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LIFE CYCLE ANALYSIS (LCA) FOR SUSTAINABLE ARCHITECTURE

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Life Cycle Analysis (LCA), a kind of cradle-to-grave paradigm based instrument for measuring the product sustainability by analyzing energy, cost, and environmental impacts that would be spent and occur along the product-life-cycle, is one of mechanisms used for Eco Labeling or Environmental Labeling, certifications of acknowledgement on sustainable product.

The labeling could possibly be carried out by way of kind of LCA instrument limited within economically established countries. What about sustainable architecture, that would always be *involving* energy, cost, and environmental impacts as well, as all we know architecture cannot separated from building in terms of building as a product of architecture.

"System Approach to Architecture", offered by A. Benjamin Handler, simplified to considering architecture as a system practically based on paradigm that similar to LCA. System that consists of designing process, construction, facility operation, and human bionomic process, will act as a building-life-cycle instrument if at the end of the system completed with a building management system or a system that concern about end of life of the building, such as recycling process, renovation, or preservation. Toward

Key Words: sustainable product, product-life-cycle, Life Cycle Analysis (LCA), cradle-to-grave, architectural system, building-life-cycle, Sustainable Architec- ture

LIFE CYCLE ANALYSIS (LCA) A WAY TOWARD SUSTAINABLE PRODUCT

Life Cycle Analysis (LCA), a kind of instrument based on cradle-to-grave paradigm for measuring product sustainability by analyzing the product-life-cycle, which means along its life cycle a product should be using either renewable or non-renewable resources in a *very* sensible way. LCA, also a popular term for who concern about environmental issues, in different phrase an instrument for improving production process and its product with the purpose of minimizing environmental impacts particularly energy and cost that would be spent along the process, with the intention of logically manage for effectiveness.

In broader terms, LCA is an instrument for evaluating environmental attributes associated with product, process, and service. The evaluation will be implemented over impacts that will occur along the cradle-to-grave or from birth until death or from a-to-z of product-life-cycle specifically from raw materials extraction until waste disposal management.

Since the first present in 1960 until early 1990, LCA was not extensively applied, but since then has been developed some methodologies, which is broadly accepted and the application of LCA progress increasingly and got some acknowledgements from international standards such as ISO 14040-14043. In 1993, ISO formed Technical Committee (TC) 207 to establish ISO 14000 as environmental management standards that consists of six (6) environmental issues:[1]

The first three (3) issues concerning about valuation on organization:

- Environmental Management System (EMS) is certification process for ISO 14001.
- Environmental Auditing (EA) is certification process for ISO 1410-12.
- Environmental Performance Evaluation (EPE) is certification process for ISO 1403 1.

The second three (3) issues concerning about valuation standards on products:

- Environmental Labeling (EL) is certification process for ISO 14020-24.
- Life Cycle Analysis ILCAI is certification process for ISO 14040-43.
- Environmental Aspects in Product Standards (EAPS).

[1] SOCM.-'Es ISO 14000 Overview

As an evaluation instrument, LCA has some prime features that have been applied since 1970. Besides used as an evaluation tool on conceptual process and quantitative evaluation, it can be used to create a consistent process in global scale throughout its three basic components:

1. Inventory of Effects
2. Impact Analysis
3. Improvement Analysis

In the very near future, manufacturer should include estimation on production processes of service, goods, and waste management under their responsibilities, and not consider them in a second place or second thought. Hence, it is needed to pay much more attention to product-life-cycle that means not only concern about the product creation and materials usage but also concern about what will happen at the end of product life. Currently, the engineers have included design for disassembly, design for recycling, and design for environment into their responsibilities, which is counting environmental aspects into their design vocabulary.

CRADLE-TO-GRAVE PARADIGM

PRODUCT-LIFE-CYCLE

"50% of energy consumption of built environment represented relationship with construction industry2", construction industry including architecture in regard with building is a part of secondary industry, which always relate with energy producing. The above statement forwarded by members of AIA (American Institute of Architects) and IUA (International Union of Architects) when proposed addendum on Agenda 213, proceedings of The 1992 Rio Earth Summit, Rio de Janeiro, Brazil, which

[2] Steele, James (1997), Sustainable Architecture, Principles, Paradigms, and Case Studies, McGraw-Hill, New York, page 16.
[3] Ibid. page 8

consists of comprehensive scope outline of Sustainable Development. Addendum itself comprise of their concerns about extensive usage of non-renewable resources, mainly fossil fuel energy resource. The 1973 United States of America (USA) oil crisis might be triggered by political issue, to be precise conflict between Arab, Egypt, and Syria as oil producer countries with Israel, accordingly oil embargo executed to all Israel adherent countries including USA. Aside from political issues, in fact there is declining of availability of world fossil fuel energy resource moreover if usage was not sensibly considered. Energy global phenomenon as consequence of extensive usage of fossil fuel energy has forced us including architecture community to take a place to be concerning, if we do not want to face more hard economic depression.

Besides producing energy for modern vehicles, heating, and other household activities, fossil fuel particularly oil and natural gas producing energy for industrial and agricultural products as well such as fertilizer, pesticides and plastics. It means, that is not dreadfully easy for replacing oil and gas with other fuels or with food supply, therefore without sufficient energy supply we will lose agricultural capacity. If fossil fuel price raise, it will be followed by price raise of fertilizer and pesticide into much more expensive one, furthermore the situation will stop farmers using such goods. "Yields will go down and the price of food will go up and that in turn is perceived as quite an economic hardship[4]".

Sustainable development as second wave of sustainability[5] is a concept that has strength on integrity between social, eco-

[4] Amos, Jonathan, *Energy Crisis 'will limit births'*. BBC News Online science staff, in Seattle, http://news.bbc.co.uk/1/hi/sci/tech/3465745.stm.

[5] Van der Ryn, Sim, and Peter Calthorpe (1986), Sustainable Communities, A New Design Synthesis for Cities, Suburbs, and Towns, San Francisco: Sierra Club Books, page iv.

nomic, and environmental systems.

Sustainable development has purpose for encouraging people to create a better way of life, to be precise can describe as net- work of activities that using renewable or non-renewable resources particularly en- ergy in a sensibly way therefore will not make future generation worry about sus- tainable availability of the resources. Sus- tainable development clearly offers prob- lem solving for the degradation of environ- mental quality and escalating of poverty but still restricted yet. Explicitly only within economically established countries envi- ronmental labeling or eco labeling could be carried out. Environmental labeling or eco labeling is certification of acknowledg- ment from Organization of International Standards (ISO) 14000 on sustainable product through Life Cycle Analysis (LCA) mechanism, by means of evaluating en- ergy, cost, and other environmental im- pacts that will be spent and occur along its product-life-cycle.

Biosphere, the whole earth surfaces in- cluding atmosphere and ocean that inhab- ited by human being and other live crea- tures representing material goods re- sources and capitals to be exploited for supporting human being and other live creatures life. For that reason, it is needed highly concerns about product-life-cycle, which always relate with energy producing in regard with maintain them. Product-life
-cycle principles can be studied on Figure
-1: The Product Life Cycle Principle.

- Raw Materials: 1. Use materials with less environmental impact; 2. Use less material;
- Manufacture: 3. Use fewer resources; 4. Produce less pollution and waste; 5. Reduce impact of distribution;
- Use: 6. Use fewer
- resources; 7. Cause less pollution and waste; 8. Optimize functionality and service life.
- End-of-life: 9. Reduce the environ-

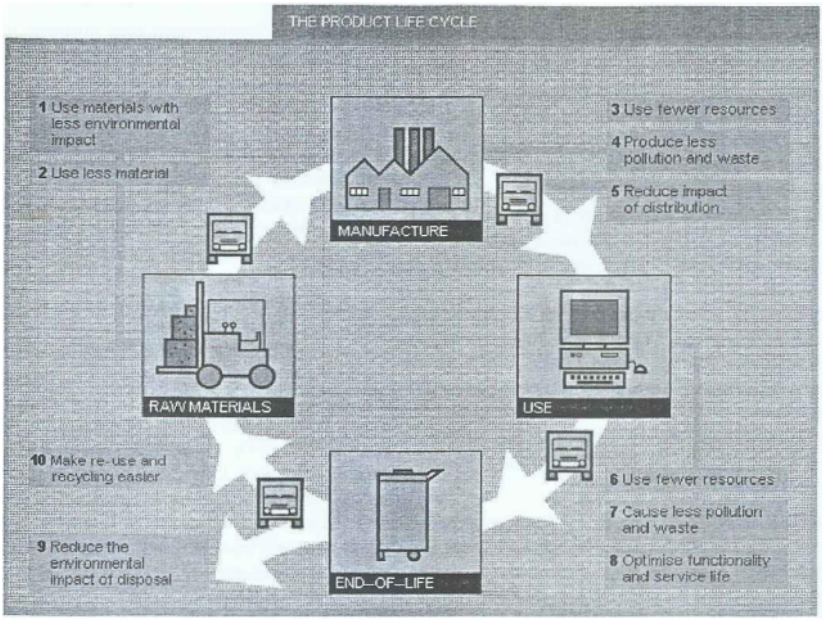


Figure-1:The Product Life Cycle Principle.
Source: http://www.weeeman.org/btml/whar/lifecvcle.html

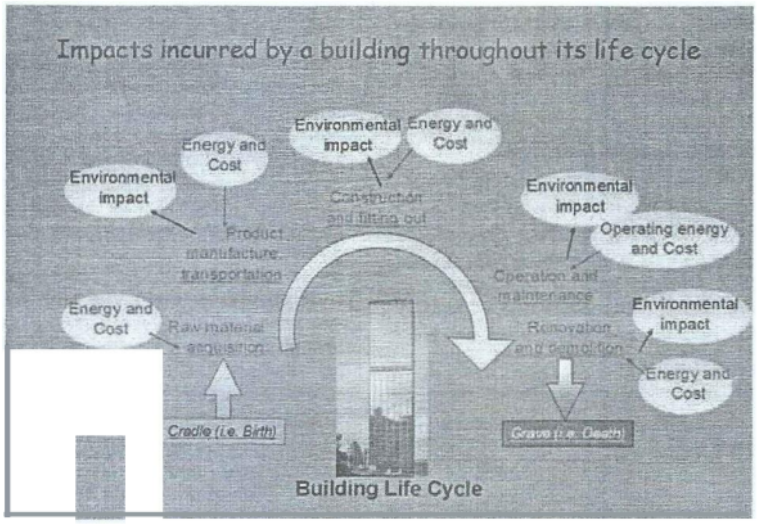
mental impact of disposal; 10. Make re -use and recycling easier.

BUILDING-LIFE-CYCLE

Figure-2 below can give an explanation about environmentalimpacts, which will occur as consequences of building-life-cycle as follow:

- Cradle (i.e. Birth): Raw material accusation will cause energy and cost usage besides environmental impact.
- Products manufacture transportation: idem ditto
- Construction and fitting out: idem ditto
- Operation and maintenance: will cause operating energy and cost usage besides environmental impact as well.
- Grave: Renovation and demolition will cause energy and cost usage besides environmental impact.

To estimate the amount of energy that will be used, there should be analysis on both energy, which is integrated into building and consumed along its life or for opera- tional and maintenance purpose. Opera- tion will depend on material usage and fabrication methods, meanwhile maintenance will depend on orientation, zone, and kind of windows, building surface sophistication, and will depend on lighting and air conditioning system, insulation, thermal characteristics of wall and roof.



Environmental impact

Figure-2: Building-life-cycle
Source: http://www.emsd.gov.hk/emsd/eng/pee/lceabc .shtml

A house which using brick cladding on concrete slab and steel sheet on steel roof

frame will need fewer energy compare to usage of energy along its life, since almost energy

will be consumed for lighting, refrigerating;and/ or heatingsystems.

The most effective way to reduce a household life cycle is by using energy conserved materials and system, which is needed along the operational process. Solar passive design principles along with energy conserved tools and lighting system is the key factor with the intention of reduces energy consumption, which produced C02 as well as consequences of the increasing of energy production.

SYSTEMAPPROACHTO ARCHITECTURE A WAY TO SUSTAINABLE ARCHITECTURE

As an instrument for environmental management and decision making on production processes, LCA denotatively showed the relationship with global recovery, however in regard with entire network how architecture will be related.

"System Approach To Architecture" simplified to "considering architecture as a system" offered by A. Benjamin Handler (Handler, 1970), that consists of four sub systems: 1. Design Process; 2. Construction Process; 3. Operational Process; 4. Human Bionomic Process, practically has similar paradigm with LCA in regard with solving architectural problems.

The entire processes carried out by the four sub systems showed that architectural system keep considering the life cycle of its product in this case the building-life-cycle, though has not included the last process that will manage the building at the end of its life. The later process can be analogized with waste management of LCA.

However, Handler explicitly has not stated environmental impacts yet particularly as result of consumption of energy and cost

that would be spent along with building-life-cycle in context building as product of architectural system or process, but implicitly Handler suggests that architectural problems should be accomplished based on a cradle-to-grave paradigm.

Within system of architecture, the architects might be merely interested with planning and designing building process. In fact, they cannot avoid involvement of construction officers, building operators, and building users, along the production of the building until the end of life of the building.

Therefore, building-life-cycle evaluation can be carried out by system of architecture, which can be analogized with LCA as an instrument inherent in system of architecture.

Throughout "Sustainable Architecture", James Steele forwarded his consideration about role of architects, environmental economy, material,even study on sustainable architecture:

- The role of architects to reach sustainable building or architecture instead of sustainable product, represented by energy conserved designs, usage of relevant literature, applying traditional wisdom, not regarding land as commodity, and responsive towards environment.
- Environmental economy substance offered by suggesting estimating life-cycle-costing.
- Materials that should be aware of that are extensively used all over the world for instance aluminum, concrete, plywood, and steel. To be precise energy intensive materials are materials that are produced by using a very large amount of energy.
- Curriculum applied should be anticipative to previous curriculum that has applied value and norm which judged nature as enemy to be conquered, and not consider them as basis for life and environment as a place where architecture can and have to harmoniously fit

in.

Similar consideration advanced by Brenda and Robert Vale throughout their "Green Architecture": "Architectural paradigm has changed", this statement forwarded since there is tend to changes towards designs of energy conserved, working with climate, minimizes usage of new resources, re- specting users, respecting site, and ho- lism.

Ih the course of "Designing with Nature", Ken Yeang offering architectural design concept by way of ecological approach. The approach including analysis, synthe- sis, and evaluation stages, which is based on "Value in Building" theory from T. Mar- kus in 1973. On evaluation stage, Yeang has more taken notice to life cycle of every step of evaluation criteria to be precise production process, construction, con- sumption, and recovery process. On those stages Yeang considered architectural design as cyclic system as "from source to sink" that similar to cradle-to-grave that is starting from resource extraction ended at the unvalued condition.

Based on stated considerations, it can be concluded that regarding architecture as a system means keep concerning about building-life-cycle in context of building as product of system of architecture. How- ever, considering architecture as a system is the right step for architecture to take place in responsibilities upon the decreas- ing of natural resources mainly non- renewable energy resources.

PROJECTION IN INDONESIA

There must be many Indonesian architec- tural theorists and practitioners who have had similar thought and commitment even have been applying the design criteria, which is formulated based on cradle-to- grave paradigm though explicitly has not showed yet the estimation of building-life -cycle using sort of instrument such as LCA.

However, merely commitment could be

less worked f it is not supported by political will or government commitment. Although only economically established country can be carrying out certification process such as eco labeling ISO 14041-14043 by way of sort of instrument such as LCA. Nevertheless as part of global architectural community, Indonesia should be involving themselves by minimizing environmental impacts as consequences of the existences of architecture, if do not want to be alienated.

Applying tropical architecture, energy conservation, using local material, awareness of preservation, revitalization, and renovation on designs besides create them as manifestation of traditional wisdom, which is expressing Indonesian architecture and architects involvement, intrinsically has been insustainable spirit.

However, it should be better if the involvement carried out systematically and holistic by considering building-life-cycle from raw materials extraction until end of life of the building in every architectural design process, in context building as product of system of architecture.

CONCLUSIONS

By keep considering building-life-cycle within an architectural process, it means that we are constantly making up life quality into a better one under economic depression that growing harder, as consequences of the decreasing of environmental quality and limitation natural resources particularly non-renewable energy resources.

As a part of industrial construction, which always relate with energy producing, architecture suppose to do something in regard with this situation, and it has been proofed by concerns from a number of architectural theorists and practitioners about the stated problems.

Accordingto this discourse, there would be uneasiness for some architects. Nevertheless, we no need to worry about the matters. Concerning about the building-life-cycle within system of architecture means analyzing energy, cost. and other environmental impacts that would be spent and occur along the building-life-cycle.

However, analysis by using a cradle-to-grave based instrument such as LCA is not a paradigm shifting of strategies or architectural design methods but it is more to be parallel, side-by-side, and a complementary process.

Inherently, architectural planning and designing still produce designs that are related to the creation of value or meaning with the intention of arousing users' emotion and sensitivity.

On the other hands, estimate life cycle of the buildingalong an architectural process in context building as product of system of architecture, offering designs that can minimize environmental impacts as consequences of building-life-cycle, or designs that associated with quality and reliable issues.

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