Energy Efficiency in the Tropics

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45 companies and institutes with about 400 employees
International Consulting & Education Service Provider in Energy Efficiency and Renewable Energy

- Freiburg Germany
- San Francisco
- Madison
- Singapore
- Chile
- Peru
- Brasilia
- Cuba
- Dominican Republic
- Shanghai
- South Korea
- Japan
- Indonesia
- Thailand
- Philippines
- India
Consultancy Services for Building Sector

Energy efficiency Optimisation

*Building Energy Optimisation of*
- Efficient façades
- Efficient cooling systems
- Efficient mechanical systems
- Efficient lighting systems

*Detailed Building Simulation of*
- Thermal performance (APACHE)
- Solar incidence (SunCast)
- Cold bridging (Therm)
- Natural ventilation & CFD

*Heat/ Cool Recovery systems*

Water Efficiency

Daylight solutions for
- Offices
- Retail
- Residential
- Circulation spaces

*Good day-lighting criteria*
- Visually pleasing (no glare)
- Good light distribution
- No penetration of direct sun
- No overheating

Renewable Energy Supply
- Building Integrated Photovoltaic (BIPV)
- Biomass/ Biofuel Cogeneration
- Solar/ Waste-heat driven Cooling
- Micro-wind turbines
- Solar Hot Water
- Geothermal Heating & Cooling supply

Assessment of Local Green Building Standards

Green Building Rating:
- Green Mark/ LEED certification

Energy Audits, Performance Contracting

Development, Proof of Concept, Project Management

Sustainable Construction
- Sustainable Materials & IAQ

Instrumentation & Control

Monitoring Tools
Integrated Design Process

Key to the work that we do is the integral design process. As Energy Consultants we optimise buildings in an integrated design process with the rest of the design team (e.g. architects, structural, mechanical & electrical engineers) to achieve the maximum energy and environmental performance.

- Use of advanced computer tools to achieve optimal performance and lower lifetime costs for the client
- Collective experience for more than 30 years in Europe and 10 years in South East Asia
- Consideration of building materials and energy systems that will not only improve sustainability but provides a comfortable and healthy indoor environment for users
- Management of international environmental assessments of buildings and districts
M & E (Energy Efficiency) Consulting

Since 1990 ~ 300 projects ~ US$ 180 M

Status Analysis Survey
- Hospitals
- School- and Sportcentres
- Museums
- Bank-Buildings

Reconstruction
- Industrial Building
- Office Buildings
- Sports Facilities
- Production-lines
- Trade Fair Freiburg
- Chirurgische Klinik

New Construction
- Badenova Lahr
- Adsorption Cooling
- Heliotrop
- Solarfabrik
- Infocenter-Hameln
- J. v. L. School
- Solar Village

Innovative Highlights

Willi Krebser, Dipl.-Ing
Private Buildings: Medical Laboratory Building Renovation & Extension

Pfizer Pharma GmbH / Goedecke GmbH, Freiburg, Germany

**Project References – Retrofit/ Reconstruction**

**Building Type**
Laboratory and Offices

**Client**
Pfizer Pharma GmbH

**Project size**
11,650m² refurbishment
3,140m² new extension building

**Project costs**
ca. 3,6 Mio €

**Period of realization**
2007 – 2008

**Project description**
- energetic optimization of a basic design for the renovation
- development of a sustainable energy concept
- implementation of integral planning process
- integration of ecologic features:
  - outside sun protection
  - heating/cooling ceilings
  - optimizing of ventilation
  - geothermal energy with heat pump and heat and cold buffer storage
- feasibility studies / cost-benefit analysis

Reduction of CO²-emissions by 1,200 tons per yr
Reduction of total annual costs by 40% (including invest annuity)
Medical Laboratory Building Renovation & Extension
Pfizer Pharma GmbH / Goedecke GmbH, Freiburg, Germany

CO₂ emissions [to/a] - heating / cooling

- Gas heating system: 53.0 tons/year
- Geothermal system: 16.6 tons/year

CO₂-emissions for oil + gas based on German average, CO₂-emission for electricity by Badenova AG & Co. KG.
Medical Laboratory Building Renovation & Extension

*Pfizer Pharma GmbH / Goedecke GmbH, Freiburg, Germany*

Project References – Retrofit/ Reconstruction

**capital cost [€] - heating / cooling**

- **Gas heating system**: 206,869 €
- **Geothermal system**: 352,352 €
Medical Laboratory Building Renovation & Extension
*Pfizer Pharma GmbH / Goedecke GmbH, Freiburg, Germany*

**Project References – Retrofit/ Reconstruction**

**annual costs [€/a] - heating / cooling**

- **Gas heating system**
  - Energy costs: 49,957 €
  - Maintenance & service: 5,274 €
  - Capital investment: 13,343.1 €

- **Geothermal system**
  - Energy costs: 10,631 €
  - Maintenance & service: 7,699 €
  - Capital investment: 22,726.7 €

- 40% decrease in costs
Energy efficiency measures

Reducing Energy Efficiency Index

<table>
<thead>
<tr>
<th>Measure</th>
<th>Base Building</th>
<th>Windows to Wall Ratio 80% down to 50%</th>
<th>Glazing Shading Coefficient 0.6 down to...</th>
<th>Insulated Roof</th>
<th>Lighting Power Density 15 down to 8 W/m²</th>
<th>50% Spaces Daylit</th>
<th>COP of chiller 5.7 improve to 6.5</th>
<th>Pumps and Cooling Tower Fan Efficiency</th>
<th>AHU Fan &amp; Motor Combined Eff 60% to...</th>
<th>Fan Static Pressure 920 Pa down to 500 Pa</th>
<th>Infiltration Rate 1.5 down to 0.5 ach</th>
<th>TABs System</th>
<th>Heat Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Efficiency Index (kWh/m²/year)</td>
<td>249.9</td>
<td>240.8</td>
<td>233.5</td>
<td>230.4</td>
<td>197.2</td>
<td>186.3</td>
<td>175.1</td>
<td>162.3</td>
<td>156.2</td>
<td>142.3</td>
<td>124.8</td>
<td>111.5</td>
<td>106.8</td>
</tr>
</tbody>
</table>

Note: Tenants Small Power Load assumed at 15 W/m²
Infiltration Rate improve from 1.5 to 0.5 air-changes per hour.

Exposed large air-conditioned façade to Hot and Humid outdoor air. Laboratory requires negative pressure. Leakages of humid air into laboratory will cause condensation and mold problems.

Exfiltration of laboratory air will contaminate atrium air quality.

EEI from 142.3 to 124.8 kWh/m²/year

Free Cooling Conducted into Atrium

Sealed Atrium minimise exposed façade. Atrium space cooler due to conducted cooling from air-conditioned spaces. Air quality better controlled. See Heat Recovery.
Heat Recovery Systems as most economic efficiency solutions

Heat recovery wheels installed on the rooftop. This will serve the function of pre-cooling and pre-drying the fresh air intake into the corridors and other common spaces (shown in green).

The negative pressure zone in the air-conditioned laboratory spaces will ensure that fresh air will be sucked in. The exhaust air from the laboratories will pass through the heat recovery wheel on the roof top where sensible and latent heat exchange takes place.

Ensuring that the building is air-tight prevents the laboratory air from leaking into corridors and other common spaces. In this way, the air quality outside the labs is also maintained and the infiltration rate will be significantly reduced 1.5 to 0.5 ach.

With such heat recovery systems in place and ensuring that the building is airtight and the infiltration rate reduced the building’s EEI can be reduced by 22.2 kWh/m²year.
**Thermal Energy Storage System to handle challenges of near future**

Following the discussion on the Thermal Energy Storage system, we would like to explore the possibility that the building's own thermal storage capacity is used to balance out fluctuations in cooling loads. In this case, the building's ceilings and walls are used as cooling stores and surfaces.

It is foreseen that near future will bring a multi-tariff systems for electricity to motivate the users to shift as much electricity loads from peak-time as possible. The thermal storage air conditioning system responds to peaks in cooling loads during the day by combining cold energy stored produced during off-peak periods with that produced during daytime. With the higher temperature of the supplied chill water, higher chiller efficiency can be attained. Consequently, the size of the installed chiller capacity can be kept to almost half that of buildings that do not utilize thermal storage. This correspondingly reduces investment and operating costs. While successfully implemented in other similar climatic regions, such a system would be a first in Singapore. With this system, the building’s Energy Efficiency Index (EEI) can be reduced from 124.8 to 111.5 kWh/m²/year.

The principle is that the solid concrete ceilings of the building are kept at controlled and desired temperature by means of flowing cold water through plastic pipe coils embedded in the concrete. 60% of the heat exchange between the conditioned concrete ceiling and the room takes place via radiation. With cooling delivered via radiation and convection, less fan power is used. This also allows for better control of relative humidity and provides better radiant comfort for the occupants. In order to ensure that the temperature of the thermo-active ceiling is evenly maintained, the building must be well insulated.

Roof Insulation can further reduce the EEI by 3.1 kWh/m²/year.
Daylight Factor modeling for “recessed” Labs on 5th Storey

50% Daylit Spaces

EEI from 197.2 to 186.3 kWh/m²/year
Renewable Energy Supply

Production of electricity, heat and cool from renewable energy sources will complement the electricity drawn from the grid to supply the building’s total energy demands. Based on the actual design, at least 50% of the building’s energy demand will be met by a combination of solar thermal, photovoltaic, biofuel-powered Combined Heat and Power (CHP) unit and fuel cell generators.

Cooling and ventilation systems constitute more than 60% of a typical building’s energy demand in Singapore. In Cleantech One, waste heat from the biofuel-driven CHP unit and solar heat collected by solar thermal systems on the rooftop will drive absorption chillers to supply a significant portion of cooling demand.

**CO₂ Emissions/m²/year**

- EEI 249.9 kWh/m² yr
- EEI of 106.8 kWh/m² yr
- 53.4 kWh/m² yr due to 50% RE supply

**CO₂ savings of 79%**

Emission factor = 0.537kgCO₂e/kWh

Biodiesel from crops such as Jatropha

Modular and expandable Biodiesel–fueled CHP unit

Source: ESU, NUS – Results from energy audit of 104 buildings
Office Goes Green

Reduced energy costs

Energy Costs Comparison CT1 Building
including Maintenance Costs for Renewable Energy Features

- 50 %
- 64%

overcompensating additional investment costs of + 4,4 %
Using energy saving potentials
*Raffles Hotel Singapore*

Energy profile

- **Lighting, Boilers & Others**: 42%
- **Chillers**: 37%
- **AHUs & FCUs**: 13%
- **Cooling Towers & Pumps**: 8%
Using energy saving potentials

Raffles Hotel Singapore

- Improving the chiller efficiency
- Optimizing chilled water pumps
- Optimizing condenser water pumps
- Optimizing cooling tower operations
- Eliminating the electrical hot water boiler
- Optimizing Ventilation system operations
Using energy saving potentials

Raffles Hotel Singapore

- **CO2 savings**: 450 to / year
- **ROI**: 2.1 year
- **Annual savings**: 172,000 SGD
Using energy saving potentials

Tanglin Club Singapore
Using energy saving potentials
*Tanglin Club Singapore*

- Estimated Annual cost savings (S$)
- Estimated Implementation cost (S$)

<table>
<thead>
<tr>
<th>Energy savings</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrofitting of new chiller system</td>
<td>300</td>
</tr>
<tr>
<td>Optimizing big chilled water pumping</td>
<td>250</td>
</tr>
<tr>
<td>Optimizing small chilled water pumping</td>
<td>150</td>
</tr>
<tr>
<td>Optimizing condenser water</td>
<td>100</td>
</tr>
<tr>
<td>Eliminating package unit</td>
<td>50</td>
</tr>
<tr>
<td>Elimination of hot water boiler</td>
<td>10</td>
</tr>
<tr>
<td>Lighting system improvements</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>750</strong></td>
</tr>
</tbody>
</table>

- **Energy savings:** 10%
- **ROI:** 1.6 years
Packaging Plant, Malaysia

**energy demand:**

- **steam:** 23.725 MWh/a
- **running hours:** 4.400 h/a
Packaging Plant, Malaysia

Improvements:

- economizer in boiler system
- optimizing steam and condens system
- changing lighting to LED
- changing one boiler from gas to biomass
Packaging Plant, Malaysia

- **CO₂ saving**

- **6.459** casual generation (gas)
- **1.138** biomass boiler

**CO₂ to/year**: - 82%

**ROI**: 5 years
Nutritionals Factory in Singapore

Target:

- Reduce CO₂ footprint
- Monetary savings

3 systems in use
1 integrated system

Energy Need
- Heat
- Cooling
- Chiller
- Electrical Power
- Power Generator

Tri-Generation System
Energy and Cost saving measure
Tri – Generation System

Integral system produces electricity, steam and chilled water

- biomass boiler -&gt; economical & environment-friendly
- no wasted heat -&gt; no wasted energy
- direct energy saving of 20%

Nutritionals Factory in Singapore
Nutritionals Factory in Singapore

Production Goes Green
Reduce CO₂ footprint

- using biomass
- no wasted heat
- optimised system

CO₂ saving - 74%

Exemplary Industry in Singapore CO₂ to/year

- casual generation: 65.771
- Trigeneration: 22.151
Production Goes **Green**

Monetary savings

**Total annual savings** compared to Business as Usual

- Year 1: **7,494** mil SGD
- Year 15: **8,408** mil SGD

remaining savings after investment
Contracting

- **Energy Performance Contract**
  - The contractor designs, constructs, and obtains the necessary financing for an energy supply project.
  - The building owner / tenant makes payments over time to the contractor in the energy bills.
  - The contractor guarantees the energy supply for heat, cool and/or electricity.
  - The contractor delivers planning, realization, operating and maintenance of the energy system.
  - Contracting can be organized in residential and nonresidential buildings, districts and industrial energy systems.

**Business Modell of Contracting - BOOM**

- Clean Energy concepts are developed in reconcilement with the building owner and the M&E consultants.
- Contractor delivers the clean energy and runs the technologie systems.
- Any certification benefits - like LEED / Greenmark points - credits to the building owner.
BOOM – Build Own Operate Maintain

Factory Owner

Recipient of energy

Contractor

- Concept, Planning
- Realization, Hardware
- Operating, Maintenance
- Accounting

Provision & Accounting of Heat, Cool (& Electricity)

Energy Production

Energy Efficiency Installations

Fuel Supply

Electricity provider

optional
Thank You very much for your attention!