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Institute for Technology and Resources Management
in the Tropics and Subtropics

SEMESTER PROJECT AFGHANISTAN

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

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Executive Summary

The concept of a semester project to **DESIGN STANDARDS FOR BIO-CLIMATIC HEALTH CENTRES IN COLD CLIMATES IN AFGHANISTAN** was developed as a partnership between the Government of Afghanistan and the Cologne University of Applied Sciences (CUAS) in the frame of the Afghan- French- German Energy Initiative (AFGEI).The province of Badakhshan being situated in the cold zone of the country, was chosen as a pilot region.

The aim of the semester project was to propose general standards for building or improving basic health clinics following the passive architectural approach and utilizing renewable energy. Aspects such as clean drinking water, solid waste disposal, and waste water management were taken into account.

Through the study of the climate data of Badakhshan and the help of Psychometric charts, heating strategies were strongly recommended. The new design of bioclimatic health clinic stresses on maximum solar gain for heating and lighting of the spaces. The building is oriented with its longer axis towards the south where the most occupied spaces are located. Sky lights are used to light the northern part of the clinic and all the exterior walls are insulated. The building has minimum openings in the northern facade to reduce heat losses. As a whole, the concept followed is visualised as a part of sustainable architecture for Badakhshan because it recommends the use of local materials and workmanship.

Taking into account the unstable delivery and price fluctuations of fossil fuels, as well as the favourable insolation conditions in Afghanistan, a photovoltaic system was designed to provide energy for lighting and refrigerating in the BHC. As a support to the passive heating of the building, a solar water heating system and efficient biomass stoves were recommended.

Clean water sources are scarce in this area. Therefore a well should be constructed using a solar water pumping system. This will be connected to a storage tank collecting enough water for cloudy days when there is no enough solar energy to pump.

Solid waste and waste water disposal technologies were suggested to eliminate the risk of spread of diseases and contamination of natural resources like soil, water and air. Incineration was found to be the best method of handling combustible waste while metallic waste like needles is to be encapsulated and buried. A septic tank connected to a soak pit is to be build for treating waste water from the clinic.

This report gives detailed information on the present situation, problems and possible solutions for constructing culturally friendly, efficient and environmentally clean BHC's. We hope that our research will make a step forward in improving Afghanistan's healthcare services and conditions.

Keywords: Bioclimatic health clinic, Afghanistan, Badakshan, passive architecture, photovoltaic system, solar water heating system, biomass stoves, solar water pumping system, clinic solid waste management, waste water management

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
ENCAP	Environmentally Sound Design and Management Capacity Building for Partners in Africa
FAO	Food and Agriculture Organization of the United Nations
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
LCD	Liters per capita per day
MEW	Ministry of Energy and Water
MoPH	Ministry of Public Health
NATO	North Atlantic Treaty Organization
O&M	Operation and Maintenance
PV	Photovoltaic
PVC	Polyvenylchlorid
U.S.	United States
V	Volt
VOCs	Volatile Organic Compounds
W	Watt
WDU	Waste Disposal Unit
WHO	World Health Organization

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1 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.

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.

2 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 Objective

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.

3 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

4 Working Area Design

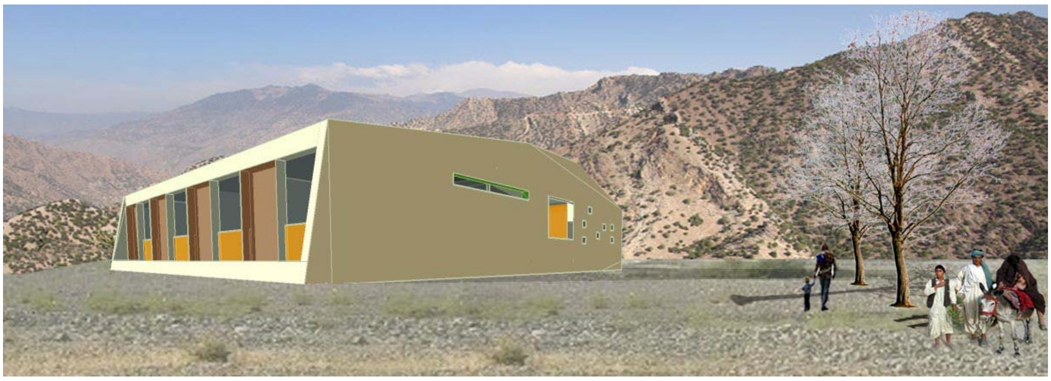


Figure 4.1:South- East perspective view

4.1 Overview

The 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 very common. Since the Industrial Revolution, but particularly from the beginning of the 20th century, 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. In addition to the fuel crisis, today the world faces an environmental crisis. The implementation of Bioclimatic and Sustainable architecture strategies helps to meet the higher standards of building design that the current energy and environmental crisis demand.

In section one of the midterm report we developed basic concepts and definitions relating to bioclimatic design. The general design parameters should be taken into account were also defined and the roll and the importance from each one was understood. Section two was designed to analyze different case studies. In section three of the midterm report were presented definitions for different types of comfort; was understood the influence that each one have on health, wellness and human performance. After that, general design recommendations were made for best performance of the building according to each type of comfort. It also became clear the importance that the materials may have not only in the performance of the building but also as potential agents of environmental contamination. Considering that the clinic should be heated, section four was devoted to describe the different passive solar heating and solar gain bioclimatic strategies. As a last step, and based on knowledge and information generated in the report, a general analysis to the current design was made. These were the advantages and disadvantages were found:

Thermal comfort:

(+) Insulation in ceilings and walls; reducing heat losses and increasing the thermal performance of the building.

(-) Low solar gain; no specific orientation facing south.

(-) Spatial distribution is not according to thermal comfort criteria.

(-) Low window insulation.

(-) Absence of floor insulation.

(-) No right specification of finishing materials in order to absorb light and store heat.

Visual comfort / Daylight

(-) No special criteria for proper use of daylight.

(-) No special criteria to provide visual comfort to users.

(-) No suitable window design

(-) No lighting of internal corridors.

Indoor Air comfort quality / Ventilation

(-) Insufficient ventilation

Materials

(-)High maintenance.

(-) Need for high skilled labour for the proper implementation of insulation materials .

(-) Building materials used are not green in its whole life cycle.

Architectural Analysis

(+) Use of a modular grid which results in low cost and a short construction time.

(+) The building is tight, gaining heat from equipment, lights and occupants.

(-)There is no definition of spatial hierarchy. 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.

(-) No spatial or architectural contribution.

Conclusion

Overall, there are no specific bioclimatic recommendations to achieve the maximum level of thermal and visual comfort, control of indoor air quality or to maximize the potential for sustainability of current the building design.

As a first step in this second and final report, are discussed the assumptions and limitations that took place in developing the final design proposal. The first section of this report provides an approach in which takes up the definitions and concepts relating to design parameters, comfort and passive solar heating bioclimatic strategies. The second section is called "Design" and focuses on the different design strategies to heat. It is divided into A) Psychometric chart B) Building form and orientation C) Sunspaces D) Opaque-solid elements E) Transparent elements-Daylight F) Ventilation. Most of these strategies are being implemented in the proposed design. The third section presents the final architectural design proposal; floor plants, sections, facades and perspectives are presented. The fourth and last section compiles specific recommendations concerning the different types of comfort, design, materials and implementation of the building. In appendix is possible to consult the case studies reviewed.

4.1.1 Assumptions and Limitations

The Bioclimatic design makes specific architecture by responding to the clues of a specific climate, environmental conditions and site. It takes into account very sensitive factors such as wind speed and direction. Make a design standards model contradicts the essence of the method proposed by the bioclimatic design.

The site visit of the Project is a constraint in the project as Afghanistan is a country that none of the students visited. The technical information was provided, however, the lack of a visit “in situ” led to the constant formulation of questions which not always were answered by the students in a concrete and certain way. Therefore the design is based on the information provided.

Poor communications infrastructure due to the difficult economic and political situation of Afghanistan, together with the mountainous area where the project take place, hampered smooth and constant communication with the tutors of the project living in that country.

The knowledge of traditional building systems was made through the material provided, however, no material was found to treat them in detail (efficiency and limitations, advantages and disadvantages of each in terms of thermal behaviour, abundance, cost and ease of use).

The system of construction of the current model was retained because it has good thermal behaviour and because lack of knowledge of traditional building systems.

The semester project “Design Standards for bio-climatic health centre in cold climates in Afghanistan” was one of the five modules that took place this semester. The architectural Project was successfully completed until the stage of the spatial design.

As the project was carried out till the spatial design, the constructive details are not reached. Therefore project costs are not estimated due to lack of constructive details.

4.2 Approach

4.2.1 Bioclimatic Architecture

The bioclimatic architecture creates spaces that are comfortable, functional, expressive, physical and psychological healthy to provide the optimum development of human activities.

4.2.2 Sustainable Architecture

A sustainable building is a structure that is designed, built, renovated, operated or reused in a resource-efficient and ecological manner. Sustainable buildings are not only to protect occupant health but also to use energy, water and other resources more efficiently as well as to reduce the overall impact to the environment.

4.2.3 Bioclimatic and Sustainable –Green Design- (Advantages)

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.

4.2.4 Bioclimatic and Sustainable -Green Design

Ergonomic considerations (rooms which are the correct size and scales)

Selection of materials related to the functions they support (quiet, warm, cool, bright, etc)

The healthy built environment

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 cultural significance through respect for regional identity

4.2.5 Bioclimatic and Sustainable –Green Design- (general design 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.

Efficiency of natural resources: Water, natural gas, etc.

Energy Efficiency: Including cost saving measures at all stages of design and construction of the building. Special emphasis to A) avoid the use of electrical equipment to achieve internal comfort B) avoid the use of electrical equipment in the daily performance of the building (operation and maintenance).

4.2.6 Bioclimatic and Sustainable –Green Design- (specific 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. The direction and speed of the ventilation it can be also planed and regulated.

Constructive systems and 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. The material and the finishing of the structure determine also the thermal behaviour. Traditional criteria for choosing building materials can include: cost, aesthetics, availability and environmental impact.

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 forests?

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.

4.2.7 Comfort and Health

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". (A Green Vitruvius)

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. (A Green Vitruvius)

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. (A Green Vitruvius)

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 problem. 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). If artificial systems are installed, a healthy indoor environment will only be achieved if systems are correctly installed, and properly maintained. (A Green Vitruvius)

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. (A Green Vitruvius)

4.3 Design

4.3.1 Psychometric chart

Each locality has different climate conditions; one country may have more than 15 climate zones. Know the unique attributes of the climate zone where we are working will influence the design and performance of the buildings; and will consequently influence on their energy consumption.

The software Climate consultant version 4 contains a series of climatic data from different cities around the world and converts this weather data into a set of the top 20 design guidelines based on the unique climate and the passive design strategies selected on the Psychrometric Chart. "The Guidelines…were based in part on Watson and Labs Climatic Building Design, and on Loftness et.al, Regional Guidelines for Building Passive Energy Conserving Homes" "Climate data is available… from the Energy Plus web site" (Milne et al.)

The present research has faced the limitation that there was no availability of Badakhshan's weather digital information. Nevertheless, this barrier was overtaken by using similar weather data of other locations (Kiev in Ukraine and Monte Terminillo in Italy) which must be properly interpreted and adapted to the specific conditions of the study area.

Afghanistan's climatic zone 1 is characterized by a high variance of precipitation, relative humidity and temperature along the year. This region is catalogued as well, as a zone of heavy snowfall. The average temperature in the region varies from -5 to 20 °C and relative humidity between 38 to 80%. Since Important similarities between Badakhshan's (Afghanistan) and Kiev's (Ukraine) climatic conditions were found; Kiev's temperature and humidity data was the base for establishing the guide lines for the a passive architectural design in coldest areas of Afghanistan (see Graphics 1 and 2).

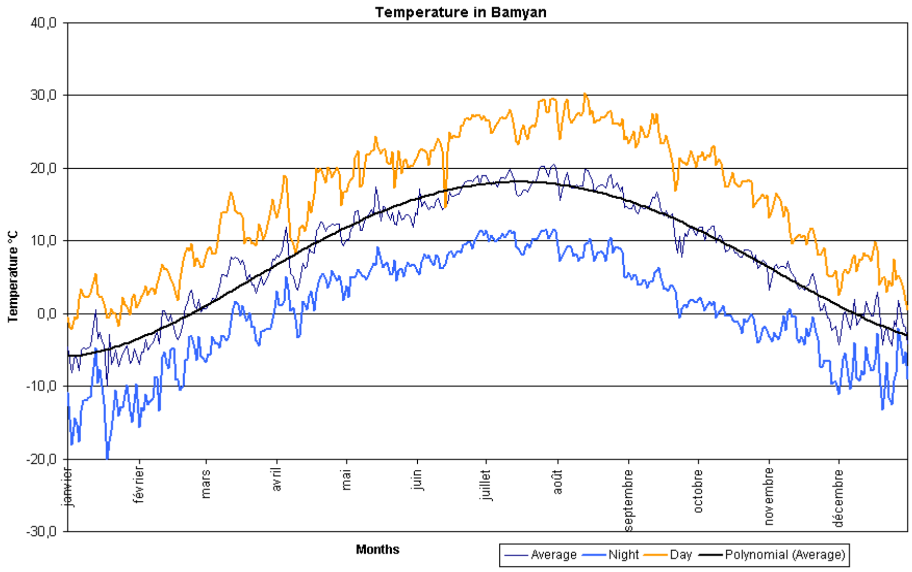


Figure 4.2 Annual average temperature in Badakhshan province, Afghanistan. Provided by GTZ

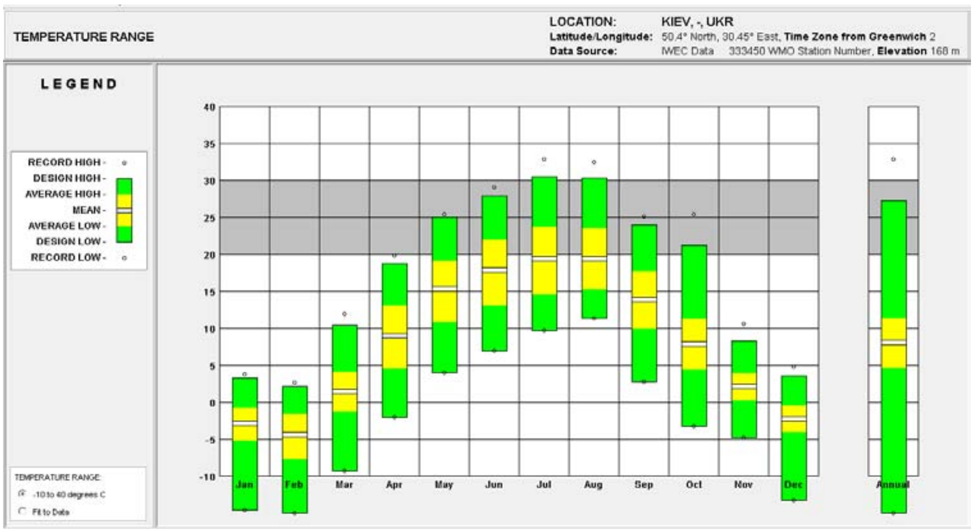
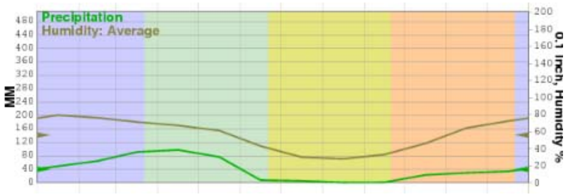


Figure 4.3 Climate Consultant analysis tool, based on: http://apps1.eere.energy.gov/buildings

Although the climate in Kiev is wet in Summer and dry in winter whereas in Badakhshan province the climate is characterized by a dry Summer and Autumn and a relatively wet Spring and Winter, the information can be carefully adapted.(See graphs 3 and 4).

AFGHANISTAN

Badakhshan’s chart



UKRAINE

Kiev’chart

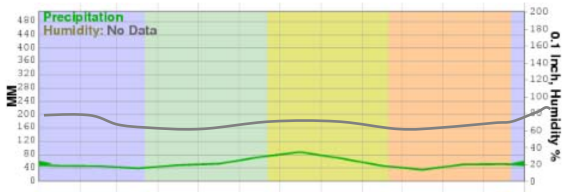


Figure 4.4 Humidity and precipitation (from: www.climate-charts.com)

Additionally it is possible to conclude that at this latitude and altitude during summer solstice there are 17 hours of daylight from 04:30 to 17:30 and the sun is reaching the earth at this position with a maximal altitude of 76 deg. (given by the formula: 90-37+23=76); while in winter solstice there are a minimum of 9 hours of daylight and the sun reach the earth with an altitude angle of 30 deg (given by the formula: 90-37-23=30).

Finally, average Climate data of temperature and relative humidity in Badakhshan was drawn (black points) above the psychometric chart of Kiev (see graphic 5). This drawing is showing that similar design strategies and approach can be used for the two cases. Main differences related to a higher humidity in summer, have to be reinterpreted.

Additionally, it is important to point out that for the computer analysis the comfort zone was shifted from 22.5 and 29.5 (at the equator) to 19.9 and 26.9 deg. Celsius at 37 N. In Badakhshan’s latitude.

On the graphic it can be concluded that average temperature never reaches the comfort zone, so that passive strategies can be used but the design should include a conventional heating system (62%). Strategies for humidification, wind protection and direct solar gain are important as well. Forced and natural ventilation are not the main issues of the design but have to be taken in consideration according to specific needs design made by the project promoters.

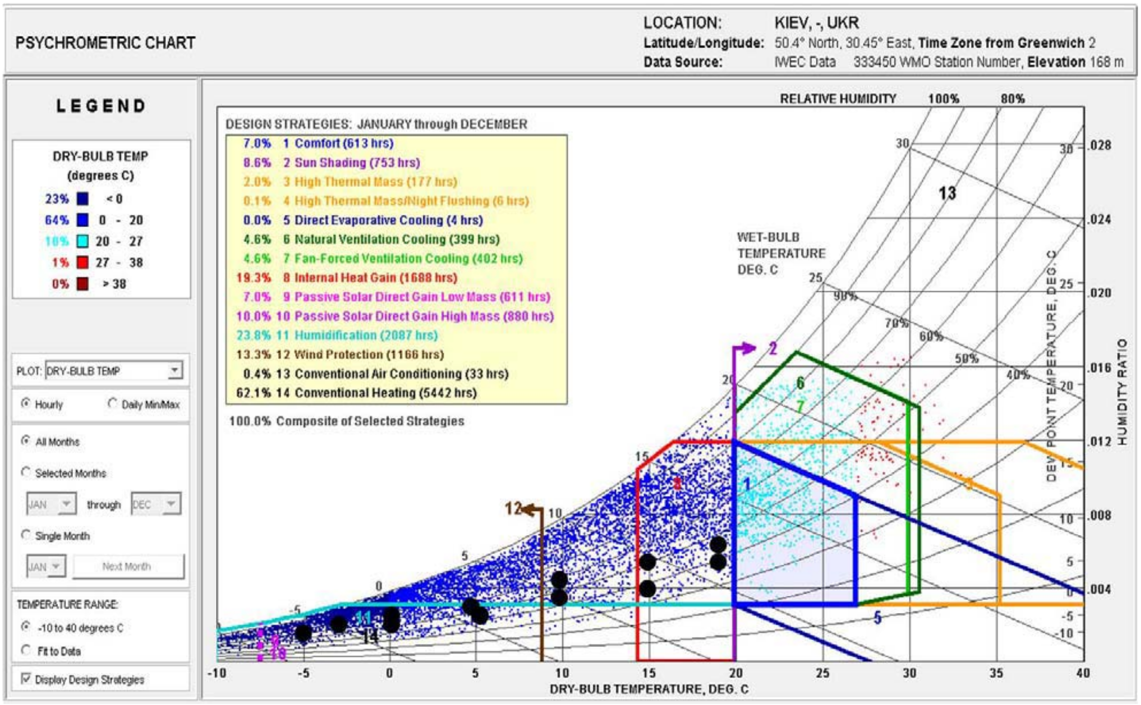


Figure 4.5 Psychometric chart (from: Climate Consultant analysis tool, based on: http://apps1.eere.energy.gov/buildings)

The 20 top design guidelines according to the Psychometric chart are:

1. Snug floor plan with central heat source, south facing windows and roof pitched for wind protection.

2. Use high thermal mass to storage heat and well insulated construction to avoid heat loss.

3. High efficiency furnace should prove cost effective.

4. Keep the building small; excessive floor area wastes heating and cooling energy.

5. Steep pitched roofs, vented to the exterior with a well insulated ceiling bellow to shed rain or snow and to prevent ice dams.

6. Heat gain from equipment, lights and occupants. Keep building tight and well insulated; use ventilation in summer.

7. Extra insulation might prove cost effective, and will increase occupant comfort by keeping indoor temperatures more uniform.

8. If a basement is used must be at least 18 inches bellow frost line and insulated on the exterior(foam) or the interior (fibreglass in furred wall).

9. Sunny wind-protected outdoor spaces to extend usable areas.

10. Locate garages or storage areas facing the coldest wind to help insulate.

11. Use vestibule entries to minimize infiltration, avoid heat loss and eliminate drafts.

12. Glazing should minimize conductive loss and gain; minimize U-factor.

13. Organize floor plan so winter sun penetrates into daytime use spaces with specific functions that coincide with solar orientation.

14. Carefully seal building to minimize infiltration and eliminate drafts(house wrap, weather stripping, tight windows).

15. Insulated blinds or heavy draperies will help reduce winter night heat losses.

16. On hot days ceiling fans or indoor air motion can be used.

17. Tiles or slate on floors or a stone faced wall can help store winter daytime solar gain and summer night-time cool.

18. Small well-insulated skylights(less than 3% of floor area in clear climates) to reduce use of electricity.

19. Use compact building form with square floor plan to minimize heat loss from building envelope.

20. Exterior wind shields and planting to protect entries from cold winds.

4.3.2 Building form and orientation

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 (A Green Vitruvius).

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.

Figure 4.6: Proposed building form

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 and winter, the north side receives very little radiation. Consequently a building elongated along the east-west axis is held to be the most efficient shapes in all climates for minimising heating requirements in winter and cooling in summer, but the extent of elongation depends on the climate Olygay, 1973 (A Green Vitruvius)

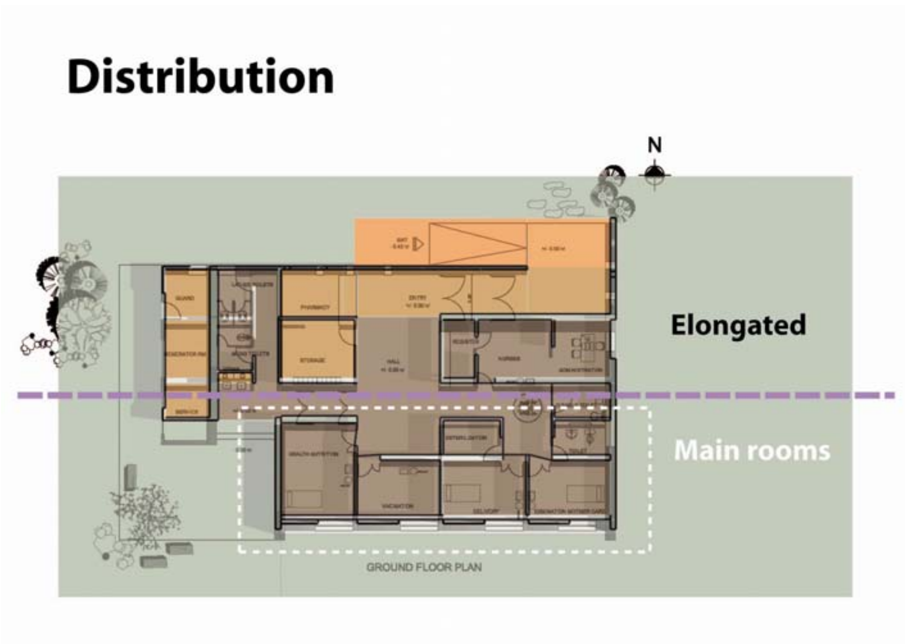


Figure 4.7: Ground floor plan

The proposed design is oriented its longer axis to the south (ref: figure 3).The important spaces of the clinic such as Health Nutrition, Vaccination, Delivery and Mother Care Examination are placed in the south side of the building. The form of the building is designed compact to avoid excessive area for heating.

4.3.3 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:

- A buffer zone
- To capture maximum sunlight and store 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.

This strategy is referred as a literature review among the different methods of passive design. This kind of design requires high skilled labours and advanced technology. Therefore is not suitable for the project area.

4.3.4 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. 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

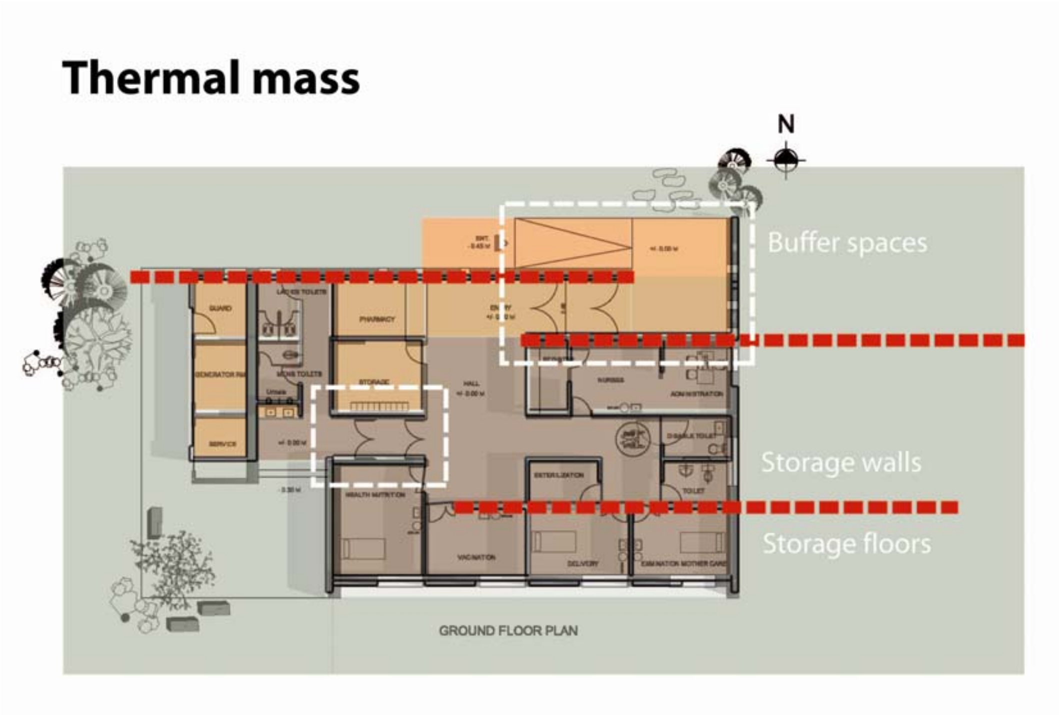


Figure 4.8 Plan showing heat storage walls

The storage and services in the design are located in the northern and western areas to create buffer zone to help insulate. Vestibule entries are used to eliminate cold drafts from the exterior cold climate.

Thermal insulation

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

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.

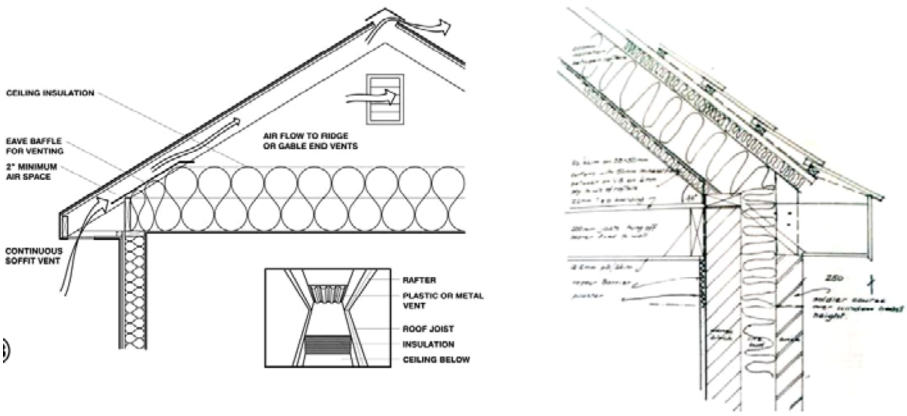


Figure 4.9: Insulation in roof (from: Climate consultant analysis tool)

4.3.5 Transparent elements-Daylight

Daylight design of buildings is becoming an integral part of the concept of sustainable buildings, along with improved indoor comfort and working conditions.

By optimizing the potential of daylight, the energy for lighting can be drastically reduced, especially during the day; the air conditioning can be also reduced or eliminated. In addition to its potential for significant savings in energy use and consequent environmental impact, good daylighting design can dramatically improve the living and working conditions.

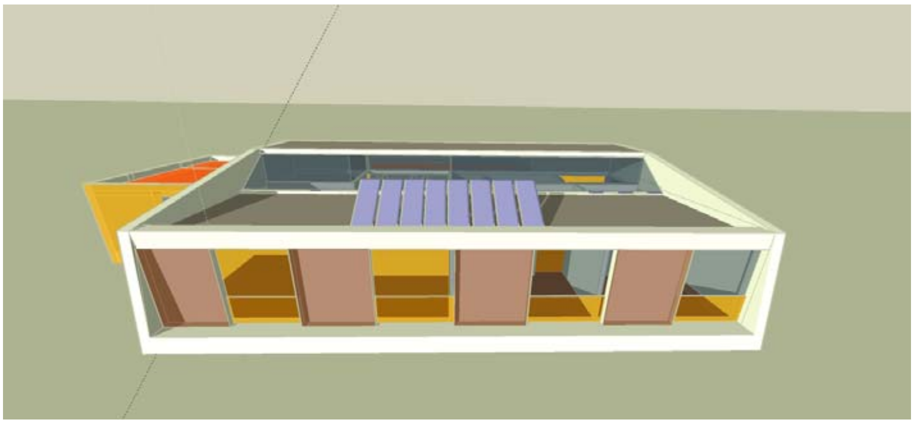


Figure 4.10 Big openings in south facade for heating and lighting

There is a wide range of issues which need to be taken into account in good day lighting design.

Daylight requires daylight admission and distribution in the building. Shallow buildings are preferable, window design and size are important and solar control and shading systems are ssential. An integrated design approach has to be adopted.

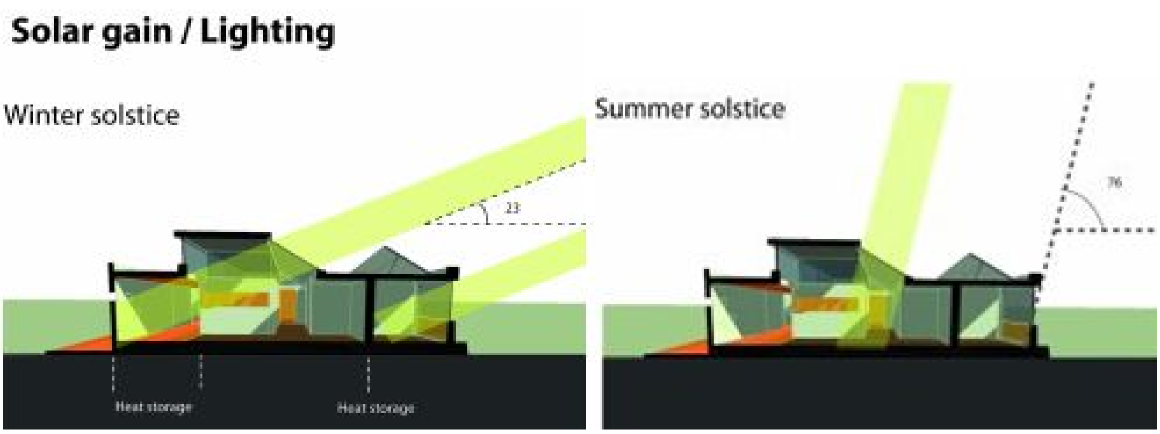


Figure 4.11 Lighting though windows and skylight in winter and summer

The amount of natural light entering a building is related to three major factors:

The luminance of the section of the sky as seen from behind window,

the associated solid angle of this section

The capacity of the window to bring daylight inside (area and transparency)

The final amount of light available inside is related to the area of the absorbing surfaces (by comparison with the window area) as well as their reflectance (particularly those which directly hit by the incident daylight).

Most of the systems with additional surfaces, even if reflective, tend to globally decrease daylight penetration through the reduction of the solid angle of light collection and adding additional light absorptions in process. This means that greater control of daylight leads to a reduced overall luminous performance.

“For this reason, it was found that a combination of simple systems (roof and facade apertures for instance) performed better than advanced facade systems attempting to deviate diffuse daylight deep into the building through the addition of reflective surfaces”. (European Commission, Fontoynont M.)

The best performance remains the horizontal roof aperture collecting daylight from a large section of the sky with very little obstruction (protection against sunlight and provision of a view to the external environment are needed in most buildings).

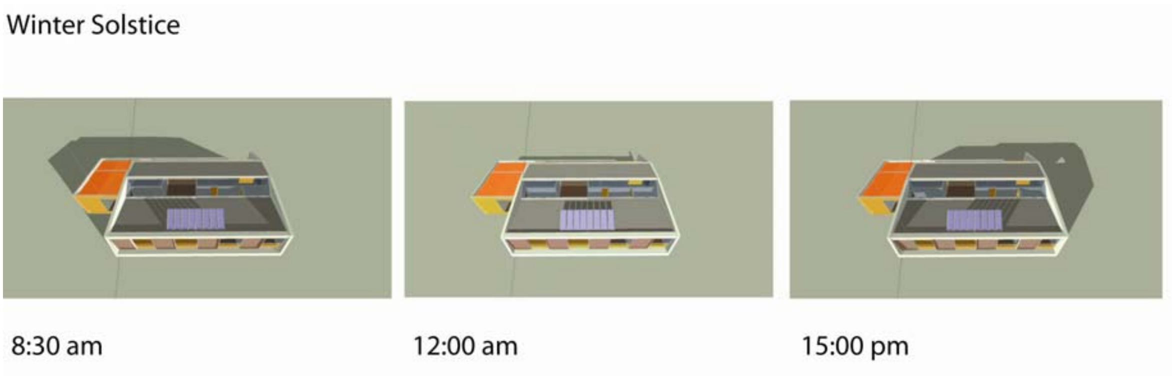


Figure 4.12: Solar gain and lighting

The figure 8 shows enough lighting in the southern façade in the shortest day of the year December 21. Whereas the sky lighting provides sufficient lighting for northern part of the building.

In a monitoring process of Daylight performance of buildings are taken into account the following aspects:

Geometric description: The dimension of the window with respect to the space to be lit. The most useful parameter is the exact glazing area, which needs to be adjusted by the transmittance of the glazing. The ratio of the glazed area to the floor area is called “glazing ratio”. Typically in the range from 5%to 30%, this ratio gives a rapid idea of the general brightness over the year.

Characterization of opaque and translucent materials: The most important aspect of the optical properties of materials is the difference in behaviour with a point light source and a diffuse light source.

Overcast sky as a reference light source: the indoor luminance under sunny conditions cannot be easily recorded. Overcast sky are the most standardized conditions in which to perform monitoring. This is the only way to draw comparisons.

Daylight factors for assessment of daylight penetration: indoor light distribution can be characterized through the measurement of luminance on all useful surfaces: work plane, walls, etc. However, since the intensity of natural light varies, it is necessary to consider the ratio of the local luminance to the simultaneous outdoor horizontal luminance due to an unobstructed sky. This ratio is called “daylight factor”.

Light flux provided by day lighting systems: Incoming light flux is the product of the average luminance behind a glazing facing outside (Iin) and the area of this glazing (A glazing).With this technique it is possible to assess the benefits of secondary windows by comparison with facade windows.

Characterization of the luminous environment: The measurements are vertical luminance and luminance in specific directions.

Sunlight penetration: There are some measurements or visual assessments which can be performed under sunny conditions. Observation should be done for equinoxes and solstices. (European Commission, Fontoynont M.)

Some of the most frequent Daylighiting systems are:

- Glazed roof
- Roof monitors
- Translucent ceiling/floor
- Atrium/courtyard
- Glazed street
- Glazed wall facade
- Windows
- Clerestories
- Light-shelves
- Prismatic devices/optical
- Secondary day lighting
- Passive and active sunlight control
- Video Display Units(VDU´s)
- Bright Indoor finishes
- Colouring effects

For the better lighting of the rooms the ratio of heat absorbing area to the window area is 9:1 (Prof. Willbord Lohr). This strategy is being applied in the proposed design for better heating and lighting.

4.3.6 Ventilation and Aeration

There are three fundamental microclimatic variables:

1. Temperature of the air

2. Relative humidity of the air

3. Movement of the air

The anemometry is used to measure the velocity of the air in m/s.

Ventilation: ventilation is the renewal of the air. Ventilation is the mechanism which regulates the composition of the air we breathe. In an occupied room without ventilation there is deterioration in the physicochemical properties of the interior atmosphere .The alteration of physical properties (elevation of temperature and humidity) is the primary factor that determines a lack of comfort. The second factor deteriorating the physical properties of the interior atmosphere is the high concentration of CO_2. A high concentration of CO_2 is the result of natural processes of cellular oxidation and household combustion. Another factor is the concentration of body odours.

A normal introduced air with 0.05% CO_2, requires a ventilation rate of 30m3/h/person.If the air has more than 0.07% concentration of CO_2, the required rate amounts is 50m3/h/persona.A 30m2 room for two people with 0.05 concentration of CO_2 will require 2 renovations/h. With 0.07% concentration of CO_2, will require 3.5 renovations. (Tudela)

Usually the outdoor elimination factor introduced stricter requirements for ventilation; it has been estimated that one linear meter of window provides minimum ventilation rate of 1.7m3 / h. (Tudela)

The ventilation processes typically comprise:

- Bringing in outdoor air
- Conditioning, mixing the outdoor air with some amount of indoor air
- Distributing this mixed air throughout the area
- Exhausting some amount of the indoor air outside

Aeration: aeration refers to the movement of air, determined by pressure difference.

Air movement is difficult to predict. In contact with roughness surfaces, the wind changes its possible laminar regime to turbulent regime. However, there are factors to try to understand the features and movement of local winds as the direction of smoke from factories and areas of accumulation of leaves of trees. Models and wind tunnels are used to predict the changes in the winds.

Some of the phenomena that must be considered when making a study of winds are: wind shadow effect, corner effect, pile effect, Venturi effect, whirlwind effect, and so on. (Tudela)

4.4 Architectural proposal

The Bio-Climatic Health clinic Programme:

- Registration desk with administration office
- Vaccination room
- Health and Nutrition room

- Examination and Mother care
- Delivery
- Sterilisation room
- Doctors and Nurses room
- Pharmacy
- Storage
- Toilets
- Guard and services

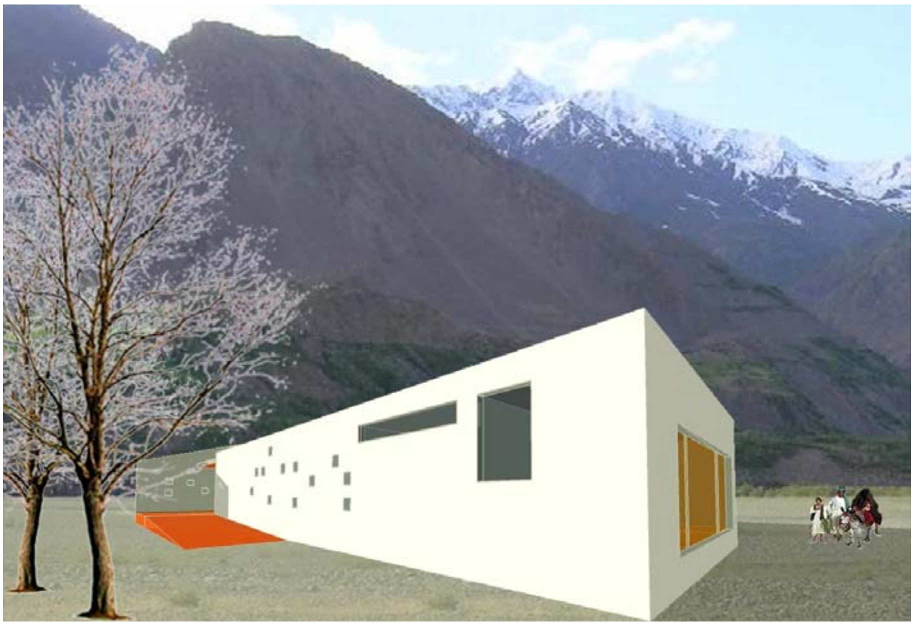


Figure 4.13: North perspective

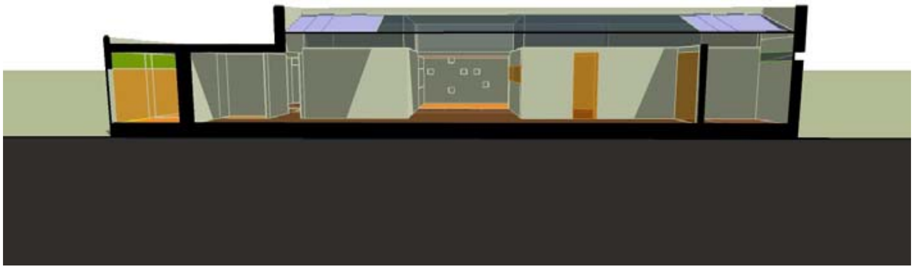


Figure 4.14: Longitudinal section to the north

Figure 4.15: South West perspective

Figure 4.16: Transversal Section to the South

The architectural drawings are available in Annex 1-3.

4.5 Recommendations

Design Recommendations

THERMAL COMFORT	The ambient temperature should be between 20-22°C in winter (adaptable)
	The ambient temperature should be between 24-26° C in summer (adaptable)
	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)
	Dark-coloured paint on external walls and roofs in cold conditions
	For best performance, locate solar shading externally
	Under floor insulation
	Locate and detail thermal insulation to avoid condensation risks
	Snug floor plan with central heat source, south facing windows and roof pitched for wind protection
	Use high thermal mass to storage heat and good insulation in building to avoid heat loss
	High efficiency furnace should prove cost effective
	Keep the building small; excessive floor area wastes heating and cooling energy
	Steep pitched roofs, vented to the exterior with a well insulated ceiling bellow to shed rain or snow and to prevent ice dams
	Heat gain from equipment, lights and occupants
	Keep building tight and well insulated; use ventilation in summer
	Extra insulation might prove cost effective, and will increase occupant comfort by keeping indoor temperatures more uniform
	If a basement is used must be at least 18 inches bellow frost line and insulated on the exterior(foam) or the interior (fiberglass in furred wall)
	Sunny wind-protected outdoor spaces to extend usable areas.
	Locate garages or storage areas on the side facing the coldest wind to help insulate
	Use vestibule entries to minimize infiltration, avoid heat loss and eliminate drafts
	Glazing should minimize conductive loss and gain; minimize U-factor

	Organize floorplan so winter sun penetrates into daytime use spaces with specific functions that coincide with solar orientation
	Carefully seal building to minimize infiltration and eliminate drafts(house wrap, weather stripping, tight windows)
	Insulated blinds or heavy draperies will help reduce winter night heat losses
	On hot days ceiling fans or indoor air motion can be used
	Tiles or slate on floors or a stone faced wall can help store winter daytime solar gain and summer nighttime cool
	Small well-insulated skylights(less than 3% of floor area in clear climates) to reduce use of electricity
	Use compact building form with square floorplan to minimize heat loss from building envelope.
	Reducing the amount of volume in a building implies less area to be heated and less energy consumption.
	Exterior wind shields and planting to protect entries from cold winds

Visual Comfort / Daylight	Reduce summer heat gain by using high efficiency lighting and good control
	Good orientation and correct spacing
	Glazing ratio and window design should ensure natural light inside the building
	Natural and artificial lighting should meet optimum intensity, similar brightness, protection against glare, avoidance of shadows and adequate contrast
	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	Recommended air movement in room: 0.1-0.15m/s in winter, 0.25m/s in summer
	Area of opening windows to be 5% minimum of floor area for ventilation
	Natural night ventilation to reduce air temperatures during hot weather
	Ventilation rates should comply with air quality standards and sanitary recommendation
	Air filtration alone may provide an acceptable level of air exchange; however, should have provision for additional controlled ventilation
	The open able 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 air
Acoustic Comfort	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	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
	Modular design to avoid unnecessary cutting and waste material

Recommendations of Implementation

Implementation	Identify professionals and public and private institutions to participate in the Project. The ideal situation is to identify in advance to an entity serving as coordinator of the Project for each participating institution.
	Having identified the participants, form a coordinating body which have convening power and responsibility for the project.
	Invite representatives of all the participating institutions to participate in an introductory session of the Project in order to secure firm commitments for participation.
	Identification of all potential problems that may arise in all stages of the project (social, economic and technical potential problems).
	Promote the interest of the inhabitants and local authorities to implement and maintain the project.
	To develop a work plan describing the activities referred to fulfil the objectives of the program and do community participle

	Preparation of technical documents that illustrate the process of implementing the Project.
	Invite and / or train professionals in the community to actively participate in the project. Perform continuous sessions with them.
	Information campaigns to local residents
	Invite members of any community that has implemented successfully a project to share their experience
	Training workshops for local people to participate in all stages of the project. Mainly on the operation and maintenance.
	Monitor the implementation, operation and maintenance of the project to identify the problems and not repeat them in the future.

5. Energy

5.1 Overview

Almost all of the country's known oil and natural gas reserves are in the northern part of the country, located in parts of two geologic basins – gas in the Amu Darya Basin to the west, and oil in the Afghan-Tajik Basin to the east. Oil reserves are estimated at 15 million tons. The current rate of domestic oil production is only 400 barrels a day (mostly the Angot oil field in Sar-i-Pol). Natural gas holds the potential (proven reserves range from 30 to 400 billion m3) to become a significant source of energy for the country and an important source of Government revenue. It suffers from a lack of investment. Consumption and production of gas has been declining from the 1990s because of deteriorating infrastructure. Additionally about 30 per cent of gas is lost during production and transmission. Afghanistan has reasonably good quality coal reserves (estimated at 400 million tonnes), most of which are located in the northern part of the country in the region between Herat and Badakhshan. The coal industry is operating at low production rates, less than 100 000 tons a year due to devastation from war and years of neglect. The country's main coal mines are in the Karkar and Ispushta districts. Dara-i-Suf appears to have the greatest potential with coal reserves of 84 million tonnes.

Hydropower, solar, wind and biomass have considerable potential for contributing to the energy supply. Afghanistan could develop about 23 000 MW of additional hydro-generating capacity, with 18 000 MW located on the Panj and Amu Darya Rivers that form the border with Tajikistan and Uzbekistan. Tapping this huge potential would require further substantial work with the neighbouring countries, where environmental cooperation, joint water resource assessment and monitoring could play a major role. The remaining potential is primarily in two areas, about 1 800 MW on the Kokcha (sub-basin within Amu Darya) and 3 200 MW in the Kabul river basin. The nation's total generating capacity supplying the networks in the early 1990s amounted to 400 MW (including 260 MW Hydro); this has declined to 250 MW. (Moeller 2009)

5.2 Approach

At present the majority (70–75%) of Afghanistan's energy needs is met by traditional energy sources such as animal dung, fuel wood and crop residues. Annual biomass energy use in Afghanistan is equivalent to 2.5 million tons of oil. The remaining requirements are met by commercial energy sources mainly petroleum products, but also natural gas, coal and hydropower. Fuel wood constitutes the basic source of energy for cooking and heating in rural areas, and for decades it has been available in unrestricted quantities. In recent years, a commercial market for it has also developed in rapidly expanding urban areas. But natural regeneration has not been able to sustain forests due to indiscriminate cutting of trees for fuel, thus creating serious environmental risks. In the areas of Jalalabad, Laghman, Kabul and Herat, firewood scarcity is already acute. However the urban centres consume a great deal of energy, mostly supplied by the country's provinces still rich in biomass resources. Such energy demand and consumption patterns affect the environment in both the immediate vicinity of population centres and far away. It also poses health hazards due to high rates of emissions of particulate matter and other pollutants. Deforestation not only contributes to the changes in the hydrological properties of soils, drainage of river basins and microclimate; it also has connections to the global climate change. The initial greenhouse gas (GHG) inventory of Afghanistan shows that deforestation plays a very significant role in the country's total greenhouse gas emissions compared to fossil fuel combustion (gasoline, coal, etc.). At the same time, soils and remaining forests absorb large amounts of carbon dioxide annually, thereby compensating GHG emissions. The current balance between emissions and removals of carbon dioxide in land use and forestry sector is fragile, but positive. Therefore further efforts should be given to maintaining this balance and other forms of climate change mitigation. (Afghanistan's Environment 2008)

5.2.1 Rural Electrification

Electricity drives modern economies and per capita consumption of electricity in Afghanistan is one of the lowest in the world. After a long period of decline, generating capacity is beginning to grow again. Hydro plants account the largest share of capacity with imports in second place and growing. The most promising long-term resource for power generation in Afghanistan is hydropower, which accounts for over 50% of grid-connected installed capacity. Following hydropower, thermal generation, primarily diesel generation, supplies power mainly to urban areas. Utilization of indigenous fossil fuels (natural gas and coal) for power generation is very limited as is utilization of solar, wind and other renewable energy resources. Reliance on diesel is both expensive and environmentally hazardous. (Energy Sector Strategy 2008)

After hydropower, solar energy probably has the greatest potential as a renewable energy source, although development costs remain a major barrier. Estimates indicate that in Afghanistan solar radiation averages 6.5 kWh per square meter per day and the skies are sunny about 300 days a year. Consequently, the potential for solar energy is high, especially for solar water heaters. For example standard home modules could provide 140–180 litres of hot-water a day at temperature of 60–75°C. Herat is a city known for its 120 days of very high wind. In fact the windy days here are regular and provide good potential for wind power generation. Wind pumps have already been successfully installed in selected villages where access to water was problematic. Biogas is another alternative and could be used in several agricultural areas. Finally, geothermal sources in the mountains of Afghanistan could be used for energy co-generation. (Energy Sector Strategy 2008)

5.2.2 Rural Health Power Supply

For some 2 billion people in developing countries, rural health stations are the only form of medical care. The services provided by these clinics range from basic health care and deliveries to vaccination programs and general health education. The energy consumption of the health stations depends on the range of services provided and the target area and the number of patients. (Fahlenbock and Haupt 2000)

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 Centre (BHC) several options need to be taken into account. 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)

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 is strongly supporting this approach. PV systems are reliable and simple to apply with all the required data for a proper design available. (Moeller 2009) Ongoing workshops carried out by Information Centre's (GTZ and DED) are spreading the knowledge how to install, use and maintain photovoltaic systems. (Heider, et al. 2007/1386)

5.2.3 Components and their requirements

In the planning of a PV System for a Health Centre, the right selection of components is of critical importance for the reliability, acceptance and permanence of the energy supply.

With the steadily growing international trade, short product lives and world-wide distribution of production sites and consumer markets in recent decades, internationally recognized standards have become increasingly important in the field of electrical engineering. Similarly, the standardization activities in the field of photovoltaic's are being pursued almost exclusively at international level by the International Electro technical Commission (IEC) and adopted by the national (and regional) standardization institutions. (Fahlenbock & Haupt, 2000)

5.2.3.1 Lighting

A well-planned illumination of all functional rooms, stations, storage rooms and outside areas that is adapted to the demand of the health station serves the general safety and enhances the quality of work and life. As a matter of principle, only energy-saving lamps like fluorescent lights and compact fluorescent lamps with electronic ballasts should be used.

Experience shows that the illumination of the service staff's private rooms (if existent) increases the consumption of energy, but that it makes a significant contribution to the smooth operation of the health station and also to the PV system, because the staff has a more direct interest in having a functioning unit. If the illumination of the private rooms is connected to the same installation as essential loads of the health station, the nonessential loads have to be switched off separately and early in any case in the event that the battery deep-discharges. A risk to important loads from a lamp that has been left on by mistake has to be excluded. (Fahlenbock & Haupt, 2000)

5.2.3.2 Refrigerators/Freezers

A comprehensive overview of solar-operated refrigeration and freezing devices and their technical data, as well as other accessories and recommendations for the installation and operation of a reliable cooling chain can be found in the "Product Information Sheets, Edition 1997“ of WHO/EPI. The devices and systems listed in this publication have been tested and approved for WHO standard requirements by independent test laboratories. These standard requirements and test procedures (“EPI Equipment Performance Specifications and Test Procedures”) can also be obtained from WHO. They are more or less accepted as the standard for refrigeration units in the health-care sector in developing countries.

If a refrigeration unit is operated to store vaccines, its operating safety has to be guaranteed. Most vaccines have to be stored at a temperature in the range of 0° and 8° C. Freezing and also higher temperatures can ruin the vaccination effect. Precise data regarding cooling temperatures for the various vaccines are indicated in the EPI Product Information Sheets.

If the vaccine is to be transported further over longer distances, the possibility of freezing and storing icepacks should be provided for. This naturally increases the unit’s energy consumption.

Energy consumption can increase considerably if the refrigeration unit is frequently opened or left open for a relatively long time, more so in the case of refrigerators with a vertical door than in the case of iceboxes with a lid on top. It is critical for reliable operation to initiate the staff in dealing with the refrigeration unit and sensitizing them to this problem. Distinct warning signals have to be installed which point to a low state of charge of the battery or to the separation of the refrigeration unit from the energy supply. If the battery capacity drops below a pre-warning threshold, a warning signal has to light up with the written notice: “Do not freeze icepacks”. (Fahlenbock and Haupt 2000)

5.2.3.3 Charge regulators

The charge regulator shall primarily protect the battery from overcharging and deep discharge and has to fit the battery type used. It shall monitor the battery’s state of charge and the charging process, and also regulate the connection / disconnection of the charge in such a way that as long a battery life as possible is achieved. Due to the charge and discharge processes in the battery, concentration differences in the electrolyte may occur, which can reduce the capacity and lifetime of the battery. This effect can be eliminated by occasional controlled gassing, causing a mixture of the electrolyte. The charge regulator has to raise the end-of-charge voltage for about one hour for this to happen, and repeat this process every two weeks or after a certain deep discharge battery voltage has been exceeded.

Own consumption by the battery charger should be minimized (=10 mA). (Fahlenbock & Haupt, 2000)

5.2.3.4 Batteries

Lead-acid batteries with grid plates or tubular plates or closed maintenance-free batteries are used. In any case, the charge regulator has to fit with the battery performance. In the case of closed batteries, it is absolutely necessary to avoid gassing. (Danger of destroying the battery or even explosion.)

To control the acid level, open lead-acid batteries should have a case made of semitransparent material or an electrolyte display. Distilled water always has to be available in sufficient quantities and the electrolyte level has to be controlled regularly.
Automotive starter batteries should not be used in any case.

The place where batteries are set up should meet the following conditions:

- Batteries have to be protected against weather influences.
- They should be put in a room that can be closed off or should at least be enclosed in a battery case.
- Access must be restricted to authorized and properly trained operating personnel.
- In no case must the batteries be accessible for children.
- The connections have to be secured against an unintentional short circuit, e.g. due to a tool falling on top of the battery.
- Sufficient ventilation must be provided for at the highest point of the room to allow hydrogen gas to escape.
- The hydrogen must not be allowed to float through rooms where there is a danger of sparking or open flames.
- There should be at least 20 mm free space between the battery and the walls and top of the battery box.
- The battery container has to be sufficiently sturdy and acid-resistant.
- A readily visible warning sign (fixed to the battery box or placed at the battery enclosure) should call attention to gases and acids escaping, danger of explosion and that no smoking and no fires are permitted.

- The batteries should be transported in an unfilled state. The acid should be transported in separate containers.

5.2.3.5 PV modules

The PV array shall consist of mono- or polycrystalline photovoltaic solar modules.
Crystalline PV modules must have been tested for qualification in compliance with IEC 61215, “Crystalline Silicon Terrestrial Photovoltaic Modules; Design Qualification and Type Approval”.
The PV modules should have a rated peak power output of at least 45 Wpeak (with an allowable tolerance of 2.5 Wpeak (-5%), alternatively 5 Wpeak (-10%)), under Standard Test Conditions (STC) as defined in IEC 61215 and IEC 60904-3. The minimum acceptable operating voltage at MPP (Maximum Power Point) of the PV module shall be no less than 16 VDC at a cell-operating temperature of 60° Celsius. In a PV array all modules should be of the same type and be interchangeable.

The modules shall be equipped with a sealable waterproof (international protection code IP54) terminal (junction) box. The poles inside shall be clearly marked. A strain relief for the cables must be provided.

Optional:
Each solar module has to have the individual clinic name sandblasted onto the bottom right-hand corner. The names are to be a minimum of 10 mm in height and are to be positioned so that the marking in no way impairs the functioning of the module or negates the guarantee issued with the module.

5.2.3.6 Support Structure

The orientation and tilt angle of the module should be optimized to the month with the lowest mean insolation sum.
Shading should be avoided the whole year round during the period from 90 minutes after sunrise to 90 minutes before sunset.
To allow for regular cleaning of the solar modules, they should be accessible for personnel, i.e., the proper ladders and safety precautions should be provided for. In many areas with regular precipitation, however, manual cleaning is only very rarely necessary as long as a minimum tilt angle of 15° is maintained in order to ensure self-cleaning of the modules. The installation has to be protected against theft and vandalism.
The connections and cable have to be protected against corrosion and unintentional damages.
If mounted on the ground, the pole should be anchored sufficiently deep (1 m) in a concrete foundation. The connecting cable should be laid under the ground and the installation should be protected with a fence against unauthorized access.
If mounted on the roof, care should be taken to ensure that there is sufficient circulation of air between the roof and the modules (minimum space: 10 cm).
Wiring that leads into the building must be protected (insulated or in a conduit) against dampness.
The PV module and the support structure must be able to withstand wind loads of up to 120 km/h.
It may be worthwhile and acceptable to use passive tracking systems if they are reliable and have been tested, can withstand the required wind loads and result in an appreciable gain in energy. This gain in energy, however, must not be taken into account when the system is sized, because in the design month, in other words, the month with the lowest solar irradiation, strong cloudiness and thus a high diffuse irradiation usually has to be expected. Under these conditions, tracking systems usually have no gain in energy compared with fixed installed PV modules; under certain circumstances, they can even reduce the energy yield due to a completely wrong orientation.
It is not worthwhile in technical or economic terms to use active (motored) tracking systems unless the systems are large (as of a few 10 kWpeak) and in regions with a very high percentage of direct irradiation.

5.2.3.7 Installation

The work must be done professionally, in a neat and tidy manner, not just to support the optically clean and hygienic impression of a health station, but also for safety reasons, to guard against accidents (no loose cables or components that are not sufficiently fastened) and maintain an overview of system operation as well as for maintenance of the system.

Cable/Wiring and junction boxes:

Cables have to be clearly colour-coded.

Reliable cable connections have to be laid out with screw-connectors or crimping ferrules with appropriate cable end sleeves (no soldered connections in the field, no “twisted connections”).

All cable connections have to be protected against dust and moisture by being enclosed in junction boxes.

Interior junction boxes shall have an IP protection code of IP 43 and external junction boxes, IP 55.

Cables passed through battery cases or junction boxes shall be sealed in accordance with the respective IP protection code.

Wiring and the insulation have to be protected against damage from strain and twisting.

Light switches can be used as junction boxes if they are in line with the stated requirements and are designed for that purpose.

Plugs and socket outlets (if system voltage is 220V):

All devices that are not connected permanently to the system can be connected via socket outlets. Sockets have to be designed for DC and have to be safe against reverse polarity. The direct current (DC) and the voltage should be clearly indicated in writing on the device.

Installation of cables:

All cables shall be laid in an orderly manner and sufficiently fixed. They should be laid at a right angle with "aesthetic" considerations in mind. Suspended cables should be avoided.

Underground cables must be laid deep enough (at least 1 m below the surface) and sufficiently marked with stones or bands lay on top. If cables cross a road or street, then an underground cable lay is preferable to overhead cables.

Suspended cables should be mounted so that the lowest point is at least 2.8 m above ground level. They should be secured with suitable brackets and strain reliefs.

Cables through rooftops should be avoided if at all possible. All wiring and insulation material must be made of UV-resistant material and must not be allowed to impair the water tightness of the roof.

In places with easily flammable materials, the cables used should be insulated with extremely flame-retardant material or laid in metal conduit pipes. No cable connections or junction boxes should be installed directly on thatch or similar materials.

Holes that penetrate outside walls shall slope slightly to prevent the ingress of water and must be well sealed.

All outdoor cables have to have a UV-resistant insulation or coating.

5.2.3.8 Operation and Maintenance

Experience has shown that the reliability of photovoltaic installations depends to a great extent on the quality of handling and maintenance. Therefore, the training of personnel and technicians must be an integral part of the program as a whole.

Maintenance by the operating personnel:
The responsible personnel should be familiarized with its maintenance tasks both in writing and verbally. All of the tools and equipment that are needed for routine maintenance should be included.

All users of the installation/system should be familiarized with the safety requirements.

Operating instructions:
Manuals with technical data and maintenance information that are easy to understand should be included with the system. Special attention should be given to the operation of the batteries, routine maintenance and safety requirements during the maintenance of the batteries.

Every refrigerator should include a set of operating instructions with clear descriptions for users and technicians, with the following contents:

- simple daily, weekly and monthly maintenance
- regular preventive maintenance checks
- diagnostic and repair procedures
- installation procedures

The use of pictures and drawings in comic's style to illustrate the technical connections has proved effective, not just for children or illiterate users.

A logbook should be provided to enter all maintenance work and inspections.

Spare parts shall be itemized in a list and shall include fuses as well as spare lamps.
The user has to be informed about the type and price of the batteries and where they could be purchased, as well as about the nearest possible sources to purchase spare lamps and similar items.
No devices may be installed for which spare parts are not sufficiently available or cannot be procured within a reasonable amount of time.

5.3 Design of the PV System

This chapter describes the procedure for designing the PV system, which is based on relevant publications but also partly on the calculations and the experience of the author. The aim was to keep the calculation process as simple and understandable as possible. This will not achieve the preciseness of a simulation program. However, the use of simulation software by the user requires fundamental knowledge of PV stand-alone systems and the various interactions between their components. The following design route has to be taken as a first practical approach and later be compared to calculations with a simulation program. The design is made for a system voltage of 12 Volts. It shows that the cable cross sections due to reduction of the losses to 3% are to big ($25mm^2$!). Cables with this cross section are practically not useful and very expensive. To reduce the cross section of the cables and with that the energy losses and the investment, an additional calculation for a system voltage of 220V could be necessary.

5.3.1 Calculating the electricity consumption

The most important stage in sizing the PV system is providing a carefully worked out breakdown of the daily electricity consumption.

Due to the considerable fluctuations in radiation during the course of a year it is necessary to differentiate according to months and seasons, or at least between the extremes of summer and winter when estimating the consumption. In this case the period from April to October was taken for the high radiation or summer season and the period from November to March for the low radiation or winter season.

All intended electric appliances and their respective power consumption are listed with their probable daily operating time and their daily consumption amounts.

Table 5.1: Consumption breakdown for a BHC

Consumer	Quantity [pcs]	nominal Power Pn [W]	Daily operating time [hours]		Daily consumption W [Wh]	
			Summer (Apr.-Oct.)	Winter (Nov.-March)	Summer (Apr.-Oct.)	Winter (Nov.-March)
Fluorescent lamb[1]	20	12	4	8	960	1920
Refrigerator[2]	1				240	70
Fan[3]	5	15	6		450	
Radio set[4]	1	20	2	2	40	40
Water pump[5]	1	-	-	-	-	-
Total		**2804**			**1690**	**2030**

[1]The planned clinic consists of 20 areas (rooms) which require independent lighting. During the summer time lighting will be provided from 6 to 7a.m. and from 6 to 10 p.m. During winter time the respective times will be from 6 to 8 a.m. and from 4 to 10 p.m.

[2] An energy-saving refrigerator is planned. Modern refrigerators are always supplied with information on their daily standard usage. Since we are interested in the numerical value, information on the daily running time of the cooling unit is not necessary for the calculation. Datasheet see Annex 1.

[3] The Fans will be distributed throughout the BHC and will run in the summer time for 6 hours/day.

[4] In rural areas in Badakhshan communication will be carried out with radio call systems. An equal usage in the summer and the winter is assumed

[5] The water pump for the fresh water supply of the BHC will be installed on top of the water storage and will be fed by separate solar panels. The calculation is explained in the chapter “Water supply”

5.3.2 Solar insolation and temperature

The following table lists the monthly mean totals for the daily global radiation on a horizontal surface for the city of Faizabad the capital of the province Badakhshan.

Table 5.2: Monthly averaged insolation incident on a horizontal surface

Monthly Averaged Insolation Incident On A Horizontal Surface (kWh/m2/day)													
Lat 37 Lon 70	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
22-year Average	2,41	3,13	4,13	5,58	6,87	8,07	8,00	7,26	6,17	4,53	3,03	2,22	5,12

Source: (Surface meteorology and Solar Energy n.d.)

For tilted areas, these values must be converted with a factor. The calculation of this factor is well explained in the relevant literature and will not be explained at this point.

Table 5.3 shows the corrected values for the monthly averaged insolation on tilted surfaces. The BHC's are located on the northern hemisphere and therefore an optimal angle for the tilted surface was calculated to 33.6°. The sizing of the PV-system is based on the average daily insolation in December.

Table 5.3: Corrected values

Monthly Averaged Insolation Incident On A Tilted Surface (kWh/m2/day)							
Lat 37 Lon 70	20°	30°	40°	50°	60°	Tilt=Latitude	33,6°
Jan	3440,5	3835,6	4133,7	4325,7	4405,8	4055,0	3954,6
Feb	3995,4	4290,8	4481,9	4562,7	4530,8	4436,0	4372,0
Mar	4733,9	4876,1	4905,1	4819,8	4623,0	4908,4	4899,7
Apr	5851,9	5792,9	5604,4	5292,0	4865,4	5674,3	5739,8
May	6716,8	6436,7	6027,2	5500,5	4874,0	6163,0	6303,6
Jun	7641,8	7210,3	6643,3	5957,6	5176,4	6826,8	7021,1
Jul	7685,6	7300,0	6770,7	6113,3	5349,8	6943,8	7125,3
Aug	7420,3	7250,9	6918,2	6432,2	5808,3	7034,7	7149,5
Sep	7004,3	7162,2	7139,1	6935,6	6557,9	7165,1	7174,8
Oct	5837,6	6276,8	6553,6	6659,6	6591,5	6488,2	6395,7
Nov	4277,8	4749,6	5099,9	5317,9	5397,2	5008,3	4890,3
Dec	3250,5	3653,0	3963,2	4171,7	4272,3	3880,4	3775,8

Source: by author

The radiation on the tilted surface in December in Faizabad amounts to 3.78kWh/ (m²d). In other words, during the course of an average day in December, the sun supplies radiation energy of

3.78kWh/m2. We would receive the same amount of energy by, as it were, comprising the radiation occurrence to 3.78 hours having the standard irradiance of 1000 W/m² (STC).
It is now possible to make a simple yield calculation by interpreting the numerical values from table 5.3 as hours per day with a standard illumination of 1kW/m².

$$\min .hours(STC) = 3.78\frac{kWh}{m^2 \cdot d} \cdot 1\frac{kW}{m^2} = 3.78\frac{h}{d} \quad (5.1)$$

The minimum operating temperature is set to 15°C

5.3.3 Loss coverage

The PV generator, load and the batteries are connected with electrical wiring. In particular the cables and the battery reduce the electricity yield. Voltage losses occur in the cables, and the battery causes conversion and adjustment losses.

5.3.4 Cable losses

When sizing the cables, the losses should be restricted to about 3%. The module yield is reduced twice by a 3% line loss:

- on the way from the generator to the battery via the charge controller
- on the way from the battery to the load via the charge controller

Therefore the generator yield must be reduced by the factor:

$$V_l = 0.94$$

5.3.5 Conversion losses

The conversion of electrical energy into chemical energy and back again into electrical energy, which takes place in the battery, is a process which is difficult to calculate in energy terms as this involves construction details, age, temperature, depth of discharge, and the charge and discharge amperage. In practice, an average loss of 10% is accepted. Therefore the generator yield must be reduced by the factor:

$$V_c = 0.90$$

5.3.6 Adjustment losses (mismatching)

These result from changes in the voltage level during operation caused by a variety of unknown, and generally uncontrolled variable conditions on a PV array that can change over time. For example cloud coverage, temperature variations, dust coverage, partial shading, alignment of modules to the sun, and manufacturing tolerances. Almost all variable conditions tend to affect the current, and in fact, as modules go from zero power to full power, the current goes from zero to maximum while the voltage remains relatively steady. Module mismatch is caused by these system variables affecting some parts of an array but not others, or affecting different parts of the array to different extents. (Strand and Harris n.d.) The mismatch losses must be estimated with an average energy loss of 10%.

$$V_m = 0.90$$

To reduce these losses, it is possible to MPP (Maximum Power Point) tracking as it is standard with grid-feeding systems. MPP trackers in the form of DC-DC converters can be deployed very effectively. Charge controllers with MPP trackers are available, but the higher investment costs must be taken into consideration. (Haselhuhn and Hemmerle 2008)

Corresponding to the statements above, the overall losses result in:

$$V = V_l \cdot V_c \cdot V_m = 0.94 \cdot 0.9 \cdot 0.9 = 0.76$$

(5.2)

5.3.7 Sizing the PV generator

The PV generator is designed around the assumed daily energy consumption W in kWh/day. In this case the values for the winter are used (Table 5.3), because they exceed the values for the consumption in summer.

We can now calculate the required generator energy $W_{req.}$ to cover the overall energy consumption W for the winter time.

$$W_{req.} = \frac{W}{V \cdot 0.80} \quad \left[\frac{Wh}{d}\right] \qquad (5.3)$$

$$W_{req.} = \frac{2030}{0.76 \cdot 0.80} = 3339 \ \frac{Wh}{d}$$

With the adjusted energy consumption to the losses, we calculate the real power P of the PV generator.

$$P - \frac{W_{req.}}{min.hours\ STC} \quad [W_p] \qquad (5.4)$$

$$P - \frac{3339}{3.78} - 883\ W_p$$

The selected module type is a poly crystal module which is available in Afghanistan.

Table 5.4: PV module data[6]

Nominal power (Pmpp)	130 W
Maximum power current (Impp)	7.39 A
Maximum power voltage (Umpp)	17.6 V
Area	0.93 m²

With these data the number of modules can be determined to:

$$Total\ number\ of\ modules = \frac{P}{P_{mpp}} \tag{5.5}$$

$$Total\ number\ of\ modules = \frac{883\ W_p}{130\ W} = 6.79\ \rightarrow 7$$

$$Modules\ in\ series = \frac{System\ Voltage}{U_{mpp}} = \frac{12\ V}{17.6V} = 0.68 \rightarrow 1 \tag{5.6}$$

$$\text{Module parallel=} \frac{Total\ number\ of\ modules}{Modules\ in\ series} = \frac{7}{1} = 7 \tag{5.7}$$

5.3.8 Coverage

With a number of 7 modules the covering-ratio R_c between the energy demand and the energy supply calculates to:

$$R_c = \frac{7 \cdot 130\ W_p}{883\ W_p} \cdot 100\% = 103\% \tag{5.8}$$

5.3.9 Battery bank sizing

The battery's task is to compensate for the mismatch between energy supply and energy consumption. At more northerly (or southerly) latitudes, we have to expect considerable radiation

[6] Datasheet see Annex 2

fluctuations. In more central climes this of course would not necessarily be the case. It therefore makes sense to provide a reserve of at least 2-3 days for the summer month, and of at least 3-5 days for the winter month. These reserve days will be stated as Days of autonomy (DOA). To determine an appropriate number of DOA, profound knowledge of the operation conditions at the specific place is from vital importance. Choosing the DOA to low could result in not covering the energy demand of the clinic at days with no sunshine. But on the other hand, a high number of DOA results in a bigger battery bank and thus in much higher costs for the batteries.

Needed battery capacity

The expected life time of the batteries is a decisive cost factor in the calculation of a PV system. The 1000 charging cycles with 35% discharge (DOD) for VRLA batteries can be used as guideline. This corresponds to a life expectancy of about 3 years.

The capacity of the battery can be calculated to:

$$C_n = \frac{W_n \cdot DOA}{DOD \cdot V} \quad \text{[Ah]} \qquad (V = System\ voltage) \tag{5.9}$$

$$C_n = \frac{3339 \cdot 3}{0.35 \cdot 12V} = 2385 \text{ Ah}$$

As well as the modules, the batteries have to be available in the respective region. A Valve-Regulated Lead Acid (VRLA) Battery was chosen.

Table 5.5: Battery data[7]

Capacity	125 Ah
Voltage	12 V
Depth-of-Discharge (DOD)	35 %
Battery efficiency	80 %
Selected battery type	VRLA (AGM)

$$Number\ of\ batteries\ parallel = \frac{C_n}{C} = \frac{2385}{125} = 19.08 \rightarrow 20 \tag{5.10}$$

$$Number\ of\ batteries\ in\ series = \frac{System\ Voltage}{Battery\ Voltage} = \frac{12}{12} = 1 \tag{5.11}$$

$$Total\ number\ of\ batteries = 20 \cdot 1 = 20 \tag{5.12}$$

[7] Datasheet see Annex 3

5.3.10 Recharge time of the battery

To determine the time the batteries need to recharge, the maximum power current demand of the batteries must be compared with the maximum power current supply.

The maximum power current $max.I_{mpp}$ $\left[\frac{Ah}{d}\right]$ supplied by the PV array calculates to:

$$max.I_{mpp} = I_{mpp,Module} \cdot number\ of\ modules \cdot min.hours\ STC \tag{5.13}$$

$$max.I_{mpp} = 7.39\ A \cdot 7 \cdot 3.78\frac{h}{d} = 195.5\ \frac{Ah}{d}$$

The maximum power current demand of the batteries $max.I_{batteries}$ $\left[\frac{Ah}{d}\right]$ calculates to:

$$max.I_{batteries} = \frac{daily\ consumption\ W}{system\ voltage\ V}\ \left[\frac{Ah}{d}\right] \tag{5.14}$$

$$max.I_{batteries} = \frac{2030\ \frac{Wh}{d}}{12\ V} = 169.16\ \frac{Ah}{d}$$

$$Recharge\ time = \frac{max.I_{batteries}}{max.I_{mpp}}\ [d] \tag{5.15}$$

$$Recharge\ time = \frac{169.16}{195.5} = 0.87\ days$$

This means the batteries need $0.87d \cdot 3.78\frac{h}{d} = 3.29\ hours\ of\ STC$ to recharge.

5.3.11 Charge regulator

With a system voltage of 12 V the maximum power needed calculates to:

$$Max.A = I_{mpp \cdot number\ of\ modules} \quad (5.16)$$

$$Max.A = 7{,}39A \cdot 7 = 51{,}73A$$

According to the requirements mentioned in chapter 5.2.2.3 a charge regulator with the following specifications has been chosen:

Table 5.6: Charge regulator data8

Charge Current max.	70 Ampere
Load Current max	70 Ampere
System Voltage	12 Volt / 24 Volt
Own consumption	14mA
Open circuit voltage solar module	<50 V

5.3.12 Cable cross section

For the design of the PV generator in the previous section, a voltage loss in the lines of 3% was assumed. The cable cross section can be calculated according to the following formula:

$$A = \frac{2 \cdot L \cdot I}{3\% \cdot U \cdot \kappa} \text{ [mm²]} \quad (5.17)$$

Table 5.7: Electrical parameters for the sizing of the cable cross section

A	Line cross section	[mm²]
L	Line length (positive + negative conductors)	[m]
I	Max. current transmitted in the line	[A]
-	Percentage line loss	[%]
U	System voltage	[V]
κ	Electrical conductivity (copper $\kappa_{Cu} = 56$)	[m/$\Omega \cdot mm^2$]

In the current layout plan of the clinic the greatest distance between the battery room and a load, a 12 W lamp is roughly 20 meters (one way).

The distance between the battery room and the room where the fridge will be placed is roughly 8 meters (one way). For these extreme values the cross section will be calculated.

[8] Datasheet see Annex 4

Table 5.8: Determining the line cross sections

Wiring between	Length [m] (pos.+neg. conductor)	Components	Max. current I [A]	Calculated Area [mm²]	Metric equivalent [mm²]
Generator-battery	10	PV generator	51,73	25.66	25
Battery to load controller[9]	1	Load controller	51,73	2,7	3
Battery-lamp (max. distance)[10]	40	Lamp	1	1,98	2
Battery-fridge (max. distance)	10	Fridge	5,83	2.89	4

5.3.13 Costs

The prices considered reflect the current price situation in Afghanistan. Since module prices change almost daily, the total costs of the system may change over time.

Table 5.9: Prices of the system components

Item	Quantity [pcs.]	Price/Unit [US$/pcs.]	Price [US$]
Modules	7	780	5460
Batteries	20	180	3600
Load controller	1	70	70
Mounting system	7	8	56
Cables, clips, assorted	assorted	100	100

[9] This cable is under load during both charging and discharging. The cable cross section is orientated according to the greater load. The maximum load occurs either when charging the batteries at maximum generator power, or when discharging the batteries through the consumers with the greatest permissible simultaneity factor in absence of irradiance.

[10] To prevent the system from damage, a fuse has to be installed between the load controller and the consumer. In case of a damaged consumer the open circuit power would apply on the cable.

material			
Transport	1	100	100
Installation	1	120	120
Training	1	40	40
		Total	9546 US$

A cost benefit analysis is available in Annex 10.

5.3.14 Limitations

The energy supply by a photovoltaic system is environmentally friendly and sustainable. Besides the positive economical aspects, running such a system confronts the user with several constraints and challenges. Besides the technical requirements mentioned in chapter 5.2, running a PV system needs commitment and a wise operation by the user. Regular check of the batteries is the most important issue. To keep the modules free of dirt and in winter time free of snow is as essential as a neat installation of the components. An overuse of the system, accompanied with a faster deteroriation of the batteries must be prevented. All this aspects must be brought to the people in properly organized training units. The involvement of the single communities where the BHC's are going to be placed is crucial for the success of its long-lasting operation.

5.3.15 Recommendations

As mentioned before, the calculation is a first approach to direct the decision-makers towards a modern, environmentally friendly and sustainable way of producing power for rural areas. Since the whole design of the BHC is meant to be a new model-standard, the appliance of a PV system suggests itself. Anyhow it may be reasonable to build up a hybrid system for regions where the irradiation is not sufficient to provide enough power, even in the winter. If the project comes to the implementation phase a closer and more detailed view on the design has to be done.

5.4 Rural Heating Systems

Stoves as an alternative for heating Basic Health Clinics

About 90% of the energy resources in Afghanistan come from non renewable biomass. The country suffers serious deforestation with forests today covering only 4% of its territory. Fuel wood collection is a driving factor which explains the forest loss and the use of poor heating and cooking stoves is a reason for the bad air quality in the more densely populated areas.

Passive solar architecture combined with rational local generation and use of electricity (proper sizing of generators, low consumption lamps) and the use of efficient stoves

is the best solution to attain comfortable indoor climate reducing heating needs by more than 70% and minimizing CO2 emissions. (GERES et al, 2004)The traditional domestic heating in Afghanistan include three widely spread heating methods: Tabakhana- an under floor heating system with hot air being connected through a series of subfloor channels; Sandeli- a low table covered by a large blanket and with a container of charcoal fire underneath; Stove- made of black iron (Appendix 5)

Considering the heating of a BHC, the use of stoves seems to be the most practical, uncomplicated and cheapest for the present situation alternative. However, an overview and compare must be made between the fuels and stoves available on the markets of Afghanistan and the most efficient and non-expensive choice should be made. Factors such as health impact, safety, fuel cost and availability, environmental impact, stove cost, efficiency and availability, repair and maintenance, as well as cultural acceptance are all essential for taking the best decision.

Using data collected in a study of the Cambridge University (Joseph Ashmore, 2002) (Appendix 6) on prices of fuel in Herat and Kabul and on means commonly used for cooking and heating some proposals can be made.

5.4.1 Fuel availability in Afghanistan

Wood: As already mentioned, Afghanistan suffers strong deforestation with 70 – 80% of natural forests being damaged. A large proportion of deforestation is due to the need of wood for cooking and heating, for construction and the illegal timber trade with Pakistan.

Wood that is burned is usually with high caloric value and burns slowly with relatively constant heat.

Charcoal: Charcoal is mainly used for heating and for boiling water. Where charcoal is available, structures are traditionally heated using a Sandeli– a small metal pan containing the charcoal covered by a low table and blankets

Bushes: Bushes are used for heating and cooking and are collected for free. The distance walk for collecting them gradually increases due to local over use. Over use of bushes can also lead to soil degradation and erosion problems over long term. The bushes burn very quickly with a high heat output over a short term and release a lot of smoke.

Sawdust: Sawdust is slow burning and used in Bukharis (stoves), mainly for heating. It is considered by Afghanis as relatively expensive fuel and has low availability. Sawdust burning stoves have been distributed to schools by UNICEF on safety grounds as they do not create sparks.

Kerosene: Is used for cooking and requires specialist stoves

Diesel: Diesel is used in domestic heating and is already widely available though the largest consumer appears to be in transportation.

Gas: Gas is used for cooking. It comes in gas cylinders and requires significant distribution networks to deliver and reclaim the empty canisters.

Coal: Coal is not really used in the country.

Biogas: Biogas may be used for cooking and heating. Several projects are currently running in Afghanistan rural areas.

Dung: Dung is used for heating and cooking. In rural areas where livestock still exist, dried dung mixed with straw is common. Dung is a slow burning fuel and often requires additional wood to keep it alight. In cities it is considered as a poor man’s fuel and it also can give a particular flavour to meals cooked with it. It is an environmentally sustainable if animals are present.

5.4.2 Stoves appropriate for heating BHC

There are several types of stoves available in Afghanistan, burning a diversity of fuels. These are generally fabricated in Afghanistan, Iran, China and Pakistan. There is no factory scale production of stoves in Afghanistan but mostly individual handwork. The critical issue with stoves is fuel availability, both in terms of fuel type and quantity. Constant work has been made on stove's higher efficiency and lower costs.

Some models that have been tested and improved, and could be sufficient for heating a BHC:

- Bukhari – stove donated by UNICEF
- Fuel – wood, charcoal, sawdust.
- Usage –cooking and heating.
- Cost –approximately $7USD, produced in Iran.
- Health issues - not significant fire problems. Burns from the stove metal are not reported as a significant problem.

This stove is made from 1mm metal. It is easy to fix and non-expensive to fabricate.

With small alterations significant increase of the efficiency has been obtained. These alterations include:

- Reducing internal volume by reducing height of stove by around 20 cm
- Cutting holes in the bottom to allow ventilation
- Removal of flue from top and reinsertion in side of stove

Bukhari – stove designed by AREA (Agency for Rehabilitation and Energy Awareness)
Fuel – wood, sawdust
Usage – used in residences for heating
Cost –$10 –15 USD
The stove has approximate dimensions of 650 (tall) x 550 (wide) x 85 (long) and it is efficiency improved. It has a small size and the heat rises in a fire box heats water container of about 20 litres. The stove is made from thin steel apart from galvanized water tank.

Figure 5.1: AREA Bukhari adapted from: http://www.shelterproject.org/downloads/peer1rep/stoves_06_02.pdf

The water tank could be very useful in the conditions of a BHC for sterilizing or hygienic reasons.

Bukhari – Domestic heating stoves
Fuel – diesel
Usage – used in residences for heating
$15-30 USD
These stoves are a little bit more expensive but are a good solution for use in schools and hospitals.

Figure 5.2: Domestic heating stove, Kabul 11/03/02Photo adapted from: http://www.shelterproject.org/downloads/peer1rep/stoves_06_02.pdf

5.4.3 Limitations and Constraints

The political and economic situation in Afghanistan is changing rapidly influencing strongly fuel availability and costs. The data used is from 2002 due to difficulties in finding similar but more actual studies. In the long term it is possible that newer fabrication methods and higher quality materials have become available for stove fabrication.

5.4.4 Recommendations

Regarding fuel, it is a fact that the availability of firewood is decreasing and for both safeguarding the environment for the future and maintaining fuel availability in the long term, alternative sources of fuel need to be identified.

5.5 Solar heating system

In the context of the passive design and the sustainability of the environment and the availability of fuels/wood fuel of the country, the use of collectors (solar water heating) represents a good alternative to improve the comfort level and sanitary conditions of the BHC during the cold season of the year.
Using the solar water heating system it is possible to convert the solar radiation into heat. The radiation is captured by the water circulating through the system and then this heat will feed the system that distributes the heat transfer fluid through the ground. The system is built together with the whole construction of the building.
The UFHS (under floor heating system) provides a continuing warm atmosphere inside the buildings and is especially efficient when properly insulation is considered in the building design. It is clean and space saving, avoiding any kind of heater on the surface because it is build simultaneously with the foundation of the ground. Several pipe loops conduct warm water under the solid floor, working primarily by heat radiation (supplemented by some convection), so that the rooms are evenly and uniformly warmed.
The initial investment may be expensive; nevertheless in the long run the sanitary benefits related with the thermal comfort, the good air quality and the environmental care due to the fuel switch are benefits to consider into the cost-benefit analysis.

5.5.1 Case Study

To establish a fair example of what could be done in Afghanistan, the feasibility study conducted in Iran by Keyanpour in 2000 will be described. They compared four climate regions in the country, being the city of Mashhad the one that presents the most comparable climatic condition with Faizabad, where the mean monthly total solar irradiance is 415 cal/cm2 day and 423 cal/cm2 day respectively. Both cities are in cold areas in altitudes of 985m and 1200m above mean see level. The city presents between 240 and 250 days of sunshine, and Faizabad 300. The economic evaluation done by the group considers a life cycle saving method. It represents the difference between life cycle cost of a conventional fossil fuel system and the solar plus auxiliary system. The initial investment consists of a fixed expense plus a cost directly proportional to the collector area. The collector area that they considered to cover at least 50% of heat load is 0.166 of collector area/m2 building, it would means around 50m2 of collectors for the case of the BHC in Faizabad. In the office building where the solar combined system was installed in Iran, the collector area was 200m2 and the price was USD $27,000. Using the figures of this feasibility study and roughly estimating a price for 50m2 of collectors would be possible to say that the BHC could have a solar heating system for around USD $ 7,000.

5.5.2 Design

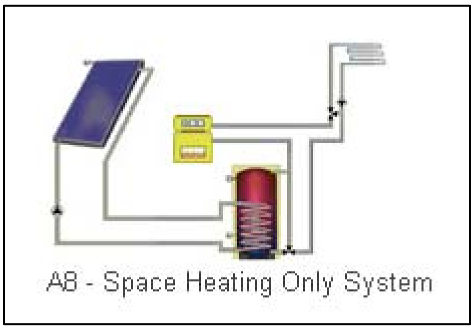


Figure 5.3: Space heating system (from: www.Valentin.de)

The design definition of the solar combined system (SCS) was extracted from the book Renewable Energy (Kaltschmitt, Streicher, Wiese; 2006), where the following parts are considered:
A collector box which holds the components required for the radiation transmission, absorption, heat conversion and insulation. It can be of aluminium, galvanized steel plate, plastic or wood. It gives the collector the mechanical firmness and makes it environmental-proof. The box should be very well isolated by polyurethane, mineral wood or fibre-glass wool.
Absorber, it converts short wave radiation into heat. This function it is carried out by a type of high absorption capacity absorber material. Inside the absorber the heat carriers (water with antifreeze or air) flow through the channels transporting the energy proportion of the solar radiation converted into heat. This system of pipes can vary in terms of material, pipe cross section, length and pipe allocation within the collector box.
Cover. The cover of the collector should be as transparent for solar radiation as possible and retain the long wave thermal reflection of the absorber. At the same time it should reduce the convective thermal losses to the environment. Usually glass sheets, synthetic plates or synthetic foils are suitable.
Pipes, on the outside of the collector box one inlet pipe for the heat charging and one outlet pipe for heat carrier discharging are installed. A flat roof is ideal because the collectors can usually be optimally adjusted and inclined when compared to the installation on pitched roofs.

The installation of the collector box could be on the roof or into the roof, the integration into the roof is preferably because it is cheaper and less visible, it also means that the collector is the rain tight surface of the roof and roof tiles can be spared; the frame within the roof can be made out of wood (just in case that the roof has the right south orientation) so it may result ideal for its implementation in the BHC. The installation should ensure that the collectors are not separated from the roof (e.g. by wind) and that the heat expansion of the collectors and pipes are not obstructed, additionally the frame should be arranged so that shading is avoided.

For the BHC the non concentrating glazed flat plate type collector would be adequate due to the high temperature level required, they can be built with one or more transparent cover sheet, in order to further reduce the convective thermal losses from the absorber to the cover, the space between the two can be evacuated, what turns the collector into a vacuum flat plate collector, due to the pressure differences the cover sheet has to be supported from inside, insulation material will avoid heat losses to the back of the collector. The piping can either be design with many parallel tubes that are connected by a distributor and a collector in the absorber or by a single bent tube covering the whole collector area, in both cases the total mass flow will be different as well as the temperature lift. The size of the collector can be between 1m2 to 16m2 the bigger ones would require a crane for the installation. For space heating flat plate collector, vacuum flat plate collector and vacuum pipe collector are the more indicated.

Collector circuit Usually several collectors are linked together; this can be either in series or in parallel or combination of the two forms, depending in the amount of total mass flow and temperature lift required. Connected in series the temperature lift will be quick and there is a high pressure loss. The pump output decreases due to the lower level of total mass flow. Collectors connected in parallel should has same flow channels in order to distribute equally the heat carrier to the distributing pipes (for charging and discharging) and thus keep the pressure loss in the connecting pipe and with keep the electricity demand of the circulation pipe at a low level. Together with the number of collectors connected in parallel, the differences in flow and thus the differences in tº rise in the collector increase, so for large collector arrays the circuits in parallel should be adjusted with control valves.

In Afghanistan the existing non-correlation between solar radiation supply and heat demand would make necessary the use of a heat store. It consists of the heat accumulation medium, a solid cover with insulation material (mineral wool, soft foam or synthetics) plus heat inlet and outlet devices. The liquid storage is the form mostly used, separately installed pressure free or tanks under pressure are used. Usually the forced circulation systems have a pressurized heat store with a heat carrier for the collector circuit plus a cold water inlet and a hot water outlet. Usually this is short term heat storage; it means it only stores heat for a number of hours. The circulation regulation is generally actively controlled by temperature difference control device which converts this difference into electronic signals, switching on the circuit pump. The heat transfer medium has some requirements like high specific heat capacity, good flow capability, no freezing or boiling at operating tº, non corrosion, non flammable and non toxic and biologically degradable. Water with antifreeze (anticorrosive turns necessary when antifreeze added); to avoid the danger freezing below 0ºC fulfils most of these characteristics. The heat transfer medium is conducted between the collector and the storage. The hydraulic flow of the circuit will determine the pressure loss to be overcome by the pump, and the mass of the heat transfer medium inherent in the pipes. A large cross-section presents reduction of the pressure loss, but making the thermal mass of the pipes bigger and so the thermal losses increases. In order to reduce these thermal losses, the pipes of the collector circuit have to be insulated; usually materials like mineral wood, polyurethane shells and foam rubber are used. So once the pipes are conducted to the heat exchanger the transfer of heat happens between one medium to another physically separated. The transfer of the heat depends on the temperature difference between two media, the area of the heat exchanger, the heat transfer medium and the flow speed on both sides of the heat exchanger. External heat exchangers are mostly design with counter current mass flow; they present the advantages of higher heat transfer output at lower tº differences and within the

storage a better layering than with internal heat exchangers can be achieved; so that they are preferably used for collector areas larger than 15m2. Usually for a ribbed exchange area 0.05 m2 are required per square meter collector, and for a bare exchange area around 0.08 m2.
In solar thermal systems with forced circulation a pump is required to operate the collector unit. Usually for the size of the BHC volume flow amounts of 30 to 50 l/h m2 are common and the pump can be directly plugged into the public grid or with a photovoltaic module of the required power, in that case they operate as direct current pumps having the corresponding solar energy supply available.

The use of this closed forced circulation system aloud the use of a solar combined system, which will support the space heating partially supplied by the sun, to integrate it is necessary to know the type and characteristics of the level of storage mass, the collector area and efficiency, the user requirements (constant room temperature or possible tº room fluctuations of several degrees) and the user goal (highest possible efficiency by large effort or good efficiency at low cost). There are different types of design systems, if the winter is not so cold the combined system may cover the whole demand, whereas in areas of colder winters the support of an extra boiler will be required to cover the demand in extreme cold days.

The under floor heating system consist of the pipe distribution and the manifolds of the different circuits. It is important to consider the correct insulation to avoid downward energy losses and to provide low thermal resistance coverage for the floor; usually a concrete slab is laid over a damp proof layer and the perimeter of external walls it is surrounded by a thick piece of insulation. The heat demand of the building will provide to the designers the basic information to elaborate the pipe distribution network; the temperature of the heat transfer fluid is directly related to the space, energy load, upward and downward losses and conductivity of the floor. The already installed system will require periodic maintenance and replacement of the central heating equipment, pump and controls, parts of the system that are easily handled, nevertheless the less joints the pipe network has, the better the durability of the system, making the loops practically maintenance free.

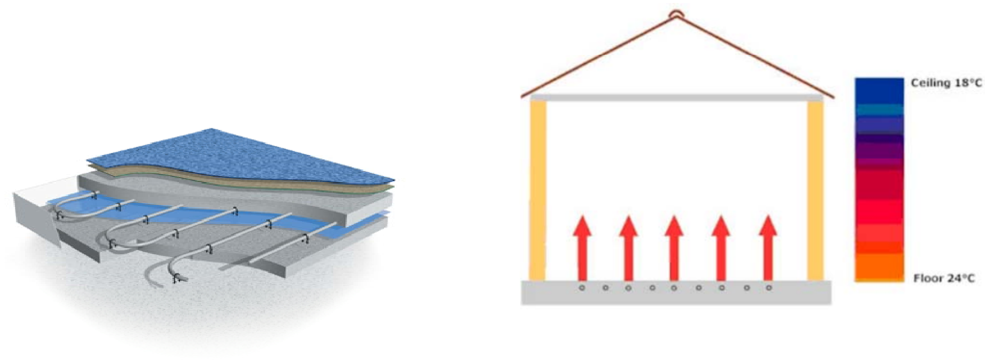


Figure 5.4: Pipe loops under the floor, Heat radiation and convection
(from: www.underfloorheating1.co.uk)

5.5.3 Costs

The high capital cost of the system usually will be seen like a big barrier, but it is strongly arguable that the life-cycle cost of the energy provided by solar systems is lower compared with the cost of the conventional fuel based systems. (Economic and Social Council 2000)

A feasibility study conducted in the region concludes that the annual savings on fossil fuels are considerable compared with the initial investment. The cost of the system would depend on the heat requirements to provide the BHC with enough energy convection, usually 50% to 70% of the budget is needed for the collectors (Keyanpour et. al, 2000).

5.5.4 Limitations

Over all in the world there are still many different barriers to face the implementation of solar heating systems; technical, financial, paucity of human resources, national policy and awareness are aspects that still need to be improved.

Technically there it is a lot to do to improve the efficiency and the economic feasibility. The solar energy still has many disadvantages, it is still perceived as an intermittent energy source, which in fact still does not cover the whole heating demand of harsh winter locations, making necessary in some areas the use of an external boiler, which makes the technology more expensive.

One of the major barriers that this technology faces is the high initial cost. Nevertheless when the life cycle cost of the solar systems it is compared with the cost of conventional fuel based system, this is lower, making the innovative financial help necessary to disseminate the use of solar systems.

The human resources still require some training and awareness, rising interest among extension work may help to spread the utilization and acceptance of the technology. The inadequate installation, operation and maintenance either individually or in combination can conduct to unsuccessfully experiences, like failures or unreachable expectations.

Considering the long term necessity of suitable energy concepts for a sustainable development of the country, the rural energy supply and energy efficiency appears like a big challenge; which enables the establishment of new alternatives. Even if these alternatives might look very difficult to reach with the present development level of the country it also represents a good opportunity to build capacities and bring stakeholders working together, to ensure a national industry development and provide better quality of life for the whole society.

5.5.5 Recommendations

Afghanistan it is not the exception in relation with the limitations above discussed. Likely the first experiences in the field, promoting the use of solar water heating, conducted by the Department of Renewable Energy of the Ministry of Energy and Water, already face these constrains. However this is the most valuable way to introduce a successful utilization of the solar resource. And hopefully it will lead to an adequate learning experience through all the country. It would be strongly advisable to consider further research and calculation for future projects owed to the important environmental and social benefits

- Decreases the pressure on the forest of the country
- Fuel switch, less CO_2 emissions and independence of fossil fuels availability
- Less indoor air pollutants
- Life cycle cheaper compared with conventional fuel based systems
- Possibility to use the BHC all year round

6 Water and Sanitation

6.1 Overview

Water is a country's most critical natural resource and key to the health and wellbeing of its people. Afghanistan has an arid climate and water resources are scarce, particularly during drought periods.

More than 2.5 million people in Afghanistan are already affected by drought or are vulnerable to the impacts of recurrent drought and water shortages. The number may increase further due to global warming and further aridization. UNEP reported that only about 31% of Afghanistan's households currently have access to safe drinking water. The rural and urban households have 26 % and 64 % of water supply respectively, based on the of minimum requirements of 20 litres per day per capita for the rural population and 50 litres per day per capita for the urban population. Access to safe sanitary facilities (improved latrines) is available to only 5-7 % of households nationwide. Bacterial contamination of water sources is widespread, increasing morbidity and mortality especially among children (half of the deaths of all children under the age of five are related to diarrhoeal disease, caused by inadequate sanitation, lack of clean drinking water and poor hygiene practices). Water resources in Afghanistan are being polluted due to indiscriminate disposal of untreated industrial and domestic effluents, and the discharge of household and street waste into streams. (UNEP, 2008)

In Badakhshan Province, on average only 13% of households use safe drinking water. About two out of three households have direct access to their main source of drinking water within their community, however 16% of the households have to travel for up to an hour to access drinking water, and for 12% travel to access drinking water can take up to 6 hours. This shows the importance of including a comprehensive water supply and sanitation plan when you plan for any project like the basic health clinic. (NABDP and MRRD, 2009)

In the context of this report, clean water will be generally referred to as water while waste water will be generally considered as the water generated from toilets and cleaning activities. This will include sewerage, anal cleansing water and hand washing water among others.

6.2 Water supply

6.2.1 Approach

In a BHC clean water is needed for drinking, hygienic and disinfection reasons. Wells are the most common source of safe water in Afghanistan and our choice in the project. Relying on background information about the fuel insecurity and the great potential of solar energy in the country, solar water pumping system was the most promising alternative to conventional technology.

6.2.2 Water Well

In a BHC clean water is needed for drinking, hygienic and disinfection reasons. Wells are the most common source of safe water in Afghanistan. The well should be located to produce the maximum sustainable yield possible as well as to protect the water source from contamination.

A proper well design includes:

- determining the depth and diameter for the best yield,
- sanitary protection
- procedures for well cleaning/development, testing, and disinfection

The site selection of the well should be based on several criteria. The location of a well should be determined by a qualified hydro geologist or experienced water well contractor or engineer based on study of the location and a test drilling. The site must not be open to contamination from latrines, washing areas, canals, ponds or other sources. Test from other nearby wells should be done to help the technical person understand the static water level, the quality of the water, and the direction of the ground water flow and the strata of existing wells. A chemical and microbiological analyses of the water will determine its characteristics and will help to predict the susceptibility of the well to encrustation or erosion, provide information on the water quality, and serve as a baseline record to detect any change in water quality or contamination. Communication with the older members of the local community may give information to the technical person about the rainfall over the past ten years as well as areas to avoid because of rocks and previous failed attempts to locate water. (Mason et al, 2005)

6.2.2.1 PV Pump

Solar pumps are powered by solar radiation energy collected using solar photovoltaic (PV) cells .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. Solar pumps generally incur a high investment cost which, however, can be offset by a long service life with minimum operation and maintenance costs over its economic life. Solar pumps are a very reliable technology and can be matched quite closely to the amount of water needed. They cannot deliver water on demand, therefore, 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 (UNEP and GEF, 2006).

Figure 6.1: Small scale solar water pumping system (from: www.mme.gov.na)

Solar pumps are well known for having the following advantages:

Require minimal attention as they are self-starting

They are “good” for boreholes as they pump over the whole day

Weak boreholes can be used effectively with a low volume pump due to pumping 8 to 10 hours a day

In most cases, a solar pump offers an ideal solution to the diesel option which requires operating funds (with uncertainty about future diesel prices), time investment for operating pump (manual starting) and logistics for fuel, maintenance, installation and de-installation

Tracking arrays can be used to increase daily water pumping rates

Solar pumps offer clean solutions with no danger of borehole contamination

Theft of solar photovoltaic panels is a problem and one needs to look at counter measures if there is a risk of theft.

6.2.3 Design

A complete solar power water pumping system consist of PV panels, support structure, switch box / controller, pumps, cables, secure wire, wire clamp as well as accessories such as pipes, flow sensor in tank and storage tank.

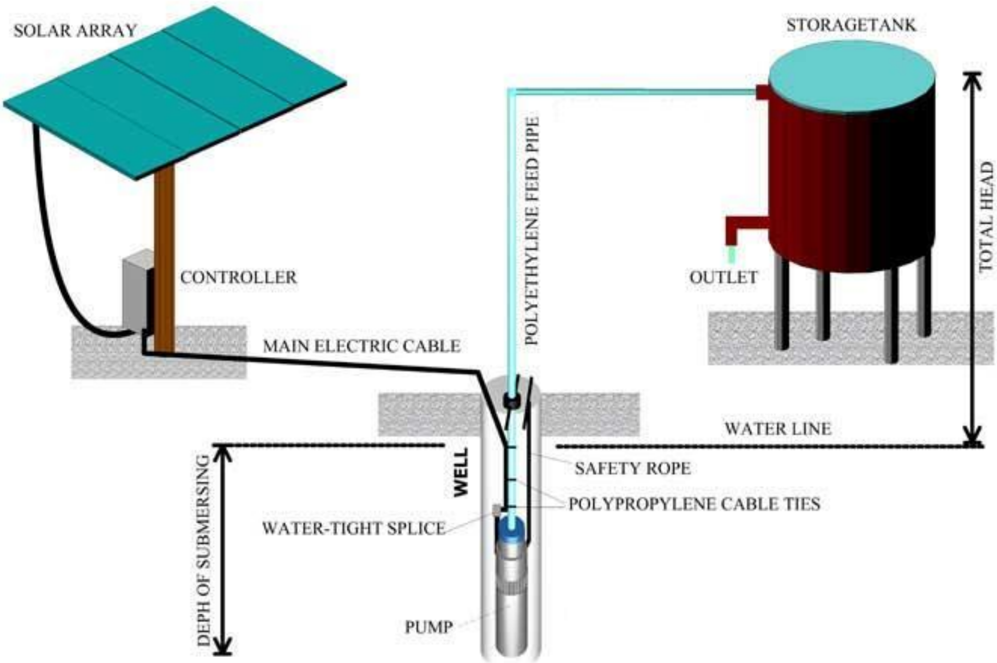


Figure 6.2: Solar water pumping system (from: www.dansksolenergi.dk)

For the right choice of pump model and storage tank volume, the water demand in a BHC should be estimated by multiplying the liters per capita per day (LCD) by the number of people visiting the BHC per day. The size of the storage tanks for PV water pumping systems should be large enough to fulfil the water demand in case of continuous cloudy days and is usually elevated

An assumption has been made of a maximum of 100 people visiting the BHC daily and a calculation of the water demand was made, choosing 20 LCD for drinking, washing, toilet flushing, etc.

Based on these assumptions:

Total water demand: 100 people X 20 l = 2 000 l (2 m3)

Storage water tank

The storage water tank can be made of steel, polyvinyl chloride (PVC), fibreglass, concrete, or steel. In general, steel, fibreglass, and PVC tanks mostly used and widely spread. The size of the storage tank is determined by the daily water demand taking into account water reserves for days with low solar radiation.

For the BHC the calculations were made as follow:

Total water demand: 100 people X 20 l = 2 000 l (2 m3)

Water reserves for about two days bad weather: 3 000 l (3 m3)

Total water tank volume: 5 000 l (5 m3)

Solar power water pumping system

Regarding water demand in the BHC the following model of a solar power water pumping system was chosen as suitable and efficient. (For design criteria and calculations see Appendix…..)

·SQF 3A-10

· IO 100

·Solar Module 7 pieces of 12V 80W, Made in India

· Wire kit will be provided.

·Solar panel stand FIXED type dully painted

6.2.4 Costs

Despite high initial costs of the solar water pumping system, a comparison between it's and diesel pumping systems all-inclusive costs including:

The initial upfront cost,

The operating costs (diesel fuel for the operating life),

maintenance costs, and

Replacement costs (diesel engine, solar submersible pump unit etc).

has shown that solar water pumps are much cheaper on a long term.

The all-inclusive cost is calculated over a twenty year period, which is the minimum life expectancy of a solar panel. The cost comparisons have shown that diesel pumps are on average two to four times more expensive over a 20 year period (with running diesel and intensive maintenance costs) than solar pumps for pumping the same average amount of water per day. (Ministry of Mines and Energy barrier removal to NAMREP, 2006)

Some specific prices in our case are:

Solar power water pumping system- Euro 3200 (see Annex 9)

Water store tank (PVC)- about Euro 500

Further calculations should be made for well-drilling and transportation of materials from Kabul.

6.2.5 Limitations and Constraints

Theft can be very costly for the PVP systems due to the main portion of the capital cost being invested in the solar PV modules. Therefore some measures should be taken to protect the device.

PVP is considered to have less redundancy, is more difficult to repair and is susceptible to lightning strike.

PVP technology requires knowledge of mechanics, electrical and electronics thus making the operator dependent on specialised service which is often not available in remote areas.

The PVP delivers less water in the morning and the afternoon when demand is at a peak.

6.2.6 Recommendations

Disinfecting the well with chlorine:

Liquid Chlorine Concentration: add 1-2 millilitres of chlorine per litre of water and drop this into the well.

6.3 Waste water management

6.3.1 Approach

In choosing the technologies, a suitable toilet design taking into consideration efficiency and acceptability has to be identified. A suitable waste water handling method is then selected considering available options, suitability, and quantity of waste water, environmental impact, costs and acceptability. Taking all these issues in to consideration, a pour flush toilet connected to a septic tank and a soak pit is recommended (Tilley, E et al).

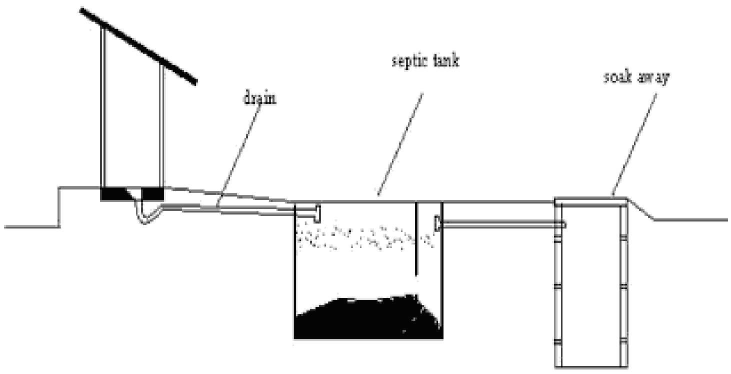


Figure 6.3: Pour flush toilet with 2-chamber septic tank and soak pit (from: Tool kit on hygiene, water and sanitation in schools website)

6.3.1.1 Pour Flush Toilet

A Pour Flush Toilet is like a regular Flush Toilet except that instead of the water coming from the cistern above, it is poured in by the user (Tilley E. et al).

Figure 6.4: Flushing a pour flush toilet (from: Tilley E. et al.)

The toilet has no problem with acceptability because it has no smell and is easy to clean hence reducing risk of spread of pathogens. It is easy to use and maintain and has low capital cost (Tilley E et al). It does not have any environmental pollution because all the waste water is collected and directed into a septic tank.

6.3.1.2 Septic tank

A septic tank is a watertight chamber made of concrete, fibreglass, PVC or plastic, for the storage and treatment of black water and grey water. Settling and anaerobic processes reduce solids and organics, but the treatment is only moderate. It has two chambers where the first chamber should be at least 50% of the total volume of the tank (Tilley E et al).When the tank has only two chambers, it is recommended that the first one should be 2/3 of the total volume.

The solids settle down in the first chamber and the liquids move to the second one and finally out through the outlet pipe. The separation between the chambers prevents solids and scum from escaping to the second chamber while T-shaped pipes reduce the amount of solids that escape with the effluent. The solids are then broken down anaerobically but since the rate of breakdown is lower than the rate of deposition, the solids have to be removed between 2-5 years but have to be checked every year to ensure proper functioning. The size depends on waste water generated and the retention time should be at least 48 hours to achieve moderate treatment. It should be connected to a drain field or a soak pit to drain off the effluent.

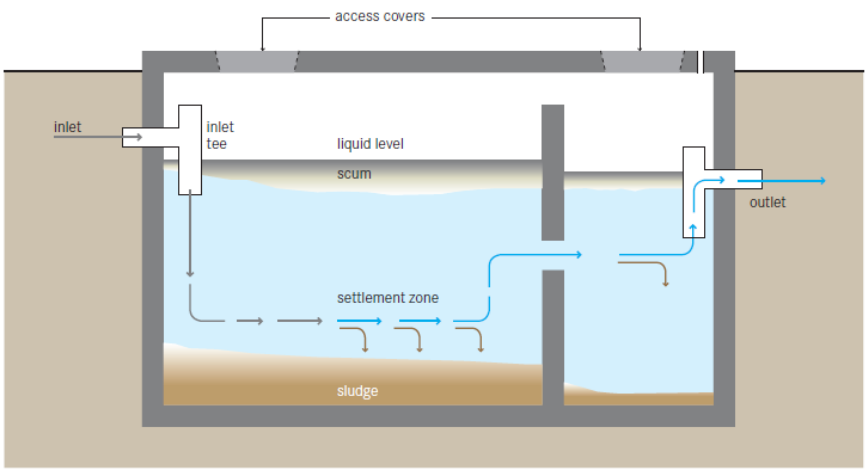


Figure 6.5: Septic tank (from:Tilley, E. et al.)

Septic tanks can be installed in any climate zone. Removal of 50% of solids and most of pathogens like E.Coli is achieved. However it should not be constructed in areas of high ground water table or near bores. They should be sited a minimum of 15 m. (Harvey P.) from the bore holes and 2 meters above water table.

6.3.1.3 Soak pit

This is an excavation in the ground which allows percolation of waste water (Tilley, E. et al.) into the surrounding soil. As the water percolates, it is purified through breakdown of the biodegradable materials which may have escaped while pathogens die off. Purity of the resulting water depends on the distance of percolation. For this reason, soak pits should be constructed at least 1 m. above impermeable soil layer. To avoid environmental and water contamination they should be sited not less than 30 meters from a bore hole, at least 1 meter above the water table in the wettest period and 3 m. from vegetation. (ENCAP)

6.3.2 Design

Design of the systems depends on the expected waste water generation which in turn depends on the water consumption. In this case, the clinics are expected to have a maximum of 100 people per day (Moeller-AFGEI). If all of them visit the toilet, they would be expected to use 1 liter of water for anal cleansing, 1 l. for hand washing and 3 l. for flushing (Tilley, E. et al.) . This means each person would generate about 5 liters of waste water. It can be further assumed that about 200 liters would be generated from general washing processes like washing equipment in the clinic sinks.

Based on these assumptions;

Total waste water generated by 100 people: 100 X 5 = 500 liters.

Add waste water from general cleaning processes: 500 + 200 = 700 liters = 0.7 M3.

This is the quantity of waste water that was used to design the whole system.

6.3.2.1 Pour flush toilet

Afghanistan being a country with water shortage and most people using water for anal cleansing, the following chart by Henze, Ujang and Soedjono recommends a pour flush toilet to be used in such an area (See chart below).

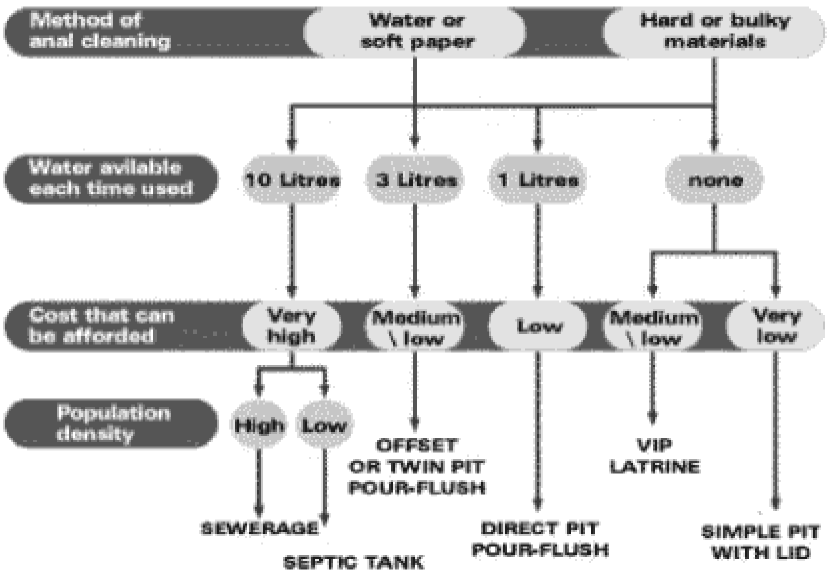


Figure 6.6: Selecting the best toilet technology (from; Henze M., Ujang Z. and Soedjono E.)

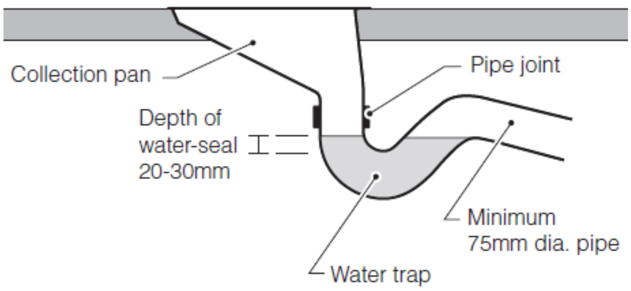


Figure 6.7: The pour flush toilet (Adapted from: Harvey P.A., Baghiri S. and Reed B.A.)

Just like a normal flush toilet, a pour flush toilet has a water seal with a slope of 20 to 30 degrees to prevent odours from coming back up the pipe. It should have a depth of 2 cm and a diameter of 7.5 cm to make flushing easy. It should be made of ceramic or plastic to avoid clogging and make cleaning easier (Harvey P.A., Baghiri S. and Reed B.A.). The toilet requires 2 to 3 liters of water per flush and is available both as squatting pan or pedestal type.

6.3.2.2 Septic Tank

The first step is to choose a suitable site that is at least 30m from the water sources and 3m from the nearest building (ENCAP). The volume of waste water is then established and the retention time in the septic tank decided. This is the length of time that effluent remains in the septic tank before moving out to the soak pit. The table below is used to establish the required retention time of the septic tank.

Daily wastewater flow	Retention time 'R' (hours)
Less than $6m^3$	24
Between 6 and $14m^3$	33 – 1.5Q
Greater than $14m^3$	12

Table 6.1: Recommended septic-tank retention times (from:Harvey P.A., Baghiri S. and Reed B.A.)

In our case, the daily waste water flow is 0.7 cubic meters. We therefore use the following formula adapted from P.A., Baghiri S. and Reed B.A:

Retention time = 33 - 1.5Q = 33-1.5 X 7 = 22.5 hours

The volume of the tank is then determined using the following formula also adapted from Harvey P.A., Baghiri S. and Reed B.A.

Total tank volume (T) = clear-liquid retention volume (A)

+ Sludge and scum volume (B) + ventilation space (V)

And A = Q x R/24

Where: A = liquid retention volume (M3) =?

Q = volume of wastewater treated per day (m3) =0.7

R = tank retention time (hours) = 24 Hours

Therefore A = 0.7 X 24/24 = 0.7 M3

B = P x N x S x F

Where: P = Number of people using the system = 100

B = sludge storage capacity in liters =?

N = the number of years between sludge emptying (we set the tank to be emptied every three years)

S = rate of sludge and scum accumulation = 25

(S = 25 liters per person per year for tanks receiving WC waste only, and 40 liters per person per year for tanks receiving WC waste and sullage. As a rule of thumb, two thirds of storage volume is for sludge and a third for scum.)

F = Sludge-digestion factor (see Table below) = 1.27

Years between desludging	Average air temperature		
	Greater than 20°C all year	Between 10°C and 20°C all year	Less than 10°C in winter
1	1.3	1.15	2.5
2	1.0	1.15	1.5
3	1.0	1.0	1.27
4	1.0	1.0	1.15
5	1.0	1.0	1.06
6 or more	1.0	1.0	1.0

Table 6.2: Sludge-digestion factors 'F' (from: Harvey P.A., Baghiri S. and Reed B.A.)

Therefore: B = 100 X 3 X 25 X 1.27 = 9525 litres = 9.525 M3.

A + B =0.7 + 9.525 = 10.225 M3

Ventilation volume (V) is the volume of air space required between the top of the liquid and the base of the cover. This should be a depth of 300 mm; hence the volume will depend on the tank dimensions.

The tank should be divided into two compartments, the first of which should be twice as long as the second. The total length should be approximately three times the width, W. The tank depth should be at least 1.2m and, ideally, 1.5m. It should not exceed three times the width.

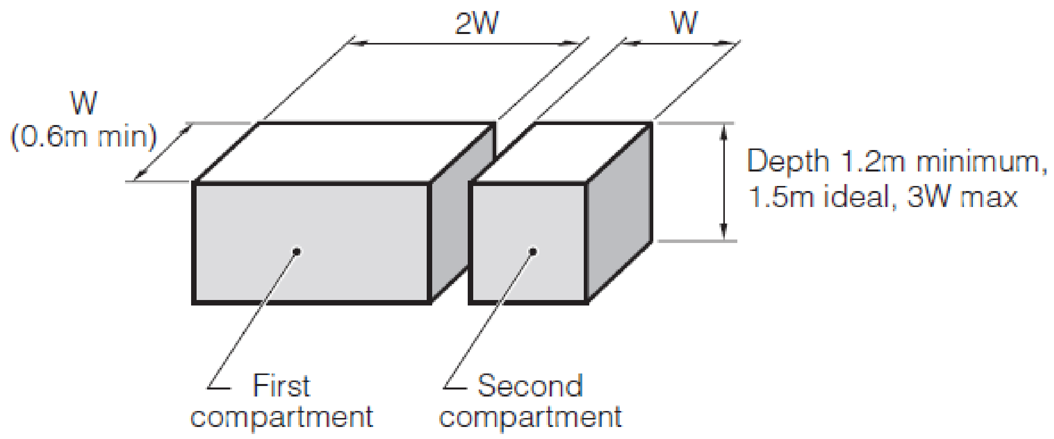


Figure 6.8: Basic tank dimensions (from: Harvey P.A., Baghiri S. and Reed B.A.)

Following the recommended W and 2W rule to calculate the required dimensions for 10.225 m3 (A+B) of waste water plus sludge and taking the tank to have the ideal depth of 1.5 M, then:

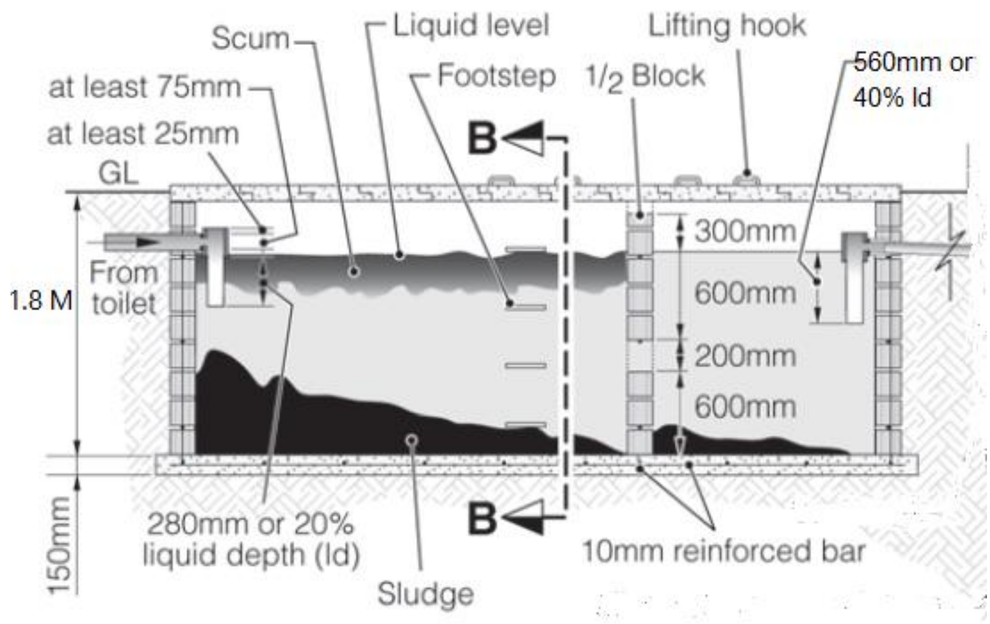
1.4 X W X 3W = 10.225 M3

Thus: W = √10.225 / 1.4 X 3 = 1.6 M.

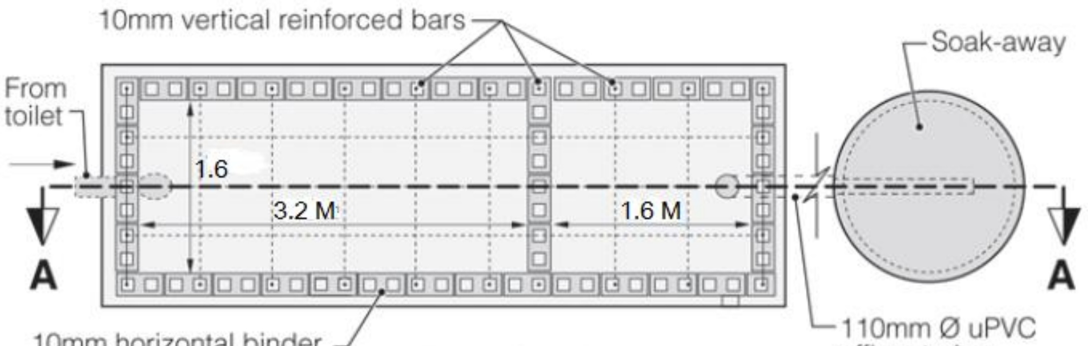
L = 1.6 x 3 = 4.8 M. Total depth of tank = 1.4 + 0.3 m = 1.7 M (ventilation volume depth)

And ventilation volume = 4.8 X 1.6 X 0.3 = 2.3 M3

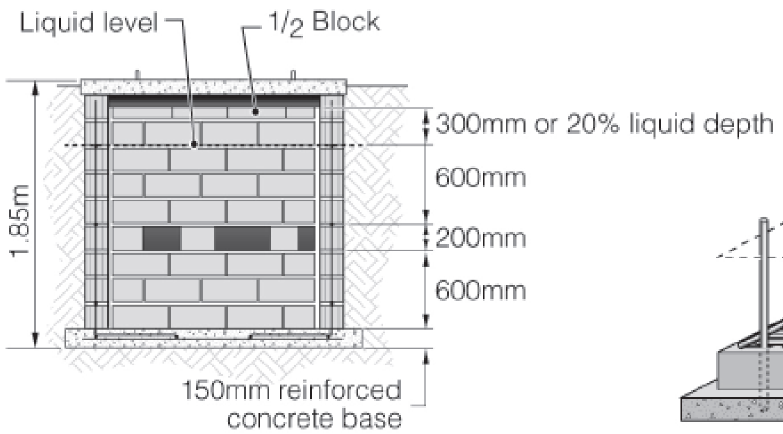
Total internal dimensions of the tank = 4.8 M X 1.6M X 1.7M = 13.056 M3



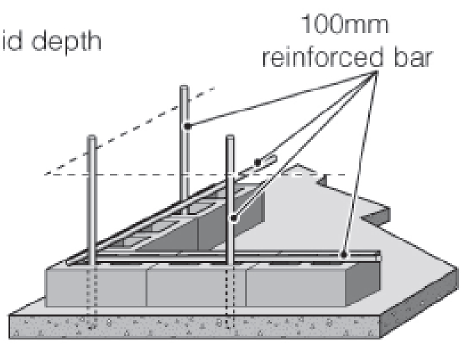
Section on A-A reinforced in unstable soil



Plan of septic-tank



Section on B-B



Reinforcement details

Figure 6.9: Septic tank drawings (Adapted from: Harvey P.A., Baghiri S. and Reed B.A .)

6.3.2.3 Soak pit

When designing a soak pit, it is assumed that the amount of effluent is equal to amount of waste water fed into the septic tank. In this case 0.7 m3 of effluent per day is taken as the basis of our design. The soil infiltration rate is then taken into consideration; bearing in mind the higher the soil infiltration rate, the faster the water can be drained in a unit time. Therefore, the soil type has to be considered or soil infiltration rate determined. The table below gives estimated soil percolation rates for different soil types. More accurate figures of soil percolation rate can be obtained by carrying out tests using the procedure outlined in Annex 12.

Type of soil	Infiltration rate ($l/m^2/day$)
Coarse / medium sand	50
Fine sand, loamy sand	33
Sandy loam, loam	25
Porous silty clay / porous silty clay loam	20
Compact silty loam, compact silty clay loam and non-expansive clay	10
Expansive clay	<10

Table 6.3: Estimated soil infiltration rates (from: Harvey P.A., Baghiri S. and Reed B.A.)

FAO in its wheat Database classifies the soils in Badakshan as mountain and alpine soils which are stony and sandy. In this case they will fall in the first category of course/medium sand in the table with 50 l/m2/day infiltration rate.

The following procedure adapted from Harvey P.A., Baghiri S. and Reed B.A. was then used to calculate the size of the soak pit.

1. Calculate the surface area of pit wall required for infiltrating the wastewater:
   Pit wall area (m^2) = daily wastewater flow (litres) ÷ soil infiltration rate (Table 4.3)
2. Choose a pit diameter.
3. Calculate the depth of pit required to dispose of all the liquids:
   Depth of pit required = pit wall area ÷ (π x pit diameter)
4. Add 0.5m (lined depth) to calculate the total pit depth needed.

In this case;

Surface area of pit wall = 700/ 50 = 14 M2

If we decide on a pit diameter of 2M, then

Depth of pit = 14M2 / ∏ X 2 = 2.3M.

Final depth = 0.5M + 2.3 = 2.8M.

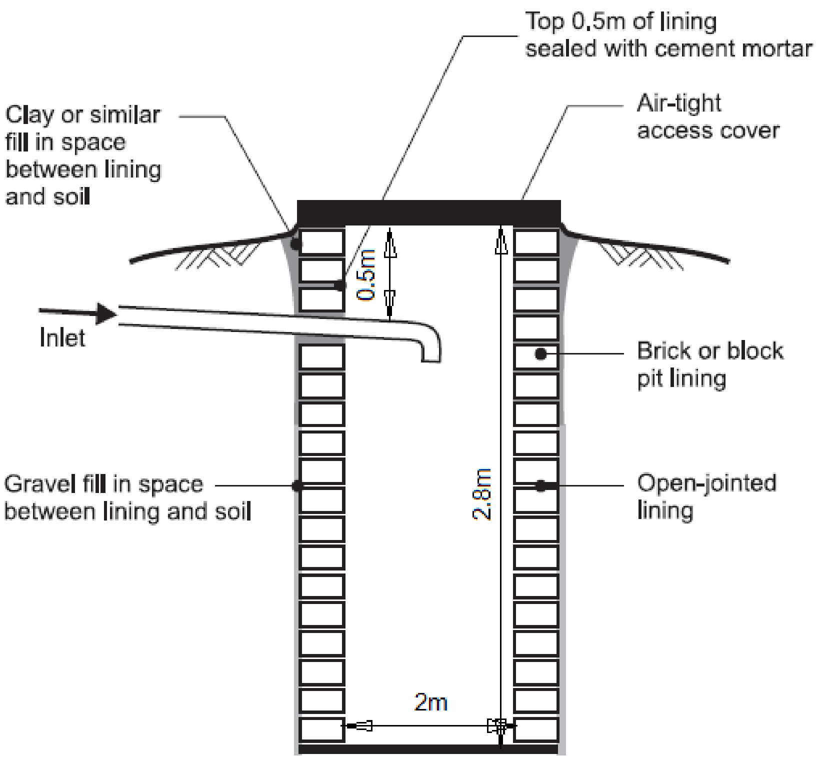


Figure 6.10: Soak pit drawing (Adapted from: Tilley, E. et al)

6.3.3 Costs

The costs of building the system were estimated using real costs of materials in Afghanistan as provided by Andre-AFGEI. The following table gives a summary of all the associated costs.

Septic tank cost estimation

No	Description	QTY	Unit	Unit price (USD)	Total price	Remarks
1	Excavation of foundation with all required activities	40	M3	5	200	
2	Stone masonry with all required activities	2.18	M3	60	130	
3	Bolder and gravel	2	M3	12	24	
4	10 mm Reinforcement bar	20	kg	5	100	
5	RCC with M20 including shattering and steel cost and all required activities	1.5	M3	50	75	
6	Supply and installation of 110 mm PVC-Tee	2	pieces	4	8	
7	Supply and installation of 110 mm PVC Pipe	10	M	4	40	
Total					581	

Soak pit cost estimation

No	Description	QTY	Unit	Unit price (USD)	Total price	Remarks
1	Excavation of pit and foundation with all required activities	30	M3	5	150	
2	Stone masonry	1.5	M3	60	87	
3	Bolder and gravel	1.5	M3	12	18	
4	10 mm Reinforcement bar	15	kg	5	75	
5	RCC with M20 including shattering and steel cost and all required activities	1	M3	50	50	
Total					380	

6.3.4 Limitations and constraints

The main constrains to be faced are during the procurement of materials. Most of the construction materials have to be bought in Kabul and ferried to Badakhshan, where the roads are in poor conditions and sometimes impassable during the winter (Andre). The septic tank also requires that there is a ready vacuum truck for disludging after the set period of three years which increases the cost and labour requirements. The pour flush toilet is easily clogged if not flushed or hard or if hard anal cleansing materials are used.

6.3.5 Recommendations

For proper functioning of the whole system, the following recommendations should be implemented.

The targeted users should be sensitised on proper usage and flushing of the toilet to avoid clogging. Hard anal cleansing materials should especially avoided

A staff member needs to be trained on caring and maintaining the whole waste water system for effective performance.

The Septic tank should be inspected at least once every year to check on the level of scum and also make sure it is properly functioning.

An ideal disposal place for the emptied sludge needs to be identified.

7. Waste management

7.1 Overview

Medical waste disposal represent a big problem in Afghanistan because of the lack of a legal framework and the absence of specifics medical waste disposal guidelines. 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). Waste disposal and inappropriate manipulation represent a threat for the population and a way to spread infectious diseases.

7.2 Approach

A waste management system is a grouping of measures and procedures to ensure that all the waste chain from the production until the final disposition is controlled and appropriate procedures are being used. The main objectives are: prevent spreading of infectious and diseases reduce the quantity of waste and reduce the risk of pollution. To ensure that a health care centre will be a safe place instead a risky place.

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 (WHO, 2005). That is why an in situ treatment is proposed.

7.3 Design

Based on the WHO waste management guide the following diagram was developed to show the steps that the program should follow.

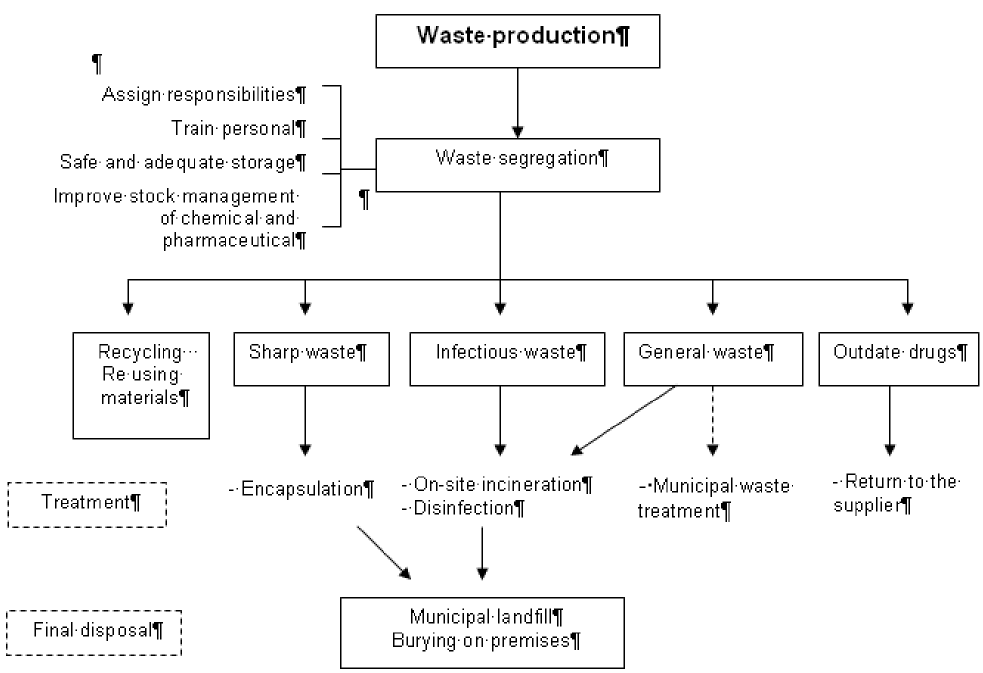


Figure 7.1: The way from waste production to disposal

7.3.1 Waste segregation

With this process the garbage is separated in:

- sharp
- infectious
- general or common
- outdate drugs
- recyclable re usable materials

This is the first step to minimize the quantity of waste to be treated and define the best solution for each category. The segregation occurs in the place and at the time that the waste is generated, that is why training is required for all people who work in the HCC. This phase must be a solid base to develop the whole program successfully.

7.3.1.1 Assign responsibilities

To have an organized work the responsibilities for each group member must be clear. The minimal personal needed is:

- One person in charge of the whole system. He should know all the procedures and control the correct going. This person should also inform the authorities about needs, improvements or problems
- One person responsible for the waste collection and storage
- One person in charge of the specific treatments (encapsulation and incineration)
- One person brings to the final disposition place

The last tree activities can be realized for one person is could be the watchman or gatekeeper.

For the segregation at the time of the generation all the stuff and people who work in the hospital are responsible.

7.3.1.2 Training personal

This is the most important part of a waste management program because all people have the right to receive information and know about the possible risk and ways to avoid them.

The training should be realized by experts from the government or by non governmental institutions. A basic trained can be done in one or two days in one school or some office where the materials are available. The training must be obligatory for all people who work in the HCC; doctors, nurses, administrative personnel, cleaning people, guards and other people who are involved. According to the WHO guide (Pruess *et al.* 199) the topics and contents of a basic training include:

- Objective.

Explain the aim of the program, why it is important and the risk that exist without appropriate measures.

- Waste and waste categories.

It must be described the type of waste (infectious, sharp and common waste) that can be generated, which can be re used, which can be recycled.

- Waste segregation

Once defined the categories explain the way to separate the waste and identified the special containers according its colours or signs.

- Safe handling and storage

Describe the times and quantity of days that the waste can be storage as well as the characteristics of the place.

- Personal protection equipment

Define all the equipment (gloves, chinstraps, protective aprons) and the importance of it use.

- Emergency responses

A procedure and measures in case of an emergency (people or organization that can help) a general instruction for everybody is needed but also a specific training according to the specific task and type of work realized. For example the person in charge of the incinerator and encapsulation must receive a special training according to need of the technologies implemented.

The training should consider all education levels using images and language appropriate and understandable for everybody.

7.3.1.3 Safe and adequate storage

Appropriate containers for each type of waste should be available as well as specific labels and spaces where should be placed. For example a container for infectious waste must be only in the delivery room or in the vaccines room.

For these specific small health clinics the WHO recommended to have three different containers.

- General waste (food, paper, plastics)
- Infectious waste (waste with human blood or other human fluids, any material used by patients, chemical or pharmaceutical resides
- Sharp waste: needles, scalpels and broken glass material.

* Thermometers and batteries contained heavy metals and should be treated together with the sharp material it must no treat together with the other waste.

Type of waste	Description	Label colour or container	Image
General	Food, paper, plastics	Black bag no label needed	
Infectious	Waste with human blood or other human fluids, any material used by patients, chemical or pharmaceutical resides	Red bag or container label needed	
Sharp	Needles, scalpels and broken glass material	Special hard container label needed	

Table 7.1: Waste type and recommended storage (Source: Quiroga; 2009)

7.3.1.4 Improve stock management of chemical and pharmaceutical

To avoid misused materials or used in the wrong way. Is better to organize the medicines according to the caducity date and used first the old ones. It will be recommended an inventory control.

7.3.2 Treatment

7.3.2.1 Reusing material

The materials that can be recycling should be stored in other place and after that it should be selling or interchange for other thinks in the near big city. In Kabul there are plastic recyclers is the transportation is available could represent a good option is not is better to put these materials with the common waste.

Re using material have to be appropriate clean and define for what is good for. The most important things are the plastic bottles and metal containers like alcohol bottles or cans because it can be used for waste containers.

7.3.2.2 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).

Justification

This is a low tech procedure, no high skill people is needed. It also promotes the re materials reusing. With this technology all the option of reuse needles is avoid and with it reduced the risk of infections.

Description

- Chose the container
- Labelled it with the international appropriate sign "Biohazard" and yellow or orange colour.(see Figure 1)
- Install in a specific and save place, where only the medical personal have access
- Lave it always closed only open to dispose new waste.
- One the container is full, fill the container with the choose material (cement or clay)
- Wait until the material dry and then deposit in other external area.

In the table some of the materials that can be treated with this technology are presented.

Sharp waste
Any item capable of piercing or puncturing skin Ampoules (opened) Broken glass Disposable sharp instruments Glass pipettes Glass slides Lancets Needles/syringes with attached needle Razor blades Scalpel blades * Brocken thermometers

Table 7.2: Sharp Waste (Quiroga, 2009)

Figure 7.2: Container for sharp waste

Limitations

Advantages: It reduces the risk of contamination, low tech, no maintenance needed, low cost

Disadvantages: New garbage (full containers) is created but it can be used for other propose because it will be a strong material

Requirements

Requirements
Containers (used oil or drinks bottles)
Labels (printed in yellow paper)
Cement
Clay
Sand
Labour force
Total

Table 7.3: Requirements

7.3.2.3 Incineration

Incineration is a process to burn solid material resulting in waste volume and weight reduction and elimination of pathogens. With the appropriate temperature and time toxics emissions can be avoid (Batterman, 2004). This technology is proposed for the treatment of infectious and general waste, but there are some materials that cannot be incinerated because the emissions are very toxic.

Type	**Example**
Risk of explosion	Pressurized gas containers
Reactive chemical waste	Special medicines
Halogenated plastics such as polyvinyl chloride (PVC)	
Waste with high mercury or cadmium content	Broken thermometers and used batteries[1]
Ampoules contains heavy metals	Any sealed ampoules

Table 7.4: Waste that cannot be incinerated (based on WHO, 2005)

[1] These type of material should be treated together with the sharp waste

Justification

There are many types of incinerator but for this specific case low tech incinerators are recommended. This type of incinerators is easy to use, no big space is needed because of its small size and many rural areas in developing countries already have positive results.

Small scale incinerators are suitable for small health centres in poor or rural areas that have limited options for waste treatment and disposal. This incinerator requires trained operators but no high skill people to use and maintained it.

Description

Single chamber incinerator

This type of incinerator treats waste in batches; loading and de-ashing operations are performed manually. The temperature cans rich 300 to 400 C and the capacity is around 100 to 200 Kg/day (even when an average of the waste produced in remote areas is 12 Kg/month), depending on the design.

The incinerator (Figure 3) is made from refractory bricks it has a chimney from at least 4 m high for a proper air flow. A small room to protect the operator from the rain and storage the garbage bags is recommended.

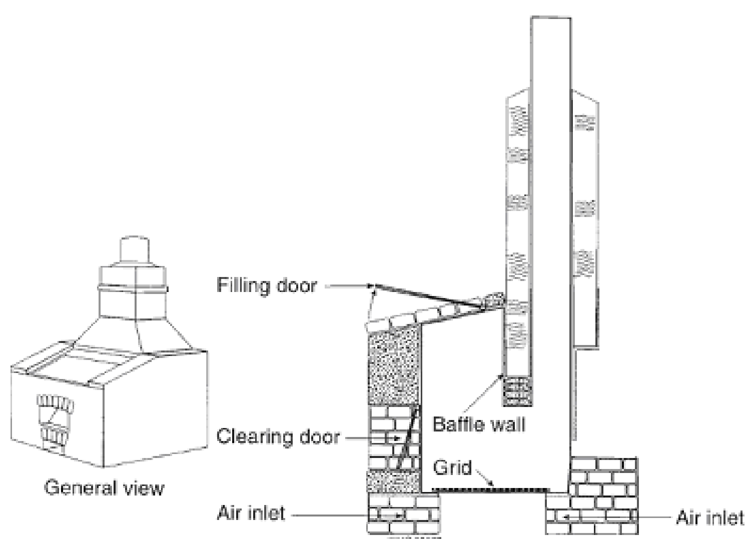


Figure 7.3: Single Chamber incinerator (Christen 1996 in Baterrman 2004)

Proper sizing is important, according to Taylor (2003) in remote areas an average of 12 Kg/month is produced and the unit should burn for periods that at least 4 hours to save fuel.

After using the incinerator must be fully heated up something around 30 minutes depending on the ambient temperature and type of fuel. After that add the waste but the flame should not extinguished during burnings. Avoid overloading. Feeding too little waste results in inadequate thermal input and is accompanied by excessive auxiliary fuel.

Location

The incinerator must not be placed to near of the clinic. Open fields in the nearly are recommended to disperse better the gases. Minimized the number of people potentially exposed that means avoid populated areas, near markets or schools.

Limitation

Advantages:

Low cost treatment that can be realized in situ avoiding the problems of transportation that are which are a limitation in remote areas. Garbage is disinfected and the volume and quantity of waste is reduced.

Disadvantages

Air pollution, some emissions are inevitable. Extra fuel is needed. Even if the maintenance is easy somebody in charge of that is needed. A trained operator is needed. One decisive factor to avoid toxic emissions is the temperature control.

Requirements and costs

To have an overview of the requirements, quantity of material, a small incinerator has been design and sized.

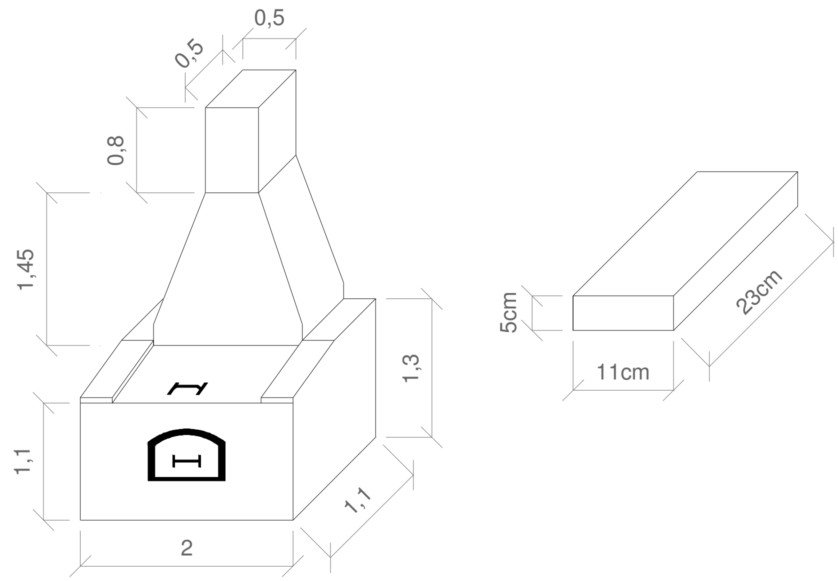


Figure 7.4: Single Chamber incinerator, Brick size.

Requirements	Quantity
Refractory bricks	860 units
Chimney and metal door	7 m^2
Cement	2 bags
Grid	2 m^2
Labour force	

Table 7.5: Costs

To have in detail drawings and the appropriate sizing the provider industry should be contacted. There are some incinerators that are pre made that can be ensemble in the country. The costs vary but according to the WHO a small incinerator costs between 1500 US$ and 2000 US$.

7.3.2.4 Return to the supplier

All the expired medicines and vaccines must being return to the supplier because they will give an appropriate treatment and additional waste in the HCC is avoided.

7.4 Costs

The cost benefit analysis of the system is complex because it is difficult to give a price to many benefits. In the table below a small detail is given

<table>
<tr><td>Benefits</td><td colspan="2">The treatment of waste, which minimises impacts on human health, urban environment.

Reduce the use of material

Promotes the re use of materials

Reduce risk of new diseases

Makes people aware of the problem and create people who can spread its knowledge</td></tr>
<tr><td>Costs</td><td>Labour force

Training

Equipment
- plastic bags
- containers
- incinerator
Fuel

Maintenance</td><td>To have the total costs it is recommended to divide the total costs of waste per kg of waste. According to Taylor (2003) operational costs have been estimated in the range from 1.8 UD$ to 8.8 US$ per kg of waste.</td></tr>
</table>

Table 7.6: Costs and benefits of the system

7.5 Limitations

To have a waste management program the most important point is to have the compromise of all the people involved: policy makers, government, citizens, health personal. To understand how important is an appropriate waste treatment to avoid future diseases or epidemics. When people are compromised then the whole plan will work even if it is a small one. The only way to achieve that is giving people information and trained them into the problematic and the risks.

One the program is developed and working the maintenance not only of the equipment is necessary but also the improvement of the system. People who are already trained can learn more and being the ones who can train other new people, children and Jung peoples. And in the health centre investments in new technology can be done because there will be people who can worked with that and use it correctly.

One more time of the whole system, what it is most relevant and difficult to achieve, compromised of the people.

7.6 Recommendations

This small plan have been developed for small scale health clinics but even in this small centres better machinery can be used.

- Have a special budget for the program to pay the operators, maintained the equipment and make it sustainable.

- No exclusion, everybody have the right to receive information and became part of the system.
- Popular opinion, public participation is one of the most important steps. First present the plan, listen opinions, observation and further needs and improve the plan. This is only one basic proposal, according to other necessities, the plan should be improve or in some cases change.
- The construction of an incinerator should be supervise by a certified engineer and the supervision from the ministry of health is needed
- It will be better to test how the incinerator works in one place to allow any mayor problem in the early initial phase before continuing construction on larger scale.

8 Social Aspects

The social aspects of a project are one of the most important to be understood by the project members and extremely essential for obtaining successful results. It is as well important to reach the community in an orderly manner as to ensure that the projects will be sustainable. There is often the misunderstanding by civil servants and donors of the importance to spend time with the community to get the right rapport.

The community needs to have a full understanding for the operation and maintenance aspects of a project and to accept it. Good contacts and written agreements, as well as regular meetings with community members can assure all this aspects.

Some objectives of the social aspects are:

- Empowerment, social organisation and participation of the community
- Good contacts with the community and know how to do this in a manner that the outsiders respect the community members and their traditions
- Respect for and learning from the experience, skills and wisdom of village communities
- An ability to evaluate the degree of community participation in project implementation
- An understanding of the importance of community participation, and training in system operation and maintenance
- Clear idea of the village level political and social structure

For the sustainability of the project it is very important to involve the user group in all stages of the project. The project members should have meetings with the community from time to time to explain the project progress and importance of the project. They should prove to the community they are working for their benefit and as if they are members of the community.

During their work on the BHC, project members should reinforce the basic health education messages when addressing the community and make the community understand why the surroundings of the BHC /well /toilets have to be kept clean at all times.

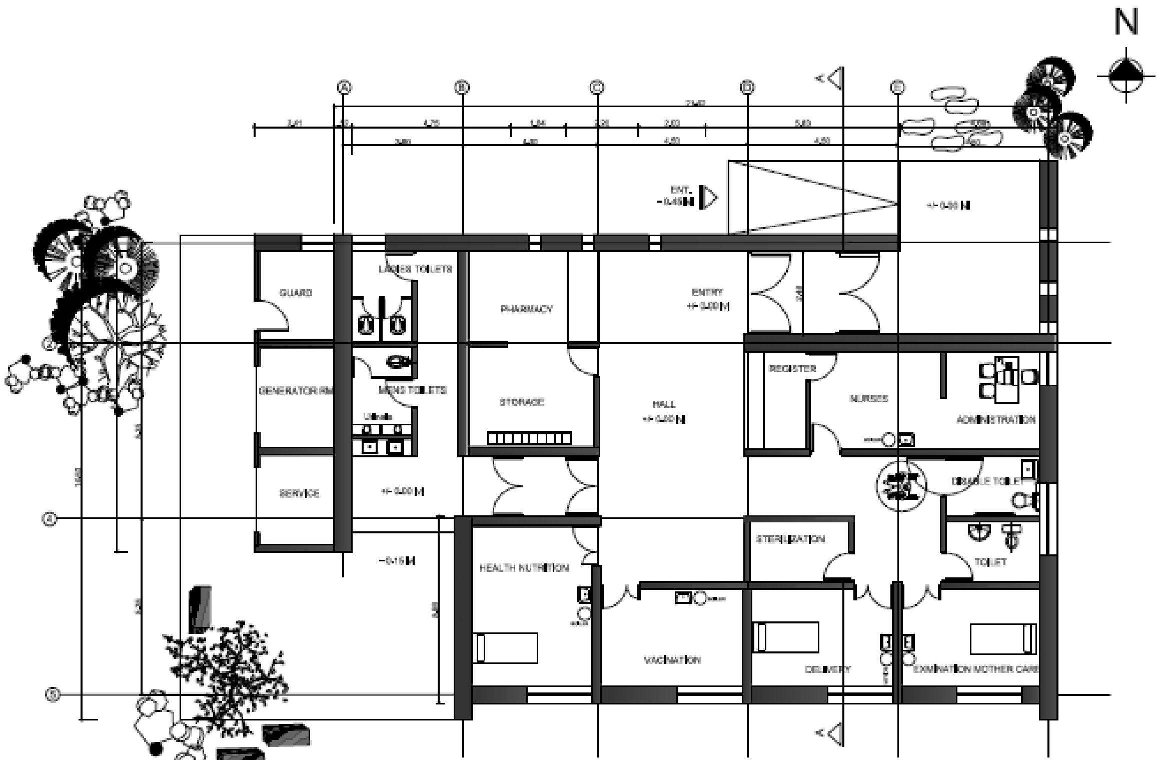
9 Conclusion

The aim of the semester project module is to place students with different cultural, professional, ethnic and religious background together to solve a common problem. During the long process of research, discussions and debates not only have we learned to work as a team, but also to express our own opinion for the reach of a common aim- to find the best possible solution and to make a change.

Working in a project is a big challenge and a piece of precious experience- especially in our case, where it was not just theoretical exercise, but a real, existing situation with a need for urgent action.

During these several months each of us has learned to search and find, to help and accept help, to defend a position and make a compromise. But above all these we have discovered the strength of being a group, we have learned the story of Afghanistan and we have realized that actually together we can do it- we can make a step toward a better world.

Annex 1: Ground floor plan



GROUND FLOOR PLAN

PROPOSED GROUNG FLOOR PLAN

BIOCLIMATIC BASIC HEALTH CLINIC

Afghanistan Badakhshan province

Semester Project 2009

DATE: 21.09.2009 SCALE : 1:200

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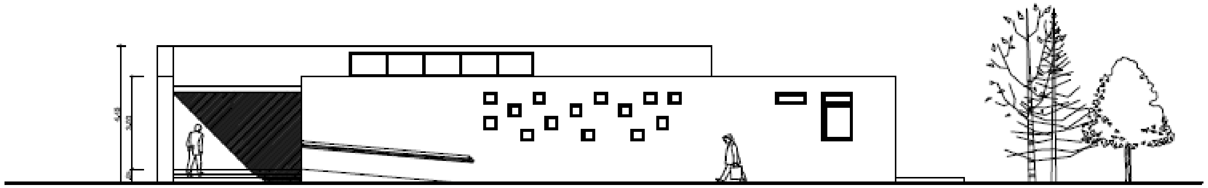
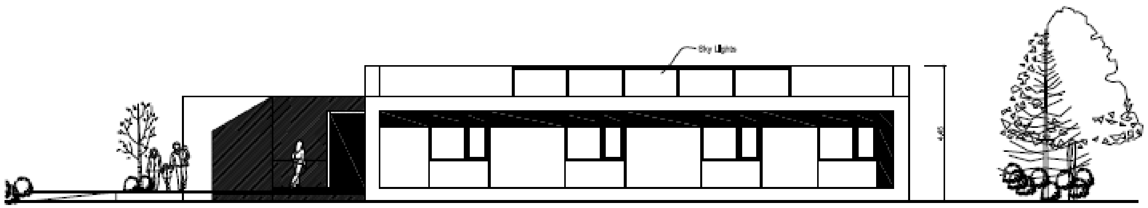
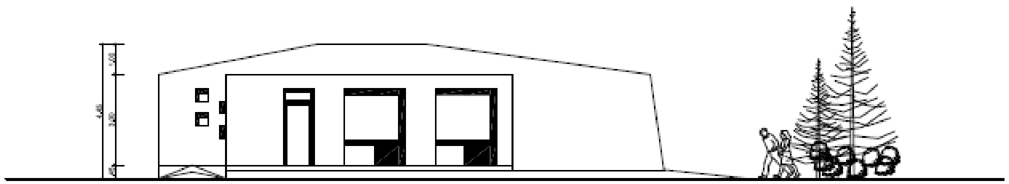
Annex 2: Elevations



North Elevation



South Elevation



West Elevation

FACADES

BIOCLIMATIC BASIC HEALTH CLINIC

Afghanistan Badakhshan province

Semester Project 2009

DATE: 21.09.2009 SCALE : 1:200

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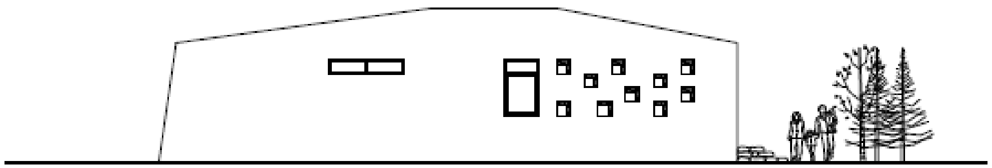
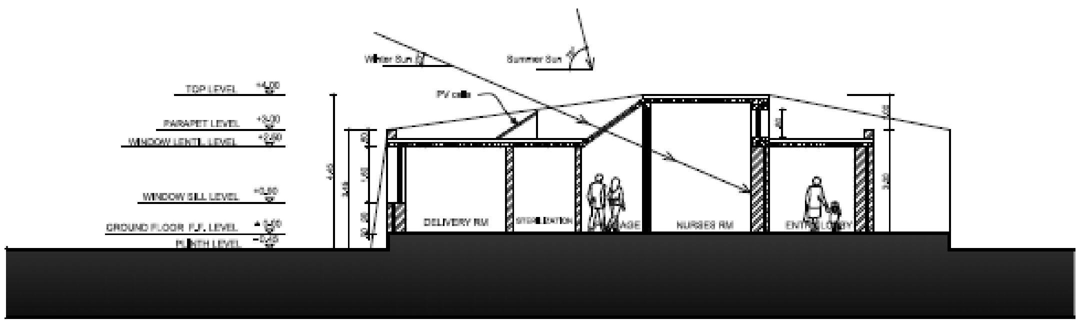
Annex 3 Section and elevation



East Elevation



Section AT A-A

FACADE AND SECTION

BIOCLIMATIC BASIC HEALTH CLINIC

Afghanistan Badakhshan province

Semester Project 2009

DATE: 21.09.2009 SCALE : 1:200

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Annex 4 Data sheet fridge

Tecnical Data

Steca PF166		
System voltage	12 V	24 V
Energy efficiency class	A++	
Cooling method	compressor	
Energy optimized speed control	yes	
Full digital and electronic control system	yes	
Configurable	yes	
Usable cooling volume	166 liters | 5,9 ft³	
Input voltage range	10 V to 17 V	17 V to 31.5 V
Deep discharge protection	10.4 V	22.8 V
Automatic switch-on threshold	11.7 V	24.2 V
Maximum power consumption	40 - 100 W	
Recommended fuses	15 A	7.5 A
Refrigerator or freezer function	adjustable	
Adjustable internal temperature	yes	
Refrigerator temperature range	2 °C | 35.6 °F – 12 °C | 53.6 °F	
Freezer temperature range	-20 °C | -4 °F – -10 °C | 14 °F	
Ambient temperature range	10 °C | 50 °F – 43 °C | 109 °F	
Display	digital temperature display in lid	
Hanging baskets	2	
Freezer trays	3	
Lock	yes	
Cold battery	1	
Celsius/Fahrenheit temperature display	adjustable	
Display brightness	adjustable	
Automatic energy-saving mode	yes	
WHO Certificate	no	
External dimensions H x W x D	91.7 x 87.2 x 70.9 cm 36.1 x 34.33 x 27.91 inches	
Weight	61 kg | 134 lbs	

Average Freezer Consumption in Wh/day					
Ambient temperature	20 °C / 68 °F	25 °C / 77 °F	30 °C / 86 °F	35 °C / 95 °F	40 °C / 104 °F
Internal temperature -10 °C / 14 °F	200 Wh/day	300 Wh/day	410 Wh/day	570 Wh/day	770 Wh/day
Internal temperature -20 °C / -4 °F	410 Wh/day	570 Wh/day	770 Wh/day	1000 Wh/day	1400 Wh/day

Average Fridge Consumption in Wh/day					
Ambient temperature	20 °C / 68 °F	25 °C / 77 °F	30 °C / 86 °F	35 °C / 95 °F	40 °C / 104 °F
Internal temperature 10 °C / 50 °F	30 Wh/day	57 Wh/day	93 Wh/day	140 Wh/day	208 Wh/day
Internal temperature 3 °C / 37,4 °F	70 Wh/day	110 Wh/day	165 Wh/day	240 Wh/day	340 Wh/day

Annex 5 Data sheet PV modules

SPECIFICATIONS

■ Electrical Specifications

MODEL	KC130TM
Maximum Power	130Watts
Tolerance	+10% / -5%
Maximum Power Voltage	17.6Volts
Maximum Power Current	7.39Amps
Open Circuit Voltage	21.9Volts
Short-Circuit Current	8.02Amps
Length	1425mm (56.1in.)
Width	652mm (25.7in.)
Depth	58mm (2.3in.)
Weight	11.9kg (26.8lbs.)

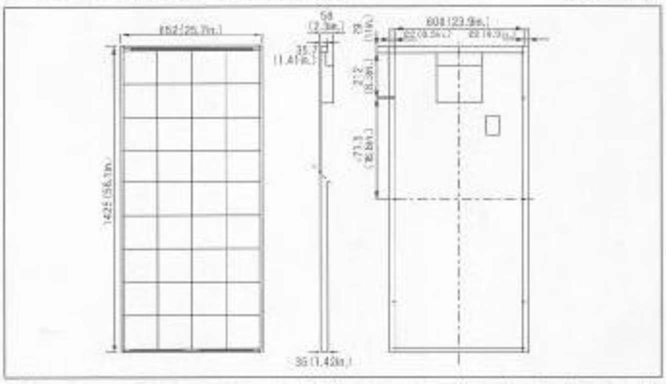
■ Thermal parameters

Nominal Operating Cell Temperature	47°C
Isc Current temperature coefficient	(3.18×10^{-3}) A/°C
Voc Voltage temperature coefficient	(-8.21×10^{-2}) V/°C

Note: The electrical specifications are under test conditions of Irradiance of $1kw/m^2$, Spectrum of 1.5 air mass and cell temperature of 25°C

■ Physical Specifications

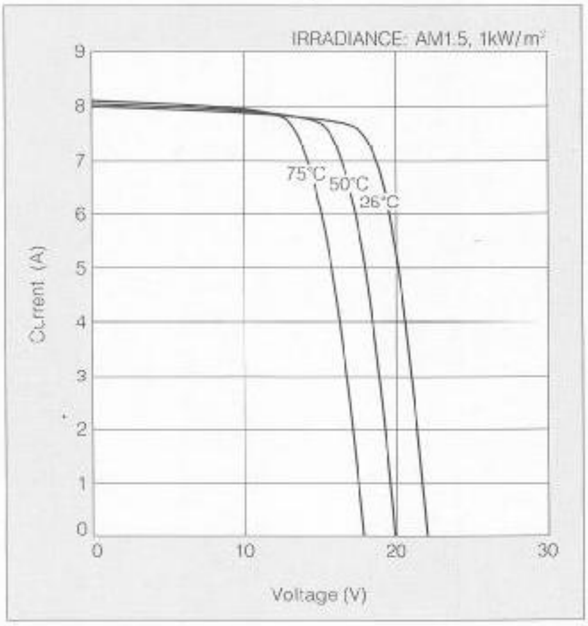
(Unit: mm)



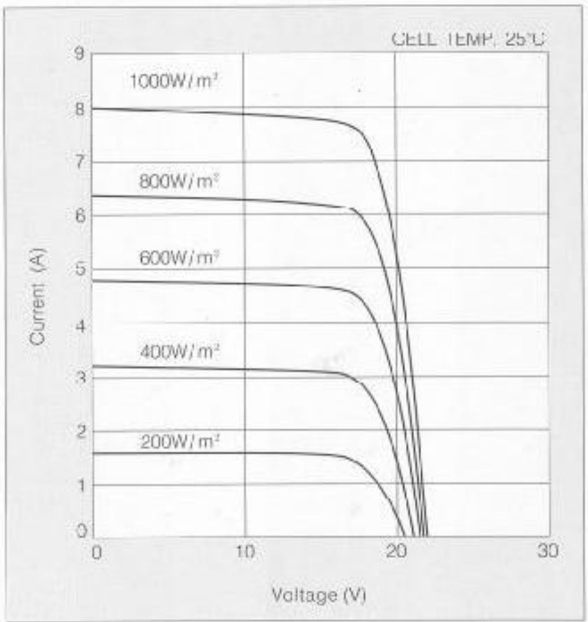
※(Long term output warranty shall guarantee that loss of output is not more than 10% of the minimum warranty value of the product specifications within 12 years and is not more than 20% within 25 years after the purchase of the product by customer. The output values shall be those measured under Kyocera standard

ELECTRICAL CHARACTERISTICS

Current-Voltage characteristics of Photovoltaic Module KC130TM at various cell temperatures



Current-Voltage characteristics of Photovoltaic Module KC130TM at various irradiance levels



Annex 6 Data sheet load controller

		2070	2140	4055	4110	4140
	Characterisation of the operating performance					
	System voltage	12 V (24 V)		48 V		
	Own consumption	14 mA				
	DC input side					
	Open circuit voltage solar module	< 47 V		< 82 V		
	Module current	70 A	140 A	55 A	110 A	140 A
	DC output side					
	Load current	70 A	70 A	55 A	55 A	70 A
programmable	End of charge voltage	13.7 V (27.4 V)		54.8 V		
programmable	Boost charge voltage	14.4 V (28.8 V)		57.6 V		
programmable	Equalisation charge	14.7 V (29.4 V)		58.8 V		
programmable	Reconnection voltage (SOC / LVR)	> 50 % / 12.6 V (25.2 V)		> 50 % / 50.4 V		
programmable	Deep discharge protection (SOC / LVD)	< 30 % / 11.1 V (22.2 V)		< 30 % / 44.4 V		
	Operating conditions					
	Ambient temperature	-10 °C … +60 °C				
	Fitting and construction					
	Terminal (fine / single wire)	50 mm² / 70 mm² - AWG 1 / 00				
	Degree of protection	IP 65				
	Dimensions (X x Y x Z)	330 x 330 x 157 mm	360 x 330 x 157 mm	330 x 330 x 157 mm	360 x 330 x 157 mm	
	Weight	10 kg				

Technical data at 25 °C / 77 °F

Annex 7: Fuel price and availability

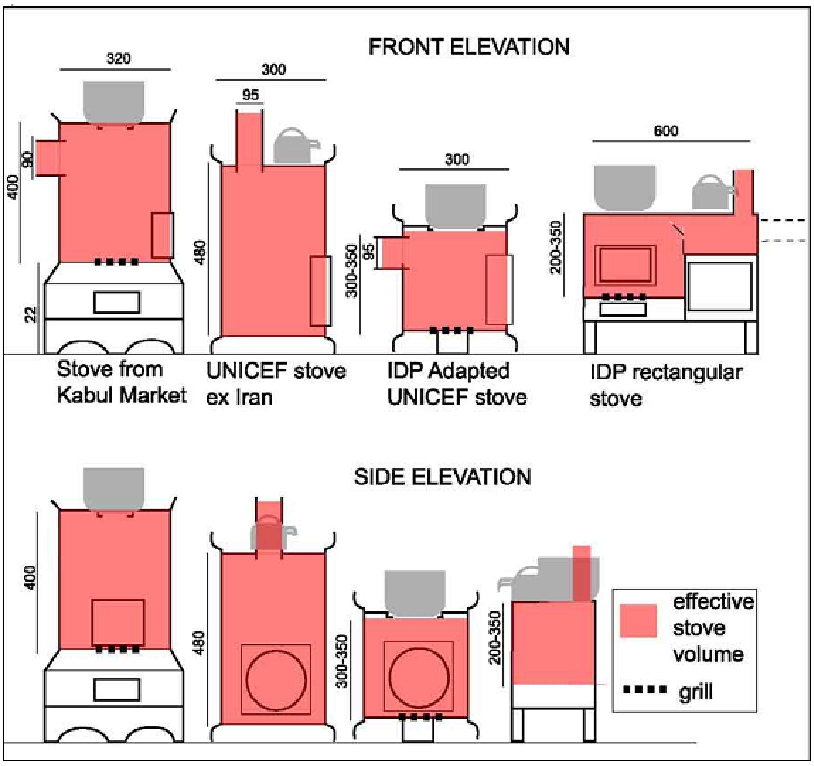
from:http://www.shelterproject.org/downloads/peer1rep/stoves_06_02.pdf)

Prices of Fuels in Kabul /2002/

	Price / kg					
Fuel	**af/kg**	**USD/kg**	**Usage**	**source**	**short term avail**	**long term avail**
Wood	1,800	0.05	Heating/ cooking			non-sustainable
Charcoal	3,000-3,400	0.1	Heating/ cooking		Good	non-sustainable
Sawdust	3,700		Heating/ cooking			non-sustainable
Bushes	-	-	-		Low	non-sustainable
Diesel	8,000	0.21	Heating/ cooking			
kerosene	10,000	0.27			Low	
Gas			cooking		OK	
electricity	NA	NA			Low	
Dung					Low in city	

Prices quoted with dollar exchange rate of 1USD = 37 000 Afghanis

Stove models compared to each other.



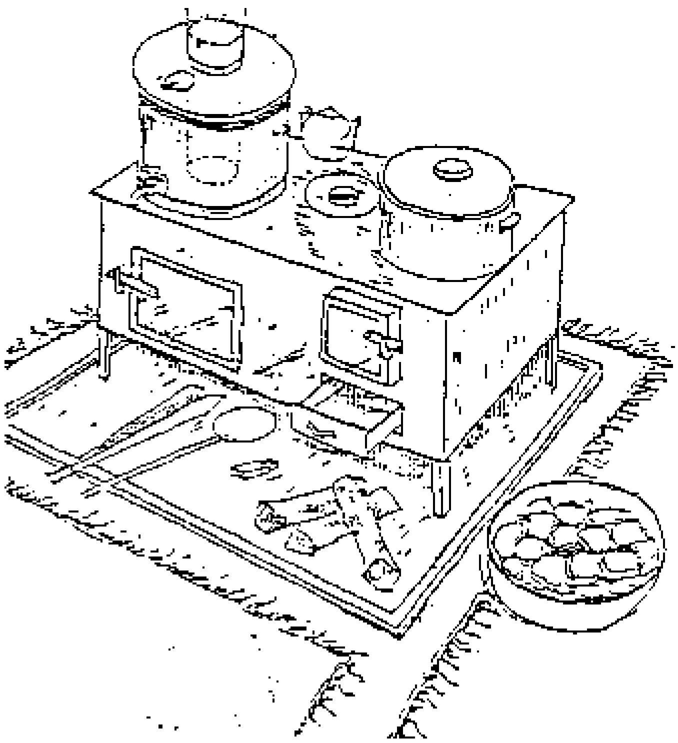
Annex 8 Traditional Domestic Heating in Afghanistan

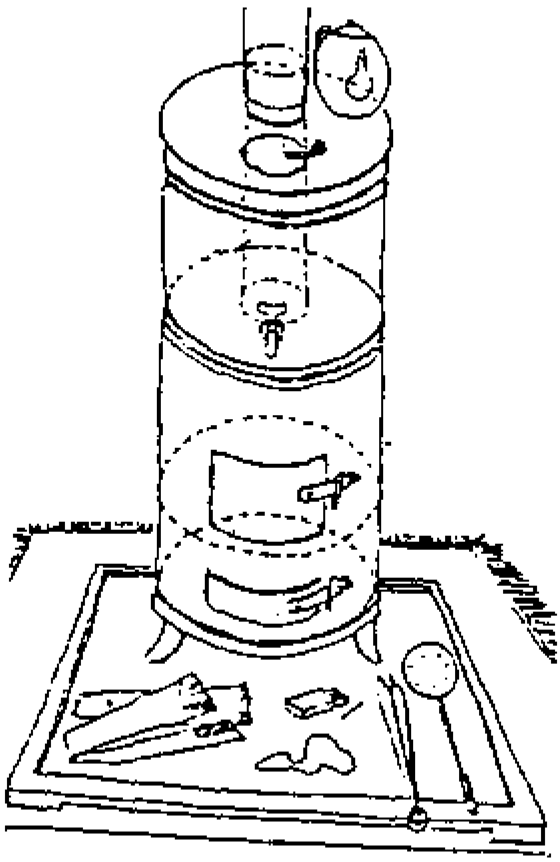
Tabakhan: In this heating system the mostly used living room is heated by the adjacent - cooking room. A cooking fire is built in the Tanur which is a conical shaped oven placed in a hole in the floor of the cooking - area. The hot air of the Tanur is channelled out through a comples of stone and mud trenches that wind their way under the floor of the living room. The underfloor trenches usually cover the whole living room and hot air finds its way out through the opposite wall. The fuel in the Tamur is usually covered with a fine ash to dissipate a uniform heat to the subfloor heating channel. A metallic or sometimes a flat stone is laid on top of the Tanur to force the heat to the channels of the neighbouring rooms.

Sandali: It is a low table placed in the middle or in a corner of the room and covered with a large square quilt or blanket. Soft and puffy cotton mattresses surround the table and rolled beds bundled together are put on the four sides of Sandali for leaning on. A charcoal brazier filled with hot coal and covered with a bed of ashes (Mangal) is placed under the Sandali to heat it up gradually. Once the Sandali is prepared, everyone gathers around and pulls the large quilt over their bodies to entrap the rising heat with only their shoulders, arms and heads uncovered.

Photo adapted from: http://www.shelterproject.org/downloads/peer1rep/stoves_06_02.pdf

Iron Stove: It is made in different sizes from a tiny little foot warmer to big furnaces that warm many rooms. Construction materials of the stove include: Black Barrel Iron, Cast Iron and Sheet Metal. It generally sits on relatively high legs and is placed on a stove board of thin wood covered usually by a sheet metal to protect the wood from burning. The stove usually has two compartments, one for fire and the other for collection of ash, but some stoves have also a small storage space for drying wood and a container for boiling water. Cooking is also, in many cases, done on top of the stove and many stoves have two to three cooking tops. The fuel for the stove is coal, wood and, in some cases, sawdust. (Abdul Shukoor Raji, 1987)





Adapted from: http://www.hedon.info/BP13:TraditionalDomesticHeatingInAfghanistan

Annex 9: Data Sheet submersible pump

95027336 SQF 3A-10 50 Hz

Input - summary

Water volume (max): 2 m³/day
Peak month: July
Head: 60 m
Sun tracking: No (fixed)
Solar data location: Faizabad, Afghanistan (37,0N, 70,0E)
Data source: NASA

Products

Pump: SQF 3A-10, 1 x 95027336
Solar module: GF 80, 7 x 96616391
Wire kit, array to control box: 1 x 91126024
Switch box / control unit: IO 100, 1 x 96475073

Sizing results - summary

Typical performance at solar radiation 800 W/m²

Flow: 0.2 m³/h
Friction loss: 0.1 m
Total head: 60.1 m
Total cable loss: 1.3 %

Water production, Peak flow and Price

Total water production per year: 886 m3
Avg. water production per day: 2.4 m³/day
Average water production per watt per day: 4.33 l/Wp/day
Peak flow: 0.57 m³/h
System price: On request

Cables and pipes:

Pump cable (pump - solar array)
Length: 60 m
Size: 1.5 mm²
Pipe Length: 60 m
Pipe diameter:

Solar module configuration:

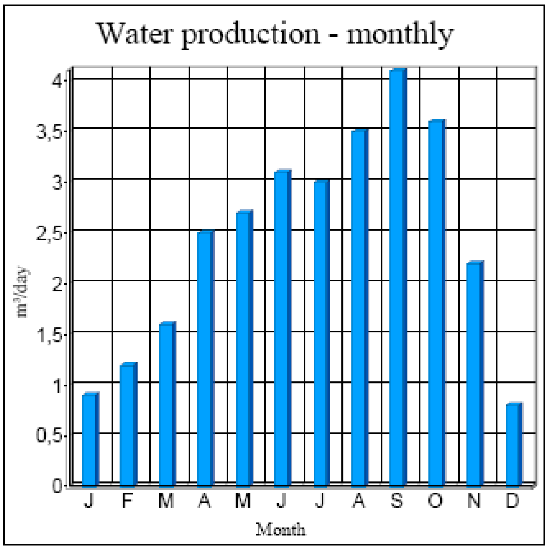
Number of solar modules in series: 7, in parallel: 1
Solar array rated power: 0.56 kWp
Solar array rated volts: 233.1 V
Sun tracking: No (fixed)

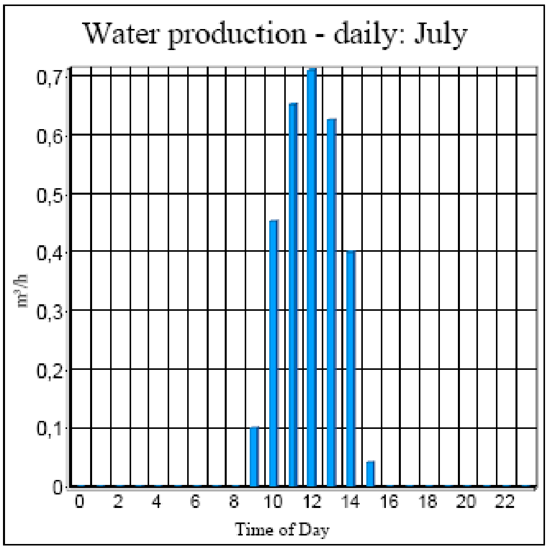
System performance - monthly average

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Water production [m³/day]	1	1	2	3	3	3	3	4	4	4	2	1
Energy production [kWh/day]	2.4	2.6	2.9	3.4	3.5	3.7	3.6	3.8	3.9	3.6	3.0	2.3
Radiation horizontal [kWh/m² day]	2.4	3.1	4.1	5.6	6.9	8.1	8.0	7.3	6.2	4.5	3.0	2.2
Radiation tilt [kWh/m² day]	3.9	4.5	5.1	6.3	7.0	7.7	7.8	7.8	7.7	6.6	5.0	3.7
Tilt angle [deg.]	37	37	37	37	37	37	37	37	37	37	37	37
Avg. Temp. [°C]	-8.7	-7	-1.4	4.5	11.5	19.3	23.1	21.4	15.7	7.8	0.9	-5.7
Temp. Variation [K]	6.6	7.2	6.8	7.8	10.5	12.8	13.7	13.7	13.0	10.0	7.3	6.2

AC power (backup) - water production

Required minimum output effect: 1.4 kW
AC 115 V: Produces: 2.11 m³/h
AC 230 V: Produces: 3.26 m³/h





95027336 SQF 3A-10 50 Hz

Installation figures

Location

Solar data
Location: Faizabad, Afghanistan (37,0N, 70,0E)
Data source: NASA

Pump
Pump type: SQF 3A-10
Pump diameter: 102 mm
Pump material: Stainless steel (1.4301 / AISI 304)

Well and pipes
Head (Height between (lowered) water level in well and water level in tank/reservoir): 60 m
Required borehole capacity (peak flow): 0.57 m³/h
Pipe diameter: DN32(25.4)
Pipe length total: 60 m

Cables
Pump cable (pump - solar array)
Length: 60 m
Size: 1.5 mm²
Cable loss max: 2 %

Solar modules
Solar module: GF 80, 80 W, Crystalline
Number of solar modules in series: 7, in parallel: 1
Solar array rated power: 0.56 kWp
Solar array rated volts: 233.1 V
Sun tracking: No (fixed)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tilt angle [deg.]	37	37	37	37	37	37	37	37	37	37	37	37

Solar array - basic orientation (azimuth): 0 deg.
(0° = south, 90° = west, 180° = north, 270° = east)
Reflection (surface): 0.20% (Grass dry)

Accessories
Switch box / control unit: IO 100

AC power (backup) - water production
Required minimum output effect: 1.4 kW
AC 115 V: Produces: 2.11 m³/h
AC 230 V: Produces: 3.26 m³/h

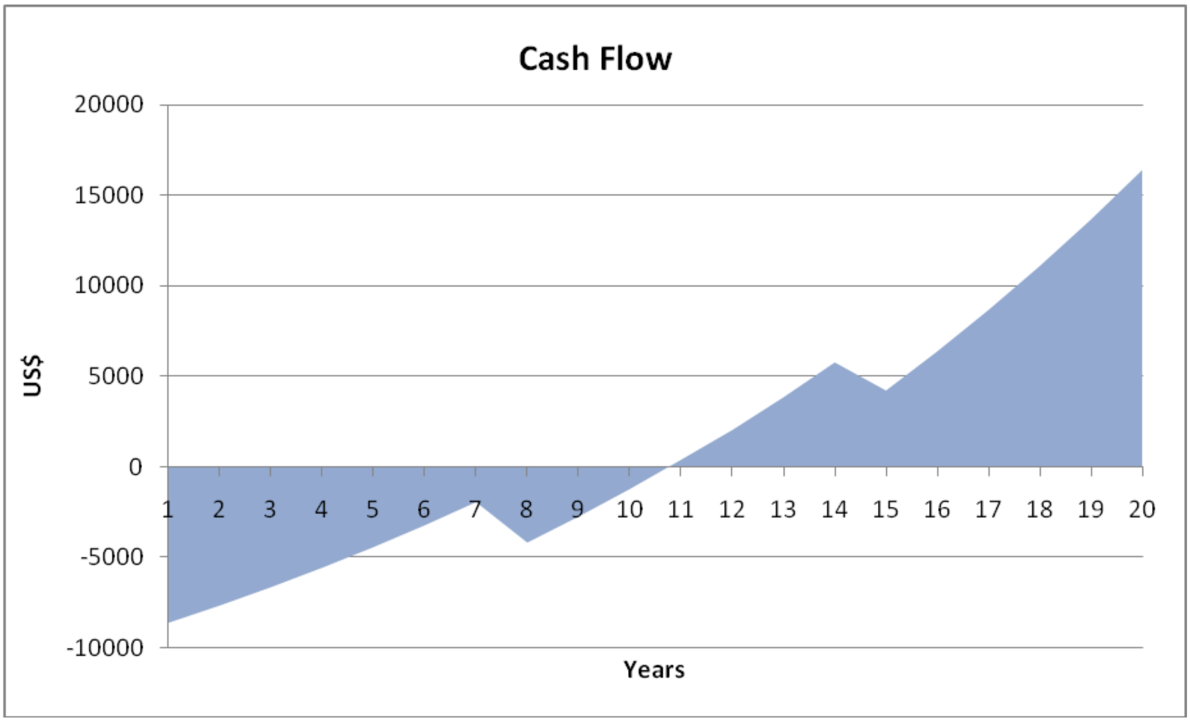
Annex 10: Cost Benefit Analysis PV System

Max. hours per day	8	hrs/day
Days/month	30	days/months
Months/ year	12	months/year
Energy needed per year	**731**	**kWh/year**
Energy delivered from PV	758	kWh/year
City power delivered	0	kWh/year
Total delivered	758	kWh/year
Life- time solar panels	20	years
Life- time batteries	6	years
Life- time controller	10	years
Life- time inverter	10	years
Costs solar panels	5460	USD
Costs batteries	3600	USD
Costs controller	70	USD
Costs city power	0	USD/kWh
Fuel costs	0.9	USD/L
Fuel heating value	8.9	kWh/L
Decrease of heating value	10	%
Height above NN	2400	m
min. Temperature	-15	°C
max. Temperature	40	°C
Air pressure	756.29	hPa
Efficiency at min. Temp.	83	%
Efficiency at max. Temp.	68.5	%

Average efficiency loss	75.75	%
max. Generator power needed	1.875	kW
Generator power selected	2	kW
Life- time	5	years
Investment costs	1000	USD
Motor efficiency	15	%
Generator efficiency	80	%
Maintenance costs	100	USD/year
Fuel heating efficiency output	0.73	kWh/L
Fuel needed per day	2.79	L
Fuel costs per day	2.51	USD/day
Fuel saved per year	1004	L/year
Electricity costs	1.24	USD/kWh
Electricity costs Afghani	61.80	AFN/kWh
Fuel saving first year	903	USD
NET saving end of time	**16413**	**USD**
Years considered	20	years
PV costs	**27146**	**USD**
Generator costs (Savings)	**39229**	**USD**
Energy price PV	1.86	USD/kWh
Energy price Generator	2.68	USD/kWh
CO2 emmission factor	3.132	kg CO2equiv./L
CO2 avoided per year	3144	kg CO2equiv.

CO2 avoided total	62872	kg CO2equiv.

Inflation rate (%)	Year	Expend.	City Power	Fuel	Cash-Flow
6	0	9546	0	903	-8643
	1	0	0	958	-7685
	2	0	0	1015	-6670
	3	0	0	1076	-5594
	4	0	0	1140	-4454
	5	0	0	1209	-3245
	6	0	0	1281	-1964
	7	3600	0	1358	-4205
	8	0	0	1440	-2766
	9	0	0	1526	-1239
	10	0	0	1618	378
	11	70	0	1715	2023
	12	0	0	1818	3841
	13	0	0	1927	5767
	14	3600	0	2042	4210
	15		0	2165	6375
	16	0	0	2295	8669
	17	0	0	2432	11102
	18	0	0	2578	13680
	19	0	0	2733	16413
				IRR=	-65


Cash Flow
20000
15000
10000
5000
0
-5000
-10000
US$
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Years

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 comfort

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.

Cultural Identity, appropriation

Socio-economic

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

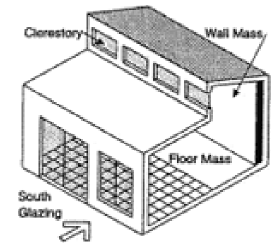
a. Passive design

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

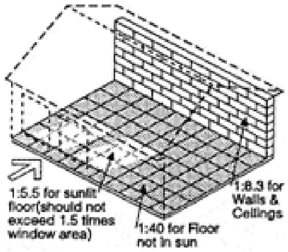
- the collection of solar energy through properly-oriented, south-facing windows,
- the storage of this energy in "thermal mass," comprised of building materials with high heat capacity such as concrete slabs, brick walls, or tile floors, and
- the natural distribution of the stored solar energy back 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.

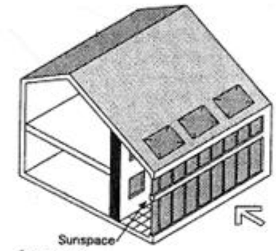
Passive solar heating in particular makes use of the building components to collect, store, and distribute solar heat gains to reduce the demand for space heating. It does not require the use of mechanical equipment because the heat flow is by natural means (radiation, convection, and conductance) and 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).

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).

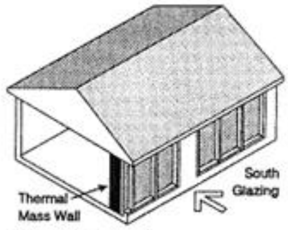


Direct Gain
Direct gain is the most common passive solar system in residential applications





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

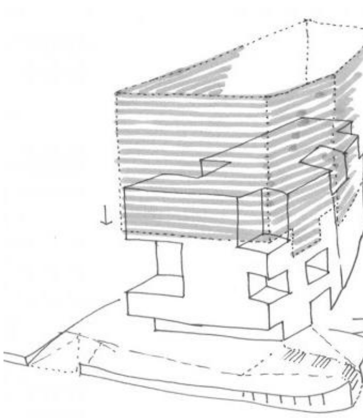


Thermal Storage Wall
A thermal storage wall is an effective passive solar system, especially to provide nighttime heating.

Source: www.wbdg.org

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

b. Efficient use of materials and procedures

- Materials
- Constructive systems
- Durability of buildings
- Maintenance

Case study – Materials / procedures

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

Extension to Great Ormond Street London Hospital:

a Green Extension

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 meters. (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)

c. 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 floods. They can be erected simply and quickly with readily available components, for very little money.'[1]

The sustainable aspects of earthbag buildings are:

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

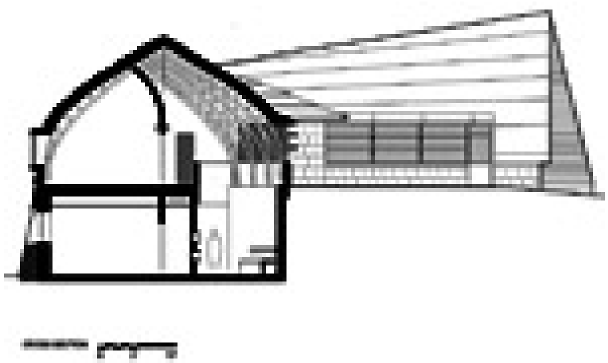
- Use of Local materials
    - No use of wood or no concrete
    - Earth bag walls, straw sacks, barbed wire cement piping
- Thick walls
    - Thermally stable (heat retaining properties)
- Local labor
    - Community Participation
    - Gender
- Affordable technologies
- Short construction time
- Fire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

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Annex 12: Measuring soil infiltration rates

The method outlined below (adapted from Davis and Lambert, 2002) gives a general feel for the infiltrative capacity of the soil under test –and provides relevant information for infiltration from soak pits or latrines. Such a test should be undertaken at the same depth as the base of the pit to ensure that the test is not distorted by any variation in material with depth.

Method: Force an open steel cylinder (i.e. without ends) of about 300 mm diameter a few centimeters into the soil so that it stands upright. Place an upright ruler or gauge stick marked in millimeters into the cylinder. Fill the cylinder with clean water and measure the fall in water level at convenient intervals (5, 10, 20, 30 minutes) as water infiltrates into the soil.

Interpretation: Determine the infiltration rate during each time period and take the average of the results. This will give a very rough guide to the infiltration rate, which is likely to be all that is required for this application.

The percolation value (or infiltration rate) in mm /day = drop in level (mm) time (days)

E.g. If the water level drops 12 mm in 30 minutes:

Infiltration = 12/30 x 60 x 24 = 576 mm/day (Typical value for sandy loam)

Note: The value in mm/day is always equal to the value in liters/m2/day.

For soak pits or pit latrines to function correctly the infiltration rate for clean water should be at least 120 mm/day.

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