International Workshop:
Improving Access to Sustainable Energy - Sustainable Built Environments

Workshop Handbook

Kampala, Uganda
22 - 25 October 2007

Workshop Coordinators:

International Solar Energy Society (ISES)
Wiesentalstr. 50, 79115
Freiburg, Germany

Uganda Martyrs University
Faculty of Building Technology and Environment
P.O. Box 5498
Kampala, Uganda

In cooperation with
Commonwealth Association of Architects

Supported by:

Intelligent Energy

UGANDA SOCIETY OF ARCHITECTS
List of PREA Project Sponsors

International Solar Energy Society (ISES)
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79115 Freiburg, Germany
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Fax: +49 (0)761 45906-99
http://www.ises.org

London Metropolitan University,
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School of Architecture and Spatial Design (ASD)
40-44 Holloway Road
London N7 8JL, U.K.
Tel.: +44 (0)20 7133 2178
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http://www.learn.londonmet.ac.uk

The Uganda Martyrs University (UMU),
The Faculty of Building Technology and Architecture
P.O. Box 5498
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Fax: +256 (0)38 410100
http://www.umu.ac.ug/

The University of Athens
Group of Building Environmental Research (GRBES)
Building of Phzsics – 5
157 84 Athens, Greece
Tel.: +302 107276847
Fax: +302 107295282
http://grbes.phys.uoa.gr/

The University of Dar es Salaam
College of Engineering and Technology
In collaboration with University College of Lands
and Architectural Studies (UCLAS)
P O Box 35131
Dar es Salaam, Tanzania
Tel.: +255 (0)22 2410752
Fax: +255 (0)22 2410752
http://ce.udsm.ac.tz

PREA Workshop 2007
List of PREA Project Sponsors

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Fax: +49 (0)231 755 5423
http://www.bauwesen.uni-dortmund.de/ka/

The University of La Rochelle
Civil and Mechanical Engineering Department
Av. M. Crépeau
17000 La Rochelle, France
Tel. +33 5 4645 7259
Fax. +0033 5 4645 8241
http://www.univ-lr.fr/labo/leptab/

The University of the Witwatersrand (WITS)
School of Architecture and Planning
Private Bag, 3, WITS 2050,
Johannesburg , South Africa
Tel: +27 11 717 7643
Fax: +27 11 717 7649
http://www.wits.ac.za
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<td><strong>SESSION 1: ENERGY and POLICIES I</strong></td>
<td><strong>SESSION 5: CLIMATE AND COMFORT</strong></td>
<td><strong>SESSION 9: SUSTAINABLE DESIGN III</strong></td>
<td><strong>SESSION 13: SUSTAINABLE DESIGN IV</strong></td>
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<td>09:15 – 09:30</td>
<td>WELCOME AND INTRODUCTION: Prof. Dr. Helmut Müller</td>
<td>09:15 – 09:30</td>
<td>INTRODUCTION AND RECAP</td>
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<td>09:30 – 09:45</td>
<td>OPENING REMARKS: USA</td>
<td>09:30 – 09:50</td>
<td>PAPER: MICRO-CLIMATE - Mr. Konstantinos Pavlou</td>
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<td>REFRESHMENTS</td>
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<td>11:35 – 11:55</td>
<td>PAPER: RENEWABLE ENERGY POLICY ISSUES IN HUMAN SETTLEMENTS - THE CASE OF TANZANIA - Dr. Levin Mosha</td>
<td>11:35 – 12:15</td>
<td>INTRODUCTION TO WORKSHOP GROUPS and LEADERS</td>
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<td>14:00 – 14:40</td>
<td>KEYNOTE: THE HOLCIM AWARDS FOR SUSTAINABLE CONSTRUCTIONS - Dr. Daniel Irurah</td>
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<td>THE SUSTAINABILITY GUIDE: ECONOMIC FACTORS - Llewellyn van Wyk</td>
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<td>14:40 – 15:20</td>
<td>BUILDING INTEGRATED PHOTOVOLTAICS - Prof. Dr. Helmut Müller</td>
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<td>15:30 – 16:00</td>
<td>PAPER: THE SUSTAINABILITY AGENDA (Introduction to the Sustainability Guide) - Llewellyn van Wyk</td>
<td>16:00 – 16:15</td>
<td>PAPER: EDUCATION PREA PROJECT OVERVIEW - Ms. Rosewitha Piesch</td>
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<td>16:15 – 16:30</td>
<td>PAPER: SUSTAINABILITY PROGRAMME AT THE UNIVERSITY OF THE WITWATERSRAND - Dr. Daniel Irurah</td>
<td>16:00 – 17:00</td>
<td>PLANNING METHODS &amp; TOOLS</td>
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<td>DISCUSSION</td>
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Dear Participant,

Welcome to the PREA Workshop 2007!

We hope this workshop will be a training event you will never forget. ISES, in cooperation with University of the Witwatersrand, the University of Dar es Salaam and Uganda Martyrs University wish you a fruitful learning and working experience.

This is the second workshop series being held within the framework of the European Commission supported project Promoting Renewable Energy in Africa (PREA). PREA is an international co-operation project between African and European Universities and ISES. PREA aims to promote the wider use of renewable energy in the urban environment of Africa, in support of poverty reduction, improved living conditions and sustainable development. The project consists of a two series of workshops on the themes on renewable energies and the built environment. The second part of the project is an MSc course to be integrated at the African partner universities. We will be presenting on the progress of the MSc courses during the workshop as well.

Throughout their life-spans building contribute significantly to energy waste and pollution, releasing an alarming amount of harmful emissions and contributing to climate change. Therefore professionals in the building fields - architects, building engineers, consultants and property managers - as well as local decision makers, such as housing authorities, municipalities and city planners must be aware of how to build and design properly to decrease the environmental impact of buildings. Reducing energy consumption and utilizing renewable sources of energy are an essential part of this. Through this workshop we hope you will gain knowledge on the use of sustainable and energy efficient architecture strategies and technologies to meet the challenges of building today.

ISES organises regional training events all over the world, and aims to provide participants with useful information on topical issues to promote sustainability in the built environment. As an international non-governmental organisation (NGO) we offer international and interdisciplinary events, providing unique opportunities to learn and exchange ideas with other participants and lecturers from many different countries who have extensive experience in these fields. Interaction is seen as integral part of this course, and we encourage you to share your ideas with the other participants and the lecture team.

We encourage you to take the knowledge you gain here, with you into your research and carriers. We wish you a successful workshop, and hope you will keep in touch with us.

With solar regards,

INTERNATIONAL SOLAR ENERGY SOCIETY

Christine Hornstein
Executive Director
INTRODUCTION
Commonwealth Heads of Governments Meeting (CHOGM) 2007 with the theme 'Transforming Commonwealth Societies to achieve Political, Economic and Human Development' will be held in Kampala, Uganda in November 2007.

An essential aim of CHOGM is to provide civil society in the host country with a legacy that will strengthen its capacity to achieve Commonwealth goals and the meeting is now always preceded by a 'Peoples Forum' comprising a series of workshops organised by the Commonwealth Foundation. The overriding objective of Peoples Forums are to allow civil society across the Commonwealth to express their views to the Heads of Government and influence the CHOGM agenda.

The most significant development of recent CHOGMs has been the developing mechanism for dialogue between Civil Society and government to bring issues forward and influence the content of the Communiqué issued by the Heads at the conclusion of their meeting. The Communiqué is essentially the action plan for the work of the Commonwealth.

At the Kampala CHOGM representatives of the Peoples Forum will meet Commonwealth Finance Ministers to raise the key issues identified at the Peoples Forum.

Built Environment Professions in the Commonwealth (BEPIC), an informal partnership between the Commonwealth Associations of Engineers, Planners, Surveyors and Architects - is organising one of the 20 official workshops as part of the Commonwealth People's Forum. The BEPIC workshop 'Towns and Cities - Realising people's potential through urban development', aims to meet these objectives by demonstrating that there can be no sustainable development without sustainable urbanisation. The one day workshop will highlight evidence and examples of how the social and environmental benefits of urban economic growth can be captured through effective governance and disseminate generic skills and identify actions to achieve urban growth to realise peoples' potential.

The Commonwealth Association of Architects contribution to the workshop is to consider frameworks for implementing sustainable infrastructure development using the example of its Architect's Guide to designing for Sustainability and to demonstrate practical application in the Ugandan context.

This then was the starting point of the Workshop on Sustainable Built Environments which CAA has supported in collaboration with the Consortium - Promoting Renewable Energy in Africa (PREA), the Faculty of Building Technology and Architecture, Uganda Martyrs University and the Uganda Society of Architects.

Presentations by speakers from Uganda and other part of Africa on aspects of sustainable Design will be followed by study sessions in which participants, students and practitioners, will carry out a 'Sustainability' analysis on a number of local housing projects identified by the National Housing and Construction company of Uganda, using the framework of the guide.

The Architect's Guide to designing for Sustainability and the outcomes of the workshop sessions will be reported to the BEPIC Workshop in a presentation by local coordinator Mark Olweny, Associate Dean/Senior Lecturer, Faculty of Building Technology and Architecture, Uganda Martyrs University.
CAA is passionate about the issue of Sustainability, introduced as a programme area by President David Jackson of Australia in 1991, and which now informs all components of its work programme. We are also passionate about networking to exchange and build architecture knowledge and professional standards. In particular networking at a regional level.

This workshop therefore matches our core objectives and is set to be a stimulating event which we hope can be a model for similar workshops in other CAA member countries.

CAA cannot work with collaboration and we are grateful to all the other organisations involved particular those hosting the event in Uganda, We are also grateful for the participation of other member countries institutes and schools of architecture in the region.

Information on the CHOGM can be found at http://www.chogm2007.ug/

Tony Godwin
EXECUTIVE DIRECTOR
Commonwealth Association of Architects
PREA – Promoting Renewable Energies in Africa
PREA Workshops, Stellenbosch, Dar es Salaam, Kampala, October 2007

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University of Dortmund
Germany

Helmut F.O. Müller, Prof. Dr.
Environmental Architecture, University Dortmund

PREA Workshops, Stellenbosch, Dar es Salaam, Kampala, October 2007

Project survey

Full title: Promoting Renewable Energies in Africa
Acronym: PREA
Proposal identification number: EIE/05/12/1924.20032 – PREA

Supported by:
European Commission
relating to the implementation of an action in the framework of the

Overview
Outline
Energy and Climate
IPSS, Parks and Patios
Schedule
Workpackages

Objectives

Access to renewable Energy and Sustainable Building Technology for:

- Poverty Reduction
- Improved Living Conditions
- Sustainable Development
PREA – Promoting Renewable Energies in Africa
PREA Workshops, Stellenbosch, Dar es Salaam, Kampala, October 2007
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World energy demand
(Source: Jahresbericht GVSt 2004)

Overview
Outline
Energy and Climate
PREA Tasks and Partners
Schedule
Workpackages

PREA Tasks

African – European Collaboration in Education:

6 Workshops in South Africa, Tanzania & Uganda

3 MSc Courses in African Universities

African Universities:

University of Witwatersrand, Johannesburg, South Africa
University of Dar es Salaam, Tanzania
Uganda Martyrs University
### European partners:

- University of Dortmund
- London Metropolitan University
- National and Kapodestrian University of Athens
- University of La Rochelle
- ISES International Solar Energy Society

### Master Courses

Capacity building in education and training at 3 African universities for building- and energy professions.

- Organization and implementation,
- Development of curricula.

Application and adaptation of European MSc Course INREB Integration of Renewable Energies in Buildings

### University of Witwatersrand, Johannesburg, South Africa

Postgraduate offers in Energy and Built Environment:
- Design and Construction modules in Architecture and Housing
- Masters and PhD research and thesis
- Continued Professional Development (architects)
- Short Certificate Courses

Co-operation with Stellenbosch University
### University of Dar es Salaam,
College of Engineering and Technology &
University College of Lands and
Architectural Studies (now Ardi-University)

**MSc with interdisciplinary contributions:**
Civil Engineering, Architecture, Urban
Design, Environmental Engineering, Energy
Engineering, Electrical Engineering,
Physics, Geophysics, Building Economics

### Uganda Martyrs University,
School of Built Environment

**MSc in postgraduate module**
**Special Topics of Environmental Design**
(Architecture, Building Technology and
Urban Design)

### Key Areas of Curricula:
- Thermal comfort and passive thermal control
- Active thermal control and energy efficiency
- Natural and mechanical ventilation
- Daylighting and lighting
- Materials and embodied energy
- Renewable energy technologies in building settlements
- Energy planning, policy and and finance
  (macro scale perspectives)
Workshops
“Improving Access to Sustainable Energy”

in South Africa, Tanzania, and Uganda, organized by ISES and 3 African Universities, in 2006 and 2007, for key actors in:

- Policy and industry
- Local authorities
- Building- and energy professions
- Higher education

Conclusions
Half way of project duration 2006 – 2008
Dialogue and know-how transfer: N-S, S-N, S-S
General similarities and local specificities
Continuation and new projects
Information: http://prea.ises.org
Africa is currently characterized by energy poverty and unsustainable use of both fossil and renewable energies, while there is an abundance of renewable energy resources. Africa is endowed with 95% of the world’s best winter sunshine.

This paper shows that buildings typically consume 40-50% of the national energy. Buildings last many decades, outlasting power stations by a factor 3 to 4. In addition, energy efficient buildings are cheaper to construct than providing new power stations and networks. Therefore, energy efficient buildings should be a national priority. It is shown that energy use in buildings is driven by a lack of indoor comfort. This is described as being visual, acoustic and thermal comfort. Thermal comfort is defined as a climate dependant variable in contrast to the mechanistic ASHRAE dogma. Consequently, high energy use is an indicator of poor architectural design. Architects and engineers should be paid according to the energy they save.

Using the psychrometric chart of a given local climate, various architectural design strategies are illustrated graphically and by photos.
Overview

- Energy impact of buildings
- Driver of energy use
- Thermal comfort
- Design strategies
- Summary

Energy impact of buildings

- Buildings demand 40-50% of national energy
- Buildings last decades
- EE buildings are cheaper than power stations
Driver of energy use

- Energy use is driven by the lack of indoor comfort
- Indoor comfort: visual, acoustic, thermal
- The more energy used, the worse the architectural design

Thermal comfort

For naturally ventilated buildings
\[
T_n = 17,8°C + 0,31T_o \pm 3,5K (80\% \text{ acceptance}) \\
T_n = 17,8°C + 0,31T_o \pm 1,2K (90\% \text{ acceptance})
\]
where
\[T_n = \text{neutrality temperature}\]
\[T_o = \text{average outdoor temperature}\]

Thermal comfort continued

- Thermal comfort is dynamic
- Depends on average outdoor temperature
- Limits of validity: $17,8°C < T_n < 29,5°C$
- Different from ASHRAE standards
- Leads to energy efficiency
Design strategies

- Implement resource efficiency
- Implement energy efficiency
- Identify local climate
- Visualise potential climate control zone
- Develop detail strategy
- Account for building management

Psychrometric chart
Window heating strategy
Evaporative cooling strategy

Shading strategy

Danae Holm
Summary

Energy efficiency in buildings:
• should be a national priority
• can be achieved by conventional means
• demands more design input
• requires more capital outlay
• saves in the long-term: health and energy costs
THANK YOU
Curriculum Vitae

Prof. Dieter Holm
ISES Secretary

Date of Birth: 3 March 1936
Place of Birth: Pietermaritzburg, South Africa

Professional Education:

1955 – 1959: BArch, University of Pretoria, South Africa
1969 -1971: MArch, University of Pretoria, South Africa
1983 -1985: DArch, University of Pretoria, South Africa

Professional Experience:

Consultant for Sustainable Development in the Built Environment
He does policy related research on the application of energy efficiency and renewable energies and lives in the first modern African self-sufficient home-office.

Previously he was Head of Research and Post Graduate Study, Division for Environmental Design and Management at the University of Pretoria.

Lecturer in Architecture, UP 1967/05/05
Senior lecturer in Architecture, UP 1971/06/01.
Associate professor in Architecture, UP 1973/07/01
Professor/Head of Department, UP 1985/10/01

Recent Conference Papers


Recent Publications:


Prizes / Awards:

- ISES Special Service Award 2007
- Star Competition Special Prize
- Generaal J B M Hertzog-monument,
- Bloemfontein First Prize
- Langenhoven student centre First Prize
- University of Stellenbosch First Prize
- Vegkop Competition, Heilbron First Prize
- Building Industries Federation of SA (BIFSA) Competition, Midrand First Prize
- Lutheran Church, The Willows First Prize
- ”Plan”, Official journal of the Institute and predecessor to ”Architecture SA” dedicates a whole issue to Holm Beyers and Holm.
- Phoenix, Munitoria Building, Pretoria, First Prize.
- Austin Whillier award, 1983
- Eta award
Energy in the building sector

Buildings and users

Expectations
- Comfort
  (thermal, visual, acoustic)
- Healthy environment
  (good indoor quality)
- Minimum capital and running cost

Example – short description
- Five store building located in Dar Es Salaam
- Glass facades
- Single, high reflective glazing
- Air – conditioned area of 320m² per floor
- Non insulated
Example – short description

- Schedule, working days 08:00 – 18:00
- 10 persons / 100m²
- 25.5m³ / person
- Installed lighting power, 20Watt/m²
- Fluorescent lamps
- Additional internal gains for equipment, 5Watt/m²

Estimated cooling load in kWh/m²

Thermal comfort conditions - PMV

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<td>0.2</td>
<td>0.3</td>
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</table>
Thermal comfort conditions - PPD

<table>
<thead>
<tr>
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<th>9:00</th>
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<td>47</td>
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<td>44</td>
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</tr>
</tbody>
</table>

Glass buildings in hot climates?

Under circumstances they may offer acceptable thermal comfort

They have lower construction cost

They are prestigious buildings

The offer acceptable but not good thermal comfort conditions.

They have very high running cost, which is paid by the user

Possible interventions (1)

- Keeping the original design
  - Some external shading
  - Free cooling
  - Demand control ventilation

124.1 kWh/m²

96.2 kWh/m²

New design

- Less openings
  - Some external shading
  - Free cooling
  - Demand control ventilation

124.1 kWh/m²

74.6 kWh/m²
Thermal comfort conditions

<table>
<thead>
<tr>
<th></th>
<th>No interventions</th>
<th>Keeping the original design</th>
<th>New design</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PMV</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Yearly average</td>
<td>0.90</td>
<td>0.70</td>
<td>0.40</td>
</tr>
<tr>
<td>from 08:00 to 18:00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PMV</strong></td>
<td></td>
<td>28.5</td>
<td>22.4</td>
</tr>
<tr>
<td>Yearly average</td>
<td>0.90</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>28.5</td>
<td>22.4</td>
</tr>
</tbody>
</table>

Required PV modules

<table>
<thead>
<tr>
<th></th>
<th>No interventions</th>
<th>Keeping the original design</th>
<th>New design</th>
</tr>
</thead>
<tbody>
<tr>
<td>**Estimated annual **</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cooling load in kWh/m²</td>
<td>124.1</td>
<td>96.2</td>
<td>74.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Estimated area of</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high efficient PV</td>
<td>54m²</td>
<td>42m²</td>
<td>32m²</td>
</tr>
<tr>
<td>modules for cooling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>the last floor</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The assumptions that have been done are:
- The efficiency of the cooling systems (COP) is 2.7
- The efficiency of the PV modules system is 14%

Addressing solutions

- Energy conservation
- Improving energy efficiency
- Use of renewable energy
Energy conservation
- Simple technological solutions
- Long average expected life time
- Low to medium capital cost
- Low running cost
- Most of the money remain to local market
- Generally short payback period

Improving energy efficiency
- Advanced technological solutions
- Medium average expected life time
- Medium to high capital cost
- High running cost
- Medium to long payback period

Use of renewable energy
- Long average expected life time
- Unstable energy flow
- High capital cost
- Low running cost
- Medium to long payback period
- Low investment for infrastructure
Promoting renewable energy for buildings

- Rather simple technologies
- Long average expected life time
- Unstable energy flow
  *Combination of technologies can loose the problem*

- High capital cost
  *The energy demand of the building affects from the condition of the building skin and the systems, therefore the capital cost for RES could be much lower for low energy buildings*
- Low running cost

- Medium to long payback period
  *The payback period of RES is comparable to the expected life time of building’s systems which are generally accepted.*
- Low investment for infrastructure
Micro climate and passive thermal control

Kostas Pavlou (konpavlou@phys.uoa.gr)
Pr. Mat Santamouris (msantamo@phys.uoa.gr)
Group Building Environmental Research,
University of Athens, Athens, Greece

Which is the current situation

- Very high energy consumption
- Thermally dissatisfied users
- Serious environmental problems such as the heat island phenomenon, bad air quality
- Insufficient power

Urbanization

Low available income

Environmental problems

Higher income

Higher energy consumption

Shift of desired thermal comfort conditions

Environmental problems

Even higher energy consumption

Higher peak load
Lower income

Thermally dissatisfied people

Thermal stress

More intensive environmental problems

Use of low quality systems

Even higher energy consumption

Higher peak load

Air quality problems

The heat island effect

As a consequence of heat balance, air temperatures in densely built urban areas are higher than the temperatures of the surrounding rural country.

This phenomenon known as ‘heat island’, increases electricity demand for air conditioning of buildings, while contributing to increased emission of pollutants from power plants. The peak electricity load is also increased.

Is the cost for all of us the same?

No, the cost is not the same for all of us. Usually the people with lower income live in:

- More dense area – around city center
- In suburban areas – higher transportation cost
- Lower quality buildings and therefore they may have to pay more for energy per m²

So, they have to give a bigger percentage of their income for energy.
Are any solutions?

- Improvement of the urban microclimate to fight the effect of heat island and temperature increase and the corresponding increase of the cooling demand in buildings.
- Adaptation of buildings to the specific environmental conditions of cities in order to efficiently incorporate energy efficient renewable technologies to address the radical changes and transformations of the radiative, thermal, moisture and aerodynamic characteristics of the urban environment.

Possible solutions for improving microclimate?

- the increased use of green areas,
- the use of appropriate materials, in particular of white and colored high reflective coatings
- decrease of anthropogenic heat from building use, transportation, industry production
- use of cool sinks for heat dissipation,
- appropriate layout of urban canopies involving the use of solar control, techniques to enhance air flow, etc.

Increased use of green areas

Increasing number of buildings has crowded out vegetation and trees even they significantly contribute to cool our cities and save energy.

Trees can provide solar protection to individual houses during the summer period while evapotranspiration from trees can reduce urban temperatures.

Trees also help mitigate the greenhouse effect, filter pollutants, mask noise, prevent erosion.
Increased use of green areas

The surface of Urban green areas may increase either by the creation of new urban parks or by integration of green species on the surface of the urban buildings.

Many recent studies on urban parks have shown that parks contribute to reduce air temperatures in the adjacent neighbourhoods however, this effect was limited to a relatively small zone, which extended only 200-400 m from the margin of a large park on a calm day. It is found that parks need a size of at least one hectare to have a significant climatic effect and thus a dense network of public green spaces is necessary.

Background - Radiative cooling

While buildings absorb solar radiation during the day time, during the night, they emit more infrared radiation than they absorb. Thus, buildings are cooled. This technique works effectively when the sky is clear.

Do decrease the solar gains the ideal coatings should be:

• high reflective
• high coefficient of emittance in long wave radiation

Energy impact of "cool" paints

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Insulated</th>
<th>Non-Insulated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Athens</td>
<td>1.8 °C</td>
<td>6.1 °C</td>
</tr>
<tr>
<td>A/C Building</td>
<td>4.6 °C</td>
<td></td>
</tr>
</tbody>
</table>

A/C Building Buildings: Reduction of the Peak Indoor Temperature

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Insulated</th>
<th>Non-Insulated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>13 %</td>
<td>31 %</td>
</tr>
<tr>
<td>Office</td>
<td>8 %</td>
<td>58 %</td>
</tr>
</tbody>
</table>

Free Floating Buildings: Reduction of the Cooling Load
1. PROTECTION FROM HEAT GAINS: Landscaping, Building form, Layout and External Finishing, Solar Control, Thermal Insulation, Control of Internal Gains

2. MODULATION OF HEAT GAINS: Use of the thermal capacity of the building.

3. HEAT DISSIPATION: Rejection of the excess heat to an environmental heat sink, (Evaporative, Convective, Ground)

---

**Passive thermal control**

---

**Solar control**

- Exterior systems
- Solar control glass
- Shading devices integrated into the gap of insulating glass units
- Interior systems
- Radiant bars

---

Internal shading devices are less efficient than the external because solar radiation partly enters the building. Internal shading devices should permit natural ventilation and transmission of daylight.

A combination of external and internal shading devices can offer efficient solar control and visual comfort.
External shading

Solar control glass
- Absorbing glass
- Reflective glass
- Glass with sun reflective foils
- Holographic films
- Screen – print glass
- Glazing with variable transmission
The term Thermal mass describes the ability of ordinary building materials to store heat. In general, the heavier the material the more heat it will store. In summer the thermal mass soaks up the excess heat that enters through the building fabric reducing thus the peak indoor temperatures. During the night, the heat is slowly released to passing cool breezes that are moving through the building.

Evaporative cooling

When the air stream comes into direct contact with liquid water, the cooling equipment is characterised as DIRECT.

When the air is cooled without addition of moisture by passing through a heat exchanger which uses a secondary stream of air or water, the cooling equipment is characterised as INDIRECT.

Evaporative cooling - limitations

DIRECT: Only Where and When the maximum Wet Bulb Temperature in summer is about 22°C and the maximum dry bulb temperature is about 42°C.

INDIRECT: As the indoor humidity is not elevated by indirect evaporative cooling, it is possible to apply in places where the maximum wet bulb temperature is 24°C and the maximum dry bulb temperature is 44°C.
Ground cooling

During the summer the soil temperature at certain depth is considerably lower than the ambient temperature. Therefore, ground offers an important sink for the dissipation of the buildings excess heat. There are two strategies for the use of the ground:

• Direct earth contact cooling
• Buried pipes

Ground cooling – buried pipes

The concept involves the use of metallic, PU or PVC buried pipes. Ambient or indoor air is delivered inside the tubes where it is pre-cooled and then is delivered to the building or the system.

When outdoor air is circulated into the pipes the system is characterised as an open loop system while when the indoor air is circulated from the building through the tubes the system is known as a closed-loop system.

Natural ventilation

The Pressure Difference across an opening is the driving force of ventilation. This is produced by the action of wind and temperature difference or / and by the operation of mechanical ventilation systems.
Solar Chimneys are ideal alternative ventilation techniques for the urban environment. May be used in deep urban canyons to promote air flow through vertical shafts.

Natural ventilation – wind towers

Wind Towers are traditionally used in urban areas as may catch the undisturbed wind flow. Inlets have to be positioned at the windward façade while outlets at the leeward one.
Thermal comfort in low carbon buildings

Fergus Nicol

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and OISD, Oxford Brookes University, Oxford OX3 0BP
f.nicol@londonmet.ac.uk

Comfort and buildings
Comfort has become increasingly costly in terms of energy use in buildings with the use of more sophisticated systems such as air conditioning.
Buildings are in any case responsible for 40-50% of the overall energy budget
This paper suggests ways in which low-carbon buildings can help reduce this
It also suggests how to fit buildings to people by conducting surveys

What is Thermal Comfort?

- That state of mind which expresses satisfaction with the thermal environment

<table>
<thead>
<tr>
<th>ASHRAE Scale</th>
<th>Bedford scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>+3 Hot</td>
<td>7 Much too warm</td>
</tr>
<tr>
<td>+2 Warm</td>
<td>6 Too warm</td>
</tr>
<tr>
<td>-2 Cool</td>
<td>2 Too cool</td>
</tr>
<tr>
<td>-3 Cold</td>
<td>1 Much too cool</td>
</tr>
</tbody>
</table>

Called the Comfort Vote
How do we achieve comfort

- People all over the world use a variety of means to achieve comfort
- Some change the environment to achieve comfort
- Others change ‘themselves’ (esp clothing) to achieve comfort
- ‘adaptive thermal comfort’ assumes these actions are a part of the comfort ‘equation’

Mean comfort votes from England, Singapore, Iraq and North India

Source: Humphreys & Nicol 1970

PAKISTAN:

Summer

Winter

Note posture as well as clothing
Open the windows!

Yazd, Iran

Yazd, Iran
Thermal comfort in the field

Michael Humphrey’s ‘survey of surveys’ 1975

Figure 3 Scatter diagram of standardized mean response and mean temperature
Source: Humphreys 1975

Figure 4 Scatter diagram of mean temperature and neutral temperature
Source: Humphreys 1975
More recent survey results

From Nicol & Humphreys Energy and Buildings 34 (6)

Extension of the ‘survey of surveys’ to outdoor temperature 1978

Source: Humphreys 1978

Comfort temperature

Comfort temperatures in European offices

Source: Humphreys 1978
Comfort is achieved by the occupants adapting to the building or by the occupants adapting the building to suit them. This has to be done within the climatic, social, economic and cultural context of the whole system.

Different controls are used in different circumstances.

Personal variables:

- Clothing insulation
- Air velocity
- Metabolic rate
- Skin moisture

Data from surveys in Pakistan.

Changes in use of windows, fans, and heaters with indoor temperature.

Data from surveys in Pakistan.
The result of these actions is shown in this graph of the level of discomfort at different indoor temperatures among office workers in Pakistan.

Another approach to thermal comfort

- “Creating thermal comfort for man is a primary purpose of the heating and air conditioning industry, and this has had a radical influence ... on the whole building industry”
- “…thermal comfort is the ‘product’ which is produced and sold to the customer…”

Thermal Comfort Models

- This meant developing models based on physics and physiology to define a psychological phenomenon (a ‘state of mind’)
- The best known of these, based on a ‘heat balance’ model is the ‘Predicted Mean Vote’ or PMV which predicts the average comfort vote of people on the basis of the temperature, humidity, air speed, and the amount of clothing worn by and the activity of occupants
Thermal Comfort Models

- PMV is based on a determinist scientific model which has been calibrated by experiments in special laboratories ‘climate chambers’ where the environment can be controlled by the experimenter
- In climate chambers the subjects are divorced from the ‘real’ variable world in which we all live

Thermal comfort standards

<table>
<thead>
<tr>
<th>Type of Building Space</th>
<th>Activity</th>
<th>Operative Temperature</th>
<th>Mean Air Velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Cooling</td>
<td>Heating</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Celsius</td>
<td>Celsius</td>
</tr>
<tr>
<td>Office</td>
<td>Clo.</td>
<td>0.5</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>24.5 ± 1.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>24.5 ± 2.5</td>
</tr>
<tr>
<td>Cafeteria/ Restaurant</td>
<td>Clo.</td>
<td>0.5</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
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<td>C</td>
<td>23.5 ± 2.5</td>
</tr>
<tr>
<td>Department Store</td>
<td>Clo.</td>
<td>0.5</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>23.0 ± 2.0</td>
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<td></td>
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<td>C</td>
<td>23.0 ± 3.0</td>
</tr>
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From Olesen and Parsons, Energy and Buildings 34(6)

Thermal comfort standards

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<td>C</td>
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</tr>
</tbody>
</table>

From Olesen and Parsons, Energy and Buildings 34(6)

'Standard' is incompatible with low-carbon buildings
Comproportions of CO₂-Production in air conditioned office buildings

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating &amp; Hot Water</td>
<td>32%</td>
</tr>
<tr>
<td>Cooling</td>
<td>13%</td>
</tr>
<tr>
<td>Pumps &amp; Fans</td>
<td>30%</td>
</tr>
<tr>
<td>Catering</td>
<td>4%</td>
</tr>
<tr>
<td>Lighting</td>
<td>21%</td>
</tr>
</tbody>
</table>

Courtesy Max Fordham

Comfort in low-carbon buildings

1. Environment should be within the comfort limits by use of shading, thermal mass (to control range of temperature) etc.
2. Building should allow occupants to control their environment by having opening windows, adjustable shades to keep sun out, fans for increased air movement.
3. Where possible occupants should feel free to adjust clothing, move to more comfortable places etc (management need to be aware of the 'cost' of a 'dress code')

Finding out what is comfortable

- Comfort is a social and cultural construct: we need to define it locally
- Conduct surveys to discover what temperatures are considered comfortable according to local, climate, culture and economic circumstances
- Investigate changes in comfort with season and the range of temperature (comfort zone)
What a survey can measure
Independent and dependant variables
- temperature
- humidity
- air velocity
- CO2 content
- background noise
- light
- subjective data (occupant satisfaction)
- clothing
- activity
- use of controls

---

What a survey can measure
subjective variables

**Comfort & preference:**
- temperature
- humidity
- air movement
- light level
- noise
- overall comfort
- air quality
- productivity

---

The trolley
- Contains: instrumentation and laptop to record questionnaire response simultaneously to collection of all physical data variables
The survey

Note use of controls

Note clothing

Lisbon, Portugal

SCATs comfort temperature


SCATs comfort temperature

- Below 10°C outdoor temperature the comfort temperature in European offices was more or less constant at 22-23°C
- Above 10°C outdoor temperature the comfort temperature indoors increases with outdoor temperature
- This is consistent with the findings from field surveys and adaptive comfort theory
Comfort temperature

Above 10°C outdoor temperature:

- Free-running buildings:
  \[ T_{\text{comf}} = 0.33 T_{\text{rm}} + 18.8 \]  \hspace{1cm} (1)

- Air conditioned buildings:
  \[ T_{\text{comf}} = 0.09 T_{\text{rm}} + 22.6 \]  \hspace{1cm} (2)

- \( T_{\text{comf}} \) is the comfort temperature
- \( T_{\text{rm}} \) is running mean outdoor temperature

Expected discomfort

Discomfort results from a deviation from the comfort temperature we would expect that discomfort is a function of \( T_{\text{diff}} \) where:

\[ T_{\text{diff}} = T_{g} - T_{\text{comf}} \]  \hspace{1cm} (3)

- \( T_{g} \) is the globe (operative) temperature

Comfort variations

### Chart

- Comfort
- Temperature
-图表

### Table

<table>
<thead>
<tr>
<th>Percent</th>
<th>Tdiff (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>-5</td>
</tr>
<tr>
<td>10%</td>
<td>-4</td>
</tr>
<tr>
<td>20%</td>
<td>-3</td>
</tr>
<tr>
<td>30%</td>
<td>-2</td>
</tr>
<tr>
<td>40%</td>
<td>-1</td>
</tr>
<tr>
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<td>70%</td>
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<td>3</td>
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<tr>
<td>90%</td>
<td>4</td>
</tr>
<tr>
<td>100%</td>
<td>5</td>
</tr>
</tbody>
</table>

- Values range from -5°C to 5°C
Inclusion in Standards

The adaptive approach is now included in some standards and guides for comfort:

- ASHRAE Standard 55-2004
- Dutch adaptive Standard (2005?)
- CIBSE Guide Section A1 2006
- **CEN Standard EN15251:2007**

CEN standard EN15251 2007

- Indoor environmental input parameters for design and assessment of energy performance of buildings- addressing indoor air quality, thermal environment, lighting and acoustics
- Provides environmental conditions based on comfort and acceptability in buildings
- Thermal conditions divide buildings into Mechanically ventilated and Free Running
Categories in EN15251

<table>
<thead>
<tr>
<th>Category</th>
<th>Applicability/level of expectancy</th>
<th>Temp range</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>High: Buildings with high expectancy for sensitive occupants</td>
<td>± 2K</td>
</tr>
<tr>
<td>II</td>
<td>Normal: New buildings</td>
<td>± 3K</td>
</tr>
<tr>
<td>III</td>
<td>Acceptable: Existing buildings</td>
<td>± 4K</td>
</tr>
<tr>
<td>IV</td>
<td>Low expectancy only for short periods</td>
<td>± &gt;4K</td>
</tr>
</tbody>
</table>

Thermal limits for Mech. ventilation:
- Category I: ± 0.2 PMV
- Category II: ± 0.5 PMV
- Category III: ± 0.7 PMV
- Category IV: ± > 0.7 PMV

Clothing/Met values are not specified so there is room for a range of indoor temperatures to take account of energy efficiency (though examples are given e.g offices 20-26°C)
Running mean temperature

The exponentially weighted running mean of the daily mean outdoor air temperature \( t_{rm} \) is calculated from the formula:

\[
t_{rm} = (1-\alpha) t_{od-1} + \alpha t_{od-2} + \alpha^2 t_{od-3} + \ldots \quad (a)
\]

Where \( t_{od-1} \) is the daily mean outdoor temperature for the previous day, \( t_{od-2} \) for the day before and so on. \( \alpha \) is a constant between 0 and 1 which defines the speed at which the running mean responds to the outdoor temperature.

Running mean temperature

Equation (a) reduces to:

\[
n_{trm} = (1-\alpha) t_{od-1} + \alpha n-1_{trm} \quad (b)
\]

Where \( n_{trm} \) is the running mean temperature for day \( n \) etc. So if the running mean has been calculated (or approximated) for one day, then it can be readily calculated for the next day.

An \( \alpha \) of 0.8 is recommended.
Conclusions

• There is no temperature at which everyone will feel comfortable, comfort is a psychological state defined by climate, culture and economics
• Good low-carbon buildings will provide
  1. Appropriate indoor conditions
  2. Possibilities for adjustment
  3. Freedom to adapt

Conclusions

• 'Adaptive comfort' allows for a variation in comfort temperature in buildings especially those which are not mechanically cooled.
• The comfort temperature can be found using field studies in buildings.
• Such field studies should use local people adapted to the climate and going about their normal daily business.
INTERNATIONAL CONFERENCE
AIR-CONDITIONING & THE LOW CARBON COOLING
CHALLENGE
27th-29th July 2008
Cumberland Lodge, Windsor Great Park, UK
Organised by the NCEUB
Contributions are invited in the following areas:
The role of cooling in comfort, productivity and energy use in different climates
Strategies for reducing reliance on AC
Adaptive behavior in AC and NV buildings: mechanical cooling and passive controls
Standards for comfort and energy use in buildings
Thermal comfort in the context of energy performance regulations
The role of renewable energy in cool buildings
Impacts of climate change, urban heat island and rising fuel costs
Practical issues for low or zero carbon cooling
Case studies of mixed-mode systems
Improving building simulation
Details from Fergus Nicol Janet Rudge or from: www.aceub.org.uk
Consider a perfectly consistent person. As the room temperature rises the window is opened at the closed/open trigger temperature.

As the room temperature falls the window is closed at the open/closed trigger temperature.
In the ‘deadband’ there is no need to close the window if it is open, or to open it if it is closed. The window status is indeterminate.

Include a random variation of the trigger temperature. As the room temperature rises, more people will open their window until all have opened it. And then if the room cools, more will close it till all are closed.

The centre of the deadband at the 50% level is the median ‘comfort temperature’ for the population. (Comfort temperatures are subject to seasonal variation, so the whole figure can ‘slide’ right or left…)

Include a random variation of the trigger temperature. As the room temperature rises, more people will open their window until all have opened it. And then if the room cools, more will close it till all are closed.
If the room cools before all have opened their window, those who have opened it have no need to close it, and those who have not opened it have no need to do so. There is therefore a horizontal ‘grain’ within the deadband.

This applies for any proportion of window open. Real data should therefore lie between the two curves. So the loop is the envelope of all possible observations of the proportion of windows open.

**Fitting procedure for the model**

1. Group the observations (after sorting by sequence and room temperature)
2. Calculate the proportion of windows open in each group
3. Transform the proportions to Logits (log(p/q))
4. Regress room temperature on the Logits (regression this way is correct because of the horizontal ‘grain’ within the deadband)
5. Adjust the regression for the binomial error in the logits
6. Take deadband as ±1.5 s.d. of temp residual (to include some 80-90% of the observations)
7. Calculate equations of zone margins
8. Transform from logits back to proportions.
Windows and fans in Pakistan

Developing an adaptive algorithm for window opening (or switching on fans).

- The relationship between people and their office windows is a dynamic one
- Even in winter, there is an active use of windows, raising questions for both comfort and energy use in buildings.
- An algorithm has been developed for the use of window opening which characterises the probability that the window is open.
- The likelihood that the window is open can be calculated on the basis of a logit formula:
  \[
  \text{Logit}(p) = \log \left( \frac{p}{1-p} \right) = aT + b \quad (1)
  \]
  Where \( p \) is the probability that the window is open, \( T \) is the temperature and \( a \) and \( b \) are the regression slope and the intercept.
Motivation for change in window state

- We can calculate whether there is a motivation for opening or closing by finding whether the temperature in the room is likely to be too hot or too cold.
- If Top, the indoor operative temperature is greater than T_{comf} + 2 then if the window is closed there will be a motivation to open it, if the window is open and to close it if the temperature is less than T_{comf} – 2.
- If the indoor operative temperature is calculated at the start of the day (assuming, say, that the windows have been closed at night) then using the criteria shown above we can estimate whether there is the desire for a change in the window state.

Is the window open or closed?

- Using a random number generator we can then make a decision whether the window should be opened (closed) based on the likelihood the window is open according to the indoor operative and the outdoor air temperature equation developed from logistic regression.
- A more detailed description of this ‘Humphreys’ window-opening algorithm can be found in Rijal et al (2007) Energy and Buildings 39(7)

Result: Comfort

![Graph showing comfort levels](image)

Percent occupied hours the indoor temperature exceeds 28°C with window opening according to the algorithm and closed
Energy use in an NV building with occupant-controlled windows compared with a constant rate of 8 l/s/p

Fans and windows

- A similar analysis of window opening in Pakistan suggest that the temperatures at which windows are opened is related to local comfort temperature
- This means that the algorithm can be generalised using adaptive principles
- Fan use follows a similar pattern

CONCLUSIONS

- A simple stochastic algorithm for the opening of windows has been developed based on adaptive theory
- The energy cost of having opening windows is small since most windows are opened in summer, though some discomfort remains
- A large energy cost of a mechanical system to provide similar increase in comfort
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- Thermal comfort in the context of energy performance regulations
- The role of renewable energy in cool buildings
- Impacts of climatic change, urban heat island and rising fuel costs
- Practical issues for low or zero carbon cooling
- Case studies of mixed-mode systems
- Improving building simulation

Details from Fergus Nicol Janet Rudge or from: www.nceub.org.uk
Curriculum Vitae
Professor Fergus Nicol

Date of Birth: 6th August 1940
Place of Birth: Kilninver, Scotland

Professional Education:
1958 – 1962: BSc in Physics, Woolwich Polytechnic, UK

Professional Experience:

1973 -1993 Bookshop manager Bookmarks Bookshop and publishers
1966 - 1972 Research in thermal comfort at Building Research Establishment and National Institute for Medical Research in the UK and Lecturer in Building Physics at the Architectural Association School of Architecture
1964 – 1966 Lecturer in Building Physics at the University of Science and Technology, Kumasi, Ghana
1963 – 1964 Scientific Officer at the Building Research Establishment working on overheating of offices in summer

SOME RECENT PUBLICATIONS
DAYLIGHTING AND SOLAR CONTROL

Prof. Dr.-Ing. Helmut F.O. Müller
Chair of Environmental Architecture
University of Dortmund
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www.bauwesen.uni-dortmund.de/ka/

PREA Workshops, Stellenbosch, Dar es Salaam, Kampala, October 2007

SURVEY

1. Transparency for light and thermal radiation
2. Daylighting
3. Thermal solar control
4. Daylighting + solar control
5. Evaluation of performance, energy efficiency and economy
6. Conclusions

1. TRANSPARENCY FOR LIGHT AND THERMAL RADIATION

Illumination of architecture and rooms,
Visual performance
Daylight source in continuous variation
Daylighting and Solar Control
Prof. Dr.-Ing. Helmut F.O. Müller
LS Klimagerechte Architektur, Universität Dortmund
PREA Workshops, Stellenbosch, Dar es Salaam, Kampala, October 2007

Solar heat gains
- Passive heating (welcome in cold climates)
- Overheating or cooling load (disadvantage in cold climates)
- Solar heat gain coefficient $g$

\[ \rho \text{ Reflexionsgrad} \]
\[ \tau \text{ Transmissionsgrad} \]
\[ \alpha \text{ Absorptionsgrad} \]
\[ G \text{ Gesamtenergiendurchlassgrad} \]
\[ g \text{ sekundäre Wärmeabgabe} \]

Shading by neighbour buildings
Shenzhen, China
Urban Canyon New York, USA

Combined solar control and daylighting: A conflict of requirements?

<table>
<thead>
<tr>
<th>DAYLIGHTING</th>
<th>SOLAR CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td>VISUAL PERFORMANCE</td>
<td></td>
</tr>
</tbody>
</table>
  - Minimal illuminance $E_{\text{min}} \geq 300 \text{ lx} < 1000 \text{ lx}$
  - Optimal illuminance $E_{\text{opt}} \geq 2000 \text{ lx} - 3000 \text{ lx}$
| THERMAL COMFORT |
  - Operative room temperature
  - Cooling

| BIOLOGICAL EFFECT |
  - Circadian Performance
  - Minimal vertical illuminance $E_{\text{vmin}} \geq 1000 \text{ lx}$ (different spectrum)
| ENERGY CONSUMPTION |
  - Automatic control
  - Range: 7-30 kWh/m²a
2. DAYLIGHTING

Horizontal illuminance for clear sky conditions (DIN 5034)

Horizontal illuminance:
- $E_s$ by the sun,
- $E_h$ by the sky, and
- $E_d$ by sky and sun, depending on solar height $g_s$

Influences on daylight coefficient

Biological effect of light

Third receptor on retina discovered [David Berson, 2002]

- Direct link to SNC (Suprachiasmatic Nucleus)
  - Biological Clock
  - Daily rhythm
    - sleep / wake

Reaction on illuminance
- $> 1000$ LUX
  - Spectral composition shifted to blue
Kontrastblendung

- Bildschirmarbeitsplätze: max = 400 – 1000 cd/m² (DIN 5053 T7)
- Ermüdung durch Anpassungsirritation des Auges

Blendung: Störung der Sehleistung durch große Kontraste der Lauchdichte im Gesichtsfeld (Kontrastblendung – rechts: Direktblendung)

Daylighting and Solar Control
Prof. Dr.-Ing. Helmut F.O. Müller
LS Klimagerechte Architektur, Universität Dortmund
PREA Workshops, Stellenbosch, Dar es Salaam, Kampala, October 2007

Daylight and artificial light
Energy consumption for lighting, automatic control of luminaires:
E.g. 7 – 30 kWh/m² for offices

3. SOLAR CONTROL
Influences:
- Climatic zone
- Thermal capacity of room
- Night ventilation
- Window orientation and tilt
Climatic zones (ASHRAE) related to energy consumption

Influences of window solar control
- Solar heat gain control \( g \)
- Shading device, shading coefficient \( fc \)
- Window size, proportion \( f = \frac{A_w}{(A_w + A_f)} \)
- Window frame proportion \( FF \)

Solar control glass
Reflective coating, e.g. Bank of China, Hongkong (Architect: I.M. Pei)
Daylighting and Solar Control
Prof. Dr.-Ing. Helmut F.O. Müller
LS Klimagerechte Architektur, Universität Dortmund
PREA Workshops, Stellenbosch, Dar es Salaam, Kampala, October 2007

Solar reflective glass

Selectively reflective coating
Posttower, Bonn

Selektive reflexion by solar control glass
Shading devices, fixed lamellas, FH Wismar, Südfassade

Fixed lamellas
FH Wismar, Innenaufnahme Südraum

Movable shading devices
Louvers
Internal blinds, combined with solar protective glass

4. DAYLIGHTING + SOLAR CONTROL

Microgrid (SITECO) for roof glazing

Redirection of sun light

Comparison with conventional shading

Conventional shading (reduced daylighting)

Lightshelf (improved daylighting)
Daylighting and Solar Control
Prof. Dr.-Ing. Helmut F.O. Müller
LS Klimagerechte Architektur, Universität Dortmund
PREA Workshops, Stellenbosch, Dar es Salaam, Kampala, October 2007

Sunlight redirection: Mirror for illuminatin of atrium
Hongkong Shanghai Bank, Architekt: Norman Foster

Conventional louvers
Light directing louvers

Light directing glass (example ssg lumitop)

U = 1.2 W/m² K (Crypton)
g = 0.29 – 0.35, angle depending
τ = 0.50
s = 32 mm
Daylighting and Solar Control
Prof. Dr.-Ing. Helmut F.O. Müller
LS Klimagerechte Architektur, Universität Dortmund
PREA Workshops, Stellenbosch, Dar es Salaam, Kampala, October 2007

Example for application of light directing glass:
"Spherion" office building in Düsseldorf, Germany
5. EVALUATION, Comparison of shading / daylighting systems

Standard louvers  Light directing louvers  Light directing glass and integrated louvers

3. SIMULATIONS FOR MODERATE CLIMATE (GERMANY)

Luminances: Visible light atmosphere

Conventional louvers  Lightdirecting glass
Annual lighting energy consumption

Annual cooling energy consumption

Primary energy consumption over window size:
Heating, cooling, lighting. Standard louver, South orientation
**4. INFLUENCE OF DIFFERENT CLIMATIC ZONES**

Dynamical simulations for identical offices

- Dortmund
- Seoul
- Dar es Salaam
- Dubai

**Lighting energy consumption in four locations & orientations**

- Lightshelves for shading and daylighting. Window area 57%.

(Simulation: Daysim, Dipl. Thesis Budweg)
5. CONCLUSIONS

- EFFECTIVE DAYLIGHTING AND SOLAR CONTROL ARE COMPATIBLE
- OVERALL ENERGY REDUCTION BY OPTIMISED FACADE SYSTEMS
- REDUCTION OF HIGH COOLING LOADS IN HOT ARID AND TROPICAL CLIMATE BY COMBINED SHADING / DAYLIGHTING SYSTEMS
- HIGH ILLUMINANCES (> 1000 lx) ON SUNNY DAYS INCREASE COMFORT

7. LITERATUR


BUILDING INTEGRATED PHOTOVOLTAIC (BIPV) SYSTEMS

Helmut F.O. Mueller
University of Dortmund, Baroper Strasse 301
D-44227 Dortmund, Germany
helmut.mueller@uni-dortmund.de

Abstract

The principles for the integration of photovoltaic power generation with the building envelope are explained. Technical and architectural aspects are considered for multi-functional solutions of PV application in roofs, facades, and shading facilities, and the annual gains of solar electricity in different climatic zones are demonstrated. A great variety of examples for outstanding low energy architecture with integrated PV in Europe is shown and hints for the building integration in tropical and subtropical climates are given. The basics about PV systems and their elements like solar cells, modules, and converters are described. Island solutions and micro grids for PV and hybrid systems in rural areas without electric grid are explained, as well as grid connected solutions. Last but not least a cost benefit analysis is given, including present and future developments of manufacturing costs and technologies as well as environmental aspects.
BUILDING INTEGRATED PHOTOVOLTAIC (BIPV)

Prof. Dr.-Ing. Helmut F.O. Müller
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PREA Workshops, Stellenbosch, Dar es Salaam, Kampala, October 2007

SURVEY

1. Objectives
2. Solar radiation on building envelope
3. Building Integration of PV
   3.1 Roofs
   3.2 External walls
   3.3 Transparent elements, shading devices
4. PV-plants
5. Economy of PV

1. OBJECTIVES
   Photovoltaic conversion of solar radiation (direct and diffuse) in electricity by solar cells:
   • Independent power supply of buildings
   • Secure power supply
   • No CO2 emission and pollution
   • Avoid land consumption and substructure by building integration
   • Architectural, functional, and constructive integration in building envelope
Role of solar electricity in future energy portfolio

![Graph showing energy sources]

Development of PV demand:

- **Europe**
- **Worldwide 2006**

2. SOLAR RADIATION ON BUILDING ENVELOPE

Influence of location

![Worldwide solar radiation map]
Orientation and tilt angle affect solar power output:

Best tilt angle is usual equal to the latitude

Higher efficiency if tilt angle can be changed to sun movement

Example of solar irradiance diagramme

Solar tracking of PV systems

maximum increase of efficiency 50%

<table>
<thead>
<tr>
<th>Type</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Einachsig horizontal</td>
<td>Einachsig pilar</td>
<td>Einachsig admoduell</td>
<td>Zweiechsig</td>
<td></td>
</tr>
<tr>
<td>Horizont</td>
<td>Point</td>
<td>Point</td>
<td>Point</td>
<td></td>
</tr>
</tbody>
</table>

Helitrop, Freiburg, Germany, Architect Disch

2-axis tracking system

Integration in landscape

PV-generator
Comparison of monthly solar power output (3 kW plant) and electricity demand

3. BUILDING INTEGRATION OF PHOTOVOLTAIC

Efficiency depending on temperature of solar cells [3]
Reduction of efficiency depending on deposition of dust \[3\]

Roof integration
Forum Barcelona (E), Arch. Antonio Martínez Lapeña and Elias Torres Tur

Horizontal roof integration, Stadtwerke, Witten, Germany
Flat roof and natural ventilation, School Building

External wall integration
Brundtland Center, Toftlund (DK), Architect: KHR AS Arkitekter

Transparent elements, shading devices
Fortbildungsakademie Mont-Clair, Hame, Germany, Architect: Jourda + HHS
Main Railwaystation Berlin, Architekt: Gerkan, Marg und Partner

Fabric shading facility
MWB Messwandler-Bau AG, Bamberg, Germany

Stadtwerke Winterthur (CH)
Drehbare Sonnenschutz-Lamellen mit PV, Architekt: Theo Hotz
4. PV-PLANTS

4.1 History

- 1836: Photovoltaic effect is discovered by E. Bequerel
- 1958: Energy supply of satellites (USA)
- 1973: First terrestrial application (oil crisis)
4.2 Principle of photovoltaic power generation

Structure of solar cell [3]

Triple layer structure of semiconductor (silicon) with conductive contacts on surfaces

Photogeneration of charge carriers (electrons and holes) in two doted semiconductor layers

Separation of the charge carriers to a conductive contact, that will transmit the electricity

Protective layers on top (transparent) and bottom

Solar cells

Poly- and monocrystalline silicon:
- 0.3 mm thick
- 10 x 10 cm to 13 x 13 cm shape
- 12% -16% efficiency

Amorphous silicon:
- 0.001 mm thick
- layer deposition on substrate (glass)
- 5% - 7% efficiency

Other cell types, a.o:
- Cadmium telluride
- CIS

Structure and colour of silicon cells [4]:

<table>
<thead>
<tr>
<th>polycrystalline</th>
<th>monocrystalline</th>
</tr>
</thead>
</table>

Image of solar cells

Structure
- Form of cells
- Distance between cells
- Gaps translucent or transparent (shadow)
- Perforation of cells
- Metallic conductors

Colour
- Dichroic thin coatings on solar cells for colour effects
4.3 PV-Modules
- Several solar cells in a module
- Building component for assembly
- Standard dimensions, e.g.:
  - 93 cm x 57 cm, 33 - 45 Wp (amorph)
  - 99 cm x 132 cm, 154 - 171 Wp (poly- / monocryystalline)
- Free dimensions, max. 3 m x 2 m

4.4 PV plant, grid connected with inverter [3]

Off-grid PV plant (standalone)
with battery storage, charge controller and inverter [2]
Standalone PV plant with micro grid, hybrid plant, option for grid connection [10]

5. ECONOMY OF PV

Investment costs: 5,000 - 10,000 USD/kWp

Cost reduction: 50% every 5 years

Energy costs: 25 – 160 US cent / kWh

Energetic pay back time: 3 – 7 years

Great variety of building integrated photovoltaic (BIPV)

Thank you for your attention
7. LITERATURE


Curriculum Vitae

Müller, Helmut F.O.

Date of Birth: 26th of October, 1943
Place of Birth: Posen

Professional Education and Professional Experience:

1966 – 72 Study of Architecture at University of Hanover and Stuttgart, Germany (Diploma) as well as at the Bartlett School, London University College, UK (one-year-scholarship)

1972 – 82 Design and research activity in the building industry, in a consulting office and at the University of Stuttgart, Germany (PhD-thesis, Dr.-Ing.)

1982 – 93 Professor in the department of Architecture at the Polytec (FH) Cologne, Germany

1991 – 97 Foundation and general management of the Institute for Light- and Building Technology, Polytec (FH) Cologne (Research about light directing holograms)

since 1993 Professor of the new chair for Environmental Architecture, Faculty of Building, University of Dortmund, Germany (Research about energy efficient facade technology)

1997 - 2005 General Manager and Stockholder of the GLB, Company for Light- and Building Technology in Dortmund, Germany (Development and production of holographic optical elements for building applications)

Conference Papers:


Recent Publications:


Prizes / Awards:

2003 1st Award in the international student competition of the EAA-Alubuild „The Window of the XXI Century“ with the student design „The Wing“ by A. Montano und R. Secin.

2004 Scientific Award BMW Group 2003, 3rd Award for diploma thesis by Dipl.-Inform. F. Eggenstein „Simulation of the Optical Performance of Redirecting Daylight Systems“.

2003 Martin Schmeißer-Medaille of the University of Dortmund for Dr.-Ing. Arch. Ssengooba Kasule for his PhD-thesis „Daylight and Sunshading in Tropical Regions, an Example of Virika Hospital, Kasese, Uganda“.

Abstract
This paper highlights energy policy issues in Tanzania. It explores strengths and weaknesses of the past and present energy policies in Tanzania. Presently, Tanzania population is estimated to be 38 million people, out of which less than 30% are urban dwellers. Seventy percent of urban population lives in unserviced settlements without basic social services such as electricity and water. Electrification in urban areas saves about 37% urban dwellers, while for the rural areas is less than 2%. Energy sources in Tanzania include hydro, coal, natural gas, biomass and imported petroleum. Only 10% of the total Tanzania population is connected to the national power grid, which calls for alternative energy source such as solar energy, biomass and wind energy. However, 80% of the population have very low purchasing power and depends mainly on wood-fuel for cooking and kerosene for lighting. This paper points out the importance of renewable energy technologies, energy efficiency and energy conservation strategies that can be used to reduce energy shortages. Conclusion is preceded by critical reflection on various energy policy issues and provision of possible recommendations.

Key words: Energy, Renewable, Policy, Settlements, Tanzania
RENEWABLE ENERGY POLICY
ISSUES IN HUMAN SETTLEMENTS
- THE CASE OF TANZANIA

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Lmosha@yahoo.com

PART ONE
GENERAL ENERGY OVERVIEW IN TANZANIA

TANZANIA FACTS AND FIGURES

- **Country Area:**
  945,000 km²

- **Population**
  - 1967: 12.3m
  - 2002: 33.5m
  - 2006: 37.5m

- **Per Capital Income**
  251USD

- **Electricity**
  - CONNECTED TO POWER: 10%
  - CONNECTED TO SOLAR ELECTRICITY: 1.6%
- **RURAL SETTLEMENTS**
  - POPULATION: 77%
  - CONNECTED TO POWER
    - Less than 2%

- **URBAN SETTLEMENTS:**
  - POPULATION: 23%
  - UNSERVICED: 70%
  - CONNECTED TO POWER: 37%

---

**PERCENTAGE OF HOUSEHOLDS CONNECTED TO NATIONAL POWER GRID**

---

**PERCENTAGE OF HOUSEHOLDS CONNECTED TO NATIONAL POWER GRID AND SOLAR ENERGY**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Dar es Salaam</th>
<th>Other urban</th>
<th>Rural areas</th>
<th>Mwanza</th>
<th>Tanzania</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any electricity (IEC, 1994)</td>
<td>51.4</td>
<td>26.7</td>
<td>26.6</td>
<td>6.3</td>
<td></td>
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<tr>
<td>Electricity grid (IEC, 2006)</td>
<td>58.3</td>
<td>29.7</td>
<td>20.0</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Solar electricity (IEC, 2006)</td>
<td>1.3</td>
<td>1.7</td>
<td>1.6</td>
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</table>
MEAN DISTANCE TO COLLECT FIREWOOD IN THE RURAL AREAS

ENERGY OUTLOOK IN TANZANIA

- Energy Sources:
  - Hydro
  - Coal
  - Natural gas
  - Imported petroleum
  - Biomass

- Commercial Energy Sources
  - Petroleum: 8%
  - Electricity: 2%
  - Biomass: 90%
    (to primary energy use)

ENERGY SHORTFALL IN THE TANZANIA

- 90% pop. not connected to power
- 80% pop. having low purchasing power
- Insufficient power supply
- Over dependence of biomass leading to deforestation

CALLING FOR ALTERNATIVE ENERGY
PART TWO
RENEWABLE ENERGY IN TANZANIA

CREATING AWARENESS OF RENEWABLES
CREATING AWARENESS OF RENEWABLES

www.solarmwanza.org

CREATING AWARENESS OF RENEWABLES

Private Investments in Solar (PV) increase in Chinese region

CREATING AWARENESS OF RENEWABLES

REX INVESTMENT LTD
Solar Energy Contractors
CREATING AWARENESS OF RENEWABLES

RENEWABLE ENERGY IN AFRICA

Renewable energy technologies can play a major role in providing clean and improved energy services and supply 10% of electricity generation in East Africa.
POSSIBLE SOURCES OF RENEWABLE ENERGY IN TANZANIA

• Solar thermal
• Photovoltaic (PV)
• Geothermal
• Biomass
• Windmills

RENEWABLE ENERGY PRACTICES IN TANZANIA

☐ Tanzania Solar Energy Association (TASEA).
  goal: to promote renewable energy applications.
  branches: 119
EXAMPLES OF ORGANIZATIONS ACTIVELY ENGAGED IN RENEWABLE ENERGY Undertakings

• 21 Governmental Organizations
• 46 Non Governmental Organizations.
• 21 Projects with development partners
• 73 Private companies

EXAMPLE OF SOLAR THERMAL USE IN TANZANIA

University of Dar-es-Salaam Health Centre

EXAMPLE OF COMMERCIAL SOLAR ENERGY IN TANZANIA

Mobile phone pv chargers
PART THREE
REFLECTION ON ENERGY POLICY
ISSUES IN TANZANIA

BIOMASS ENERGY USE % OF TOTAL ENERGY USED

- Tanzania 90%
- Seven countries: Over 50% of Total energy
INTERNATIONAL AND NATIONAL EFFORTS ON RENEWABLE ENERGY POLICIES

• Need to consolidate international institutions and donor agencies with locals.
  – Goals
  – Strategies
• Integration of national and national energy policies
  – Resources
  – Sources
  • Renewables

POLICY SUPPORT FOR RENEWABLES AND ENERGY EFFICIENCY

CONSTRUCTION POLICY IN TANZANIA

• To support the development of sustainable human settlements
• To promote the optimum use of low cost and local building materials
• To promote innovative technologies and practices
• Facilitate self-help initiative and informal sector activities for adequate shelter delivery

Noted that promotion of renewable energy not emphasized
ELECTRICITY LAW IN TANZANIA

- Electricity Ordinance of 1931 and its subsequent amendments
- Electricity Ordinance has been drafted but not yet enacted.
- Outdated human settlement policies

BUILDING PERMIT BYLAW

I hereby certify that plans, sections, calculations and particulars submitted in respect of the building specified above are in conformity with the regulations of the London Country for reinforced concrete British Country codes of Practice structure for being in force with such modifications of the said regulations as are permitted by the London Country Council.

CONSEQUENCE OF OUTDATED LAWS/POLICIES

Inefficient use of available little energy

(Photo taken at midday)
Kawawa Road (Morocco)
Dar-es-Salaam

THE NEED FOR ENERGY POLICIES

Objective is to ensure availability of reliable and affordable energy supplies and their use in a rational and sustainable manner in order to support national development goals.
RENEWABLE ENERGY POLICY STATEMENT

• Have affordable and reliable energy supplies in the whole country
• Enhance the development and utilization of indigenous and renewable resources and technologies
• Adequately take into account environmental considerations for all energy activities
• Increase energy efficiency and conservation in all sectors

ENERGY EFFICIENCY AND CONSERVATION

• Energy efficiency efforts is defined as the concern for the reduction of energy used for a given energy service.
• Energy efficiency involves the use of technology that requires less energy to perform the same function

SIMPLE/PRACTICAL EXAMPLES OF ENERGY EFFICIENCY AND CONSERVATION

• Charcoal stove which uses less charcoal to cook the same food are examples of energy efficiency.
• The decision of replacing 100W bulb with an energy saver 18W bulb is an example of energy conservation.
• Switching OFF the street light during the day
• By choosing energy efficient product you can reduce energy bills by up to 30%.
ENERGY SAVING TIPS (...1)
- Purchase energy efficient equipment.
- Turn off all tools, lighting, and portable appliances when not in use.
- Don’t switch on appliances unless you are ready to start using them.
- Publicize the energy conservation programme by placing energy saving posters.

ENERGY SAVING TIPS (...2)
- Keep the temperature of your fridge between 13 C and 15 C and freezer between -15 C and -18 C.
- Reduce the frequency of boiling tea/coffee water using electric kettles by the use of thermos flasks.
- Use split units AC as are more energy efficient than the window type.
- Maximize use of natural ventilation.
- Use of energy saver bulbs as they consume five times less energy than incandescent bulbs.

POLICY RECOMMENDATIONS ON ENERGY
- Government should introduce energy efficiency standards and labels to all electric appliances.
- Countries, Tanzania in particular, to further extends policy support to renewable energy technologies and practices.
- Energy law/policies can provide incentives. Example is cash given or package by the Germany Energy Renewable Act (EEG).
- Inclusion of energy conservation in building regulations and bylaws.
- Need of Renewable Energy policy!
CONCLUSION

WISHFUL TANZANIAN DREAM: BY THE YEAR 2025 IS …

- Serviced Human Settlements to “all” Tanzanians
- “All” houses built by Industrial Materials
- “All” houses connected to power

Is it realistic to expect such changes by the year 2025?

There is a need of realistic policies, regulations and laws and proper realization strategies.

THANK YOU FOR LISTENING
CURRICULUM VITAE
Dr. Livin Henry MOSHA

1.0 PERSONAL PARTICULARS
Date of Birth: 03. 01.1960
Place: Kilema-Moshi, Tanzania

2.0 PROFESSIONAL EDUCATION
2.1 Ph.D., Katholieke Universiteit Leuven (KUL) Belgium, 2005
2.2 Certificate in Consultancy Skills Development, Dar-es-Salaam, 2000
2.3 Master Degree in Architecture in Human Settlements, KUL, 1993
2.4 Certificate in Low Cost Housing, Bangkok, Thailand, 1991
2.5 Certificate in Housing Development, (KUL), 1991
2.6 Advance Diploma in Architecture 1986 - Ardhi Institute, Dar-es-Salaam.

3.0 PROFESSIONAL/EMPLOYMENT RECORDS
3.1 UNIVERSITY OF DAR-ES-SALAAM, DEPARTMENT OF ARCHITECTURE
3.1.1 Dean, School of Architecture and Design, Ardhi University (ARU), from 8th August 2007 to -date
3.1.2 Head, Department of Architecture – University College of Lands and Architectural Studies (UCLAS), from 5th April 2005 to 7th August 2007
3.1.3 Lecturer, Department of Architecture – University College of Lands and Architectural Studies (UCLAS), from 14th February 2005 to-date.
3.1.4 Assistant Lecturer, Department of Architecture – University College of Lands and Architectural Studies (UCLAS), from 10th June 2001 to 13th February 2005.
3.1.5 Assistant Lecturer on secondment basis 11th June 2000 to 9th June 2001, Department of Architecture – UCLAS.
3.1.6 Part-time Assistant Lecturer to the Departments of Architecture and Urban and Regional Planning (URP) – UCLAS, from October 1999 to 10th September 2000.

3.2 MINISTRY OF LANDS AND HUMAN DEVELOPMENT
3.2.1 Architect (Registered) Grade I – From 1st November 1999 to 10th June 2000.
3.2.2 Occasionally Acting Director for the Building Research Unit (BRU) in 1999.
3.2.3 Senior Assistant Architect – 1st October 1990 to 1st November 1999.
3.2.4 Head of Human Requirements Section (Architectural and Sociology Department) at Building Research Unit (BRU) 1993 – 1995.
3.2.5 Assistant Architect – 14th May 1986 to 31st September 1990.

4.0 PROFESSIONAL PARTICULARS
4.1 Board Chairman, School of Architecture and Design (ARU) from 8th August 2007 to-date.
4.2 Board Chairman, Education Board of the East Africa Institute of Architects (EAIA) from June 2005 to June 2007
4.3 Chairman Education Committee of the Architects Association of Tanzania (AAT) from 5th April 2005 to 7th August 2007
4.4 Council member, Architects Association of Tanzania (AAT) from 5th April 2005 to 7th August 2007
4.5 Registered Architect with the Tanzania Board of Architects and Quantity Surveyors, since 1998.

5.0 RETRIEVABLE CONFERENCE AND WORKSHOP PAPERS


5.0 PUBLICATIONS
5.1 Articles Published in Books
5.1.1 MOSHA, L. (2005), Architecture and Policies; The Transformation of Rural Dwelling Compounds and the Impact of Ujamaa Villagisation and the Nyumba Bora Housing Campaign in Missungwi – Tanzania, KULeuven.


‘Traditional Building Materials in Tanzania (General Outlook)’

Signature October, 2007
ABSTRACT
If Africa is the least "guilty" of unsustainable development, why should we bother with sustainable architecture? Some personal comments on what lead this architect to try practice sustainable architecture as well as what makes this continent different in terms of this problem compared to the rest of the world. Sustainability in architecture can encompass such a wide field, that attempting it for the first time can be daunting. By broadening my own frame of reference through research, I built up a catalogue of ideas and issues that are a personal guide to incorporating sustainability in my own work. This ranges from broader philosophical issues to the nitty-gritty of practical materials specification and detailing. The talk will be illustrated with examples from the Habitat Research and Development Centre in Windhoek, as well as a few other project recently completed or in process. The presentation can act as an example for students to find their personal way "into" the field.

PREA Workshop 2007
The Educational Programme of PREA

PREA Workshops October, 2007

ROSWITHA PIESCH
Dortmund University

South Africa, Tanzania, Uganda 

November 2007

PREA – Promoting Renewable Energies in Africa
PREA International Workshop
© 2007, University of Dortmund, Germany
Slide 1

Outline

1. PREA project
2. The educational programme
3. The workshop series
4. MSc courses
5. E-learning packages
6. General ideas of PREA

PREA Project

Is a joint programme of

• Four European Universities
  • London Metropolitan University
  • Dortmund University
  • University of La Rochelle
  • University of Athens
• Three African Universities
  • Uganda Martyrs University
  • University of Dar es Salaam
  • University of Witwatersrand
• ISES (International Solar Energy Society)

Partly sponsored by the EU and national agencies

PREA – Promoting Renewable Energies in Africa
PREA International Workshop
© 2007, University of Dortmund, Germany
Slide 3
E-learning packages
• Make material available for everybody
• Sustainability
• worldwide dissemination

General ideas of PREA
• Make knowledge available to everybody
• Use all possible dissemination activities
• Make the principals of PREA part of national educational programmes
• Make materials available for everybody
• Sensitize people for ideas of PREA
• Sustainability: national universities carry on the MSc courses and e-learning material is available

Become an ambassador of PREA!
Thank you very much
The educational programme

Three pillars
• Workshops
• MSc courses
• E-learning materials

The workshop series
• Two series of workshops
• Held 2006 and 2007
• In Tanzania, Uganda and South Africa
• Topic: Sustainable and Energy Efficient Building in Africa
• Target group: professionals, decision makers, representatives of local government

MSc courses
To be established at the three African partner universities
• Based on existing teaching modules from European universities
• Adaptation of material to local situation
• Integration in existing teaching structure
• Exchange of staff and students
Curriculum Vitae

Roswitha Piesch

Date of Birth: 01.07.58
Place of Birth: Cologne, Germany

Professional Education:

1977 – 1984: MSc in Agricultural Science, University of Bonn, Germany

Professional Experience:

Since May 2007: Project co-ordinator for PREA, curriculum development; Joint master programmes with African universities, development of e-learning materials
Lectures in Nepal
1991- 2004: deputy of SPRING MSc programme; senior lecturer at the SPRING programme in project planning and management, Alumni coordinator

Conference Papers
Beijing, 2005: " EU ASIA link: An international curriculum for urban planning and management" presented at:" Spring Alumni Conference in China

Recent Publications:

Curriculum Development for Urban Planning and Management with a special emphasis on Poverty Alleviation, Piesch, R. et al. Enschede, 2005


The Guide for Community Based Environmental Management Systems, Piesch R. et al. (eds.); SPRING Research Series No 26, Dortmund, 2000
OUTLINE OF PRESENTATION

- THE CONTEXT
  - EXISTING OPPORTUNITIES AND CONSTRAINTS IN ARCHITECTURE
  - ENVISAGED OPPORTUNITIES THROUGH SHORT CERTIFICATE AND CPD-COURSES
  - TOWARDS AN MSC IN SUSTAINABLE AND ENERGY EFFICIENCY IN BUILT ENVIRONMENT

THE CONTEXT

UNDERSTANDING AND COMPETENCIES FOR THE TRI-ENERGY CHALLENGE FOR SETTLEMENTS IN DEVELOPING COUNTRIES

- To facilitate access to adequate/safe energy for socio-economic development (link to MDGs) in face of rapid urbanisation
- To ensure this is achieved through resource- and environmentally-sustainable means
- To ensure this is achieved through more equitable means in regards to regions, race, gender generations etc

To ensure access to adequate and safe energy for socio-economic development (link to MDGs) in face of rapid urbanisation, it is crucial to achieve this through resource- and environmentally-sustainable means. Moreover, this should be done in a manner that is more equitable in regards to regions, race, and gender generations.
EXISTING OPPORTUNITIES AND CONSTRAINTS IN WITS-ARCHITECTURE

Three-Degrees Programme
Towards Professional-Graduate Qualification

- 3-Year BAS – Bachelor of Architectural Studies (Through design and Construction)
- 1-Year BAS(Hons) (Through design and Construction)
- 1-Year M.Arch (Prof: Design-Thesis Focus)

Several Options in Post-Graduate Programmes

- M.Arch (Academic - 2-Year Minimum: By Research and Thesis: With sustainability/energy efficiency focus Open)
- MSC-Housing (Course-Work and Research Report: With Sustainability in Housing Module: Open)
- PhD (3-Year Minimum: By Research and Thesis: With sustainability/energy efficiency focus Open)

ENVISAGED OPPORTUNITIES UNDER PREA: INTER-DISCIPLINARY LEARNING/TEACHING AS KEY STRATEGY

POSTGRADUATE OPTIONS IN ENERGY AND BUILDINGS UNDER PREA PROJECT

DESIGN/CONSTRUCTION
APPLICATION MODULES:
BAS(HONS), MARCH
(MARCH), MARCH(HOUS)

MASTERS AND PHD BY RESEARCH AND THESIS
CONTINUING PROFESSIONAL DEVELOP (CPD) COURSES

DEMONSTRATED THROUGH DESIGN AND CONSTRUCTION COURSE OUTCOMES AS WELL AS RELATED RESEARCH REPORTS (WRITTEN THESIS IN M.Arch(Prof) AND BAS(HONS) AS WELL AS HONS-LEVEL RESEARCH REPORT: INTERNAL RESOURCES OF SCHOOL WITH SYSTEMATIC INDUSTRY COLLABORATION

HONS: Arch417: 35 students
Arch419: 10 students
MArch (Thes): 5 students
MArch (Hsg): 5 students

THROUGH RESEARCH AND THESIS: ONGOING EXAMPLES INCLUDE RESEARCH ON:
- LABELLING FOR ENERGY EFFICIENCY IN COMMERCIAL BUILDINGS
- SUSTAINABILITY ASSESSMENT TOOLS (WITH ENERGY AS ONE OF THE ISSUES)
- GREEN FINANCE IN ENERGY EFFICIENT LOW-COST HOUSING ETC. MAINLY BASED ON SCHOOL'S INTERNAL RESOURCES, BUT COULD OPEN TO INDUSTRY COLLABORATION

MArch: 1 student/year graduating
PhD: 1 student/year graduating

NEW OPPORTUNITY WITHIN AN ESTABLISHED PROFESSIONAL FRAMEWORK:
BASED ON SCHOOL'S RESOURCES, BUT SUPPLEMENTED WITH:
-WITS' ENTERPRISE MARKETING SUPPORT
-INDUSTRY SPONSORSHIP (GLASS, INSULATION, SOLAR WATER, PV ETC)
-PROFESSIONAL BODY (SAIA ETC)

1 OR 2 CERTIFICATE COURSE/YEAR
APPROX: 20 – 30 PARTICIPANTS/COURSE

NEW OPPORTUNITY WITHIN A GROWING FIELD: RENEWABLE ENERGY AND ENERGY EFFICIENCY
BASED ON SCHOOL'S RESOURCES, BUT SUPPLEMENTED WITH:
-WITS' ENTERPRISE MARKETING SUPPORT
-INDUSTRY SPONSORSHIP (GLASS, INSULATION, SOLAR WATER, PV ETC)
-INDUSTRY BODIES: SESSA, TIASA ETC
-ADDITIONAL DONOR FUNDING

1 OR 2 MODULES/CERTIFICATE COURSES/YEAR
APPROX: 20 – 30 PARTICIPANTS/COURSE

OPEN SHORT-COURSES: INITIALLY TO START AS COLLABORATIVELY DELIVERED
ENERGY EFFICIENT CITIES: The Scoping Module (with US/SI)

DEFINITION:
Urban-system which equitably support/facilitate the minimal/zero-carbon lifestyle-goals of its organizational and human residents

BUILDING SCALE:
(Commercial and Residential)

INDUSTRIAL
(Industrial efficiency and ecology:
Out of scope of this module)

CITY SCALE

EMBODIED ENERGY
(INDIRECT: production process)

OPERATIONAL
ENERGY
(DIRECT:
use/operational)

TRANSPORT
(commuting, distribution)

URBAN SERVICES
(energy, water, sewage, waste)

URBAN FORM

LOCALISE
Urban/organic agriculture
Localised processing
Pedestrian-friendly
Smart-ITC-Optimised

MASS TRANSIT
CLEANER
FUELS
(hydrogen, bio-diesel)

REDUCE, RE-USE, RECYCLE

LOCALISE ACCESS AND DISPOSAL

RENEWABLE/CLEANER
ENERGY SOURCES

TECHNOLOGIES, MARKETS, POLICY-INSTRUMENTS, INSTITUTIONAL STRUCTURES

LONG-LIFE AND RE-USE OF BUILDINGS
REUSED MATERIALS AND COMPONENTS
LOW-IMPACT MATERIALS
HIGH-IMPACT BUT RECYCLABLE MATERIALS

ENERGY EFFICIENCY
(orientation, insulation, thermal mass, ventilation, etc)

RENEWABLE ENERGY
(solar water heating, pvs, solar cooking, bio-fuels, etc)

IN-DEPTH SHORT/CPD COURSES Delivered collaboratively for optimised interdisciplinary learning

- Anchored on the four key themes:
  - Embodied energy
  - Operational energy
  - Transport, commuting and localising economy
  - Urban services and related sustainable energy opportunities

- Each theme initially structured into several modules (Short/CPD courses: 2008/2009)

- Modules later structured into MSC-Curriculum/Qualification (2009/2010)
IN-DEPTH SHORT/CPD COURSES
Delivered collaboratively for optimised interdisciplinary learning

- Short/CPD courses open but with initial focus on Built Environment Professions competencies
- PREA-Programme facilitates module adaptation and contribution by PREA-partners
- Staff and support resources as initial constraining factors (short-to-medium term)
- To be initially run on a full-cost-recovery basis

BUILDING ON A SOLID TRACK RECORD

Holcim Awards for Sustainable Construction
Africa Middle East Awards Ceremony: Sandton Johannesburg

Southern African Solar Academy: ISES, WITS, SESSA SUNNYSIDE HOTEL JOHANNESBURG, SEPTEMBER 2002
The College of Engineering and Technology of the University of Dar es Salaam, Tanzania has decided to develop an M.Sc. in Renewable Energy Engineering TO BE HOSTED AT THE Department of Energy Engineering. The course will be multidisciplinary in nature. This will encompass students coming from Civil Engineering, Mechanical Engineering, Electrical Engineering Architecture, Town Planning, and other Applied and Basic Sciences. The programme structure is proposed to run on a modular system, each module having 3 units. A total of ten course modules will be offered as compulsory before specialization. The program shall consist of coursework and dissertation with aduration of 18 Months. The time for the dissertation phase shall be 6 months. The unit system shall be used to gauge the workload involved in a programme. One unit of coursework shall imply 15 contact hours. A minimum of 42 units shall be obtained out of which, 30 units are obtained from core courses and the rest 12 units from a specialized option, to satisfy the coursework requirement before proceeding to the dissertation phase, unless otherwise stated. There will be Compulsory General Courses, Bioenergy Specialization, Solar Energy Specialization, Hydropower Specialization and Energy Efficiency in Buildings Specialisation.

The course is still under the scrutiny of the decision bodies and the course is now scheduled to take off in February 2008.

**Compulsory General Courses**

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**Compulsory Courses for each specialization**

**Bioenergy Specialization**

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## Solar Energy Specialization

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<th>Lectures</th>
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## Hydropower Specialization

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## Energy Efficiency in Buildings Specialisation

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**Total Units for each Specialization**: 9

### Dissertation

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</tbody>
</table>
MASTERS OF SCIENCE DEGREE PROGRAMME IN RENEWABLE ENERGY AT THE UNIVERSITY OF DAR ES SALAAM

The College of Engineering and Technology of the University has started to develop M. Sc. in Renewable Energy

The degree is to be hosted at the Department of Energy

NATURE OF THE COURSE

• The course will be multi – disciplinary
• Admission Qualifications: B. Sc. in civil engineering, mechanical engineering, electrical engineering, architecture, urban planning, and other related applied and basic sciences
• Specialization : Bioenergy, solar energy, hydropower, energy efficient in buildings.

DELIVERY MODE

• On modular system each module with 3 units;
• Total units 48 (42 for coursework and 6 for dissertation)
• Coursework and dissertation
• Duration 18 months
EFFECTIVE DATE

• The course is still under scrutiny of university decision bodies,
• Scheduled to take off in February 2008.
Programs

The Environmental Design programs offered by the School of the Built Environment aim to improve the energy, health and environmental performance of new and existing buildings, through the co-education of people who are, or will become, building industry professionals involved in the design, construction and operation of these buildings. These include built environment professionals from the disciplines of architecture, planning, engineering, construction and property development. It is also appropriate for people from social sciences, ecology, politics, local authorities etc without a design background but working in relation with or having an interest in the built environment.

The programs are to provide innovative approaches to environmental design of built environments, integrating across architectural, landscape architecture and engineering solutions. The programs are tailored for both professionals working in the built environment in various capacities, as well as for individuals seeking to enter this rapidly growing field. It provides a practical and theoretical grounding in the subject, enabling the development of skills in a range of different methodologies for evaluating environmental conditions and predicting the effects of design solutions.

Immediate ethical and concerns regarding the impact of built environments on the the environment through the degradation of sites, depletion of material resources and excess energy used to cool, ventilate and light buildings lead us to ask whether there is an alternative.

Program Structure

The MSc program is available both full-time (one year) and part-time (two years) to provide flexibility for those who want to work and study. Courses are taught in a module system with the full program consisting of six modules (48 credits) and a dissertation (24 credits).

Career Opportunities

The Environmental Design programs prepare students to take their place in the expanding field of environmental design sustainable development. Students acquire the knowledge and skills needed to specialise in the environmental design of built environment, particularly in those areas falling between the normal professional interests of architects and building services designers. The program is suitable for junior to mid-career professionals in fields related to the built environment such as architecture, building services, building technology or environmental studies and will appeal to engineers from private engineering consultancy, architectural practice and government.

Further Information:

Administrator, School of the Built Environment
Uganda Martyrs University
P.O. Box 5498, Kampala, UGANDA, East Africa
w. www.umu.ac.ug
t. +256 38 241 0611
f. +256 38 241 0100
e. sobe@umu.ac.ug
Entry Requirements

An Honours degree in architecture, engineering or any built-environment-based program. In addition professional or practical experience is highly valued. Interest and enthusiasm are essential.

The Master of Science in Environmental Design is a minimum of one-year full-time or two-years part-time). The program consists of three core modules (30 credits), two elective modules (12 credits) and two dissertation modules (30 credits). Students who enroll in the Masters program and successfully complete the coursework modules but not the dissertation module are eligible to receive the Graduate Diploma in Environmental Design (Grad.Dip.EnvDes).

Program Structure¹

<table>
<thead>
<tr>
<th>Core Courses</th>
<th>Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENVI-6101 Energy, Comfort and Buildings</td>
<td>12</td>
</tr>
<tr>
<td>ENVI-6103 Introduction to Environmental Policy and Planning</td>
<td>6</td>
</tr>
<tr>
<td>ENVI-6202 Designing Sustainable Environments</td>
<td>12</td>
</tr>
<tr>
<td>Elective</td>
<td>6</td>
</tr>
<tr>
<td>Elective</td>
<td>6</td>
</tr>
<tr>
<td>ENVI-7401 Masters Dissertation Preparation</td>
<td>6</td>
</tr>
<tr>
<td>ENVI-7402 Masters Dissertation</td>
<td>24</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Elective Courses</th>
<th>Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENVI-6401 Energy Management in Buildings</td>
<td>6</td>
</tr>
<tr>
<td>ENVI-6402 Daylighting in Buildings</td>
<td>6</td>
</tr>
<tr>
<td>ENVI-6403 Building Performance Analysis and Modeling</td>
<td>6</td>
</tr>
<tr>
<td>ENVI-6404 Renewable and Sustainable Resources</td>
<td>6</td>
</tr>
<tr>
<td>ENVI-6405 Special Topic in Environmental Studies</td>
<td>6</td>
</tr>
<tr>
<td>ENVI-6406 Special Topic in Environmental Studies</td>
<td>6</td>
</tr>
</tbody>
</table>

The formal program is preceded by an induction period in which students are introduced to fundamental computing, presentation and study skills. This is particularly helpful for students without recent experience of full-time education.

Assessment

Assessment in taught modules will be through coursework. For the research-based modules you may choose to complete either a substantial written dissertation or a substantial design and evaluation project.

¹ Program and Modules developed based on the MSc (Integration of Renewable energies in Buildings) offered by the Low Energy Architecture Research Unit (LEARN) of the London Metropolitan University.
Entry Requirements

An Ordinary three year degree in any non built environment-based program. In addition professional or practical experience is highly valued. Interest and enthusiasm are essential.

The Graduate Certificate in Environmental Design is a semester length program, while the Graduate Diploma in Environmental Design is a two semester long program. Both the Graduate Certificate in Environmental Design and the Graduate Diploma in Environmental Design are designed as a bridging programs for graduates of the three year Bachelor of Environmental Design degree of Uganda Martyrs University or for graduates of other related three year degrees who wish to enter the field of Sustainable Design. Both programs are designed to lead into the Master of Science (Environmental Design) degree. The Graduate Diploma consists of four core modules (42 credits) and one elective module (6 credits).

Students who enroll in the masters program and successfully complete the coursework modules but not the dissertation module are eligible to receive the Graduate Diploma in Environmental Design (Grad.Dip.EnvDes).

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<tr>
<th>Core Courses</th>
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</tr>
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<tbody>
<tr>
<td>BEDS-31xx or ARCH-41xx</td>
<td>Sustainable Built Environments</td>
<td>12</td>
</tr>
<tr>
<td>or ENVI-6103</td>
<td>Urban Design Studio</td>
<td></td>
</tr>
<tr>
<td>or ENVI-6202</td>
<td>Introduction to Environmental Policy and Planning</td>
<td>6</td>
</tr>
<tr>
<td>or ARCH-42xx</td>
<td>Buildings and the Environment</td>
<td>12</td>
</tr>
<tr>
<td>or ENVI-6202</td>
<td>Building Design Studio</td>
<td></td>
</tr>
<tr>
<td>ENVI-6401</td>
<td>Designing Sustainable Environments</td>
<td>12</td>
</tr>
<tr>
<td>ENVI-6402</td>
<td>Elective</td>
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Elective Courses

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<td>ENVI-6403</td>
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<td>ENVI-6405</td>
<td>Special Topic in Environmental Studies</td>
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<td>ENVI-6406</td>
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2 Program and Modules developed based on the MSc (Integration of Renewable energies in Buildings) offered by the Low Energy Architecture Research Unit (LEARN) of the London Metropolitan University.
Assessment

Assessment in all modules will be through coursework.
Integrating Sustainability into Architecture Education: Perspectives from Uganda

Mark R. O. Okony
Uganda Martyrs University

Background
Architectural Education in Uganda
Sustainability in UMU Curriculum
Looking Forward
Background - Architecture

... need to know what the actual conditions are (information)
Architecture Education in Uganda

- Makerere University
  - Faculty of Technology
  - 5-Year Bachelor of Architecture Programme - (1986)

- Uganda Martyrs University
  - Faculty of Building Technology and Architecture
  - 3-Year Bachelor of Science (Building Design and Technology) (2000)
  - 2-Year Graduate Entry Bachelor of Architecture (2004)
Undergraduate Programme

- Year I
  - Culture Environment and Settlements
  - Natural and Built Environment Systems
- Year II
  - Buildings and the Environment
- Yr. III
  - Sustainable Built Environments

Graduate Programme

- Year I
  - Integrated Building Design Studio
  - Integrated Urban Design Studio
- Year II
  - Integrated Building Design Studio
Need Information / Local Knowledge
Teaching
Teaching and Assessment Methods
Students
Learning Approaches (Rote Learning / Compartmentalisation)
Perceptions of Architecture / Change in Attitude
View of Built Environment / Built Environment Education
What Architects Do ...

What are our responsibilities?
Educators / Practitioners
Exponential Growth - Urban Areas
Post Occupancy
Clients
Context
Workshops on Sustainability
External Support

Changing perceptions
Isn't Sustainable Architecture ... just ... Architecture?
Curriculum Vitae

Mark Olweny

Date of Birth: 17 April, 1969
Place of Birth: Kampala, Uganda

Professional Education:

2006 – PhD Candidate Welsh School of Architecture, University Cardiff, Wales
1997 – 1999: Bachelor of Architecture, University of Adelaide, Australia
1995 – 1996: Master of Regional and Urban Planning, University of South Australia, Australia
1993 – 1996: Master of Architectural Studies, University of Adelaide, Australia
1987 – 1989: Bachelor of Architectural Studies, University of Adelaide, Australia

Professional Experience:


2004 – present: Design Architect, dESIGN@UMU, Uganda Martyrs University, Kampala, Uganda. Design and Project Architect.


Conference Papers


Recent Publications:

- **Olweny, M.R.O.** (2004) "Architecture is more than just design drawings" *The East African*, Kampala, October 11-17, pp22.

Prizes / Awards:

- **Australian Research Council Grant Funded Scholarship in Architecture (1994 - 1996)**