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ICT PILOT OF KPMG BUILDING SUSTAINABILITY ASSESSMENT IN DESIGNBUILD CONTRACTING.

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Abstract: *In response to popular awareness of issues it is now most important to apply broad spectrum building sustainability decision-support tools. It is as essential that such tools apply early on in project initiation, concept design and to detail design. It remains, however, very difficult to deliver the technical and practical information needed to support cost effective holistic decisions considering the building life cycle. The Australian Cooperative Research Centre for Construction Innovation has developed and trialed novel decision-support tools for Architectural, Engineering, Construction Property and Building practitioners. One such tool LCADesign with a rapid take off from 3D object Computer Aided Drafting (CAD) models was developed to automate assessment of building environmental costs. This paper outlines how this tool was applied in a Dutch pilot along with procurement to integrate effort to deliver more sustainable building.The paper argues that it is important to adopt new approaches to facilitate integrated project management and ICT so developers, contractors, architects and investors can better work together on sustainability. It also illustrates LCADesign benefits include automated design assessment at all levels of design, choice of performance measures and impact ratings.*

Keywords: *Sustainability Assessment, Life Cycle Assessment, Decision-making*

1. BACKGROUND

Sustainable development to deliver more responsible built outcomes is increasingly driving uptake of new approaches by Architectural, Engineering, Construction (AEC) Property, Building and Manufacturing practitioners [1-5]. Because it is now popularly accepted that a healthy, sustainable built environment is indispensable more attention is being paid to improve practice and more new industry solutions are emerging [6-11].

Sustainability requires assessment of environmental, economic as well as social impacts. These often conflict with each other or are so dominated by traditional thinking that balanced outcomes become hard to ascertain [3, 4, 6, 8, and 12]. Such conflicts inevitably call for trade offs so capacity to deliver rapid, integrated and comparative assessments of “what if” scenarios to assist project teams’ decision-making is advantageous [12, 13-15].

2. OBJECTIVE

The aim of this paper is to illustrate a procurement strategy applied to integrated effort and pilot novel information and communication technology (ICT) to support practitioner decision-making in design for life cycle towards more sustainable building. It describes methods used to develop new information and communication technology (ICT) and to facilitate adoption of such ICT through DesignBuild strategies applied in project procurement and delivery. Environmental assessments were developed using ISO 14000 Environmental Management Series methods for Life Cycle Assessment (LCA), Life Cycle Inventory (LCI) and Life Cycle Improvement Assessment

3. INTRODUCTION

Buildings provide essential shelter and services but globally they have very significant environmental impacts that are much broader than any single issue. In recent years, new solutions for meeting cost, time and environmental aims of stakeholders have emerged in many market sectors [1-4, 6, 11-12]. As well as better quality management practice and products, such solutions encompass novel information and communication technology (ICT) and procurement systems [2, 6, 11-12].

3.1. New information and communication technology

The Australian Cooperative Research Centre for Construction Innovation (CRC CI) has exploited enabling ICT to deliver novel building software to meet core market demand for timely, cost-effective project management and delivery. Global standard industry foundation class (IFC) data transfer protocols allow software interoperability in and off object-oriented CAD models[12, 14]. An IFC compliant building information model (BIM) platform has been developed and used to assess performance in a suite of CRC CI software tools across planning, design, checking and scheduling applications including those in Table 1.

Table 1 Selection of CRC CI Tool Prototype Names, Applications and Functions

Tool Name	Application and Function
Design View	Viewer outside CAD to visualise BIMs of assets and work plans
Estimator	Generates elements cost & quantity survey, bills and reports
Scheduler	First cut elements, activities, resources & sequence to detail further
DesignCheck	Checks compliance to building code e.g. Design for Access
Design Spec	Specification tool with viewer, encoding of rules to flag e.g. clashes
FM Exemplar	Global ICT business case for IFC specification of BIM data assets

In response to environmental sustainability and climate change drivers the CRC CI has also exploited enabling ICT to deliver novel building eco-profiling software. In 2001 it funded development of an eco-profiling tool called LCADesign, an acronym for Life Cycle Assessment (LCA) of Computer Aided Drafting (CAD) for Design to automate building environmental impact and economic cost assessment. The main aim was to integrate environmental assessment in a 3D CAD model to avoid any manual transcription of data from one step to another in evaluation processes.

LCADesign is a prototype that has undergone local and overseas testing and assessment [12]. It covers resource acquisition, refining, manufacture, transport and assembly to construction plus maintenance and replacement considering service and refurbishment schedules but excludes operations and fate at end of life. A new commercial cradle to grave version being encoded to cover energy and water use in operations as well as fate on deconstruction and disposal is due for completion by 2008.

3.2. New project procurement and delivery strategies

KPMG, the client for the first Dutch LCADesign pilot is an international company, offering complementary audit, tax and advisory services underpinned by knowledge and insight that enable them to meet their client's needs. They aim to turn such knowledge into value benefiting their clients, employees and capital markets. KPMG's vision to be market leaders is underpinned by their aim to have the best reputation in the industry.

At corporate level they were advised by a real estate agent and together developed a procurement strategy to deliver the best value proposition for budget. After rethinking their accommodation strategy, KPMG decided to choose new office locations, including one in Rotterdam. Traditionally the architect designs and documents the brief and tenders for the contractor. A contractor's bid is then selected on best price with stages of design and construction distinctly separate [13].

As a client, KPMG sought added value from integrating design & construction disciplines so they decided to put out a DesignBuild-tender rather than traditional procurement where different project partners works separately as shown in Figure 1. For comparison, a schematic of DesignBuild in Figure 2 shows more portals and channels for communication and integration. It also meant the project was tendered on a preliminary design that leaves room for a bidding party to add value to the proposition.

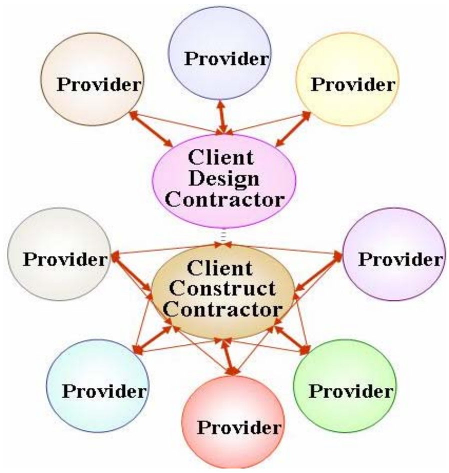


Figure 1 Traditional Project Coordination

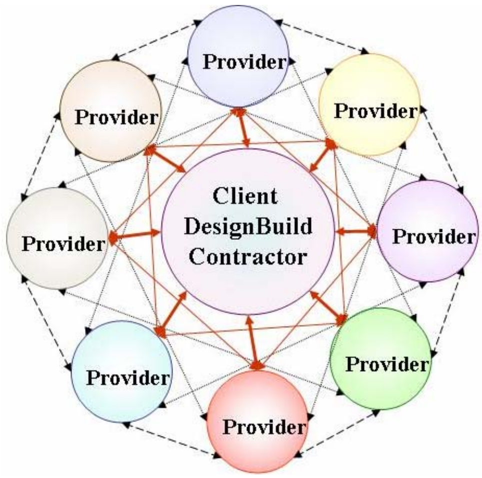


Figure 2. Design Build Project Integration

3.3. DesignBuild market and reposes

The DesignBuild market is growing in most European countries as well as other regional markets[13]. Despite little Dutch market research further growth appears feasible within the local construction market if DesignBuild can displace other forms of procurement. Any procurement method has to deliver certainty in quality, cost and time so to displace traditional procurement and overturn prejudices, DesignBuild has to achieve more and outperform traditional procurement.

The greatest strength of DesignBuild is that it deals contractually with issues that cause most concern in traditional procurement where customers often complain about the lack of a single point of responsibility. Clients view this as a great weakness in the construction sector generally whereas DesignBuild addresses this concern contractually [13]. Another client concern is the lack of integration across design and construction where for example designers do not always or completely take account of how something will be built. Again, DesignBuild addresses this explicitly, by ensuring integrated management of otherwise separated design and construction processes [13].

DesignBuild contracts also offer opportunity to link subsequent efforts in concept and detail design through to the construction phase directly to a contractor's sustainable building knowledge. Since many investments in sustainable building are considered possibly too expensive[14] such integration has been shown to save costs if the contractor invests in sustainable building measures from project initiation through to early and detailed design and in integrated effort in delivery processes[14]. DesignBuild can also make such decision-making easier and, if effectively supported by advanced ICT, costs can be saved and decision making about environmental performance can also be easier[14].

3.4. DesignBuild contractor integration roles

Slavenburg was the DesignBuild contractor selected for KPMG's project based on references, proposal, budget and human resources. As they contracted all partners, including the architect and engineers Slavenburg was the client's single point of contract. The DesignBuild contract enabled the contractor to fully integrate and therefore to lead throughout design and construction making it more feasible to conduct an LCADesign Pilot. This involved developing:

- GreenCalc analysis comparable to three Dutch reference buildings by TU Delft.
- New BIMs of total building structure and all levels;
- A Dutch LCI inventory of results and
- Comparative LCADesign of substructure, structure and inner floors and walls.

4. LCADESIGN DEVELOPMENT

LCADesign employs real-time automated take-off from 3D models which occurs through enabling ICT that factors embedded BIM data including all drawn object's dimensional quantities The software exploits IFC data transfer protocols and is built on a BIM platform that acts as a hub to integrate outputs of global standard:

- 3D object-oriented CAD models used in modern design documentation practice;
- Life cycle costing schedules of economic costs considering service life;
- ISO 14000 Environmental Management Series Life Cycle Assessment (LCA);
- Supply chain Life Cycle Inventory (LCI) database for ecoprofiling and
- Life Cycle Impact Assessment (LCIA) for improvement assessment[16].

The automated take-off from 3D CAD IFC export files provides quantities of all building components embedded in BIM files.

This information is combined using encrypted rules for material component quantity and density estimation along with results of LCI databases and LCIA indicators[14-16]. Reasoning rules were developed and encrypted in the software to automatically transform dimensional data embedded in all IFC compliant BIMs into metrics e.g. kilograms required for LCA calculations. So LCADesign data automatically flows from data embedded in all drawn objects via reasoning rules defining dimensional and component formulae to become factored with LCI resource and emission results to produce LCIA assessments of a BIM[15, 16].

LCADesign was developed to provide industry sector stakeholders benefits by facilitating users' direct analysis of building profiles, without data re-entry. It employs repeatable evidence-based calculations aggregated from components and allows users' rapid analysis as data already in the tools is used to calculate eco-profiles. The software tabulates environmental impacts of each object selected in a design.

Resource use and emissions generation results are sub totalled and factored together for each damage and impact category result to produce eco-profiles of impacts, damages and point scores in charts of relative intensity/m^2 in e.g. building, windows and floors. Results are also expressed as damage to human health, ecosystem quality and resource depletion and a single score normalised to average per capita annual impact. With such indicators users can view and apply changes to reduce overall impacts [15-17].

CRC LCI databases developed for Australian, Dutch, German and Californian supply chains to inform pilots are unique stage 5 national building supply chain models developed partly on top of Boustead Ltd Global Model 3, 4 and 5 databases and one New South Wales Government developed for the 2000 Green Olympic Games [16]. The new commercial version will also plug in other key commercial inventories.

5. USING LCADESIGN SOFTWARE

Users can directly analyse models because data already in the software is used to calculate eco-profiles. How the software works is depicted in Figure 3 with the EcoIndicator-99 method depicted in part 4 of the Figure [16]. The software interface is the front end to building environmental analysis which is the basic unit of work provided to users who take 4 steps to:

1. Obtain building plans and create an object-oriented 3D CAD virtual BIM;
2. Tag all objects by class type; extract and save the model as a standard IFC file;
3. Apply default reasoning rules linking tagged object with product type, and
4. Upload, view and check the tagged file and select metrics to compare options [15].

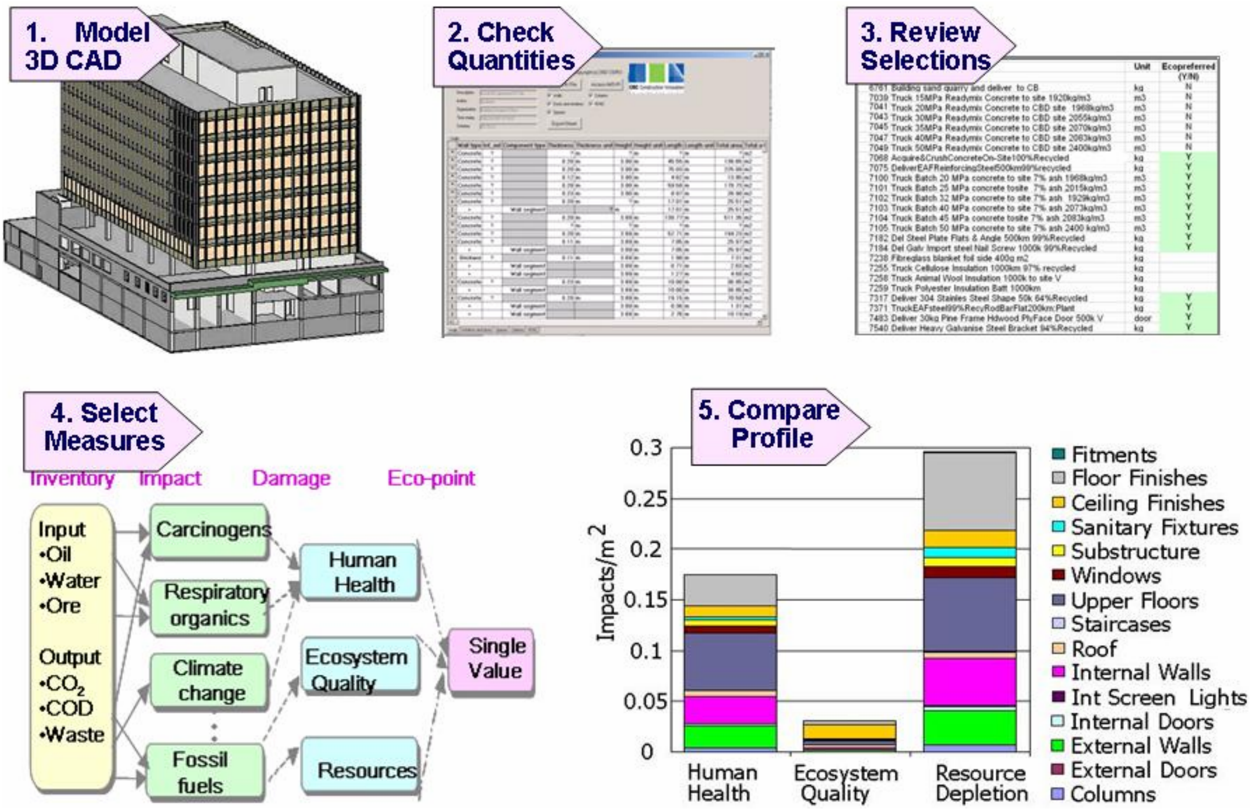


Figure 3 How LCADesign Works

Users can select from standard or eco-preferred items but if they need new choices a reasoning rules manager allows them to make new rules by selecting and defining volumetric and compositional formula of component types in each object e.g. concrete: cement and steel and matching these to >3000 eco-profiles in the LCI database.

6. LCADESIGN CASE STUDIES

To demonstrate LCADesign in practice, the following case studies all show results per square metre floor area to explicitly compare gross and detailed impact intensities.

6.1.Melbourne City Council (CH1) offices in Victoria Australia

Seongwon Seo analysed renewal options for the 35 year old 7668 m2 office building made of reinforced concrete slabs, beams and encased steel columns with steel edge beams shown in Figure 3.1[17]. LCADesign results in Figure 3.5 show most resource depletion was from CH1 floor finishes mostly carpet that had four new installations in 35 years.

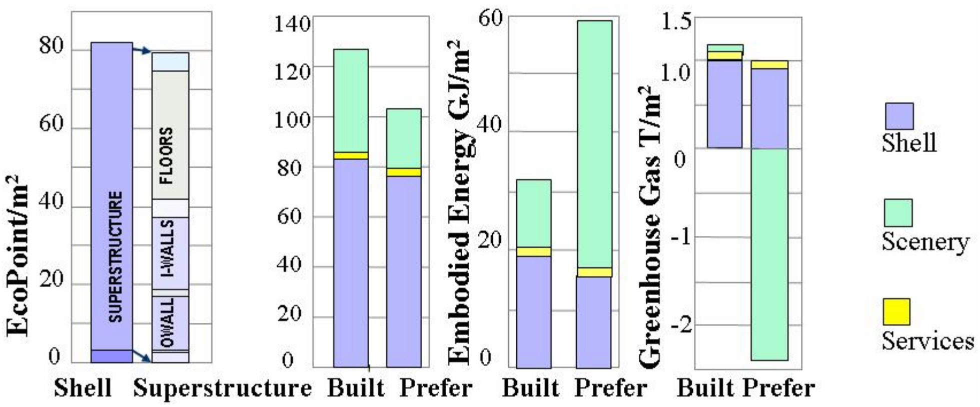


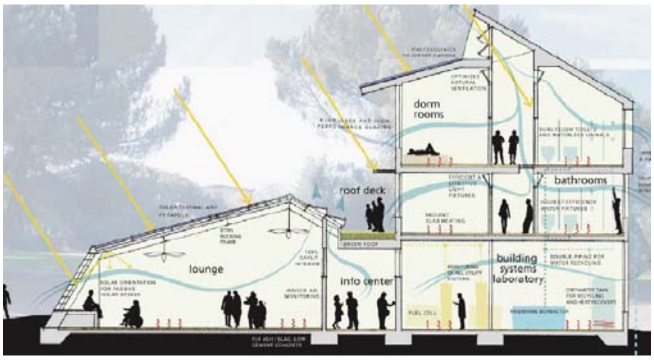
Figure 4 Environmental Impact by Component Life, as Built and as Preferred

Figure 4 then shows a breakdown of the127 ecopoints/m^2 total building for the shell superstructure impact. The upper floors next dominate results with next largest impact from internal and then outer walls (noted as I and OWALL respectively on the chart). The next pair of column charts compare results of the as built CH1 with preferred components including 97% recycled steel reinforcement and 7% fly ash concrete which reduced ecopoints by 19%[17].

While this total score was lower in terms of overall impact, the highest embodied energy component was still the wool carpet which dominated the high result from scenery shown in the column charts of embodied energy in Figure 4. The last pair of column charts in this Figure, of greenhouse gas emissions however shows large negative greenhouse emissions mostly from the carpet's renewable sheep wool pile and jute fibre backing that more than offset the shell's total embodied greenhouse impact[17].

6.2. Stanford University Green Dorm in California United States of America

A second study by Jennifer Tobias is of a very early concept sketch of the Stanford University Green Dorm in California depicted in Figure 5a and results shown in Figure 5b[18]. The work seeks an optimum timber and steel composite rocking frame to mitigate earthquake damage potential considering the site's proximity to the San Andrea Fault[18]. Figure 5b shows preliminary results with highest human health and resource depletion damage from internal walls where also most structural components arise in the design[18].



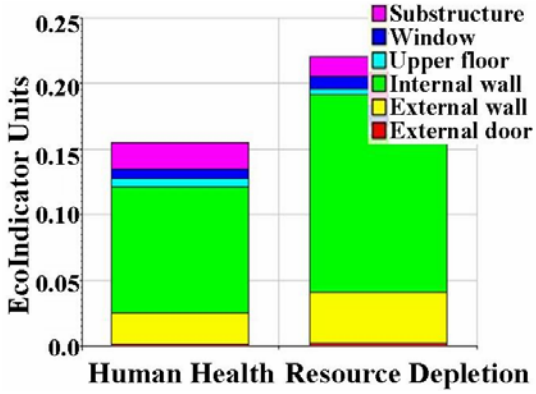


Figure5a EHDD Arcitecture's Dorm Schematic

Figure 5b Results from LCADesign

6.3. The KPMG building in Rotterdam The Netherlands

The authors and colleagues undertook the first Dutch LCADesign Pilot on the new KPMG building for 1000 office workers in Rotterdam[19]. It has 25,000 m2 gross floor area of offices with a 13,000 m2 semi-basement car park in two 13 and 10 level wings as shown in Figure 6. The building shell and interior structural elements from underground garage to level 14 were analysed by levels.

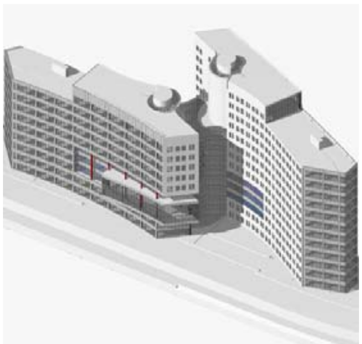


Figure 6 View of KPMG BIM

Structural analysis results found level 1 had highest impact for all 3 damage indicators with superstructure dominant overall. Lack of internal walls plus recycled reinforcing steel in substructure compared to virgin steel in precast flooring was the reason for this. Figure 7 shows level one has such a significant impact mostly from in situ and precast floor elements.

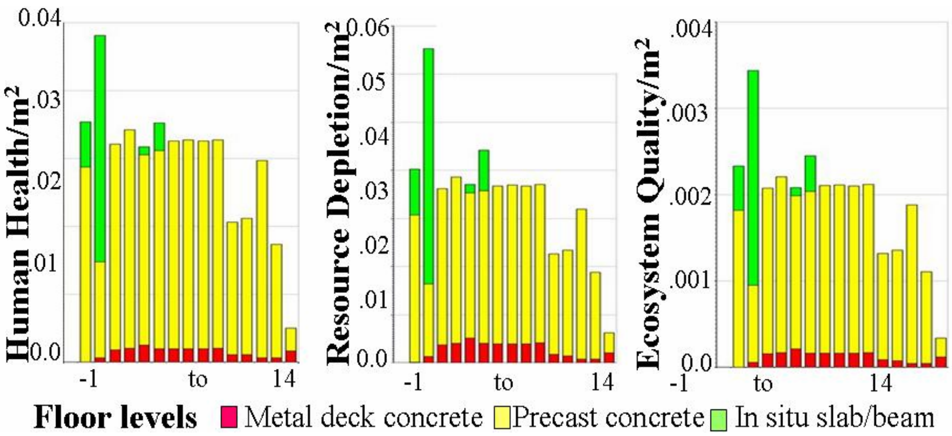


Figure 7 Building Shell Concrete Impacts by Floor Level

Had >95% recycled steel scrap electric arc furnace produced high strength steel been available for in situ slab and beam it would lower such impacts[19]. Next improvement option was internal upper floors where precast concrete systems had highest score. Metal decking was least because of high strength to weight ratio and recycled content steel.

Figure 8 shows contributions of embodied water and greenhouse gas to the Eco-Indicator 99 score where again inner upper floors have higher and walls and roof lower embodied water and greenhouse gas and columns and staircases had least. Roofing had high embodied water from steel coil rolling, quenching and finishing operations[19].

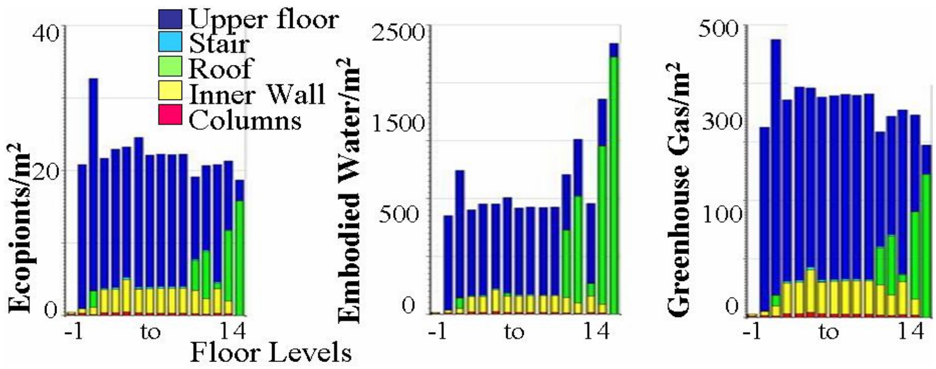


Figure 8 Internal Element Impacts by Floor Level

7. DISCUSSION

7.1. Architects and BIM's

During this pilot, Slavenburg found a lack of experience in producing BIMs among the Dutch architects. Commercial real estate sector is one where, besides quality, speed and costs are crucial, so architects are often not given the time and money to produce these elaborate designs. Coupled with the usually fragmented traditional procurement, with different liabilities and responsibilities for developers, architects and contractors this creates an adverse climate for BIM development. Producing a BIM also entails more effort in the early design stage, but the benefit arise later during the detailed design (concurrent engineering), construction (4D modelling), and use (facility management) phases.

When different partners in the whole construction process are responsible for different parts of the process, it becomes most difficult to develop BIM and apply such integrated tools. Since Slavenburg was working with a DesignBuild-contract and only this one party was responsible for design, production and delivery of the building, once the commitment to produce one had been made it became more feasible to produce a BIM since this was also driven by the DesignBuild contractor. Nevertheless, the architect involved, did not have the competences in his design office to produce one and therefore it was produced separately from scratch. Because AutoCAD-education only became regular at Technical Universities and Polytechnic Schools from the mid nineties, now ten years later only a small group of younger architects may develop these 3D BIM's locally. Recently specialist CAD local and overseas designers in India and Asia are becoming more common.

7.2.Cultural issues

During KPMG BIM design development some cultural barriers arose including some aversions to ICT, iterative processes and client involvement. The construction sector was found to be underdeveloped in ICT that support the business. The authors argue that this is probably because of scepticism that ICT can add value to processes, communications and workflow. Also some people that were insecure about the database behind LCADesign tried to persuade others that this way of working would be inaccurate. This experience suggests that project partners needed to become more confident about increased reliance on such BIM-based software tools where the program does the work.

The partners preferred not to hand over preliminary designs to avoid them resurfacing later in the design stage. The detailed design is the model that the architect is responsible for and also liable for. But, in order to do a good LCA in design and to be able to change the design on lessons learned partners need to get used to an iterative process. The LCADesign pilot was a very 'open' and 'honest' way to assess the design of the building on environmental impacts but the authored found that project teams feared openness because clients may then make changes that interfere with and delay schedules.

7.3. Case study results

The three case studies illustrate a tool enabling practitioners to make timely, informed decisions, facilitating self-assessment in early design and throughout the building life. Assessment of a broad spectrum of impacts is facilitated in the cascade of outcomes in the Eco-Indicator 99 method with a single normalised score, component damages and individual impact shares. From proposed design models users can identify hot spots and drill down on components to compare them. Gross scores along with damage and impact breakdowns are useful to show components with most potential for improvement. With such awareness practitioners can compare alternatives to reduce largest contributions. LCADesign supports eco-assessment with objective comparative assessment and dimensionally relevant appraisals and generation of comprehensive graphics of alternatives at all levels of design analysis.

The main benefit of LCADesign is from use of an automated tool to derive dimensionally relevant eco-profiles to facilitate eco-design. Delays, however in developing the KPMG BIM meant the LCADesign analysis was conducted after the drawings were developed when it was already too late to influence most design decisions. Nevertheless the pilot study demonstrated how to further improve building performance to the partners. Slavenburg has since undertaken, and completed during early design, a second LCADesign case study on another new Office building during design development.

7.4. Need for Dutch green ratings

At the time of the pilot there were insufficient drivers for and tools available in the Dutch real estate market to objectively and quantitatively assess a building's full environmental impact. From 2008 new EU legislation on building energy use will apply an Environmental Product Data Management (EPDM)-standard to assess the energy-use of buildings. With the current Dutch EPDM-standard most new buildings built under current legislation will get an A-rating (highest score) so this new legislation will not markedly improve building sustainability unless the partners wish to go above A ratings.

A Green Rating system and legislation such as the US LEED system could be very suitable to increase our built environment quality and sustainability. Members of the Dutch construction industry also need to make the different quality of more sustainable buildings transparent and to require an economic and public push for developers, contractors, architects and investors to make progress on sustainability.

8. CONCLUSIONS

The paper discussed experiences from one trial of novel procurement strategies to integrate effort and pilot novel approaches in procurement and ICT to support practitioner decision-making for sustainable building. In striving for a Dutch construction industry Green Rating system, and improving real estate it is important to adopt new approaches to facilitate integrated project management and ICT so developers, contractors, architects and investors can better work together on sustainability. BIM in design can capture data as a longer term asset and deliver more integrated information on project design, scope and costs with models for use throughout design, construction and management of building life. LCADesign benefits include design evaluation and assessment direct from BIMs at all levels of design analysis, choice of performance measures and comparative ratings of impacts.

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