Design Process Modeling with BCA Green Mark

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Abstract

Green Mark is a Singapore based green building rating system launched in January 2005 by the Building and Construction Authority (BCA). It adopts a checklist scoring system to assess two sets of criteria namely, the Residential Building Criteria and Non-Residential Building Criteria, in five environmental impact categories. Each requirement is credited with some numerical points assigned based on the degree of compliance with the applicable criteria and the scoring methodology. However, there is little description about process to serve as a guideline on how to design and develop a green building. In this paper, we present a method for mapping the Green Mark scheme to process model, based on which a design firm can model its own design work flow and integrate it with the Green Mark process model. This helps achieve more integrated and efficient management of work flow and data flow with a strong focus on Green Mark implementation.

Keywords: Process modeling, Green mark, Green building, Building Information Modeling, building performance design

Introduction

A green building, also known as a sustainable building, is a structure that is designed, built, renovated, operated, or reused in an ecological and resource-efficient manner. Green buildings are designed to meet certain objectives such as protecting occupant health; improving employee productivity; using energy, water, and other resources more efficiently; and reducing the overall impact to the environment (California Department of Resources Recycling and Recovery). The growing concern on environmental conservation and the momentum of sustainable development have initiated a trend for green buildings globally. The Singapore government recently announced an ambitious blueprint setting a target for 80% of the existing buildings to be certified by Green Mark rating by 2030 (Tan, 2010).

Green Mark is a Singapore based green building rating system comparable to Leadership in Energy and Environmental Design (LEED), an internationally recognized green building certification system developed by the U.S. Green Building Council (USGBC). The Green Mark scheme was launched in January 2005 by the Building and Construction Authority (BCA), Singapore, to promote environmental sustainability in the construction industry, raise the awareness among developers, building owners and industry professionals on the environmental impact of their projects, accord recognition to building owners and developers who adopt building practices that are environmentally conscious and socially responsible, and identify best practices in the development, design, construction, management and operation of “green” building (BCA, 2005).

The Green Mark scheme adopts a checklist scoring system to assess two sets of criteria namely, the Residential Building Criteria and Non-Residential Building Criteria, in five

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environmental impact categories. Each requirement is credited with some numerical points assigned based on the degree of compliance with the applicable criteria and the scoring methodology (BCA, 2010a and 2010b). However, there is little description about process to serve as a guideline on how to design and develop a green building. The lack of design process guidance can deter those who are new in green building design and, on the other hand, result in repeated mistakes on each new project for those who are unaware of good practices. Therefore, an integrated design process and methods to facilitate such processes are required to increase the efficiency of this complicated process for design professionals (Korkmaz et al, 2010).

In this paper, we present a method for mapping the Green Mark scheme to process model, based on which a design firm can model its own design work flow and integrate it with the Green Mark process model. This helps achieve more integrated and efficient management of work flow and data flow with a strong focus on Green Mark implementation.

BCA Green Mark Scheme

Green rating systems and design guidelines emerged one decade ago to facilitate designing for sustainability. LEED, for example, is an open and transparent process where the technical criteria proposed by USGBC members are publicly reviewed for approval by the almost 20,000 member organizations. Since its inception in 1998, the U.S. Green Building Council has grown to encompass more than 7,000 projects in the United States and 30 countries covering over 1.501 billion square feet (140 km^2) of development area (Wikipedia, 2011). Other rating systems are also available, including BRE Environmental Assessment Method (BREEAM), adopted in the UK, Comprehensive Assessment System for Built Environment Efficiency (CASBEE), adopted in Japan, Green Rating, adopted in Europe, Green Star, adopted in Australia, Green Globes, also adopted in the US, and Three Star, adopted in China (Lambersky, 2010).

In Singapore, BCA launched Green Mark rating system in January 2005 to encourage more green buildings and improved sustainability in the built environment. The Inter Ministerial Committee on Sustainable Development has set a target of 35% reduction in energy intensity (consumption per dollar GDP) by the year 2030 from 2005 levels. At present the building sector in Singapore consumes 1/3 of electricity and contributes about 16% of carbon emission (Tan, 2010). BCA is reportedly implementing the 2nd Green Building Master Plan and introducing the $100 million Green Mark Incentive Scheme for Existing Buildings (GMIS-EB) to encourage building owners to undertake the necessary retrofits to upgrade their buildings (BCA, 2011a), which provides a cash incentive that co-funds up to 35% of the costs for energy efficiency improvement. For new buildings, an enhanced $20 million Green Mark Incentive Scheme for New Buildings (GMIS-NB) (BCA, 2011b) and a Green Mark Gross Floor Area Incentive Scheme (GM-GFA) (BCA, 2011c) are available.

The Green Mark scheme evaluates both residential buildings and non-residential, new and existing buildings for their environmental impact and performance based on five categories of criteria: (1) energy efficiency; (2) water efficiency; (3) environmental protection; (4) indoor environmental quality; and (5) other green features. The environmental performance of a building development is determined by the numerical scores (i.e. Green Mark points) achieved in accordance with the applicable criteria using the scoring methodology and the prerequisite requirements on the level of building performance. The final Green Mark Score determines whether the building development is eligible for certification under one of the four ratings namely, Green Mark Certified (50 to <75), Gold (75 to <85), Gold^{Plus} (85 to <90), or Platinum (90 and above), with a maximum of 155 points for residential building or 190 points for non-residential building (BCA, 2010b).

The Green Mark Certification Standard provides detailed information on assessment framework, point allocation, scoring methodology and documentation, but does not include any guidance on implementation processes. Although every company has its own preferred work methodology, many of them are still unfamiliar with green building design or, on the other hand, unaware of the best practice in industry. The following process modeling would be a good starter to help achieve enhanced management in work flow, data flow, documentation, collaboration and evaluation, which leads to a greener footprint in the Green Mark assessment.

Process Modeling

Process modeling is to create a formal representation of a work flow (or data flow) with a series of processes of the same nature that are classified into a model based on their relationships. Process modeling generates conceptual models which can be mapped to real life activities. It has been extensively used in the scope of business management to improve the efficiency and quality of business operation. Process modeling can describe simple and complex workflow patterns. Wil et al (2003) identified 21 patterns that describe the behavior of business processes as shown below (White, 2004).

- **Basic control patterns**: sequence, parallel split, synchronization, exclusive choice, simple merge
- **Advanced branching and synchronization patterns**: multiple choice, multiple merge, discriminator, N out of M join, synchronizing merge
- **Structural patterns**: arbitrary cycles, implicit termination
- **Patterns involving multiple instances**: MI with a priori design time knowledge, MI with a priori runtime knowledge, MI with no priori knowledge, MI requiring synchronization
- **State-based patterns**: deferred choice, interleaved parallel routing, milestone
- **Cancellation patterns**: cancel activity, cancel case

Process modeling can greatly facilitate managing complex building design workflows, especially those demanding higher standards on energy efficiency and indoor environmental quality. A formal design process modeling helps identify major activities and their interdependency and interaction from site selection, to the traditional design of architectural, structural, envelope, mechanical and electrical systems, to the green design of thermal energy efficiency, water efficiency, lighting, airflow, and acoustic. The values of design process modeling are identified as follows.

- Formalizing best practice and generating an unambiguous plan for execution
- Identifying system bottlenecks and deciding a strategy to resolve them
- Locating potential problems in each process and reducing delay and rework
- Creating uniformity to achieve higher quality and better cooperation and collaboration
- Shortening the learning curve for whoever wants to use the present process or integrate with the present process

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IDEF3 Process Description Capture Method

IDEF3 is part of IDEF, or Integrated DEFinition, family of modeling languages in the field of systems and software engineering. IDEF3 was created specifically to capture description of sequences of activities. Its goal is to provide a structured method by which a domain expert can express knowledge about the operation of a particular system or organization (Mayer et al, 1995). IDEF3 is more suitable for process modeling comparing with other IDEF methods. In this paper, we use IDEF3 to do a sample process modeling for Green Mark rating system. Our source of information is the fourth version of BCA Green Mark Certification Standard for New Building (GMCSNB) (BCA, 2010b).

Top Level

GMCSNB describes its certification process in Figure 1, which is mapped to the top level process model in Figure 2. A rectangle box is called a Unit of Behavior (UOB), which represents an activity, action, process, or operation. The link between UOB 2 and 3, for example, represents a constrained precedence link which indicates that Actual Assessment must be preceded by Pre-Assessment.

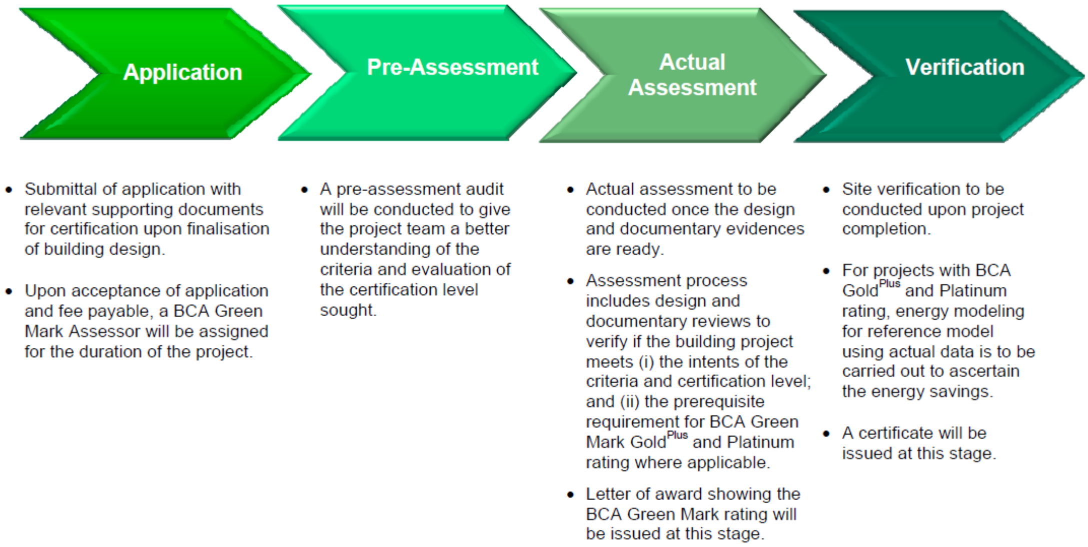

Figure 1: Green Mark Certification Process (BCA, 2010b)

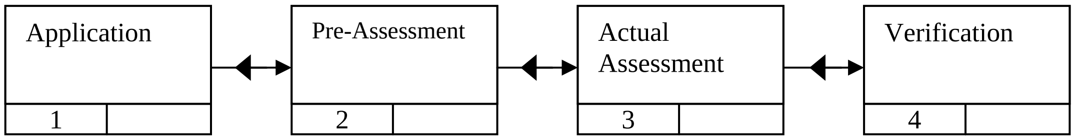

Figure 2: Green Mark Certification Process Model (Top Level)

Decomposition of Actual Assessment

Figure 3 shows the decomposition of [3 Actual Assessment]. [3.1 Verify design & documentary] requires the input of [Drawing & Documents] (expressed as a synchronous referent). The submitted application is classified as either Residential Building (UOB3.2) or Non-Residential Building (UOB3.3) connected by asynchronous exclusive OR junctions. After the assessment, a Green Mark rating is assigned to the application.

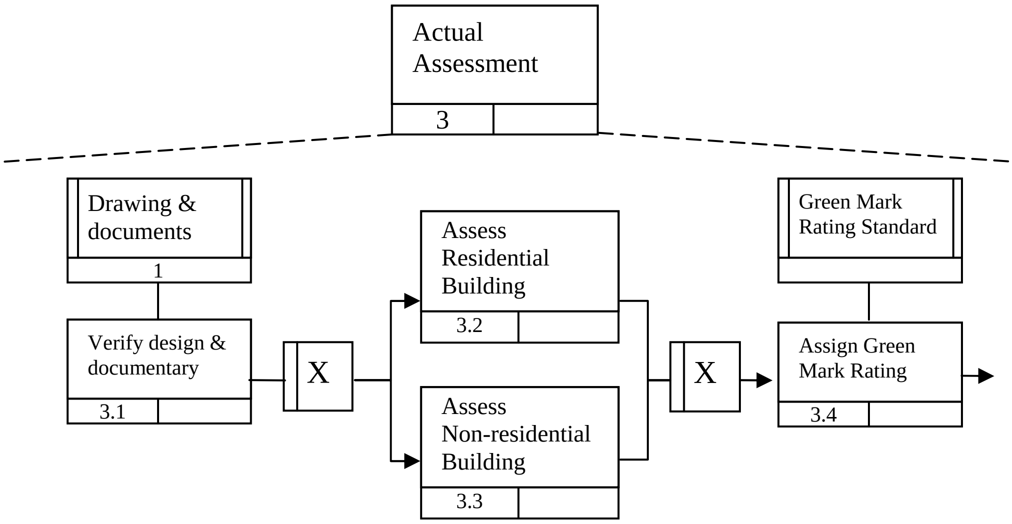

Figure 3: Decomposition of [3 Actual Assessment] (2nd Level)

Decomposition of Assess Residential Building

Figure 4 lists the framework and point allocation for residential building criteria, which can be mapped to process model. In Figure 5, [3.2 Assess Residential Building] is decomposed in five sub-processes: [3.2.1 Energy efficiency], [3.2.2 water efficiency], [3.2.3 environmental protection], [3.2.4 indoor environmental quality], and [3.2.5 other green features] connected by asynchronous AND junctions, where UOB3.2.1 is further decomposed into eight sub-processes to assess individual criteria related to energy efficiency.

Take [3.2.1.2 Naturally Ventilated Design and Air-conditioning System] as an example. The objective of process [3.2.1.2] is to enhance building design to achieve good natural ventilation for better indoor comfort or through the use of better efficient air-conditioner if needed. This is applicable to all dwelling units within the development. There are two options as baseline standards (see Figure 6). The criteria description is shown in the left-side column, and the point allocation is shown in the right-side column. Details about [3.2.1.2.1 Dwelling unit indoor comfort] is decomposed in Figure 7. Input for rating criteria and prerequisite requirement is shown in Figure 7.

Once all the individual rating criteria (see Figure 4) are evaluated and points are assigned, a total score can be assigned in [3.4 Assign Green Mark Rating] (see Figure 3). The process [3 Actual Assessment] is then completed.

Integration with External Design Processes

This sample process modeling is focused on Green Mark rating system. It provides a guide on how to generate process model based on the criteria and methodology of the rating system. However, it does not include any external process related to the work flow of a design firm. Given enough information, this can be done in a similar way. The result would be useful for improving design process through a clear understanding of the system and better data management.

	Category	Point Allocations
(I)	**Energy Related Requirements**	
Minimum 30 points	**Part 1 : Energy Efficiency**	
	RB 1-1 Thermal Performance of Building Envelope – RETV	15
	RB 1-2 Naturally Ventilated Design and Air-Conditioning System	22
	RB 1-3 Daylighting	6
	RB 1-4 Artificial Lighting	10
	RB 1-5 Ventilation in Carparks	6
	RB 1-6 Lifts	1
	RB 1-7 Energy Efficient Features	7
	RB 1-8 Renewable Energy	20
	Category Score for Part 1 – Energy Efficiency	**87 (Max)**
(II)	**Other Green Requirements**	
Minimum 20 points	**Part 2 : Water Efficiency**	
	RB 2-1 Water Efficient Fittings	10
	RB 2-2 Water Usage Monitoring	1
	RB 2-3 Irrigation System and Landscaping	3
	Category Score for Part 2 – Water Efficiency	**14**
	Part 3 : Environmental Protection	
	RB 3-1 Sustainable Construction	10
	RB 3-2 Sustainable Products	8
	RB 3-3 Greenery Provision	8
	RB 3-4 Environmental Management Practice	8
	RB 3-5 Green Transport	4
	RB 3-6 Stormwater Management	3
	Category Score for Part 3 – Environmental Protection	**41**
	Part 4 : Indoor Environmental Quality	
	RB 4-1 Noise Level	1
	RB 4-2 Indoor Air Pollutants	2
	RB 4-3 Waste Disposal	1
	RB 4-4 Indoor Air Quality in Wet Areas	2
	Category Score for Part 4 – Indoor Environmental Quality	**6**
	Part 5 : Other Green Features	
	RB 5-1 Green Features & Innovations	7
	Category Score for Part 5 – Other Green Features	**7**
	Green Mark Score :	**155**

Figure 4: Framework and Point Allocations for Residential Building Criteria

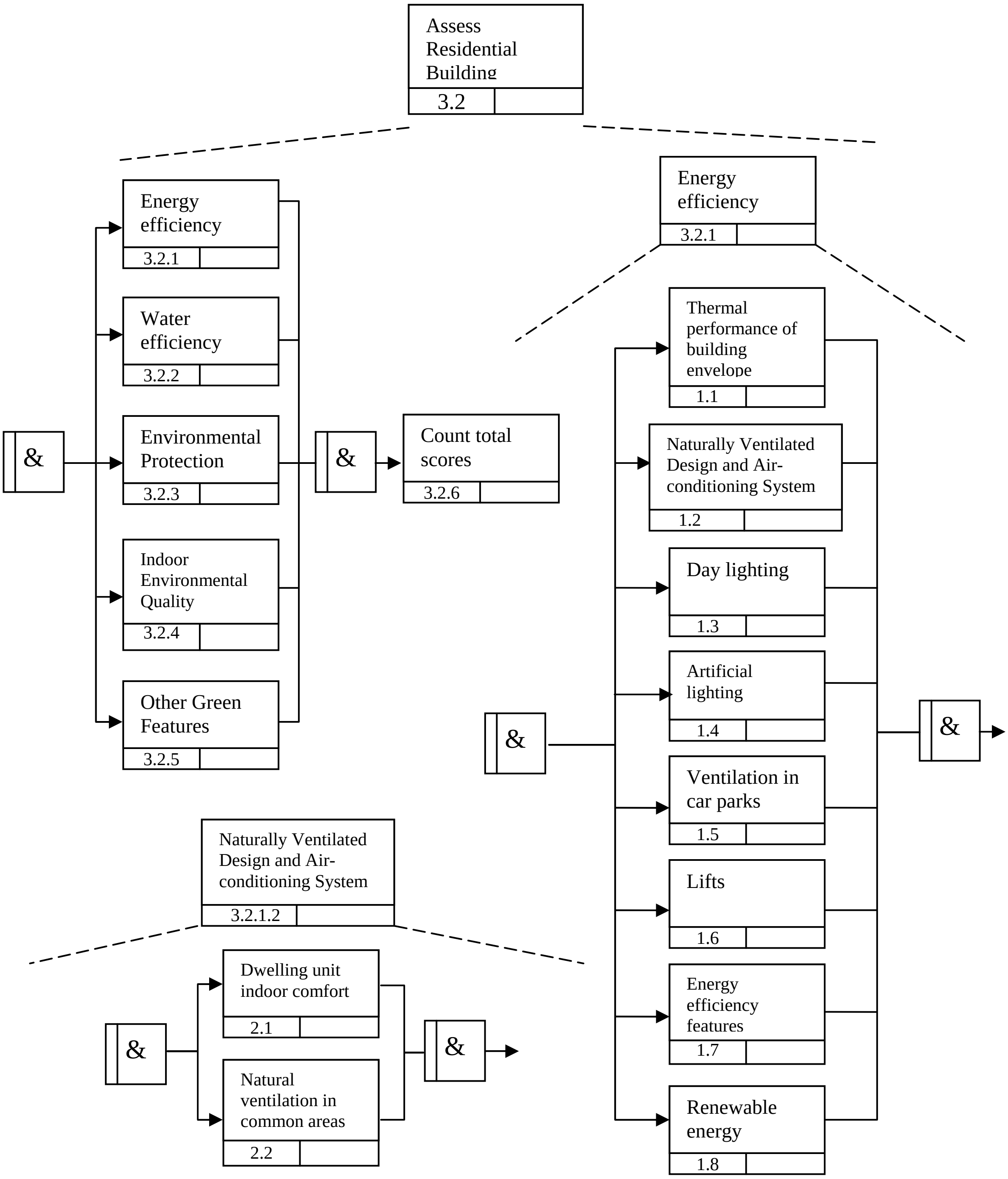

Figure 5: Decomposition of [3.2 Assess Residential Building] (3rd-5th Levels)

<u>RB 1-2 Naturally Ventilated Design and Air-Conditioning System</u> <u>(a) Dwelling Unit Indoor Comfort</u> Enhance dwelling unit indoor comfort through the provision of good natural ventilation design and energy efficient air-conditioners	
<u>Option 1 – Ventilation Simulation Modeling</u> Use of ventilation simulation modeling and analysis or wind tunnel testing to identify the most effective building design and layout to achieve good natural ventilation for all unit types. *<u>Prerequisite Requirement :</u>* *Green Mark Platinum –Minimum 80% of selected typical dwelling units with good natural ventilation. Common areas are to be designed as naturally ventilated spaces.* OR	0.2 point for every percentage of typical units with good natural ventilation Points scored = 0.2 x (% of typical units with good natural ventilation) (up to 20 points) OR
<u>Option 2 – Ventilation Design (without the use of simulation modeling) and Efficient Use of Air-Conditioning System</u> (i) Air flow within dwelling units	
• <u>Building layout design</u>: Proper design of building layout that utilizes prevailing wind conditions to achieve adequate cross ventilation.	0.5 point for every 10 % of units with window openings facing north and south directions Points scored = 0.5 x (% of units /10)
• <u>Dwelling unit design</u>: Good ventilation in indoor units through sufficient openings.	0.5 point for every 10% of living rooms and bedrooms designed with true cross ventilation Points scored = 0.5 x (% rooms/10) (Up to 8 points)
(ii) Provision of air-conditioning system Use of energy efficient air-conditioners that are certified under the Singapore Energy Labelling Scheme. Note (1) : Option 2(ii) is not applicable for developments where air-conditioners are not provided. Points will be scored and prorated accordingly under Option 2(i) *<u>Prerequisite Requirement :</u>* *Green Mark Gold^{Plus} / Green Mark Platinum } Air-Conditioners with 4 ticks under the Singapore Energy Labelling Scheme or equivalent COP*	Extent of Coverage : At least 80% of the air-conditioners used in all dwelling units Air-conditioners labelled with : Three Ticks – 4 points Four Ticks – 8 points

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Figure 6: Rating criteria for [3.2.1.2 Naturally Ventilated Design and Air-conditioning System]

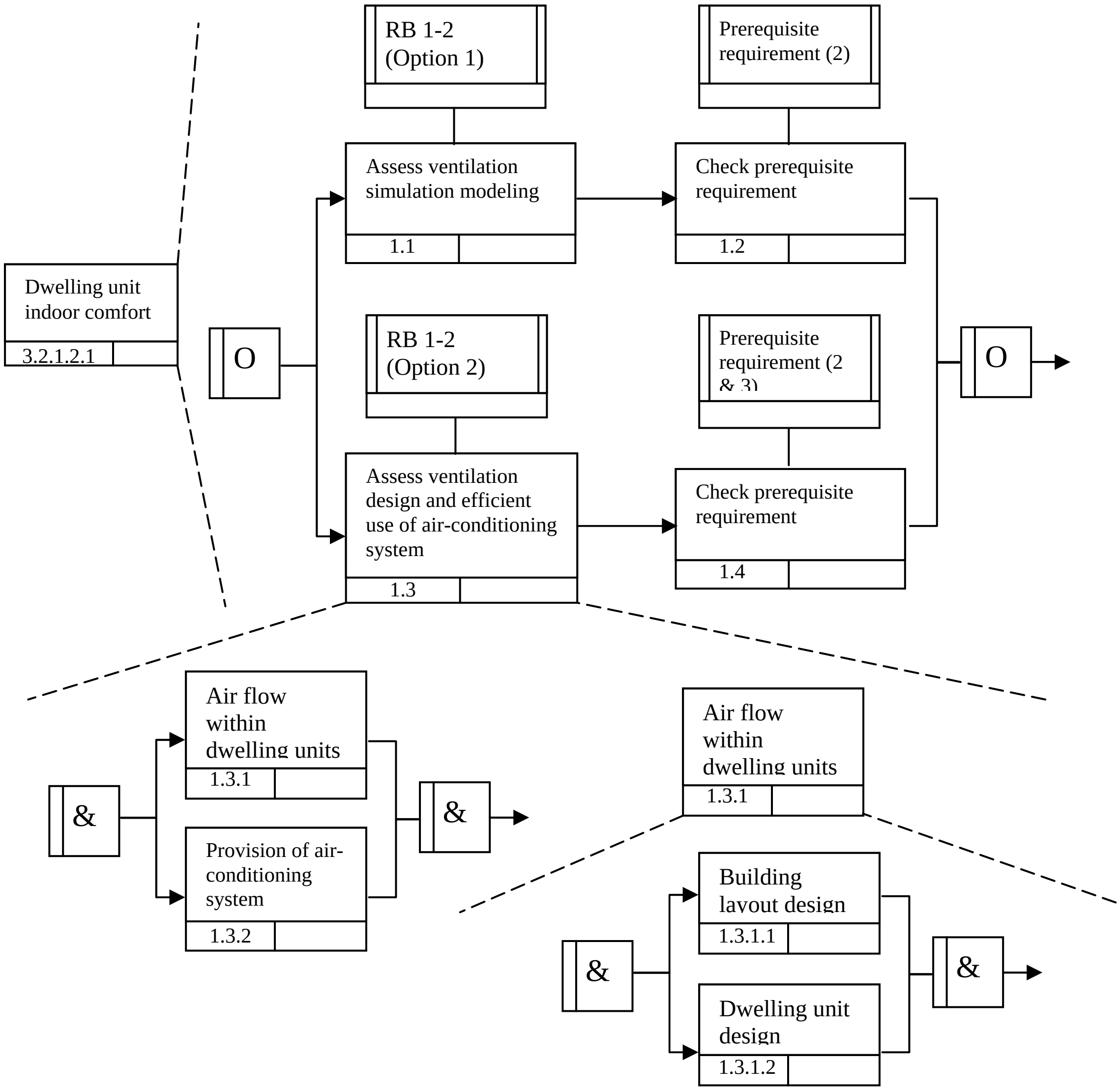

Figure 7: Decomposition of [3.2.1.2.1 Dwelling unit indoor comfort] (6th-7th Levels)

Conclusions

In this paper, we presented a method using IDEF3 Process Description Capture Method to map BCA Green Mark rating system to a process model. Details on the decomposition of processes in multi-levels are shown. The sample process model can be used as a guidance to produce a full process model from the Green Mark scheme, and integrate with external process models provided by design firms. This would encourage good practice in managing work, data flow, documentation, and collaboration, which leads to a strong focus on green design and eventually helps achieve better deliverables.

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