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

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

SERA Sustainable Energy & Resources Availability

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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

Energy efficiency in buildings reduces consumption and peak load!

Electricity networks cause massive distribution losses

High electricity peak demand (e.g. in the evening)
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.
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
<table>
<thead>
<tr>
<th>What people demand for</th>
<th>How to achieve what occupants demand for</th>
<th>Energy-efficient method</th>
</tr>
</thead>
</table>
| **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

<table>
<thead>
<tr>
<th>Zone</th>
<th>Type of climate</th>
</tr>
</thead>
<tbody>
<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
Improving the energy efficiency in buildings

Energy efficient buildings must provide comfort solutions

<table>
<thead>
<tr>
<th>Zone</th>
<th>Type</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>Very hot</td>
<td>Evaporative cooling</td>
</tr>
<tr>
<td>A</td>
<td>Hot</td>
<td>Evaporative cooling &amp; wind velocity</td>
</tr>
<tr>
<td>B</td>
<td>Hot and humid</td>
<td>Wind velocity</td>
</tr>
<tr>
<td>C</td>
<td>High humidity</td>
<td>Dehumidifying</td>
</tr>
<tr>
<td>D</td>
<td>Very dry</td>
<td>Humidifying</td>
</tr>
<tr>
<td>E</td>
<td>Very cold</td>
<td>Solar radiation</td>
</tr>
</tbody>
</table>

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
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

Whole Life Cost (WLC)

Life Cycle Cost (LCC)

Non Construction Costs

Construction

Income

Maintenance

Operation

Occupancy

Externalities

End of Life
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!

Methods of optimisation: LCA and LCCA

Practical application | sustainable public procurement

Best Value Sustainable Solution

Position on site

Solar protection of walls and windows (shading)

Solar protection of the roof

Insulation of east and west sides

Natural ventilation

Thank you for your attention!

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