Training on Energy Efficiency in Buildings of stakeholders in urban planning, construction and building

Organised by ECREEE

PRAIA, CABO VERDE, 9th-10th June 2014

SERA Sustainable Energy & Resources Availability

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Basic concepts and examples of relevant buildings, life cycle of buildings concerning energy consumption

Energy efficient buildings

Basic concepts | definitions, context, practical relevance

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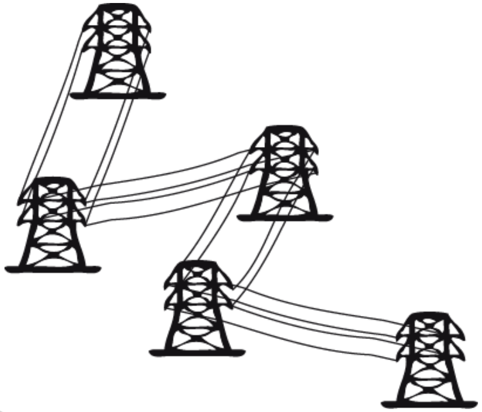
Motivation for energy efficient buildings

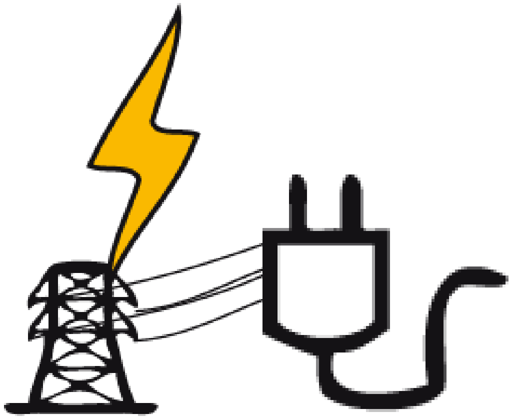
Power outages | reasons

Natural cause, e.g. draught, seasonal problem of hydro power plant

Electricity networks cause massive distribution losses



High electricity peak demand (e.g. in the evening)



Energy efficiency in buildings reduces consumption and peak load!

Motivation for energy efficient buildings

Increasing energy consumption | urbanisation in West Africa

Africa is the fastest urbanising continent, currently **40% of the African population** (in total over 1 billion inhabitants) lives in urban areas, and by 2050 this will **increase to 60%** (in total 2 billion).

The section about West African Cities in the UN Habitat publication 'The State of African Cities 2010 Governance, Inequality and Urban Land Markets' says about urbanisation trends in this region:

> "In 1950, a mere 6.6 million people lived in Western African cities. The number and the rate of urbanisation increased only slowly until 1990. Around that time, the urbanisation rate of Western Africa overtook the continental average and began to accelerate. … Western Africa will become predominantly urban around 2020 with an estimated 195.3 million city dwellers. By 2050, that number will reach 427.7 million, or 68.36 per cent of the total population. … The message embedded in these statistics should be clear: Western African nations must give urgent attention to their rapidly growing urban populations. They must build governance and management capacities in cities of all sizes and plan for significant spending on services provision."

Motivation for energy efficient buildings

Energy services needed to achieve development goals

Population in ECOWAS countries in 1998 and 2010: Comparing these two years, there was an increase of about 6 million people in Ghana, 40 million people in Nigeria, 4 million people in Ivory Coast, 5 million people in Niger and Burkina Faso (examples).

Electricity consumption is still low: Looking at the annual electricity consumption in kWh per capita (where data were available) in the ECOWAS region, this indicator is still very low (around 200 kWh per capita), compared with other countries in the world where the indicator is beyond 1,000 kWh per capita. In fact, an increase is necessary, in order to achieve the development goals.

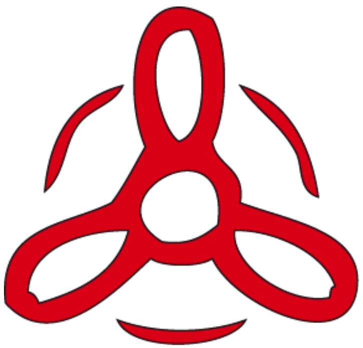
Development goals, together with the phenomenon of urban growth and increasing population numbers represent an enormous challenge for the electricity supply in the ECOWAS countries.

Motivation for energy efficient buildings

Electricity consumption, peak load | influence of building design

The major amount of electricity is consumed for the following purposes:

Cooling, ventilation air conditioning



Lighting

Targeted program: efficient lighting

Electric appliances

Targeted program: Eco-labels

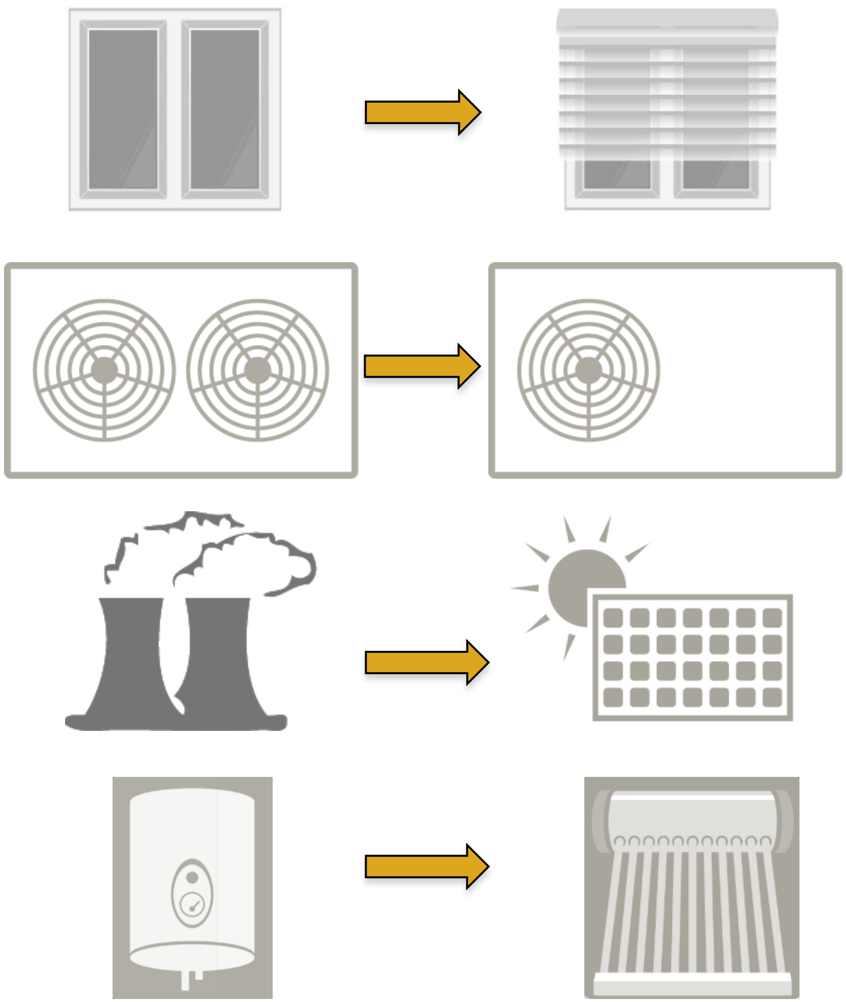
Hot water

Energy efficiency of building envelope, good architectural design for natural ventilation and cooling, use of daylight and integration of renewable energy systems reduce electricity consumption during building utilisation.

Improving the energy efficiency in buildings

Building design | renewable energy technologies

- Avoid energy consumption by means of building design: correct building orientation; shading of window and walls
- Reduce energy consumption: use a more efficient technology which provides the same service with less energy consumption
- Substitute electricity from fossil fuels with renewables, e.g. PV
- Use electricity only where electricity is necessary: replace electric water heaters with solar water heaters



What people demand for	How to achieve what occupants demand for	
	Usual method	**Energy-efficient method**
Shelter and comfortable indoor climate	Cooling and air conditioning	**Option 1:** No cooling and air-conditioning: Use local materials and traditional know-how how to make use of local conditions **Option 2:** Very little cooling and air-conditioning: reduce cooling energy consumption due to correct building orientation and appropriate façade technology
Lighting	Incandescent bulbs	**Option 1:** Architectural building concept makes use of daylight, and at the same time avoids overheating **Option 2:** Energy saving lamps in combination with presence/occupancy sensor and daylight depending control
Hot water	Electric water heaters	**Option 1:** Solar water heaters **Option 2:** Use waste heat from other processes
Communication, computers for work, etc.	Electricity consumption for electric appliances	Reduced energy consumption for electric appliances due to energy saving products **(see ECOWS initiative on standards and labelling)**

Improving the energy efficiency in buildings

Comfort requirements I thermal, visual and acoustic

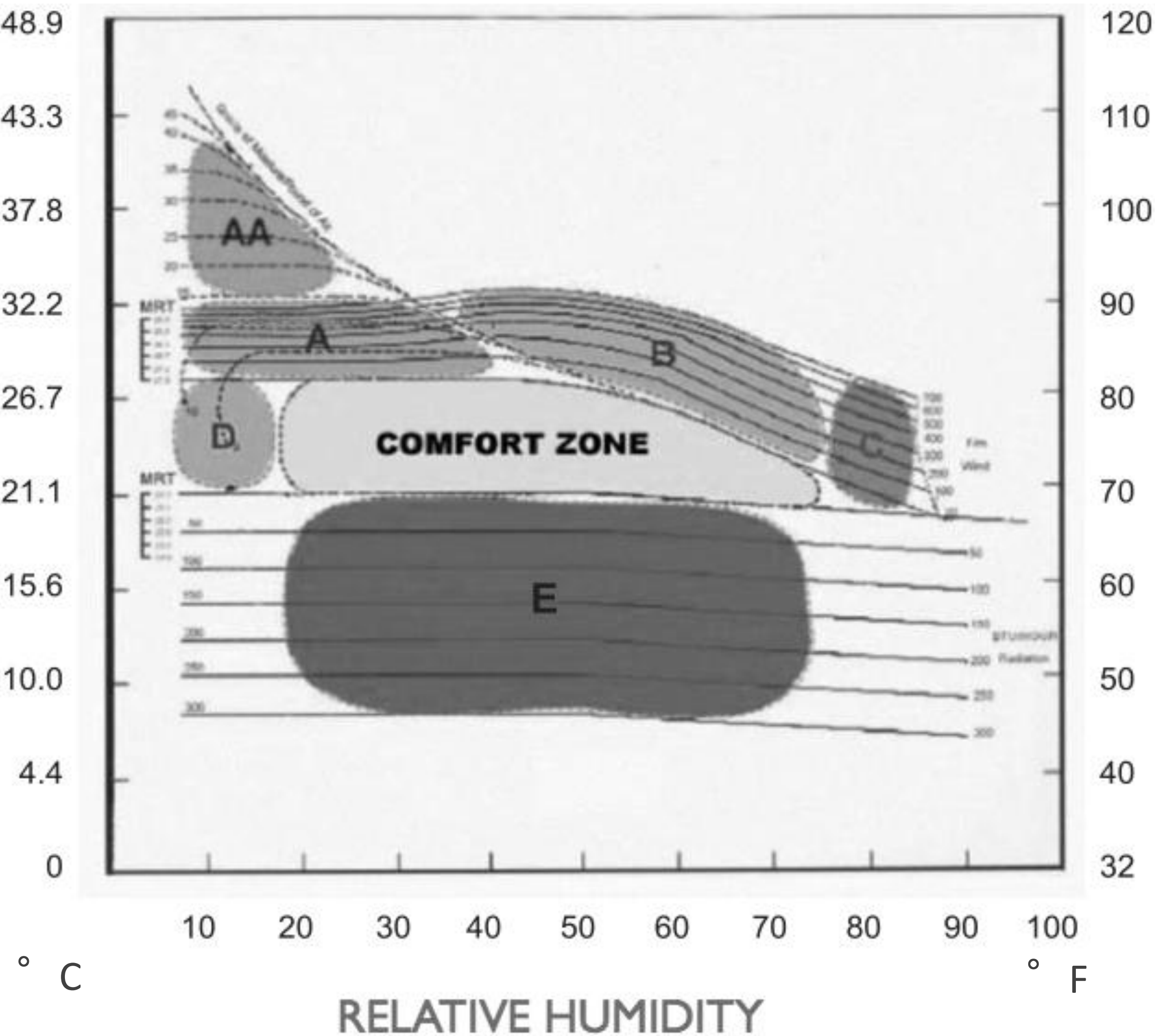
Humans require thermal, visual and acoustic comfort conditions.

Thermal comfort depends on six environmental and physiological factors:

> Air temperature
> Relative humidity
> Temperature of surrounding surfaces
> Air velocity
> Clothing
> Metabolic rate

Improving the energy efficiency in buildings

Energy efficient buildings must provide comfort



Zone	Type of climate
AA	Very hot
A	Hot
B	Hot and humid
C	High humidity
D	Very dry
E	Very cold

Source: Boonyatikarn, S. & Buranakarn,V.,2006; in: Eco-housing Guidelines for Tropical Regions; UNEP RRCAP; Bangkok,Thailand, December 2006

Improving the energy efficiency in buildings

Energy efficient buildings must provide comfort I solutions

Zone	Type	Solution
AA	Very hot	Evaporative cooling
A	Hot	Evaporative cooling & wind velocity
B	Hot and humid	Wind velocity
C	High humidity	Dehumidifying
D	Very dry	Humidifying
E	Very cold	Solar radiation

Evaporative cooling: The temperature of dry air can be dropped significantly through the phase transition of liquid water to water vapour (evaporation), which can cool air using much less energy than refrigeration. In extremely dry climates, evaporative cooling of air has the added benefit of conditioning the air with more moisture for the comfort of building occupants.

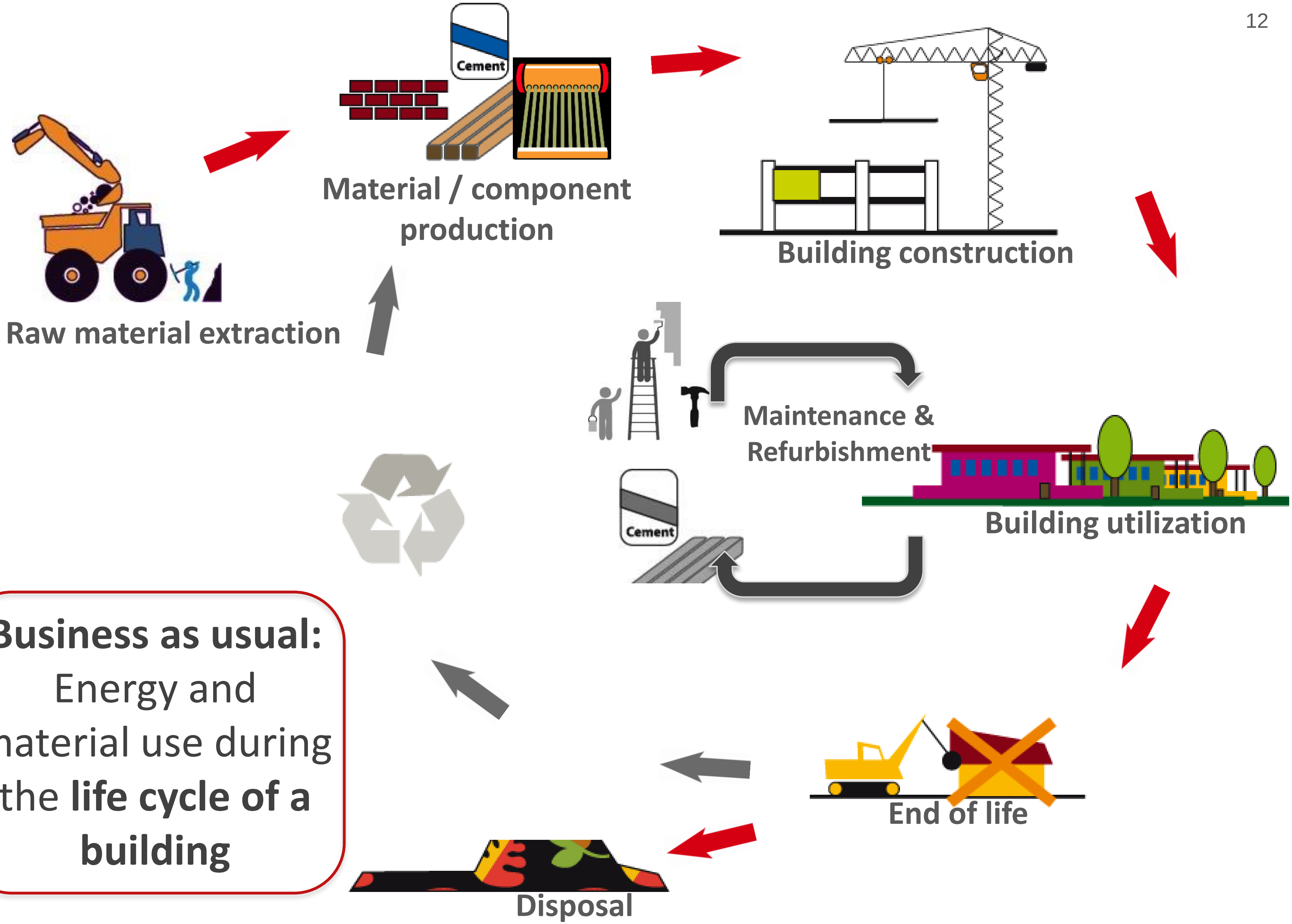
Source: Boonyatikarn, S. & Buranakarn,V.,2006; in: Eco-housing Guidelines for Tropical Regions; UNEP RRCAP; Bangkok, Thailand, December 2006

Methods of optimisation: LCA and LCCA

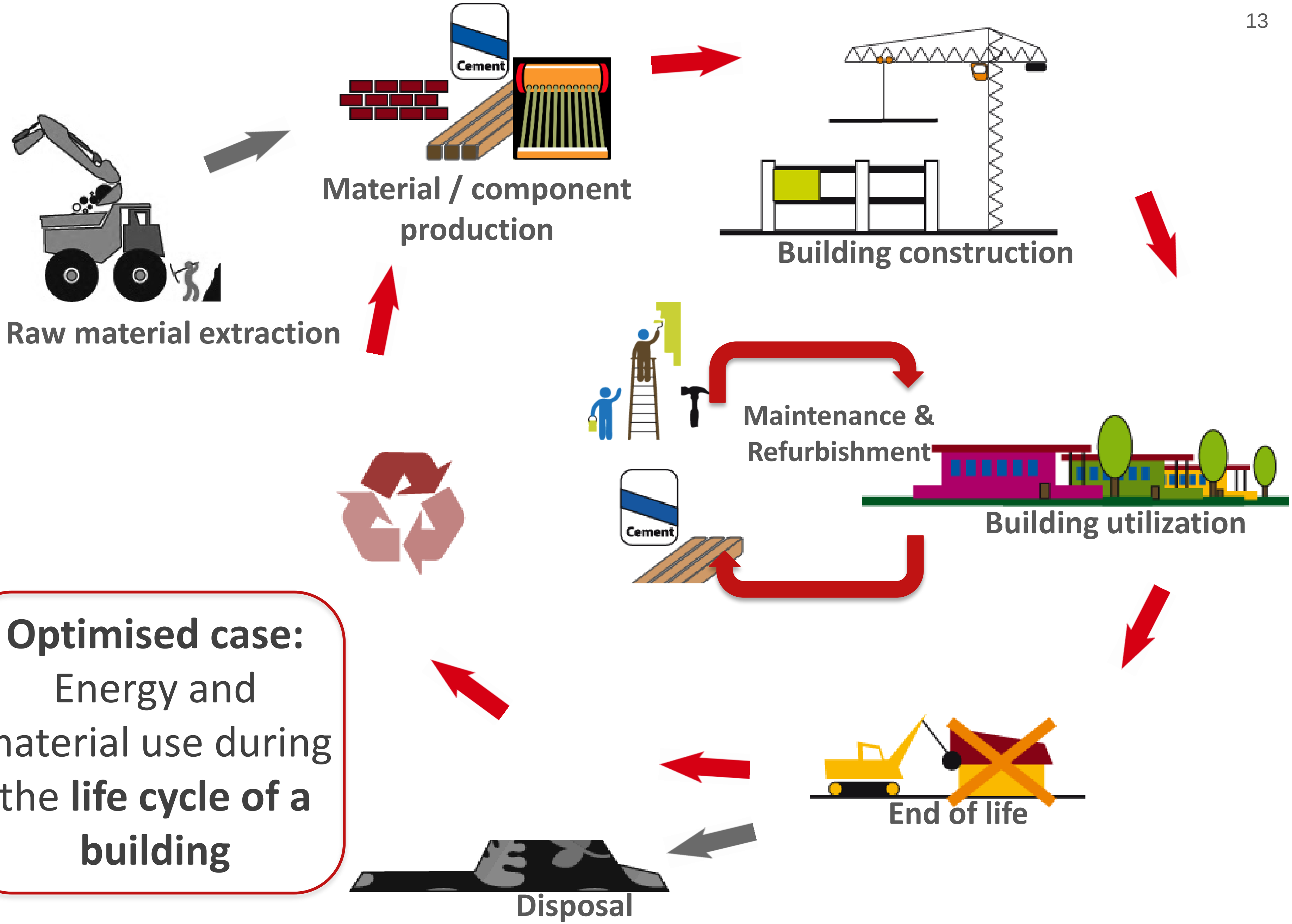
Energy consumption during the life cycle I optimisation

- Raw material extraction
- Material / component production
- Building construction
- **Building utilisation**
- Maintenance and Refurbishment
- End of life treatment
  - Disposal
  - Recycling

Material database with **Life Cycle Assessment (LCA)** results provides information about energy needed for production



Business as usual:
Energy and material use during the **life cycle of a building**



Optimised case:
Energy and material use during the **life cycle of a building**

Methods of optimisation: LCA and LCCA

LCA – Life Cycle Assessment I procedure

A Life Cycle Assessment is conducted in four steps (ISO 14040/44):

1. Definition of goal and scope

The first step of a Life Cycle Assessment specifies the objective(s) and the framework of the investigation. This includes: definition of the system boundaries, of the system's functional unit, and of requirements in terms of data quality.

2. Life Cycle Inventory (LCI)

The Life Cycle Inventory step includes data collection for all required input and output materials (resources, emissions), as well as energy flows. All material and energy flows are recorded and compiled in the inventory.

3. Life Cycle Impact Assessment LCIA)

Life Cycle Impact Assessment refers to the calculation of potential environmental impacts, effects on resource availability, and human health impacts. Impacts are calculated based on the inventory results and specific characterization models for each substance in the inventory.

4. Results and Interpretation

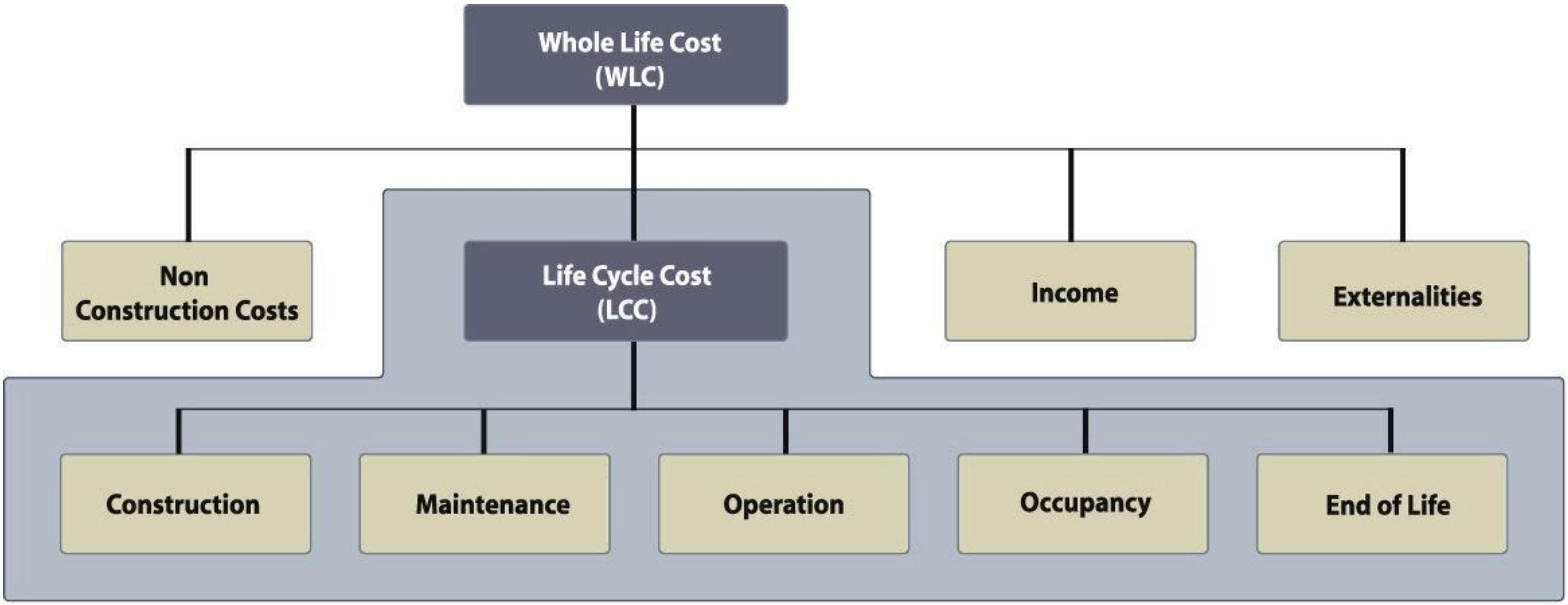
The calculated LCI and LCIA results are interpreted with respect to the goal of the LCA study and recommendations for decision-making are given.

Source: http://www.ibp.fraunhofer.de/en/Expertise/Life_Cycle_Engineering/Life_Cycle_Assessment.html

Methods of optimisation: LCA and LCCA

Definition of terms | Whole Life Cost and Life Cycle Cost

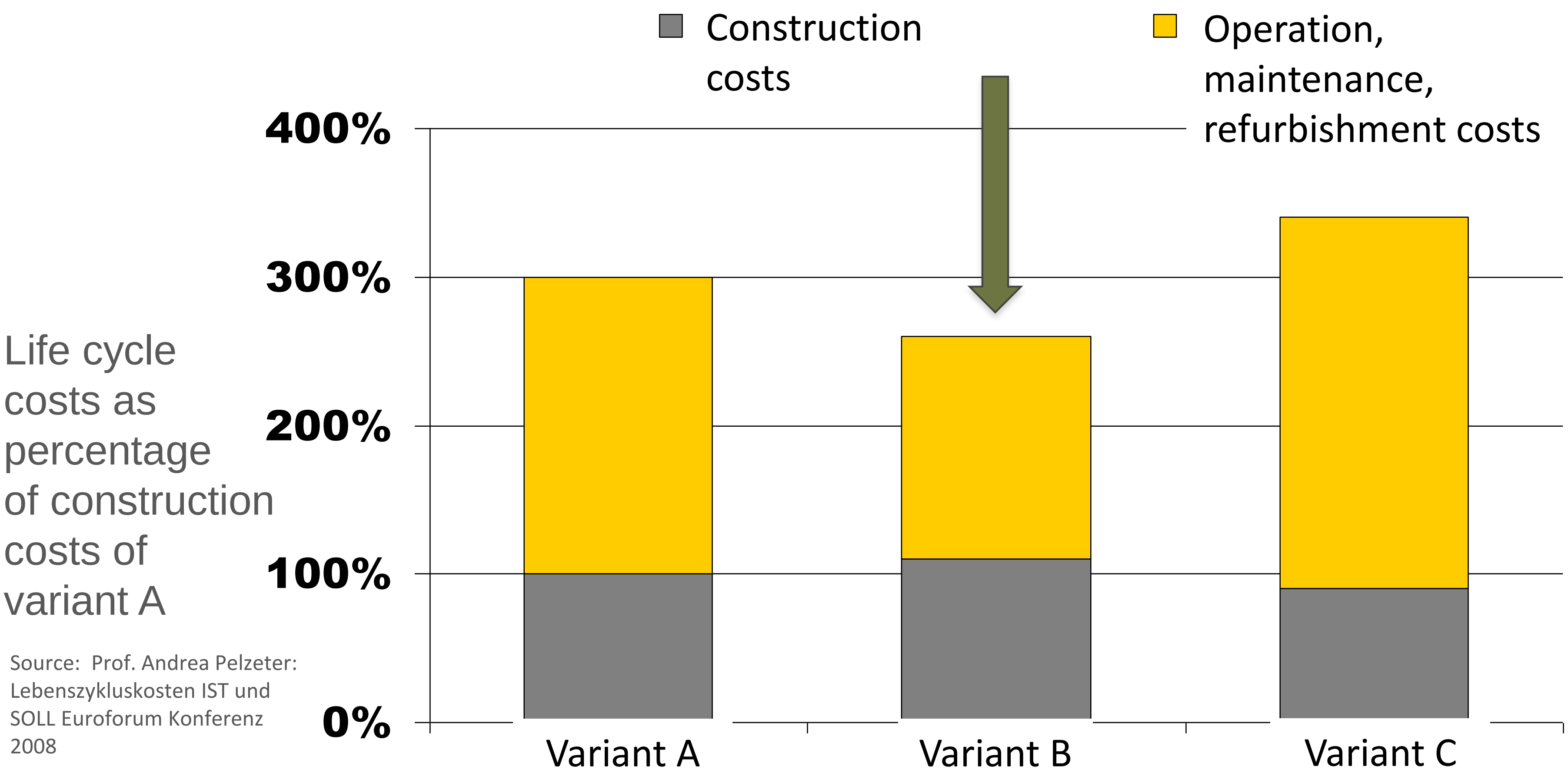
Data inventory (Life Cycle Inventory - LCI) of LCA provides a good basis for LCCA.



Methods of optimisation: LCA and LCCA

Life cycle optimisation I assessment of design variants

Motivation for LCCA: Slightly higher up front cost could result in substantially lower running costs.

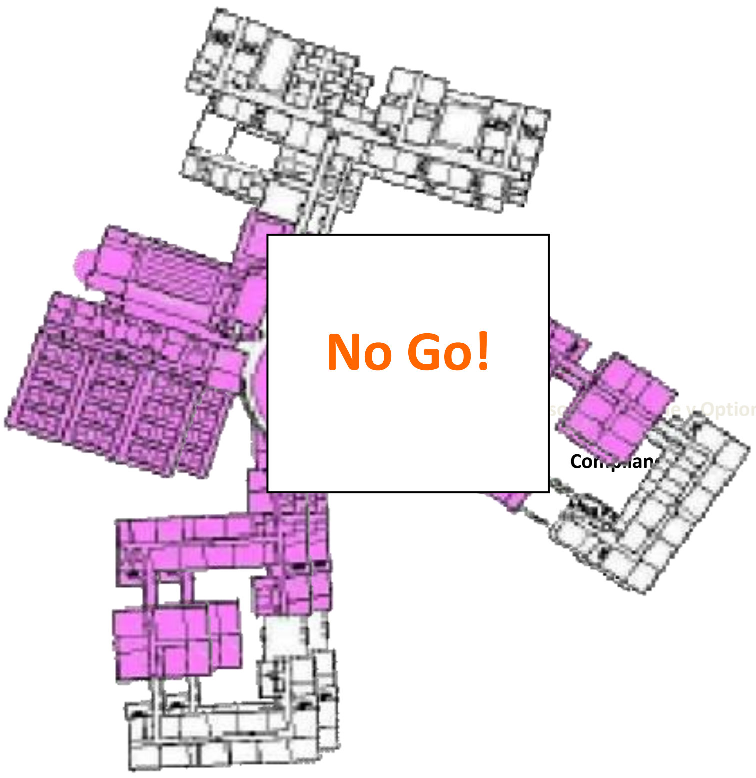


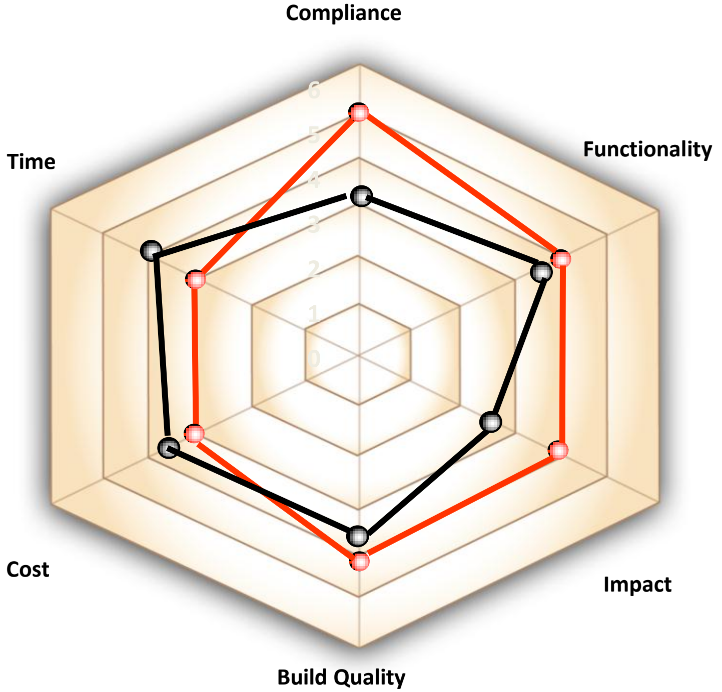
Source: Prof. Andrea Pelzeter: Lebenszykluskosten IST und SOLL Euroforum Konferenz 2008

Methods of optimisation: LCA and LCCA

Practical application | sustainable public procurement

Option – Cost Cutting Solution

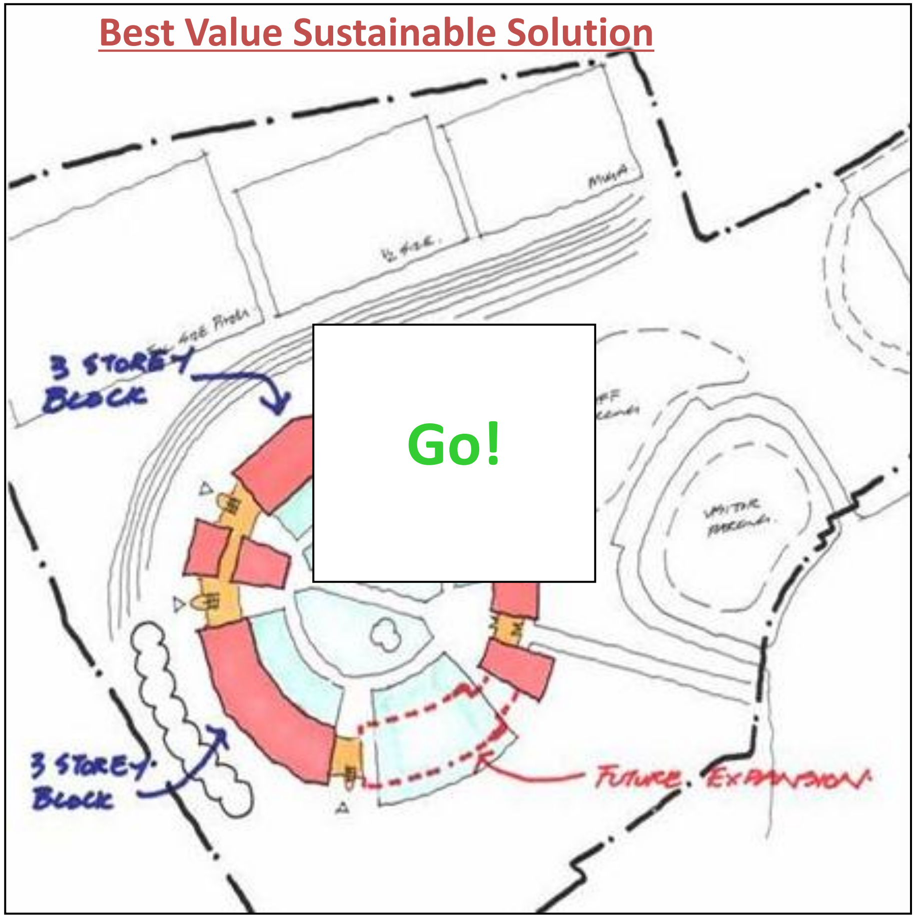


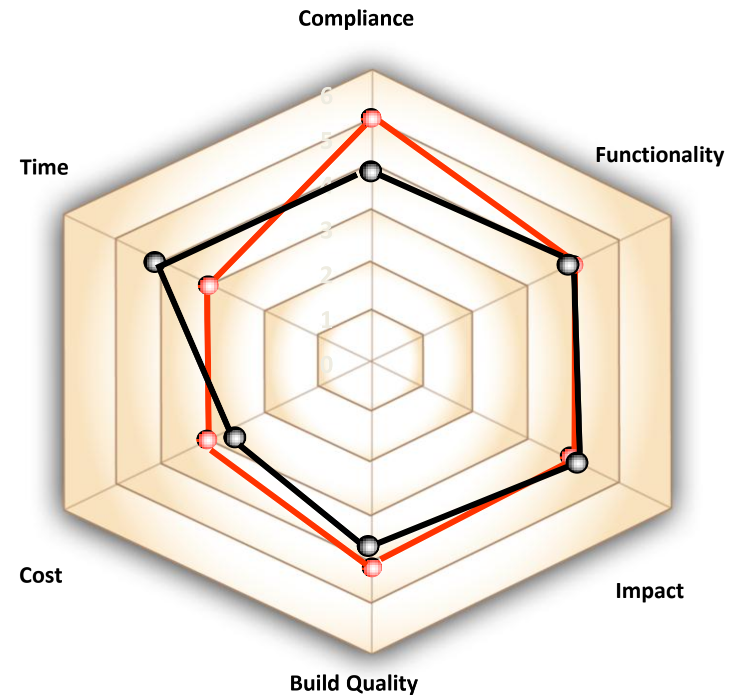


Source: Introducing the New Standards for Life Cycle Costing in Construction. BS ISO 15686-5:2008 for LCC and the New UK Supplements. Stockholm Conference, Friday 27th November 2009. Presented by Andrew Green

Methods of optimisation: LCA and LCCA

Practical application | sustainable public procurement

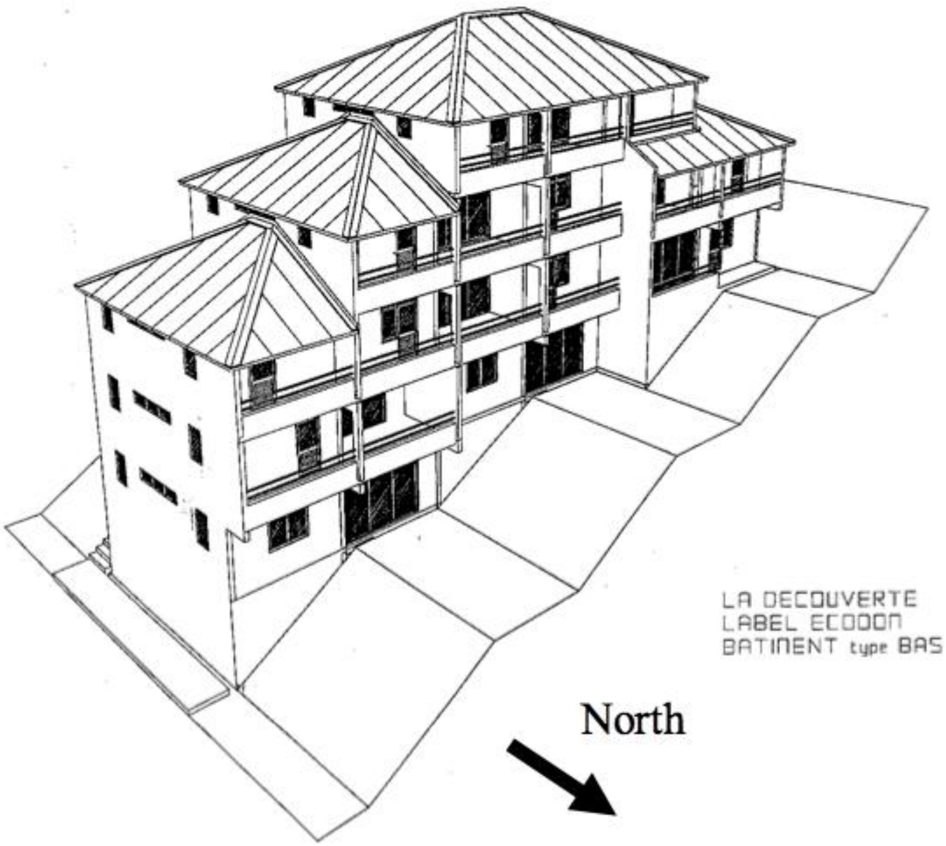




Source: Introducing the New Standards for Life Cycle Costing in Construction. BS ISO 15686-5:2008 for LCC and the New UK Supplements. Stockholm Conference, Friday 27th November 2009. Presented by Andrew Green

Energy efficient buildings

Building design in tropical climates | some elements



Position on site

Solar protection of walls and windows (shading)

Solar protection of the roof

Insulation of east and west sides

Natural ventilation

François Garde et al.: Building Design in Tropical Climates. Elaboration of the Ecodom Standard in the French Tropical Islands. ISES'99, International Solar Energy Society, Jérusalem, ISRAEL, Juin 1999

Energy efficient buildings

Features we should take into account

> Thermal capacity
> Insulation
> Passive heating
> Cooling elements
> Thermal bridges
> Installations for hot water supply
> Air-conditioning installations
> Natural and mechanical ventilation
> Built-in lighting installation
> The design, positioning and orientation of the building, including outdoor climate
> Passive solar systems and solar protection
> Indoor climatic conditions
> Internal loads
> Local solar exposure conditions, active solar systems and other electricity production based on renewable energy
> Electricity produced by cogeneration
> Natural lighting

Energy efficient buildings

Built examples | features

> **New U.S. Embassy Compound** – first LEED-certified building in West Africa Ouagadougou, **Burkina Faso**

(general contractor B.L. Harbert International of Birmingham, Alabama; architecture firm Page Southerland Page of Arlington, Virginia; Mechanical, Electrical and Plumbing by Hankins and Anderson of Glen Allen, Virginia)

> Features

> a host of green features

> occupancy sensors and daylight harvesting add to the sustainability by reducing energy consumption

Energy efficient buildings

Built examples | features

> uses solar energy for providing hot water and incorporates variable frequency drives

> facility has been equipped with low-flow and low-flush plumbing systems to reduce water wastage

> the used water undergoes treatment at a wetland within the building site and is filtered and recycled to be re-used for irrigation needs

Energy efficient buildings

Built examples | features

> First building with maximum energy efficiency in Barcelona, **Spain**

> Features

> Reduces (20%) energy consumption and reduces (50%) CO_2 emissions

> Systems for providing hot water and heating

> Efficient insulation systems

> Ventilated facades

> Windows with shading devices

> Flushing control mechanisms on cisterns

> Water-efficient taps

> Motion sensor light

> Low power elevators

Energy efficient buildings

Built examples | features

> Opera Village, Laongo, **Burkina Faso** (Kéré Architecture)

> Features

> Use of bioclimatic architecture principles

> Respect for the characteristics of the site

> Integration of local people, local workforce

> Use of local and low emboided energy materials (clay, laterite, cement bricks, gum wood and loam rendering)

> Self-constructed modules (simple basic modules)

Energy efficient buildings

Built examples | features

> Solar panels

> Rainwater collection

> Vented roof

> Due to large overhang of the roofs and massive walls, air conditioning could be discounted in most buildings

> Use of natural lighting

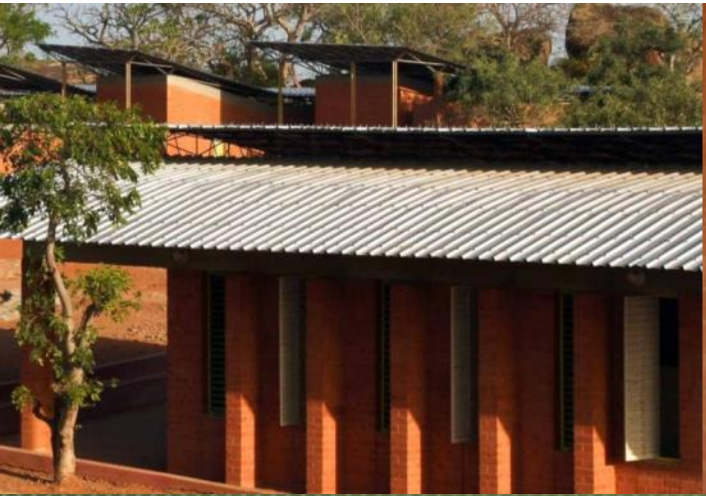


Energy efficient buildings

Built examples | features

> Windows with shading devices

> Solar cooker



Energy efficient buildings

Built examples | features

> SOLAR XXI building, INETI Campus, Lumiar, **Portugal**

> Features

> Optimization of thermal envelope

> Increase the area of solar heat gains – south solar façade, as a direct gain system for heating

> External shading devices in the south oriented windows

> Photovoltaic façade for electric use

> Photovoltaic system, shading devices, natural ventilation

Energy efficient buildings

Built examples | features

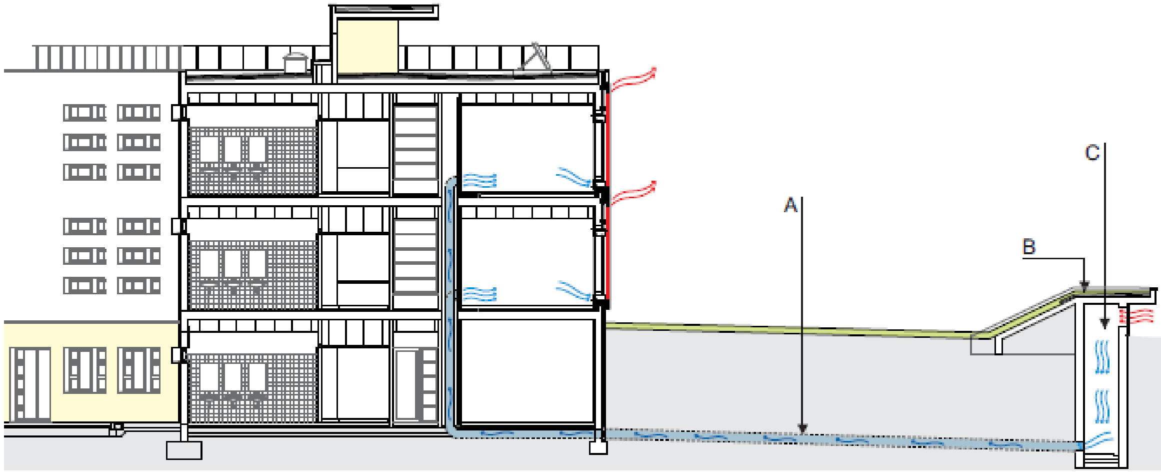
> Heat recovery by natural convection in the photovoltaic façade for indoor environmental heating

> Solar collectors for heating

> Natural ventilation

> Passive cooling system - using buried pipes

> Natural lighting



> Cooling air system through buried pipes

Thank you for your attention!

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