Fachhochschule Köln
Cologne University of Applied Sciences
Institute for Technology and Resources Management in the Tropics and Subtropics

SEMESTER PROJECT AFGHANISTAN

DESIGN STANDARDS FOR BIO-CLIMATIC HEALTH CENTRE IN COLD CLIMATES IN AFGHANISTAN

Midterm Report

Authors: Alejandra Quiroga
Mariela Pino
Anika Dhaubhadel
Marina Montelongo
Ina Yanakieva
Natalia Dulcey
Geoffrey Ndegwa
Mario Gelhard

Tutors: Simone Sandholz
Andreas Böhler

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ABBREVIATIONS

A	Ampere
AC	Alternating Current
ADB	Asian Development Bank
AFGEI	French-German Energy Initiative
AFGEI	Afghan French German Energy Initiative
BHC	Basic Health Center
BHC	Basic health centre
BPHS	Basic Package of Health services
CUAS	Cologne University of Applied Science
DC	Direct Current
DED	Deutscher Entwicklungsdienst
EIA	Energy Information Administration
GERES	Groupe Energies Renouvelables, Environnement et Solidarités
GTZ	Gesellschaft für technische Zusammenarbeit
HCC	Health Care Centre
IEE	Institute for Electrical Engineering
IROA	Islamic Republic of Afghanistan
ITT	Institute for Technology and Resources Management in the Tropics
kWh	kilo Watt hours
MEW	Ministry of Energy and Water
MoPH	Ministry of Public Health
O&M	Operation and Maintenance
PV	Photovoltaic
V	Volt
W	Watt
NATO	North Atlantic Treaty Organization
U.S.	United States
VOCs	Volatile Organic Compounds

Introduction

In the frame of the Afghan- French- German Energy Initiative (AFGEI), a delegation of the Government of Afghanistan visited the Cologne University of Applied Sciences (UASC) in July 2008. The mission was hosted by the Institute for Technology and Resources Management in the Tropics (ITT) and the Institute for Electrical Engineering (IEE).
During the visit, it has been discussed that a potential partnership could be in the form of a common research project between the involved partners in the field of renewable energy and energy efficiency. The Afghan delegation, accompanied by the French NGO GERES, presented a verbal proposal of a “Zero Energy” health clinic.
On this basis a concept of a semester project to **DESIGN STANDARDS FOR BIO-CLIMATIC HEALTH CENTRES IN COLD CLIMATES IN AFGHANISTAN** was developed.
The concept is being developed at the moment for the pilot province of Badakhshan in the Northeast. This should be the regional focus for the semester project as well, because it also focuses then on cold climate regions, where most Afghans live.

Overview

Afghanistan is a country that faces not only the challenge of redevelopment after almost 30 years of war, but as well the circumstances of a still battled political unrest, which shows in a critical security situation in most provinces. Infrastructure like roads, electricity or water supply, especially in rural areas, is still destroyed or not in place at all. Currently, the Ministry of Public Health (MoPH) of Afghanistan runs 1085 health clinics all over the country. More than 500 clinics have been built since 2002 with the help of international donors. In the next three years, 371 clinics are planned to be built according to the Afghan National Development Strategy (ANDS) for the health sector.
The clinics that have been built and that are in consideration to be built follow one standard design of the Ministry of Urban Development (MoUD), which is not appropriate for the specific circumstances in Afghanistan:

- The architectural design does not address the different climatic zones. GERES identified three zones: about 5 Million people live in very cold climate with 3 winter months below 0 deg. Celsius; 16 Million people live in cold climate with 1 winter month around 0 deg. Celsius; 5 Million live in hot desert climate. The clinics now are not insulated and not oriented appropriately.
- The electrical supply system is insufficient and not sustainably manageable. A generator room is included in the design as well as the installation of the electrical system such as

light and fans. The clinic is equipped with a diesel generator (typically 10 kW). The MoPH has a budget for the running costs of the electrical system, which is very limited. Usually, it is not sufficient for providing enough electricity even during one day- let alone regularly maintenance.

- The water supply and waste water system is not appropriate. Depending on the region and season, clean (drinkable) water supply is lacking. In winter times, water supply is not possible due to freezing of the pipes. Hot water is not available and there is no sufficient waste water system in place.
- Especially for the cold climates, no space heating system is available. In winter times, temperatures inside the clinics can fall to 0° C and below.

The points above lead- beside other factors like underpaid doctors and nurses- to a miserable account of health services in Afghanistan.

Study area

The **Islamic Republic of Afghanistan** (IROA) is a landlocked country located in the central part of Asia. Neighbouring countries are: Pakistan, Iran, Turkmenistan, Uzbekistan, and China. Afghanistan has a very strategic location being on the crossroad between the East and the West, and connecting South and Central Asia and the Middle East.

Political situation

Since the late 1970's Afghanistan has suffered continuous civil war and foreign interventions. In the period of 1979-1989 the country experienced a soviet invasion and in 2001 U.S. and English troops entered Afghanistan intending to remove the Taliban government. In December 2001 a plan for a new democratic government was established and an International Security Assistance Force was created, composed of NATO troops that were to assist the new government with a chairman Hamid Karzai. In October 2004 a new constitution was ratified and an election was held where Hamid Karzai won and became the official President of the Islamic Republic of Afghanistan. In December 2005 with legislative elections including women as voters and candidates, the National Assembly was sat.

The instability of Afghanistan has lasted for almost 40 years in which period the country has been governed by almost every system of government- monarchy, republic, theocracy and communist state (ADB, *2008*)

Despite the progress in establishing a new government and administrative structures, and the presence of about 70,000 international troops in the country, Afghanistan continues to suffer even increasing in the period of 2005- 2008 insecurity due to the resurgence of the Taliban and other anti-government and illegally armed groups that aim at government staff, national and international military personnel, international and domestic development workers, contractors and consultants, as well as the civilian population. Kidnappings remain rampant, and roads are increasingly unsafe for foreigners and Afghans, especially at night (United Nation Security Council Report, *2006*).

The country's reconstruction has been paced down by ongoing conflict, weak and inexperienced state institutions and somewhat ineffective coordination of international donor support.

Social

About 12 million Afghans (42% of the population) live below the poverty line (~14 per month per capita) and further 20% live just above it. In addition, with the short life expectancy of 43 years, the high analphabetism (64%-80%) and child mortality, Afghanistan's HDI is estimated as one of the lowest. However, the country is not ranked officially by the lack of quality data. 57% of the population is under 18 years of age but not or underemployed; gender inequality is strong.

There are some positive changes. Between 1979 and 2000 one third of the population escaped from the war. Nevertheless, since 2001 about five million out of eight million total have returned. About half of Afghanistan's children now attend school, including girls. Because of the increase of child immunizations to around 70 percent child mortality has declined from about 165 deaths for every 1,000 individuals aged five or less early in this decade to 130 per 1,000 in 2008 (ADB, *2008*), (Federal Research Division, *2008*)

Economical

Afghanistan is one of the poorest countries in the world, with very few resources and limited human capital.61% of the population works in agriculture. The unskilled people represent around 3 million persons with 40% of unemployment.

Despite its difficult situation, Afghanistan has performed well on economical level in the period 2003-2008 fuelled by large inflows of foreign assistance and increased earnings from opium production. The major contributors to Afghanistan's economic growth have been services and industry. It is supposed that about 50% of the country's GDP comes from the cultivation of illegal poppy and opium trade. (ADB, *2008*), (Federal Research Division, *2008*)

Natural gas and petroleum are seen as potential resources for improving the national budget.

Technical:

The country has a poor infrastructure. However there are airlines that fly inside and outside the country and automobiles have recently become widely available. Nearly all highways are being rebuilt. Telephone use has increased and more than five million people now have phones. Project for fiber optic cable network should improve the telephone, internet, TV and radio broadcast. The national post service is also operating.

Capital (and largest city)	Kabul
Official languages	Dari (Persian), Pashto
Government	Islamic republic
President	Hamid Karzai
Vice President	Ahmad Zia Massoud
Vice President	Karim Khalili
Chief Justice	Abdul Salam Azimi
Area	
Total	647,500 km^2
Water (%)	0
Population	2008 estimate
	32,738,376
GDP (PPP)	2007 estimate
Total	$20.099 billion
Per capita	$733
HDI (1993)	0.229 (unranked)
Currency	Afghani (AFN)

Data on Afghanistan

Table 1: Data on Afghanistan, Source: **http://de.wikipedia.org/wiki/Afghanistan**

Objectives

Overall objective

Enable the MoPH to implement health clinic designs depending on several factors that determine the most appropriate design in order to be able to provide sufficient and long- lasting health services to the people of Afghanistan.

Specific objective

To understand the issues involved in the design and implementation of sustainable buildings in the developing world and, moreover, the understanding of the different views and opinions that occur in a north- south- development effort.

Project goals

The semester project aims the general understanding of the issues involved in the design and implementation of sustainable buildings in the developing world and, moreover, the understanding of the different views and opinions that occur in a north- south- development effort.

Methodology

Step I: Understanding and Analysis of the local context

The analysis includes relevant background- analysis (e.g. general background, political situation, environmental issues including natural resources, energy, constraints and specific challenges concerning health clinics in Afghanistan).

Step II: Understanding local health services, needs and clinic design

- Analysis of the factors that influence the availability and the quality of the local health services, in order to translate these factors into design requirements.
- Analysis of the existing clinic design standard regarding the needs of the population considering the requirements of the National Health Policy 2005-2009 and National Health Strategy 2005-2006 of the MoPH.

Step III: Design and Evaluation of a bio climatic health clinic

Finding of technical possibilities for the construction of the clinic and compilation of a catalogue of feasible solutions to address the main specifications according to step 2.

The solution catalogue should be prioritized according to the main constraints. Technical constraints as well as economical and socio- cultural factors will be included and the most feasible and appropriate solutions will be shown.

Step IV: Preparation of the final results and presentations

The results will be delivered as:

- Project report (PDF- file)
- CD- Rom with all documents, data, drawings, etc.
- Internet project- website
- PowerPoint presentation covering most relevant results

Midterm results

Midterm results according to each working area will be described to understand the local health services, needs of the population and the clinic design.

Local health services

After the departure of the Taliban's regime in 2001 the new Transitional Islamic state of Afghanistan faced a critical health situation whit a infant mortality of 165 per 1000 live births and 1600 maternal deaths for every 100 000 live births (BPHS 2005). To improve this situation and reconstructed the health care system in the country, in 2003 the MOPH developed a strategy called Basic Package of Health services (BPHS).
The general objectives of the BHPS are:

- To provide a standardized package of basic services which forms the core of service delivery in all primary health care facilities
- To promote the redistribution of health services by providing equitable access, especially in underserved areas

And the main components to be implemented are (Ministry of health, 2005):

- Maternal and newborn health
- Antenatal, delivery and postpartum care; family planning and care of the newborn
- Child health and Immunization: Integrated management of childhood illness
- Public nutrition
- Micronutrient supplementation and treatment of clinical malnutrition
- Communicable diseases: Control of tuberculosis and malaria
- Mental health: community management of mental problems and health facility based treatment of outpatients and inpatients
- Disability: physiotherapy integrated in PHC services; Orthopaedic services expanded in hospitals
- Supply of essential drugs: according to the region, distances and populations four categories where established
    1. Health post
    2. Basic health centre (BHC)
    3. Comprehensive health centre
    4. District hospital

Analysis of the local health care centres

The main factors that influence the availability and the quality of the service in rural areas are:

1. The coverage of health system
    - There are not enough HCC resulting in a insufficient coverage over the country. Despite the improvement between 2001 and the present years, differences between rural and urban areas still exist.
2. Availability of personal
    - There is a lack of personal, doctors and nurses are strongly needed. One reason can be that in many rural areas communal doctors and traditional medicine represent the health care system. The gender factor also influences the personal situation because women were not considered or could not work.
3. Resources access
    - In the most rural areas water, electricity, roads, garbage management are a problem. The precarious situation and the lack of basic services hinder the development or -in most of the cases- the implementation of the health system.
4. Health treatments and diseases
    - The main reasons for the deaths are: No antenatal and delivery care.
    - Child health services and immunization (vaccines)
    - Tuberculosis as mayor health problem
    - Malaria, Diarrhoea and Pneumonia

Design requirements

For the present project we can only focus on the design requirements for the clinics because the decision of the number and location of the health centres depends on the Afghan government. Based on the original design the following requirements for the special distribution can be added:

- Delivery and postpartum room
- Vaccines room, suitable place to store vaccines (refrigerator)
- Special room for the female doctors and nurses
- Water wells and latrines or bathrooms with techniques of water efficiency
- Program of Waste management considering the final disposal

Working area energy supply

Energy situation in Afghanistan

Despite the existent oil and gas fields in the northern area of the country, Afghanistan still needs to import petroleum, diesel, and gasoline and jet fuel from Pakistan, Uzbekistan and

Turkmenistan. According to the Assian Development Bank (ADB) more than 85% of the energy need are met by wood, resulting in deforestation and degradation of the soils. Only 10% of the population has access to electricity, which is imported as well in the border regions from Turkmenistan and Uzbekistan (EIA, 2006). Since this supply it is not regular, large variations of the price can occur. The per capita consumption per year is in average less than 25kWh. The electricity is quoted a very low price for private, domestic and public sector. (Rozis, 2007) For non grid connected buildings, generators are the most common used source of electricity production but its efficiency and the economical application; especially in terms of maintanance, are highly debateable.

The international community has invested in infrastructure for energy supply for both off grid and grid connected systems but still there is a lot to be done to keep managing and maintaining these investments. Main challenge for the government is to set the further steps for a self sufficient energy supply for the whole of Afghanistan (AFGEI Newsletter No. 5, April 2009). The reconstruction of the Ministry of Energy and Water (MEW) its taking place to achieve the energy policies for urban and rural areas, for instance planning projects in hydro power, renewable energy, solar energy, wind energy, use of biomass and transmission and distribution. Workshops are taking place to teach the people about efficient energy management. Aditionally the AFGHAN FRENCH GERMAN ENERGY INITIATIVE (AFGEI) has already set 16 posters about renewable energy and energy efficiency to raise awareness among the population (AFGEI Newsletter No. 3, April 2008). An evaluation has been done to evaluate the energy efficiency in public buildings and schools and new technologies to improve the production of bricks have been introduced (50% energy saving + 90% reduction of air pollution). (AFGEI Newsletter No 2, January 2008). Electrification worshops are also planned, to support the use of small hydropower stations, solar lamps and solar home systems (AFGEI Newsletter No. 1, October 2007).

Possible solutions for a Basic Health Centre

Most health facilities require some artificial lighting and refrigeration. Lighting is crucial for maternities, where night time births are common. Refrigeration is necessary for child immunization programs and many common medicines. Larger clinics may also need electricity for fans or heaters, medical equipment, and computers. Kerosene lighting may be a safety hazard and contributes to poor indoor air quality. To supply a Basic Health Center (BHC) several options need to be taken into account. The first and apparently the most suitable option is to generate power through to a photovoltaic system. The fact that Afghanistan has some 300 days of sunshine and the good availability of the necessary components to install such a system is strongly supporting this approach. PV systems are reliable and simply to apply with all the required data for a proper design available (Moeller, 2009). Ongoing workshops carried out by Information Centres (GTZ and DED) are spreading the knowledge how to install, use and maintain photovoltaic systems (AFGEI Newsletter No. 1, October 2007).

The application of small wind turbines strongly depends on the local micro climate which itself depends on a number of factors such as ground relief, mountains, trees, houses, local winds, etc. and needs to be verified by local measurements. Therefore it seems not to be suitable for a standard application in a basic health centre in Badakhshan (Moeller, 2009).

Further research on suitable alternatives has to carry and will be presented in the later stage of the project progress.

PV Systems

PV systems offer consumers the ability to generate electricity in a clean, quiet and reliable way. Photovoltaic (PV) cells convert sunlight directly into electricity without creating any air or water pollution. PV cells are made of semiconductor material. When light enters the cell, some of the photons from the light are absorbed by the semiconductor atoms, freeing electrons to flow through an external circuit and back into the cell. This flow of electrons is electric current.

Off-Grid Solar Systems

An off grid PV system, sometimes called a stand-alone system, is designed to provide electricity to a home or business without drawing on supplemental power from the electrical utility (if available at all). These systems consist of a PV array, control and safety equipment, a battery bank, and usually an inverter. An optional backup system, such as a generator, could be required in cases where perishables like vaccines or other medical drugs are stored.

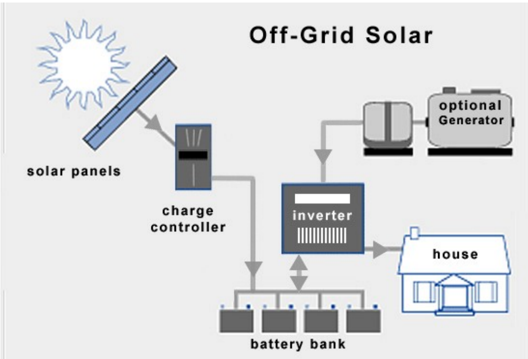


Figure 1: Off-Grid Solar System (Wikipedia, 2009)

PV Array

The number of panels in a PV array varies depending on the wattage of the PV panels and the desired output of the system. The PV array can be mounted on a south facing roof, on a static frame at ground level, or on a tracker. A tracker is a PV rack that rotates on top of a pole. The tracker rotates to follow the sun across the sky during the day, insuring maximum solar exposure for the PV panels and thus a maximum yield.

Control and Safety Equipment

Each PV system has a charge controller to monitor the electrical input of the PV panels, and to guard against overcharging of the batteries. The safety equipment includes an electrical fuse box.

Battery Bank

Batteries are used to store energy for use at a later time, like night time or on cloudy days. The batteries used in a PV system are deep cycle batteries. Deep Cycle Batteries are used where discharging and charging occurs frequently. The number of batteries used in a system varies on the type of battery, and the anticipated storage needs.

Inverter

An inverter converts the low voltage DC (Direct Current) power that is produced by the PV panels and stored in batteries, into AC (Alternating Current) power. In Germany for example the AC voltage in the national grid is 230 V. Systems can be designed without an inverter. In these systems all appliances and lights must run off DC power. In general, DC appliances are more expensive and less available than traditional AC appliances and lights. But the fact that in a pure DC system the application of inverters can be neglected could make it again cost effective.

Side requirements

There are three factors to consider when determining whether a site is appropriate for a PV installation. First, systems installed must have a southern exposure. For maximum daily power output, PV modules should be exposed to the sun for as much of the day as possible, especially during the peak sun hours. Second, the southern exposure must be free of obstructions such as trees, mountains, and buildings that might shade the modules. Consider both summer and winter paths of the sun, as well as the growth of trees and future construction that may cause shading problems. Finally, the unobstructed southern exposure must also have appropriate terrain and sufficient space to install the PV system. Seasonal variations affect the amount of sunlight available to power a PV system.

System sizing

The size of the PV system (number of panels, batteries, etc.) is dependent on how much electricity must be generated to power the clinics loads (consumption data). The procedure for determining system size requires looking at the wattage required for each appliance and light bulb in the clinic and multiplying it by the number of hours it will be used each day. This number is the total daily consumption. System losses which occur on the way from the power generating PV panels to the power consuming devices have to be calculated as well. Finally the cable cross sections have to be calculated, requiring a detailed plan of the location (clinic).

Operation & Maintenance

No PV system is maintenance-free. Regular inspections of the system will ensure that the wiring and contacts are free from corrosion, the modules are clear of debris, and the mounting equipment has tight fasteners. Storage batteries will also require regular maintenance. This will consist of a monthly check of the electrolyte levels, occasional addition of distilled water to the battery cells, and routine equalization of the batteries. An operation and maintenance guideline for the ones responsible has to be developed.

Cost considerations

A PV system can be a cost effective alternative for providing electricity to remote locations, or locations where power lines do not exist. While the initial capital investment is higher, PV provides electrical power at less than the cost of electricity from generators, based on lifecycle cost.

Heating

Concerning health centers in the surroundings of Kabul a great variety of heating equipments depending on the fuel availability, can be seen.The notion of confort is relative, usually the heating needs are mainly satisfied with intermittent heating systems. (Rozis, 2007)

Further research on the possibilities of heating has to be carried out in the ongoing process of the project.

Working area water and sanitation

Fresh Water Resources

There are two main water sources: surface water and groundwater. Surface water sources are rivers, streams, man-made ponds or reservoirs, lakes, and seas. Streams are generally seasonal; depending on the size and tributaries, river-water sources can be seasonal or year round. Seasonal water sources require man-made dams or reservoirs for water supply and irrigation purposes. However, water resources from year-round rivers or lakes do not require such storage. Groundwater resources are formed when the surface is over-saturated and the excess water filters down.

Raw Water Quality

Surface water is exposed to contamination due to human, animal, and industrial activities upstream. Surface water can be contaminated with both pathogenic and non-pathogenic organisms and suspended solid particles from precipitation or runoffs.

Groundwater is usually clear and odourless. Groundwater does not usually contain suspended solid particles or bacteria or organic matter, but does usually contain dissolved mineral ions. The type and concentration of these dissolved minerals can affect how the groundwater can be used. Although groundwater may not have bacteria, there is a risk of contamination, especially for shallow wells, from human and animal activities in the area. Contaminants can seep into the ground from the top of the borehole. Therefore, the area surrounding the borehole should have proper drainage to keep it dry, and the borehole should be properly capped.

The WHO guidelines for five categories of contaminants for drinking water:

1. Microbiological and biological standards (micro organisms and other organisms)
2. Inorganic constituents that pose health risks (arsenic, cadmium, nitrate, lead, and sodium)
3. Organic constituents (benzene, phenols, dichlorodiphenyltrichloroethane (DDT), and others)
4. Aesthetic guidelines (door, taste, hardness, and colour)
5. Radioactivity guidelines (mostly for groundwater).

Water Storage

Depending on the intended purposes and the kind of water resources, there might be a need to have raw water storage. Raw water storage is necessary if the water resource is not available year round. Cities require large amounts of water and in most cases dams are used for storage. For rural water supply, however, dams (or any surface water source in general) are not recommended because surface water usually requires expensive treatment. If there is a groundwater source, several wells can be drilled, depending on the water demand. In some cases, runoff can be guided to flow into the groundwater catchments field for quick borehole recovery or for higher discharge. Such methods are also used to raise the groundwater table. Generally, domestic water requires clean storage to improve water distribution management and to prolong the life of the pump. Water tanks can help improve water distribution networks and can even supply water while major or minor maintenance is being performed on pumping systems and distribution pipes. A critical factor for the life of a pump is how often the pump runs to fulfill the water demand. The size of the storage tank determines how often the pump is operating to meet the water demand. Clean water storage for a domestic water supply can be designed based on the geographical location, topography of the area, and the water demand. The storage can be made of steel, polyvinyl chloride (PVC), fibreglass, concrete, or steel based on the conditions mentioned. In most cases, steel, fibreglass, and PVC tanks are used for renewable-energy-based water supply systems. However, the size of the water tanks for renewable-energy-based systems should be large enough to fulfil the water demand for the worst-case situations (e.g. in case of continuous cloudy days). Generally, elevated water tanks are used for PV- (photovoltaic) and wind-powered water supplies in rural areas to easily distribute the water to the communities using gravity. Such systems have simple distribution networks where the villagers get water from central distribution points. Figure 2 shows a typical rural water supply storage tank and distribution system installations.

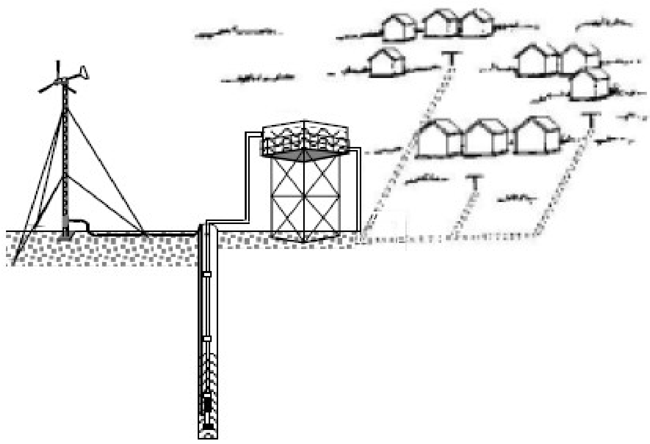


Figure 2: Village water supply powered by an electrical wind turbine

Energy Sources for Water-Supply Technologies

There are several power source options for rural water supply applications, including diesel/gasoline/kerosene pumps, grid-connected electric pumps, wind pumps, solar pumps, biofuel pumps, animal-drawn pumps, and hand pumps.

Electrical Wind Pumps

Electrical wind turbines are designed to produce alternating current (AC)-or direct current (DC)-electric output and can be used to pump water by directly connecting to AC or DC motors. Electrical wind turbines are designed for low solidity rotors and are best suited for centrifugal pumps. A typical electrical wind turbine used to pump water is presented schematically in Figure 3. This technology eliminates the use of batteries and inverters by directly coupling the wind turbine with an AC motor, which then drives the centrifugal pump at varying speeds. This technology simplifies the problem of matching wind turbines with the appropriate water pump by varying the load electrically instead of mechanically (i.e., varying the stroke as in the case of windmills).Because wind is best at the crest of a hill, and water is found on lower ground, wind turbines can be located where the winds are strongest at the optimum-cost cable length from the well.

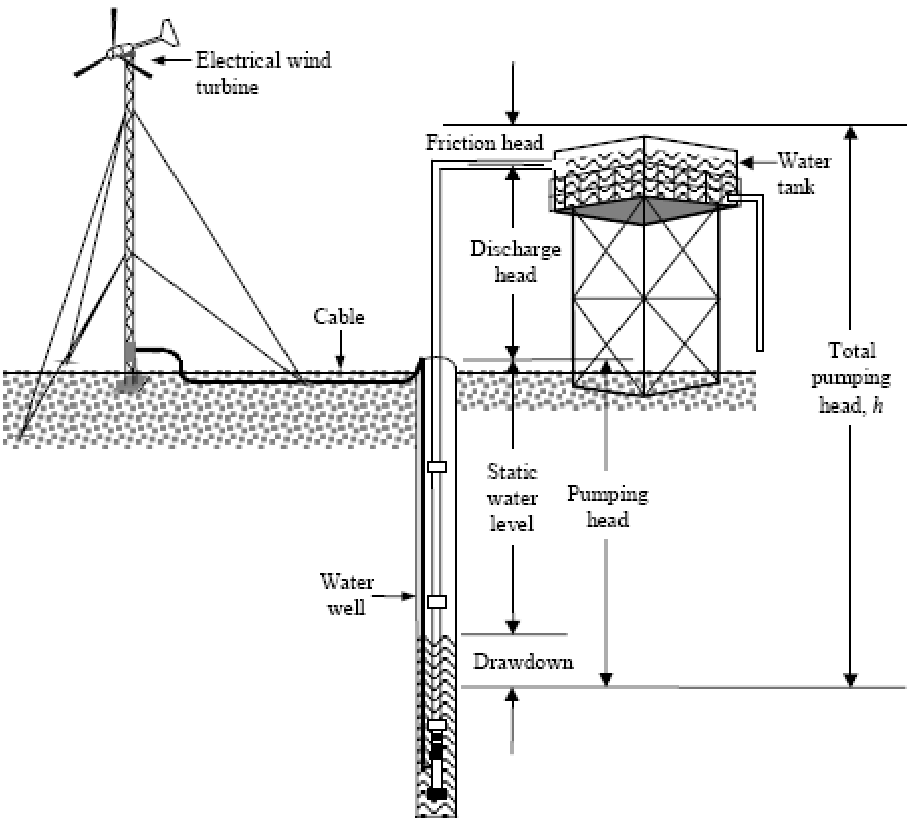


Figure 3: Electrical wind turbine connected to a submersible centrifugal pump

Electric wind pumps are twice as efficient as traditional windmills and are cost competitive compared to diesel, PV, or traditional windmills. Modern electric wind turbines have fewer moving parts than the traditional windmills and this keeps maintenance costs low. Electric wind turbines are also quite versatile.

Solar (Photovoltaic) Pumps

As the name implies, solar pumps are powered by solar radiation energy impinging on the surface of semiconductor materials by electromagnetic means. The smallest semiconductor material is a PV cell. Because the maximum voltage from a single silicon cell is only about 600 mill volts (mV), cells are connected in series to obtain the desired voltage. Usually about 36 cells are used for a nominal 12-volt charging system. Currently available standard PV modules range in output from less than 2 watts (W) to about 110 W. The PV module constitutes the basic building block from which any size PV array can be configured to suit the application. The PV array converts the solar radiation into DC power, and this power is then used directly or indirectly (converted into AC using an inverter) to power the electrical motor to drive the pump. A typical village water supply using a PV pump is shown in Figure 4.

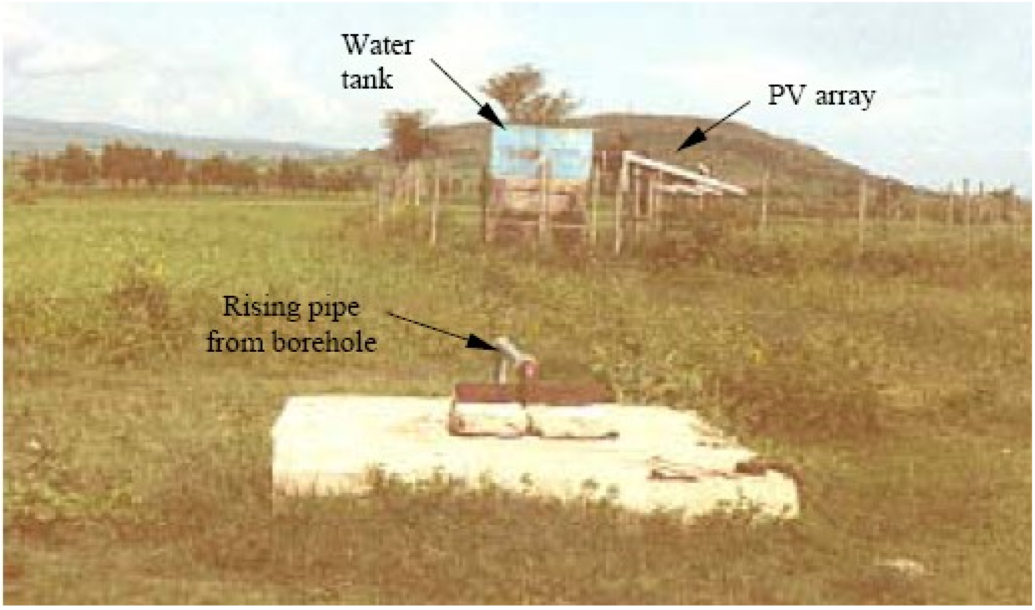


Figure 4: Typical village water supply using a PV pump

Unlike other alternative pumping options, solar pumps generally incur a high investment cost; however, this cost can be offset by a long service life since operation and maintenance (O&M) costs are minimal over its economic life. Solar pumps are a very reliable technology and can be matched quite closely to the amount of water needed. However, since solar pumps cannot deliver water on demand, a careful assessment of the solar energy resource and water demand is needed. Water tanks should be adequately designed to store enough water for days when there is little or no solar radiation.

Other Water Supply Systems

Rainwater is another source of water for rural villages. Rainwater can be collected either from gutters or by using a large rainwater catchments area in an open field (ponds). However, pond water is exposed to contamination, depending on human and animal activities surrounding the area. Another cause of contamination is water stagnation. Water collected in a pond has no outlet, unless the water is used for irrigation and canals are dug to bring the water to the fields. Stagnant water is a breeding place for most waterborne diseases (microorganisms such as bacteria, viruses, and parasites), and it is not generally recommended for drinking without some kind of treatment. Unfortunately, many people around the world still use untreated pond water for drinking as well as for watering cattle and irrigating fields.

However, this water source is good for irrigating small fields. A simple schematic diagram of rooftop rainwater catchments is shown in Figure 5.

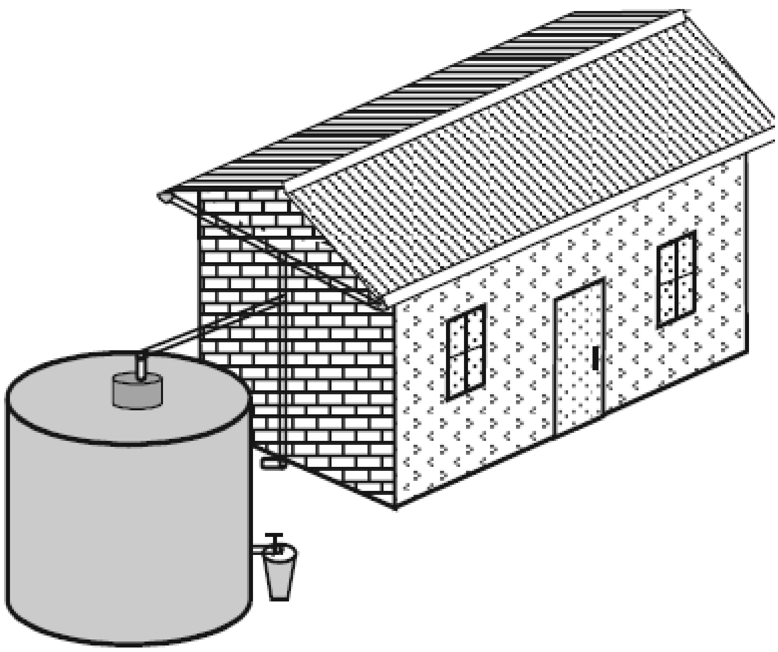


Figure 5: Rooftop rainwater catchments

Water Treatment in Rural Areas of Developing Countries

Most rural water supplies in developing countries do not use any type of water treatment. The local people have little understanding of waterborne diseases, they lack qualified technicians to operate or maintain the system [including the amount of chemicals (mostly chlorine) to apply and how much to apply], and they don’t have the money. Additionally, in many rural villages, the quantity of water is more important than the quality. The rural people in arid regions of developing countries search for any water source, which is frequently difficult to find, and consequently they are more exposed to infectious diseases related to personal hygiene caused by a lack of water. In such cases, the availability of adequate water is more important for survival than its quality. In a country with limited financial resources, where supplying water for people and their cattle is critical, water treatment is considered secondary. Hygiene education can promote increased awareness of waterborne diseases. Most water development organizations focus on providing an adequate quantity of water from the best available source.

In most rural areas, the main microbiological and biological contamination comes from pathogenic and non-pathogenic organisms. Pathogenic organisms are nonfatal coli form bacteria found in soils. These organisms mainly cause diarrhoeal diseases. Faecal coli form bacteria are primarily non-pathogenic and reproduce in the intestines of warm-blooded animals. Other contaminants are organic and inorganic constituents. Inorganic constituents include such minerals as arsenic, cadmium, nitrate, lead, fluoride, and sodium, which occur naturally in groundwater or surface water, but may also result from industrial activity and agricultural practices. In rural areas, water is disinfected by using a chlorine solution (made from high-test hypochlorite powder or liquid bleach). Urban water treatment water treatment systems use chlorine gas. Chlorine in solid form (tablets) is mainly for individual home use. The simplest method of disinfecting water is pasteurization by simply boiling it. However, boiling water consumes lots of fuel. According to the World Bank Report, more than $50 million per year is spent in Jakarta, Indonesia, alone for fuel to boil water in households.

Traditional Groundwater Treatment

Unlike surface water, groundwater is purified by passing through the aquifer and is generally safe to drink. However, in some areas, the groundwater contains minerals, such as iron, manganese, salt, fluoride, and other substances, which causes an undesirable taste and odour. In that case, surface water may be unavoidable. On the other hand, there are several simple techniques available to remove minerals and salts. For example, concentrations of dissolved iron and manganese can be removed by a simple aeration technique and sand. Aeration causes the iron and manganese to become insoluble so they form fine dark sediment, which is more easily removed. It can be constructed in a simple way that does not require a motorized pump. A hand pump can be used directly to pump the mineral water into the aeration system. However, other chemicals like salt, fluorides, and nitrates are not easily removed under rural village conditions. It may require some form of chemical and settling process. For example to remove fluoride, alum (aluminium sulphate) needs to be mixed with the water, followed by a settling process. Such a chemical is not easily available in rural villages

Ecological sanitation (ecosan)

The concept behind ecological sanitation (ecosan) is that sanitation problems could be solved more sustainably and efficiently if the resources contained in excreta and wastewater were recovered and used rather than discharged into the water bodies and the surrounding environment. Ecological sanitation is a new paradigm in sanitation that recognizes human excreta and water from households not as waste but as resources that can be recovered, treated where necessary and safely used again.

For toilets the following systems can be distinguished.

- Urine Diversion
- Dehydration Toilets
- Composting Toilets
- Vacuum Technologies

Urine Diversion

The major difference between urine diversion (UD) and other sanitation systems is that a urine-diverting toilet has two outlets and two collection systems: one for urine and one for fasces, in order to keep these excreta fractions separate. UD toilets may, or may not, mix water and faeces, or water and urine, but they never mix urine and fasces.

Purposes of UD Toilets

1. Reduce **odour** (in dry toilets): when urine and faeces are not mixed, the odour from a dry (or waterless) UD toilet is much, much less than when urine and faeces are mixed together (as in a pit latrine). Therefore, a dry toilet with UD can even be placed indoors without causing odour problems.
2. **Avoid production of wet, odorous faecal sludge**, which has to be removed by someone when the pit latrine is full. Faeces collected dry, separately from urine and water, are hardly offensive, especially after an extended drying period in a faeces vault); this is particularly relevant for hilly or crowded areas with difficult access for vacuum trucks to pit latrines.
3. **Reduce water consumption** – in the case where UD devices are of the waterless type (i.e. waterless urinals; UD toilets without flush water) or of the water-saving type (UD toilets where the urine is flushed with a smaller amount than the faeces).

1. C**ollect urine pure** so that it can – after sanitisation by storage – be safely used as fertiliser in agriculture. This is particularly important for small-scale farmers who cannot afford costly artificial fertilisers.

Advantages of UD

Listed are the most obvious advantages which are closely linked to the purposes of UD toilets mentioned above:

1. Significantly **less odour** when compared to pit latrines.
2. Toilet can be **indoors** (when comparing UD toilets to pit latrines), which leads to higher security, privacy and user comfort. This aspect is very important for women and girls, who may fear to go to the toilet outside in darkness if security levels in the com-munity are low.
3. **Water savings:** the amount of flush water can be set to a low volume to flush away some remaining urine and the toilet paper. If urine-soiled toilet paper is collected in a bin, rather than flushed away, water savings can be even higher.
4. **Recycling of phosphorus from urine** is easier if urine is collected pure, rather than mixing it with other wastewater.
5. Ability to use collected urine as **fertiliser**, which can lead to higher food security for poor farmers

Disadvantages of UD

Urine diversion may also have disadvantages and challenges, which are case dependent. They depend on what the situation was like before (e.g. did the users have pit latrines before? Or did the users have conventional flush toilets before?), and what is compared with what
Possible disadvantages include:

- Users have to think a bit when they use the toilets especially if they use them for the first time (this point does not apply to waterless urinals, which are used in the same way as water-flushed urinals). Thus urine diversion needs a certain level of **awareness rising** to achieve social acceptance.
- If users do not cooperate, the resulting abuse can result in odour (if users urinate in the faeces compartment of a UDD toilet) or a “messy” toilet (if users defecate into the urine compartment of a UD flush toilet).
- Anal wash water has to be collected separately (in the case of UDD toilets), which requires again a basic level of understanding/cooperation from the user.
- In the case of UD flush toilets, maintenance requirements of urine diversion systems may be higher in comparison with conventional sewer-based systems. Users commitment to the proper use of these facilities is very important:
  - Cleaning of UD flush toilets is more time consuming than cleaning of conventional flush toilets, due to the separate urine compartment.
  -Blockages of urine pipe work due to precipitates can occur

- If urine diversion is applied in cities, urine needs to be transported to the reuse areas by truck, leading to in-creased truck movements (and related CO_2 emissions).
- When urine is used in gardening and agriculture, there are some aspects which the farmers needs to consider – as with other fertilisers.
- If urine is not reused, but infiltrated, this could lead to groundwater pollution with nitrate (depending on the amount of urine infiltrated, soil properties, groundwater table).

Social Acceptance

Regarding social acceptance, successful adoption of urine diversion is closely linked to:

- Political will, messages from the media and local “champions”
- Users' motivation and willingness to change existing habits and behaviours
- Supportive attitude of all stakeholders involved (e.g. users, maintenance staff, planners, farmers, politicians)
- Demand for urine as a fertiliser (or some other reuse/disposal option for collected urine if agricultural reuse is not possible).

Hence, careful planning with stakeholder participation is crucial. For the users, odour is obviously a potential obstacle to social acceptance, but with the correct design and operation, odours from waterless urinals and UD toilets should be the same or less than conventional urinals and toilets. Also, UDD toilets can be expected to have significantly less odour than pit toilets, and can therefore be placed indoors which can be a significant driver for social acceptance.
Social acceptance also depends to a high degree on:

- What people are currently using (are they used to “flying toilets” (plastic bags) or to water-flush toilets?) and what they are expecting to get.
  -UDD toilets may be perceived as a sub-standard, unhygienic solution, compared to flush toilets which the wealthy people have. It is important that UDD toilets are not seen as a solution for the poor only.
- Does their culture have a tradition of reusing human excreta (e.g. in China) or not? Are their taboos surrounding faeces? If yes, these taboos need to be addressed.

Design criteria for UD toilets

Appropriate design is essential for successful application of UD toilets. They should be designed for the needs and the customs of the intended users. Attention needs to be paid on the question if the users intend to wash the **anal area with water** after using the toilets instead of using toilet paper (“washers” as opposed to “wipers”). This is customary in many Muslim cultures but is not 1:1 linked to religion, e.g. in parts of India also Christians practise this. It is therefore also linked to cultural norms, climate, availability of water, habits, etc. Consideration of convenience of use for disabled people, elderly, and children needs to be given, especially in health clinics.

The preference of the user can be distinguished between:

- **Sitting toilets** (with pedestals): these can be wall-hung or floor mounted. Specific connection parts may be necessary for proper installation. For the installation of toilets, following the manufacturer's instructions is recommended to ensure precise fit. Easily accessible and removable connections can help in case of required replacement.

Figure 1: UD toilet (pedestal  type)

Figure 6: UD toilet (pedestal type)

- **Squatting toilets** (with squatting pans)

Figure 7: UD toilet (squatting type)

Urine-diversion dehydration toilets (UDD toilets)

UDD toilets do not use water for flushing. They use a very simple system where the urine is captured in a bowl which is integrated in the front of the toilet pedestal or squatting pan. From here, the urine is drained off to a storage container (or leaching pit if the urine is not collected – beware of possible groundwater contamination with nitrate). For the faeces, a straight drop is provided from the toilet pedestal or squatting pan to a collection chamber (faeces vault) below. The faeces vault can also be in the form of a bin which is normally used for household rubbish. A ventilation system is provided to ventilate the faeces chamber and speed up the drying process.

For the urine pipe, an odour seal may be used if the toilet is indoors and odour control is very important and especially in systems with many toilets (same types of seals as for waterless urinals can be used (see Section 3.3)). For outdoor UDD toilets, the connection to the urine storage tank is usually direct, without any odour stop device. UDD toilets are not designed for composting to take place in the faeces chamber (on the other hand, composting toilets can be designed with urine diversion).

Dehydration Toilets

In a dehydration toilet, the excreta inside the processing vault are dried with the help of sun, natural evaporation and ventilation. The toilet requires no flushing water. Dehydration toilets are increasingly popular in the developing world. They can be successfully used in various climatic conditions and are most advantageous in arid climates where water is scarce and faces can be effectively dried. The faces are collected in a chamber below the toilet (or squatting hole) and are dried. High temperature in the chamber, together with sufficient ventilation is the most important mechanisms in the drying process. The ventilation also reduces odors due to air currents, which flow towards the vent pipe out of the chamber. Moisture content below 25% facilitates rapid pathogen destruction.

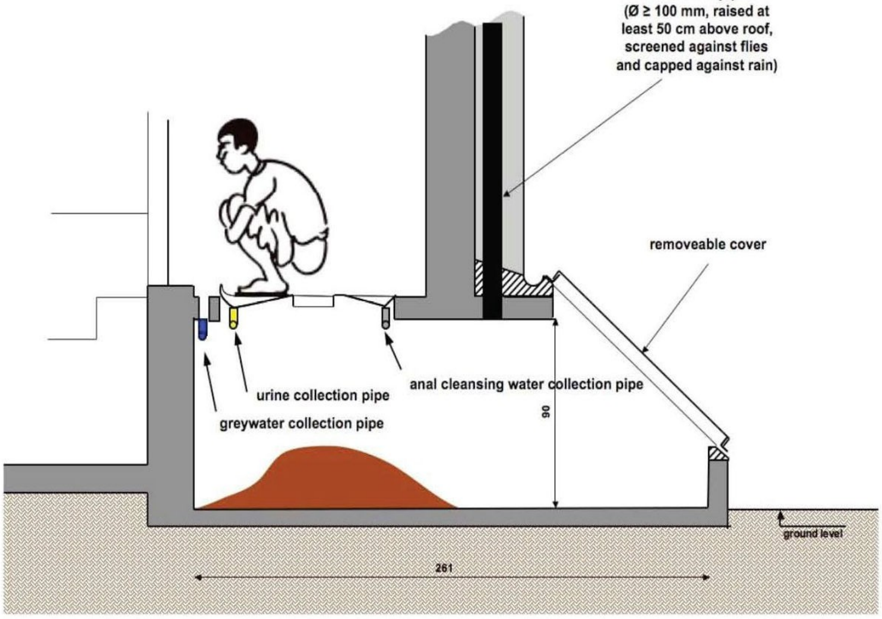


Figure 3:
Section of a UDD toilet (squatting type)

Figure 8: Section of a UDD toilet (squatting type)

Composting Toilets

The basic principle of a composting toilet system is the biological degradation of excreta and toilet paper in a specially designed container. Urine is usually collected separately, or in some types of composting toilets collected and treated together with faeces.

Compared to dehydration toilets, composting toilets require higher costs in term of excreta management. The most important difference between this technology and that of dehydration is the moisture content of faeces within the vault (around 50% comparing to 25% in dehydration toilet). Composting toilets need organic bulking materials to increase carbon content whereas dehydration toilet can use also other dry absorbents as ash or dry soil to lower the moisture content.

Vacuum Technologies

The vacuum technology is applied as a sewage collection tool in ships, trains and aircrafts for years. But it can also be used in domestic technology for wastewater. Vacuum technology is a high tech solution and offers the opportunity to keep the high standard in urban drainage and bathroom equipment, thus the users don't need to change their habits.

A major weakness of this system is the additional energy required. Vacuum sanitary installation require about 4 kWh/(pa) and cause 40 % higher investment cost.

Waste water handling and treatment

Waste water from a clinic can be basically divided into two categories namely;

- The waste water from toilets
- Waste water from general cleaning processes in the clinic.

Waste water from toilets

Waste water from the toilet has mostly biodegradable suspended solids, dissolved solids and pathogens. The water needs to be carefully handled because it has a big health risk of transmitting diseases like Typhoid and cholera. In cases where sewer lines are present, this water is channelled directly into the municipal sewer line for treatment. However in the rural areas of Afghanistan, there are no sewer lines hence a safe and appropriate method of disposal has to be employed. The best way of handling this waste water is putting it in a septic tank where the organic components are biologically broken down anaerobically by bacteria naturally found in waste water and the effluent water drained out through a soak pit or a draining field. The remaining solids settle down and have to be periodically emptied to ensure the septic tank functions efficiently.

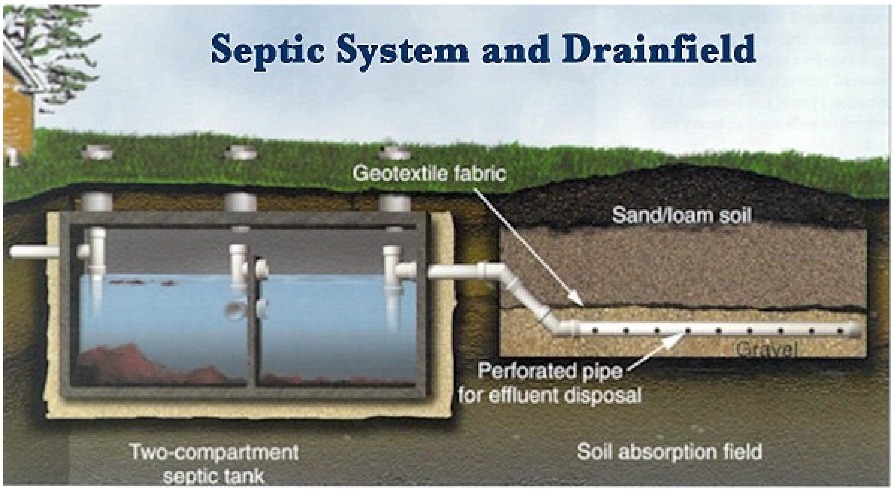


Figure 9: Septic System

The effluent is drained by the water seeping into the ground water or through uptake by plants. Due to the anaerobic conditions in the septic tank, most pathogens do not survive and the rest sieved by the soil as the water is drained. In some cases, especially where the ground water table is close to the draining field, there may be need to treat the effluent water before discharging to the draining field so as to avoid contamination. The easiest and cheapest way is by use of a tablet chlorinator before the effluent is discharged into the draining field.

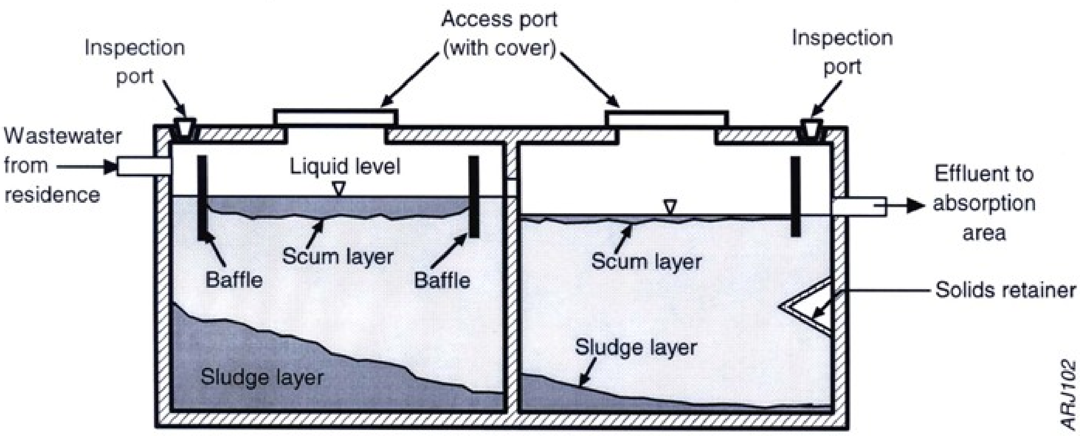


Figure 10: Septic tank

Waste water from general cleaning processes in the clinic

This is water generated from cleaning the clinic, washing hands etc.

The water is known to contain detergents and disinfectants which when added into a septic tank can inhibit the functioning of the bacteria making the septic tank ineffective. As such, the best way of handling the waste water is by construction of a soak pit from when the water will be purified through seepage.

Working area Design

SECTION 1. Bioclimatic Design

Bioclimatic design - Eco design - Sustainable design – Bioclimatic construction

Introduction

Bioclimatic design is place-sensitive. It has the potential to make place specific architecture by responding to the clues of a specific climate, environmental conditions and site. In past centuries, the lack resources to construct and maintain buildings were the norm. Since the Industrial Revolution, but particularly from begin of the 1900, the relatively cheaper energy have resulted in widespread increases in energy use. After the 1973 and 1979 oil crisis, the society starts to conserve energy. Oil crisis + Environmental crisis = higher standards of building design. The current strategies of Bioclimatic Design have their origin in the vernacular type of house from every place –even their simple design, most of them achieve high levels of thermal comfort inside the constructions-

Principles of Bioclimatic Architecture

To create habitable spaces which achieve the next characteristics: functional, expressive, physical and psychological healthy and they must be **comfortable** to provide the optimum development of human activities. Optimum use of energy and resources, promoting a trend toward the self-sufficiency of the buildings.

Quality of Architectural Design

Suitability for use: ergonomic considerations (rooms which are the correct size and scale) and correct selection of materials, related to the functions they will support (quiet, warm, cool, bright, etc).The healthy built environment most be considered.

Durability of performance: buildings most be dry, economic in energy consumption and maintenance. Proper length of life, taking into account the environmental costs.

Delight: elegance of proportion, colour, light and shade. The contribution to the building´s architecture made by the smallest details. The cultural significance through respect for regional identity most also to be take into account.

Advantages of green design

-Contribution to control of environmental crisis

-Savings in the winter heating costs

-Buildings with more natural and fewer artificial inputs are better.

-Daylight buildings are more pleasant (and cheaper) than artificially light ones.

Parameters to be considered in green building design

General parameters

- **Occupant comfort.**
- **Occupant health**. A poor internal environment may contain toxic or allergenic substances, it may be stressful or unsafe and it may facilitate the transmission of communicable diseases.
- **Environmental impact of the building**. Including the whole processes of construction and operating a building, the carbon dioxide caused by emissions from building heating (global warming) and depletion of resources. It is also necessary to take into consideration the whole building´s life cycle. Materials, construction processes as well as building performance can have impacts on environment.

Design parameters

- **House face (orientation)**. The optimum orientation is the first factor to decide. Depending of the location, some parameter will become more important than other: the axis wind, the thermal axis , the lighting axis, the visual axis, etc.
- **Form**: the form and association of the elements can to establish the thermal behaviour, the air patron and the lighting conditions.
- **Location of spaces**: the spaces most to have a hierarchy according their function and their environmental requirements (thermal, acoustic, lighting requirements).
- **Windows design**: the windows design evolves very important functions like the sunlight, natural lighting, ventilation and communication(links).
- **Proportion between walls and hollows:** these house face elements can to determine and to control the amount of direct and indirect solar energy, the heat, the light and the wind flow inside the building.
- **Solar control, natural ventilation and lighting devices** help to control sunlight according to specific hours and date also the level and lightness distribution can be managed. The direction and speed of the ventilation it can be also planed and regulated.
- **Constructive systems:** the material and the finishing of the structure determines also the thermal behavior.
- **Materials:** traditional criteria for choosing building materials can include: cost, aesthetics and availability, nevertheless environmental impact should be considered as well.
  Some aspects are:
  - Availability of the material: Are the materials renewable or not? Are they scarce or not? (Cupper, oil)
  - Natural production process: How the material is being produced, does it come from sustainable managed forest? (Wood)
  - Industrial production process: Does its production imply a big environmental degradation? (Aluminium)
  - Extraction process: Is its extraction causing habitat losses or changes? (Sand and limestone)

- Transport: How long does the material need to be transported to the side? Use of materials in small amounts can cause significant environmental degradation due to emissions resulting from transport it to the site.

SECTION 2. Case study

This section it is explained in appendix 1.

SECTION 3. Comfort, Health and Design

Thermal Comfort: “The Comfort zone could be described as the point at which man can spend the minimum energy adjusting to his environment” (Olygay, 1973).Thermal comfort can be defined as a sense of well-being with respect to temperature. It depends on achieving a balance between the heat being produced by the body and the loss of heat to the surroundings. The actual balance depends of three individual parameters (metabolism, clothing and skin temperature) and four linked to the surrounding environment (air temperature, relative humidity, surface temperature of the elements in the room and air speed).Metabolism is the sum of the chemical reactions that occur in the body to keep body temperature balanced at 36.7°C and the production of metabolic energy (heat) depends on the level of physical activity. Studies report that the range of temperatures which people report as comfortable is wider than might be expected; it follows that each region could adopt temperatures suitable to the prevailing climate and season.

Design recommendations

- The ambient temperature should be between 20-22 °C in winter and 24-26°C in summer (adaptable)
- There should not be any excessive air movement in room (0.1-0.15 m/s in winter, 0.25 m/s in summer)
- Relative humidity should be kept between 40%-70% at northern latitudes
- An average ratio of window to wall of 30% for the building as a whole (adaptable)
- Light-coloured paint on external walls and roofs in warm conditions
- Natural night ventilation is effective in reducing air temperatures during hot weather
- Depending on plan form, area of opening windows to be 5% minimum of floor area for ventilation
- For best performance, locate solar shading externally
- Under floor insulation
- Reduce summer heat gain by using high efficiency lighting and good control
- Locate and detail thermal insulation to avoid condensation risks

Visual Comfort: Poor lighting can cause eyestrain fatigue, headaches, irritability, mistakes and accidents. In hospitals, the absence of a view out produces psychological discomfort. Comfortable lighting conditions in a space are dependent on quantity, distribution and quality of light (distribution of light in a space is often more important than quantity). For comfort there are also limits to the amount of contrast and glare (glare is usually caused by an intense light source, causing a feeling of discomfort and fatigue).

Daylight: Windows and daylight are beneficial to health. The absence of daylight can cause depression (seasonal affective disorder), bone disease (due to vitamin D deficiency) and disturbances of sleep and concentration.

Design recommendations:

- Good orientation and correct spacing
- Glazing ratio and window design should ensure that building interiors receive natural light
- Natural and artificial lighting should meet optimum intensity, similar brightness, protection against glare, avoidance of shadows and adequate contrast
- Rooms should have roof lights or windows, giving occupants visual contact with the outdoor
- Movable internal screens or shutters can modulate day lighting
- Screen grids to limit direct glare
- Decreasing surface reflectivity from ceiling to floor can result in pleasant luminous environment
- Use of energy efficient lamps with good colour rendition
- On the working plane diffuse light with fluorescent lamps reduce shadows and glare
- Adjustable luminaries can reduce reflections from glossy surfaces.

Indoor Air comfort – quality

People spend 80%-90% of their lives inside buildings. With an increase in the use of solvents, interior finishes emitting VOCs (volatile organic compounds) and cleaning agents, indoor air pollution has become a serious concern. Health effects include allergies and asthma, infectious disease, cancer and other genetic damage. Indoor air quality is determined by air quality outside the building, pollutant emissions within the building and the ventilation rate, as well as by the efficiency of filtration and standard of maintenance of mechanical systems. Lower ventilation rates are creating unhealthy conditions; in under ventilated spaces mould-spores and dust and VOCs reach higher concentrations. It is also well established that where artificial systems are installed a healthy indoor environment will only be achieved if systems are correctly installed, fully commissioned and properly maintained.

Design recommendations*:*

- Ventilation rates should comply with air quality standards and sanitary recommendation
- Air filtration alone may provide an acceptable level of air exchange; however, all buildings should have provision for additional controlled ventilation.
- The openable area of windows should extend close to ceilings to allow hot air in the upper part of the room to escape.
- Windows should incorporate “trickle ventilation” features such as two-position casement fasteners
- Windows should allow for easily operated and controllable ventilation.
- Where possible site buildings away from roads and other sources of pollution
- Provide internal and external planting to absorb pollutants and reduce dust
- Avoid gaps in the external envelope which allow unplanned infiltration of external air

Acoustic comfort - quality

Exposure to excessive noise levels can produce stress related illnesses and hearing loss. Natural ventilation may imply open windows or ventilation openings between interior spaces; obtrusive or loss of acoustic privacy are not acceptable. If absorbent floor finishes are omitted to allow the structure to act as a thermal store, other measures may have to be taken to provide enough sound absorption in occupied spaces.

Design recommendations

- Buildings can be protected from outdoor noise by orientation and by the use of barriers such as walls, earth mounds or vegetation
- Noise-generating activities or equipment should be located as far as possible in unoccupied spaces
- Spaces with shared walls and floors should preferably be of similar use
- Reduction of sound transmission is best achieved by increasing the mass of structural building elements(particularly effective al lower frequencies
- Window openings are one of the main sources of noise infiltration; they may be sealed or incorporate insulated glazing components such as laminated glass
- Resilient layers under floating floors and suspended ceilings reduce impact noise
- Ventilation fans should be as large as possible so as to run the lowest possible speed.

Materials

A number of toxic chemicals and materials are used in building materials, finishes and consumer goods. Some of these products pollute indoor air or water supplies; others cause damage by contact or ingestion. Lead and asbestos are well-established health hazards. Some synthetics such as PVC can also lead to hazardous emissions in use. Paints, preservatives and adhesives are common sources of toxic emissions.

Design recommendations:

- Require manufacturers or suppliers to indicate the content of any materials or components it is proposed to incorporate in the building and select the least injurious
- Minimize the use of VOC-emitting finishes which will be exposed to the indoor air
- Design for easy access to facilitate proper maintenance of any ventilation equipment
- In existing buildings replacement of lead piping and lead-lined water tanks should be considered where chemical attack from water represents a problem.

SECTION 4. Strategies

Building Form

The form of a building plays a very important role in bioclimatic design. The external factors wind, solar availability and direction, shelter and exposure, air quality and noise condition effect the form and the design of the envelope. Therefore considering these factors and making the building the right shape and the correct orientation can reduce the energy consumption by 30%-40% at no extra cost (book name citation).

All the spaces requiring continuous heat should be located in southern facades for maximum solar gain and buffer it from the north with less prominent spaces. The optimal performance of passive solar heating, day lighting and natural cooling, the heat gaining spaces should all faces within 15° of due south.

Combining with the form of building, depth and section of building are critical design elements for natural ventilation.

Orientation: A building elongated along the east west axis exposes the longer south side to maximum heat gain in the winter months and the shorter east and west sides to maximum heat gain in summer. In summer de receives very little radiation. Consequently a building elongated along t to be the most efficient shapes in all climates for minimising heating requi oling in summer, but the extent of elongation depends on the climate. (Ol

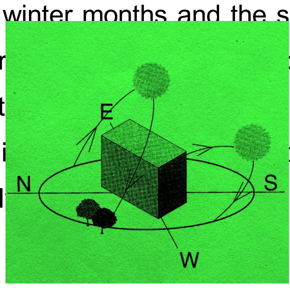


Figure 11: BuildingOorientation

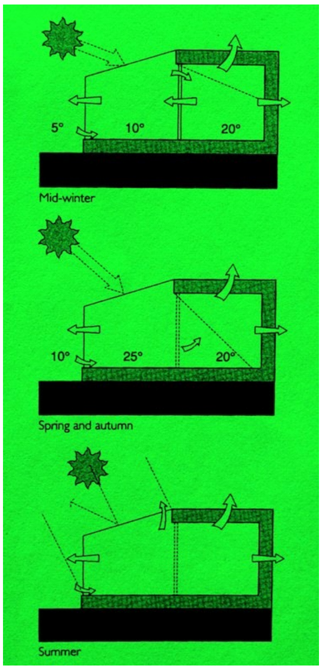


Figure 12: Sunspaces

Sunspaces: Glazed balcony or loggia, the sunspaces are of the multipurpose element of passive solar heating in bioclimatic designs. It is the combination of both direct and indirect gain approaches to passive solar heating.

The sunspace consists of glazed balcony with its wall and roof made of glazed materials.
The functions of sunspaces are as following grounds:

- A buffer zone
- To capture maximum sunlight and stored in solid elements as heat energy.

The concept of the sunspace is to acts as a buffer zone for a building, dramatically reducing heat loss. In addition in the absence of direct solar gain it is a functional energy efficient device. Sunlight entering the space via the glazing is stored in the solids elements as heat energy. This heat energy can be transformed in many ways. A masonry wall, forming a partition between the sunspace and the rest of the house can provide sufficient thermal mass to store absorbed heat and release it later. A natural convention loop can be created by inserting vents in the floor and ceiling level. Similarly, a fan coupled with a thermostat will allow heat exchange between the sunspaces and the rest of the house.
It is important to make 2/3 of the fenestration open-able to avoid summer overheating. But the thermal properties of framing material are not important.
Sunspaces should be separated from adjacent heated spaces by tight-fitting doors or windows, which need a good work detailing. When heat from the sunspaces is available and needed, convected heat can quickly be admitted to the main spaces. At night time or in cold weather, the sunspaces can cut of to serve as a thermal buffer.
A sunspace fitted with a heating system will be a source of energy loss instead of energy gain.

Opaque / Solid Elements

The solid elements of the building envelop can perform both heating and cooling function through use of thermal mass, insulation and protection of the internal environment from air infiltration.

Heating and cooling

For both heating and cooling function the thermal properties of and opaque wall can be controlled by.

- Thermal conductivity and thermal storage capacity of material (Thermal mass)
- Thermal insulation
- Good detailing

Thermal mass

Recent studies analysing passive solar design of non-domestic building (HGA 1994) found that:

- High thermal mass is desirable to stabilize daytime temperature and for night cooling, but may marginally increase heating costs
- Thermal mass is best increased by maximising surface area, increase in thickness is relatively ineffective
- Thermal mass should not be thermally isolated from circulating air
- Secure and controlled night cooling should be provided where exposed thermal mass is intended to moderate day time temperate.

Good thermal inertia materials

- Clay bricks
- Concrete blocks
- Rammed earth

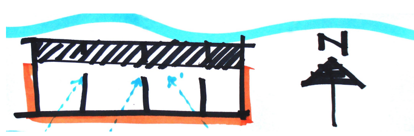
Low thermal inertia materials

- Timber
- Steel – framed structures
- Lightweight cladding panels

Passive Solar Design In cold Climates (North Hemisphere)

HEATING

Orientation

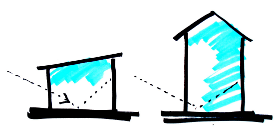


An adequate building orientation along the west east axis maximizes solar gain in winter and reduces it in summer.

Prevailing winds

Orientation should reduce the amount of surface area facing predominant winds and north.

Volume ratio

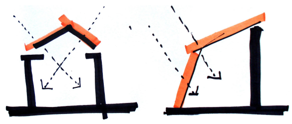


In passive design reducing the amount of volume in a building implies less area to be heated and thereby less energy consumption.

Solar gain

Transparent surfaces in walls and roofs allow direct solar exposition.

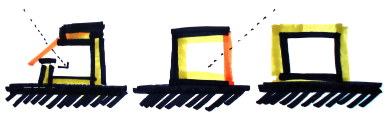
Glass walls, roofs and atria are some design tools for maximizing solar gain.



Insulation

Walls roofs and other opaque parts should be insulated in order to reduce heat losses and enhance the temperatures of internal surfaces.

The position of insulation varies according to the specific heating requirements.

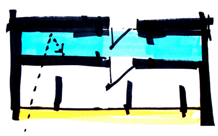


Internal insulation can be used in intermediate heated buildings which can have periodic maintenance of finishing materials in order to repair problems caused by bridging and condensation.

External insulation provide a more stable temperature since it allows the internal side of the walls to act as thermal mass. It needs continuous heating since it takes longer to heat up and cool down. Continuous temperature variations can result in damages in the exterior layer of finishing's.

Cavity insulation is the most used in some European countries since it avoid problems derived from condensation and thermal bridge, reducing costs for maintenance and increasing life span of finishing materials.

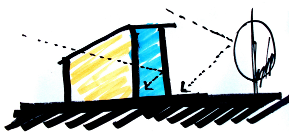
Thermal mass



Termal mass stores heat and release it in the interior space if it is well insulated.

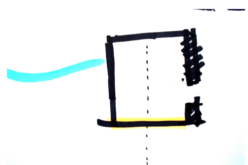
Control of ventilation and infiltration

Buffer spaces



Atria, sunspaces, courtyards and draught lobbies, among others are design tools which act as a buffer reducing the temperature difference between two areas decreasing heat losses.

Location of entrances:



Entrance doors should be placed away from corners and from prevailing winds.

Materials

Surface materials at ground level and walls contribute with high temperatures absorbing and storing heat. Materials with a high storage capacity such as concrete, brick and water heat up and cool down relatively slowly.
Water, vegetation should be considered since they can have a cooling effect on the building due to evapo-transpiration and shading.
LIGHTING
Daylight
By maximizing use of natural daylight, energy consumption and environmental damage is reduced and significant savings of electricity can be made. Daylight is also important for providing more pleasant spaces. Atrium is one of the design strategies for controlling and getting a more uniformly spread light.
Shading elements such as threes or mountains have to be taken into consideration for selecting the right side of the building. Since they can have shading effects reducing the lighting time.

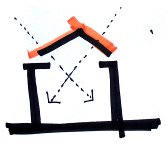


Figure 13: Passive Design recommendations

Working area waste management

According to the Children Protection Action Network (C-PAN in IRIN 2008) in the past days seven children involved in scavenging in Herat Province, western Afghanistan, have been infected by hepatitis B, syphilis and suspected cases of HIV.

Waste disposal and inappropriate manipulation represent a threat for the population and a way to spread infectious diseases. That is why an appropriate treatment is necessary. According to the World Health Organization (WHO, 2005) the waste management should include:

- Waste minimization
- Health Care Waste generation
- Segregation and containerization
- Intermediate storage in the health Care centre (HCC)
- Internal transport (in the HCC)
- Centralized storage in the HCC
- External transport
- Treatment and final disposal

All these steps are important but the way to implement best practices for each step differs from the type of health center and the environmental, social cultural and economical characteristics of the area.

Waste situation in Badakhshan

Medical waste disposal is a big problem in the country because they do not have laws or guidelines on the safe management of medical waste in Kabul more than 60 public and private hospitals do not have equipment to deal with it and medical waste is disposed in dumpsites together with the domestic waste. In rural areas is worst because they do not have even municipals dumpsites (IRIN, 2008).

To develop an appropriate waste management program for a rural area we have to consider that no legislation or guideline exists, no municipal services are available and people are in constant contact with the garbage. Following the World Health Organization classification (WHO, 2005), Badakhshan is a remote area without access to legally approve modern waste treatment or disposal facility and the health centre must operate its own waste treatment system using multiple technical options for sharps, infectious and non-infectious wastes.

Possible solution for waste treatment

The final waste disposal represent the most challenge step of the waste stream that is why we have to define first the most appropriate treatment for small health clinics.

Waste burial (enterramiento de residuos)

Pit sides covered with a low permeability material, covered and fenced. The pit should be sealed with cement once it is full or at least the last 50cm should be filled with compacted soil and the area identified (SIAR, 2006).

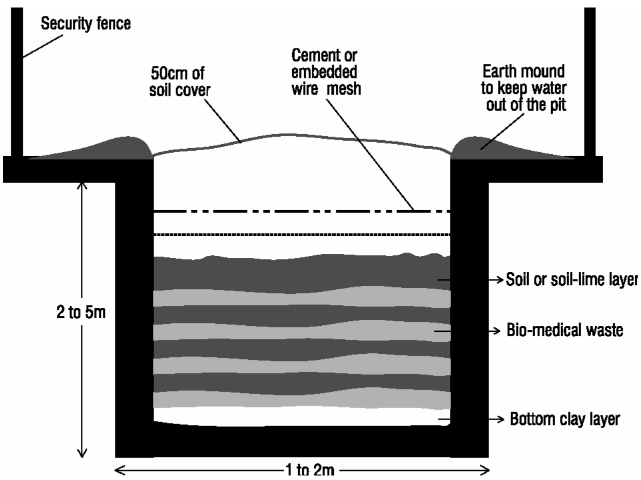


Figure 14: Waste burial (WHO, 2005)

Encapsulation

In this treatment sharp material like needles and bistouries are collected in small containers and when they are full an immobilizing material such as sand, cement or clay is added. Once dry the containers are sealed and disposed of in landfill sites or waste burial pits (SIAR, 2006).

Figure 15: Encapsulation container (SIAR, 2006)

Incineration (800 – 1000°C)

Incineration is a process to burn solid material. When using an incinerator the temperature, time and emissions can be controlled to avoid any possible risk of contamination (Guendehou et al. 2006).

The minimum temperature needed is 800 °C at this high temperature burning reduces combustible waste to incombustible matter resulting in a very significant reduction of waste volume and weight. The high temperatures attained via incineration ensure full combustion and sterilization of used needles. Incineration produces a small amount of ash and waste material that must be buried (Guendehou et al, 2006. SIAR, 2006).

In the table we can se a resume of the strengths and weakness of each treatment.

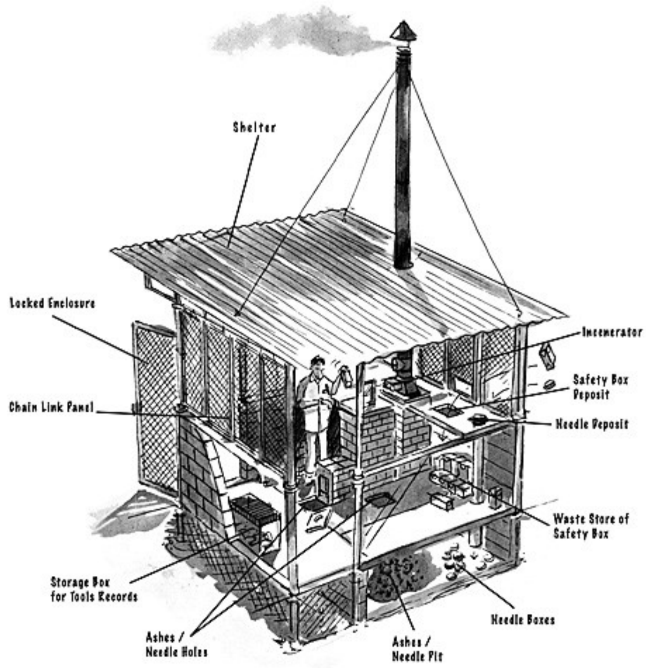


Figure 16: Small incinerator (Path, 2004)

Table 2: Final disposal treatments evaluation (Source: Based on SIAR, 2006)

Option	Strengths	Weaknesses	Decisive factors	Costs
Waste burial	- Low tech, simple - Small quantities of waste - No atmospheric pollution (NAP)	- Big Space - No waste disinfection - No volume reduction - Soil and water pollution - Other people	- Waste segregation - Depth of ground water, rainy season - Lining of pit (cement)	Low cost construction

		contamination		
Encapsulation	- Low tech - Prevent needle reuse and infections - NAP	- Space - No volume reduction	- Sealing method	Cost of containers Immobilizing material
Burning	- Reduction in volume and weight. - Disinfection efficiency - No need for highly trained operators	- fuel - no good for needles - secondary waste, ashes may be hazards - Toxic emissions Smog	- Temperature control - Maintenance and repair	Price of a single chamber incinerator

A waste burial is no recommended because of the small space in the clinic but encapsulation could be a good solution for the needles to avoid the re use. Burning following the technical recommendations and standards could be the best way to reduce the amount of waste and avoid infections.

Discussion

So far we compiled various information on energy, water and sanitation, waste management and architectural design which can be applied in the construction of a basic health clinic in Afghanistan. Nevertheless, there are still questions concerning the current practices in the country, and more specifically in the province of Badakhshan, such as local waste and water management and traditional building.

Current standard analysis

Some advantages were found in the existing heath standard of Afghanistan. They were concerning to no need for high skilled labour, use of a modular grids which results in low cost and short construction time. Nevertheless a real implementation of passive design was not found. Based on the cased studies and on the research on sustainable building, following assessment can be made.

Thermal comfort

Low solar gain; no specific orientation facing south
Spatial distribution is not according to thermal comfort criteria
Low window insulation; no suitable window design
Roof material reflecting light / no storing heat
Absence of floor insulation
No right specification of finishing materials in order to absorb light and store heat

Visual comfort

No special criteria for proper use of daylight
No lighting of internal corridors

Ventilation

Insufficient ventilation

Materials

Low durability
High maintenance
Building materials used are not green in its whole life cycle.

Architectural Analysis

No definite spatial hierarchy

No use of landscapes concepts for entrance squares and courtyards

The building is not iconic in order to promote cultural identity.

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APENDIXES

SUSTAINABLE BUILDING

CASE STUDIES

I. A sustainable building incorporates technologies, practices and materials which optimize efficiency in resource management and operational performance. A proper design, a right selection of materials, technologies and constructive procedures can lead to optimal conditions of thermal, visual and acoustic comfc

Comfort

- design
- technologies
- materials - procedures

Resource management and operational performance

II. Sustainable procedures reduce risks and impacts to the environment throughout its whole life cycle. A building can be environmental friendly according to the materials, constructive techniques and performance.

Environment

- Materials prod.
- Construction process
- Performance

Whole building's life cycle

III. Goes beyond energy efficiency and environmental impacts, it promotes social well-being, involving community participation and strengthening cultural identity.

Socio-economic

Cultural Identity, appropriation

I. A sustainable building Incorporates technologies, practices and materials which optimize efficiency in resource management and operational performance.

Comfort

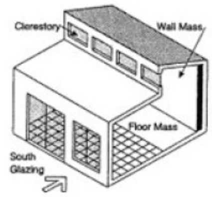
a. passive design
b. materials procedures
c. technologies

Resource management & operational performance

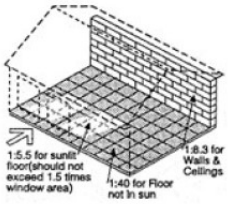
Passive design

Typically, passive Solar heating (temperate / cold climates) involves:

- the collection of solar energy through properly-oriented, south-facing windows,
- the storage of this energy in "thermal mass," comprised of building materials with high heat capacity such as concrete slabs, brick walls, or tile floors, and
- the natural distribution of the stored solar energy back to the living space, when required, through the mechanisms of natural convection and radiation,
- Window specifications to allow higher solar heat gain coefficient in south glazing.



Direct Gain
Direct gain is the most common passive solar system in residential applications



Passive solar heating in particular makes use of the building components to collect, store, and distribute solar heat gains to reduce the demand for space heating. It does not require the use of mechanical equipment because the heat flow is by natural means (radiation, convection, and conductance) and the thermal storage is in the structure itself. Also, passive solar heating strategies provide opportunities for day lighting and views to the outdoor through well-positioned windows (Fosdick, 2008).

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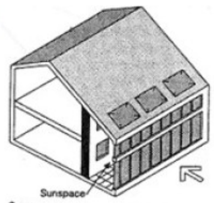
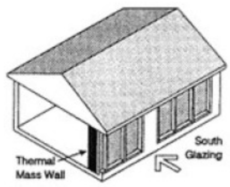


Sunspaces
Sunspaces provide useful passive solar heating and also provide a valuable amenity to homes.

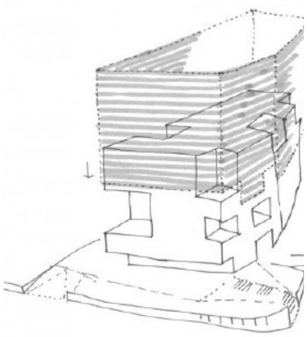
Passive solar systems utilize basic concepts incorporated into the architectural design of the building. They usually consist of: buildings with rectangular floor plans, elongated on an east-west axis; a glazed south-facing wall; a thermal storage media exposed to the solar radiation which penetrates the south-facing glazing; overhangs or other shading devices which sufficiently shade the south-facing glazing from the summer sun; and windows on the east and west walls, and preferably none on the north walls (Fosdick, 2008).



Thermal Storage Wall
A thermal storage wall is an effective passive solar system, especially to provide nighttime heating.

Case study – Passive design

Medical center's Split (Croatia)

Source: http://www.archdaily.com

The Medical center of Split (Croatia) is a project of 3LHD architects which won the competition for the design of a private medical center in a historic neighborhood, following some principles of passive design.
The project:

- Provides a connection with nature in urban environments.
- Use shading devices such as a membrane controlling:
    - Lighting
    - Heating
- Provides terraces allowing interior
    - Ventilation
    - Lighting

Source: http://www.archdaily.com

Efficient use of materials and procedures

- Materials
- Constructive systems
- Durability of buildings
- Maintenance

Case study – Materials / procedures

Extension to Great Ormond Street London Hospital: a Green Extension

source: www.bdonline.co.uk/story.asp?storycode=3137027

Designed by Architect Llewelyn Davies Yeang, Ken Yeang, know as both Architect and ecologist. He said in an interview, "We are right now in a momentous time in the Endeavour of green design", "I don't believe we have built the ultimate green building yet, but we are making advances."

The hospital at Great Ormond Street is well-known as an NHS run children's hospital. This is phase 2 of a longer-term 4 part redevelopment program. These plans have developed into 2 new buildings, comprising of a new clinical building, and a cardiac wing. The building work started in October 2008 and is currently scheduled to be completed by the winter of 2011. The entire project is forecast to cost 300 million pounds, and will include new wards, clinical facilities including operating theatres, offices and a new restaurant, covering some 30,000 square metres. (SustainableBuild, 2009)

Green Aspects of the New Extension's Design

In examining the brief from the NHS, Yeang sought to illuminate green and sustainable aspects in the planning and execution of the new building and refurbishment of the old. The NHS trust had requested that the architect should 'significantly raise the bar on sustainability', as well as remain a good neighbour within the Camden community, and also remain a place of healing and medical excellence. (SustainableBuild, 2009)

According to SustainableBuild, Specific green and sustainable aspects of the design for the hospital's extension include:

- a central circulation hub that links all facilities, and allows easy movement of people and air
- natural ventilation access throughout all areas of the building
- glass extrusions across the entire facade, allowing plenty of light in, with options for solar heating
- the estimated ability to offset approximately 20,000 tons of CO_2 annually, through energy saving and energy creation

The plan has won the approval of the Office of the Mayor of London, and a BREEAM 'excellent' rating of 77% from the Building Research Establishment. (SustainableBuild, 2009)

Efficient technologies

- Energy efficiency of appliances, equipment, building products and materials
- Renewable energy technologies (solar, wind, geothermal, connection to grid)
- Waste disposal and treatment
- Collection storage cleaning and water distribution systems

Case study – Technologies

McKay Center - University of Wisconsin Arboretum

source: http://www.ecw.org/wisconsun/learn/cs_mckaysolarthermal.shtml

The 4,600 ft2 center is home to a visitor center, arboretum staff offices, and meeting rooms. Combined the active and passive solar heating systems provide 44% of the building heating requirements (WisconsUn, 2000).

The center's heating load is largely met by a combination of passive solar heating and the active solar air heating system with a 16-ton pebble bed. The pebble bed, located in the basement, stores the thermal energy until it is needed to heat the building during winter nights and cloudy days (WisconsUn, 2000).

The 70 solar collectors are oriented due south and have a 55o slope to catch the winter sun and shed snow quickly. After over 20 years of continuous operation, the system continues to operate effectively (WisconsUn, 2000).

II Reduces risks and impacts to human health (physical psychological) and to the environment.

Environment

- Materials prod.
- Construction process
- Performance

Whole building's life cycle

Case study – Environment

Earthbag buildings.
Clinics in Philippines

Source: http://earthbagbuilding.com/

'Sandbags have long been used, particularly by the military, for creating strong, protective barriers, or for flood control. The same reasons that make them useful for these applications carry over to creating housing. Since the walls are so substantial they resist all kinds of severe weather (or even bullets) and also stand up to natural calamities such as earthquakes and floo They can be erected simply and quickly with readily available components, for very little money.'[1]
The sustainable aspects of earthbag buildings are:

- Use of Local materials
  - No use of wood or no concrete
  - Earth bag walls, straw sacks, barbed wire cement piping
- Thick walls
  - Thermally stable (heat retaining properties)
- Local labor
  - Community Participation
  - Gender
- Affordable technologies
- Short construction time
- Fire proof

[1] Earthbag building, Sharing information and promoting earthbag building (2000) http://earthbagbuilding.com (09.04.2009).

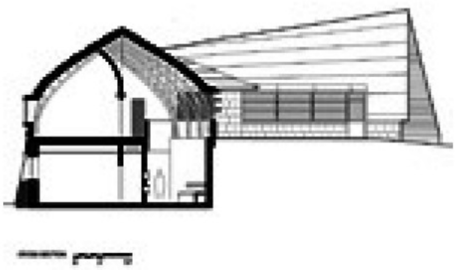
- Hurricane resistant
- Earthquakes good behavior

III Goes beyond energy efficiency and environmental impacts, it promotes social well-being, involving community participation and strengthening cultural identity.

socio-economic ► Cultural Identity, appropriation

Case study – socio-economic

Canadian Health center



Source picture at night: http://www.canadianart.ca/online/features/2008/07/17/cambridge/
Source maps and pictures http://www.chebucto.ns.ca/Business/PHARCH/pages/pages_pictou_landing/plhc_frame_index.html

The new health centre for Pictou Landing First Nation (PLFN) Community in Northern Nova Scotia, was designed by the architect Richard Kroeker with the participation of the local community. The main approach of the project was to develop a sustainable building combining local traditional knowledge and modern technologies.

The sustainable aspects of the building are:

- Is highly insulated, and opens up to the sun through its open "arms".
- provides shelter from the ocean.
- Uses ground-sourced heat pumps
- Has a high efficient heat recovery
- Implement strategies for the future energy, water and waste treatment needed for the community incluiding:
  - Tidal power through the Boat Harbour Pond,
  - Anaerobic digestion and
  - Wind turbine.