Energy Efficiency Building: Alternative Energy Resources in Buildings in Africa for bigEE

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Abbreviations and acronyms

Abbreviation/acronym	Description
EE	Energy Efficiency
POET	Performance, Operation, Equipment and Technology
SANS	South African National Standards
SWAH	Solar Water/Air Heating systems
SWH	Solar Water Heaters

The objective of this energy efficiency (EE) document is to provide useful information of the best available technologies (BAT) of existing plug devices in office buildings in the South African and international markets.

1 Introduction

In this document, the efficiency of application of Alternative Energy Resources in Buildings is discussed in terms of the technology, equipment, operation, and performance (POET) framework. The EE is classified when possible in groups of South Africa available practices and international available practices.
The feasibility of using energy efficiency technologies outlined in this report shall be evaluated based on the investment cost incurred to achieve energy saving and resulting cost saving. An easy and quick decision making indicator is the payback period. A maximum payback period should be fixed for each energy efficiency technology or optimal component design. The energy efficiency technology or optimal component design will therefore be used if its payback period does not exceed the maximum payback period.
In addition to the financial factors, the following factors must be taken into consideration when applying alternative energy sources in buildings (Hayter and Kandt, 2011):

- Available renewable energy resource at or near the building site
- Available area for sitting of the renewable energy technology
- Cost of energy purchased from the electrical or thermal energy provider for the building
- Available incentives for offsetting the installation cost of the renewable energy system
- Local regulations affecting renewable energy systems
- Desire to preserve or not alter existing architectural features (in case of retrofitting)
- Characteristics of the energy profiles to be offset by the renewable energy installation.

2 Technology of Alternative energy resources

2.1 Photovoltaic systems

A. International available practice: single crystal solar cells, which made from silicon, are generally the most efficient (has an efficiency of 14–19%).
B. South Africa available practice: The same as international.

2.2 Solar thermal systems

A. International available practice (Hayter and Kandt, 2011; Pveducation.org, 2017): Solar Water/Air Heating systems (SWAH) use a collector to absorb and transfer heat from the sun to water/air.
B. South Africa available practice: The same technology is used to heat water.

2.3Heat pumps

A. International available practice (Hayter and Kandt, 2011): Use air-source heat pumps to heat, cool, and, if so equipped, supply homes and buildings with hot water, using the constant temperature of the earth or air as exchange medium for heat.
B. South Africa available practice: Use heat pumps to supply hot water, replacing traditional electric geysers.

2.4Wind turbines

A. International available practice: Harnessing the wind flow, or motion energy by modern wind turbines to generate electricity at utility and commercial sites.
B. South Africa available practice: N/A.

2.5 Biomass systems

A. International available practice: biomass boilers are used to burn organic matter to produce heat and/or electricity.
B. South Africa available practice: N/A.

2.6 Recommendation

International available practice and/or South Africa available practice shall be used subject to financial feasibility, resource availability and local regulations.

3 Equipment of Alternative energy resource systems and their maintenance

3.1Solar panels

A. South Africa available practice: Solar water heaters (SWH) and solar power plants.
B. International available practice:
    - Solar panels are used to heat water/air and generate electricity.

- Solar panels made of mono-/single-crystal cells should be used for maximum efficiency.
- Self-shading of panels should be avoided as much as possible.
- Panels can be mounted either as roof-top system or façade system, or a combination of these two where suitable.
- Solar tracking systems can be considered if necessary and financially viable.
- Ventilation of panels with at least 100 mm air gap is recommended for better efficiency.
- Utilisation of heat generated by the module, heat given off at the back of the panels, is of value during the heating season.

3.2Wind turbines

A. South Africa available practice: N/A
B. International available practice (GL Garrad Hassan, 2013):
   - Wind turbines of the Horizontal Axis type should be used.
   - The turbines should sit high atop towers to take advantage of the stronger and less turbulent wind at 30 meters or more aboveground.
   - Proper maintenance following Reactive Maintenance (fix it when it breaks), Preventive Maintenance (time-based) and Predictive Maintenance (condition-based) is recommended.

3.3Heat pumps

A. South Africa available practice: Air-sourced heat pumps to heat water.
B. International available practice:
   - Air-source and ground-source heat pumps should be used according to application.
   - There are four types of geothermal heat pumps available today. Three of these—horizontal, vertical, and pond/lake—are closed-loop systems. The fourth type of system is open-loop. Which system is best for a particular site depends on the climate, soil conditions, available land, and local installation costs. All of them can be used for residential and commercial building applications (USDOE, 2017).
   - Continuous indoor fan operation can degrade heat pump performance unless a high-efficiency, variable-speed fan motor is used.
   - Proper maintenance of the system can operate 10% to 25% more efficient than unmaintained one.
   - Clean or change filters once a month or as needed, and maintain the system according to manufacturer's instructions.
   - Service the heat pump at least every year by one professional technician.

3.4Biomass systems

A. South Africa available practice: Building biomass power plant to generate electricity.

B. International available practice:
   - Direct-fired and gasification systems are available to convert biomass to power.
   - Direct-fired systems, of which fluidized bed boiler has the highest conversion efficiency, are used most commonly today.
   - Gasification technology is still under extensive development and has limited application around the world.

3.5Batteries

In standalone application of alternative energy resources, such as solar electric system and wind power generating systems, batteries are of essential component to the system to safely transmit the electricity to the load that will use it, and/or store the electricity for future use.

A. International available practice:
   - The "deep-cycle" (generally lead-acid) batteries should be used.
   - The life cycle of the battery should be typically 5-10 years.

B. South Africa available practice: N/A.

3.6Recommendation

South Africa available practice and International available practice shall be used.

4 Operation of Alternative energy resource systems

4.1Solar systems

A. South Africa available practice: Same as international available practice.

B. International available practice:
   - Obtain a thorough understanding of the size and nature of an electric load to properly select and size a PV system.
   - Install solar panels on rooftop if possible as façade installation suffers a big loss in the ability to generate electricity.
   - Install solar panels on trackers when financially favourable.
   - Mount the PV modules at an incline (10-15° for framed modules, or as little as 3-5° for unframed modules), to allow rain water to properly drain off and keep the module clean.
   - Orient fixed-mount panels due South in the northern hemisphere and due North in the southern hemisphere.

- Use a light concentrator to improve the efficiency of solar systems (up to 15%).

4.2Wind turbine systems

A. South Africa available practice: NA.
B. International available practice:
    - Size of wind turbines must be selected according to the wind resource quality and electricity demand of the building.
    - The system can be connected to grid if wind resource in the area is good and the utility's requirements for connecting your system to its grid are not prohibitively expensive.
    - In stand-alone application, can be used in combination of other energy resources, such as solar power, geothermal, and biomass.

4.3Heat pumps

A. South Africa available practice: air-source heat pumps are used mainly to produce hot water.
B. International available practice:
    - Size of the system should be determined according to space available on site, available budget, etc.
    - A proper control system is important, and must be based on time and temperature information for different zones.
    - Energy storage is important for operation of heat pumps. In under floor application, use the floor slab as a thermal storage facility is very important in improving efficiency.
    - In other applications, a buffer tank is usually incorporated into systems using radiators to provide the required thermal storage for efficient heat pump operation.
    - Proper maintenance is required.

4.4Biomass systems

A. South Africa available practice: one biomass power plant is being planned.
B. International available practice (SEAI, n.d.):
    - Co-firing (in coal power plants) is recommended as the cheapest way of producing electricity.
    - Large-scale biomass heating stations (cogeneration heat and power plants, local heat network) is recommended for commercial and residential use.

4.5Batteries

A. South Africa available practice: N/A.

B. International available practice:
   - Batteries should be located in a space that is well ventilated and isolated from living areas and electronics
   - The space should provide protection from temperature extremes.

4.6Recommendation

International available practice shall be used.

5Performance of Alternative energy resources systems

5.1 Efficiency of solar panels

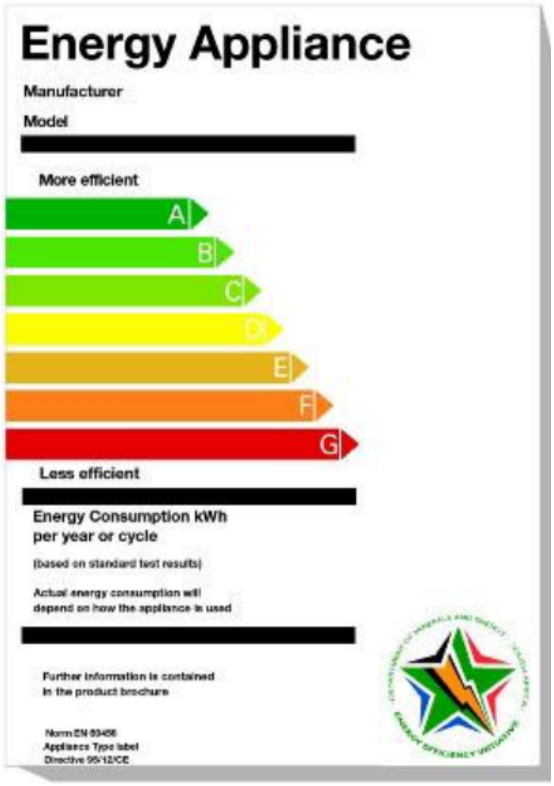
A. South Africa available practice: N/A
B. International available practice (Pveducation.org, 2017):
   - The efficiency of solar cells that are technically available and that of solar cells commercially available are different.
   - The recorded efficiency of solar cells that are technically available ranges from 20% to 41.1%.
   - The record efficiency of solar cells that are commercially available ranges from 11% to 25%.

5.2 Efficiency of Wind Turbines

A. South Africa available practice: N/A
B. International available practice: The commercially available wind turbines have efficiencies ranging from 75-80% of the Betz limit (maximal achievable extraction of wind power by a wind turbine is 59% of the total kinetic energy of the air flowing through the turbine).

5.3Efficiency of heat pumps

A. South Africa available practice: The South African energy labels (The Green Business Guide, 2017).
   - The current South African label gives a rating from A down to G – with A being the best. Old equipment may be the inefficient equal of a G-rated appliance. In addition to the letter rating, the label should carry an energy consumption number in kilowatt hours. It is often more useful to compare this number between models than to compare the letter rating.

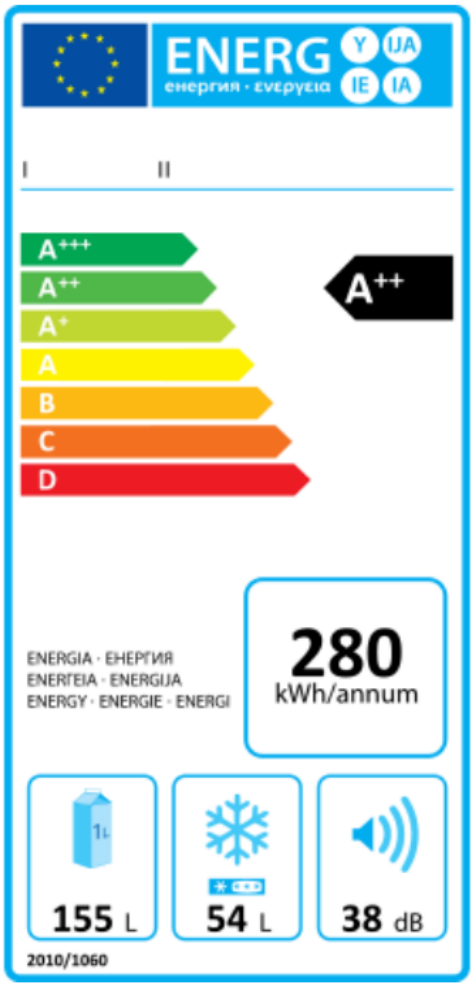


B. International available practice:

- The Energy Star label – US (energystar.gov, 2017): The blue Energy Star label system was developed in the United States but it is used in many other countries. The label guarantees the equipment to be fairly efficient. Following table gives key product criteria for air-source heat pumps.

Equipment	Specification
Air-Source Heat Pumps	>= 8.2 HSPF/ >=14.5 SEER/ >=12 EER* for split systems

C. European Union energy label – EU (Newenergylable.com, 2017): The EU ratings look very similar to the South African label, which is based upon the EU model. And the standards are similar, so a B-rating on an EU label is equal to a B-rating on an SA label. However, the EU label has added higher grades as appliances have become more efficient, all the way up to A+++. SA labels with higher grades are being planned for release in the future.



5.4Efficiency of biomass conversion processes

A. South Africa available practice: N/A
B. International available practice: The overall efficiency of biomass power/heat generating system varies quite distinctly according to application and size of the boiler. The best practice found in the world is summarised in (Steve Luker Associates Ltd & Reheat, 2014), which states that on average72-81.5% conversion efficiency can be expected.

5.5 Recommendation

International available practice shall be used.

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bigEE is an international initiative of research institutes for technical and policy advice and public agencies in the field of energy and climate, co-ordinated by the Wuppertal Institute (Germany). It is developing the international web-based knowledge platform bigee.net for energy efficiency in buildings, building-related technologies, and appliances in the world's main climatic zones.

The bigee.net platform informs users about energy efficiency options and savings potentials, net benefits and how policy can support achieving those savings. Targeted information is paired with recommendations and examples of good practice.

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