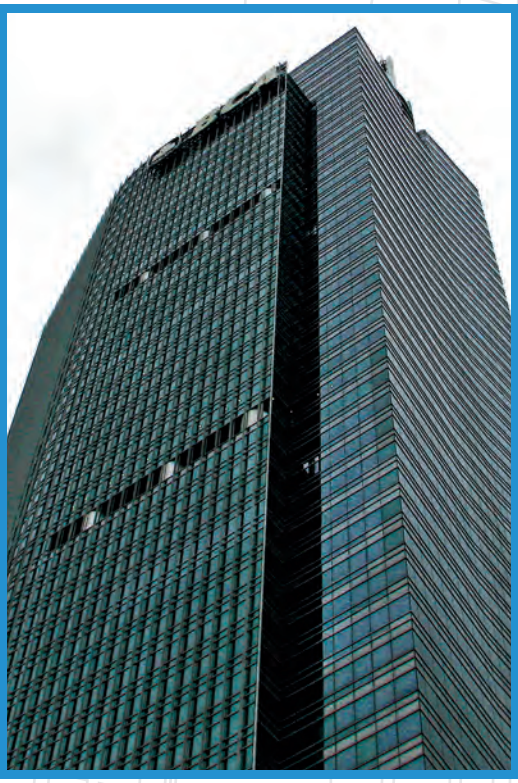
Energy Efficiency Guidelines for Building Design in Indonesia







1 Developers and Building Owners

EECCHI
Energy Efficiency and Conservation Clearing House Indonesia

Kementerian Energi dan Sumber Daya Mineral

Ministry of Foreign Affairs of Denmark
DANIDA International Development Cooperation

Danish Energy Management A/S

Energy Efficiency Guidelines
for Building Design in Indonesia
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First Edition 2012

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Foreword

The Energy Efficiency (EE) Guidelines for the commercial and building sector are an output of the Energy Efficiency in Industrial, Commercial and Public Sector (EINCOPS) programme. This programme is supported by the Danish Government as part of its assistance to the Government of the Indonesia in the area of Energy Efficiency through the Danish International Development Assistance - Environmental Support Programme II (DANIDA - ESP II), Component 2. The purpose of EINCOPS' activities is to provide support throughout Indonesia in promoting energy efficiency through a variety of activities, aligned with international and national efforts to improve energy efficiency efforts and reduce the impacts of climate change.

The EE Guidelines will provide a holistic overview, up to date advice and references, and practical guidelines aimed to building owners / developers and professionals on how to design buildings to minimize energy use while still meeting comfort, health, and safety needs.

On the national level, energy efficiency and conservation programs aim to reduce energy subsidies, reduce the gap between the supply and demand of energy, reduce greenhouse gas emissions that affect global warming and climate change, and improve national energy competitiveness. Energy conservation needs to be a part of all phases of energy management, ranging from upstream sustainable energy (exploration, exploitation, refining, power, etc.) to downstream energy use in all sectors as stipulated in Law no. 30/2007 on Energy and Government Policy No 70/2009 related to the conservation of energy. Currently, the share of national energy consumption in the commercial and building sector is only about 4% (industry 39.4%, transport 32.2%, non-energy use 10.5%, 10.2% of households, other 3.4%), but in the last 20 years the growth of energy consumption in the commercial and building sector has been the highest at 8.58% (industry 5.1%, transportation 6.4%, non-energy use 5.4%, 3.1% of households, others 0.03%).

The EE Guidelines are separated into three parts: 1) for building owners, developers and investors; 2) for professional designers; and 3) energy efficiency case studies. This piece, Part 1 can be used by building owners, developers, and investors in guiding their project development team in considering the cost analyses to ensure low energy consumption targets are met, while still challenging existing design concepts and building more efficiently and environmentally friendly. Part 2 of the guidelines, for professional designers, architects, and engineers in the fields of mechanical, electrical, structural, and landscaping will act as a guide to help their designs maximize energy efficiency achievements for new buildings as well as in the retrofit of existing buildings. As a companion Part 2 also features comprehensive technical guidelines that can be used as preparation for the development of standards (SNI) and codes (code) for buildings in the future. These standards and codes will help buildings be designed more appropriately to the needs of the whole community, accounting for cost, efficiency, environmental, and health considerations.

Finally, we would like to thank the authors, team of experts, stakeholders, and all those who helped in the preparation and development of the Energy Efficiency Guidelines for Building Design in Indonesia.



Maryam Ayuni
Director of Energy Conservation
Directorate General New Renewable Energy and Energy Conservation
Ministry of Energy and Mineral Resources of Indonesia

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1. Introduction

1.1 Background

The programme "Energy Efficiency in Industrial, Commercial and Public Sectors" is a cooperation between the Ministry of Energy and Mineral Resources and DANIDA, Danish International Development Assistance, initiated in 2008 with the following overall objectives in supporting Indonesian government policy:

> *"Energy efficiency measures are increasingly adopted by major industrial, commercial and public sector consumers of energy". This objective has been pursued in support of the development objective of promoting "Sustainable Environmental Management in Support of Livelihoods in Indonesia".*

One activity of this programme was to develop guidelines for the design of energy efficient buildings. This has been done through a process of consultation with key stakeholders and interested parties through the assistance of a panel, established for this purpose, of recognized experts in various relevant disciplines.

It is expected that this document will need to be regularly revised over the coming years to keep it up to date with developments in the knowledge base and the regulatory environment of the building sector. The Guidelines and any subsequent revisions will be available as pdf files on the website of the Energy Efficiency and Conservation Clearing House Indonesia (EECCHI) at http://www.konservasienergiindonesia.info.

1.2 Overview

The Energy Efficiency Guidelines for Building Design in Indonesia have been developed to provide information on energy efficient building design in Indonesia based on international best practices within the Indonesian physical, social and economic climate. The intention of these Guidelines are to inform and provide practical and technical guidance on how to develop, design, operate and maintain energy-efficient buildings. The Guidelines specifically target the major role players in the development of any building: firstly, the building owner/ developer as overall project driver and decision maker; and secondly, the consultants as designers and implementers of the developer's ideas.

1.2.1 Aim of the Guidelines

The aim of the Guidelines is to inform, educate, assist and create awareness regarding all the issues related to Energy Efficient building design for the building owner or developer, as well as the consultants, designers and specifiers on the building project.

Further to this the Guidelines aim to make all the role-players aware of their responsibility and potential impact on the energy efficiency of a building both during the design and construction process.

Building owners and developers should use the Guidelines to inform themselves of the issues, benefits, and pitfalls related to energy efficient

The Energy Efficiency Guidelines for Building Design in Indonesia have been developed to provide information on energy efficient building design in Indonesia based on international best practices within the Indonesian physical, social and economic climate.



Figure 1. Guidelines Structure

design, as well as to ensure that they are able to instruct their project teams to design energy efficient buildings.

Consultant teams should use the Guidelines as an inspirational and educational tool to convince their clients of the benefits and necessity of energy efficient design as well as a resource for the issues and knowledge required to design an energy efficient building. Thus the Guidelines aim to ensure that they can understand and participate in discussions with designers and/or engineering consultants to achieve an energy-saving building for new construction or retrofittings.

Lastly the Guidelines aim to ensure that all the role-players in the design and construction of a building or in the retrofitting of an existing building are able to speak the same language related to energy efficiency.

1.2.2 Who are the Guidelines intended for?

The Energy Efficiency Guidelines consist of Three Parts distributed in 3 books.

The first part is intended for the building owner/developer and operators and focuses on policy and general information on the cost-benefits of energy efficient buildings. It also contains a summary of the major aspects that influence energy efficient building design. The aim of this part is to enable building owners and developers to make informed decisions regarding the benefits of Energy Efficient building implementation.

The second part is intended for the project teams, designers and specifyers, and gives more detail technical information on the design procedures to achieve optimal energy efficiency in buildings that will positively affect capital and operational costs.

Building owners and developers should use the guideline to inform themselves of the issues, benefits, and pitfalls related to energy efficient design, as well as to ensure that they are able to instruct their project teams to design energy efficient buildings.

The third part is intended for everyone involved in a project to understand the implications of energy efficient design at the hand of real life examples. These case studies aim to motivate and inspire both building owners/developers and consultant teams to achieve the ultimate in energy conservation through effective design.

1.2.3 Structure of the Guidelines

Part 1. Energy efficiency for developers and building owners

Part 1 is specific to building owners and developers and guides them to consider:

a. The importance of setting up a proper and complete design brief that guides the project team towards the most energy efficient building within the available budget.

b. The importance of the implementation of an Integrated Design Process to ensure the optimisation of energy efficiency through effective design collaboration.

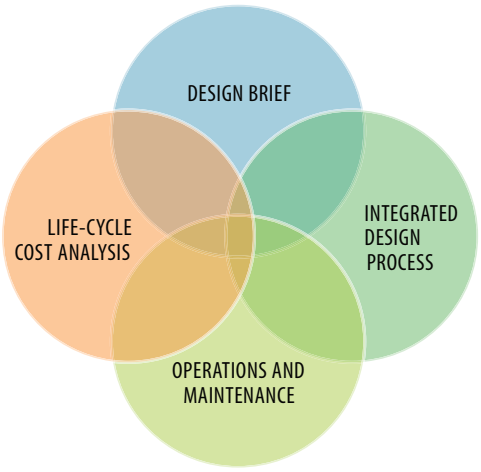

Figure 2. Four major aspects that influence the possibility for energy efficient design that are controlled by the developer.

c. The impact of capital investments and the running cost of a project in relation to the overall lifecycle cost of a project (long-term).

d. The importance of proper maintenance, and management of an energy efficient building to maintain its operations within its design parameters.

Part 2. Energy Efficiency Technical Guide

Part 2 consists of practical guidance and design strategies to achieve an energy-efficient building design with specific focus on helping the design team understand the principles and influences of:

a. The importance of understanding the impact of climate on the energy efficient design strategy.

b. The importance of the influence of human comfort and creating a comfortable indoor environment on the energy efficiency of a building.

c. The importance of the application of basic passive solar design principles to optimise the design for maximum energy efficiency.

d. The importance of effective building envelope design on the overall energy efficiency of a building.

e. Understanding the performance of buildings through different kinds of simulations and modelling.

f. The impact of different building systems on the energy efficiency of buildings as well as how the integration of systems could lead to major benefits from an energy efficiency point of view.

g. Lastly the importance of ensuring the best possible implementation of the design through a process of effective procurement, quality control and finally testing, measuring and verification of the parameters in the completed building.

1.2.4 Classification of buildings

Based upon the Law of the Republic of Indonesia no. 28, 2002 concerning Buildings (Undang-Undang Nomor 28 tahun 2002 tentang Bangunan Gedung), the function of a building is classified into five groups. Furthermore,

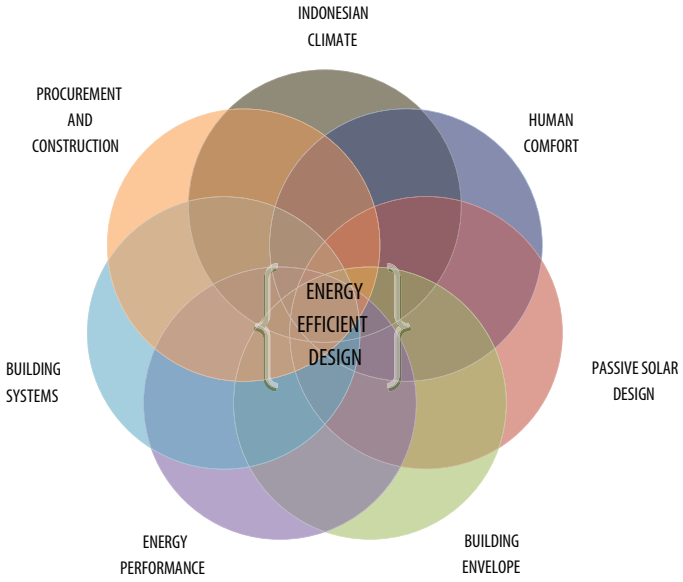

Figure 3. Seven major aspects that influence the possibility for energy efficient design that are controlled by the design team.

according to the Regulation of the Republic of Indonesia no. 36, 2005 concerning the Implementation of the Regulation no. 28, 2002 concerning Buildings (Peraturan Pemerintah nomor 36 tahun 2005 tentang Peraturan pelaksanaan Undang-Undang nomor 28 tahun 2002 tentang Bangunan Gedung), each building function is classified such:

- **Housing, for human settlement/ residence,** such as a detached house, terrace house, apartment, or temporary shelter.
- **Places of worship,** for religious purposes, such as a mosque, church, monastery, synagogue and temple.
- **Commercial,** for commercial use, such as offices, shops and stores, industrial buildings, hotels, tourist and resort facilities, terminals and warehouses.
- **Social and cultural,** for social and cultural activities, such as educational institutions, health facilities and hospitals, laboratories, and public service agencies.
- **Special purposes,** for special functions such as a nuclear facility, defense and military facility, and other classified buildings.

Although this classification of buildings does not seem to relate directly to their energy consumption, it is a good to understand that the use of a building does have a direct influence on the design, systems, and operations of that building and that

The Guidelines aim to ensure that all the role-players in the design and construction of a building or in the retrofitting of an existing building are able to speak the same language related to energy efficiency.

It is important to understand the impact of the climate on the design strategy, as well as creating a comfortable indoor environment that will accomodate to the energy efficiency of the building.

these aspects greatly influence the energy consumption and energy efficiency potential of the building.

1.2 5 Standards, codes and regulations

A number of standards, codes, and regulations promote energy efficiency in buildings:

a. Standards
The Indonesian National Standard (Standar Nasional Indonesia – SNI) is commonly used as a reference for building design. A list of standards that are generally used is attached in Part 3.

b. Codes
There are currently only a limited number of codes that are used for building designs and most are relating to safety and security aspects. There are none relating specifically to energy efficiency in buildings.

c. Regulations
Regulations related to building design are published by the Ministry of Public Works (PERMEN PU). The Ministry of Energy and Mineral Resources (PERMEN ESDM) has also published regulations on energy efficiency. These regulations are listed in Part 3.



2. Motivation for Developers and Building Owners

Scientists forecast that in the not-too-distant future, dwindling energy resources like oil, natural gas and coal will make these non-renewable energy sources inaccessible.

As this will have a tremendous impact on energy use for the future, two fundamental steps should be pursued :

- Development of alternative renewable energy sources by the Government, and
- Large scale implementation of energy conservation in the Public and Private sectors. All sectors of industry should implement Energy Efficiency measures.

Buildings clearly constitute an enormous environmental burden. The State Electricity Company (PLN) in its electricity statistics and energy report from 2011 states that buildings account for almost 50% of the total energy expenditure in Indonesia and more than 70% of the overall electricity consumption. They are also responsible for about 30% of greenhouse emissions, and expend 30% of raw materials.

Approximately 50 percent of energy use in buildings is due to the processes required for creating an artificial indoor climate through heating, cooling, ventilation and lighting. The energy consumption of a typical building constitutes approximately 25 percent of the building's total operating costs. Estimates indicate that climate-sensitive design using available technologies in buildings could reduce ventilation and cooling energy consumption by 30 percent and lighting energy requirements by at least 50 percent.

Building owners and developers can expedite energy conservation by requesting the design of energy-efficient buildings from the outset. Properly designed energy efficient buildings will result in much lower utility bills than from conventional buildings (buildings with no energy efficiency strategies). Energy efficiency is also part of a bigger drive towards more sustainable living and thus should also encompass other resource issues such as water conservation.

Improving energy efficiency in building designs not only leads to financial benefits throughout the lifecycle of a building, but it can also contribute to the greater good in the sense of environmental (overall sustainability) and infrastructure-related benefits such as:

a. Government is able to allocate energy and financial resources to other users.

b. Less energy use requires less energy production which reduces overall require-ments for infrastructure development along with reducing CO2 and other greenhouse gas emissions.

c. Sustainably designed buildings tend to be more user friendly and can improve productivity and quality of life.

According to the Regulation of the Republic of Indonesia no. 36, 2005, each building function is classified such: Housing, Places of worship, Commercial, Social and cultural, Special purposes.

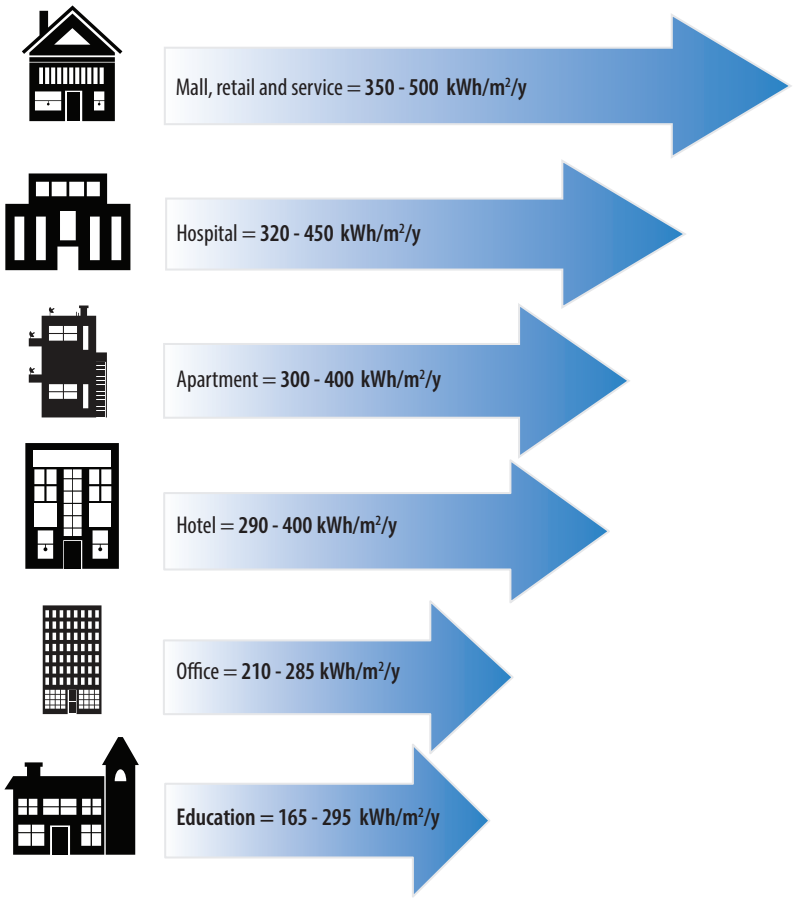

Figure 4. Building Types and Energy Efficiency Index

There is currently only limited data available in Indonesia regarding the energy consumption of different building types, but based on local experience and international studies it is estimated that the energy consumption of different building types are as in the Figure 4. These numbers also used by the Jakarta Provincial Government Green Building Regulation to calculate an Energy Efficiency Index (EEI) based on benchmark operational hours of 2080 hours/year (for education), 2600 hours/year (for office), 4368 hours/year (for mall, retail and services), and 8736 hours/year (for hotel, apartment and hospital).

Implementing energy efficiency in building designs not only leads to financial benefits throughout the lifecycle of a building, but it can also contribute to the greater good in the sense of environmental (overall sustainability) and infrastructure-related benefits

2.1 Energy Efficiency Trends in Indonesia

Indonesia has a lot of potential to be more efficient in energy use, not only in buildings, and is going through significant progress in terms of energy efficiency. Jakarta just launched a gubernatorial regulation on green buildings (Pergub 38 – 2012) which sets mandatory energy efficiency requirements on large buildings to be more energy efficient. The Pergub 38 – 2012 also requires mandatory energy use consumption (W/m2) which can be used to create energy use benchmarks for buildings in Jakarta. There are similar plans for green building regulations in other big cities and provincies. So far there are no maximum power density (W/m^2) nor maximum energy density (kWh/m^2) requirements per year.

It is important to note that the gubernatorial regulation (Pergub 38 - 2012) does not regulate only energy, but also indoor environment, water and other aspects and is therefore a green building regulation and not just a building energy regulation.

The Ministry of Energy and Mineral Resources has produced energy labels for lamps, and is formulating energy labels for other equipment such as air conditioning (split unit) and refrigerators. Four (4) stars indicates very energy efficient equipment. Indonesia also has produced ratings to assess commercial buildings in Indonesia initiated by the Green Building Council of Indonesia (GBCI). These ratings are to be used to encouraged buildings to be greener and more energy efficient, and to incentivize building owners since higher rated buildings are increasingly marketable.

Energy reserves are under pressure. and Indonesia has become a net importer of oil. Thus the subsidized prices may not last long as it is a fiscal burden to the country and limits growth potential. South Africa has a history of low electricity prices, similar to Indonesia. However since 2008, the price of electricity has been steadily increasing by more than 20% each year as the government reduced and eliminated energy subsidies as reserves were low (maximum increase was 31.3% in the year between 2009-2010).

2.2 Basic Principles

In anticipation of the predicted energy scarcity in the future, not only must the Government make an effort to develop renewable energy but industries must also adopt energy conservation measures. It is important for building owners and developers to integrate energy efficiency strategies at the initial design stages to be implemented at the construction, procurement and operational stages of a building.

To be able to set up and guide the energy efficient design and construction processes needed to achieve an energy efficient end-product, developers should understand the main elements of Energy Efficiency which are:

a. Integrated Design Process. An integrated design process encompassing both site characteristics and building design, which incorporates architectural, structural, mechanical and electrical options with the aim of minimizing energy consumption. To achieve its aim, this integrated approach requires close collaboration between the architect, mechanical, structural and electrical engineers as well as the contractor in both the design and construction phases.

b. **Material and technology choice.** All materials and technology used in or on the facade and glazing of the building envelope, for water conservation, electrical fittings (lamps, etc.) and air conditioning systems, need to be accurately designed to minimize the resulting energy consumption, while at the same time fulfilling the functional and other requirements of the building.

c. Climate. As most of the energy in buildings is used to insure human comfort it is clear that the surrounding climate has a big impact on building performance and thus energy consumption:

- *Solar radiation* (heat and light) affects the building's cooling load and lighting design requirements. These can be influenced through the orientation of the facades and and the materials used for the building's envelope
- *Air temperature* is together with relative humidity the dominant parameter to consider in air conditioning design in order to achieve the desired human comfort and indoor environment
- *Relative humidity* has a major impact on indoor climate and human comfort and is therefore an important concern in air conditioning design and achievement of a good indoor climate..
- *Prevailing winds* can in some cases be harnessed to reduce cooling and ventilation needs and are therefore important to take into consideration

d. Operations. A Guide for Building Operations and Maintenance focussing on energy efficiency measures is essential to achieve and maintain the energy performance targeted through the building design. Furthermore, Building Automation, and Building Energy Management Systems (BAS and BEMS) are – especially for large buildings – powerful tools to achieve and maintain efficient building operations.

e. Behaviors. An awareness and attentiveness on energy and indoor environment from everyone using the building is important. Education and training can strengthen the building occupants' understanding of the importance of, and ability to assist, building management's effort to maintain and enhance the energy efficiency of the building.

2.3 Benefits

In response to climate change, dwindling global energy resources and the associated rise in energy prices, it is imperative that property owners and developers seek ways to create energy efficient buildings by way of better and more concientious design. The main benefits for the owner and the occupants are in general:

- Lower utility costs,
- Higer property value,
- Enhanced technical life of structures and equipment,
- Improved indoor environment and better performance by the occupants, and
- Reduced GHG emissions

To be able to set up and guide the energy efficient design and construction processes needed to achieve an energy efficient end-product, developers should understand the main elements of Energy Efficiency

In general however, building owners and developers tend to be mainly concerned with the capital expenditures and return on investment from their building projects.

Therefore, in order to harness the substantial benefits that can be obtained through energy efficient and environmentally conscious design, it is important to understand the differences between a Conventional Building and an Energy Efficient Building. This guide aims at providing a foundation for making good decisions and choosing effective implementation strategies when embarking on a new construction project.

The Green Building Council of Indonesia, through its Greenship rating tool, also provides guidance for the design, construction, and operational stages of buildings. Among other things they provide a comparison of energy savings between energy efficient and more conventional Buildings (also called Baseline Buildings). The number of points available for energy efficiency and conservation (EEC) in the Greenship Rating Tools is around 26% of the available points in their assessment.

Greenship Certified Building	Energy Saving Achievement (*)	Energy Consumption Index (kWh/m2/year)
Ministry of Public Work Building (Platinum-design recognition)	38%	155
ITSB Deltamas building (Gold-design recognition)	19%	202
Dahana Building (Platinum-Final)	32%	131
BCA Tower - Grand Indonesia Building(Gold-Final)	30%	174
Rasuna Tower Building (Gold-Design recognition)	18%	205

Table 1. (*) The percentage of savings above is in comparison with conventional buildings which are calculated based on a minimum the requirements as stated by SNI 2000 and 2001 (such as for office building EEI=240 kwh/m2/year). This number have been taken from the Energy Conservation Technical Guide Book for Energy Audit, 2000. With a concerted effort even better performance can be achieved

Table 1 lists a number of examples of buildings that have already achieved substantial benefits from an energy conscious design effort.

2.4 Pitfalls

The biggest pitfall for any developer is the misconception that capital expenditures are more important than the lifecycle cost of a building. The majority of building owners and developers concern themselves primarily with initial costs without realizing that initial costs correlate closely with a building's operational costs. The use of uninformed designers, improper and less durable construction materials and mechanical and electrical equipment will over time have impacts on the operational and maintenance costs of a building as shown in the Figure 5.

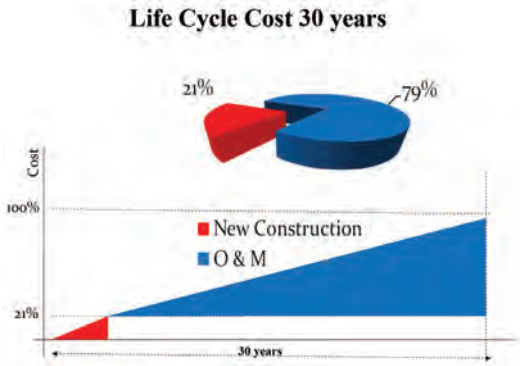

Figure 5. Building Life Cycle Cost

Further to this it is very important to understand that decisions made as early as the setting up of the design brief have a strong influence the energy efficiency and ultimately the capital and lifecycle costs of the overall building project. Good decisions made early on in the design process will have a much greater benefit than good decisions made later in the process.

The impact of design decisions on project costs are shown in the Figure 6.

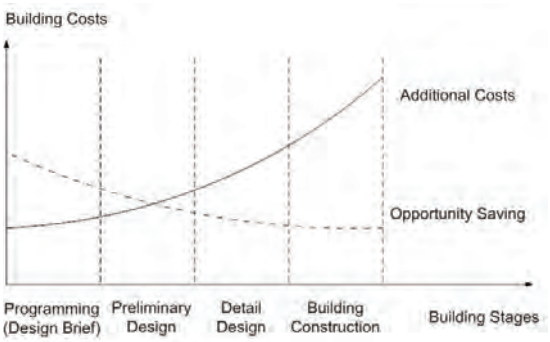

Figure 6. Cost Influence at Different Stages of Buildings

Good decisions made in the early stages of the building design process using an integrated design process to achieve energy efficiency will provide benefits in terms of capital investment costs as well as overall operational costs.

2.4.1 Reasons why many buildings are not energy efficient

Oversizing

Oversizing starts with 'safe' design assumptions regarding items such as cooling load, which can be reduced by 30% using detailed simulations. Even after using 'safe' design assumptions, most engineers will include safety factors. On top of these 'safe' design assumptions and safety factors, there are times where equipment availability is a problem, which can lead to a up-sized equipment.

Lack of attention to supervisory, commissioning and handover procedures

To do accurate supervision commissioning and handover procedures are extremely important for the developer as tools to make sure the targets in the design brief are reached (and also to ensure that the contractor follows the specifications with the installed equipment, finishes, etc.). Proper commissioning is also indispensable in order to uphold and claim warranties later on. For these reasons it is obvious that poor and sloppy commissioning and construction supervision is highly detrimental to the quality in general and to energy performance in particular. For those equipment and construction parts that can not be commissioned and checked at handover, it is essential that good site supervision and commissioning are done **during** construction. Commissioning is an ongoing process; **handover** is where there needs to be a very detailed and conscious effort to ensure all has been delivered according to specs. If the contractor knows up-front that this will be checked in detail, both at handover and during construction, he will deliver a much better product. It may cost more, but those costs are easily saved in reduced need for after the fact fixes and lack of performance.

Poor Operations and Maintenance

Operational maintenance is a critical part of energy efficiency. Some simple measures such as cleaning/calibrating a sensor or motor maintenance can mean savings in energy and prolonged equipment life.

2.5 Arguments for Energy Efficiency

Constructing an energy efficienct building entails lower life-cycle costs that can be achieved with a limited increase in the initial capital investment. In many cases designing an energy efficient building will be more expensive than a conventional building; however these costs can be limited through an integrated design process and careful planning. The additional construction costs associated with an energy efficient building will be compensated by the savings produced on energy consumption. In most cases they will be recouped within a short period of time because the overall operational costs of the building will be lower.

For example, a conventional building with a single layer clear glass façade has a "low" investment cost, but a high energy cost because it requires a higher cooling effort to achieve a comfortable indoor climate inside the building.

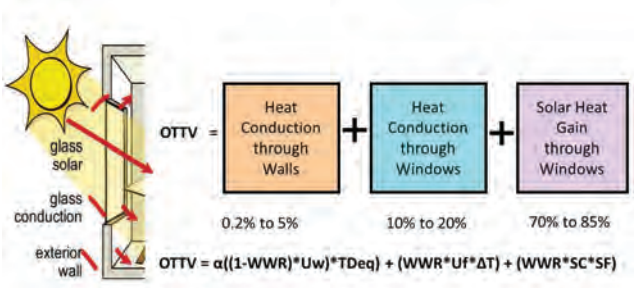

Figure 7. Heat gain through single clear glass façade of a conventional building

On the other hand, an energy efficient building with a building envelope using an alternative glass façade, such as double-glazed or "low e" glass panes will have a higher initial investment cost but due to the reduced heat transfer into the building it will require less cooling effort. This will then result in lower operational and energy costs for the lifetime of the building.

An informed building owner or developer will not be overly concerned about a marginal increase in initial costs, because he will understand and be able to calculate that the higher returns from the building's rent and the lower operational costs will pay back the higher initial investment. More simply, the savings can finance the additional investment.

Singapore has effectively implemented Green Buildings since 1993 and they have more than 1000 certified Greenmark buildings.

For those equipment and construction parts that can not be commissioned and checked at handover, it is essential that good site supervision and commissioning are done during construction.

BCA Singapore has issued data regarding the increased investment and annual pay backs for certain Greenmark category buildings.

Greenmark Category	Investment Cost Increased (%)	Paid Back Additional Investment by Yearly Saving from Operation
Platinum	Up to 8 %	Up to 8 years
Gold plus	Up to 3 %	Up to 6 years
Gold	Up to 2 %	Up to 6 years
Certified	Up to 1 %	Up to 5 years

Table 2. Additional Investment Costs for Green Buildings in Singapore

Typical arguments for and against efficient energy are usually related to additional investment that occurs during the implementation. However, since this additional investment actually helps to reduce operational costs, the annual savings from reduced operational costs can be used to cover the higher initial investment (life cycle cost investment).



3. The Design Brief

The design brief is the building owner / developer's first line of defence against rising capital investment costs as well as insuring that he benefits completely from the lower operational costs of a well-designed energy efficient building.

The Design Brief is a description of the project options which have been approved in principle, detailing the objectives and parameters to be considered by the project consultants when designing the project. The design brief should be designed for project consultants as a Terms of Reference to set out the client's objectives, requirements, constraints, targets and the design approach to be implemented for new buildings or major building renovation projects.

As a minimum requirement the Design Brief should assist the client and consultants to understand the opportunities and associated potential benefits that exist in a project if they improve the efficiency of the building. Further it should give everyone involved a background on the key issues to be addressed during design and implementation.

A well-prepared Design Brief can be used throughout the project as a reference to ensure that the developer's original requirements and objectives are achieved. It should be understood that the design brief is a live document which should be revised as necessary to reflect any changes in the design criteria, requirements and/or objectives.

TYPICAL DESIGN BRIEF STRUCTURE

Project Background and Physical information
Project Objectives
Project Requirements
- Schedule of accommodation
- Indoor Environment Requirements
- Aesthetic considerations

Opportunities and Constraints
- Siting
- Climate
- Finance
- Time

Performance Targets
- Financial
- Energy

Design and Construction Approach
- Procurement strategy
- Integrated design approach
- Planning and landscape
- Envelope and structural design
- Lighting and electrical design
- HVAC design
- Operations and maintenance requirements
- Decommissioning considerations

The more competitive the procurement process for consultants, contractors and suppliers is, the more pressure there will be on them to reduce costs, and hence the need to verify performance against an agreed upon scope of work. A well-prepared and detailed Design Brief is a valuable

component of the contract between a client and his consultant.

The Owner's Project Requirements (OPR) provide the foundation for successful delivery of a project. It is defined by the owner and users who deliver their mission through the completed project. As defined in ASHRAE/NIBS Guideline 0 – 2005, The Commissioning Process:

> *"The Owner's Project Requirements (OPR) form the basis for evaluating all activities and products during pre-design, design, construction, acceptance, and operational decisions are made... The Commissioning Process is a quality-based method that is adopted by an Owner to achieve successful construction projects. It is not an additional layer of construction or project management. In fact, its purpose is to reduce the cost of delivering construction projects and increase value to owners, occupants and users".*

The OPR includes all general aspects of the project while leaving out the details.

3.1 Project Background

The design brief should start with the background information of the project focusing on a description of the client's vision for the project. Further it should indicate the physical information of the project such as where the project is located, property size, zoning (including height restrictions), allowed floor space ratios, coverage, etc.

3.2 Project Objectives

Any good design brief should have a clear set of objectives. A description of the background for the project should be followed by general statements regarding the project objectives to indicate what is required from the project, and what is important to the client.

This will include the 'direct' objectives that have motivated the client to initiate the project, e.g. the need for additional office space, a building that is needed to implement a business plan for example. It can also include indirect or secondary objectives that relate to the client's overall philosophy or mission statement. These could include an emphasis on environmental sustainability, a desire to promote the local economy, or the wish to communicate a particular corporate identity.

To successfully instruct the design team regarding the indoor environment one must understand that thermal comfort conditions depend on several factors, including air temperature, relative humidity, air movement and the temperature of surrounding surfaces

A general statement could be included here relating to the energy efficiency of the building such as:

> *"The development shall be designed to achieve an appropriate level of energy efficiency, with regards to life cycle costs and also considering the escalation of energy costs relative to other costs over the design life of the building."*

Similar statements could be included for other environmental considerations such as water management and waste management.

3.3 Project Requirements

This section contains the specifications for the building and other developments. The actual structure and content will vary depending on the type of development that is required.

3.3.1 Spatial planning

Spatial planning takes into consideration the main types of spaces required, the size, and any other particular requirements related to the use of each space. It is also beneficial to define the way in which different spaces should relate to each other from a functional as well as organisational point of view.

3.3.2 Indoor environment specifications.

Specifications for comfort conditions will be described in more detail in Part 2 Section 4, Human Comfort Levels & Indoor Environment. It is important however to understand that the specifications as set out in this section will greatly affect the energy efficiency and costs of a building.

To successfully instruct the design team regarding the indoor environment one must understand that thermal comfort conditions depend on several factors, including air temperature, relative humidity, air movement and the temperature of surrounding surfaces. Therefore, several methods for maintaining thermal comfort are possible, and these have to be agreed to during the design phase. One should always aim for the lowest energy options first (natural ventilation) before considering HVAC and other mechanical systems. These specifications should always consider the types of activities for which the space and building is intended.

With regards to energy efficiency, it is important that the specifications are appropriate to the actual needs of the building. An unduly restrictive specification may result in higher capital and recurrent cost as well as increased energy consumption. From an energy efficiency and air quality perspective, natural ventilation is usually the best choice. Natural ventilation should be considered in all spaces without special indoor environment constraints. However the feasibility of natural ventilation depends heavily on the climatic conditions, building functions and building location. **It must also be understood that only meeting the requirements of the SNI codes will not necessarily result in an energy efficient building.** In most cases it will yield the most benefit for developers if they strive towards international best practices when specifying design criteria.

Dry bulb	25.5 oC ± 1.5 oC (1)
Relative humidity	60 % ± 5 % (1)
Minimum ventilation rate	
Office	0.15 m3/min/person (2)
Hotel	0.21 m3/min/person (2)

1) SNI 6390_2011
2) SNI 03_6572_2001

Table 3. Indoor Environment Recommendation by SNI

The specifications may also indicate the period of time for which they could be exceeded. For example, HVAC system design could allow for a total of one week where the temperature exceeds the comfort zone, since this will not cause significant problems for the occupants but would allow using a smaller capacity HVAC system compared to designing the HVAC system to never exceed the comfort zone. This will bring savings in both energy consumption, and capital and recurrent costs. Requirements for air quality should also be considered, as these will affect the need for ventilation. Again, unnecessarily demanding specifications will lead to increased costs and energy consumption.

Natural ventilation should be considered in all spaces without special indoor environment constraints. However the feasibility of natural ventilation depends heavily on the climatic conditions, building functions and building location.

3.3.3 Lighting requirements

Lighting requirements should be specified and elaborated on in the design brief along with some indications of the approach to be taken in the design of lighting.

Lighting levels in different areas or rooms should conform to the intended use of these spaces. See Part 2 Section 8.1, Electrical Lighting. Artificial and daylighting should relate to specifications for lighting levels for different activities, as well as refer to standards and codes that provide more detailed information.

Office, work room	350 lux
Hotel, bedroom	150 lux
Educational faciliies, drawing room	750 lux
Industry, warehouse	100 lux
Mall, clothes shop	500 lux

SNI_6197_2011

Table 4. Indoor Lighting Recommendation by SNI

Table 5 can be used to consider the type of lighting that will be used by wattage, lumens, life time and the initial cost.

	Incandescent	Linear fluorescent	Compact fluorescent	LED	Mercury	Metal Halide	High Pressure sodium	Low Pressure sodium
Wattage	25-150	18-95	13-26	2-10	50-1000	70-1500	35-1000	18-180
Output (Lumens)	210-2700	1000-7500	1000-3200	200-1000	1000-45000	7000-150000	2000-140000	1800-40000
Efficiency (lm/watt)	8-18	5-79	75-81	40-60	30-35	60-95	60-125	80-180
Lumen Maintenance	90% (85%)	85% (80%)			85% (80%)	75% (65%)	90% (70%)	100% (100%)
Lamp Life	750-2000	10000-20000	10000	35000-50000	18000-24000	10000-20000	18000-24000	16000
CRI	80-95	30-90	30-90	40-90	30-80	80-90	20-39	<20

Table 5. Characteristics of Different Types of Lamps Available in the Market

***Wattage** and **Output** refers to the common available lamp rating for outdoor lightins.*
***Efficiency** refers to luminous efficiency taken at 50% mean lifetime and at end of lifetime (parenthesis).*
***Lamp Life** refers to the approximate mean lifetime of a lamp.*

Lifecycle cost analysis performed at the initial design stage most effectively allows for opportunities to refine the design to ensure a reduction in overall lifecycle costs

Again it must also be understood that only meeting the requirements of the SNI codes will not necessarily result in efficiency.

3.3.4 Aesthetic considerations

The greatest challenges in improving energy efficiency in public and commercial buildings is to develop an architecture that is both aesthetically satisfying and meets the technical requirements determined by the local climate and available material options.

It is important to set clear objectives regarding how the building should look, and to understand the implications on energy performance, initial cost and lifecycle cost on the overall aesthetics of a project. It is further important for a developer to set the priorities of importance for the different aspects in the design brief.

3.4 Opportunities and Constraints

3.4.1 Site

If the client already has a site for the project an assessment should be made of the opportunities and constraints of the site that are relevant to the project and energy efficiency. These are discussed in more detail in Part 2 Section 5 - Passive Solar Design Principles. These considerations will include the orientation of the site in relation to the sunpath and typical wind directions, shading features such as trees, hills, other buildings, and other factors affecting the local climate such as prevailing wind, etc.

If the client does not have a site yet it would be advisable for him to involve his design team in setting the criteria for choosing a site as the site could have a fundamental influence on the overall design and energy efficiency potential of a project.

3.4.2 Climate

The energy performance of a building is largely determined by how well the design is adapted to the local climate. It is therefore important that the developer and the design team have a clear understanding of the local climate, its daily and seasonal variations, and its influence on the energy efficiency potential of the design.

Indonesia has a tropical climate characterized by heavy rainfall, high humidity, high temperature, and low winds. The wet season is from November to March, the dry season from April to October. Rainfall in lowland areas averages 180–320 cm (70–125 in) annually, increasing with elevation to an average of 610 cm (240 in) in some mountain areas. In the lowlands of Sumatra and Kalimantan, the rainfall range is 305–370 cm (120–145 in); the amount lessens southward, closer to the northwest Australian desert. Average humidity is 82%.

Further details are included in Part 2, Section 3 - Indonesian Climate.

3.4.3 Budget

Opportunities and constraints regarding the financing of the project should be considered at this stage. Possible trade-offs between initial cost and lifecycle costs may affect the way the project is financed. It is important that the developer sets out the budgetary constraints as well as the order of importance of elements that should be included in the design within the existing budget.

Life-cycle cost analysis performed at the initial design stage most effectively allows for opportunities to refine the design to ensure a reduction in overall lifecycle costs. See Part 1 Section 5 - Life-Cycle Cost Analysis.

Energy costs can be difficult to predict accurately in the design phase. Assumptions have to be made about the user profiles and occupancy rates, which impact energy consumption. Data on the amount of energy consumption for a building can however be obtained from engineering analysis or from energy efficiency software programs.

3.4.4 Time

The amount of time available for the design process needs to be established along with determining the specific time related requirements of the project.

Detailed analyses of different approaches towards energy efficiency take time to conduct. The costs, both in consultant fees and project timing need to be considered and evaluated in relation to the opportunity to achieve a more cost-effective and better quality project. As part of the design brief the developer can set certain timeframes that will have to be met by the design and construction team. It is advisable to involve the different steakholders in this process to insure that the timeframes are relevant and

achievable. Unrealistic timeframes can severly affect the project budget as well as quality.

3.4.5 Availability of materials / technology

To produce an energy efficient building, the materials should be selected taking into consideration specifications such as performance, price, availability, aesthetics and sustainability.

As part of the design brief the developer should clearly indicate the quality of the development and associated construction materials. This could be a general statement about the intent regarding the development quality. It could also go further and indicate the desire of the developer to use only local materials or materials sourced from a specific area.

It is important for designers to ensure that the materials used for the project meet with the client's requirements. The selection of material suppliers is based on detailed information about the performance of their products.

Material Safety Data Sheets (MSDS) are a useful tool for eliminating building materials that may be hazardous to the environment and subsequently endorsing products that are environmentally prefereable.

3.5 Performance Targets

3.5.1 Financial

Building construction is costly and a long-term investment. The owner has a target as to when the investment might yield returns and has an estimated cash flow of the project.

The first step is to establish financial targets which include detailed expenditure and revenue plans. These should be closely linked to the project timeframes. Only then can one estimate and incorporate the changes in cost that will occur during the design and construction stages. Financial performance targets should be categorized into capital costs, expenses, and income. This method is useful for developing a lifecycle cost performance model.

3.5.2 Energy

Energy cost is an important element in the financial performance of a building. Setting realistic and achievable energy performance targets could greatly improve the energy efficiency of a building during operation. In addition to this, an estimate of energy consumption should be prepared as carefully as possible by considering the energy unit tariff set by the government. These Guidelines assumes electricity as the main energy source in buildings.

The adjusted unit cost of the electricity tariff is set by PLN and is divided into two classifications; business and industrial.

Numbers for specific energy consumption (energy consumption per unit area) as indicated in the Figure 3 may be used for comparison. The Directorate General of New Energy, Renewable Energy and Conservation strives to continiously update and develop such benchmarks for Indonesia.

3.5.3 Environmental performance targets

In the early stages of building design, objectives and targets for environmental performance should be established and agreed upon in advance by the building stakeholders along with the consultant.

The objective of environmental performance is to improve the environmental sustainability of the building through reducing the building's greenhouse gas emissions, minimizing the volume of potable water being consumed and minimizing the use of resources and waste.

Issues such as legal requirements, the availability of technology, and financial constraints/ opportunities should be taken into account for each environmental aspect.

3.5.4 Maintenance and lifecycle performance

The objective of building maintenance is to preserve not only the physical condition of the building but also the performance of its systems so they continue to function effectively throughout their lifecycle. Generally there is a strong correlation between effective maintenance and energy efficiency, as poor maintenance tends to result in lower efficiency, and hence a higher cost in relation to performance and operations.

To effectively manage a building over its lifetime it is important to include in the design opportunities for equipment monitoring for all of the different performance criteria. This should include meters for electricity and water usage, but could also include temperature, humidity

To produce an energy efficient building, the materials should be selected taking into consideration specifications such as equipment performance, price, availability, aesthetics and sustainability.

The GREENSHIP rating system is an Indonesian rating tool used in the building industry by entrepreneurs, engineers, and other stakeholders to implement best practices and achieve measurable standards that can be understood by the general public, especially the tenants and building users.

and CO_2 monitors. The use of an integrated Building Mangement system is highly advised to insure that the performance of the integrated building systems are easily managed from a central system.

3.6 Environmental Rating Schemes

A green building rating tool sets standards and benchmarks for green buildings, and enables an objective assessment to be made as to how "green" a building is. The rating system sets out a "menu" of all the measures that can be incorporated into a building to make it green. Upon assessment of a building, design points are awarded according to the sustainability measures that have been incorporated into the design. After appropriate weighting, a total score is arrived at, which determines the final rating of the building or design. In most cases green building rating tools have certifications for designs as well as completed buildings.

It is important for developers wanting to do energy efficient buildings to consider these tools since, on average, around a third of these rating tools' assessments are based on the energy performance of the building.

Well known rating tools include BREEAM (Building Research Establishment Environmental Assessment Method), LEED (Leadership in Energy and Environmental Design) and Green Star.

The BREEAM rating system is from the United Kingdom and consists of 9 categories, namely: management; energy use; health and well-being; pollution; transport; land use; ecology; materials; and water.

The Leadership in Energy and Environmental Design (LEED) program of the U.S. Green Building Council is a rating system for buildings that assesses energy and environmental performance. LEED addresses 6 categories, namely: sustainable sites; water efficiency; energy and atmosphere; materials and resources; indoor environmental quality; and innovation in design. The LEED Green Building Rating Systems are consensus-based, market-driven programs that are intended to be voluntary.

Green Star is a voluntary environmental rating system for buildings in Australia divided into nine categories, namely: management; indoor environment quality; energy; transport; water; materials; land use and ecology; emissions; and innovation.

The GREENSHIP rating system is an Indonesian rating tool used in the building industry by entrepreneurs, engineers, and other stakeholders to implement best practices and achieve measurable standards that can be understood by the general public, especially the tenants and building users. GREENSHIP assessment standards cover the areas of planning, construction, operation and daily maintenance. Assessment criteria are grouped into six categories, namely:

1. ASD - Appropriate site development (Tepat Guna Lahan)
2. EEC - Energy efficiency and conservation (Efisiensi dan Konservasi Energi)
3. WAC - Water conservation (Konservasi Air)
4. MRC - Material resources and cycling (Sumber dan Siklus Material)
5. IHC - Indoor air health and comfort (Kualitas Udara dan Kenyamanan Ruangan)
6. BEM - Building and environment management (Manajemen Lingkungan Bangunan).

3.7 Design Approach

3.7.1 Procurement strategy

There are a number of procurement strategies that can be used to appoint a professional team and contractors for a building project. These can have implications for the energy performance of the building, which are discussed in more detail in Part 2 Section 9.2 - Construction Process.

The most appropriate approach for a particular project should be determined based on the priorities and resources of the owner.

3.7.2 Integrated design approach

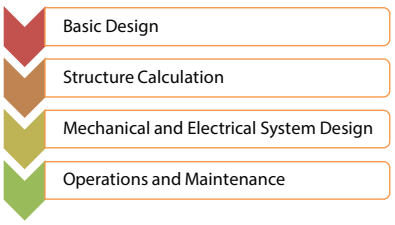

Figure 8. Conventional Design Approach

In contrast to an Integrated Design Process, conventional design can be understood as a linear process. The drawback of this traditional approach is that sequential work routines

may be unable to support adequate design optimizing efforts during individual decoupled design exercises.

For example, typically the architect and the client agree on a design concept consisting of a general massing scheme, orientation, fenestration and (usually) the general exterior appearance, and basic materials, at which point the the mechanical and electrical engineers are asked to implement the design and to suggest appropriate building systems. This generally results in the engineers having to retrofit technology to make the existing design work.

The integrated design approach emphasizes the integration and iteration of design concepts early in the process by involving a full, coordinated team of specialists. The result is that participants contribute their ideas and their technical knowledge very early and collectively. It is important that in the early design phases all the concepts and design issues are worked out together. In this approach, the concepts of energy and building equipment are not designed as a complement to the architectural design but as an integral part of the building from the start.

An integrated design approach ensures that different fields of expertise, including mechanical and electrical engineering, are introduced and integrated at the initial project stage and takes into account a wide variety of opportunities and options from the very beginning of the design process.

Typically, energy efficiency has not been a key consideration in building design, and as a result, the added requirement of ensuring that the different design aspects work together to achieve optimum energy efficiency has tended to be overlooked.

By deliberately adopting an integrated approach to energy efficient design, the design team can be encouraged to take advantage of opportunities to achieve improved energy performance.

It is helpful therefore to have a systematic approach to the coordination of these approaches, and the Design Brief is a good opportunity for providing this. It is suggested that a framework for the desired process is included in the Design Brief at the project inception stage, and that the consultants amend and update this as the design develops. For a full detail discussion please see Part 1 Section 4 "Integrated Design Process".

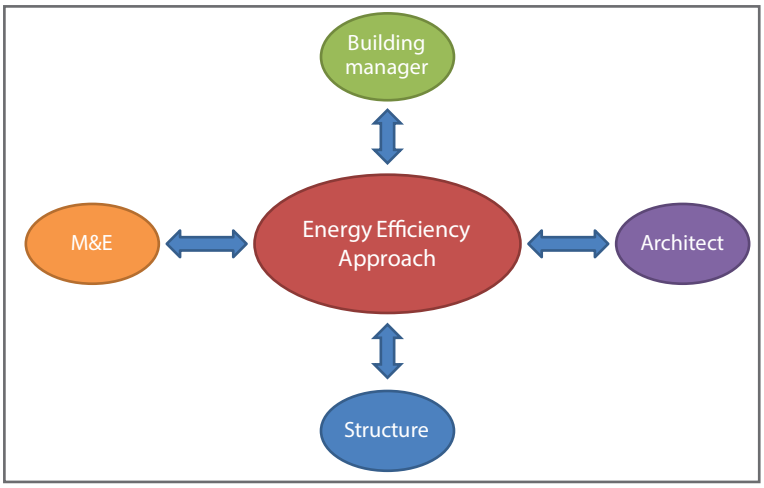

Figure 9. Integrated Design Approach

3.7.3 Planning and landscape design

There are a lot of opportunities for the enhancement of a building's energy efficiency that are determined by the project site. These opportunities can be unlocked by understanding the opportunities and constraints of a site and incorporating them into the design.

In addition to the siting and orientation of a building, the type, form, and the designation of the building such as office building, hotel, hospital or mall will determine the type of air conditioning system. To achieve comfortable thermal conditions, most buildings in Indonesia use a thermal or mechanical cooling system.

The overall shape of the building is important in achieving energy efficiency. It has been found that the walls perform an important role in removing heat from a building, suggesting that a high surface area to volume ratio is useful. This also allows for maximum use of daylight, reducing the energy needed for lighting, and indirectly helping to keep the building cool since artificial lighting also generates heat.

Environmental conditions around buildings such as landscaping and the number of trees can reduce the temperature immediately surrounding the building as they reflect sunlight and provide shade around its base. Adjacent buildings that cast shadows can also help improve building energy performance.

The integrated design approach emphasizes the integration and iteration of design concepts early in the process by involving a full, coordinated team of specialists.

3.7.4 Envelope and structural design

The materials of a building's construction, such as walls, floor, ceiling, windows and roof have a significant role in the thermal performance of the building. The heat and moisture behavior of the building envelope is an important aspect in the overall performance of a building.

Energy codes and standards for buildings typically specify the performance requirements for the building envelope in terms of an 'Overall Thermal Transfer Value' (OTTV) to indicate the amount of heat that flows between the building and the surrounding environment. In some cases, the standard defines the requirements for the thermal properties of different building elements.

Efficient design strategies, power distribution systems and electrical equipment can increase the energy efficiency of a building and reduce energy consumption and associated costs.

A building envelope has an OTTV and Roof Thermal Transfer Value (RTTV). To reduce energy consumption, Indonesia National Standardization Agency has established a standard value of OTTV. OTTV can be calculated either manually or using software by combining the OTTV on each side of the building.

It is important to define the intended performance of the building envelope and to set minimum and maximum standards for this aspect. It must again be understood that only meeting the requirements of the SNI codes will not necessarily result in an energy efficient building. It is recommended that developers target international best practice when specifying the desired performance and design criteria.

3.7.5 Lighting and electrical design

Daylighting can be provided through an opening in the wall, roof or ceiling via transparent or translucent panels such as windows, glazed doors, skylights or other sources. These glazed apertures are referred to as fenestration.

The need for electrical lighting, especially during daytime, will depend on the size and placement of a building's windows, the building's location and orientation, combined with the use of each particular space. The first priority in any design should be to maximise the use of natural daylight before electrical lights are used.The need for electrical lighting and the associated energy consumption can also be reduced by the use of automatic controls such as automatic louvres, daylight sensors, day-night switches, etc. The use and success of these depend on the orientation of the spaces and windows, the availability of daylight and the use and occupancy of the room.

Efficient electric lighting systems also reduce internal heat gain, which can save air conditioning energy consumption, increase the potential for natural ventilation, and improve thermal comfort. To achieve energy savings in daylit spaces, electric lighting must be integrated with the daylighting.

The specification of certain lighting technologies can have a huge effect on energy efficiency and should be considered carefully. Efficient design strategies, power distribution systems and electrical equipment can increase the energy efficiency of a building and reduce energy consumption and associated costs.

3.7.6 HVAC design

Air conditioning (AC) systems are intended to provide adequate cooling comfort, dehumidification, and ventilation to an occupied space. AC sizing, together with zoning and system layout, is an important aspect of AC design. AC sizing is a complex issue that needs to be approached systematically. Appropriate size depends on many factors, including climate, building configuration, space usage, system zoning and layout. Many factors can lead to oversizing an air conditioning system and its components. When this is done, it is a significant contributor to higher energy use.

The cooling load calculation is usually set for the hottest design day. The calculated results provide no more than the peak load during a 24-hour profile. While the design cooling load is adequate to determine the total cooling capacity of the AC equipment, optimal selection of AC equipment may need an annual cooling load profile, which can help decide the number and size of chillers that should be selected to achieve the most energy efficient operation.

3.7.7 Computer simulation program

Computer simulation programs are a powerful tool for energy efficienct building design. The use of a computer simulation program can be:

- For existing buildings to understand their energy performance and how to improve it.
- For new buildings at the design stage: to find the best possible designs that

explore all possible potentials for creating a sustainable building (low energy).

Selection using computer simulation programs will, compared to more traditional design approaches, result in:

1. Relatively lower labor costs (for a computer operator and a result analyst)
2. Relatively lower tool costs (for software and computer)
3. Faster calculation (such as to simulate partial load profile, to simulate configuration of chiller capacity)
4. Easier to modify / manipulate the design.
5. Safer (no hazardous materials involved)
6. Less space required (need only a space for working with a laptop)
7. No scale dependencies (model can be made full-scale)
8. No weather dependent (except weather files)

The Figures 10, 11, 12 and 13 are examples of the output of computer simulation programs.

Figure 10 shows the possibility to determine the wind velocity and direction sorrounding the new building.

Figures 11 and 12 show daily average solar radiation and heat gains that will be used for estimating the cooling load of the building.

Figure 13 on the next page is an example of the needs of lighting exposure.

3.8 Operations and Maintenance (O&M)

The objective of O&M is to plan, design, operate, maintain, and improve the facilities to provide reliable, safe, healthy, energy efficient, and effective performance of the facilities to meet their designated purpose throughout their lifecycle.

During the planning and design phases, O&M personnel should be involved and be able to identify maintenance requirements for inclusion in the design, such as equipment access, built-in condition monitoring, sensor connections, and so forth.

The overall approach to O&M should be specified in the Design Brief, to influence decisions taken in the design process.

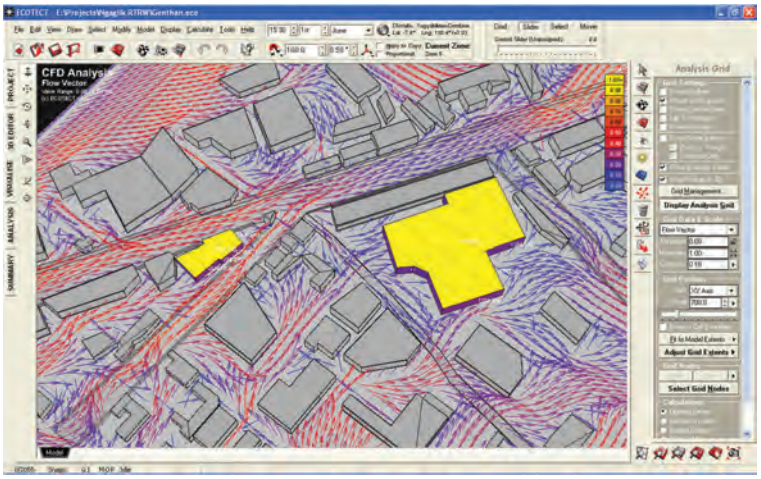

Figure 10. Urban ventilation and solar radiation

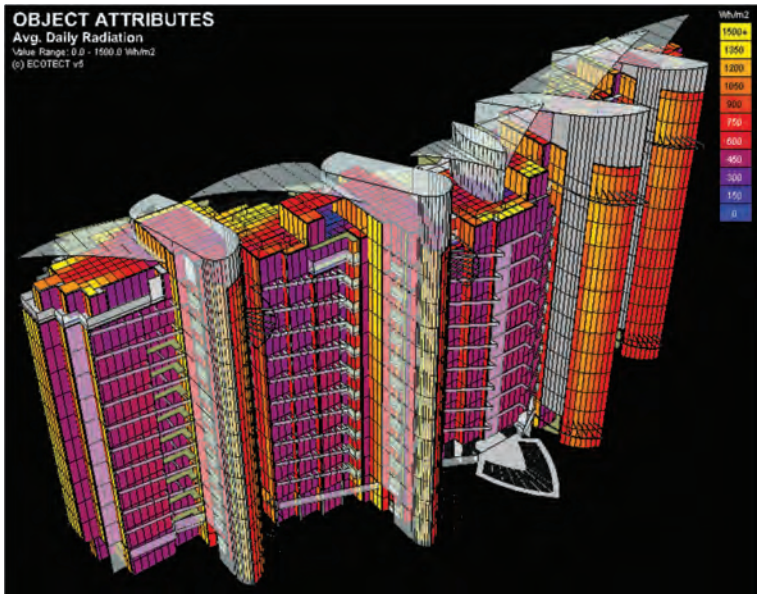

Figure 11. Solar exposure - Simulation results

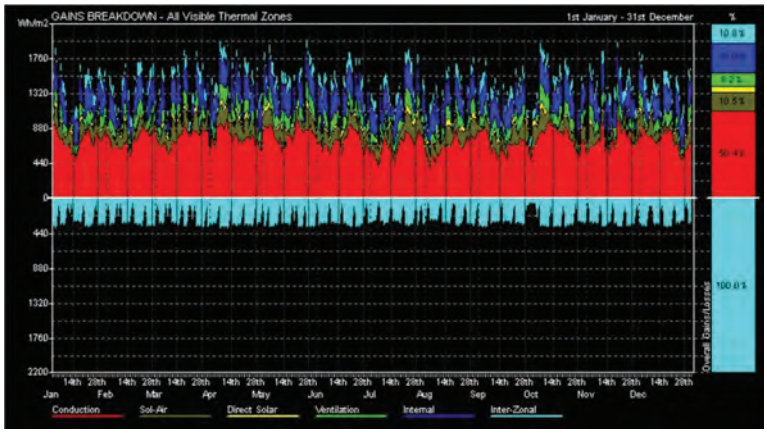

Figure 12. Heat gains breakdown

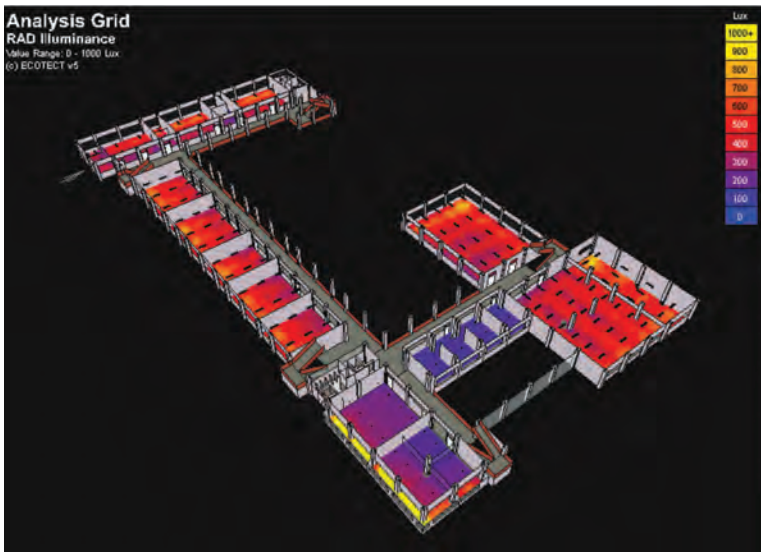

Figure 13. Lighting exposure

The Design Brief should specify the requirement for the design team to prepare a draft Operations and Maintenance Manual as one of their tasks. This should be developed as an ongoing process during the design, to ensure that the O&M requirements are given consideration. The draft O&M Manual will then be revised and finalized during and following the commissioning of the building.

3.9 Resource Materials

1. Agas Aroth; Energy Efficiency Building Design Guidelines for Botswana. Danish Energy Management A/S and Government of Botswana. Botswana, 2007.
2. SNI (Indonesia National Standardization Agency) 03-6572-2001 Tata cara perancangan sistem ventilasi dan pengkondisian udara pada bangunan gedung.
3. SNI (Indonesia National Standardization Agency) 6389:2011: Konservasi energi selubung bangunan pada bangunan gedung.
4. International Energy Agency: Task 23 Integrated Design Process. Germany, 2003.
5. International Energy Agency: Energy Efficiency Requirements In Building Codes, Energy Efficiency Policies For New Buildings, OECD/IEA. France, 2008.
6. Hawaii commercial building guidelines for energy efficiency. Hawaii, USA. 2004.



4. Integrated Design Process (IDP)

4.1 Definition of the Integrated Design Process

The Integrated Design Process is a "new" design approach that is distinguished from the "old" way of conventional, or linear design. The integrated design process views the building and its surroundings as a whole entity, comprised of different systems interacting with each other to achieve optimum performance in every respect. It is essentially a holistic approach to the design, construction, operation and decommissioning of a building.

The integrated design process requires collaboration among key stakeholders and design professionals from conception to completion. This collaborative approach enables cross-disciplinary decision-making relative to building orientation, configuration, building envelope and the overall systems.

Interdisciplanary communication is paramount and must start as early in the design process as possible. The earlier the integration of systems and the energy efficiency planning begins, the less costly the project will be and the more likely it is that the project will meet its goals.

4.2 The Benefits of IDP

IDP fosters an understanding of the building as a set of interrelated, interdependent systems wherein a single solution can trigger improvements in several other building systems simultaneously.

Integrated Design Process	Conventional Design Process
Inclusive from the outset	involves team members only when essential
Front-loaded - time and energy invested early	Less time, energy, and collaboration exhibited in early stages
Decisions influenced by broad team	More decisions made by fewer people
Holistic iterative process	Sequential process
Whole-systems thinking	System often considered in isolation
Allows for full optimization	Limited to constrained optimization
Seeks synergies	Diminished opportunity for synergies
Lyfe-cycle costing	Emphasis on up-front costs
Process continues through post occupancy	Typically finished when construction is complete

Table 6. Comparison of Integrated and Conventional Design Processes

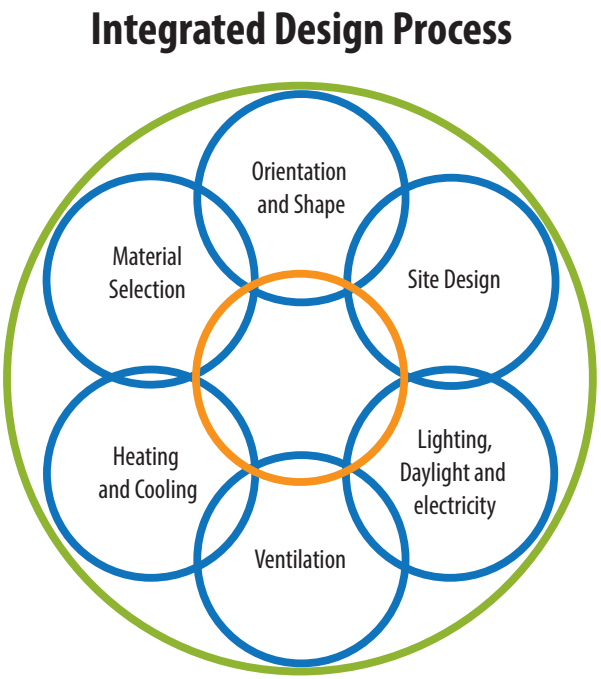

Figure 14. Energy Efficiency Design through IDP

At the outset of this integrated approach during the initial design stage, specific goals (that can be measured and validated) are agreed and set between the different design disciplines. Before any designs are attempted or concepts developed, interdisciplinary design strategies are developed that are designed to meet these goals. This results in a design process where all aspects of a building are optimised for best performance during the design process, as well as having a set of parameters against which the design can be measured throughout the lifecycle of the building.

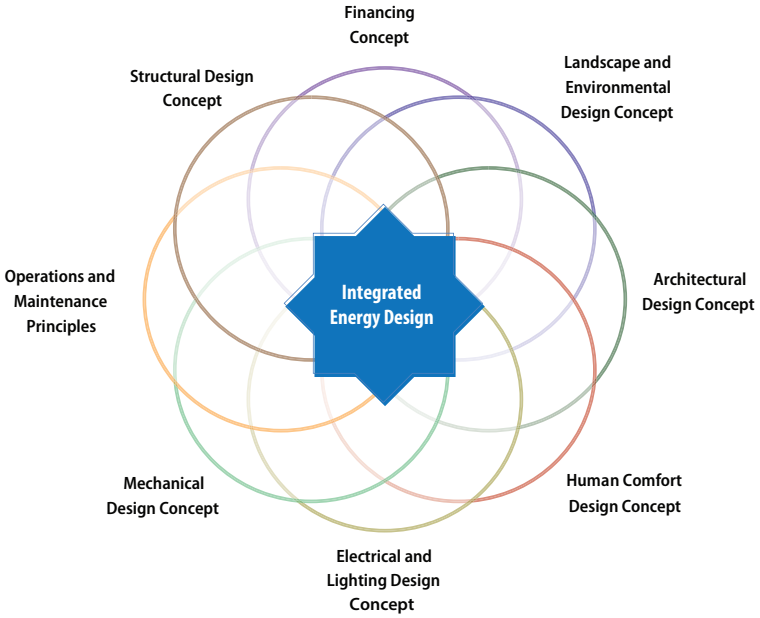

Figure 15. Energy Efficiency Design through IDP

If this process is properly implemented it will harness synergies that will result in improved performance of the buildings.

4.3 Persons Involved in IDP

IDP directly affects building owners and building managers, major tenants, building occupants and the entire design and construction team.

It is important that as many members of the entire design team as possible are involved with the IDP from the onset of the project. Design and construction professionals such as architects, structural, mechanical and electrical engineers, interior designers, landscape architects, lighting designers, energy consultants, façade specialists, project managers, and general and specialist contractors all have an influence on the energy efficiency of a building. As a minimum the main building design disciplines should be involved from day one (Architects, Mechanical, Electrical, Civil and Structural Engineers).

4.4 How IDP is Different

The conventional way of design follows a linear process: project design, construction plan, bidding process, construction, commissioning, handover and operations.

In this approach, the architect develops an overall design concept, the engineers take the concept, work it out and ensure that it is structurally feasible. Then the HVAC, lighting and other services system are designed and fit into the building as efficiently as possible.

In this process all the specialists usually work in isolation, each focusing on their separate area of project expertise and interacting ONLY when absolutely needed.

An Integrated Design Process is a collaborative and reiterative approach that follows these steps:

- Define the specific goals of the building,
- Set attainable goals,
- Meet with ALL team members,
- Communicate the plans and goals,
- Select appropriate technologies and approaches, (design concepts)
- Design the project with ALL goals in

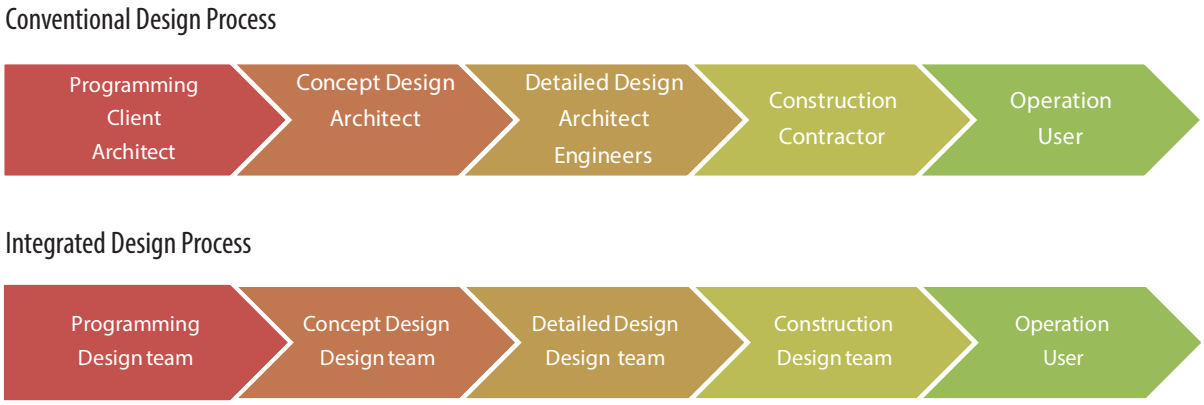

Figure 16. Conventional Design Process and Integrated Design Process

mind, (collaborative team approach)
- Construction plans,
- Bidding process,
- Construction,
- Commissioning and handover.
- Building maintenance

This process improves the overall design because:

- There is no "proceed without questioning our assumptions", thus there are no opportunities.
- There is an understanding of interdis-ciplinary linkages, thereby creating more opportunities.
- There is a shared vision and common purpose.
- There is a great possibility that this will save time, effort and initial construction costs.

In Figure 16 can be appreciated the 4 major stages among 5 stages of the design process that clearly define the differences between IDP and conventional design approaches. These encompass the responsibilities of each party at every stage, interactions with others, equipment selection and energy saving possibilities. Iterations of the design process within each stage and between stages can also be highlighted.

It must also be understood that there is a direct correlation between the opportunities for implementing an energy efficiency strategy, the effort to implement the strategy, the cost involved in implementing the strategy, and where the design team is in the process as shown in Figure 17.

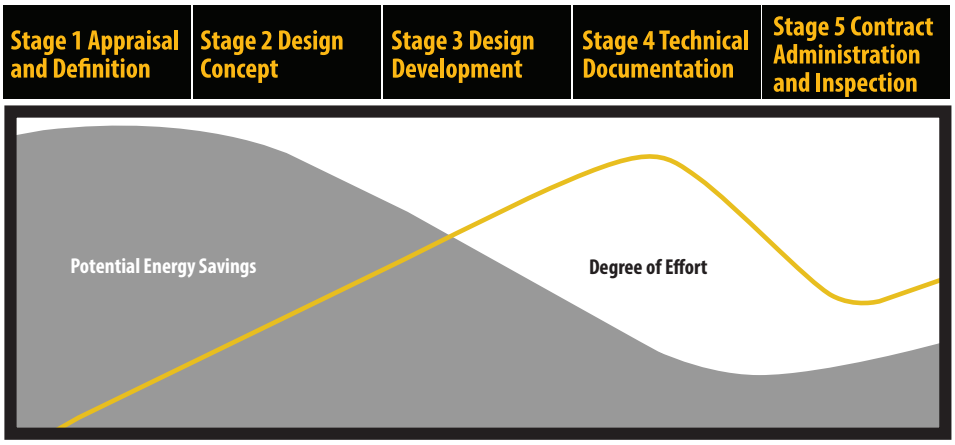

Figure 17. Potential Energy Savings in Every Stage



5. Life-Cycle Cost Analysis

5.1 Overview

Life-Cycle Cost Analysis (LCCA) is essentially a design process for controlling the initial and future costs of property ownership. LCCA can be implemented at any level of the design process and can also be an effective tool for evaluating existing building systems. LCCA can be used to evaluate the cost of a full range of projects, from an entire site complex to a specific building system component.

The importance of energy efficiency as a component of the life-cycle cost of a building is clear when the energy cost of a building is calculated using life-cycle cost analysis principles. There are two ways to indicate the benefit-to-cost ratio of energy savings:

- One is the ratio of the total value of British thermal units (BTUs) or kilowatt hours (kWh) saved during the lifetime of the system compared to the total system cost (initial cost, operating, maintenance and repair; and replacement cost).
- The other way uses the value of yearly net energy savings (i.e. the difference between the energy saved and the energy used for operation and maintenance) divided by the annual levelized cost of the capital equipment.

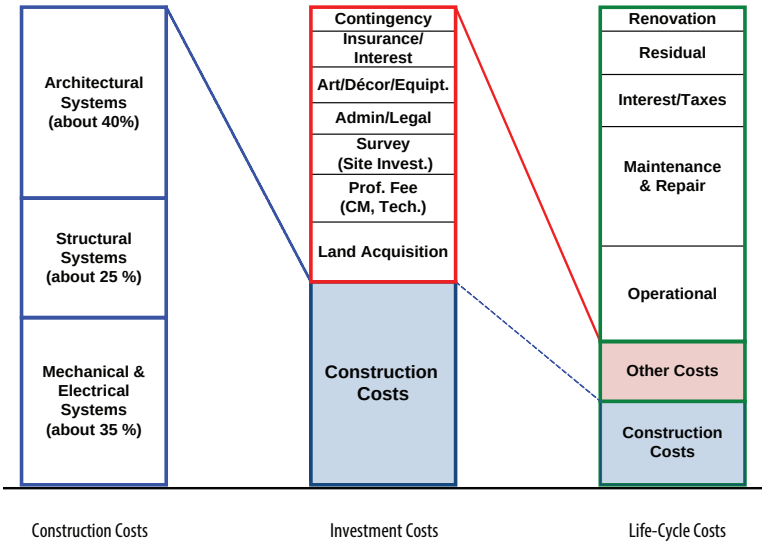

Figure 18. LCCA for Buildings

Singapore has been promoting Green Building designs since 1993. There are now more than 1000 certified Greenmark buildings in Singapore.

5.2 Benefits and Uses of Life-Cycle Cost Analysis

The main benefit of life-cycle cost analysis is that it can be used to understand the economic impact of an up-front building design decision over the entire life of a building. That is, what the implementation of a decision now will cost the building owner over the 30 years of the building's operation. Usage of life-cycle cost analyses has been widely implemented in the construction industry and in product manufacturing.

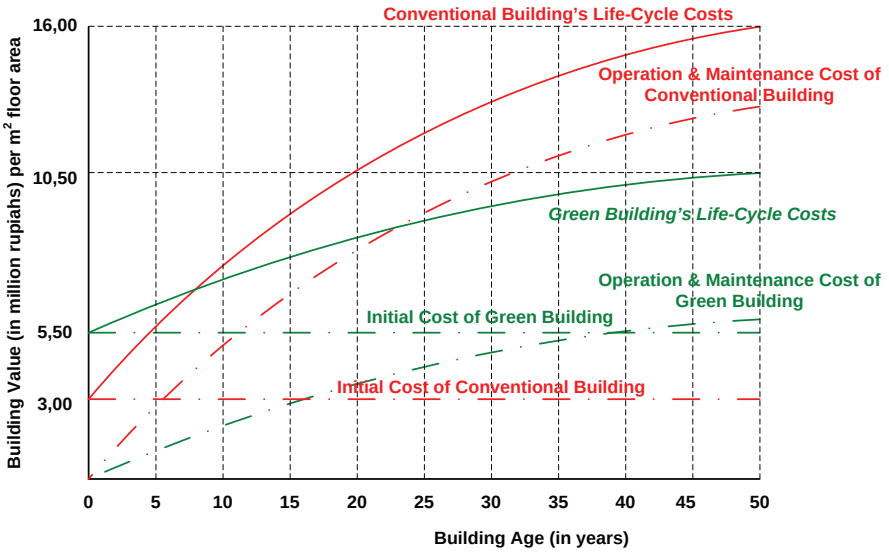

Figure 19. The Comparison of Conventional and Green Building Life Cycle Costs

Figure 19 shows the comparison between a conventional building and a green building which incorporated energy efficiency as one of its considerations over the life-cycle of the building.

5.3 Elements of Life-Cycle Cost Analysis

The most important elements in life-cycle cost analysis are choosing materials or equipment that have better quality, durability, and operating efficiency while needing lower maintenance. This equipment might be more expensive in terms of initial cost, however the use of these materials and equipment will produce long-term efficiency in operations and maintenance. LCCA is thus used to weigh the long-term impact of different design options, by comparing their cost over the entire life-cycle of the building.

5.3.1 Initial costs

The first step in the completion of a LCCA is to define all of the initial investment costs of the project. Initial investment cost is a cost that will be incurred prior to the occupation of the facility. All initial costs are to be added to the LCCA total at their full value and include:

1. Construction management
2. Land Acquisition
3. Site Investigation
4. Construction
5. Equipment
6. Technology
7. Administration
8. Art/Decoration

5.3.2 Future costs

1) Operational Costs (annual costs)

The second step in the completion of the LCCA is to define all of the future operational costs of the project. The operational costs are annual costs, excluding maintenance and repair costs, required to operate the facility. Most of these costs are related to building utilities and custodial services. All operational costs are to be discounted to their present value prior to addition to the LCCA total.

Operational costs that are not directly related to the building should be excluded from the LCCA, such as the cost of office materials. While this is an annual operating expense, it has nothing to do with the operation of the building and is rather a function of the building user.

2) Maintenance and Repair Cost (scheduled and unscheduled upkeep costs)

Maintenance costs are scheduled costs associated with the upkeep of the facility. An example of a maintenance cost is the cost of an annual roof inspection and caulking of the building's roof penetrations. This task is a scheduled activity that is intended to keep the building in good condition.

The most important elements in life-cycle cost analysis are choosing materials or equipment that have better quality, durability, and operating efficiency while needing lower maintenance.

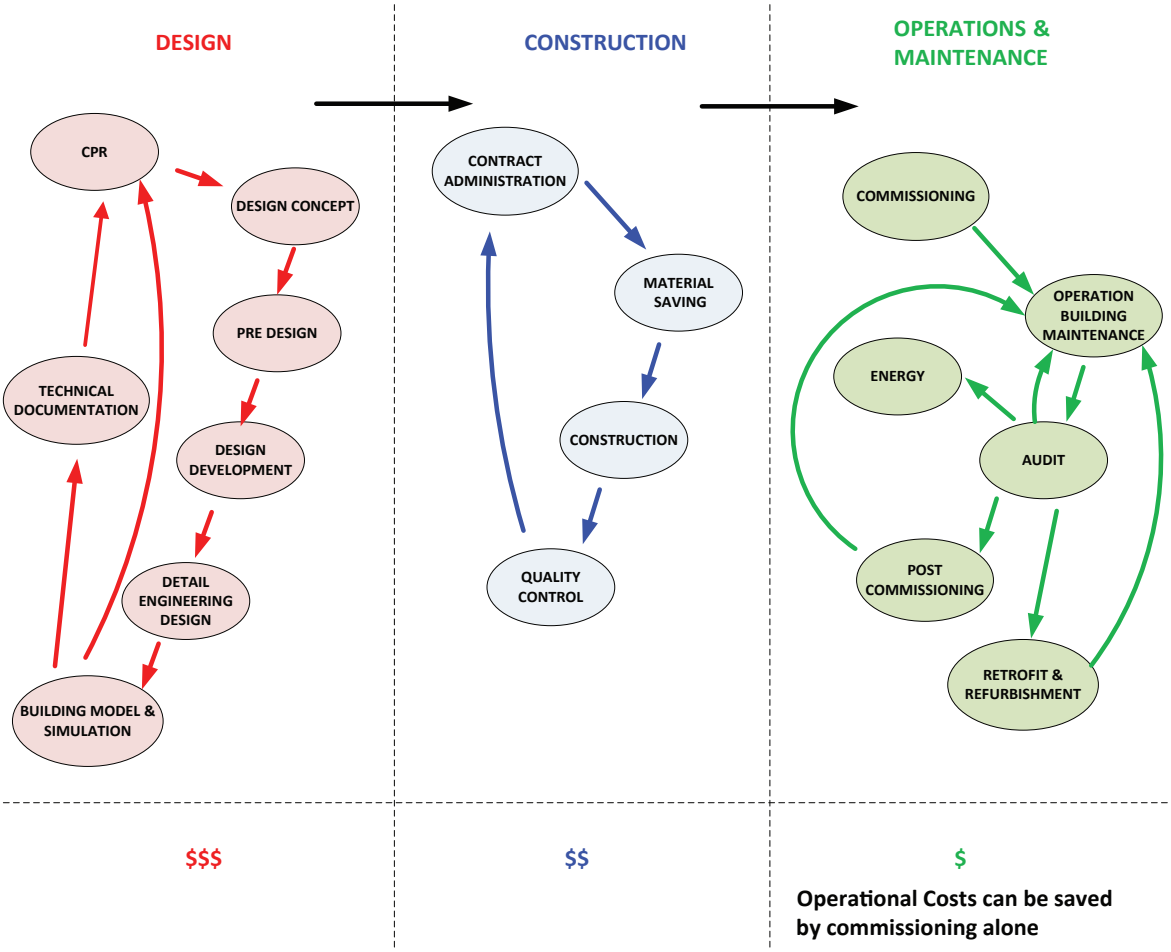

Figure 20. Energy Saving Phases based on the experience of the panel of experts of this guidelines on building construction.

Repair costs are unanticipated expenditures needed to prolong the life of a building system without replacing the system. An example is the repair of a broken window. This is an unscheduled event that does not entail replacement of the entire window unit, merely the replacement of the broken pane.

Some maintenance costs are incurred annually and others less frequently. Repair costs are by definition unforeseen so it is impossible to predict when they will occur. For simplicity, maintenance and repair costs should be treated as annual costs. All maintenance and repair costs are to be discounted to their present value prior to addition to the LCCA total.

It is important to note that all options are not created equal. At first glance, maintenance and repair costs could be judged to be equal for all alternatives. However, it must be asked if it is possible that one alternative is more susceptible to damage than another.

Facility location, age of the building systems, and variations in the exterior envelope area are just a few factors that should be considered when estimating maintenance and repair costs for project alternatives. Credible explanations of evaluation assumptions should be included in the LCCA.

3) Replacement Cost (scheduled replacement of building system components)

The third step in the completion of the LCCA for a project alternative is to define all future replacement costs of the alternative. Replacement costs are anticipated expenditures to major building system components that are required to maintain the operation of a facility. All replacement costs are to be discounted to their present value prior to addition to the LCCA total.

Replacement costs are typically generated by replacement of a building system or component that has reached the end of its

useful life. An example of a replacement cost is the replacement of a boiler. A boiler has a life expectancy that is shorter than that of the facility it serves. At some point it will fail and require replacement to keep the facility operational.

4) Residual Value (value of facility at end of project period)

The fourth step in the completion of the LCCA of a project alternative is to define the residual value of the alternative. Residual value is the net worth of a building or building system at the end of the LCCA building period. This is the only cost category in a LCCA where a negative value, one that reduces cost, is acceptable.

The residual value of a facility or building system is especially important when evaluating project alternatives that have different life expectancies. An example is the evaluation of two roofing alternatives, a metal roof and a composition shingle roof.

The shingle roof has a life span of 20 years whereas the metal roof is expected to last 40 years. In a LCCA over a 30-year building period the shingle roof will have to be replaced, thus incurring replacement costs. The metal roof will not require replacement; thus no replacement costs will be incurred. The residual value of each option is to be calculated as follows:

Metal Roof Residual Value =
(Initial Cost) x (Age of Metal Roof/Metal Roof Life - 1)

Shingle Roof Residual Value =
(Initial Cost) x (Age of Shingle Roof/Shingle Roof Life - 1)

The residual value of a project alternative can be established in several different ways depending on the extent of details available. However, project solutions that opt for a new replacement facility in lieu of a renovation or addition to the existing facility should establish residual value on a building system basis.

The residual value of a facility or building system is especially important when evaluating project alternatives that have different life expectancies.

5.4 Cost vs. savings, as it relates to effort

To achieve these savings requires a three pronged approach, as shown in the Figure 21.

a. Reorganizing housekeeping: without any additional investment, changing the behaviour of staff and occupants could save about 5 – 10% of energy costs.

b. Modifying equipment: with minor investments such as key tags (in hotel) or thermal / movement and daylight sensors, could save about 7 – 15%.

c. Modifying processes: with a major investment in process and plant modification, such as a gas absorption chiller, ice bank storage or capacitor bank, could save about 15 – 30%.

Table 7, on the next 2 pages, presents the energy saving opportunities in several building components based on experience in the field.

The table is derived from the Technical Manual of the SNI - Energy Audit Procedures in Buildings (2000). This handbook has never been updated but is still considered relevant to the state of buildings, especially existing buildings. To this table has been added several items in connection with the development of more sophisticated technologies after the year 2000.

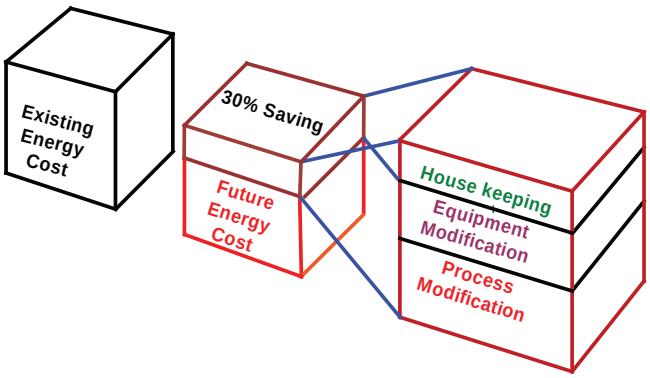

Figure 21. Energy Saving Phases. Source: Industrial Sector Energy Audit DJLEB, Jakarta 1986

Items		Average Saving
I. Electrical Systems		
1	Increase power factor	5.1
2	Reduce excessive transformer capacity	3.3
3	Install motors having the highest economical efficiency *)	0.1-0.5
II. Air Conditioning Systems		
4	Install Frictionless Chiller **	24.3
5	Install VAV Control	12.6
6	Install air intake exchange	12.0
7	Install high efficiency chiller	9.6
8	Maintain filter cleaner, AHU, cooling oil	7.2
9	Minimize air flow from outside	6.0
10	Install cooling thermal storage **)	0.5-5.0
11	Optimize more than one chiller	4.9
12	Increase condenser temperature	4.1
13	Replace oversize electric motor	3.8
14	Increase set-point up to 25°C	3.6
15	Re-assess building location to reduce cooling load	3.0
16	Modify air flow to condenser	2.8
17	Reduce working hour of AC	2.3
18	Install pump with variable speed	1.6
19	install smaller AC capacity for separate room	1.3
20	Install high efficiency pump	1.3

Items		Average Saving
III. Lighting System		
21	Reduce Lumen of lamp	5.1
22	Replace fluorescent lamps with high efficiency **)	05-5.0
23	Reduce working hours of lighting system	2.8
24	Eliminate excesive lighting**)	0.1
25	Substitute higher efficiency lamps in existing fixtures **)	0.1
IV. Modify Building Envelope		
26	Reduce ration between opening and wall	12.7
27	Install high efficiency glazing and supplemental glazing **)	05-5.0
28	Reduce the area of glazing and install thermal shutter **)	0.5-5.0
29	Install double glass in windows	2.1
30	Insulation, infiltration, roof absorber	0.8
V. Control and Use of Sunlight		
31	Install external shading devices appropriate for each exposure of the glazing **)	0.5-5.0
32	Install internal shading devices **)	0.5-5.0
33	Install skylight or ligh pipes	0.5-5.0
34	Apply paint, coating, or sheathing that minimizes absorption of sunlight	1.0-5.0
35	Install a system of light helves and shading. use light interior colors or mirrores surfaces	0.1
VI. Elevators/Lifts		
36	Reduce traffic one floor	0.2
37	Install hidraulic lift	0.10
38	Install regerator lift	0.12
39	Install VVVF technology	0.15

*) Reference: Steve Dotty; 2009
**) Reference: Paul Kistler, PE, CEM, 2009
***) Reference: Energy Efficient Elevators And Escalators; 2010

Table 7. Energy Savings Opportunities

By utilising this approach it is possible to better understand and create more certainty around the potential savings that are achievable in a project.

From Table 7, it can be seen that better energy efficiency can be achieved in most buildings by:

- Increasing the room temperature from 22°C to 25°C to reduce the cooling load.
- Operating a fan in AHU (Air Handling Unit) from 10 to 9,5 hours to save energy consumption.
- Replacing ordinary light bulbs with energy efficient ones to increase lumen and reduce energy consumption.
- Reducing air leaks to prevent loss of cooled air and the infiltration of hot air.

These actions could save about 3.2 – 14.1 % energy cost for a building.

Furthermore, using different types of air conditioning systems could impact energy cost (see Table 8). Compared to the conventional water-cooled refrigerant chiller used in most constructions, the following savings are achievable by replacing this system with different technology.

Type of Chiller	% Saving	Operation Cost (examples)
- Air cooled gas absorption chiller	38%	Rp. 23.864.040,
-Air cooled reciprocating chiller	50%	Rp. 31.315.200,
-Water cooled gas absorption chiller	74%	Rp. 46.190.400,-

Table 8. Saving Cost on Chiller

Most additional capital costs for existing buildings are usually caused by the requirement to provide an integrated building system which will meet and fulfill regulations, codes, and technical standards along with other requirements needed to achieve an energy efficient building.

The opportunites for energy savings, during the operational stages of the building is best realised by replacing or retrofitting conventional systems with integrated energy efficient building systems.

5.5 Conclusion

Using life-cycle analysis, property owners and developers have a chance to assess the benefits as well as the financial implications of fitting, replacing, retrofitting, and changing building materials, building components, and mechanical and electrical components for energy efficient solutions before any decisions are made. It also allows a fair comparison of the full financial impact of different systems over the entire lifetime of the building.

5.5.1 Summation

There are great benefits to property owners and developers that use the tools available to them, such as life-cycle cost analysis, to maximise the energy conservation opportunities that are available for their buildings.

These tools enable decision makers to make more informed and better decisions in building development. By utilising this approach it is possible to better understand and create more certainty around the potential savings that are achievable in a project.

It is clear that Indonesian standards, codes, and regulations are not keeping up with the fast development of building and energy efficiency requirements and technology. As a result some of these should be revised and renewed. Adopting international best practices could accelerate this process by filling the gap of technical requirements with regards to energy efficiency building standards.

5.5.2 International Energy Efficiency Trends

A lot of energy efficiency standards which have already been applied around the world can, with slight modification and arrangement, be implemented in Indonesia, especially the methods used for reducing carbon footprint.

New codes and regulations related to renewable energy could also become an important consideration in energy efficient and green building design.



6. Operations and Maintenance

6.1 Warning Signs of Inefficient Energy Use in Existing Buildings

A few warning signs that building managers and building owners can look out for are:

- Increase in electricity/energy usage and water usage in the building.
- Tenant complaints regarding uncomfortable temperatures and humidity, loud noise from air diffusers, (poor occupant comfort typically means inefficient air-conditioning, but it can also be caused by other factors such as higher thermal loads from the sun or equipment; than the AC was designed to cope with whereas loud noise from air diffusers may mean an inefficient air handling unit).
- For buildings using chillers, monitor the approach temperature on the condenser and evaporator side and look out for changes.
- Compare the actual energy consumption of the building against the design parameters or available standard data for similar building types.

These warning signs are easily tracked by measurements and the recording of electricity/energy usage, water usage, temperature and relative humidity. Tracking these simple parameters and tackling the issues early will be more cost efficient.

6.2 Understanding the Existing Building

Understanding the Existing Building				
	Building Modeling	**Energy Audit**	**Energy Management System**	**Human Behavior**
Consider	- Owner Project Requirement - Design Parameters - Cooling Load - Dry Bulb/Wet Bulb Temp. - Target Indoor Temp. & RH - Artificial Lighting	- Historical Energy Consumption - Weather data - Occupancy/ People Traffic - Energy end use breakdown - Hourly Simulation	- HVAC - Lighting Systems - Proper Sensor Maintenance - Proper Control - Proper Commissioning - Periodic recalibration for optimum performance	- Building policy for energy efficient appliances - Observe actual operation procedure - Observe actual maintenance procedure - Behavior that allows outside air infiltration - Educate tenants on energy efficiency
Goals	To understand energy consumption according to design	To compare actual energy consumptions design and find opportunities to be more efficient	To automate control and monitoring of lectromechanical equipments	To understand impact human on energy use
Result	Documentation on building model	Audit report on energy use and suggestions on energy saving measures	Lower energy use of building	- Update building policy - Education campaign for tenants

Table 9. Understanding Existing Building

6.2.1 Existing building modeling

To know if a device is inefficient, it needs to be compared with a standard (baseline). Likewise, a building's efficiency is relative to a standard and is typically addressed in the design phase. When the building is in operation, the standard is the building design.

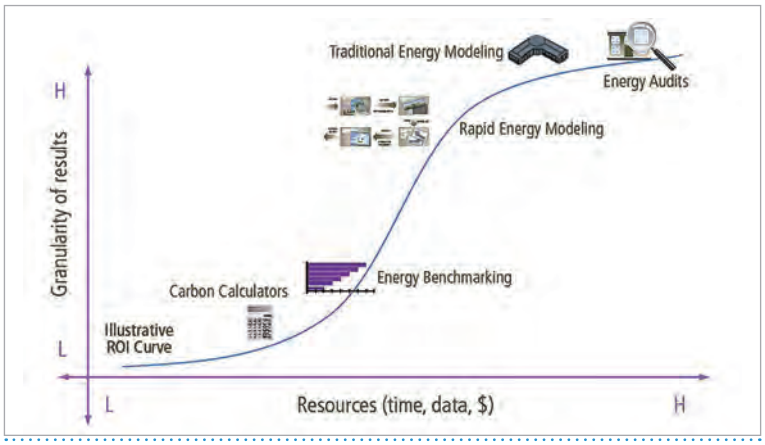

Figure 22. Building Energy Modeling compared to other methods (From http://images.autodesk.com/adsk/files/rem_icf_report.pdf)

To know its efficiency, the building must be compared with its design before embarking on any improvements. Modelling a building or design will produce the expected energy usage through software simulation. Inefficiencies can then be detected by comparing the actual energy usage with the expected energy usage using the modelled building simulation data.

Although carbon expenditure in most cases is a function of energy consumption, carbon calculators only calculate the carbon footprint of the building using actual energy usage data such as electricity consumption and fuel or gas usage, but do not indicate whether or not the building is efficient.

Energy benchmarking uses the actual building energy consumption and compares it with a similar building (or with itself). With benchmarking, the building efficiency can be compared; however there are no detailed and regularly updated energy usage benchmarks currently available for Indonesia.

Building Energy Modelling will produce an estimated electricity consumption, and also a simulation of energy use patterns. This technology can be used to assist in making decisions about the replacement and retrofitting of building systems by modeling the energy usage of the equipment that will be installed.

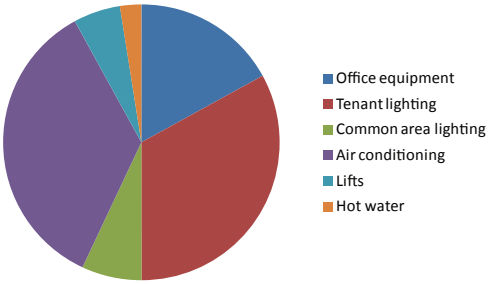

Figure 23. Typical Electricity Usage of a Building

6.2.2 Energy auditing

An energy audit, by definition, is a process by which to evaluate where a building uses energy, and identify opportunities to reduce waste. An instrument-based energy audit conducted by a certified, skilled and experienced technician frequently reveals circumstances that are unique to a particular building. This is especially the case with older buildings which more often than not have been modified over the years.

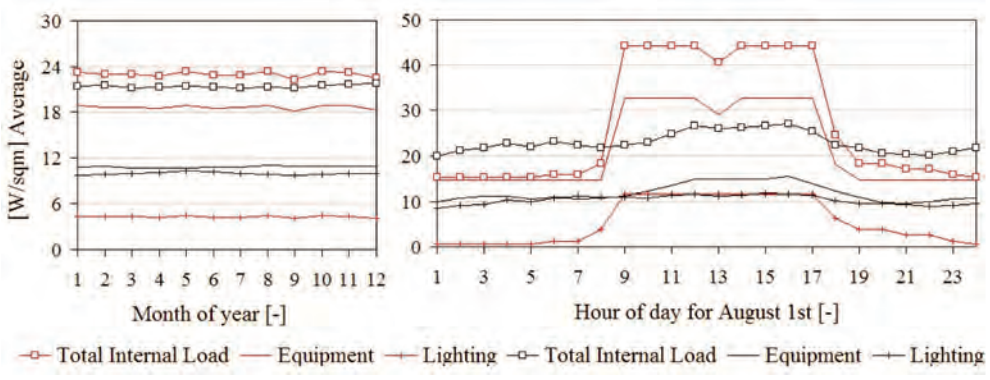

Figure 24. Example of Energy usage simulation for a Building – Red is actual, black is simulated (Source: Calibration of a detailed simulation model to energy monitoring system data: a methodology and case study, Raftery et al, 2009)

On every project, the auditor's aim is to identify health, safety and energy problems and figure out the best ways to solve them cost-effectively. The scope of the energy audit, complexity of the calculations, and economic evaluation varies on each audit and should be discussed thoroughly with the energy auditor.

Indonesia also has a Standard Audit Energy Procedure for Buiding (SNI 6196:2011). Depending on the purpose there are four levels of auditing: walk through, preliminary, and detailed audit.

Generally, Energy audits are divided into four levels:

(ASHRAE - Procedures for Commercial Building Energy Audits, Second Edition)

- **Level 0 – Benchmarking:** This audit consists of a preliminary Whole Building Energy Use (WBEU) analysis based on the analysis of past utility use and costs and the comparison of the performance of the buildings to those of similar buildings. This benchmarking will help determine if further analysis is required. ASHRAE categorizes this as Preliminary Energy-Use Analysis.
- **Level I – Walk-through:** This audit assesses building energy efficiency to identify not only simple and low-cost improvements but also a list of energy conservation measures (ECMs), or energy conservation opportunities, (ECOs) to orient a future detailed audit. The audit is based on visual verifications, study of installed equipment and operating data and detailed analysis of recorded energy consumption collected during the benchmarking phase. Capital Projects also can be identified as part of ECMs/ ECOs.
- **Level II – Detailed/General energy audit:** Based on the results of the walkthrough audit, this type of energy audit consists of an energy use survey in order to provide a comprehensive analysis of the building, a more detailed analysis of the facility, a breakdown of the energy end-use and a first quantitative economic evaluation of the ECOs/ECMs selected to correct the defects or improve the existing installation. This level of analysis can involve advanced on-site measurements and sophisticated computer based simulation tools to accurately evaluate the selected energy retrofits. Operations and Maintenance changes may also be part of the recommendation.
- **Level III – Investment-Grade audit:** Detailed Survey and Analysis of Capital-Intensive Modifications focusing on potentially costly ECMs/ ECOs requiring rigorous engineering study which stresses the return of investment (ROI) of the modifications. Additional measurements such as hourly simulations can be part of the audit.

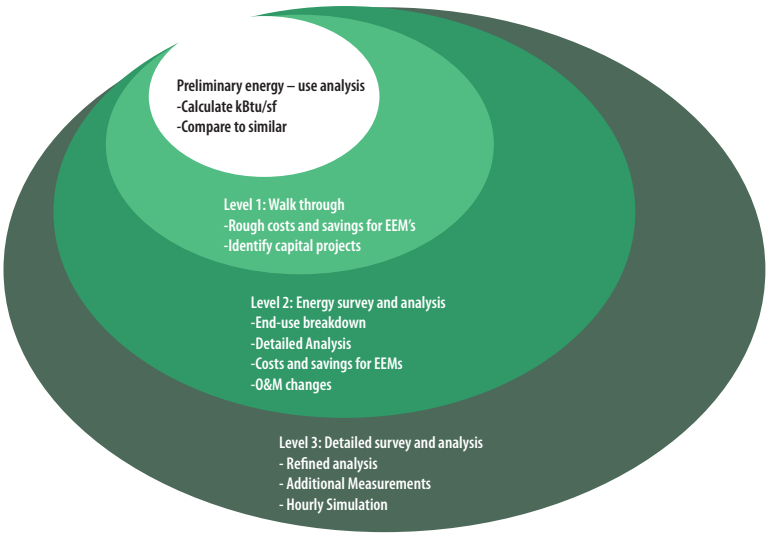

Figure 25. Relationship of ASHRAE Energy Audit Levels 1, 2, and 3. (Procedures for Commercial Building Energy Audits, 2nd Edition. 2011)

6.2.3 Energy management systems

"The judicious and effective use of energy to maximize profits (minimize costs) and enhance competitive positions" (Capehart et al. Guide to Energy Management, 2nd Edition. 1997) is a definition of an Energy Management System (EMS) which comprises certain key principles.

ISO 50001 uses the following definition for EMS: *"A set of interrelated or interacting elements to establish an energy policy and energy objectives, processes and procedures to achieve those objectives."*

Energy management takes many different forms, from simple operational and maintenance activities to ensure equipment and systems use energy efficiently and effectively, to capital intensive installations of new, more efficient technology. An energy management system systematically records the energy usage and serves as a basis mainly for investments in improving energy efficiency.

An energy management system systematically records the energy usage and breakdown and serves as a basis mainly for investments in improving energy efficiency.

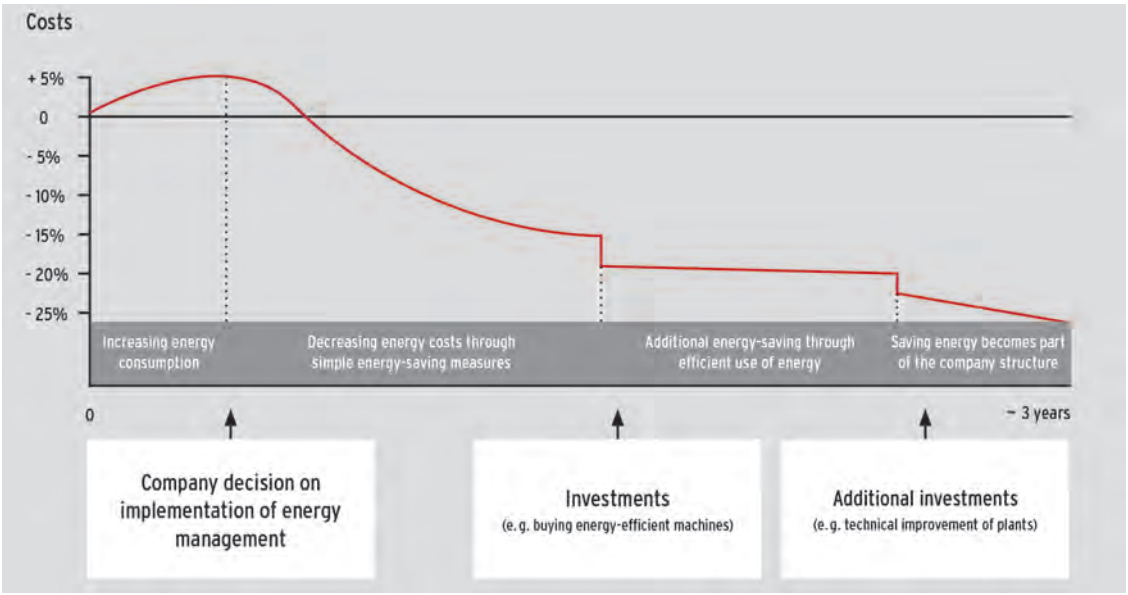

Figure 26. Continuous cost reduction with energy management (Source: DIN EN 160001: EMS in Practice, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Germany, 2010)

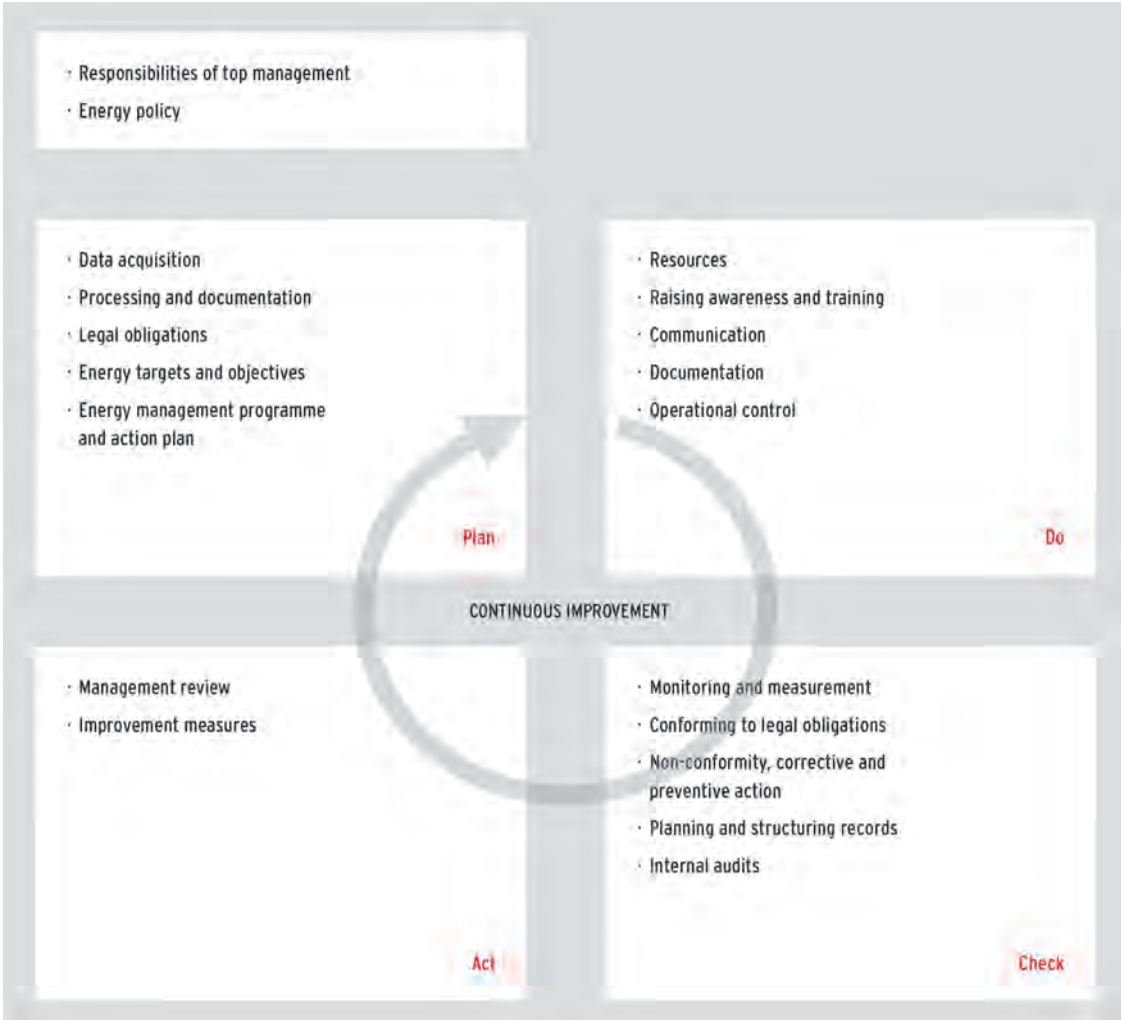

Figure 27. Plan-Do-Act-Check Cycle. (Source: DIN EN 160001: EMS in Practice, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Germany, 2010)

A functioning energy management system enables organizations to continuously and systematically improve its energy performance.

Setting up an effective energy management system in an enterprise must be a top-to-bottom process. An enterprise structure and policy that supports the energy management activities is the most important component for a successful energy management system. Another important component is an energy manager within the company structure who drives the processes to reach energy management goals.

The ISO 50001 standard is based on the common elements found in other ISO's management system standards, assuring a high level of compatibility with ISO 9001 (quality management) and ISO 14001 (environmental management). ISO 50001 prescribes the following processes:

- A framework for integrating energy efficiency into management practices.
- Making better use of existing energy-consuming assets.
- Benchmarking, measuring, documenting, and reporting energy intensity improvements and their projected impact on reductions in greenhouse gas (GHG) emissions.
- Transparency and communication regarding the management of energy resources.
- Energy management best practices and good energy management behaviors.
- Evaluating and prioritizing the implementation of new energy efficient technologies.
- A framework for promoting energy efficiency throughout the supply chain.

The energy management system in ISO 50001 follows the PDCA (Plan, Do, Check, Act) cycle. The PDCA cycle provides a framework for the continuous improvement of processes or systems. It is a dynamic model - the results of one cycle form the basis for the next one. This structure enables the ability to continuously reassess and optimize the current energy consumption and to gradually reduce costs.

With greater focus on energy efficiency from the government in Indonesia, commercial buildings using 6000kVA of power and above will be required to have an energy manager in the near future.

6.2.4 Human behavior

Human behavior can also greatly impact energy efficiency. Behavior such as turning off equipment when not in use, choosing energy efficient equipment, and changing behaviors that increase building loads, such as opening windows to allow outside air in, leaving doors or barriers open to non-air conditioned areas etc., will impact overall building efficiency. Education, incentives and policies can inspire tenants and staff to save energy. **Up to 5% of total building energy usage** can be saved as a result of educating tenants and changing energy consuming behaviors to energy saving behaviors.

Up to 5% of total building energy usage can be saved as a result of educating tenants and changing energy consuming behaviors to energy saving behaviors.

The following results have been obtained after providing training awareness in a hotel in Jakarta as shown in the Table 10.

No	Item	Unit	Jan	Feb	March	April
1	Rooms sold	room	2410	2160	2805	2715
2	Occupant rate	%	77	70	93	96
3	Electrical consumption/Mo	kWh	381.000	288.000	348.000	306.000
4	Electrical Cost/Mo	Rp/Bl	242.328.744	195.679.632	268.366.400	158.652.000
5	Electrical Consumption / room	kWh/Kmr	158	133	124	113
6	Total Revenue	Rp	1.268.000.000	1165.000.000	1.489.000.000	1.454.000.000
7	% Electrical vs Revenue	%	19	17	18	11

Table 10. The influence of energy consumption and revenue for Energy Efficiency awareness training results

To encourage behavior changes, the building manager should include energy efficient policies in the tenancy agreement. One example would be having a policy that only allows equipment that meets a minimum energy star rating to be used in the building.

6.3 Commissioning and Building Tuning

"*Commissioning is a quality assurance oriented process for achieving, verifying and documenting that the performance of facilities, systems and assemblies which were planned, designed, installed, tested, operated and maintained meets defined objectives and criteria.*" (ASHRAE Guideline O).

6.3.1 Why proper commissioning and tuning is worth doing?

A real-life example of how commissioning can be beneficial is evident in a commercial building in Jakarta that was running a big pump for its chilled-water loop. Before commissioning the pump was measured to be using 75kWh of energy for its operations. After proper commissioning, the same pump was measured to be using 15kWh of energy with no performance shortcomings to the building. This simple commissioning step required NO additional capital investment, yet managed to save 60kWh on pump running costs for the entire life span of the building. *Note: Oversizing is a common practice in the industry to provide safety margins to calculated requirements. However, the pump in this example is significantly oversized.*

6.4 What is commissioning?

A commissioning plan consists of:

- Commissioning Procedures
- Commissioning Checklist sheets and forms
- Commissioning Schedule
- Data to be recorded

The term commissioning comes from shipbuilding. A commissioned ship is one deemed ready for service. However, before being awarded this title, a ship must pass several key stages. Equipment is installed and tested, problems are identified and corrected, and the prospective crew is extensively trained. A commissioned ship is one whose materials, systems, and staff have successfully completed a thorough quality assurance process.

Building commissioning is the process of verifying that all the subsystems such as electrical, fire/safety, HVAC, plumbing, building

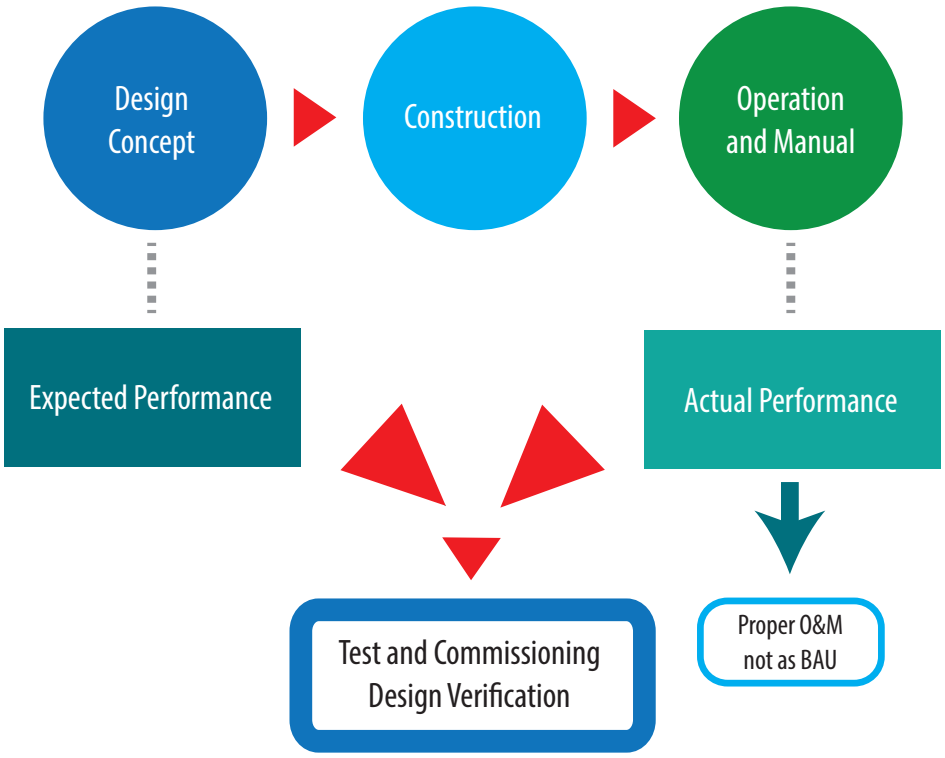

Figure 28. Proper Commissioning Steps

envelopes, interior systems, backup systems, lighting, wastewater, controls, and building security achieve the project requirements intended by the building owner and designed by the building architects and engineers.

The commissioning process consists of 5 components:

- Testing
- Commissioning
- Training
- Monitoring
- Tuning

Normally the initial commissioning team and a team leader (typically known as the commissioning authority) is involved from project initiation through one year of occupancy. While the methodology can vary from owner to owner and project to project, the basic formula for a successful building commissioning process involves a synergy of teams from pre-design teams to operation and maintenance teams that conduct testing, commissioning, monitoring and tuning of sub-systems and equipment.

The realization of long term performance in a building is dependent on the continuous successful operation of its various systems. Thus it is essential that the operators of the building's systems have a thorough understanding of the relevant aspects of the system for which they are responsible. This is achieved through a comprehensive commissioning process.

While the building commissioning process is still fairly new in the construction industry, it has quickly become common practice as building owners and developers try to get more return from their investments.

6.4.1 Testing

The first step of commissioning is to test if the equipment and subsystems function properly as designed. Testing also involves inter-operability of equipment and subsystems and testing the EMS/BMS for controls. Simulations may also be run to test the system under certain operating conditions, which is typically done for fire/safety systems. The main result of testing is a checklist and quality assurance that all equipment and sub-systems are working as designed.

Commisioning					
	Testing	Commisioning	Training	Monitoring	Tuning
Goal	-Equipement working as designed -Simulation Test (smoke test, etc.) -Interoperability of equipments	-Configure setting & optimize -Compare to design & OPR	-Transfer knowledge -Train to operate properly -Train to troubleshoot	Collect performance data -Repeat selected System performance test -Review energy bills	-Rightsizing equipment -Optimum result with minimum energy
Result	-Test documents (Checklist of test, result, etc) -QA Documents -Simulation test report - Report of corrective actions	-Commisioning report -Report of system deficiency & corrective actions -System performance report	-Operations and Maintenance Manuel -Training documents -Checklists	-Monitoring report -Report of system deficiency & corrective actions -System performance report	-System tuning report -System performance report -Report of system deficiency & corrective actions
Involvement	-Enginer -Operation Staff -Vendor -Builder -Commisioning Agent -Representative of Architect	-Engineer -Operations Staff -Vendor -Builder -Commisioning Agent -Representative of Architect	-Engineer -Operations Staff -Vendor -Builder -Commisioning Agent -Representative of Architect	-Engineer -Operations Staff -Commisioning Agent -Representative of Architect	-Engineer -Operations Staff -Vendor -Commisioning Agent -Representative of Architect

Table 11 Building Commissioning Process

6.4.2 Commissioning

Commissioning includes configuring, setting, and optimizing all equipment and subsystems of a building. Ideally this should be done by a third party, a commisioning agent that operates as an independent consultant. A report with any past system deficiencies identified and how they were resolved, including any outstanding issues or seasonal testings scheduled for later during the warranty phase, is typically produced. So is a report on system performance test results and evaluations. The Commissioning Agent also have to evaluate if each of the systems meet the Owner's Project Requirements (OPR) and design.

6.4.3 Training

Testing and Commissioning organizes the training for all operators (chiller, pump, cooling tower, elevator, generator) in a proper sequence to allow the operators to get a complete and logical overview and understand how to operate the utilities properly, safely and efficiently.

This should be done after the Post Construction Evaluation meeting, attended by representatives from MK, Quantity Surveyor, Architect, Owner's Engineer, Mechanical Engineer and Operations & Maintenance. During the meeting an asset list is handed over and a training schedule is made along with a discussion on how the building actually compares to OPR and the building concept. Building concept discussions can also address matters such as whether the 9th floor of a particualr building can be converted from office space into a restaurant.

6.4.4 Monitoring

During the warranty phase, the commissioning agent, staff, and representatives of the architect, engineer and contractor teams shall verify the on-going system performance by repeating selected System Performance Tests and by reviewing energy bills and other performance-related documentation. The commissioning agent shall prepare a report to the building manager stipulating any issues with the on-going system performance and/or confirming that the systems are functioning as designed.

Testing and Commissioning organizes the training for all operators (chiller, pump, cooling tower, elevator, generator) in a proper sequence to allow the operators to get a complete and logical overview and understand how to operate the utilities properly, safely and efficiently.

6.4.5 Tuning

If equipment and subsystems are not performing as designed during any of the tests, tuning must be undertaken, typically by configuring settings or making changes in operational and maintenance procedures. The goal is to optimize the equipment and subsystems to operate as efficiently as designed. In most cases, the systems installed are oversized (pumps, fan, AHU), therefore rightsizing the operation of all related energy consuming equipment may reduce energy consumption quite significantly.

6.5 Retro-commissioning, Retrofit & Refurbishment

Retro-commissioning is the execution of the commissioning process to existing buildings. Retro-commissioning is a process that seeks to improve building equipment, system performance, and inter-operability. Depending on the age of the building, retrocommissioning can often resolve problems that occurred during the design or construction phase, or address problems that have developed during its life. More simply, retro-commissioning a building improves its operations and maintenance (O&M) procedures in order to enhance overall building performance.

For older buildings, energy audits or retro-commissioning may recommend a retrofit and refurbishment of systems or equipment. Though some retrofits/refurbishments are often associated with high costs, they can also provide significant savings. Thus there is a need to evaluate cost vs. savings and the benefits of retrofits and refurbishments.

The energy weakness of a 20 or 30 year old building may include:

- Wear and tear on equipment, especially motors, will reduce energy efficiency of a device, thus increasing operational costs.
- Insulation most likely needs to be repaired or completely refurbished especially for chilled water risers.
- State-of-the-art equipment may run efficiently with only 30% of the energy use of older equipment, thus saving 70% on the operational costs of the equipment. (Example: most 20 year old chillers in the market may run at 1.5kW/TR; nowadays chillers are available that run at 0.5kW/TR)

Conducting an energy audit or retro-commissioning on a building can help to evaluate whether a capital investment is worth it or not. Sometimes a simple retro-commissioning

can reveal ways of optimizing equipment, thus reducing operational costs without additional capital investment.

6.5.1 Cost vs. savings

The most important factor of any capital expenses is cost compared to real savings, which is calculated as return on investment (ROI). Some retrofits may provide significant savings, such as replacing old chillers that use old technology with new more efficient chillers. This could also provide an opportunity to replace an old oversized chiller with a new smaller capacity chiller. A more accurate appreciation of what size is really needed can be obtained by analyzing the log-sheet and results of the energy audit. A lifecycle cost analysis of equipment may also offer better insight into whether or not the investment into new equipment is a feasible choice.

6.5.2 Benefits of retrofit and refurbishment for energy efficiency

Another factor to consider is the benefit of retrofit and refurbishments on lowering operational and maintenance costs. An example of this would be replacing lighting systems with LED technology to reduce energy consumption, which also lowers maintenance and operational costs as they last longer than traditional light bulbs.

6.5.3 Maintenance and system tuning

Equipment maintenance and system tuning, which can generate savings without retrofitting and refurbishing should also be considered. Some maintenance and system tuning can lower the energy use of a system and also optimize performance systems. Maintenance and system tuning can also prolong the life of equipment, in the same way as we maintain our cars.

6.6 Energy Efficient Appliances

Over time equipment and appliances installed in a building by the tenants may contribute to significant energy use if they are not efficient. Furthermore, tenants must be educated on energy efficient appliances and their impact on overall building operational costs. Tenants must abide by building policies that only allow equipment and appliances with a minimum energy efficiency rating in the building.

Example

CRT Monitor	LCD Monitor
17 inch	15 inch (equivalent viewing area)
80W	25W (operational)

This is a 55 Watt savings per monitor or 69% lower energy use. When there are 1,000 monitors in a building, this can result in a savings of 55kW.

Equipment maintenance and system tuning, which can generate savings without retrofitting and refurbishing should also be considered. Some maintenance and system tuning can lower the energy use of a system and also optimize performance systems.



7. Extract from the Technical Design Guide 2

To encourage and promote energy efficient design for buildings and their services, the following key factors need to be considered based on a summary of the more detailed discussion in Part II of these guidelines.

Aspect	Description	Impact to Capital Cost	Impact to Operation Cost	Best Practice Consideration	Remark	Refer to
Climate	Temperature	Higher cost for higher temperature	Higher cost for higher temperature	-	34°C DB and 28°C WB	Part 2 Chapter 3 and Part 3
	Relative Humidity	Higher cost for higher humidity	Higher cost for higher humidity	-	55% - 97%	
	Radiation	Higher cost for higher radiation	Lower operational cost with shadowing	Shadowing (canopy, building, landscape)	-	
	Wid Flow	No cost	Lower cost with wind flow integration	-	-	Part 2 Chapter 4 & 5 and Part 3
Thermal Comfort	Temperature	The lower chiller capacity, the lower capital cost	Increase of 1°C = reduce total energy consumption 5%	25,5 $\pm$ 1,5 °C	SNI 6390 - 2011	Part 2 Chapter 4
	Relative Humidity	The lower chiller capacity, the lower capital cost	Increasing RH will decrease operational cost	60 $\pm$ 5%	SNI 6390 -2011	Part 2 Chapter 4 and Part 3
	Air Movement	Slightly additional cost for ceiling fan	Increasing air movement from 0,25 m/s to 0,8 m/s could increase room temperature from 25°C to 27°C reduce total energy consumption 10%	Combination AC system and ceiling fan	0, 25 m/sec (ASHRAE)	Part 2 Chapter 4 & 5
	Ventilation Rates	Higher cost with higher ventilation rates	Higher cost with higher ventilation rates	2.5 L/s/person 0.3 L/s/m^2 of outside air	ASHRAE	Part 2 Chapter 4

Aspect	Description	Impact to Capital Cost	Impact to Operation Cost	Best Practice Consideration	Remark	Refer to
Lighting	Day Light	No cost	Saving more than 50% lighting energy cost	300 lux (room depth equal to twice window height)	GBCI	Part 2 Chapter 4&5
	Light Power Density	T5 no additional cost for new building, high potential for retrofitting 2 year PP	Replace by T5 reduced lighting energy consumption up to 30%	8-12 Watt/m^2	SNI 6197-2011	Part 2 Chapter 4.8.1
		LED Additional cost for new building, have max years payback period	Replace by LED reduced lighting energy consumption up to 50%	8-12 Watt/m^2	SNI 6197-2011	Part 2 Chapter 4.8.1
Passive Cooling	Site location	-	-	-	-	Part 2 Chapter 5.2
	Orientation	No cost	Dramatically lower than East-West direction	Opening wall in North-South direction	-	Part 2 Chapter 5.3
	Building form	The shorter the perimeter wall the lower the cost	-	-	-	Part 2 Chapter 5.2
	Building envelope - WWR	Lower cost WWR lower constrction cost	The lower WWR the lower energy consumption	*)Hypotetic Building Singapore	-	Part 2 Chapter 6.1, 6.2
	Building envelope - insulation	Higher insulation cost save chiller investment	Higher insulation cost lower energy consumption	Reduce heat gain by calculating OTTV 35 W/m^2	SNI 6389-2011	Part 2 Chapter 6.1, 6.2
	Cross ventilation	No cost	Significantly reduced operational cost	Opening area 5/10% of floor area	Suitable for low rise building only	Part 2 Chapter 4.4, 5.6
Energy Simulation	Modeling for optimization	Consultant cost	Significantly reduced energy consumption around 50%	Involving the energy expert from the initial design stage	EEI 250 kWh/m^2/y	Part 2 Chapter 7.1, 7.2
Building System	Integrated approach to pursue an energy building system	Expertise cost	Significantly reduced energy consumption around 50%	Involving the energy expert from the initial design state	EEI 250 kWh/m^2/y	Part 2 Chapters 8 and 9
Procurement	LCC analysis	Higher cost for quality materials and equipment	Lower operation maitenance and repair	Quality assurance and certification	NPV approach	Part 2 Chapter 10



8. Conclusion

By considering various aspects which affect building design, construction, and operational such as climate, thermal comfort, passive cooling, energy simulation, and building systems and procurement, the target of an energy efficient building can be accomplished.

8.1 Summation

Building parameters which affect the use of energy are:

a. Climate
Locations where the temperature, relative humidity, and radiation are quite high will impact capital costs. Wind flow has no effect on initial costs but with some modification to building designs, it can result in lower operational costs.

b. Thermal comfort
The internal building environment, where the temperature and relative humidity can be controlled, can lower the capital and operational costs. However, controlling air movement could result in additional capital costs but would still reduce total energy consumption, which could therefore reduce operational costs.

Ventilation rates will result in both capital and operational costs; and daylight will impact capital costs and saving opportunities for lighting energy costs. Furthermore, replacing the type of lamp will impact light power density and give opportunities to reduce plug loads.

c. Passive cooling
Site location and orientation of a building where the wall opening faces in a North-South direction will not add to capital costs and will give a substantial savings on operational costs. Furthermore, a building form and building configuration which has less perimeter wall will give lower capital costs.

Building envelope covering window-wall-ratio (WWR) and wall insulation will impact energy consumption while cross-ventilation could reduce operational costs significantly.

d. Energy simulation
Using modeling simulation by involving experts and computer software at the early design stage will not only give a better building design solution, but also the opportunity to reduce energy consumption during building occupancy.

e. Building systems
Using an integrated building system approach by involving experts from the early design stage will create a more energy efficient building system.

f. Procurement
The owner should consider life-cycle costs more than focusing on initial costs. The lower initial costs will usually result in higher operational and maintenance costs.

8.2 Indonesian Standards, Regulations and Codes

To provide an energy efficient building the building owners and developers should always try to exceed the requirements of existing regulations, technical standards and requirements, and other building codes pertinent to energy efficiency.

In cases where the availability of national or local regulations are insufficient, international best practices should be applied to every design stage.

8.3 International Energy Efficiency Trends

Worldwide there is a growing concern about energy consumption and the associated energy production requirements, especially as most countries still make use of fossil fuel based power generators. As fossil fuel resources are starting to shrink the urgency to reduce consumption and develop alternative energy sources is continually growing.

In light of a potential energy crisis and ever-rising energy costs many countries have improved their regulations, technical standards, and practical codes to meet the new trend in energy efficient building design, operation, and maintenance, such as ASHRAE, Uniform Building Code, etc.



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