zone approach. Even the 2-zone approach is only 0.4 stars higher than the 12-zone approach. The reduction of thermal zones appears to result in slightly higher ratings to the House 1.

Further research is required to determine more precisely the effects of zoning in hot climates because climates 32 and 36 display more significant differences for the 2-zone and 12-zone templates. In addition, it was found that the smaller number of zones results in larger heated and cooled floor areas. However, the range of overall energy requirements remains small.

To evaluate the effect of thermal zoning approaches in different climate zones, the four combinations were tested with 8 different climates zones (corresponding to BCA climate zones 1 to 8). Figure 9 shows that the rating results are close and consistent in most climate zones, except for two very hot climate zones (32 and 36) where the differences are quite significant.

Based on the sensitivity study of thermal zoning approaches, we can conclude that the merge of similar thermal zones within a house only has minor effect on the rating results, usually leads to a slightly higher rating. This indicates that a template-based approach is a viable technology to achieve a faster data input in most climate zones.



	32	36	37	42	54	62	66	25
12 Zones	4.1	3.3	4.9	3.9	4.9	4.0	3.7	3.6
7 Zones	4.8	4.1	4.9	3.9	5.1	4.1	3.9	3.8
5 Zones	4.9	4.3	4.9	4.0	5.4	4.2	3.9	3.8
2 Zones	5.6	4.9	5.2	4.2	5.6	4.4	4.2	4.1

Figure 9 Star ratings for different zoning approaches in different climate zones.

3.2 A sample template model

In order to facilitate the development of a generalized template, the internal partitioning features of House 1 were simplified further. Details such as cupboards and robes which make the data input process unnecessarily complicated and tedious were removed. The resulting simplified partitioning layout has an added benefit of making the template more adaptable to different house settings.

Figure 10 shows a simplified floor plan for House 1. Cupboards and built-in robes were removed from this version of the floor plan. Some internal walls were straightened and realigned to minimize the measurements required. In addition, two thermal zones were merged: Laundry and WC as well as WIR and Ensuite. The area-adjusted energy requirements and star ratings of this simplified floor plan and the original 12-zone floor plan are shown in Table 3. The results show that the differences are small.

Figure 10 A simplified floor plan for House 1.

Table 3 Area-adjusted energy requirements (in MJ/m^2 annum) and star ratings for the original 12-zone floor plan and the simplified floor plan.

	Base Design	Template
Heating	202.0	194.5
Cooling (Sensible)	15.6	15.2
Cooling (latent)	1.8	1.7
Total Energy	219.3	211.4
Star Rating	4.0	4.1

3.3 An XML interface for AccuRate

An XML interface mechanism was developed jointly in the Fast Input Mechanism and Feedback Mechanism projects. In addition to supporting the data interchange between these projects, the XML interface provides an avenue through which external applications can modify data in and communicate with AccuRate. This was not possible previously because the native binary format that AccuRate uses is proprietary.

The AccuRate software was enhanced to support the importing and exporting of XML data. This new feature was used to generate 30 AccuRate project files as XML files. Subsequently, these files were used to generate a comprehensive XML definition file through which the XML-equivalent Java classes were generated. Fast Input Mechanism and Feedback Mechanism use these Java classes to modify AccuRate's assessment models.

4. SYSTEM IMPLEMENTATION AND VALIDATION

4.1 System implementation

Fast Input Mechanism was developed as a standalone Java-based Rich-Client Platform (RCP) application using the Eclipse Modeling Framework (EMF). Java was chosen as the preferred language to implement Fast Input Mechanism because it allows applications to be deployed on various Operating Systems (OS) (e.g. Windows, Linux, Mac OX) with minimal changes in most cases. This feature may allow higher levels of software adoption by assessors who use OS's other than the Windows platform.

On the other hand, RCP is a Java-based technology that uses the Standard Widget Toolkit (SWT) to present applications in "OS-native" ways while maintaining OS-independence. For instance, the look-and-feel of scrollbars and text boxes for RCP applications running on the Windows platform will look and behave in the same manner as conventional Windows applications. In contrast, off-the-shelf Java uses the Swing library which creates user interfaces that have the same look and feel across OS's. The drawback is that the look and feel of Swing applications is usually different from the native OS. As a result of using RCP (and SWT) in Fast Input Mechanism, users can work in familiar software environments and invest more time in performing productive assessment tasks rather than learning how to use the software.

EMF is a Java-based technology that encapsulates application-specific information that allows Java modules to be generated automatically. Together with the EMF library, these classes can be extended to support standard modern user-interface features such as copy/cut/paste and undo/redo.

Based on a combination of these technologies, Fast Input Mechanism was designed from users' perspective. For instance, the software includes a Floor plan frame to help users visualize and edit dimensions of houses. Furthermore, relevant images are associated with assessment data so that users can input data based on recognition of images instead of relying solely on the recollection of textual information. This shift towards graphical visualization and input is expected to increase the software's user-friendliness and improve users' experience.

Fast Input Mechanism uses a template-based approach where users choose the template that matches most closely to the house under assessment. This template will provide the users with a set of default values and optimize the number of data entries needed for the assessment. This leads to a reduction in the complexity and amount of time required for each assessment. Where necessary, the selected template data can be edited by users during the data input process.

The house templates were built using AccuRate and exported as XML files. The format of these files and ways of interacting with them were developed jointly by the Fast

Input Mechanism and Feedback Mechanism projects. Having a common file format allows data to be shared and transferred more easily between the applications. The XML-based data is mapped to high-level Java modules that present the data in relevant business logic without revealing the underlying storage mechanism. This is useful when future versions of the Fast Input Mechanism and Feedback Mechanism applications are to be deployed as multi-user web-based applications. In this version of Fast Input Mechanism, the house templates are stored in a local template repository that is created during installation.

Similarly, Fast Input Mechanism maintains material repositories containing definitions of external wall construction types, ceiling construction types, and window specifications. These repositories are used to populate the user interface with user-selectable data and relevant images. Both the house template and material repositories can be expanded in future version of the software.

4.2 Fast input process

Users of Fast Input Mechanism will perform house assessments in the following sequence:

- Configuring Fast Input Mechanism for initial usage
- Filling in information that can be provided by clients
- Assessing external features of the house (e.g. external walls, windows, roofs)
- Assessing internal features of the house (e.g. internal walls, ceiling height)
- Saving and exporting the assessment for analysis

4.2.1 Software configuration

Using the `Preferences` dialog in the `Edit` menu, users can customize Fast Input Mechanism to automatically fill in their assessor details (Figure 11) and specify the location in which AccuRate is installed (Figure 12). This is a one-off process that needs to be performed for new installations of the software.

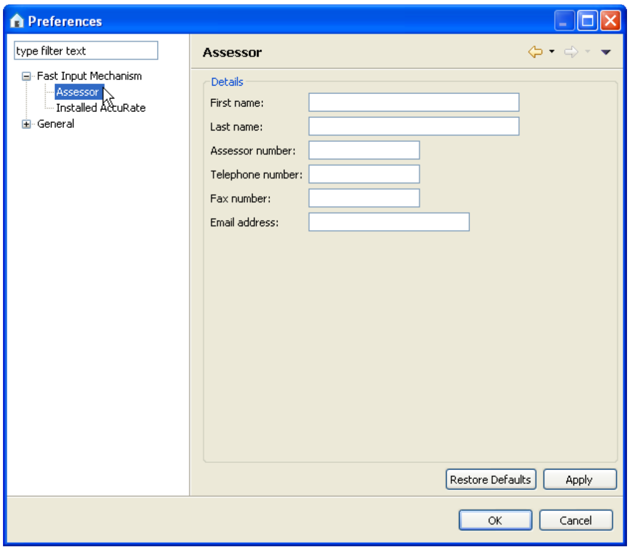


Figure 11 The `Assessor` preferences dialog box.

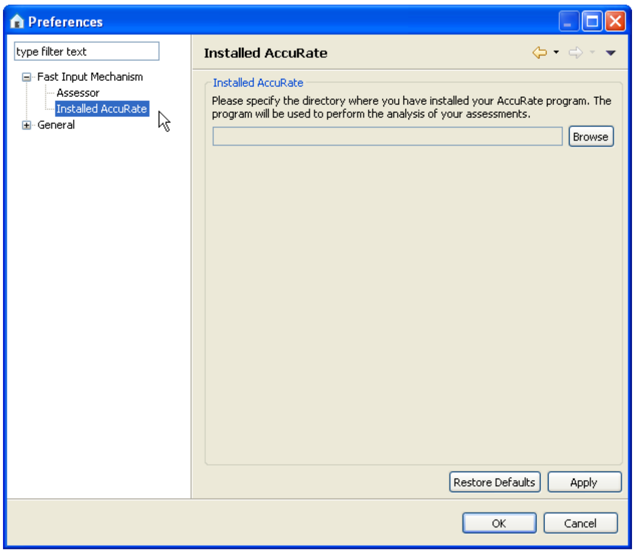


Figure 12 The `Installed AccuRate` preferences dialog box.

4.2.2 Information that can be provided by clients

When a new assessment is created, Fast Input Mechanism generates a temporary assessment file where users can enter basic information about their clients and houses before visiting the house sites. This information includes the clients' particulars and house features such as the number of bedrooms (Figure 13 and Figure 14).

Users are recommended to visit the client's sites before committing to house types (in the General page). Once committed, the house types cannot be changed within the assessments because every house has a distinct set of customizable parameters and cannot be mapped easily between houses without losing data.

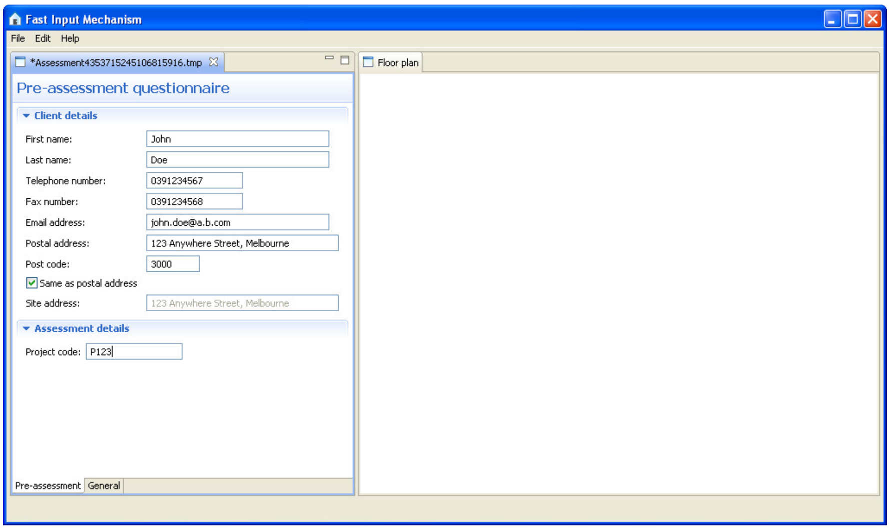


Figure 13 The `Pre-Assessment` page in a new assessment.

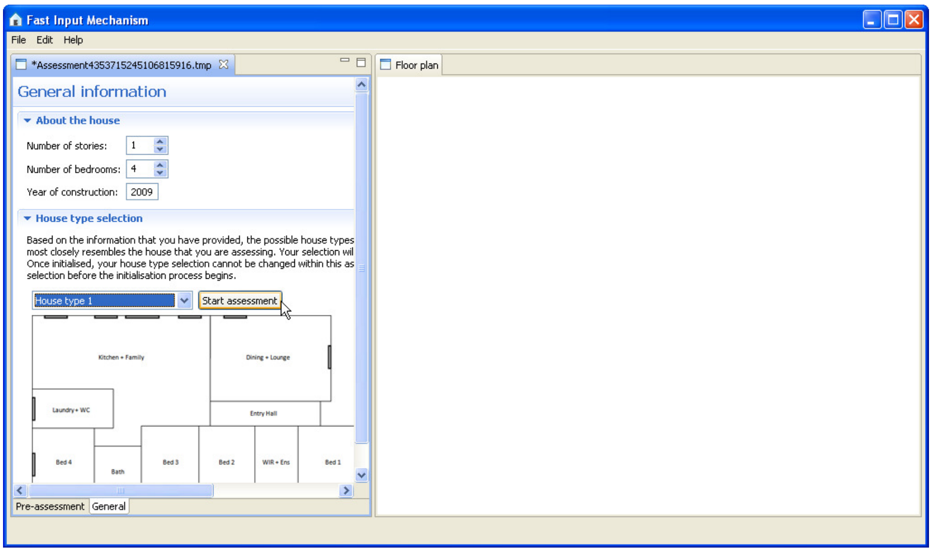


Figure 14 Choosing a house type to assess.

4.2.3 Externally-assessable data

On arrival at the houses to assess, users are recommended to enter the externally-assessable data in the `External` page. These data include azimuth, external wall construction types, and roof types (Figure 15).

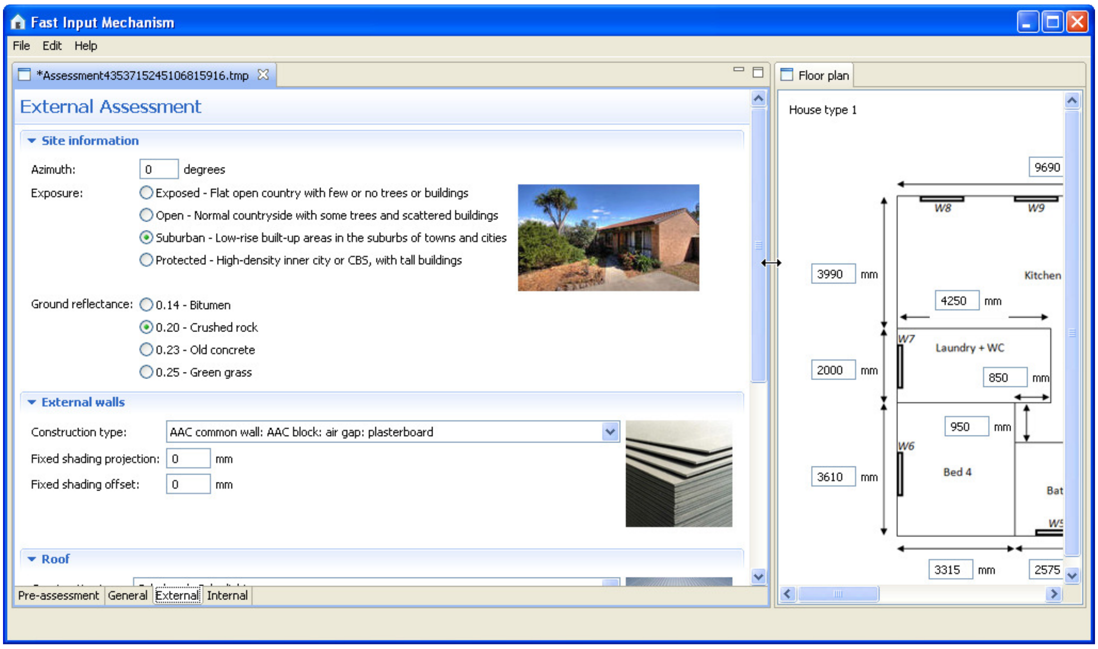


Figure 15 The `External` assessment page.

4.2.4 Internally-assessable data

After assessing the external parts of houses, users can proceed to the `Internal` page for the set of data required for internal parts of the houses. These data include internal wall construction types, dimensions of rooms, window types and dimensions, and ceiling/floor construction types (Figure 16). The data entry fields of rooms are arranged in a logical sequence that minimizes the path that users have to take to determine the required measurements.

Dimensions of rooms can also be entered through the graphical visualization of the house in the Floor plan frame on the right of Fast Input Mechanism's main window.

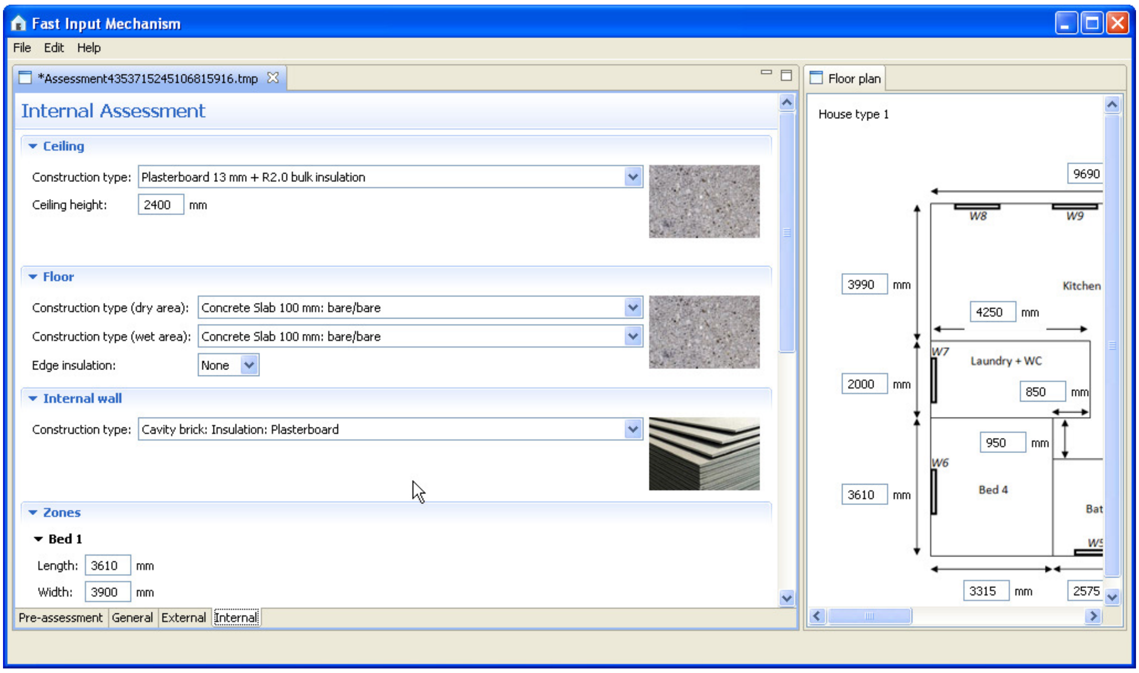


Figure 16 The `Internal` assessment page.

4.2.5 Analysis of assessment data

After all data fields in an assessment are completed, users can export the assessment to the AccuRate XML format using the `Export` menu item in the `File` menu. Upon successful completion of the export process, Fast Input Mechanism will generate an analysis report (Figure 17) or open the exported assessment in AccuRate (depending on users' choice) (Figure 18).

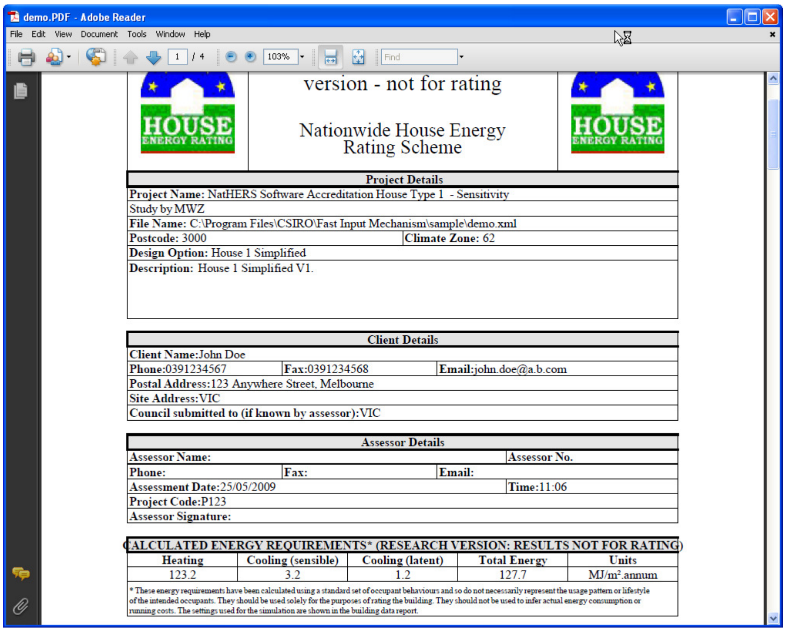


Figure 17 Results of the analysis of the exported assessment.

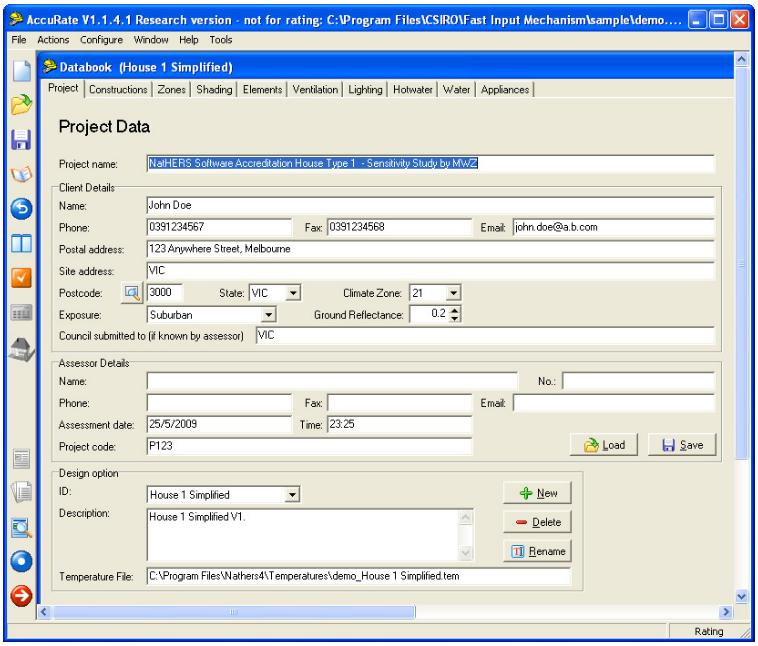


Figure 18 Opening the exported assessment in AccuRate.

4.3 System validation

In order to validate Fast Input Mechanism, a comparative study was conducted and evaluated against the AccuRate system. The study involved the manual development of a variation design based on the House 1 template. Subsequently, Fast Input Mechanism was used to produce the same variation design. It took us about 30 minutes to produce the variation in AccuRate, while it only took about 3 minutes to produce the same variation in Fast Input Mechanism.

Table 4 Comparisons between the analysis results of House 1 that were generated using AccuRate and Fast Input Mechanism.

	Result type	AccuRate Interface	Fast Input Mechanism
Calculated energy requirements	Heating	166.1	164.5
	Cooling (sensible)	13.2	13.6
	Cooling (latent)	2.0	2.0
	Total energy (MJ/m2.annum)	181.3	180.1
Area-adjusted energy requirements	Heating	149.9	148.5
	Cooling (sensible)	11.9	12.2
	Cooling (latent)	1.8	1.8
	Total energy (MJ/m2.annum)	163.6	162.5
Star rating		5.0	5.1

Table 4 presents the assessment results of the two systems. The results demonstrate that Fast Input Mechanism is able to maintain the accuracy of the analysis outcome while reducing the complexity of the house template. Upon closer scrutiny of the results, it was found that the slight differences in the results are caused by the simplified modelling of floor coverings. For instance, Fast Input Mechanism specifies only two types of floor covering: one for wet areas and the other for dry areas. Furthermore, the Dining/Lounge zone is treated as a dry area (instead of a combination of wet and dry areas). There are some minor rounding errors in the Fast Input Mechanism model but they appear to be negligible.

Based on conversations with experienced assessors, the preparation of an AccuRate model for a typical house such as House 1 can take up to 2 to 6 hours. In contrast, a full implementation of Fast Input Mechanism will allow assessors to construct a similar model within 15 minutes (assuming all necessary data and suitable templates are available). This represents potentially significant savings in time and cost for assessors.

5. DISCUSSION AND FUTURE WORK

5.1 A Smart Pen and Paper Interface

The Smart Pen and Paper interface is one of the human computer interaction (HCI) technologies that the CSIRO team is exploring to support fast input for building data. It uses a digital pen that can be used to write like a normal pen. At the same time, the pen records the data digitally in its built-in memory. The digital pen works on specially designed paper that has a matrix of nearly invisible micro-dots that are superimposed on readable content.

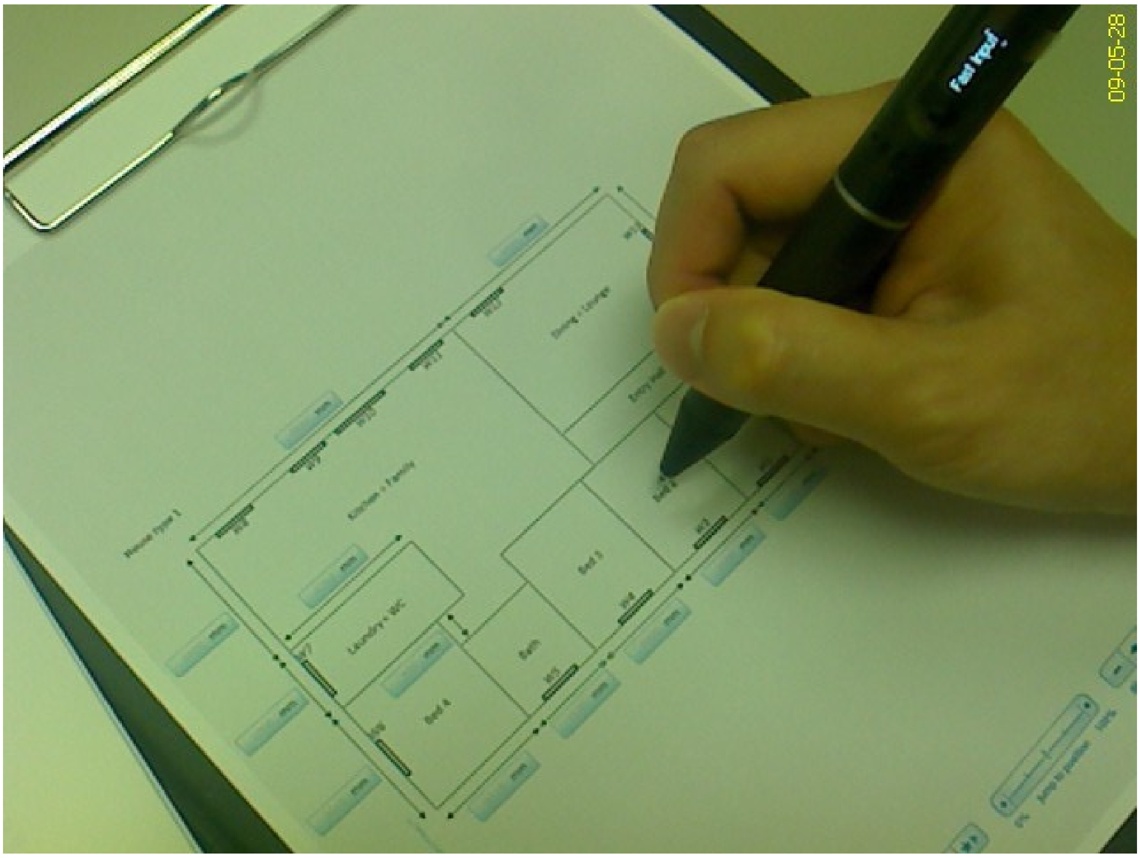


Figure 19 Fast Input Mechanism using the Smart Pen and Paper.

As shown in Figure 19, a template of a house plan can be printed on this specially marked paper. An interface has been implemented as a proof-of-concept experiment to link the Smart Pen and Paper with the Fast Input Mechanism. This proof-of-concept system was demonstrated to representatives of DEWHA and ABSA.

With this technology, assessors can visit houses and conduct assessments with just a folder, pen, and paper. Assessors will be able take notes on check lists, record voice messages, and select suitable templates to store relevant measurements. The recorded data can be read into the computer for further processing by Fast Input

Mechanism. Fast Input Mechanism will be able to populate the written measurements onto the corresponding template and data entry areas. As such, assessors will not need to re-enter the values into Fast Input Mechanism.

An additional benefit of using the Smart Pen and Paper technology is that the maintenance of quality control and meeting of auditing requirements are facilitated through the digital and written data.

At present, the CSIRO team is still investigating the features and feasibility of the Smart Pen and Paper technology. The outcomes have been promising and merit further research and development.

5.2 Future Work

The outcomes of this project demonstrate that the template-based Fast Input Mechanism technology is an effective approach to improving the productivity of assessors when conducting house rating processes. Future research may focus on the development of a rich library of typical house templates. A software function and possibly a commercial incentive may need to be developed to support the ongoing enrichment of the template library. In addition, further developments of the Smart Pen and Paper technology will also complement the Fast Input Mechanism technology.

More research will be required to develop more comprehensive guidelines on the use of the Fast Input Mechanism technology for rating purposes. This is especially important for the hotter climate zones because their assessment results appear to be sensitive to different zoning approaches.

A full implementation on a new platform would also provide a closer integration of the Fast Input and normal data input mechanism.

6. ACKNOWLEDGEMENT

This Project is co-funded by the CSIRO Climate Adaptation Flagship through its Integrated Sustainability Assessment Platform research focal area under the Sustainable Cities and Coasts Theme, and by the DEWHA through its Green Loan's Program.

The project team would also like to acknowledge the assistances and advices from the DEWHA Residential Building Efficiency Team.

The project team would also like to acknowledge the assistances and advices from Mr Paul Nagle, an ABSA member and consultant to DEWHA.

Finally, the project team would like to thank Prof. John Ballinger for his valuable contributions and his services to the project.

REFERENCES

Ballinger J. (2006). Basic rules about zones in the use of AccuRate (draft V4). In *The AccuRate Trainer CD*. [CD].

Boyd R. (1952). Australia's home: its origins, builders and occupiers. Victoria, Australia: Melbourne University Press.

Solar Logic (2009). BERS Pro software details. Retrieved May 29, 2009, from http://www.solarlogic.com.au/bers-pro/details.

Contact Us

Phone: 1300 363 400
+61 3 9545 2176
Email: enquiries@csiro.au
Web: www.csiro.au

Your CSIRO