RENEWABLE ENERGY AND ENERGY EFFICIENCY IN THE GHANA BUILDING CODE

The Emergence of Green Buildings and the Contribution of Renewable Energy and Energy Efficiency
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WHAT IS A GREEN BUILDING
HISTORY OF GREEN BUILDING COUNCILS
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GHANA BUILDING CODE: CHAPTER 37

Presented at the 4th Ghana Renewable Energy Fair @ Accra International Conference Centre
9-11 October, 2018
Theme: Renewable Energy: Exploiting Energy Resources at the District Level
What is a Green Building:
Green Building is a term use for buildings that are energy efficient, environmentally friendly and uses resources wisely
History of Green Building Councils:
Around 1992 David Gottfried an Engineer and owner of World Build Technologies Inc. in the United States of America, together with some 12 individuals and organizations formed the US Green Building Council.

In November 1999, 8 countries namely: Australia, Japan, Canada, Spain, United Kingdom, Russia, United States of America and the United Arab Emirates met in California for the founding meeting of the World Green Building Council.
World Green Building Council:

Formally incorporated in 2002

Its primary role being to formalize international communications, help industry leaders access emerging markets, and provide an international voice for Green Building Initiative.
Ghana Green Building Council (GHGBC):

Officially Launched on 17th August, 2011, in Accra, Ghana, the

GHGBC is a member of the World Green Building Council (WGBC) family of the 92 Countries with Green Building Councils to date.
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WHAT IS RENEWABLE ENERGY

Renewable energy can be defined initially as any energy source that is derived directly or indirectly from solar energy.

In the broadest sense, however, almost all of the energy we use today, including fossil fuels, can be considered a form of solar energy.

The most familiar forms energy, such wood, oil, gas, and coal, are embodied forms of solar energy gathered, and transformed by natural processes.
WHAT IS RENEWABLE ENERGY: Continuation

Climate change due to emissions of GHGs, particularly Carbon dioxide, becomes an issue when stored solar energy is converted to useable forms of energy (heat, electricity, fuels, chemicals) at a rate far exceeding the rate of formation.

For coal, oil, and natural gas, the ratio of time between formation and use is on the order of 1 million to one:

that is, the world uses in one year what took natural processes one million years to create. Only biomass among these stored forms has a time ratio that is within a human time frame of years or decades.
WHAT IS RENEWABLE ENERGY: Continuation

Renewable energy can now be defined as forms of solar energy that are available and replenished in time scales no longer than human lifetimes.
Given the definition of renewable energy, it becomes clearer why renewable energy is an important option for mitigating climate change.

Because renewable energy creates little if any net greenhouse gas emissions, its use will not disrupt the radiative energy balance of the earth's atmosphere and will permit sustainable, long-term mitigation of climate change.

The renewable energy option will allow climate change mitigation, energy use, and economic development to proceed in synergy rather than in opposition.
<table>
<thead>
<tr>
<th>RESOURCE</th>
<th>TECHNOLOGY</th>
<th>END-USE APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOLAR</td>
<td>Photovoltaics-Flat Plate</td>
<td>Electricity</td>
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<tr>
<td></td>
<td>Photovoltaics-Concentrator</td>
<td>Electricity</td>
</tr>
<tr>
<td></td>
<td>Solar Thermal Parabolic Trough</td>
<td>Electricity, Industry</td>
</tr>
<tr>
<td></td>
<td>Solar Thermal Dish/Stirling</td>
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<tr>
<td></td>
<td>Solar Thermal Central Receiver</td>
<td>Electricity/Industry</td>
</tr>
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<td></td>
<td>Solar Ponds</td>
<td>Electricity/Industry/Building</td>
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<td></td>
<td>Passive Heating</td>
<td>Building</td>
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<tr>
<td></td>
<td>Active Heating</td>
<td>Building</td>
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<tr>
<td></td>
<td>Daylighting</td>
<td>Building</td>
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RENEWABLE ENERGY TECHNOLOGIES: WIND

<table>
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<tr>
<th>RESOURCE</th>
<th>TECHNOLOGY</th>
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<tbody>
<tr>
<td>WIND</td>
<td>Horizontal Axis Turbine</td>
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<td></td>
<td>Vertical Axis Turbine</td>
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Theme: Renewable Energy: Exploiting Energy Resources at the District Level
# Renewable Energy Technologies: Biomass

<table>
<thead>
<tr>
<th>Resource</th>
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<th>End-Use Application</th>
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<tbody>
<tr>
<td>Biomass</td>
<td>Direct Combustion</td>
<td>Electricity/Industry/Building</td>
</tr>
<tr>
<td></td>
<td>Gasification/Pyrolysis</td>
<td>Electricity/Industry/Transport</td>
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<tr>
<td></td>
<td>Anaerobic Digestion</td>
<td>Electricity/Industry/Building</td>
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<tr>
<td></td>
<td>Fermentation</td>
<td>Transport</td>
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## Renewable Energy Technologies: Geothermal

<table>
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<tr>
<th>Resource</th>
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</thead>
<tbody>
<tr>
<td>Biomass</td>
<td>Dry Steam</td>
<td>Electricity</td>
</tr>
<tr>
<td></td>
<td>Flash Steam</td>
<td>Electricity</td>
</tr>
<tr>
<td></td>
<td>Binary Cycle</td>
<td>Electricity</td>
</tr>
<tr>
<td></td>
<td>Heat Pump</td>
<td>Building</td>
</tr>
<tr>
<td></td>
<td>Direct Use</td>
<td>Industry/Building</td>
</tr>
</tbody>
</table>

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<table>
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<tr>
<th>RESOURCE</th>
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<th>END-USE APPLICATION</th>
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<tr>
<td>HYDROPOWER</td>
<td>Conventional</td>
<td>Electricity</td>
</tr>
<tr>
<td></td>
<td>Pumped Storage</td>
<td>Electricity</td>
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<tr>
<td></td>
<td>Micro-Hydro</td>
<td>Electricity</td>
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</table>

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RENEWABLE ENERGY TECHNOLOGIES: OCEAN

RESOURCE

TECHNOLOGY

OCEAN

Tidal Energy

END-USE APPLICATION

Electricity

Thermal Energy Conversion

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ARE WE READY AS A COUNTRY?

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9-11 October, 2018
Theme: Renewable Energy: Exploiting Energy Resources at the District Level
17 goals that will transform our world

The 2030 Agenda is a global commitment to “leave no one behind” in realizing the Sustainable Development Goals (SDGs). Nowhere is the challenge of leaving no one behind more salient than in rural areas.

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Theme: Renewable Energy: Exploiting Energy Resources at the District Level
How GREEN HOMES can provide the building blocks towards several UN SUSTAINABLE DEVELOPMENT GOALS

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GHANA BUILDING CODE: CHAPTER 37

SCOPE: Mandatory requirement for Energy Efficiency

Option 1: Prescriptive Compliance Path

Option 2: Alternate Compliance Path - Green Building Certification
SCOPE: Mandatory requirement for Energy Efficiency

To achieve Energy Efficiency, it is recommended that the Chapter 37 of the Ghana Building code to applied as a mandatory requirement for new residential, commercial and public buildings that need to apply for a construction permit.
Due to the current limited enforcement capacity in Ghana, it is recommended that the code requirements be mandated in the first 3 years after code approval only for

- Private buildings throughout Ghana that are above 5,000m² total gross floor area and
- Public buildings located in all the Regional Capitals Accra, Kumasi and Takoradi that are above 500 m² in total gross floor area

After 3 years the area limit should be revised, based on the outcome of implementation.
SCOPE: Mandatory requirement for Energy Efficiency (Continuation)

All projects in Ghana within the defined scope must comply either with option 1 (prescriptive compliance path) or with option 2 (alternative compliance path) to obtain the construction permit.
Option 1: Prescriptive Compliance Path

Energy Efficiency Requirements

Achieving high energy efficiency in buildings starts with the three (3) Passive Design Strategies namely: Passive Ventilation, Passive Cooling and Daylighting.

E1. Building Envelope Properties
Building envelope consists of walls, windows and the roof. An efficient building envelope is the most important and the primary step in increasing the energy efficiency of a building. In Ghana, the most important parameters of the building that needed to be controlled are as follows:
Option 1: Prescriptive Compliance Path: Continuation

Window to Wall Ratio (WWR): This is the ratio of the area of the window or other glazing area to the area of the gross exterior wall area of the building. The gross wall area will include all openings like doors and windows measured horizontally from one surface to the other and measured vertically from top of the floor to the top of the roof.

Solar Heat Gain Co-efficient (SHGC) of the Glazing: SHGC is the amount of heat admitted through the glass vis-à-vis the total heat incident on the glass by direct solar radiation. The unit is a simple fraction or percentage. Thermal transmission for glazing material is measured in terms of U-value for conduction and Solar Heat Gain Coefficient (SHGC) or Shading Coefficient (SC) for solar radiation. Note that SHGC = 0.86 SC.
Option 1: Prescriptive Compliance Path: Continuation

Exterior Shading: External shadings are more effective in reducing solar heat gain than internal shading devices because it blocks the solar radiation before it reaches the building envelope. The geometry of the shading devices must be designed in response to the sun path, which leads to different shapes and sizes for different orientations.

It is recommended that this version of the code only include requirements on SHGC, dependent on the WWR, as shown below.

The requirements are based on the logic that the amount of solar radiation entering through windows should be kept at a defined maximum level. This maximum level was determined to be equivalent to the amount of radiation coming through clear glass (SHGC = 0.8) in a building with 30% WWR. So, if the building-wide WWR is increased beyond 30%, a lower SHGC glass should be used to maintain the same amount of solar radiation coming into the building.
Option 1: Prescriptive Compliance Path: Continuation

E1 RECOMMENDATION:

Table 1: Maximum Unshaded Glass Solar Heat Gain Coefficient for different WWR

<table>
<thead>
<tr>
<th>Window to Wall ratio (WWR)</th>
<th>&lt;30%</th>
<th>31-40%</th>
<th>41-50%</th>
<th>51-60%</th>
<th>61-70%</th>
<th>71-90%</th>
<th>&gt;90%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Unshaded Glass Solar Heat Gain Coefficient (USHGC)</td>
<td>0.80</td>
<td>0.60</td>
<td>0.48</td>
<td>0.40</td>
<td>0.34</td>
<td>0.30</td>
<td>0.26</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$D_h/H$</th>
<th>&lt;0.25</th>
<th>0.25-0.32</th>
<th>0.33-0.49</th>
<th>0.50-0.99</th>
<th>&gt;1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Shading Adjustment Factor (HAF)</td>
<td>0</td>
<td>0.31</td>
<td>0.36</td>
<td>0.43</td>
<td>0.50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$D_v/W$</th>
<th>&lt;0.25</th>
<th>0.25-0.32</th>
<th>0.33-0.49</th>
<th>0.50-0.99</th>
<th>&gt;1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical Shading Adjustment Factor (VAF)</td>
<td>0</td>
<td>0.14</td>
<td>0.16</td>
<td>0.18</td>
<td>0.21</td>
</tr>
</tbody>
</table>

Maximum Allowed SHGC = USHGCE [1+(HAF+VAF)]

E1 RECOMMENDATION:

Table 1: Maximum Unshaded Glass Solar Heat Gain Coefficient for different WWR

If there is permanent exterior shading provided, these Unshaded Glass SHGC (USHGC) requirements can be relaxed. The following adjustment factors can be used:

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Option 1: Prescriptive Compliance Path: Continuation

The above shading adjustment factors have been calculated for Accra weather using the EDGE Annual Average Shading Factor (AASF) calculation methodology. The shading factors were calculated for different orientations; however, it was found that the difference in resultant SHGC requirements for different orientations was less than 5%. Therefore, the same adjustment factors have been used for all orientations.
Option 1: Prescriptive Compliance Path: Continuation

An example for this calculation is shown below:
WWR, Window to Wall Ratio (from drawings): 67%
USHGC, Unshaded Solar Heat Gain Coefficient (from table 1 above): 0.34
Horizontal Shading:
  \( D_h \), Depth of horizontal overhang (area weighted average): 1 m
  \( H \), Glass height (area weighted average): 2 m
  \( D_h/H \): 0.5
HAF, Horizontal Shading Factor (from table 2 above): 0.43
Vertical Shading:
  \( D_v \), Depth of vertical overhang (area weighted average): 0.3 m
  \( W \), Glass width (area weighted average): 2.5 m
  \( D_v/W \): 0.12
VAF, Vertical Shading Factor (from table 2 above): 0

Maximum Allowed Glass Solar Heat Gain Coefficient:
USHGC \( X(1+HAF+VAF) = 0.34(1+0.43+0) = 0.49 \)
Note that the Shading factors calculation should account for all exterior glass in the building. If the exterior shading type and depth varies across the building façade, then an area-weighted shading depth should be used.

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Option 1: Prescriptive Compliance Path: Continuation

Energy Efficiency Building (E2)

E2. Openable windows
To give building occupants the opportunity to use natural ventilation for free cooling and fresh air in frequently occupied areas, a minimum area of the openable windows should be provided.

**E2 RECOMMENDATION:**
At least 5% of the occupied floor area must be specified as openable window. Openable balcony doors can be counted for this calculation. The gross area of the openable part of the window must be used for this calculation.

**Applicability:** Offices, Hotels, Hospitals, Schools, Residential Buildings (only apartments)
Option 1: Prescriptive Compliance Path: Continuation

Energy Efficiency Building (E3)

Heating, Ventilation and Air-conditioning

E3. Energy Efficiency of Air-conditioning Equipment
Air-conditioning typically accounts for around half of total electricity costs in centrally air-conditioned buildings. Hence, efficiency of HVAC systems is of prime importance. The efficiency (COP) recommendations are based on the size of the cooling system, as bigger systems typically are available with higher efficiencies.

E3 Recommendation:
The cooling system efficiency must meet or exceed the minimum efficiency requirement according as listed in Table below.

Table 3: Minimum efficiencies requirements for electric air-cooled air conditioning systems

Applicability: Offices, Retail Buildings, Hotels, Hospitals, Residential Buildings, Schools
Option 1: Prescriptive Compliance Path: Continuation

Energy Efficiency Building (E4)

E4. Variable Speed Drives
Variable Speed Drive (VSD) control the speed of machinery by changing the frequency of the motor operating it. Where process conditions demand adjustment of flow from a pump or fan, varying the speed of the drive save energy as compared to constant speed drives.

E4 RECOMMENDATION:

a. Cooling towers and closed-circuit fluid coolers: must have variable speed drives for controlling the fans.

b. Hydronic System Design and Control: HVAC hydronic systems having a total pump system power exceeding 7.5 kW must use variable speed drives.

c. Air handling units: The air handling units, which are more than 7.5 kW, must use variable speed drives with variable air volumes boxes.

d. Exemptions: Kitchen ventilation fans are exempt from the above rule.

In addition, all the equipment such as pumps and fans must use only high efficiency motors.

Applicability: Offices, Retail Buildings, Hotels, Hospitals, Residential Buildings, Schools

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Energy Efficiency Building (E5)

**Lighting and Electrical Power**

**E5. Lighting control system**

Building perimeter zones exposed to daylight generally do not require artificial lighting during the day. However, sub-optimal design and operation of the building results in use of artificial lighting when not required.

Buildings with good daylight access improve indoor ambience. However, energy savings are only available if the lights are switched off or dimmed. While this could be done manually, higher energy saving is possible by using strategically placed photoelectric sensors in the space. This reduces consumption of lighting energy as well as cooling energy due to lowering of internal heat gain from lights.
Option 1: Prescriptive Compliance Path: Continuation

Energy Efficiency Building (E5): Continuation

**E5 Recommendation:**

Lights in following areas must have photo sensor control, if they are on the perimeter, bigger than 50m2 in area, and have exterior windows:

1. Offices - open offices, lobby, meeting rooms
2. Retail Buildings -
3. Hotels - meeting rooms
4. Schools - meeting rooms/auditorium

Lights in following areas must have occupancy sensor control:

1. Offices - meeting rooms, staircases, enclosed office spaces, and corridors
2. Hotels - meeting rooms and corridors
3. Residential Buildings - enclosed car parks, staircases and corridors
4. Schools - enclosed car parks, classroom and corridors

Note: If occupancy sensors are installed in the daylight area, the occupancy sensor must override the daylight sensor during non-occupancy period. Emergency/exit lighting are not required to have occupancy sensor controls.

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Option 1: Prescriptive Compliance Path: Continuation

Energy Efficiency Building (E6)

E6. Energy efficient lighting system
Lighting accounts for a substantial portion of a typical household’s energy bill. Cutting lighting bill is one of the easiest ways to save energy and money.

**E6 RECOMMENDATION:**
Interior electric lighting in all building types given must not exceed the maximum installed lighting presented in the table below. This maximum LPD values apply for general lighting installation and do not include task lighting and display lighting.
### Option 1: Prescriptive Compliance Path: Continuation

### Energy Efficiency Building (E6): Continuation

#### Table 5: Maximum Lighting Power Densities (LPD)

<table>
<thead>
<tr>
<th>Building Type</th>
<th>LPD (W/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office</td>
<td>11</td>
</tr>
<tr>
<td>Hotel</td>
<td>11</td>
</tr>
<tr>
<td>Hospital</td>
<td>13</td>
</tr>
<tr>
<td>Health care center</td>
<td>11</td>
</tr>
<tr>
<td>Library</td>
<td>14</td>
</tr>
<tr>
<td>Convention</td>
<td>15</td>
</tr>
<tr>
<td>School</td>
<td>12</td>
</tr>
<tr>
<td>Commercial, services</td>
<td>16</td>
</tr>
<tr>
<td>Indoor parking space</td>
<td>3</td>
</tr>
</tbody>
</table>

**NOTES:**
- The Lighting power density – LPD, is determined by the total design lighting load divided by the serviced gross floor area.
- In a mixed-purpose (complex) building, LPD shall be determined using the lighting load and the floor area for each purpose.
- For areas or parts with special lighting needs in educational, health care facilities or others, the Lighting power density – LPD adopted shall be the applicable designed values.
Option 1: Prescriptive Compliance Path: Continuation

Energy Efficiency Building (E6): Continuation

LPD for car parks is the total lighting power divided by the total car park area. In the mixed used buildings, each building type area must comply with the LPD of corresponding building type.

Applicability: Offices, Retail Buildings, Hotels, Hospitals, Schools
Option 1: Prescriptive Compliance Path: Continuation

Energy Efficiency Building (E7)

E7. Residential Energy efficient lighting system

**E7 RECOMMENDATION:**
For residential buildings, one of these lamp types must be used in the lighting system:
1. Fluorescent Lamps – Size T5 with electronic ballast
2. Compact Fluorescent Lamps
3. LED (Light Emitting Diode) Lamps

**Applicability:** Residential Buildings
Option 2: Alternate Compliance Path: Green Building Certification
Green Building Certification (BUILDING RATING TOOLS)

Buildings certified at design and construction stage with any of the international green building certification systems (EDGE, DGNB, LEED, BREEAM, Green Star or any other government approved rating system) shall be considered as a replacement to all prescriptive requirements of this code.

Project owners must submit the design certificate for one of the above-mentioned certification systems to be eligible to receive the Construction Permit.

To get the Certificate of Habitation, the project owner needs to provide either the final certificate from the above-mentioned systems, OR arrange for an accredited 3rd party inspector to conduct a site visit and issue a report of compliance with the respective certification requirements.
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THANK YOU