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

Organised by ECREEE

PRAIA, CABO VERDE, 9th-10th June 2014
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.”
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.
<table>
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<th>Cooling, ventilation</th>
<th>Lighting</th>
<th>Electric appliances</th>
<th>Hot water</th>
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<td>air conditioning</td>
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<td></td>
<td>Targeted program: efficient lighting</td>
<td>Targeted program: Eco-labels</td>
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The major amount of electricity is consumed for the following purposes:

- Cooling, ventilation, air conditioning
- Lighting
- Electric appliances
- 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
<table>
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<th>What people demand for</th>
<th>How to achieve what occupants demand for</th>
<th>Energy-efficient method</th>
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| 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) |
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

<table>
<thead>
<tr>
<th>Zone</th>
<th>Type of climate</th>
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<tr>
<td>AA</td>
<td>Very hot</td>
</tr>
<tr>
<td>A</td>
<td>Hot</td>
</tr>
<tr>
<td>B</td>
<td>Hot and humid</td>
</tr>
<tr>
<td>C</td>
<td>High humidity</td>
</tr>
<tr>
<td>D</td>
<td>Very dry</td>
</tr>
<tr>
<td>E</td>
<td>Very cold</td>
</tr>
</tbody>
</table>

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

Material / component production

Building construction

Building utilization

Maintenance & Refurbishment

End of life

Disposal

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.
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

No Go!

Presented by Andrew Green
Methods of optimisation: LCA and LCCA

Practical application | sustainable public procurement

Best Value Sustainable Solution

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

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%) CO2 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 embodied 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
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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SERA Sustainable Energy & Resources Availability

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