Building Simulation 2009

Eleventh International IBPSA Conference
Glasgow, Scotland
July 27-30, 2009

DEVELOPMENT OF RIBA SUB-PROCESS TO ASSIST REDUCTION OF BUILDING LIFE CYCLE IMPACT: INTEGRATION OF RIBA WORKSTAGE WITH EU EIA LEGISLATION AND ISO14040

Eugene Loh[1], Nashwan Dawood[2], and John Dean[3]
Centre for Construction Innovation Research
University of Teesside, School of Science and Technology
Middlesbrough TS1 3BA, UK.
Email: e.loh@tees.ac.uk, n.n.dawood@tees.ac.uk, j.dean@tees.ac.uk

ABSTRACT

Lack of attention to the early design process in relation to Environmental Impact Assessment (EIA) has lead to an unsustainable built environment. Often building auditing/monitoring utilising EIA and Life Cycle Cost Assessment (LCCA) tools are used after the completion of the project, when it is too late to influence the design, materials or components to be used. A sub-processes focusing on environmental issues at early design process based on the UK construction process guideline- Royal Institute of British Architect (RIBA) work stages has been developed. The sub-process is an extension of RIBA work stage and intended to be used by project environmental analyst in parallel with the RIBA work stage. Outputs from the proposed sub-process will be a useful data for EIA analyst to carry out an EIA for the project. This paper reports the development of RIBA sub-processes that are based on RIBA work stages A-H and associate these processes with the EIA procedure of European EIA Legislation and the Life Cycle Assessment (LCA) procedures of ISO14040. As an outcome, this sub-process will be a useful reference for the Architecture Engineering and Construction (AEC) industry to enable the utilisation of good practice in the early design stage processes.

INTRODUCTION

Circular 2/99 (Department of the Environment, Transport and the Regions 1999b) and government guidance (Department of Environment, 1994a) are a major manual or reference for LPA in British planning system. According to the Circular 2/99, EIA should carry out in the early design process in order to *'produce improvements in the planning and design of the development; in decision-making by both parties; and in consultation and responses thereto, particularly if combined with early consultations with the local planning authority and other interested bodies during the preparatory stages* (Department for Communities and Local Government 1999)*'*. However, recent study by Oxford Brookes University found that *'about 10% of planning authorities may never have undertaken screening (EIA) to determine whether a proposed development requires environmental impact assessment, and around 50% of authorities may only have limited experience* (Note on environmental impact assessment directive for local planning authorities 2009)'. Low numbers of screening process undertaken by planning authorities reflect the fact that EIA is not a normal practice for developers at early design process. The two main reasons for developers to neglect the EIA are: 1) minimising design cost, Latham (1994) and Egan (1998) showed that due to clients priorities in the construction stage they often set a low budget for design stage. Carrying out an EIA may require approximately 0.1 to 1% of project cost and 2) longer time periods are needed for EIA applications where an application for planning permission without the EIA process takes eight weeks (Wood 2003).
The current practice of 'assessing after built', technically known as auditing/monitoring can only maintain or slightly reduce the building impact in its 70 years life cycle. Without prior assessment, extra costs and time can be incurred in changing the design during the construction stage. Therefore, it is important for the AEC industry to assess and rehearse potential impacts during the outline design process in order to control the building's life cycle impact.

The Royal Institute of British Architect (RIBA) work stage procedures for construction projects have overlooked the environmental responsibility of AEC professionals (McElroy 2008). In our view, it is important for the project stakeholders to understand when/why and how to fit in the EIA during the building construction process. The disintegration of RIBA work stages and EIA legislation clearly does not help the global aim of mitigating climate change impact when environmental assessment has not been fully appreciated in the construction sector. Hence, an RIBA sub-process focusing on the environmental aspects will be developed based on RIBA stages A-E, these stages can be intepreted as the conceptual stage, early design stage and detail design stage. The RIBA sub-process is an extension of an RIBA work stage and in undertaken by the project consultant and the environmental analyst in parallel to the RIBA work stage.

This paper reports the development of RIBA sub-processes for early design stages based on Royal Institute of British Architect (RIBA) work stages (A-E) and associates these construction processes with the LCA evaluation process of ISO14040 and the EIA evaluation process of EU EIA Legislation to allow stakeholders to understand the flow of tasks/practices during early design stages that can lead to carbon minimisation. As an outcome, the RIBA sub-process will be a useful reference for the AEC industry to understand the procedure of employing good practice during early design process.

LITERATURE REVIEW

Life Cycle Assessment (**LCA)** is an assessment tool to evaluate life cycle impact of an object/product considering the upstream and downstream impact of the whole process (Vigon 1996). The Life Cycle Cost Assessment **(LCCA)** is applied to assess cost effectiveness/economical aspect of product/project life cycle by considering: capital cost, maintenance cost, operation cost, recycling cost and disposal cost (Horner 2002) while Environmental Impact Assessment (**EIA)** is a methodology uses to assess impacts of a propose project (RICS Environmental Faculty 2007). In other word, EIA is an umbrella for the LCA and used after the LCA. LCCA can be applied with LCA to analyse product life cycle costs or it can also used with EIA to analyse the project life cycle cost. Similarity for LCA, LCCA and EIA where; they are normally use after the completion of the project, when it is too late to be effective. It is therefore important to provide a sub-process to inform the implementation of these tools during early design process RIBA stage A-E. RIBA work stages, EU EIA Legislation and ISO 14040 will be the core enablers to develop this secondary guideline-RIBA sub-process.

RIBA work stage

RIBA work stage is defined by the Royal Institute of British Architect as a standard construction process in UK covering processes from outline design to the constructed stage of buildings (RIBA plan of work 2007). There are 14 stages in total, namely RIBA stages A to M. In general, stage A and B looks at the project feasibility, stage C to H is mainly concerned with the pre-construction process whilst stage J to M is for the construction process. The function of each stage is briefly indicated below:

RIBA stage A – Appraisal
RIBA stage B – Strategic Brief
RIBA stage C – Outline proposals
RIBA stage D – Design Development
RIBA stage E – Technical Design
RIBA stage F – Production Information
RIBA stage G – Tender documentation
RIBA stage H – Tender action
RIBA stage J – Mobilisation
RIBA stage K – To practical completion
RIBA stage L – After practical completion
RIBA stage M – Feedback

The overall RIBA sub-process is the base for the RIBA work stage A-E, EIA evaluation process refers to EU EIA Legislation, LCA evaluation process and ISO14040.

ISO14040

Is an international standard that indicates the procedure of Life Cycle Assessment (LCA) for building materials, ISO14040 is a reference for the development of RIBA sub-process. The standard procedures within ISO14040 are literally located in the RIBA sub-process stage D to assist the initial project materials trade-off.
ISO14040 outlines four major steps (Guinee 2001, Davidson 2001) including:

1. Goal and Scope setting

This step is to identify the main aim and scope of the LCA for the particular product or object.

2. Inventory analysis

This step is also known as life cycle inventory (LCI), where this stage is mainly for material data collection and identifing the cradle to grave for each manufacturing process for building components. In some cases, an output of raw materials from upstream procedure can be taken as an input to the LCI, it depends on the boundary set. In other words, LCI is a foundation proceeding life cycle impact analysis of the product.
Guinee et al (2001) indicated that LCI is used to track the process from cradle to grave but there is an argument that the LCI is impossible in practice due to the limited data. The solution is to simplify or cut down part of the LCI process in order to cope with a project's diversity and complexity. The down side is an absence of such details drives the LCA away from completeness.

3. Life cycle impact assessment (LCIA)

With sufficient data from the LCI, the LCIA can carried accordingly without constraint.

4. Intepretation

This is the final stage to transform assessment results to the public via a report, statement, etc.
Unfortunately, the ISO 14040 does not include the economic aspect of LCA (Norris 2001). The proposed RIBA sub-process that integrates LCA, LCCA and EIA should close this gap.

European EIA Legislation

In addition to ISO14040, EU EIA Legislation is another reference for the development of RIBA sub-process. The reason it was selected to support the development of RIBA sub-processes is a result of the EU adopted EIA procedure/policy. Figure 1 is the standard EIA procedure (Department for communities & local government 2006, Wood 2003) that has been integrated into the RIBA sub-process.

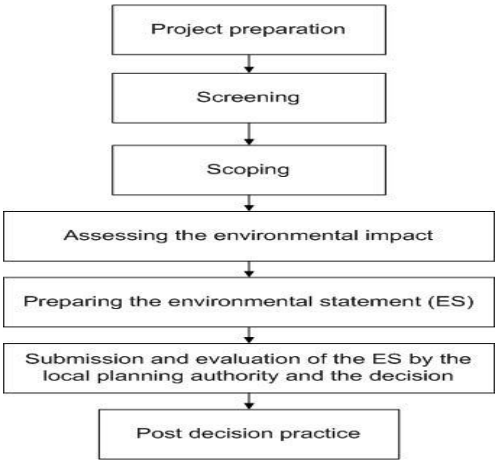

Figure 1: Standard EIA procedure (figure adopted from Wood 2003)

Whether or not EIA is required in a project depends on which category the project falls into. According to Regulation SI 1999/193 Annex 1, if the project is in the Schedule one then EIA is compulsory and a project in Schedule two is likely to require EIA, it depends on the location of the project (Hughes et al, 2002).

In the UK, the Local Planning Authority (LPA) hold power of screening and determine whether or not a EIA is applied to the project. In any case, if the LPA instructs the developer to use EIA and there is no agreement from the developer then an appeal can be made to the Secretary of State.

Few case studies have been undertaken to identify the adoption of EIA in UK practice. Most people are positive towards the application of EIA and agreed that there are more advantages such as addressing the potential problem at the early stage than disadvantages (Jones 1995) whilst there are still a numbers of practitioners that assume the cost and time to be spent into EIA does not produce a worthwhile outcome (Pritchard et al 1995). The Department of Environment, Transport and the Region (DETR 1997b. Consultation paper) had recommends an amount of £35,000 as the suitable cost to be spent on the EIA evaluation.

Statistics show that an experienced planner would be more likely to include the EIA as part of the project scope. With the introduction of stricter environmental related regulation by the UK government, the industry has started to adopt EIA and this provide an opportunity to enhance the value of the RIBA sub-process by including the EIA as one of the trade-off variables.

The next section demonstrates the integration of RIBA work stages, EU EIA Legislation and ISO14040.

DEVELOPMENT OF RIBA SUB-PROCESS

In our view, the environmental assessment should be carried out as early as possible to reduce construction cost (ie. change of materials/facilities) and long term cost (ie. maintenance/building operation cost). The proposed RIBA sub-process is applicable for building projects that require EIA where, outputs from such sub-process can be use as EIA's assessment criteria.

Figure 2 is an overview for the RIBA sub-process for a design and build project. It consist of the outline design process (Stage A and B) to the first stage tendering process and contractors' early design process (Stage G,C and H) then detail design process and second stage tender process (Stage D, H) and finally followed by application for detail planning permission (Stage D). A modelling method called Integration Definition for Function Modelling or IDEF0 had been used to develop the RIBA sub-process.

At the beginning of the project, preliminary team meetings amongst consultants, clients and BREEAM advisor will be carried out to prepare the project outline. EIA screening is implemented after identifying the general project outline and site investigation in **Stage A**. If EIA is not necessary, the project can start immediately. Otherwise, further information of site topography, appropriate legislation, stakeholders planning requirements and budget have to be outlined in order to prepare an initial design scope.

In **Stage B**, a consultant will study the project feasibility based on client's requirement, development constraint, ecology impact, budget, etc. The result of EIA screening should be received from LPA in Stage B and consultant will decide on the appointment of an EIA advisor. If EIA is required for the project, then an EIA project scoping will be implemented. A design brief will also be prepared at this stage in order to use as one of the tendering documentation in the next stage.

In the third stage- **Stage G**, A full set of tendering documentation including the design brief, site data, project schedule, project budget and client requirements will be prepared and given to tendering contractors.

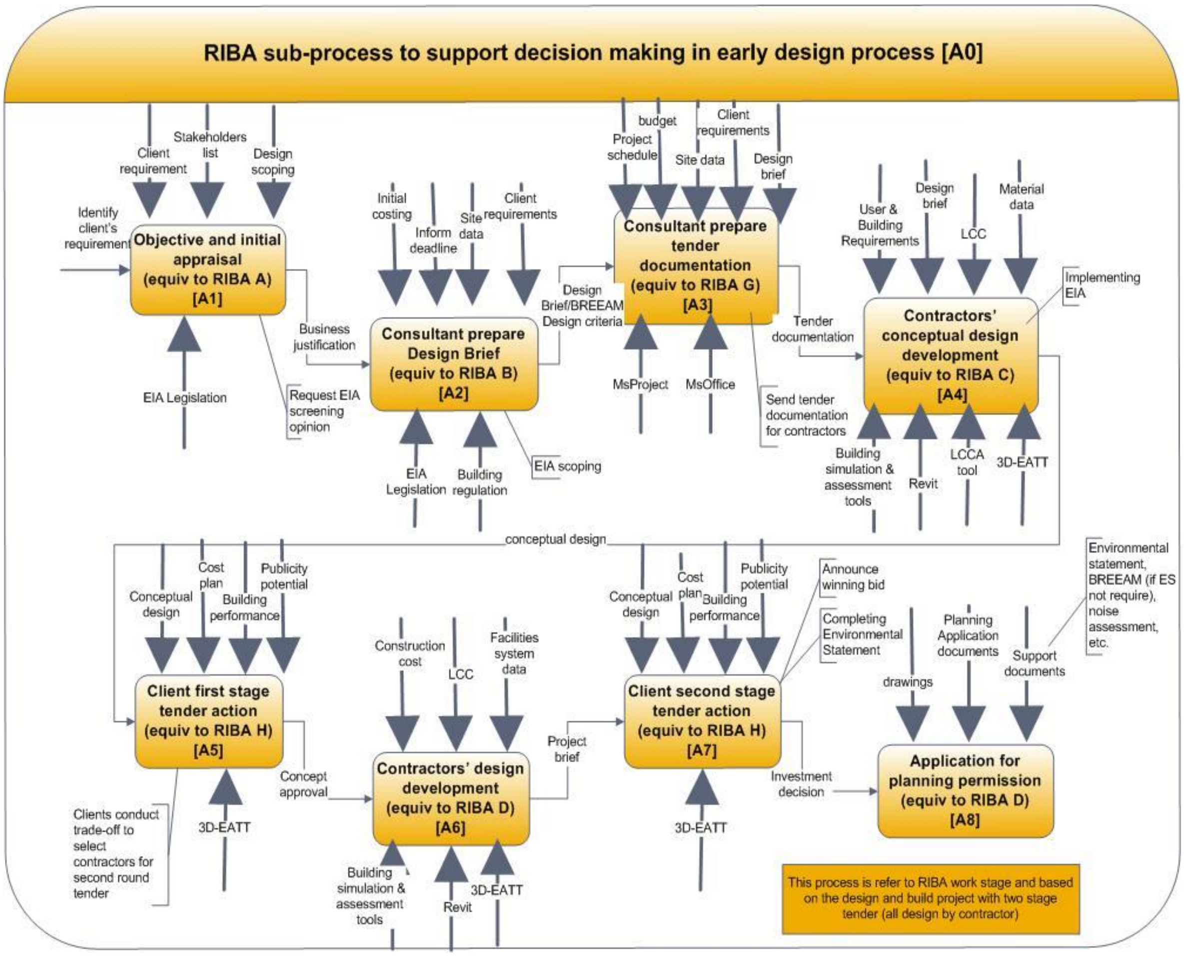

Figure 2: Overview for RIBA sub-process

Stage C is the focus of the research and detail discussion will be done in this paper (figure 3). In this stage, a simultaneous trade-off process is being use to select the external building design/materials follow by internal building layout/materials using the 3D-EATT (Loh et al 2008, 2009). After the overall design (in BIM model) was approved, the BIM model will be exported to the IES to ensure that the propose building was energy efficient and complied with the Part L. Trade-off for the building layout/materials will be repeating if the proposed building does not achieve the CO2 reduction target. After the ideal design was selected, trade-off for renewable systems will be carried out to enhance the building performance. This also means that the propose building is exceeding the building energy efficiency requirement.

Following reporting the trade-off process for conceptual design. Detail trade-off description was given to the external building design. However, these steps are applicable for other trade-off proposes:

- Step 1: Sketching based on the design brief

As soon as the tendering documentation received, architects will refer to the design brief and sketch a few options for the external building design. All building design and material LCA will be input into the performance matrix (figure 4).

- Step 2: Trade-off to decide external design

To decide the priority, a global weighting needs to be assigned for each criteria. This process will involve objective and subjective decision. Tangible data for material rating and LCA from BRE green guide specification will allow an objective decision based on 'pairwise comparison', the rest of criteria are based on subjective valuation. This is very common during conceptual design process as architects in practice tend to use their experience and refer only to the building regulation and it is not cost effective to run simulation for all sketching.

The next step is to assign weights for sub-criteria (material rating for external wall, cladding, curtain wall, roofs, insulation, window, door; publicity potential; uniqueness and sustainable design; materials' cost; materials' global warming potential, material toxicity to environment and human health, water extraction for materials' production, air pollution potential and materials recyclability) based on the weight distribution of the primary criteria. For example, if the weight for external material rating is 40% then the sub-criteria should share the weight of 40%. Sub-criteria provide the benefit of data transparency that clients can view their priority distribution better. After the priority of criteria and sub-criteria is calculated, priority for alternative buildings design will be assigned based on each criteria and sub-criteria. Finally, each of these alternatives output will be added up and the model with highest percentage represents the model with most criteria achievement. It is the best option (Figure 5).

- Step 3: Produce BIM model

After the external building design is decided, the architect creates a 3D model using the BIM software. This model updates along the whole design process.

- Step 4: Trade-off to decide building layout/materials

The trade-off process in step 4 is similar as the trade-off process in step 2. The only difference is this step uses 3D-EATT to decide internal layout/internal materials (figure 6) and considers different sub-criteria including the function of each zone, well design, fire escape route, layout that reduces noise level, sufficient window opening, internal materials rating, internal materials' cost/LCA and design/aesthetic of materials combination.

- Step 5: Ensure building achieved CO2 target

This stage is to ensure the proposed building complies with Part L. This is done by importing the BIM model (using gbXML format) into the IES. If the model fails to achieve the Part L requirements, then the next step will be to modify the building layout and materials to achieve the target.

- Step 6: Select renewable system to enhance the building performance

After best option for building internal/external design with material combination is selected. The renewable systems/equipments will be introduced to the proposed building to enhance the building's performance.

- Step 7: Prepare outline proposal for structure/building service system

A brief outline for structure and building service system will be prepared for the tender submission. Contractors/architects selected for the second stage tender will use this brief outline for further design development.

- Step 8: Submission for first stage tender

After all tender documents including the conceptual drawing, costing, structure outline proposal, support documents (company background, track record) are ready, documents will be submitted to clients.

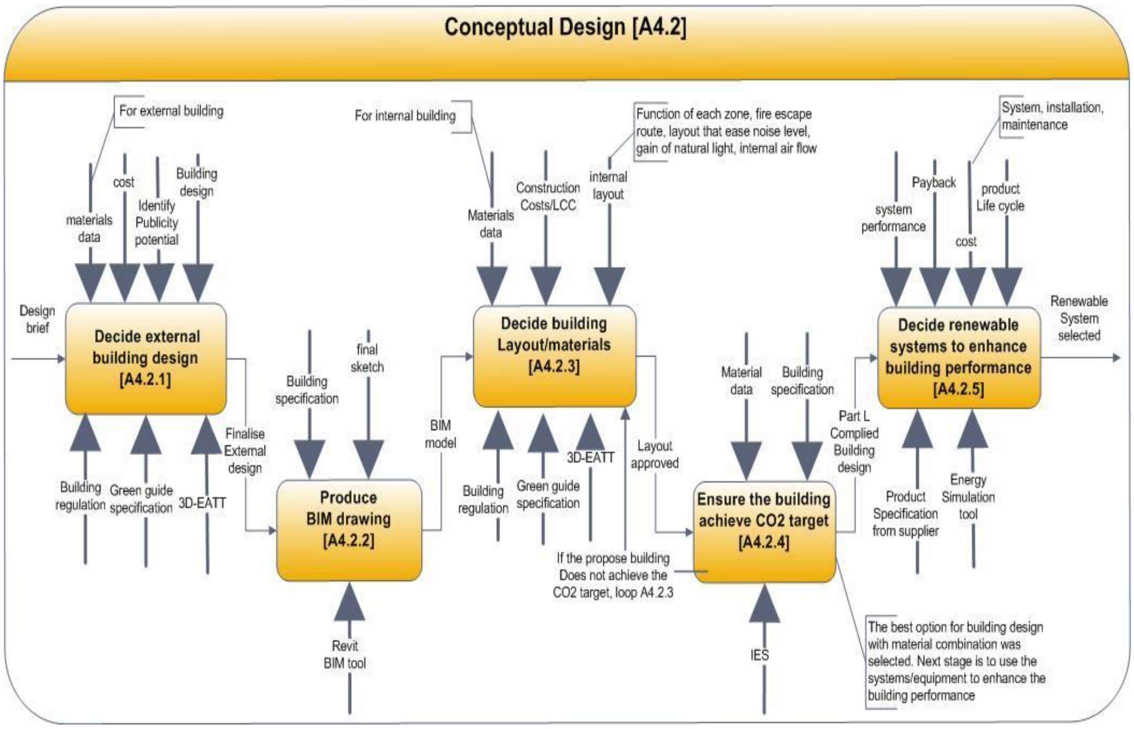

Figure 3: Trade-off process for conceptual design

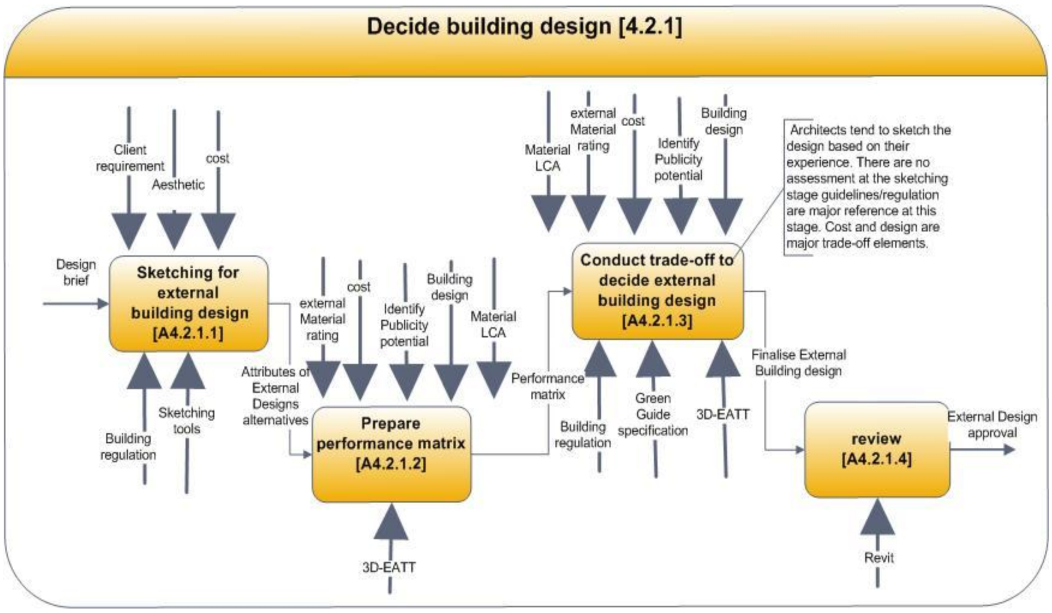

Figure 4: decide building design

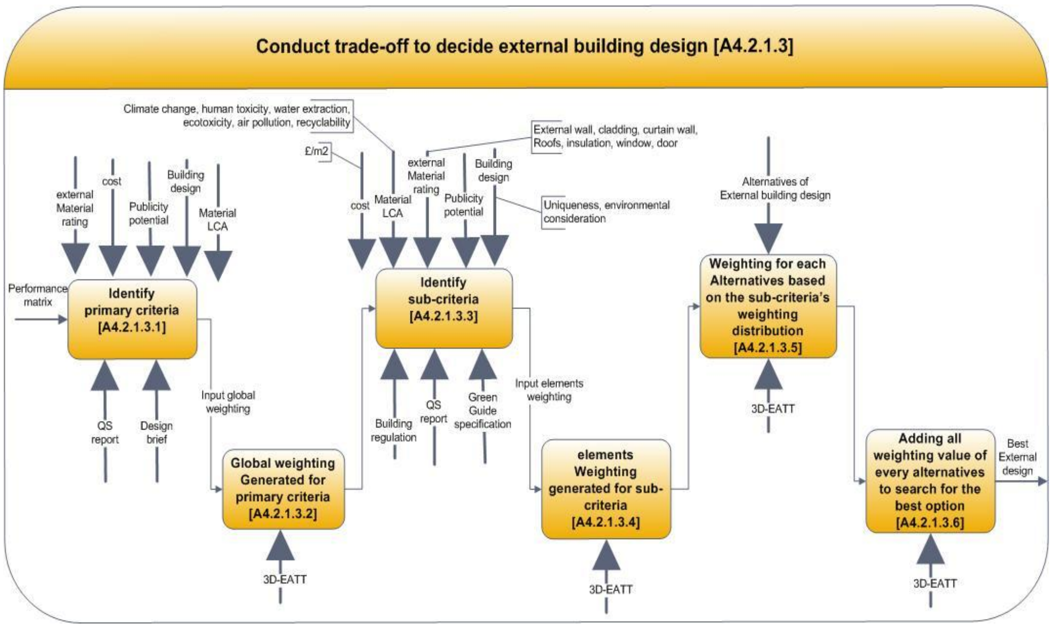

Figure 5: conduct trade-off to decide external building design

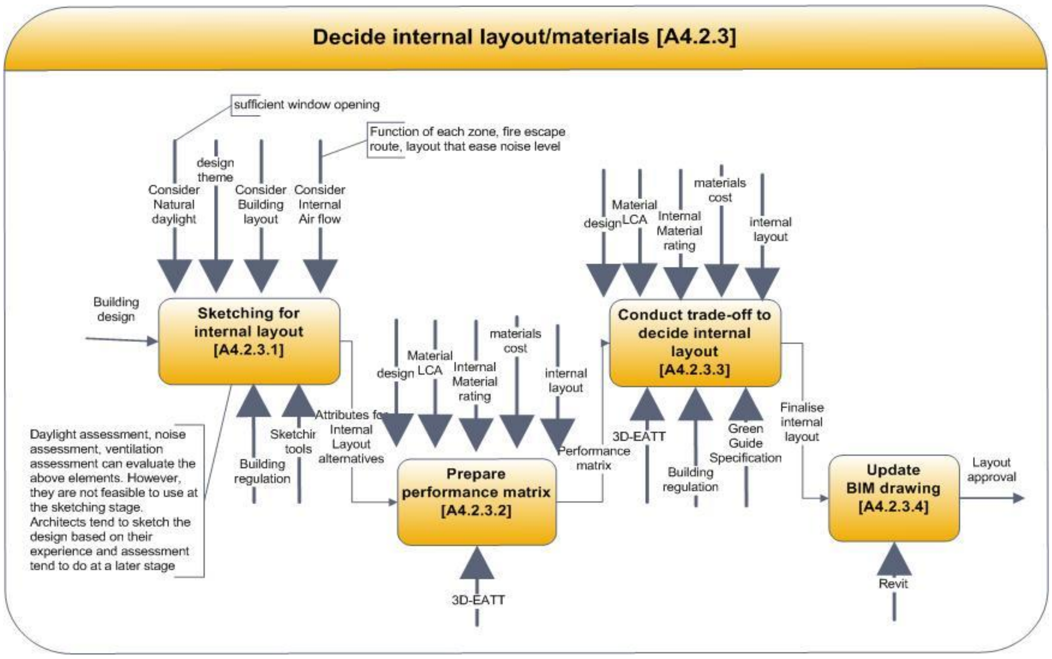

Figure 6: decide Internal layout/materials

In **Stage H**, clients can use the 3D-EATT to assist them to select contractors/architects for the second stage tender process by input the selection criteria into the decision support tool.
Detail design including structure and facilities system will be prepared in **Stage D**. Again, facilities engineer can use the 3D-EATT to assist them to select the best options (figure 7).
A second stage review is carrying out in **Stage H** after received the tender documents. At this stage, a full BREEAM assessment can be proceed to obtain a BREEAM interim design stage certificate as a support document for the planning application. Simultaneous trade-off process during the conceptual (Stage C) and detail design stage (Stage D) means the proposed building is more likely to achieve the BREEAM 'Excellent' rating without spending more time/cost to earn the BREEAM credit at the later stage.

Outputs from different stages in the conceptual/detail design stages (ie. facade/internal building materials, floor plan) as well as data from the proposed building project (ie. site data, noise assessment) can be used by EIA advisor to assess the potential ecological impact, health issues and risks from the project. Environmental Statement will be prepare and to be used as a support documents for the planning application (figure 8).

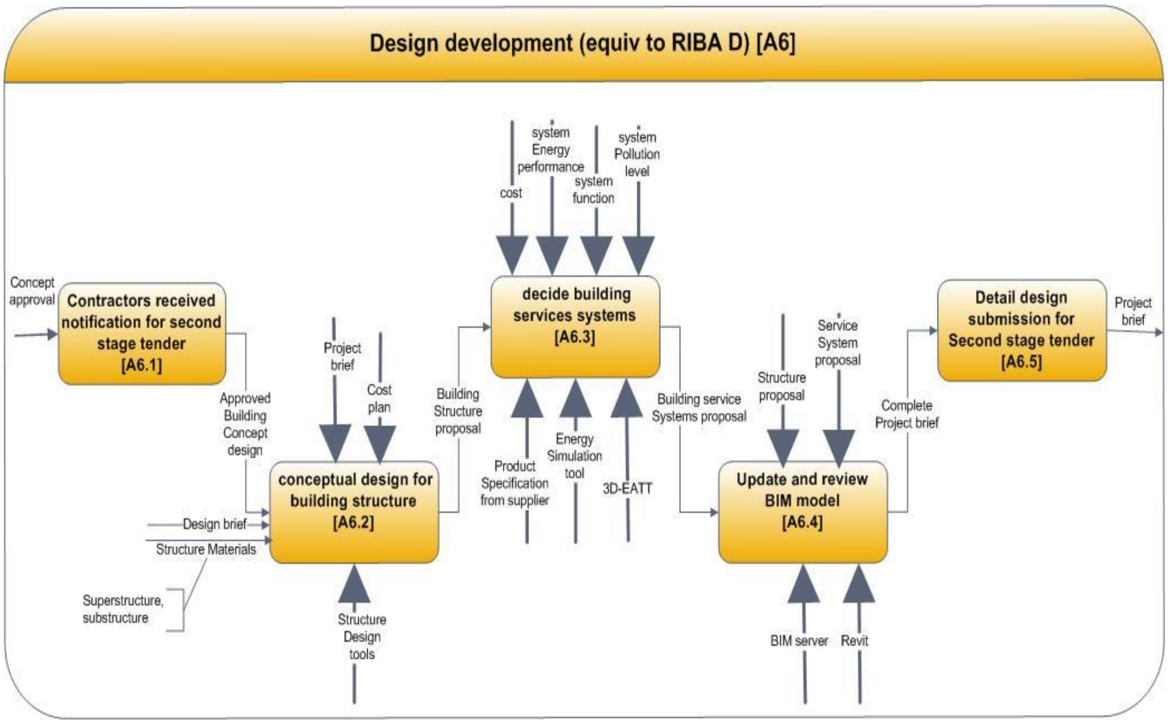

Figure 7: Design development

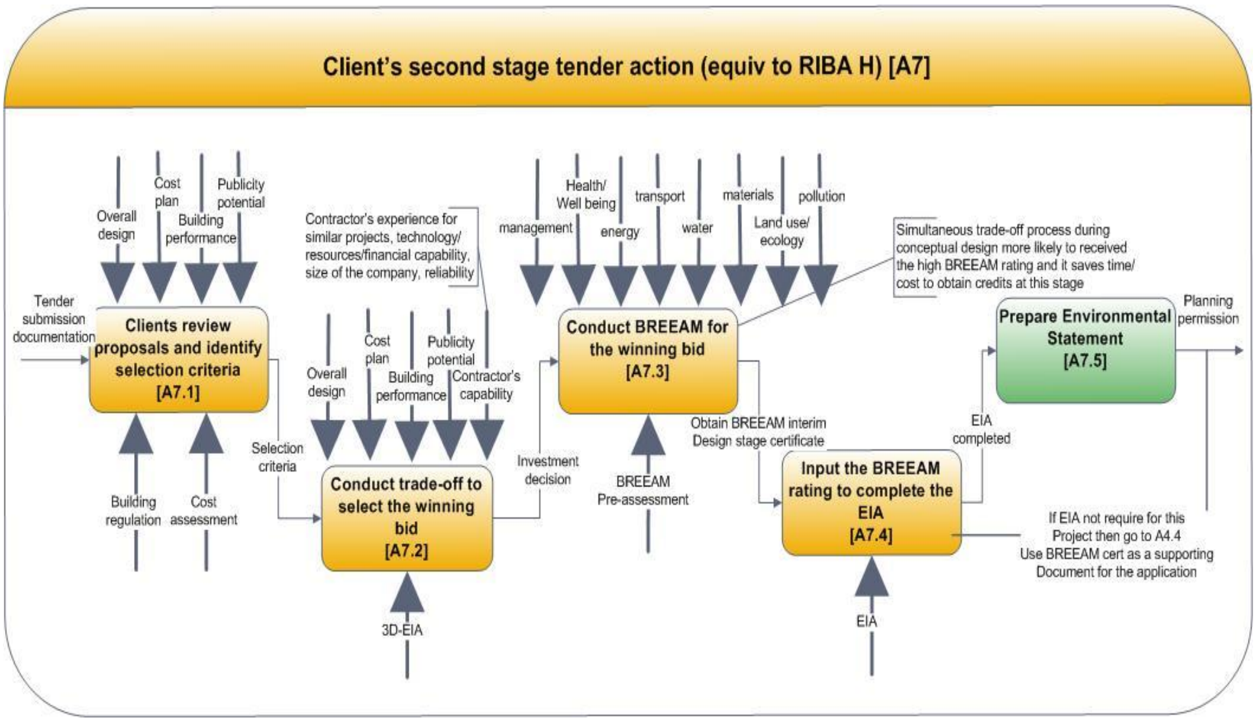

Figure 8: second stage tender action

SUMMARY AND CONCLUSION

The well-known RIBA plan of work procedure focuses on the construction process and lacks environmental consideration. The proposed RIBA sub-process can be taken as a guideline to carry out everyday construction work that will benefit professionals in the AEC industry to understand when to bring in the environmental assessment during the early design process. The proposed RIBA sub-process is an extension of RIBA work stage criteria and can be used by project consultants and environmental analysts in parallel to the RIBA work stages.

In summary, the development of RIBA sub-process is important in combating challenge of global warming and following benefits have been identified:

- Address potential impact during the outline design process can minimise the building environmental impact.
- Save long term costs including building operation cost by implementing best combination for layout and materials
- Extended building life cycle

REFERENCES

Davidson, C.I., 2001. Environmental Life Cycle Assessment. In: Rubin, E.S., Davidson, C.I. (eds.), *Introduction to engineering and environment*, McGraw-Hill International edition: environmental engineering series

Department for Communities and Local Government (1999). Circular 02/99- Environmental Impact Assessment, DCLG publication

Department for communities & local government (2006). Environmental Impact Assessment: A guide to good practice and procedures, DCLG.

Department of Environment (DoE) 1994a, Evaluation of Environmental Information for Planning Projects: A Good Practice Guide. London: HMSO.

Department of the Environment, Transport and the Regions (DETR) 1999b, Environmental Impact Assessment. Circular 2/99. London: The Stationery Office.

DETR 1997b. Consultation paper: implementation of the EC Directive (97/11/EC) determining the need for environmental assessment. DETR

Loh, E., Dawood, N., Dean, J. (2008). Development of framework for 3D-Environmental Assessment trade-off tool (3D-EATT), paper proceeding for 8th CONVR 2008, 20th-21st Oct, K.L, Malaysia.

Loh, E., Dawood, N., Dean, J., Crosbie, T. (2009) Development of trade-off algorithm with AHP for building lifecycle cost and Environment Impact Assessment, SUE-MoT Conference 2009, 2nd International Conference on Whole Life Urban Sustainability and its assessment, 22nd-24th April, Loughborough, UK.

Egan, J. 1998. Rethinking Construction, DETR.

Guinee, J.B., Gorree, M., Heijungs, R., Huppes, G., Kleijn, R., de Koning, R., van Oers, L., Sleeswijk, A.W., Suh, S., Udo de Haes, H.A., de Bjuijn, H., van Duin, R., Huijbregts, M.A.J., Lindeijer, E., Roorda, A.A.H., van der Ven, B.L., Weidema, B.P.(2001). Life Cycle Assessment - An operational guide to the ISO-standards, Part 2a: Guide. http://www.leidenuniv.nl/cml/ssp/projects/lca2/part2a.pdf

HORNER, M., 2002. Conference: The real cost of building at London; Presentation slide: WLC-what is it (University of Dundee), http://www.cnplus.co.uk/promotions/realcost/

Hughes,D., Jewell, T., Lowther, J., Parpworth, N., Prez, P.D., 2002. Environmental Law: Fourth Edition, Butterworths LexisNexis, pp 206-221

Jones, C.E., 1995. The effect of environmental assessment on planning decision, Report, special edition (Oct), 5-7

Latham, M. 1994. Constructing the team. HMSO.

McElroy, L., 2008. Research project overview conducted from ESRU, University of Strathclyde website, http://www.esru.strath.ac.uk/

Norris, G.A., 2001. Integrating Life cycle cost analysis and LCA, *International journal of LCA* 6 (2), p.118-121

Note on environmental impact assessment directive for local planning authorities 2009, conducted from DCLG website, http://www.communities.gov.uk/planningandbuilding/planning/sustainabilityenvironmental/environmentalimpactassessment/noteenvironmental/#

Pritchard, G., C. Wood, C.E. Jones,. 1995, The effect of environmental assessment on extractive industry planning decisions. Mineral Planning 65 (December), 14-16

RIBA plan of work (2007). http://www.architecture.com/Files/RIBAProfessionalServices/ClientServices/RIBA%20Outline%20Plan%20of%20Work%202007.pdf , conducted by Nov 2008.

RICS Environment Faculty (2007). Environmental Impact Assessment, published by RICS

VIGON, B. W., 1996. Environmental Life Cycle Assessment, Chapter 3: software systems and databases, McGraw Hill Company Inc.

Wood, C., 2003. Environmental Impact Assessment: A comparative review,2nd edition, Prentice Hall.