"IT" Approach To Sustainable Architecture

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ABSTRACT

Nowadays, we cannot avoid decreasing of availability of non–renewable energy resources, mostly fossil fuels, and environmental degradation, consequently. Sustainable Architecture, respectably answered those conditions by streamlining architecture as system. Beneficially, Information Technology (IT) has all potencies needed to simplify Life Cycle Analysis (LCA), instrument for assessing sustainable product, which considered as being too complicated. Streamline computer software LISA, stands for LCA in Sustainable Architecture, offering an instrument to those extents particularly in regard with Construction Process. Besides simplifying the process, LISA will help reducing energy, cost, and environmental impacts that will be spent and occur along the so-called process.

Keywords:

Sustainable Architecture, LISA, Energy, Cost, Environmental Impact.

1.0 INTRODUCTION

As intentionally mentioned on the topic, this paper will illustrate the effectiveness of application of streamline computer software LISA, stands for LCA (Life Cycle Analysis) in Sustainable Architecture (courtesy of BHP Australia), in streamlining architecture process, to be precise architecture as system, particularly Construction Process phase, on purpose to achieve Sustainable Architecture.

2.0 SUSTAINABLE ARCHITECTURE

Based on global state of mind, architecture at present not any longer architecture merely known as building design, but architecture that based on the cradle to grave paradigm known as well as from source to sink to Malaysian Architect Ken Yeang.

With the intention that, similar to product in general, architecture should always be sensible in using various resources by keep maintaining their availability, to be exact sustanability of the resources mainly non–renewable energy resources such as fossil fuels.

To those extents architecture should be considered as system (Handler, 1970) that includes:

- Design Process
- Construction Process
- Operational and Maintenance Process
- Human Bionomic Process

Furthermore, according to Building Life Cycle shown on Figure 1, building as enclosure of architecture should be deal with,

- Cradle (i.e. Birth) stage, consists of material acquisition that will need energy and cost besides will cause environmental impacts.
- Similar to material acquisition, product manufacture transportation will need energy and cost besides will cause environmental impacts, and this will occur as well to the consecutive:
- Construction and fitting out process,
- Operation and maintenance process, and
- Grave (i.e. Death) stage, consists of renovation and demolition.

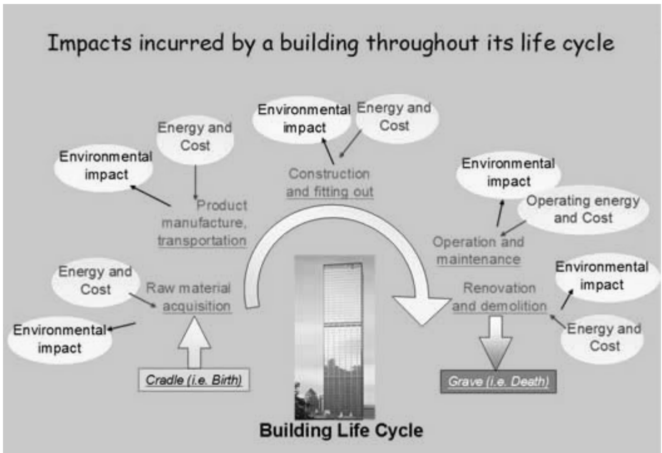


Figure 1: Building Life Cycle

From the coverage mentioned above, Sustainable Architecture can be understood as architectural system that nothing other than streamlining process of resources usage, mostly non–renewable energy resources. The process is the entire architectural process that embraces processes of design, construction, operational and maintenance, human bionomic and finally yet importantly, the demolition and/ or recycle process at the end of building life.

However, architectural processes remain able to producing designs that related to the creation of value and/ or meaning, intentionally to affect users' emotion and sensitivity. In view of the fact that sustainable architecture offering designs that associated with quality and reliable issues.

3.0 STREAMLINE

Streamline, in general, known as make more efficient or make simpler. In regard with architecture, streamlining process actually has come up several times. The earliest occurred ever since the shifting of design method, from traditional design method into modern one, in other term from trial and error design method into design by drawing method. The latter can simplify the making of corrections, moreover supported by Computer Aided Design (CAD) as drafting tools, besides enable the process carrying out some fast track actions that is paralleling several sub processes that can be accomplished in the same time or simultaneously.

Sustainable Architecture that based on cradle to grave paradigm, subsequently streamlining the energy usage, cost, and environmental impacts that will be spent and occur along architectural process. Nevertheless, in order to achieve sustainability, architecture needs a kind of instrument that similar to LCA, instrument to assess sustainability of product in general.

On the other hand, currently LCA methodologies too complicated and not widely accessible to designers and quantity surveyors, besides detailed study of LCA divert attention from the key environmental issues and tend to focus attention on inter–material competition rather than optimize construction systems (LCA – BHP Australia, 2003).

Beneficially, Information Technology (IT) has all potencies needed to simplify Life Cycle Analysis (LCA) including similar instrument for architectural process. Streamline computer software LISA, offering an instrument for those extents particularly in regard with construction process. Besides simplifying the process, LISA will help reducing energy, cost, and environmental impacts as well that will be spent, and occur along the so–called process.

4.0 LISA (LIFE CYCLE ANALYSIS IN SUSTAINABLE ARCHITECTURE)

As users' friendly streamline computer software, particularly for construction process, LISA has an attractive, informative, and comprehensive interface, Figure 2., LISA contends with the entire computation concerning:

- Specification
- Construction
- Fit Out
- Utilization
- Repair/ Maintenance

In general, the computation items stated above supported by Decommissioning and Material Transport.

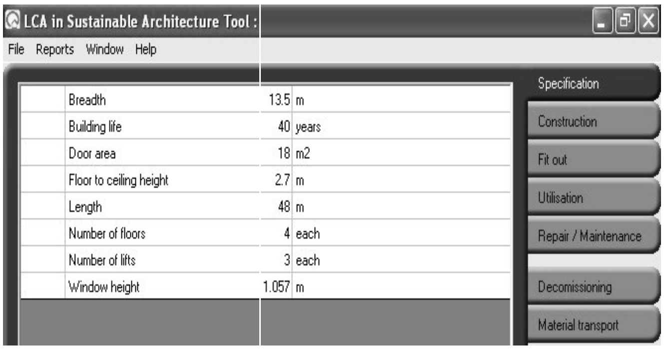


Figure 2: LISA Interface.

4.1 LISA Application

For illustrative purpose, the following coverage will show application of LISA on the Construction Process of an Office Building.

The structure of problems of Construction Process of an Office Building according to LISA, stated on Figure 4, shows the items involved within respective design process, construction, and repair/ maintenance process. Even though as mentioned before that LISA mostly used for construction process, in fact we cannot avoid related processes that will influence and will be affected by the Construction Process.

The Design Process will produce design and specification that furthermore will determine the type of structure, walls, and windows under Construction Process besides fitting out components that consists of air conditioning, finishing, installation, and stair. In comparable way, Operational Process will be affected by characters of structure, walls, and windows besides affected by the fit out equipments needed that will be built and assembled along with or within the Construction Process.

The Construction Process of An Office Building, stated on Figure 3 on the next page, shows the details of specification of consecutive structural items: Upper Floors/ Frame, Substructure, Roof Structure that consists of respective specifications. In similar way, the figure shows as well the items of Walls and Windows that consist of their respective specifications. All specifications followed by decomissioning and material transport remarks. Moreover, each item of the specifications has respective LCI (Life Cycle Information) data.

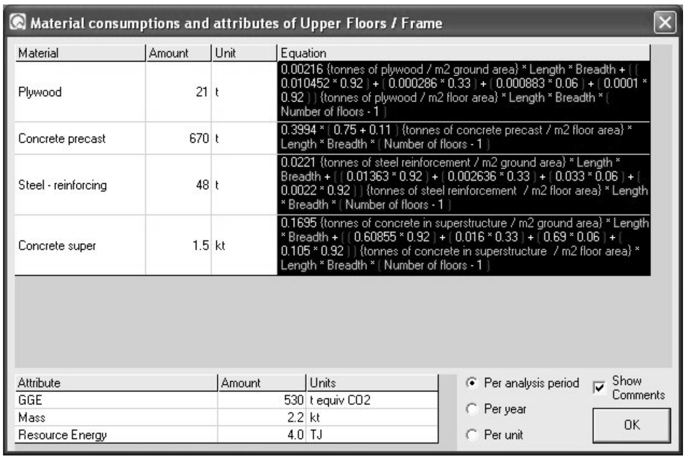
LCI data, stated on Figure 5 on the next page, shows the material consumptions and attributes of Upper Floors/ Frame: Number of floors–1. Each used material has respective equation of the mount. Notes: GGE = Greenhouse Gass Emissions stated in t equiv; CO_2, Mass stated in kg, t.; Resource Energy stated in TJ. GGE calculation including IPCC weighting factors (global warming potensials) such as CH_4 dan N_2O.

L I S A	L I S A SUB SYSTEMS	DECOMMISSIONING	MATERIAL TRANSPORT
DESIGN PROCESS			
Specification	▪ Building Breadth ▪ Building Life ▪ Door Area ▪ Floor to Ceiling Height ▪ Length ▪ Number of Floor ▪ Number of Lift ▪ Window Height	–	–
CONSTRUCTION PROCESS			
Construction	▪ Structure ▪ Walls ▪ Windows	NO	YES
Fit Out	▪ Air Conditioning ▪ Finishing ▪ Installation ▪ Stair	NO	YES
OPERATIONAL PROCESS			
Utilization	▪ Heating ▪ Lighting ▪ Office Equipment ▪ Other Electrical Appliances ▪ Water Heater	–	–
Repair/ Maintenance	▪ Air Conditioning ▪ Finishing ▪ Installation ▪ Structure ▪ Walls ▪ Doors	–	YES

Figure 3: The structure of problem of construction process of an office building according to LISA.

CONSTRUCTION		SPECIFICATION	DECOMMISSIONING	MATERIAL TRANSPORT	
STRUCTURE	Roof Structure	Pitched Roof, Concrete Slab	No	Railway	No
				Highway	Yes
				Sea	No
	Substructure	Foundations, slab, and groundbeam.	No	Train	No
				Highway	Yes
				Sea	No
	Upper Floors/ Frame	Celullar beams and composite slabs.	**No**	Train	No
		Composite beams and composite slabs.			
		Precast hollow concrete core units.		Highway	Yes
		Reinforced concrete slabs.			
		Precast beam and floor slab.		Sea	No
WALLS	External Wall	Concrete blocks with brick face.	No	Train	No
				Highway	Yes
				Sea	No
	Internal Wall	Concrete blocks, timber studs, plasterboard lining.	No	Train	No
				Highway	Yes
				Sea	No
WINDOWS	Windows	UPVC frame, doubled glazed.	No	Train	No
				Highway	Yes
				Sea	No

Figure 4: Construction process of an office building according to LISA.



Material consumptions and attributes of Upper Floors / Frame

Material	Amount	Unit	Equation
Plywood	21	t	0.00216 {tonnes of plywood / m2 ground area} * Length * Breadth + ((0.010452 * 0.92) + (0.000286 * 0.33) + (0.000883 * 0.06) + (0.0001 * 0.92)) {tonnes of plywood / m2 floor area} * Length * Breadth * (Number of floors - 1)
Concrete precast	670	t	0.3994 * (0.75 + 0.11) {tonnes of concrete precast / m2 floor area} * Length * Breadth * (Number of floors - 1)
Steel - reinforcing	48	t	0.0221 {tonnes of steel reinforcement / m2 ground area} * Length * Breadth + ((0.01363 * 0.92) + (0.002636 * 0.33) + (0.033 * 0.06) + (0.0022 * 0.92)) {tonnes of steel reinforcement / m2 floor area} * Length * Breadth * (Number of floors - 1)
Concrete super	1.5	kt	0.1695 {tonnes of concrete in superstructure / m2 ground area} * Length * Breadth + ((0.60855 * 0.92) + (0.016 * 0.33) + (0.69 * 0.06) + (0.105 * 0.92)) {tonnes of concrete in superstructure / m2 floor area} * Length * Breadth * (Number of floors - 1)

Attribute	Amount	Units
GGE	530	t equiv CO2
Mass	2.2	kt
Resource Energy	4.0	TJ

Per analysis period
Per year
Per unit
Show Comments
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Figure 5, Material consumptions, and attributes of Upper Floors/ Frame.

4.2 Reports

Under reports button on horizontal bar of LISA Interface provided information of,

- Impact Chart, stated on Figure 6, shows total investigated environmental impacts that will occur along the process, for instance energy consumption that will be used by the building, GGE (Greenhouse Gas Emissions), NO_x, SO_x, NMVOC (Non Methane Volatile Organic Compounds), SPM (Suspended Particular Matter), and Water consumption. The left vertical bar indicate base example and the right bar indicate edited example, if the environmental impacts exceed the base one so the color of right bar will changed, and vice versa.

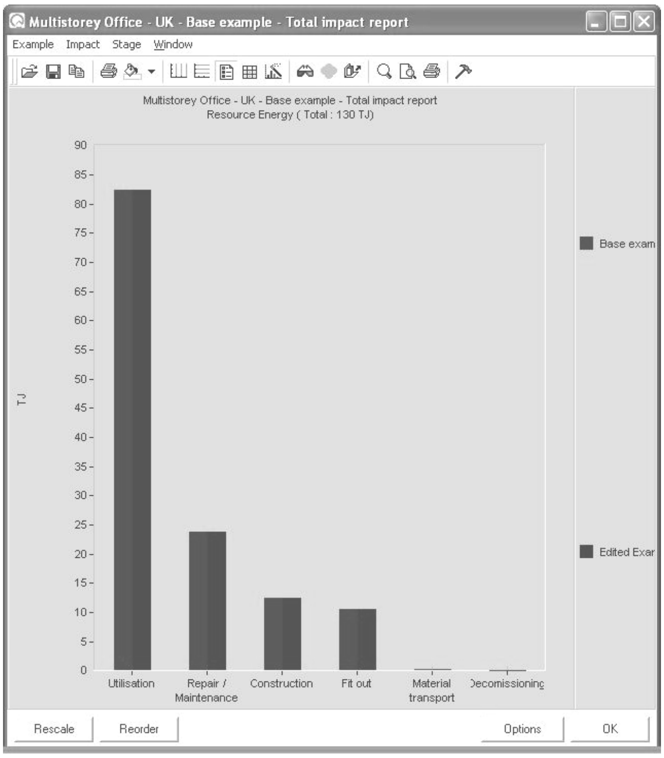
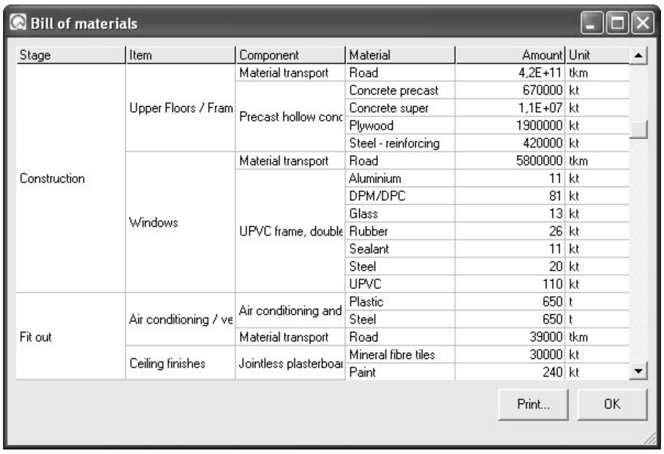


Figure 6: Total impact reports.

- Bill of Materials, stated on Figure 7, shows the amount of each material needed. For instance, Upper Floor/ Frame item of Construction Process Stage that consists of following components, Concrete Block, Timber, and Material Transport, and respective component consists of various materials. The amount of materials including material transport will be calculated for each component.



Bill of materials

Stage	Item	Component	Material	Amount	Unit
Construction	Upper Floors / Fram	Material transport	Road	4,2E+11	tkm
		Precast hollow conc	Concrete precast	670000	kt
			Concrete super	1,1E+07	kt
			Plywood	1900000	kt
			Steel - reinforcing	420000	kt
	Windows	Material transport	Road	5800000	tkm
		UPVC frame, double	Aluminium	11	kt
			DPM/DPC	81	kt
			Glass	13	kt
			Rubber	26	kt
			Sealant	11	kt
			Steel	20	kt
			UPVC	110	kt
Fit out	Air conditioning / ve	Air conditioning and	Plastic	650	t
			Steel	650	t
		Material transport	Road	39000	tkm
	Ceiling finishes	Jointless plasterboar	Mineral fibre tiles	30000	kt
			Paint	240	kt

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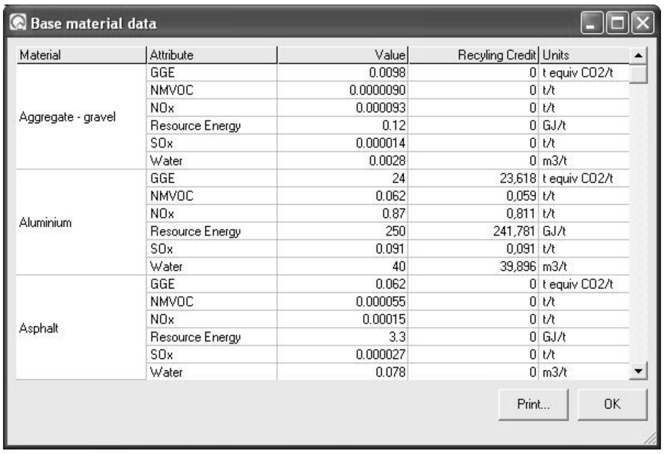
Figure 7: Bill of materials

- Base Materials Data, stated on Figure 8, provide data base information of base materials, such as Aluminium and Asphalt, concerning environmental impacts attribute for instance GGE (Greenhouse Gas Emissions), NMVOC (Non Methane Volatile Organic Compounds), NO_x, Resource Energy, SO_x, and Water, that followed by their respective value and recycling credit.



Base material data

Material	Attribute	Value	Recyling Credit	Units
Aggregate - gravel	GGE	0.0098	0	t equiv CO2/t
	NMVOC	0.0000090	0	t/t
	NOx	0.000093	0	t/t
	Resource Energy	0.12	0	GJ/t
	SOx	0.000014	0	t/t
	Water	0.0028	0	m3/t
Aluminium	GGE	24	23,618	t equiv CO2/t
	NMVOC	0.062	0,059	t/t
	NOx	0.87	0,811	t/t
	Resource Energy	250	241,781	GJ/t
	SOx	0.091	0,091	t/t
	Water	40	39,896	m3/t
Asphalt	GGE	0.062	0	t equiv CO2/t
	NMVOC	0.000055	0	t/t
	NOx	0.00015	0	t/t
	Resource Energy	3.3	0	GJ/t
	SOx	0.000027	0	t/t
	Water	0.078	0	m3/t

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Figure 8: Base materials data

4.3 Lisa Application Conclusion

Project	:	Office Building
Stage	:	Construction Process
Item	:	Upper Floors/ Frame
Components	:	Material Transport and Precast Hollow Concrete Core Units

Materials : Road, Concrete Precast, Concrete Super, Plywood, Steel Reinforcing.

According to Sustainable Architecture that based on cradle to grave paradigm, which is subsequently streamlining the energy, cost and environmental impacts that will be spent and occur along the architectural process particularly Construction Process, LISA application can be wrapped up as follow:

- Energy – Sensibility of energy resources usage noticeable provided by LISA, by means of Impact Chart reports and LCI data of each item of each stage.

- Cost – Sensibility of cost usage noticeable provided by LISA, by means of Bill of Materials report, Decommissioning and Material Transport of each stage, item, component, and material.

- Environmental Impacts – Sensibility of investigated environmental impacts noticeable provided by LISA, by means of Impact Chart reports of:
  1. Energy Resources,
  2. GGE (Greenhouse Gas Emissions),
  3. NO_x,
  4. SO_x,
  5. NMVOC (Non Methane Volatile Organic Compounds),
  6. SPM (Suspended Particular Matter),
  7. Water Consumption

  On each stage, each item, each component, and each material.

In regard with Grave (i.e. Death) Stage, that embrace renovation and demolition, furthermore recycle process, as crucial part of cradle to grave paradigm, LISA sensibly manage them by giving recycling credit to environmental impacts attribute of each base material on Figure 8: Base materials data, as well. Besides intrinsically the building should be designed based on consideration to be renovated, recycled, and moreover easy and economical to be demolished at the end of building life.

5.0 CONCLUSION

Beneficially, IT (Information Technology) has all potencies needed for streamlining architectural system to be precise architectural process in regard with sustainable architecture, that require sensibility of the process in using various resources, principally in relation to the sustainability of the resources that mostly non–renewable energy resources.

In fact, architectural process has changed consecutively into streamlined model since the shifting of design method from trial and error method into design by drawing method, and since the coming up of sustainable development issues.

However, architectural process in relation to sustainable architecture needs a kind of LCA instrument to assess the sustainability of building. On the other hand, the instrument currently considered to being too complicated and not widely accessible to designers and quantity surveyors, besides detailed study of LCA divert attention from the key environmental issues and tend to focus attention on inter–material competition rather than optimum construction systems (LCA – BHP Australia, 2003).

To those extents, streamline computer software LISA offering instrument to simplify the process without avoiding the fundamental objective of sustainable architecture that is constantly concern of energy, cost, and environmental impacts that will be spent and occur along the architectural process that based on cradle to grave paradigm, to be precise along the building life cycle.

As mentioned in the coverage of LISA application conclusion above, besides enabled the architectural process to make occurrence streamlining, LISA enabled the process to reduce the use of energy and cost, and minimize the environmental impacts as well.

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