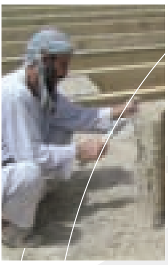
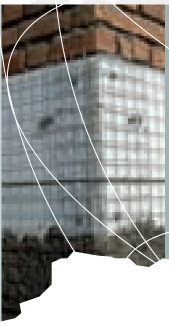
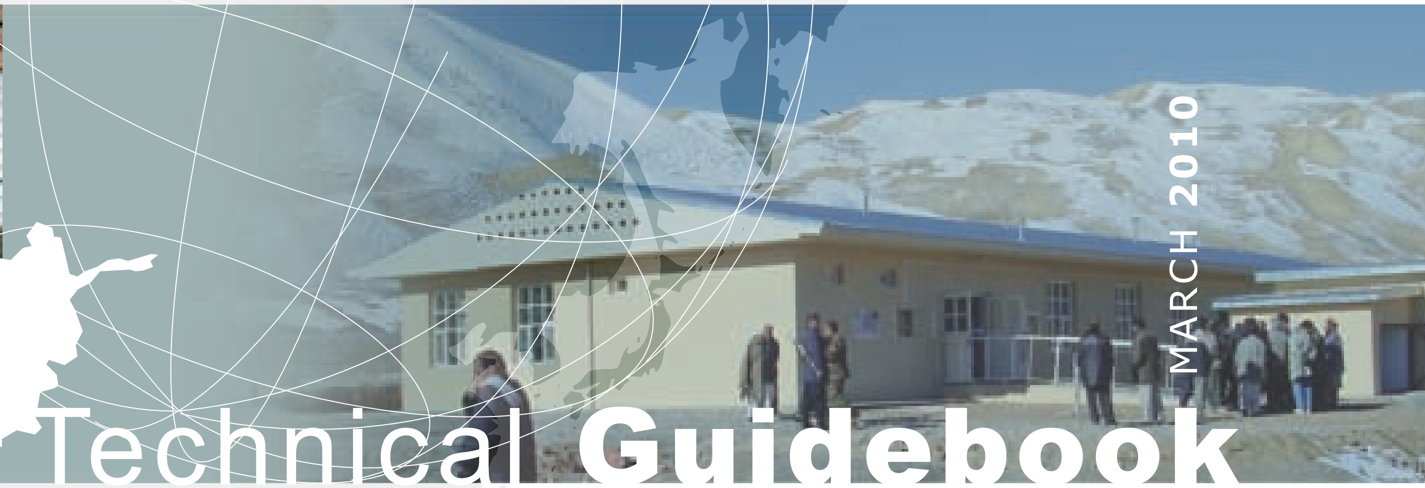




Energy-efficient public buildings in Afghanistan



MARCH 2010

Technical Guidebook

ADEME
Agence de l'Environnement et de la Maîtrise de l'Energie

NEPA MoPH MoE MoEW

geres
Energy
Environment
Solidarity

Foreword

Context

In Afghanistan, four-fifths of the population have to cope with cold winters (6 months below 0°C). Summer heat is also a constraint and an increasing number of buildings use air-conditioning systems. With the help of the international community, public sector reconstruction has involved hundreds of thousands of square metres of buildings every year since 2002. The standard plans adopted for these buildings will have a significant impact on Afghan energy expenditure for the coming decades (heating, lighting and cooling).
However, until now, public buildings were mostly not energy-efficient, with a very low level of comfort that does not help to provide good public services. Inefficient heating and cooling systems and poor thermal insulation increase fuel consumption and deforestation pressure and have an impact on social life. Afghanistan is facing financial difficulty in heating its public buildings properly.
Afghanistan crucially needs an efficient and sustainable energy approach for new buildings and for the renovation of existing ones.

Scope and use of this guide

Based upon 3 years' experience in Afghanistan, this technical guide to energy-efficient public buildings in Afghanistan – construction and renovation – has been designed for implementers and decision-makers. The guide aims to facilitate the construction of energy-efficient buildings. It provides decision-makers with practical information, databases and energy efficiency guidelines for various types of buildings. Technicians and engineers will find detailed insulation systems with their implementation criteria. Detailed technical sheets help in choosing the most suitable thermal insulation depending on the public building concerned (use, location, investment, etc.) The guide is organized into five parts. The first describes the global context of Afghanistan and gives general information about the project supported by the FFEM. The second part describes more specifically the issue of energy efficiency in the Afghan context. The third presents five demonstration cases which can be replicated in other projects. The fourth chapter is dedicated to appropriate energy behaviour. The last provides feedback on the project's design and on-site experience. The main plans for the projects presented appear in the annexes, together with the contact details of relevant Afghan contractors and main stakeholders.

About the GERES experience in Afghanistan

The experiments detailed in the guide were carried out between 2006 and 2009 as part of the "Dissemination of best energy efficiency practice in the public building construction sector in Afghanistan (health and education)" project. The aim was to demonstrate that the energy performance of public buildings can be sustainably improved.

The project was endorsed by the French Ministry of Foreign and European Affairs in 2004. It is the successor to a pilot operation carried out in Afghanistan between 2002 and 2004 by GERES (Renewable Energies, Environment and Solidarities Group). The project was backed by 1.35 million Euro in funding from the French Global Environment Facility (FFEM). Project implementation was co-ordinated by the Afghan National Environmental Protection Agency (NEPA) working with the French Environment and Energy Management Agency (ADEME) and GERES. From the outset, the project worked with the heads of the construction departments at the Ministry of Health (MoPH) and Ministry of Education (MoE), as well as receiving support from the Ministries of Energy and Water (MoEW),

Its main objectives were:

- Assistance in erecting 100 energy-efficient public buildings
- Capacity-building to strengthen local authorities' work in the field of energy efficiency
- Support for companies producing insulation materials and energy-efficient heating equipment
- Training for contractors and builders in energy efficiency techniques relevant to the construction industry

Energy-efficient solutions have been implemented for more than 270 buildings or 170,000 m2. The work was carried out on schools, clinics, army facilities (offices and dormitories), energy information centres and a museum.

Energy-efficient buildings (2006-2009)	
Health Centres	13
Buildings for Education and Training	28
Offices	70
Energy Information Centres	2
Dormitories	161
Museum	1

Table 1:
New or renovated buildings (2006-2009)

Over 1000 villagers, technicians and officers from the administration, higher education establishments and the private sector have attended short training programmes. In Kabul, local production of modern insulation products such as expanded polystyrene panels came on-stream in 2005.

A prototype new standard bioclimatic school, using local, cement-free materials, has been built and the design of a passive solar clinic was implemented by Caritas for the Ministry of Public Health.

The project has paved the way for detailed collaboration with decision-makers from the Afghan government to include fundamental energy efficiency principles in standard construction plans for schools, clinics and hospitals.

Main achievements of the programme (2006-2009):

- *Over 270 buildings have been insulated, representing a total area of over 170,000 m²*
- *Over 1000 technicians and officers from the administration, higher education establishments, villages and the private sector have attended short training programmes.*
- *Two demonstration buildings have been erected*
- *A prototype bioclimatic standard school has been built with the Afghan Ministry of Education*
- *A prototype passive solar clinic has been built.*
- *Official standards for clinics include thermal insulation specifications*
- *The pilot projects showed the way for replication by most Afghan stakeholders, decision-makers, development co-operation agencies and NGOs.*

Looking ahead

Against a background of steeply rising energy prices, and with the aim of strengthening energy efficiency policy in Afghanistan, NEPA, working with the Ministry of Energy and Water, is examining ways of taking the project forward. Implementation of energy-efficient building codes, designing courses for the private sector, universities and technical colleges, and awarding a label to energy-efficient equipment will take the process to the next level.

The success of the first phase has paved the way for enhancing the use of energy efficiency principles in other public building programmes and bringing in the commercial and residential sectors as well.

This guide is designed to facilitate the replication of the best practice implemented with the support of the French Global Environment Facility and to hand over that expertise to Afghan contractors. We hope that the guide will find a good audience and be helpful to Afghan practitioners.

The book

This book has been funded by the French Global Environment Facility (FFEM) as part of the "Best energy efficiency practice in the public building construction sector (health and education)" programme in Afghanistan between 2006 and 2009.

Lessons were learned from the project on how to build energy-efficient buildings in Afghanistan. At the end of the project, the partners decided to gather together the knowledge gained and produce a book for use by Afghan builders and decision-makers.

The authors

Mathieu Faureau is a French engineer. He was involved in the above-mentioned project from May 2007 to July 2008, during which time he was in charge of joint projects with GTZ and following up energy-saving indicators in the buildings concerned.

Cyril Jarny is a French energy specialist. He acted as project manager for GERES in Afghanistan from February 2005 to December 2006. He now works for GERES in France.

Edgard Dezuari is a Swiss architect. He was co-ordinator of this project for GERES in Afghanistan from August 2006 to December 2008.

Acknowledgements

We would like to thank the partners of this project and among them Mr. Philippe Bosse from the French Global Environment Facility, who was one of the project’s architects. He supported and advised in the production of this book. We would also like to thank Mr. Michel Hamelin, Deputy Director of International Affairs at the French Agency for Environment and Energy Management (ADEME), who strongly supported the project and facilitated production of this book.

Special thanks go to Mr. Alain Guinebault for his advice and ongoing, knowledgeable monitoring of all the activities mentioned in the book.

We are also grateful to our local partners, especially engineer Younus Yusufzi, Director of the Department of Construction at the Afghan Ministry of Education, and Dr. Mohammed Akram Rahimi, Director of the Planning Department at the Afghan Ministry of Public Health. Both of them initiated or supported the implementation of the pilot projects described in this book to illustrate best practice.

We would like to thank the private companies and NGOs which devoted their efforts to demonstrating the feasibility of energy-efficient architecture in Afghanistan. We will not mention all their names here; they are many and they will know we are grateful. However, we would like to single out architect Grahame Hunter from Turquoise Mountain Foundation, who drew up and co-ordinated the Istalif pilot project and produced the details of its techniques and architecture presented in this guide.

The GERES team in Kabul has provided most of the content used to write this book. Some of the technical solutions implemented were prepared by Mr. Francois Gallez in Kabul during 2005 and 2006. We take this opportunity here to thank him and acknowledge his overall contribution.

We want to stress the comprehensive work done by Mr. Denis Noël Rouge during winter 2007-2008 and 2006-2007. He helped us to identify climate zones in Afghanistan and made use of Pleiades software to simulate heating needs for different levels of comfort for all types of buildings in the three Afghan climate zones identified. His field experience in many Afghan rural areas went a long way towards identifying real Afghan energy needs and sources.

We also want to thank Mr. Simon Biney, who made a major contribution to finding reliable climatic data and ran valuable consumption surveys in health centres during winter 2007-2008. His methodological approach to Afghan energy habits was very helpful in quantifying energy consumption in rural and urban areas.

Finally, we want to thank the Afghan staff at GERES Afghanistan for their dedication to implementing the project described here. Some among them have left GERES meanwhile, but we remain grateful to them. GERES staff helped us with translation during surveys and advised us in the writing of this book. Civil Engineer Riaz Rameen monitored implementation of the pilot buildings described here. He provided us with his technical knowledge and expertise on Afghan buildings and construction techniques for this book. Engineer Toryali Himat is the field engineer who helped us to introduce new techniques and insulation systems to Afghan contractors. His role and clear understanding displayed on site were particularly appreciated by all partners. We wish to give special thanks to Ms. Hosay Rahimi, who dealt with co-ordination in Kabul, for sending us data and information. She has been a key support person for us.

We want also to thank the Afghan people for their kindness and participation in this project in the villages, provinces and Kabul. This book is dedicated to them.

Table of contents

Needs for energy efficiency in buildings

Part 1

The Afghan reconstruction: a challenge to the sustainable approach

After 30 years of conflict, Afghanistan had lost a significant part of its infrastructure (public buildings, roads and equipment). Since 2002, the country has been the focus of rebuilding programmes and striving to rehabilitate the principal public sectors (health, education, transport infrastructure and energy). This infrastructure is essential to the country's economic revival and social cohesion, but long-term sustainability should not be forgotten in the rebuilding emergency. The building reconstruction undertaken by these programmes must not only find funding for today but must also take into account recurring costs in the future (maintenance and energy consumption). Added to the difficulties in providing local energy resources, these constraints make it imperative to build energy-efficient buildings, with affordable costs for the administrations and owners.

For education and health alone, the country was in need of tens of thousands of schools and hundreds of clinics. The first task was to produce standard designs ready to be built everywhere in the country. Although international contractors from the US did produce initial standards for clinics and schools, these designs did not take account of the local context, i.e. that Afghanistan had almost no construction economy, factories to produce materials and equipment or contractors. However, the “traditional” way of building emerged again rapidly in the country with the development of private buildings. Engineers and contractors coming back from Pakistan did bring with them technologies and knowledge suited to the materials and know-how available on the regional market.

Afghanistan has a long architectural tradition, but its know-how has been lost or forgotten in the construction emergency. Many craftsmen and technicians left or retrained and it is a question of reintroducing techniques for buildings in urban and rural environments.

In rural areas, new infrastructure helps to provide better public services in better conditions. About 500 schools have been built in villages every year between 2003 and 2009 and 500 clinics have also been built since 2002. Infrastructure reconstruction (roads, public buildings, etc.) and NGO programmes have boosted the local economy and employ Afghans of various social origins. Informal trade has also been developed with neighbouring countries.

For health centres in cold zones, the cost of energy can represent up to 20% of the budget (from €5,000 to €25,000 per year according to the type of establishment). This is the only expenditure where substantial savings are possible. Schools are strongly dependent on climatic conditions. In winter, and especially in the centre of the country, schools which do not have sufficient fuel are obliged to close for long periods (up to five months).

Building in a harsh climate

Afghanistan is a landlocked, mountainous country in South-Central Asia, with plains in the north and south west.

Fig 1: World map

Located at the heart of the Hindu Kush, most of the country is covered by mountains, except the far north which is a fertile valley. Large parts of the country are arid and fresh water supplies are limited. The south of Afghanistan is desert.

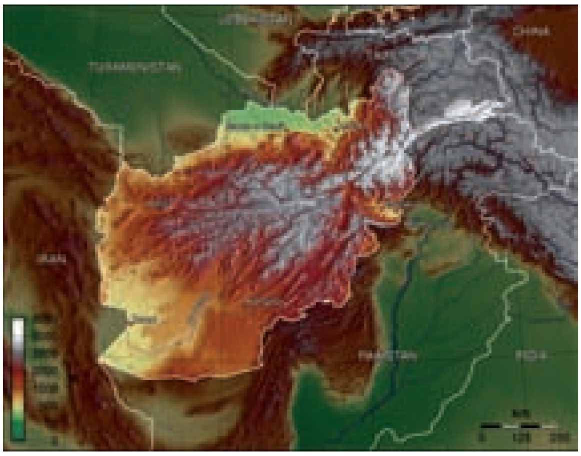


Fig 2:
Central Asia physical map

The country's capital, Kabul, is located at an altitude of 1800 m. The map below clearly shows that the major part of the country is at an altitude of over 1000 m.

Afghanistan has extreme climatic conditions, with very cold winters and hot summers. The literature provides various climatic maps to describe this situation. The country faces a variety of climates due to its location between the Indian continent, central Asia and the Iranian highland. The Hindu Kush mountain range is also a factor of this variety and generates micro-climates in specific regions and valleys.

In 2008, GERES produced a study in Kabul to identify the main climate zones, with a view to using simple methodology to calculate energy savings and CO_2 reductions. Once you start to quantify a building's energy needs, you need to know the climatic features of that building's environment (coldest and hottest temperatures, hours of sunshine). Unfortunately, Afghan climate literature is not complete and not always recent. Consequently, GERES decided to identify climate zones in Afghanistan to facilitate the identification of appropriate insulation systems for each zone. This method already exists in France, where the country is divided into climate zones with similar characteristics. Each zone requires specific insulation values.

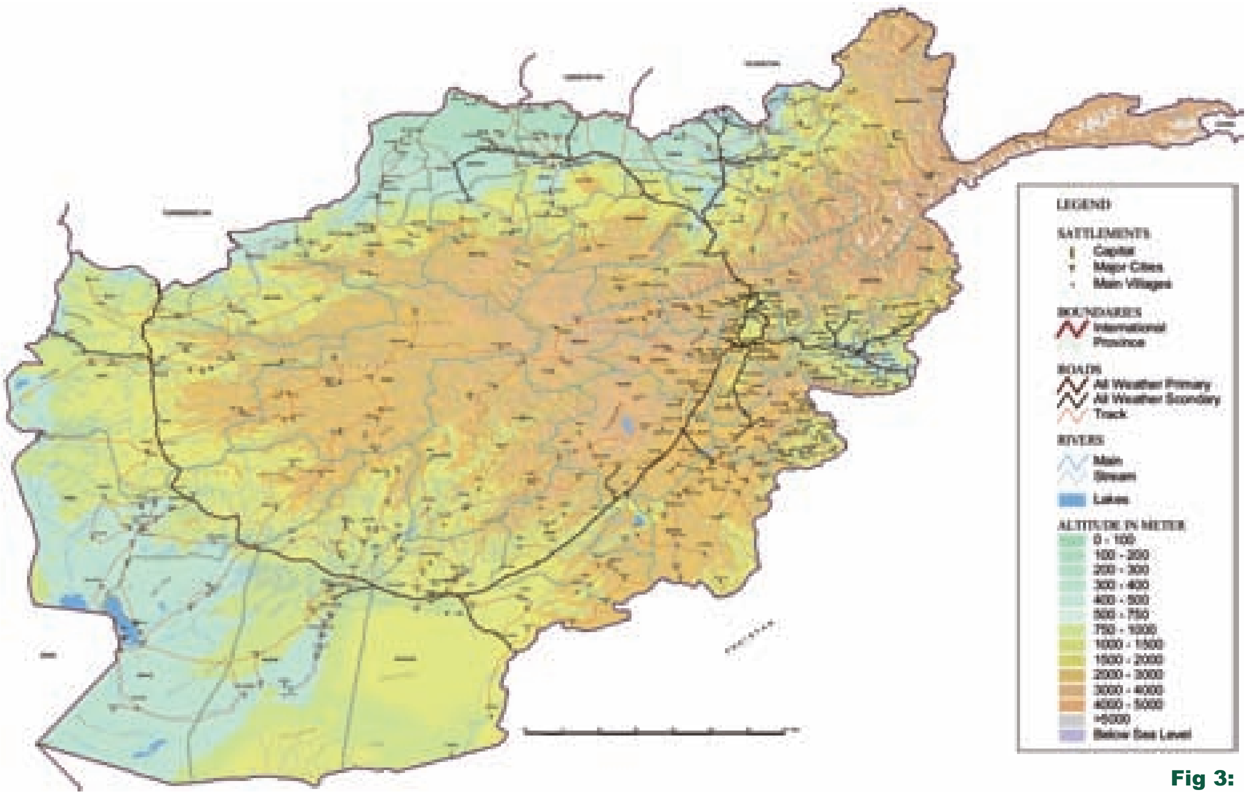
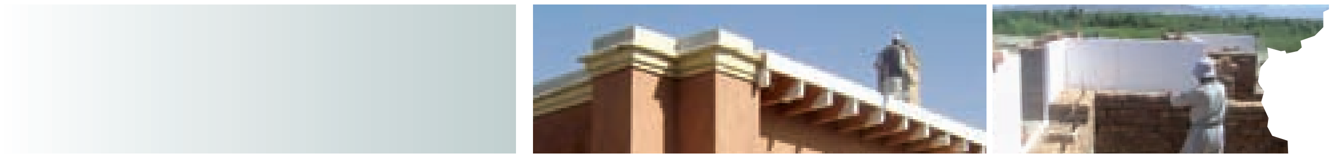


Fig 3:
Afghanistan physical map



As a result, the following climate zone map is the superimposition of three maps (hottest and coldest temperatures and hours of sunshine, figs. 5 & 6). The result is not a scientific climate map (fig. 4) but it does help to identify the geographical distribution of the three main different climates existing in Afghanistan. It is a relatively precise indication of the Afghan climate to facilitate classification of building insulation values according to climate zone.

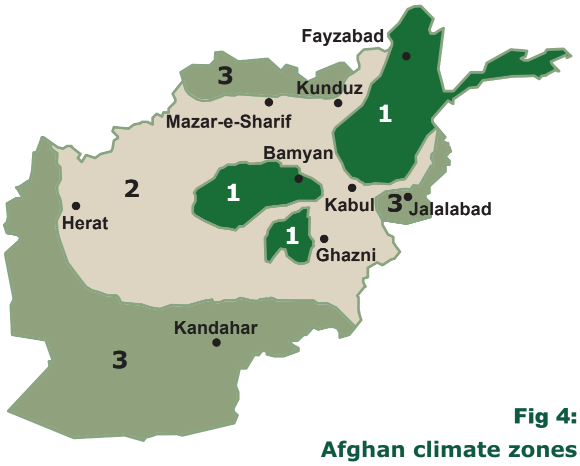


Fig 4:
Afghan climate zones

A description of the Afghan climate helps in visualizing the three climate zones:

- **Zone 1:** The Central Mountains represent a *subarctic climate* where summers are colder and the winters harsher than in the continental climate. Temperatures in January may drop to -15°C or lower in the highest mountain areas; July temperatures vary between 0 and 26°C depending on altitude. During a three-month period, average temperatures fall below 0°C. Most of the region is at an altitude of over 2500 m. Permanent snow covers the highest mountain peaks.
- **Zone 2:** Most of Afghanistan (the centre except the high mountain regions) has a *continental climate* with hot, dry summers and cold winters. During three months in winter the average temperature falls below 5°C.
- **Zone 3:** The southern and northern plateau region has a *hot arid climate*. This climate is characterized by high evaporation and low precipitation. It receives little rainfall, with the highest temperatures and the lowest precipitation in the country being registered in this area.

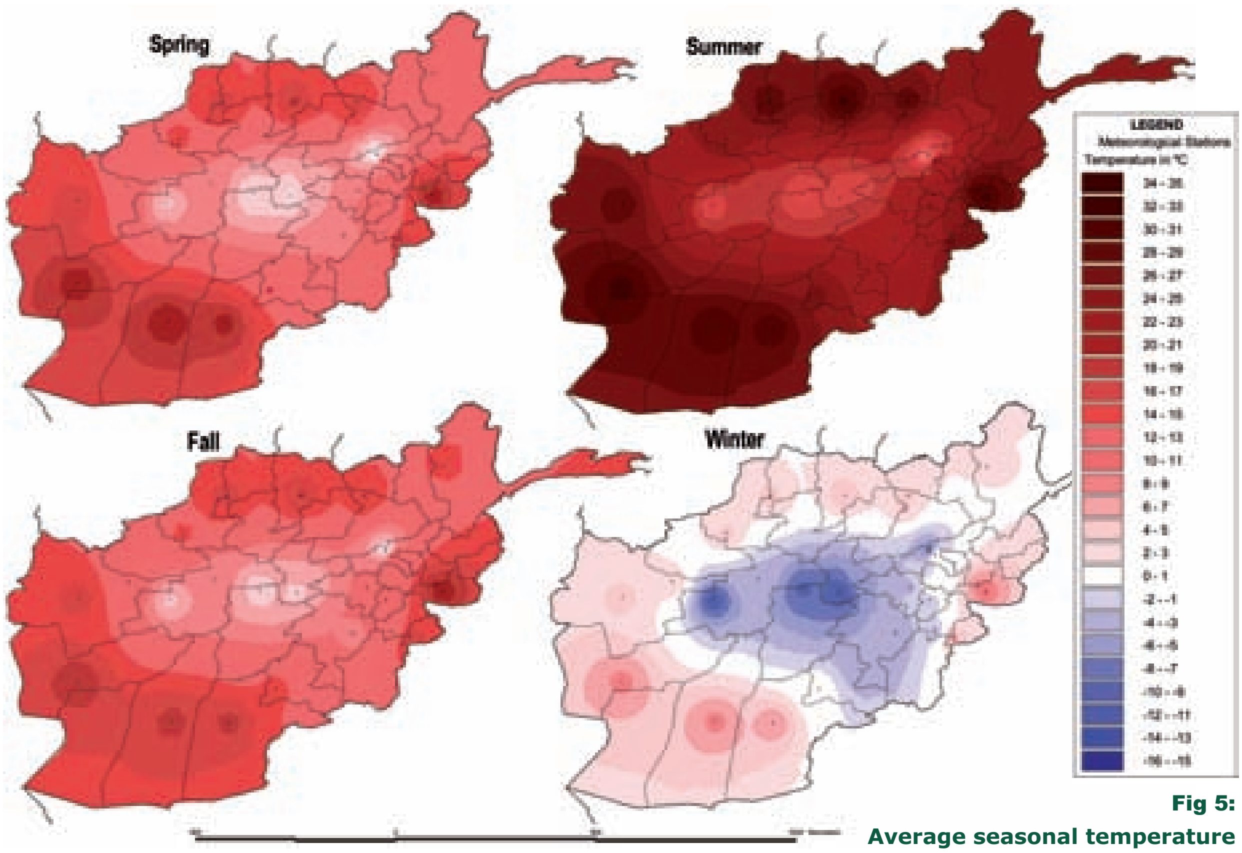


Fig 5:
Average seasonal temperature

This climate is characteristic of desert or semi-desert areas surrounded by mountains. During the coldest month, temperatures stand between 5 and 10°C. During summer they can rise above 40°C.

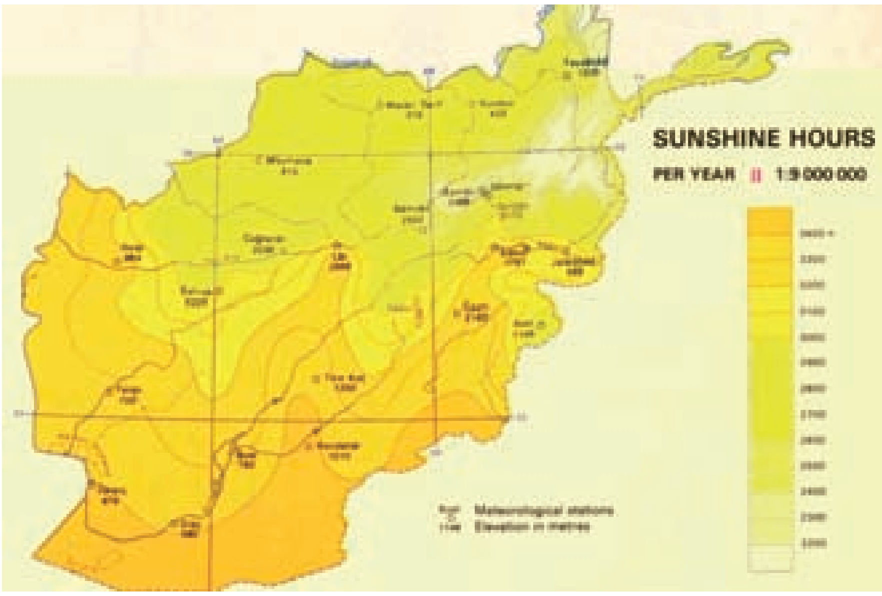


Fig 6: Afghan sunshine hours

The Afghan climate therefore ranges from subarctic to hot arid, which means that extreme conditions are common all year round in the country. The following maps show a wide variation in average temperatures (±25°C) during different seasons around the country. Summer and winter maps have been used to draw the climate zone map (fig 4).

Afghanistan is a sunny country; it gets an average of around 3000 hours of sunshine per year (300 days), whereas France for example gets an average of 1500 hours per year. This map has also been used to produce the climate zone map.

The three temperature graphs for three different cities situated in each climate zone enable average temperatures around the year (day and night) to be visualized. They summarize average temperature changes in one year per zone.

We can also conclude that the average temperature difference between day and night, at any time of the year in any climate zone, is around 15 to 20°C.

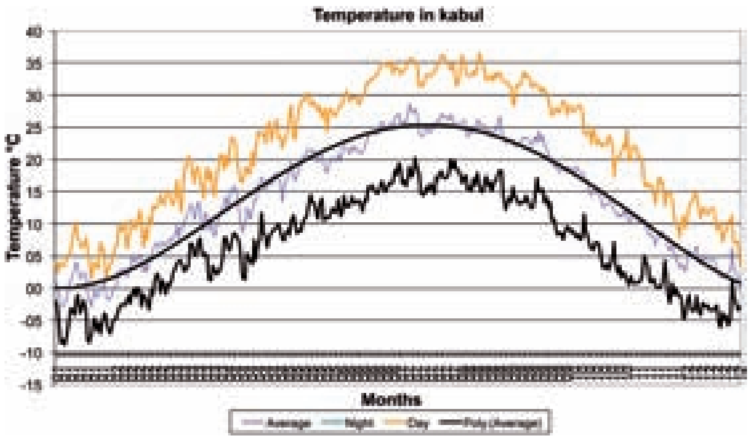


Fig 8: Temperature in Zone 2, Kabul

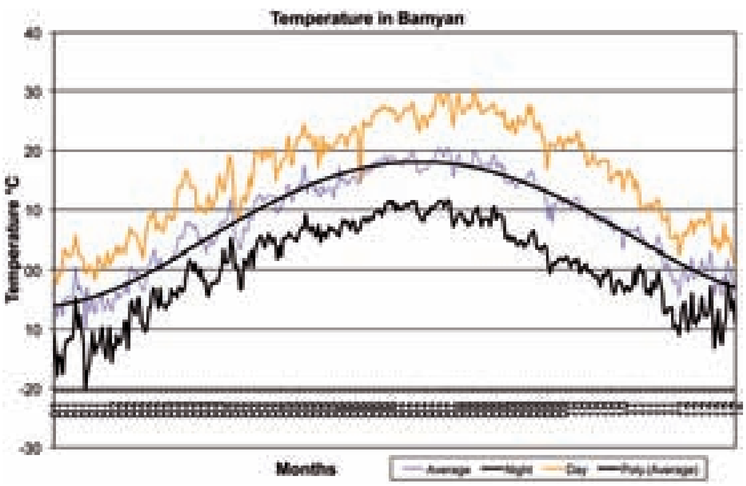


Fig 7: Temperature in Zone 1, Bamyan

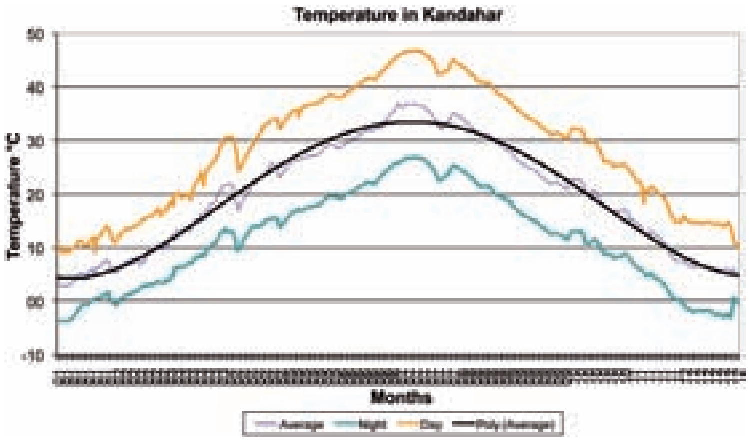
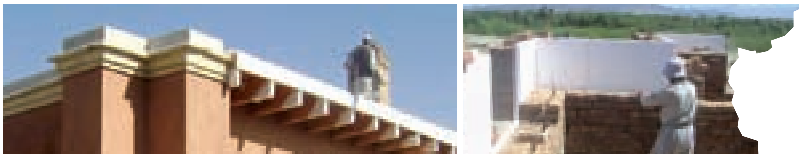


Fig 9: Temperature in Zone 3, Kandahar



To sum up, Afghanistan's climate is divided into three zones :

- **Zone 1:** *Subarctic climate*. Cold in winter, moderate in summer, (-5°C; 20°C).
- **Zone 2:** *Continental climate*. Cold in winter, hot in summer (0°C; 25°C).
- **Zone 3:** *Hot semi-arid climate*. Moderately cold in winter, very hot in summer, (5°C; 35°C).

The following precipitation maps show that Afghanistan has a very low precipitation rate. In fact, most of the year, precipitations are below 60 mm all over the country. Only in winter do precipitations exceed 80 mm in a few areas. In Afghanistan, yearly precipitations barely reach 300 mm in zones over an altitude of just 1000 m. In comparison, precipitations in mountain zones in France (over 1000 m) are around 1500 mm per year.

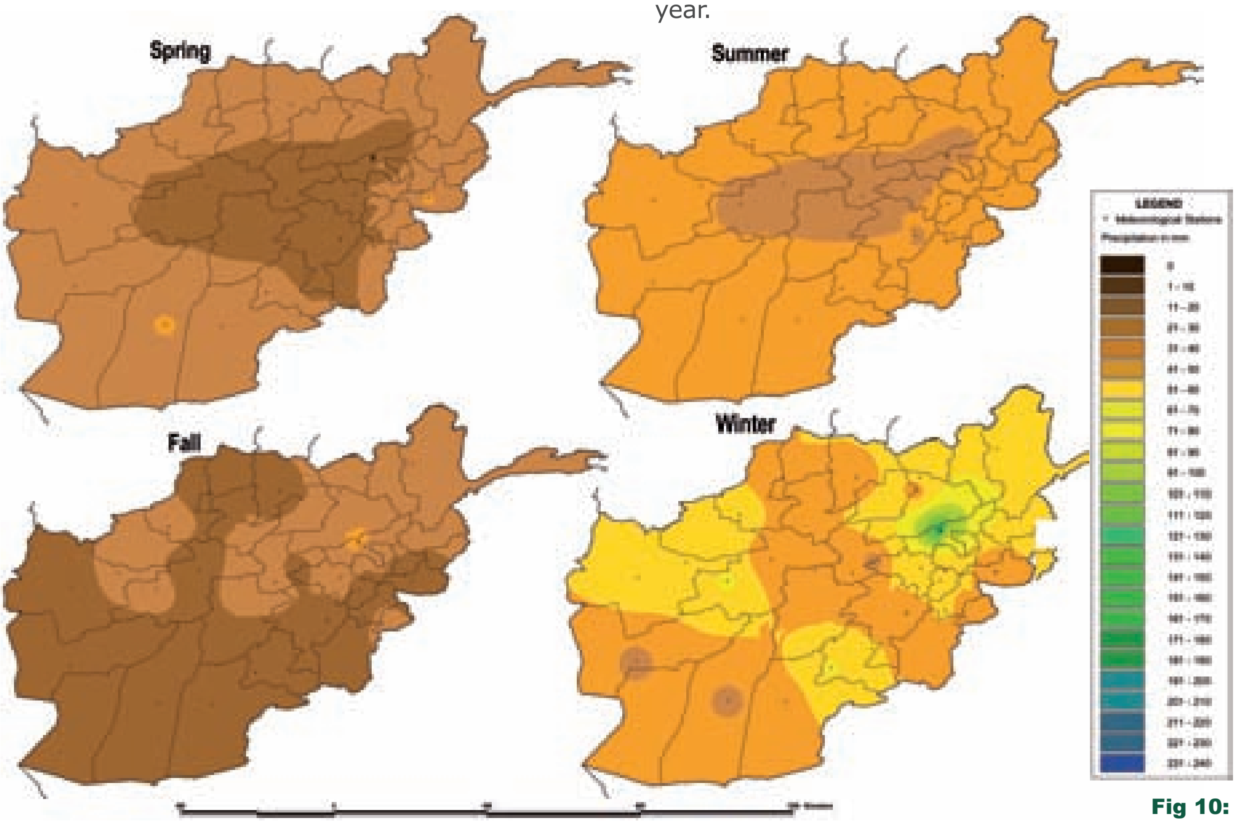


Fig 10: Average seasonal precipitation

To sum up:
Afghan climate characteristics are:

- *Hot, dry summers and cold winters*
- *Very high average temperature amplitude between seasons (±25°C)*
- *High temperature differences between day and night all year round (15 to 20°C)*
- *High solar radiation potential (more than 300 days per year)*
- *Very low precipitation rate (less than 300 mm per year)*

This clearly shows that the country needs an energy-efficient policy to minimize heating and cooling needs and maximize solar gains.

A population with limited access to energy resources

The population of Afghanistan is around 31 million (2008). The majority (about 3/5 of all Afghans) live in the continental climate. A fraction of the population (about 1/5 of the total) lives in the subarctic climate, with the remainder (1/5 of the total) living in the desert climate.

The country's population distribution clearly shows that Afghans are concentrated in areas where climatic conditions and the environment are the most suitable for human beings (i.e. zone 2, a continental climate with available natural resources).

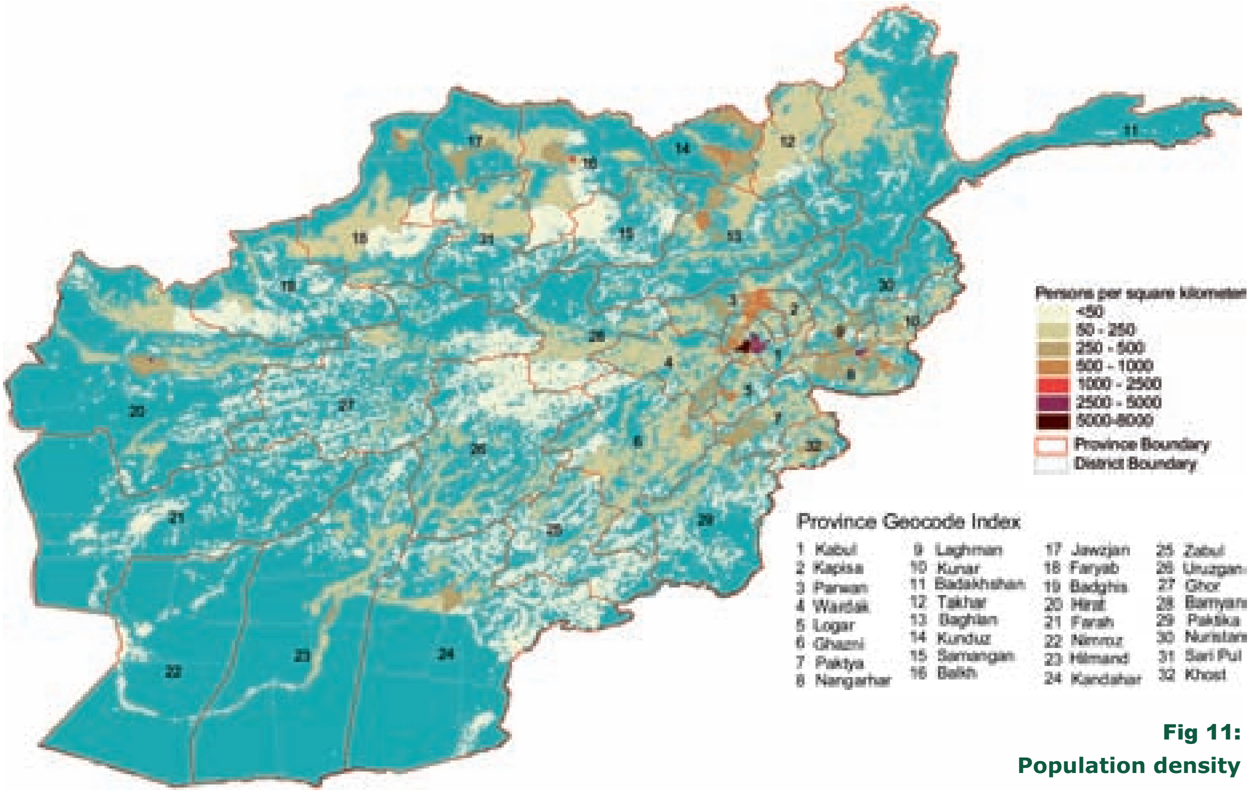
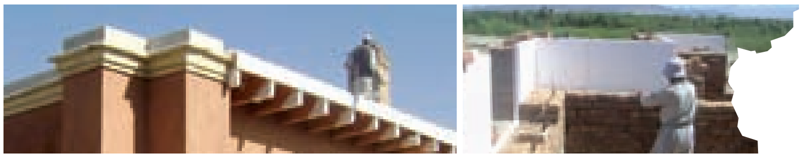


Fig 11:
Population density

As a result of the recent rapid increase in urban population and development of the economy, Afghanistan today has growing energy needs which are not covered by the existing energy supply. Although almost 80% of Afghans live in rural areas, the main urban centres are attracting an increasing proportion of the population. Kabul, for example, had 500,000 inhabitants in 2001 but 3 million in 2005. In most rural areas, rural households have little or no resources to buy fuel. Traditionally, Afghans burn dung and bushes collected in the mountains to cook or to heat their houses. In cities, with the development of new jobs and higher salaries, new needs have emerged rapidly with higher demands for comfort and energy. Urban dwellers have new aspirations to get good houses, cars and electrical appliances. New urban sectors in the Afghan economy are booming, including services, manufacturing, construction and public administration. This trend in cities and the development of new sectors of the economy represent an issue for the government in terms of energy. Supply covers less than one third of Afghan energy needs and this gap is going to widen in the future.

A few figures and facts can help to visualize the Afghan rural domestic energy scene

- Less than 4% of rural households have access to electricity. Of those with access, 7% use electricity for lighting.
- The main source of cooking fuel is self-collected firewood, for which there is no monetary outlay, or charcoal.
- The average rural household spends only 3.5% of its budget on energy and this includes attributed expenditure or non-cash outlays.
- Wood and charcoal are used mainly for cooking and heating, while kerosene is the main source of energy for lighting.
- The remoteness of rural locations and the rough terrain mean that expansion of the electricity grid into these areas is not economically feasible.
- Wood cost AFA2/kg in 2001, rising to AFA10.4/kg in February 2008.



Energy supply in Afghanistan

Afghan energy production is presently restricted to hydroelectric or coal-fired power stations (very few). Most electricity is imported via high-voltage lines from Uzbekistan and Tajikistan. Afghanistan also has high hydro and solar energy potential. Solar radiation averages about 6.5 kWh per square metre per day and the skies are sunny about 300 days a year. Consequently, the potential for solar energy development is high, not only for solar water heaters for homes, hospitals and other buildings, but also for generating electricity. In addition, some 125 sites have been identified for micro-hydro resource development with the potential to generate 100 MW of power 9. Hydro units are expensive and time-consuming to build; they are still not sufficiently exploited.

Moreover, energy distribution infrastructure is virtually non-existent.

The country has a limited stock of biomass; forests have until now been the main source of energy for the population for heating purposes. Forests now cover only 1.3% of the country.

Afghan forest trees grow very slowly and the present rate of deforestation will result in the complete destruction of the forest within 25 years. In the 19th century, most of the central, northern and eastern regions were forested. 70% of the forest has disappeared during the last 40 years. The use of wood from the Afghan forest is also an ecological disaster for the Afghans.

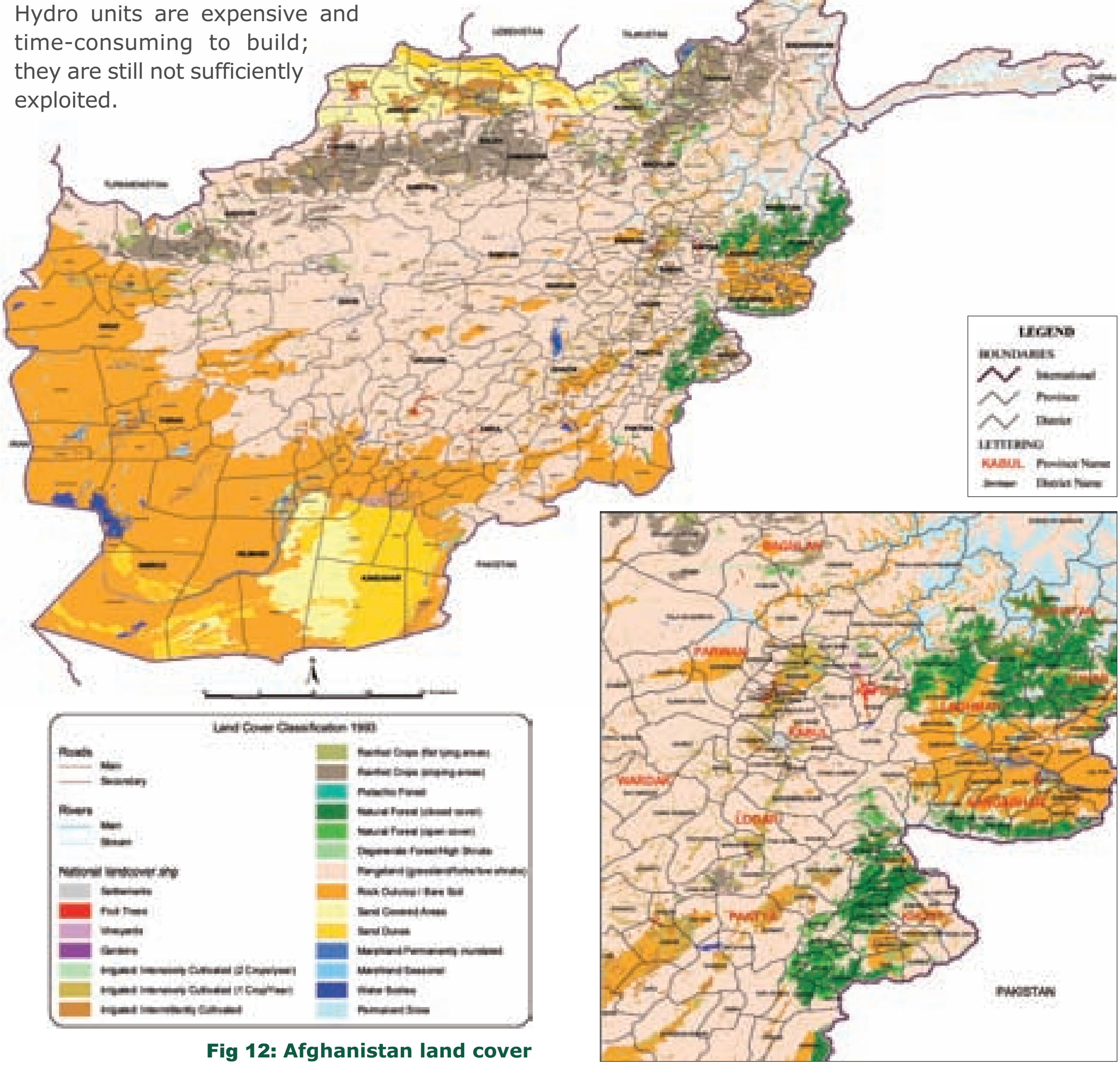
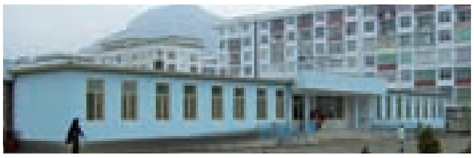


Fig 12: Afghanistan land cover

The exhaustion of the forest means that a whole ecosystem is going to disappear. With it, an important part of Afghanistan's flora and fauna will be lost. Moreover, the soils which are no longer fixed by the trees are being washed away by rain and wind. This process accelerates desertification.
If nothing is done, destruction of the forest will also be a human disaster for a population without access to affordable sources of energy during winter, especially for basic purposes such as heating and cooking.

Energy consumption

Energy consumption in Afghanistan relies on two main resources:

- the formal market, mainly electricity, coal, gas and petrol
- "informal" sources of energy extracted from biomass and forests.

Hydro power and imports account for the vast majority of electricity consumed. This is followed by coal, natural gas and then petroleum (for power stations but also individual generators). It is estimated that 30% of electricity is lost during transportation due to the very poor state of the distribution network. Moreover, a significant part of the electricity consumed is not billed. Combined losses and subsidies are costing the Government $128.5 million annually.

Biomass represents a major source of energy but is barely mentioned in any research or statistics. Biomass consumption (coal, wood, bushes, dung, etc.) is almost impossible to measure. Moreover, fuel research is very expensive in time and money. People are left alone to determine their vital daily energy needs. In cities, they use what they can afford (e.g. sawdust, charcoal, wood, kerosene or gas) and, in rural areas, what they can find (e.g. bushes, crop residues, dry dung or wood).

Major cities import electricity from neighbouring countries and have their own production units (coal-fired thermal power stations and large generators). But even in Kabul, electricity is not available 24 hours a day. Supply largely depends on the power available and the daily demand, so people who can afford it have electricity for a few hours per day in main cities. Otherwise, as is common in many developing countries, private houses may have clandestine connections or small generators.

In rural areas, the only means of getting electricity are "off-grid" systems (photovoltaic panels or generators).
There are very few central heating systems in public buildings. Most of the time, only a few rooms per building are heated using individual heaters (gas, kerosene, wood or sawdust bukharis). For further details, please refer to the heating system chapter. Investigations show that collecting combustible material (wood, vegetation waste, dung, etc.) represents no less than one month of work in rural environments. This means that the poorest families cannot always provide for their energy needs and are sometimes constrained to migrate towards the warmer areas of the country in winter. It explains why it is so difficult to find reliable heating energy data in Afghanistan (production and consumption). Identifying and measuring this type of daily individual energy consumption is very difficult. The energy consumption peak is in winter so all energy prices increase at this time, as shown in the following diagram.

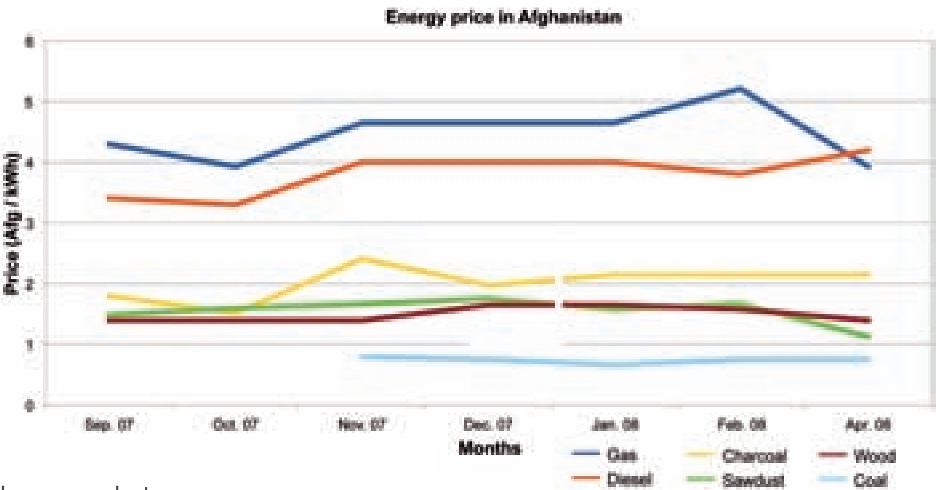


Fig 13: Energy prices in winter 2007-2008 (Kabul)

Wood prices have multiplied by five over the last few years. Wood cost AFA 2/kg in 2001, rising to AFA 10.4/kg in February 2008. The survey conducted in winter 2007-2008 clearly shows that prices rise during the coldest months when

demand is at its peak. Depending on energy sources, prices can increase by 10 to 30% during the coldest period (December to February).
Reversible heat pumps (air-air) using electricity to heat or cool a building are gradually coming into use. These heating systems are cleaner and easier to use than the traditional wood stove. They have become a must in the offices of high-ranking officers in the ministries and in the international organizations and development co-operation agencies. From there the market is expanding towards the private sector. The system is based on the assumption that the building will be continuously grid-connected.
Industrial or commercial electricity costs AFA 5/kWh up to 600 kW. For housing, electricity prices depend on needs: AFA 1.5 /kWh up to 300 kW; AFA 3/kWh up to 600 kW and AFA 7/kWh up to 1200 kW.

To sum up:

- *Less than 10% of the population in Afghanistan has access to reliable electricity (mostly urban areas).*
- *Average household income is estimated to be no greater than $231 a year.*
- *The average rural household spends only 3.5% of its budget on energy*
- *61% of Afghan energy needs are covered by biomass and the rest by oil products.*
- *Wood prices have multiplied by at least five on average since 2001.*
- *80-90% of economic activity in Afghanistan takes place in the informal sector.*

Building and energy data

Public buildings: typology

Before presenting theoretical heating needs, it is worthwhile to identify the characteristics of the main types of buildings insulated with support from GERES between 2004 and 2009 and their respective heating systems.
The size of all buildings is around 600 m², which corresponds to middle-sized single-storey public buildings (schools, offices, health centres, etc.). These buildings are new or have been renovated (insulation work).

For heating, public institutions have a fixed budget set by their respective ministries, except for schools which are not heated. Clinics have a limited budget, while army facilities are comfortably heated.

However, it is important to note that the lifespan of a building is around 30 years and levels of comfort might change in the future. The thermal insulation operation, even if not profitable today, might prove to be so in the medium term when improvements in comfort have been achieved in the building.

Name	Building type	Heating/ cooling	Comfort level	Number insulated	Building cost $/m²
Type 1	Standard schools	No	Depending on outdoor conditions	15	150-250
Type 2	Military facilities	Yes	18°C	237	350-500
Type 3	Health centres	Partly heated	5 to 15°C	2	250-550

Table 2: Building types

Insulation typology

Having established building typology, it is important to identify the type of insulation implemented in those buildings. This helps to classify results and identify heating needs according to a building's environment and role.

Name	Characteristics	Insulation cost ($/m²)
Not insulated	• Concrete flat roof • Brick wall • Single-glazed windows	-
Semi-insulated	• Roof insulation: 10 cm polystyrene or glass wool • Brick wall • Double-glazed windows	6.8
Fully insulated low cost	• Roof insulation: 10 cm polystyrene or glass wool • Wall insulation: 5 cm to 10 cm polystyrene • Double-glazed windows	20.5
Fully insulated high cost	• Roof insulation: 10 cm glass wool • Wall insulation: 5 cm to 10 cm polystyrene (STO technique) • Double-glazed windows	46.4

Table 3: Insulation typology and cost

Thermal calculation

Thermal calculation is necessary to forecast savings, payback time and CO_2 reduction. These are the main factors in an energy efficiency policy. Due to lack of field data for the Afghan context, many assumptions have been made. These hypotheses enable us to characterize comparative building envelope performance.

The main assumption concerns heating needs in winter. As Afghan public buildings are not heated permanently and totally, only some rooms per building can be considered as heated for a few hours per day.

The second assumption concerns the average indoor temperature in Afghan buildings. In these calculations, we assume an indoor temperature of 18°C for the building (EU standards) which is not the case in Afghanistan (less than 15°C). We also assume that the temperature is even and constant in the entire building, which is not true in Afghanistan, because central heating rarely exists.

Theoretical heating needs

These results are based on theoretical assumptions made for buildings insulated in 2008 and 2009.

As an example, we present here only results for the most common public building size (more than 500 m², single storey). We have chosen to present heat losses in kWh/m²/year.

These figures are calculated for a daily ambient temperature of 18°C in a building heated during the day (from 7 a.m. to 4 p.m.). Annual heating degree days have been calculated in many locations with precise weather data. Note that permanently heated buildings' needs will be roughly 3 times those of day (only) heated buildings.

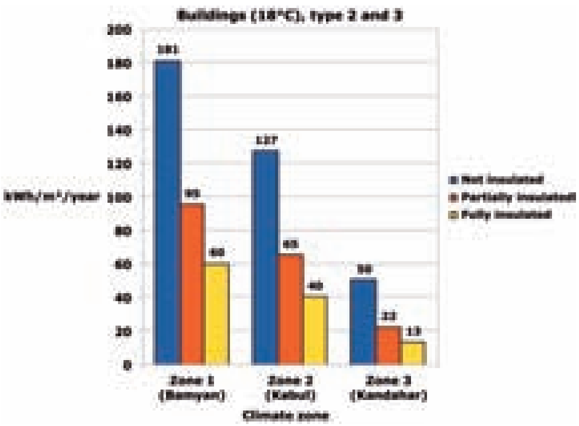
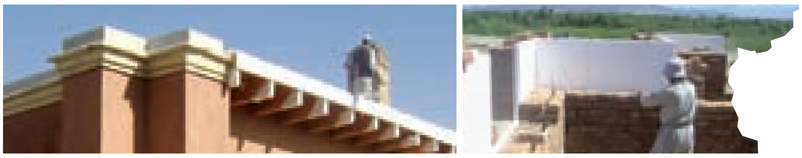


Fig 14: Comparison between heating needs with different insulation types for the three Afghan climate zones



All results are in comparison with non-insulated buildings. Only the results of zones 1 and 2 are presented because heating needs in zone 3 are too low to require an investment in insulation.

18°C	Zone 1 Heating needs reduction	Zone 2 Heating needs reduction
New building partially insulated (wood only)	49%	48%
New building fully insulated (wood only)	77%	70%

Table 4: Heating needs for zones 1 & 2 (18°C)

To sum up:

If we assume that the comfort level for insulated and non-insulated buildings is 18°C in zones 1 and 2:

- *Partially insulated buildings could reduce heating needs by 50%*
- *Fully insulated buildings could reduce heating needs by 70%.*

Thermal insulators available in Afghanistan

Most Afghans do not presently insulate their homes. Mud, straw and earth are used in traditional architecture. Rural buildings have a natural thermal inertia adapted to the Afghan environment.

Unfortunately, modern concrete buildings are becoming more and more popular in major cities because they are robust and easily and quickly built.

Genuine modern building techniques do, however, also take account of energy issues, through their design as well as the insulation material used, whereas the new concrete buildings in Afghanistan (which do not adopt energy-efficient techniques) are uncomfortable and not adapted to the Afghan climate. Their heating and cooling systems are expensive to run and they consume a lot of energy (e.g. air-conditioning systems).

Straw:

In Afghanistan, rural homes and their surrounding walls are traditionally made of mud and straw mix. Straw serves to reinforce the wall structure. Its use is very popular but the straw proportion in the mud mix is too low to be an efficient insulator. Straw is also quite expensive, so that even in small quantities it is not affordable for everyone. Straw retailers are found everywhere in Afghanistan; it is part of the construction sector economy. Nevertheless, using straw for insulation would result in substantial scaling up of the quantities needed, which could have a major social impact given that much straw is currently used for livestock.

Glass wool:

Glass wool is known and used in Afghanistan. It is not seen as a systematic answer for internal insulation as it is in Europe. The construction sector is starting to use it for office building insulation and for domestic roof insulation.

Polystyrene:

This is becoming popular due to its very handy properties and has been used successfully during the GERES pilot project phases for health centres. It is readily available in big cities, where some companies specialize in polystyrene insulation (e.g. AEP, Yarash Huma and NCDC).

Sheep wool:

Sheep are present all over the country; their meat is very popular and part of Afghan culture. Their wool is used to make carpets, pillows and clothes. Sheep are the foundation of the local economy. Sheep wool is not much appreciated as an insulator, because its added value is low. In any event, it requires specific chemical and mechanical treatment before it can be used as a genuine, efficient manufactured insulator. GERES used it as a roof insulator in a few pilot projects. Although the experiments received good feedback from users, Afghans prefer to keep it for the carpet industry, which is much more lucrative. After having proved its potential, a social and economic study will be needed to evaluate the real development possibilities of sheep wool as an insulator.

Cotton:

This is also part of the Afghan economy, but unfortunately wars have reduced Afghan cotton production. Like sheep wool, cotton requires special mechanical and chemical treatment to become an insulator, so investment is necessary for this new industrial product. Even though some big cotton processing companies are present, production barely covers demand from the Afghan and Pakistani clothing market.

The following diagrams give a rapid overview of the Afghan insulation market.
To figure out the thermal efficiency of an insulator, it is commonly said that 1 cm of polystyrene has an equivalent insulation (thermal resistance) value of 50 cm of concrete.

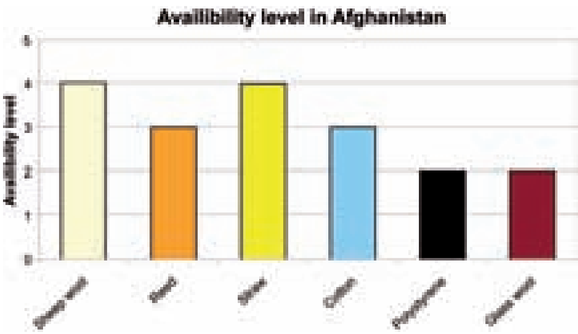


Fig 15: Insulator availability level (Kabul)

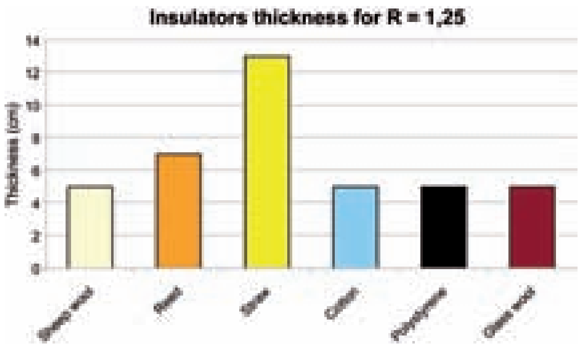


Fig 16: Insulator resistance comparison

Availability*	
0	None
1	Possible (but not developed)
2	Available in big cities (only), imported materials
3	Available in a few regions and big cities
4	Available everywhere

The prices shown do not include processing of natural materials (sheep wool and cotton). With the exception of straw, local natural materials are at least 50% cheaper than industrial ones. For similar thermal resistance, a mud and straw mix is much cheaper than 100% straw insulation. Cost is difficult to evaluate as it depends on the straw density in the mud.

The most effective insulators available immediately in Afghanistan are sheep wool, polystyrene, glass wool and recycled cotton.

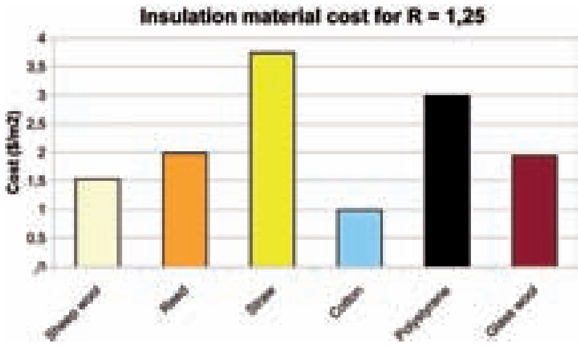


Fig 17: Insulator cost (Kabul)

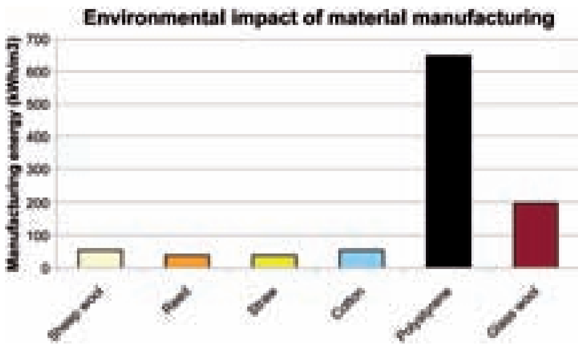
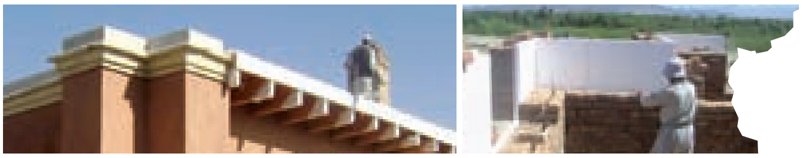


Fig 18: Insulator environmental impact

Sheep wool and straw are the most common materials that can be used as insulators in Afghanistan. Polystyrene and glass wool require a lot of energy during the manufacturing process. Their transport impact is not included in calculations; polystyrene and glass wool are entirely imported manufactured products, so their environmental impact is even worse than the values presented in previous tables.

These diagrams show that the most suitable insulators could be cotton and sheep wool if industrial processing (chemical and mechanical treatment) were available. In rural buildings, the available natural insulator is straw. Due to its cost, its use as an insulator is still limited in the construction



sector. The only real insulators currently available on the market are glass wool and polystyrene. This explains why they are mostly used in public and private buildings despite their price and environmental impact.

Main technologies to insulate buildings

The presentation below concerns only buildings renovated or built in Afghanistan with technical assistance from GERES.

Energy efficiency in buildings relies mainly on thermal insulation, but there are different types of insulation depending on the building's condition, environment, use and function. All these factors must be identified to choose the most appropriate insulation type for roof and walls.

First, we shall outline the different types of insulation for roofs and walls. Windows are mostly single- or double-glazed. If the budget permits, the use of double-glazed windows (for acoustic and thermal insulation) is obviously recommended.

Roof insulation

Roofs account for 40% of heat loss, so they are the first parts of a building to insulate. Insulation is also recommended for summer comfort, as it prevents overheating (high solar gains in Afghanistan). Most of the public buildings are of "cold roof" or "flat roof" design. In rural areas, flat roofs are common. The cold roof is the most common for public buildings such as clinics and schools.

"Cold roof" Insulation

The space between the galvanized iron sheet roof and the slab is not used or heated and is responsible for most of the thermal losses, so roof insulation is required.
This design is very practical for insulation. In fact, with this configuration, we can:

- limit the insulator surface, which is less than if we had to insulate the pitched sides of a roof;
- ensure air ventilation in summer and winter;
- facilitate insulation implementation (simply laying down insulator)

Fig 19: "Cold roof" insulation
Thermal insulation (minimum 10 cm):
(Glass wool, polystyrene, cotton, etc.)

NB: Do not cover the insulator with a tight film. Humidity (condensation coming from heated lower parts or water infiltration from the roof) will be naturally evaporated from the top.

"Flat roof" Insulation

This configuration is not present in the five pilot projects described in the guide but, as it is a design used in rural areas, we will quickly show how to insulate this type of roof.
There are two types of flat roof:

- one allowing human movement; and
- another which is not accessible to people. In this case the main constraints are solely climatic, so most of the time the roof will be covered with fine white gravel.

Insulation is always over the slab to avoid thermal shocks and dilatation phenomena.
Where people access the roof, the insulation is covered with reinforced cement concrete and flat stones or slabs.

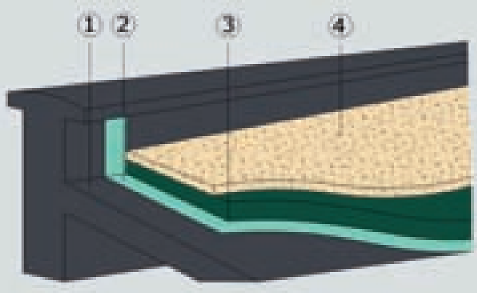


Fig 20: Flat roof insulation
1. Fine gravel 2. Insulator (e.g. XPS board)
3. Sealing 4. Cement flagstone

Wall insulation Walls account for 20% of thermal losses, so this is the second part of a building to insulate.

"Distributed Insulation wall"

This is a wall made with a substantial mass of material. Its great thickness enables the wall to withstand static, thermal and climatic stress. This technique is old and traditional (e.g. large stone or mud wall with mud plaster).

Advantages:
- Simple, single technique
- Satisfactory compromise between insulation and inertia, providing noticeably greater comfort, mainly in the hot season.
- No thermal bridges
- Good management of moisture helping to regulate condensation problems inside walls
- Variable environmental assessments according to the techniques and materials used
- Use of local materials (e.g. stone, mud and straw)

Disadvantages:
- Should be included at an early stage of the project in the architectural designs
- Walls relatively thick
- Experienced labour required
- Long implementation time and lot of labour required

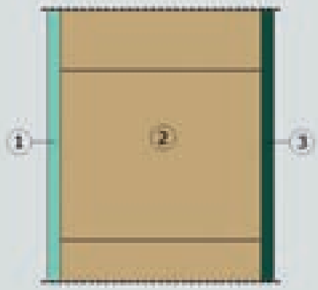


Fig 21:
Distributed insulation wall

1. External coating
2. Monolithic wall
3. Internal coating

Conclusions:

Technique adapted to rural projects with local materials available on site in large quantity, with plenty of time and labour available for construction. Good technical supervision is also necessary.

This technique is recommended for hot climates with high thermal amplitude. Due to its inertia, this technique allows for satisfactory comfort in summer.

"Double wall" with cavity Insulation

This comprises two walls (bricks, stones, concrete blocks, etc.), with the empty space between them filled with an insulator.

Advantages:
- Simple, single technique (masonry)
- Satisfactory compromise between insulation and inertia
- Good management of moisture helping to regulate condensation problems inside walls.
- Possibility of avoiding thermal bridges
- Insulator can be of mineral (industrially pre-made) or vegetable origin
- Variable environmental assessments according to the techniques and materials used

Disadvantages:
- Should be included at an early stage of the project in the architectural designs
- Experienced labour required
- Long implementation time and lot of labour required
- Detailed, accurate design required
- The internal and external wall must be linked by steel bar in order to prevent seismic effects

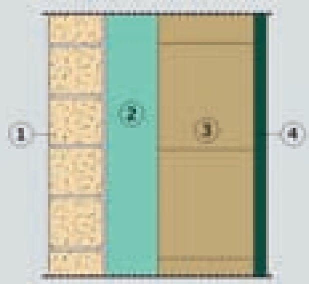


Fig 22:
Double wall with cavity insulation

1. External wall
2. Insulator
3. Ternal supporting wall
4. Internal coating

Conclusions:

A technique that requires time and labour. Good technical supervision is also necessary to check proper implementation of the insulation. This technique is recommended also for hot climates with high thermal amplitude. Technique recommended in rural and urban contexts depending on materials available on site.

"Internal wall" Insulation

Mostly used in renovation to improve the thermal resistance of the wall. Insulation is necessary to reduce sensations of cold next to the wall.

Advantages:
- Indoor air quickly heated, suitable for intermittent use (schools, offices, etc.)
- Easily implemented
- Implementation per room which facilitates expenses and planning
- Can be done in any season
- Large choice of insulators

Disadvantages:
- Vulnerability to mechanical shocks (especially in schools)
- Low inertia
- Thermal bridges not treated
- Substantial renovation work inside a building (not convenient for users)
- Structure wall is more vulnerable to thermal shocks

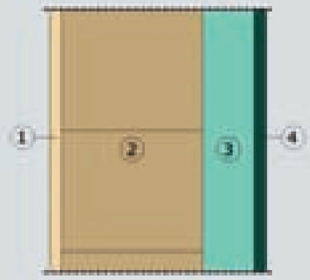


Fig 23: Internal wall insulation

1. External coating
2. Supporting wall 3. Insulator
4. Internal protection, such as cement plaster, bricks, gypsum board, wood, etc.

Conclusion:

This insulation is recommended for public buildings with intermittent occupation and "soft" use. In fact, with internal insulation, a room can be heated and cooled down very quickly (due to the walls' low thermal mass). In renovation cases, it is a common technique due to its ease of implementation. This technique has no impact on the façade architecture.

"External wall" Insulation

Used for new building and renovation, the technique is a bit more expensive than double wall, but it provides very efficient insulation.

Advantages:
- High inertia (not suitable for intermittent use)
- Thermal bridges treated
- Preserves the wall from thermal shocks (not recommended for schools)
- No internal work (building can be used during works)

Disadvantages:
- Requires trained or professional worker
- Expensive
- Manufactured insulator
- Humidity can appear (ventilation required)

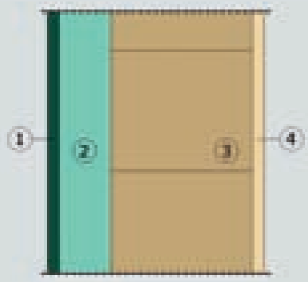


Fig 24: External wall insulation

1. External coating 2. Insulator
3. Supporting wall 4. Internal coating

Conclusion:

Due to its cost and high inertia, this kind of insulation is recommended for public buildings that are fully heated and used more than 8 hours per day with roughly constant occupation (e.g. hospitals and clinics).

Window insulation

Windows account for 25% to 35% of thermal losses in a building. There are two methods of achieving energy-efficient windows. The first is to buy double-glazed windows (Fig. 22). The second is to rehabilitate existing single-glazed windows by adding a second pane of glass sealed with silicon (diagram below). The full method for installing secondary glazing is described in Annexe 1.

Fig 25: Double-glazed window

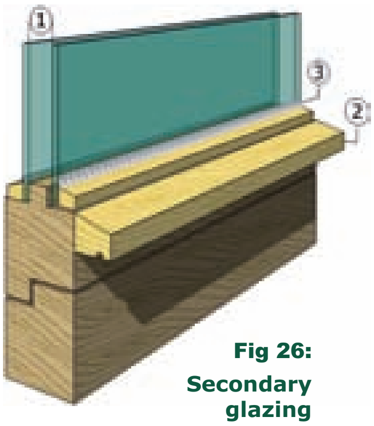


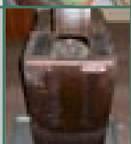
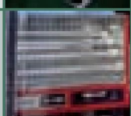
Fig 26: Secondary glazing

1. Glazing 10 to 30 cm spacing
2. Rain droplet breaker
3. Silicone joint

Heating: state of the art for public buildings in Afghanistan

In Afghanistan, central heating is still the exception. In most buildings, rooms are heated one by one using individual heaters. Even if this kind of heating is not the most sustainable and efficient, most public bodies cannot afford to invest in central heating. Individual heaters correspond to social and cultural habits; they are light, cheap and can be removed easily in summer.

Here, we will just give a quick overview of the individual heating systems available in Afghanistan.
The following table presents the most popular individual heaters by type of fuel used. Only family-type heaters are shown, with a summary of their main characteristics. This table is based on

Items	Picture	Fuel(1)	Heating system efficiency (2)	Cost per unit	Yearly energy cost in Kabul(3)
"Bukhari" Traditional wood stove (Open fireplaces with chimney)		Wood Sawdust	40-50%	$15-30	$180-200
Fuel oil/diesel stove (carburettor or "drop-in" technology)		Fuel oil diesel	50-60%	$25-180	$250-310
Gas heaters (Infrared-ceramic, blue flame with chimney, catalytic)(4)		Gas	80-90%	$30-150	$150-190$
Electricity infrared lamp		Electricity	100%	$30-50	$400-500
Combined gas electricity infrared lamp		Gas-electricity	80-100%	$90-100	$150-420
Air-air Heating cooling units "Heat pumps"		Electricity	200%-400% (COP(5) =2 to 4)	$300-600	$200- 400

(5) Coefficient of performance: this is the ratio of heat injected into the system to the work furnished by the system. For heat pumps this coefficient always exceeds 1.

Table 5: Heating systems in Afghanistan

(1) Lower cost for electricity and 100% efficiency; for quartz radiant systems, efficiency is normally around 86% because part of the energy is transformed into lighting. Infra-red ceramic electric heaters have higher efficiency (96%). For chimney stoves, efficiency has been estimated by exhaust temperature registered (450°C for diesel and wood "bukhari", 350°C for sawdust "bukhari"); CO_2 content estimated using the Siegert formula; losses due to unburnt elements and CO ratio in the smoke estimated according to results usually recorded with such poor combustion equipment.

(2) Lower Calorific Value: Diesel: 9.51 kWh/l, Kerosene: 9.5 kWh/l, Wood: 4 kWh/kg, LPG: 12 kWh/kg

(3) 4-5 month heating period, Kabul prices, 24 working days/month

(4) for LP Gas prices we need to add US$40 for the tube-regulator-13 kg bottle package.

the survey entitled “Definition of strategy for improving heating equipment offer in public buildings in Afghanistan” conducted by J.F. Rozis in March 2007.

The first point to note is the very low efficiency of some heating equipment. Unfortunately, wood “bukharis” are the most commonly used (less than 50% efficiency). The useful energy is about half of the energy used, i.e. more than 50% of the energy that could have been used is lost.

For public buildings, as shown in the previous table, we might advise the use and dissemination of mobile gas heaters on the basis of efficiency, GHG emissions and money savings. However, mobile gas stoves are expensive for most Afghans. In addition, for safety reasons, these types of gas heater have a device to shut them down when the CO or CO_2 level in the room is too high. Mechanical ventilation or efficient natural ventilation is therefore necessary to use them. Unfortunately, ventilation barely exists in Afghan buildings so gas heaters do not work properly. They shut down very often for safety reasons, so users have to restart them frequently.

We could see the attraction of dual energy infra-red gas/electricity equipment, representing the best compromise validated by genuine enthusiasm from customers during last year.

The catalytic gas mobile heater is also promising in term of energy saving and combustion quality. Its limited power of 3 kW is suitable for rooms of 10 to 30 m^2, commonly found in standard public buildings. There are some suppliers in Kabul and the price is a bit higher than infra-red gas heaters (10 to 20% higher).

The two technologies are very similar and of equal quality. As infra-red gas heating is well established and high-quality equipment is cheaper than catalytic equipment, it seems logical to recommend high-quality infra-red technology. It is extremely important to support marketing of a package for infra-red gas heaters (high-quality heater; adapted, safe regulator; and safe gas tube).

Electricity is presently quoted at a very low price for the private domestic and public sectors. For non-grid-connected buildings, it is therefore provided by generator, in which case electricity is not economically attractive (worst in terms of overall efficiency).

The price of grid electricity will be adjusted to its real cost and regularly increased in coming years. If buildings are grid-connected with a low electricity rate, heat pumps are the most efficient electrical devices. Their performance coefficient (2 to 4) is very economical and eco-friendly, but some air-source heat pumps do not work properly when temperatures fall below −5°C.

To sum up:

- *When public buildings are grid-connected, heat pumps are a good alternative to gas heaters due to their efficiency and cooling capacity (winter and summer comfort).*
- *Catalytic gas heaters are recommended in terms of efficiency, GHG emissions and money savings*
- *Wood or fuel oil heaters, even if they are very cheap to buy, should be banned due to their low economic and thermal efficiency. They are also not appropriate in terms of air quality and deforestation.*
- *Good room ventilation is required when a non-electrical heating device is installed in a room.*

Basic rules for setting up energy-efficient buildings

Part 2

What is energy efficiency?

Energy efficiency is the principle of reducing the quantity of primary energy required to perform the same service, i.e. making better use of energy whilst ensuring consistent levels of comfort.

Energy efficiency is applicable in all sectors: transport, construction, industry, agriculture, etc. Energy is required for many human activities. It is a universal concept that affects everyone's everyday life. Energy-efficient appliances are becoming more and more popular, with simple energy labels for refrigerators, freezers, ovens, stoves, dishwashers, washing machines, etc.

The car industry faces a new challenge in producing cars that emit less CO_2 and consume less petrol. Energy-efficient buildings are becoming more popular and helping to make savings on lighting and heating. Energy efficiency is also needed in industry where very large quantities of heat are lost in industrial processes; co-generation technology is one of the solutions here. (Also combined heat and power, is the use of a heat engine or power station to generate both electricity and useful heat simultaneously).

Great progress has also been made in the lighting industry, where compact fluorescent lights use two-thirds less energy and last 6 to 10 times longer than incandescent light bulbs.

Energy efficiency and renewable energy are said to be the "twin pillars" of a sustainable energy policy. Efficient energy use is essential to slowing the growth of energy demand so that increasing clean energy supplies can make deep cuts in fossil fuel use.

Why should we build energy-efficient buildings in Afghanistan?

An "energy saving" strategy must also become a priority for Afghanistan to limit energy dependency on neighbouring countries, reduce its energy bill and preserve its biodiversity.
In the building sector especially, an energy efficiency policy means:

- increasing comfort levels
- reducing energy expenditure
- generating economic and social benefits
- preserving natural resources.

The concept of energy efficiency in the building sector is therefore seen as a medium-term business strategy to save money and natural resources in the long term.

Increasing comfort levels

Because budgets are limited, comfort requirements are not the same when building schools, health centres and army facilities.
As we have said, comfort standards are much lower in Afghanistan than developed countries, meaning that an energy-efficient building can reach Afghan comfort standards with much lower fuel consumption.

Clinics (daily or 24/24 hrs)

In Afghanistan, clinics are partially heated (some rooms only). They are not heated constantly and temperatures are not consistent (ranging between 5°C and 15°C, sometimes less). Energy-efficient clinics have a higher indoor average temperature for the same amount of fuel use (at least +5°C). This also helps to get a more even temperature throughout the building. Even now, in a new fully insulated clinic, the low maintenance (heating) budget and inefficient heating devices make it impossible to reach a satisfactory level of comfort (18°C).

Schools

Most schools are unused in winter (December to March) because they are unheated (and so unusable). We may imagine therefore that improving their energy efficiency and comfort will allow school buildings to be used for longer. Instead of closing for 4 months in winter due to the cold, it is planned to close them for only 2 or 3 months. Moreover, in the rural areas, school premises may be used for other public purposes (community meetings, night lectures, etc.), in which case they could be heated. Increasing the period of use and options for use is an additional reason to opt for full building insulation.

Where the budget is very limited, inconsistent with complete energy renovation, efforts could be focused on designing for summer comfort rather than complete insulation for winter. Anyway, even for "non-winter usage" buildings, roof insulation is required to minimize temperature differences between different parts of the building. It also reduces the average indoor temperature in summer.

Army facilities

These facilities have a higher budget for heating and are now heated and cooled using heat pumps. The thermal insulation applied in these buildings makes it easier to manage energy resources (size of the heating and cooling system, size of the generators). It also helps to raise the temperature of walls and the roof surface, which has a positive impact on comfort.

Air quality

In Afghanistan, diesel, wood and poor quality heating devices ("bukharis", 3-stone open fires, gas heaters, etc.) used for heating buildings are responsible for poor indoor air quality and respiratory illnesses.

Users' comments

Mr. Mirza, Chief Engineer of Ibnsina Sar-e-pul Health Centres explains that: *"The effects of rehabilitation have been noticeable; double glazing is especially appreciated in delivery rooms".*

Spontaneously, Abdul Samat, a laboratory assistant who used to work at the health centre, came to congratulate us for the comfort our rehabilitation had brought.

Dr. Feda Paykan, IbnSina provincial director, recently declared that, in certain rooms of insulated buildings, a "comfortable" temperature was possible without a stove.

Reducing energy expenditure

Fuelwood prices in Kabul have multiplied by 5 between 2001 and 2007. Inflation like this has substantial repercussions on the heating budget for public buildings. Most of the time, it means that public buildings are poorly heated, hampering quality of service and comfort level. It also confirms that not much saving can be made on operating costs for heating. In fact, public institutions spend the totality of their heating budget but are not really able to heat their buildings properly (15 to 18°C). Heating needs (fuel consumption) are not established in terms of the level of comfort but rather the "heating budget" allocated per building. So an energy-efficient building will achieve a higher level of comfort (+5°C) rather than generating savings on the heating budget in comparison with a conventional one.

However, energy is the only expense that can be reduced amongst conventional operating costs. At the moment, savings cannot be made for the above-mentioned reasons. However, over the lifespan of a building, if we suppose a higher level of comfort due to cheaper and easier access to energy in the coming years, then thermal insulation will have a direct effect on operating cost savings.

In theory, if conventional buildings were heated at 18°C, energy-efficient Comprehensive Health Centres (CHC) could save up to $3500/year in energy costs (around 10% of total operating cost). Energy efficiency techniques are cheap (12% overcost), efficient (up to 70% energy savings) and simple to implement in new buildings. Significant savings and lower CO_2 emissions from heating public buildings will therefore be achieved once Afghan standards of comfort are reached (15° to 18°C).

If we assume the same level of comfort for insulated and non-insulated buildings, we can estimate that:

- The payback time for new partially insulated buildings is around one year anywhere in Afghanistan (at 18C°).
- The payback time for fully insulated new and partially insulated rehabilitated buildings is less than 5 years (at 18°C°).

Generating economic and social benefits

Implementing energy-saving techniques and putting new materials and equipment on the market offer an opportunity to create new jobs and develop small and medium enterprises. Energy and wood savings can be invested in labour and the local economy. Moreover, better indoor comfort means that more rooms can be used or the use of some buildings in winter can be extended. Therefore, social or economic activities become possible during this period: schools can stay open longer, patients can benefit from better conditions for recovery at health centres, offices can improve their activities and so on.

Buildings fitted with thermal insulation between 2004 and 2009 have created a market and job opportunities for some Afghan companies (refer to Annexe 3). Some companies have developed their own insulation techniques and are now specialists in this area (e.g. MSCC, Yarash Huma, Network of Construction and Development Companies (NCDC), Ansari Engineering Products and Services AEP). Moreover, foreign companies (e.g. STO) are also interested in the insulation market in Afghanistan which generates income for Afghan contractors and creates new jobs.

It is difficult to identify and evaluate the real social and economic (jobs and income creation) impact of energy efficiency practices in Afghanistan at this stage. However, a demand from institutions has clearly been created and a new dynamic has been launched in the building sector.

Preserving natural resources

CO_2 emissions

Virtually all scientists now agree on the unprecedented global warming phenomenon that is taking place at an accelerated pace. Human activities, particularly with the industrial revolution and the economic boom, have increased and are still increasing emissions of greenhouse gases (GHGs): water vapour, CO_2, methane and nitrous oxide. Most of these emissions are due to the high level of energy consumption derived from burning fossil fuels such as oil, coal and natural gas (combustion producing CO_2). The increasing volume of GHGs is causing more energy to be returned to the earth. The greater concentration of GHGs is therefore a major factor behind the climate change now being experienced.

It can be stated today with certainty that climate warming will continue and that it will have a major overall impact on the planet, with its manifestations varying considerably according to the area involved. Future risks firstly relate to the continued rising of the earth's temperature and of the sea level. The rise in temperature and changes in precipitation patterns will have a heavy impact on ecosystems. Biological diversity will be threatened. Climate zones could move vertically towards the poles, disrupting forests, deserts, prairies and other ecosystems. Deserts and other arid regions could be subject to even more extreme climatic conditions; some mountainous zones would be affected (displacement of species to higher altitudes because of the warmer temperatures). Alterations are expected to affect the ice cover of Greenland and Antarctica, shorelines and coral formations. The frequency and intensity of extreme weather events will increase (thunderstorms, flooding, cyclones, etc.).

Energy efficiency spares some CO_2 emissions and helps to reduce the impact of human activities on global warming. Reduction of CO_2 emissions is directly calculated from fuel consumption. If we assume the same level of comfort for insulated and non-insulated buildings:

- Partially insulated buildings reduce CO_2 emissions by 50%
- Fully insulated buildings reduce CO_2 emissions by 70%
- In the coming thirty years, the comfort level in Afghanistan buildings will hopefully increase, so CO_2 saving will increase at the same time in insulated buildings.

It is estimated that an average Afghan emits 1.2 tons of CO_2 per year, which breaks down as follows:

- 1 ton resulting from burning wood for heating and cooking
- 0.1 ton emitted by burning kerosene/gas
- 0.1 ton from using electricity.

Deforestation

As fuel becomes more expensive, people are using the biomass they can find. This is closed-circle logic for which forests are paying the price. Between 1990 and 2000, Afghanistan lost an average of 29,400 hectares of forest per year. The amounts to an average annual deforestation rate of 2.25%. In total, between 1990 and 2005,

Afghanistan lost 33.8% of its forest cover, or around 442,000 hectares 21. To conclude, Riaz Rameen, GERES Engineer in Kabul, said at the "International workshop on energy" at AEI headquarters in Paris on July 2008: *"Afghans are cold in winter, they have no resources, so they have to burn their forest even if they love it"*.

Energy efficient systems using electricity or gas can help to reduce deforestation, but these systems are limited to owners who can afford this technology and its running costs (gas and electricity bills, maintenance). One example is the fitting of heat pumps in 237 Afghan National Army buildings in place of wood-burning "bukharis". Unfortunately, no solution has been found at this point to disseminate energy-efficient wood-burning stoves widely in Afghanistan.

To sum up:

Currently, savings on budgets and CO_2 emissions (deforestation) in insulated buildings in Afghanistan are non-existent or barely measurable. However, comfort has certainly increased (+5 to 10°C) for the same amount of fuel used. Savings and lower CO_2 emissions from heating public buildings will be achieved when Afghan standards of comfort are reached (15° to 18°C). Then, savings will be made in insulated heated buildings as shown below. Energy efficiency is also a factor of job creation and generates local economic activities in the construction sector.

Basic rules for setting up energy-efficient buildings

Most of the recommendations below do not induce overcosts if they are integrated right from the beginning. The following suggested concepts can be implemented at the start-up stage of a project. Energy efficiency techniques are cheap (12% overcost, mostly insulation), efficient (up to 70% energy savings) and simple to implement in new buildings.

The passive solar concept

The sun is higher in the sky in summer than in winter. In summer, most of the solar radiation is picked up by the roof.

During winter, the south face picks up the largest amount of solar radiation: the sun warms the east face during the morning, at midday the south face is exposed to solar radiation and during evening time the west face picks up the sun's energy. The north wall is always in the shade.

The sides of a building that are exposed to the sun gain heat during the day, while the other sides in the shade lose heat. Rooms located on the south side of a building are more suitable for heating by solar energy than those located on the north side. The collection of a large amount of solar radiation is sometimes enough to warm the inner space of a room during the day and the night. However, although the collection of solar radiation warms the space while solar radiation is being absorbed during the day, as soon as this absorption stops at night, the rooms may become cold.

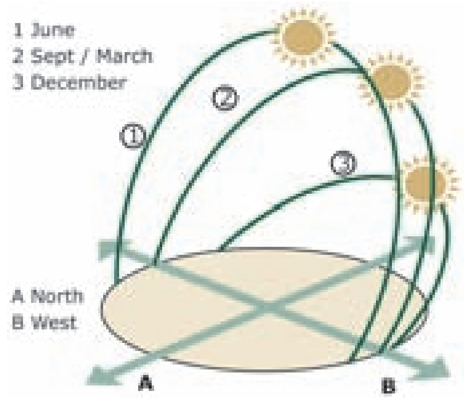


Fig 27:
Course of the solar year

The concept: "Gain energy from the sun, minimize heat losses"

In addition to the collection of solar radiation, three other components are required, and these four inter-related components work together to make the building an efficient user of energy:

Main points:

- collect the maximum amount of solar radiation during the day
- store the heat collected from the sun's rays during the day
- release this heat to the interior of the building during the night
- insulate the whole building to retain as much heat as possible in the building.

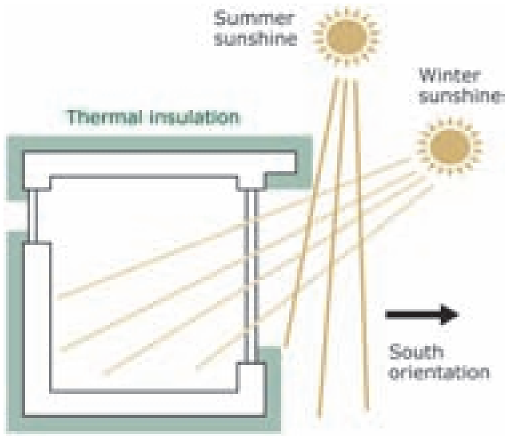


Fig 28: Solar architecture concept

South orientation of the building

- The implementation site must receive sun from 9 a.m. to 3 p.m. (solar time) to justify passive solar architecture design.
- The wide face of the building will be oriented directly South. This orientation will also help to keep the building fresh in summer.

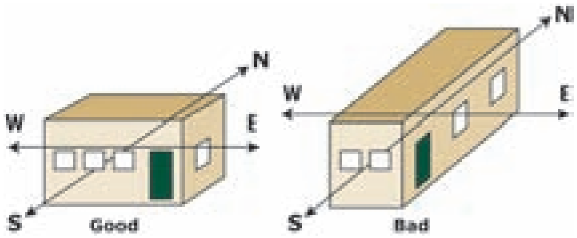


Fig 29: Building orientation

The building is oriented south. A deviation of up to 15° East or West from South is permitted.

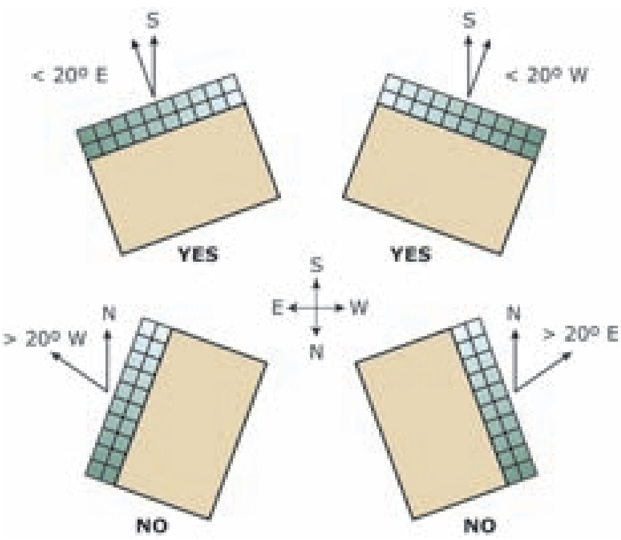


Fig 30: Building orientation

Remarks:
As some buildings such as schools and Basic Health Centres are used mostly during the day, the South face can be oriented about 10 to 15 degrees East to capture early sun energy in the morning. On the other hand, buildings which are also used at night, such as hospitals, can have South orientation up to 15 degrees West, so western sun can penetrate efficiently and therefore keep the building warm throughout the night.

Site: protect from shading

The presence of obstructions can significantly reduce the amount of sunlight reaching a building and therefore limit the passive solar benefits.
Two types of obstruction can be distinguished: distant and nearby.

- Distant obstructions are mountains or landscape.
- Nearby obstructions are buildings, trees, etc.

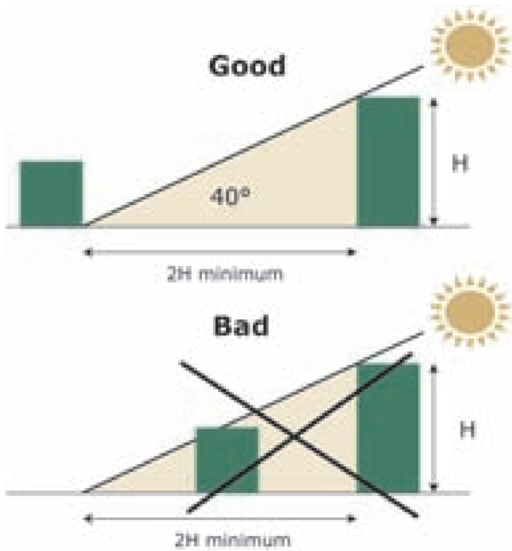
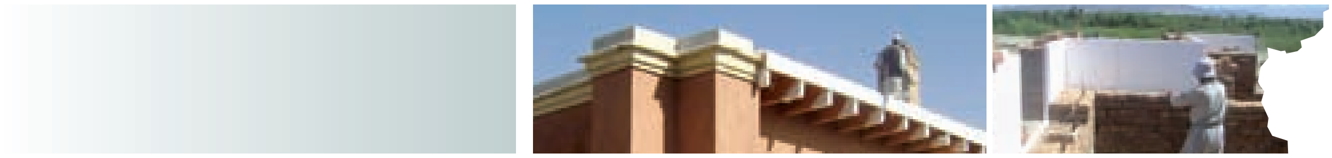


Fig 31: Example of a nearby obstruction

NB: There is a quick way of checking whether a nearby obstruction will have a significant effect on the amount of sunlight reaching a building to be retrofitted: The nearby obstacle should be at least at twice its height away from the building in question.



Landscape protection

- North side protection from wind with landscaping, buildings, vegetation, etc.
- Sun protection with seasonal vegetation on the south side
- Storage rooms on the north side

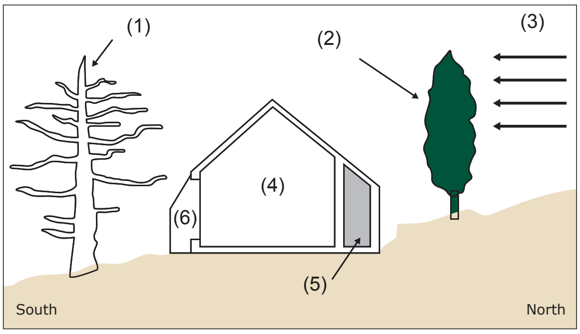


Fig 32: Land protection

1. Seasonal vegetation 2. Persistent vegetation 3. Wind 4. Heating space 5. Storage space 6. Veranda

Building shape: asymmetric and compact

- High, wide South face with windows to allow maximum solar gains
- Small North face to reduce heat losses
- Minimize indentations to reduce heat losses

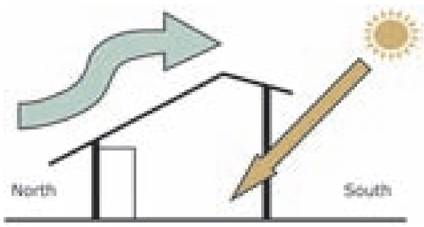


Fig 33: Building shape diagram

The following diagram gives examples of suitable building shapes:

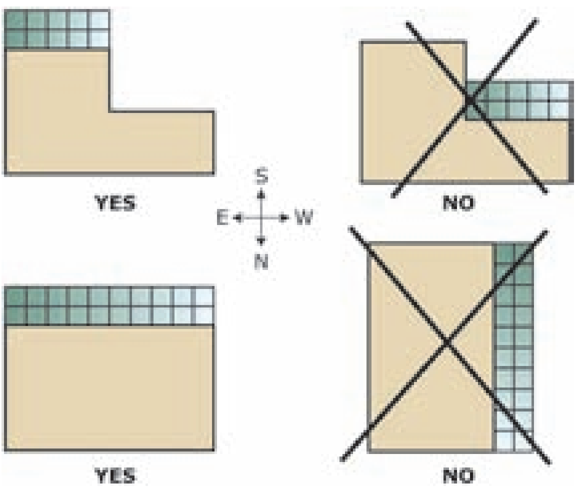


Fig 34: Suitable building shapes

Room layout

All "living" rooms or "main" rooms should be on the south side: these rooms will provide more comfort in terms of heat and light.
Others rooms needing less heating and comfort can be on the north face, operating as a buffer space.

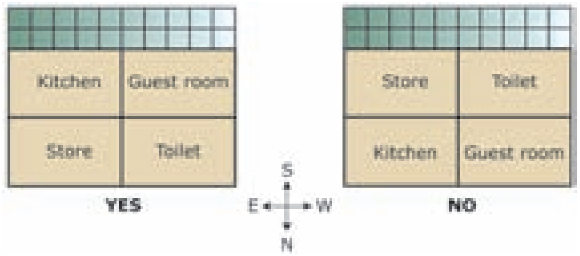


Fig 35: Concept of room layout

Roof overhang

The roof overhang has to be sized to limit solar radiation penetration in summer, but not in the winter. For example, 50 cm roof overhang width is needed in the Kabul climate, while this roof overhang has to be limited to 30 cm only in very cold climate areas.

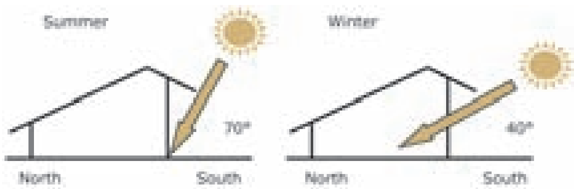


Fig 36: Roof overhang principle

- Protect from sun in summer
- Allow the sun's rays to get in during winter

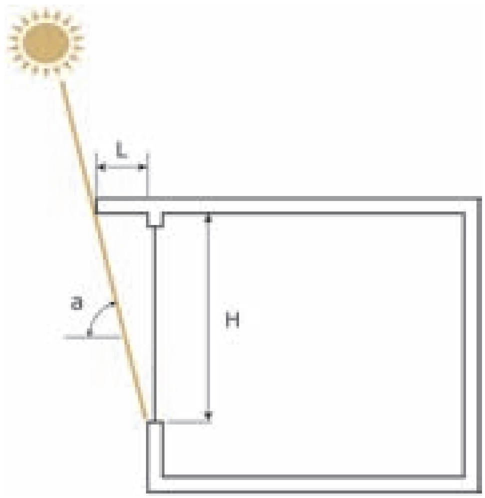


Fig 37: Roof overhang design

L= 30 to 50 cm

Thermal inertia

Heavy materials (e.g. stones, mud and bricks) inside the southern parts of the building store heat during the day and release it at night. Material mass plays the role of energy storage. This mostly concerns floor and wall materials.

This thermal inertia should be adapted according to the building's usage:

- if the building is used during the day only, thermal inertia should be low to be able to take advantage of solar heat immediately
- if the building is used day and night, thermal inertia should be higher to store enough heat during the day to release in the night.

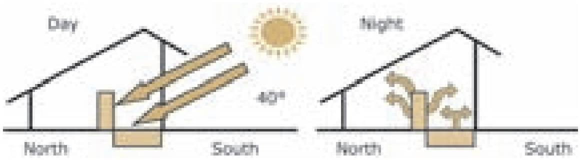


Fig 38: Thermal inertia principle

Large south-facing windows

The south face is a net energy provider while the other faces lose energy. Therefore, solar architecture designs provide large windows on the south face. Small windows on other faces are sufficient to allow natural light penetration. Moreover, if the room usage allows it, windows should be avoided on the north face.

South-face window ratio

The appropriate area of glass is determined according to the living floor area of the building. It is characterized by the **x ratio**: the glass area divided by the floor area of building living space.

$$x = \frac{\text{Glass area of the building face } (m^2)}{\text{Living floor area } (m^2)} = 0.16 \text{ to } 0.18$$

Orientation	Window area ratio
South	Around 60%
East	10 to 20%
West	10 to 20%
North	Around 5%

Table 6: Window distribution around the building

Double glazing

The air layer trapped in between two sheets of glass typically improves thermal insulation by 40% compared with a single-glazed window. The transmission coefficient (K) expected is 2.9 W/m² K. It also provides better acoustic insulation.

As previously explained, two techniques of double glazing are possible: secondary glazing assembled on site, for renovation on existing windows, and double glazing, in the event of new window installation, which is assembled and sealed in factory (then the complete window can be brought on site) and is condensation-proof. Most assembled double glazing can be mounted on PVC, aluminium or wood frames.

Good quality PVC frames are as strong as aluminium but provide better insulation. PVC and aluminium frames have the great advantage of having rubber seals to keep the frames dust-proof. Windows may be left open when ventilation is needed, meaning that occasional sudden air draughts can sometimes cause glazing breakage. To avoid this, a blocking mechanism should be available to keep the windows in the open position.

Insulation types

All components of a building such as windows, doors, walls, roof and foundations should be insulated. For a single-storey building:

- 30 to 40% of heat is lost through the roof.
- 25 to 35% of heat is lost through windows
- 15 to 20% of heat is lost through the walls
- 15 to 20% of heat is lost through thermal bridges
- 5% of heat is lost through the floor
- 5% of heat is lost through the natural ventilation of the building

Two main types of insulation:

- **Internal insulation:** Walls, roof and floor are insulated from inside the building
- **External insulation:** Walls and roof are insulated from outside the building

External insulation is recommended for public buildings with permanent occupation (24h/24h).

Insulation type	Advantages	Disadvantages
Internal	• Easy to implement	• Mechanical and thermal shock vulnerability for the wall • Thermal bridges not treated • Disturbs building occupation
External	• Thermal bridges treated • High energy efficiency • Prevents wall thermal shock • No disturbance of building's activity during implementation	• Unknown in Afghanistan, training is required • More expensive than internal techniques

Table 7: Insulation types

Thermal resistance recommendations for public buildings

The following table shows the recommended thermal resistance for new buildings whatever the insulation technique and insulators chosen.

Altitude	Minimum polystyrene thickness (CM)	R (m^2 k/W) Thermal resistance coefficient required
Below 1000 m		
Walls[(1)]	5	1.75
Roof[(2)]	10	3.2
Floor[(3)]	No specifications	No specifications
From 1000 m to 2000 m		
Walls[(1)]	10	3
Roof[(2)]	15	4.46
Floor[(3)]	Insulation layer required	Insulation layer required
Above 2000 m		
Walls[(1)]	10	3
Roof[(2)]	20	5.71
Floor[(3)]	Insulation layer required	Insulation layer required

Table 8: Thermal resistance and insulator thickness

(1) ***Walls:*** *For R calculations, we assumed that they are 36 cm thick, made of cooked ricks (1 1/2 brick) covered by cement plaster insulated with the appropriate thickness of polystyrene.*

(2) ***Roof:*** *This is a traditional roof made of mud and soil (10 cm) supported by wooden planks insulated with the appropriate thickness of polystyrene.*

(3) ***Floor:*** *Insulation layer recommended is 10 cm polystyrene (35 kg/m^3). R for the floor is hard to determine without any information about ground conditions and the floor design.*

NB: Polystyrene is used here as an example for ease of reference. Other insulators could also be used depending on site conditions.

Basic rules for ventilating buildings

Part 3

Why should we refresh indoor air?

Building ventilation consists of changing indoor air which becomes polluted due to building usage: occupants' breathing, activities, cooking, etc. Ventilating a building is necessary for the following reasons:

- Oxygen renewal
- Evacuation of room humidity
- Reducing air pollution and improving air quality (elimination of odours, smoke, etc.)

As in the case of heating systems, systems to renew indoor air can be "passive" or "active":

- passive means that ventilation is done naturally without any energy requirement
- active means that ventilation is ensured by a mechanical system such as a fan or extractor.

Considering the current situation in Afghanistan, most buildings are not supplied with electricity continuously. Furthermore, implementation and maintenance of an active ventilation system requires specific skills which are still not readily available there.

Therefore, active systems would be considered only in a few particular cases, while passive systems should be preferred in most cases.

Natural ventilation

Description

Natural ventilation is recommended for old buildings with stove heating systems. Natural ventilation consists of ventilation without any mechanical (or electrical) ventilation systems. There are three ways to ventilate an old building:

- Open windows many times per day (1 to 3 min. per opening)
- Thermal chimney (using natural convection and wind) or natural cross-ventilation (Fig. 45)
- Lack of building permeability can provide partial ventilation.

Main implementation rules

Opening windows:

This option is very simple and very efficient but requires users' awareness (which can be promoted through information posters or stickers).

- 5 minutes twice a day: for example, while opening curtains in the morning and closing in the evening
- 3 minutes 3 times per day: morning, noon and afternoon (after meals)
- to lose less heat, windows may be opened for longer but only when the sun is shining: 15 minutes at noon for example.

Specific windows can be adapted for this application:

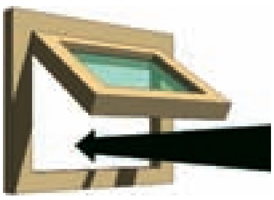


Fig 39
Outward opening windows provide efficient rain protection

Fig 40
Outward vertical opening windows can channel the wind

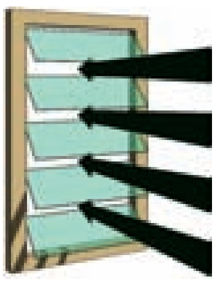


Fig 41
Leaf windows improve air diffusion

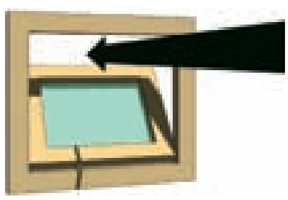
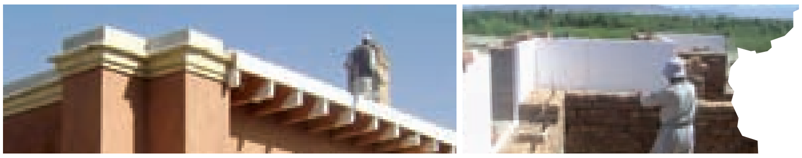


Fig 42
Inward opening windows can channel outside air towards the roof



Natural draught ventilation:

This technique is difficult to design but, when it is installed, nothing is needed to run it and it works alone. Natural ventilation can be vertical or transverse.

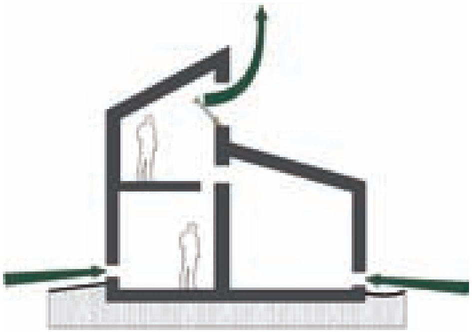


Fig 43 Vertical ventilation

Fig 44 Transverse ventilation

Air entry:

Grids must be on the outside walls of a building's main rooms. Grids should be located above windows or at the bottom of walls. On walls, square grids must not exceed 20 cm width. Air entry grids must remain clean and unobstructed. Air must circulate between rooms by transfer grid or air gap (at the bottom of inside doors for example).

Air extraction:

Grids should be situated as high as possible close to the ceiling in the most polluted rooms (such as toilets, kitchen and bathroom). On walls, square grids must not exceed 20 cm width. Air entry grids must remain clean and unobstructed.

For greater comfort, thermal chimneys with exhaust on the roof are advised (fig. 46). Grids should be situated in the ceiling or on the chimney side inside the room. Different kinds of chimney outlet are possible (Fig. 47).

- The chimney must be at least 2.5 m high and at least 40 cm above the roof
- The chimney section must be around 20 cm
- Outside exhaust grids must be covered for rain protection
- Each ventilation grid must have its own pipe
- For (single) bathrooms and toilets, a manual opening system for air extraction is advised.

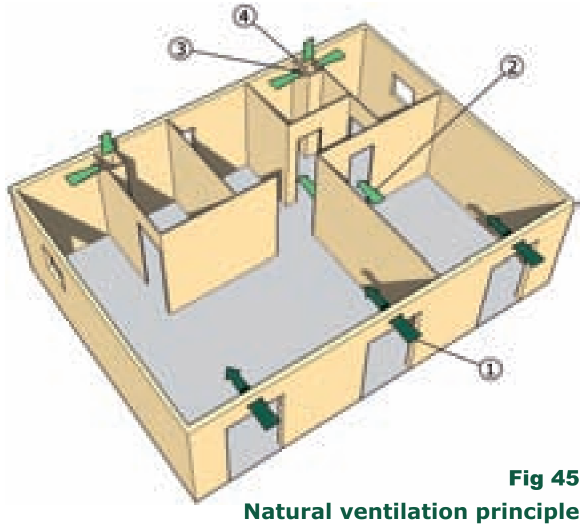


Fig 45

Natural ventilation principle

1. Air entries 2. Air circulation paths
3. Air extraction (damp rooms)
4. Thermal chimney for polluted air

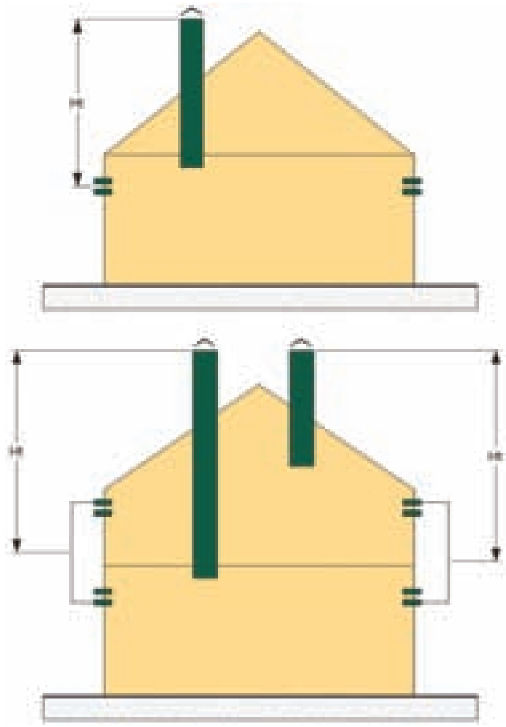


Fig 46 Thermal chimney layout

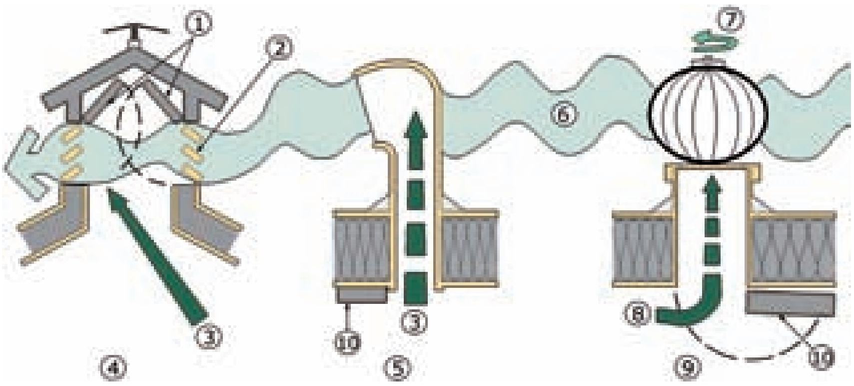


Fig 47 Different kinds of chimney outlet
1. insulating flaps 2. wooden slats 3. hot air 4. static
5. elbow shaped 6. breeze 7. rotation 8. extraction 9. rotatable 10. flap

Building permeability/leakage:

This is not a genuine ventilation technique, but it should be considered that, in the case of old or damaged buildings, air permeability is high and results in significant air flow. This flow will not be enough to renew inside air completely but will greatly contribute to ventilation.

Therefore, in such low-quality buildings, ventilation could just be supplemented by opening a few windows. (Cf. § Opening windows)

Controlled mechanical ventilation

Description

For new buildings with continuously available electricity, controlled mechanical ventilation is recommended especially in public buildings. Mechanical ventilation means that fresh air enters from the outside through a grid, while an electric fan extracts stale air from inside to outside. "Hygro-adjustable" ventilation is an efficient and independent regulation system. Airflows in entry and extraction grids are regulated by the humidity level in rooms.

Air extraction grids are all connected by air ducts to one main fan. The polluted air is extracted on the roof. This mechanical regulation means that fan motor speed can be reduced depending on room needs. The system reduces thermal losses by a factor of two to four in comparison with non-regulated mechanical ventilation. Electricity consumption required to run the system is also divided by two or three in comparison with classic mechanical ventilation.

This system is particularly recommended for buildings that are not constantly occupied (e.g. schools). In fact, the fan motor would be shut down and air grids closed if nobody is in the rooms. (Figs. 48 and 49)

Main implementation rules

Air entry

Grids must be on the outside walls of a building's main rooms. Grids should be located above windows or at the bottom of walls. On walls, square grids must not exceed 20 cm width. Air entry grids must remain clean and unobstructed.

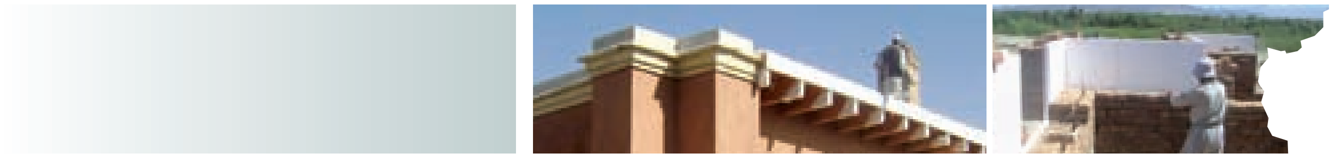
Air extraction

Grids should be situated as high as possible close to the ceiling in the most polluted rooms (such as toilets, kitchen and bathroom). On walls, square grids must not exceed 20 cm width. Air entry grids must remain clean and unobstructed. Air must circulate between rooms by transfer grid or air gap (at the bottom of inside doors for example).

Important

- *Electricity must be available during occupation of the building*
- *This type of system has to be installed by a specialist who will also take care of maintenance*
- *If a stove system is the main heating source for the building, a specialist must adapt the system*
- *In renovation, the same system is available without air ducts. The system is not centralized. Each extraction grid has its own small fan (fig. 50)*

In conclusion, this kind of installation would be used only for a few specific pilot projects in Afghanistan.



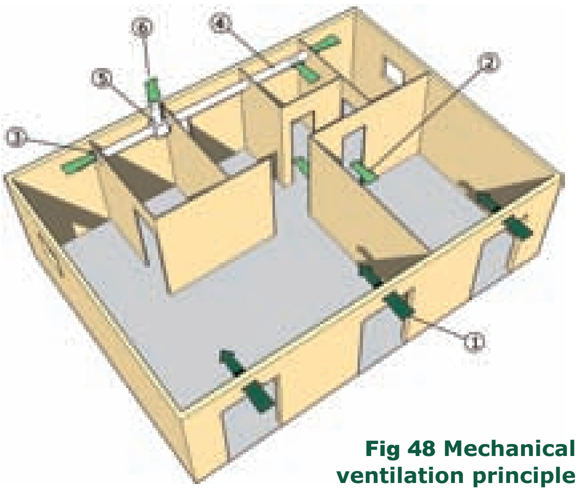


Fig 48 Mechanical ventilation principle

1. Hygro-adjustable grids (air entry)
2. Air circulation paths
3. Hygro-adjustable grids (air extraction
4. Air duct 5. Extraction block (motor)
6. Polluted air evacuation

Fig 49 Hygro-adjustable ventilation kit (three hygro-adjustable grids, one extraction block)

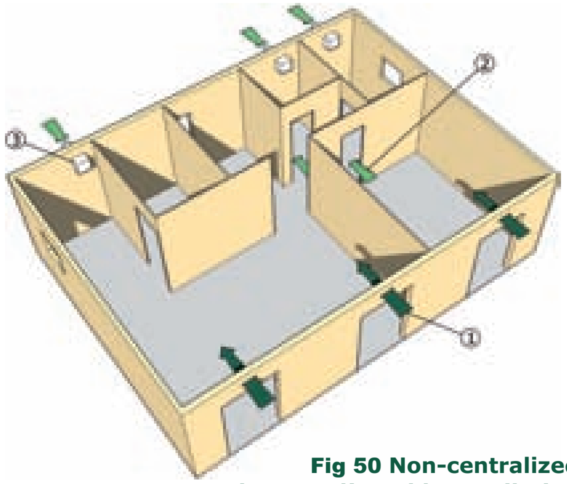


Fig 50 Non-centralized hygro-adjustable ventilation

1. Hygro-adjustable air entries 2. Air circulation paths
3. Motorized hygro-adjustable air extraction grids

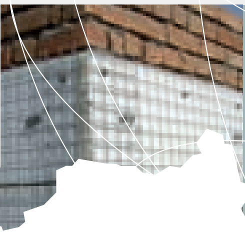
Summary

Building type	Situation	Recommended ventilation
Old or low quality (high permeability)	No rehabilitation	Air leakage + opening a few windows
	Rehabilitation	Window opening technique
Recent	No rehabilitation	Air leakage + opening a few windows
	Rehabilitation	Window opening technique Natural draught ventilation
New	Construction	Natural draught ventilation
New (pilot project)	Construction	Controlled mechanical ventilation

Table 9: Ventilation indicators summary

Important

- *Where rooms are occupied by lots of people (such as classrooms), entry and extraction grids must be in the same room.*
- *For multi-storey buildings, entry and extraction grids must be fitted on each floor.*



Implementation of five public building types

Part 4

This section describes five typical "energy efficiency" projects implemented in five kinds of building with various contexts, specific budgets, partners and uses. Architectural plans are provided in annexes. Implementers and contractor details are also available in specific lists. More information can be provided by the partners involved in each project.
The following table gives a quick overview of the five projects:

Project type	New			Rehabilitation	
Picture					
Name	Bioclimatic school	Standard clinic (double wall)	Standard school	Health clinic	ANA Military Barrak
Fonction	Rural school	Rural clinic	Urban school	Urban clinic	Army Dormitory
Location	Istalif District, Khoja Hassan Village	Paktia province, Gardiz district, Spahi khill village	Afshar school, Kabul, district 5	Kabul, Airport road	Mazar-e-Sharif
Insulation type	Insulated (Roof, wall, windows)	Insulated (Roof, wall, windows)	Semi insulated (Roof, windows)	Insulated (Roof, wall, windows)	Insulated(Roof, wall, windows)
Heating device	Integrated stove walls	Bukharis/wood gas stove	None	Central heating fuel	Electrical heating and cooling units (A/C heating pumps)

Table 10: Typical energy-efficient pilot buildings

The chapter comprises a technical presentation of the five main building types. A table shows the main features of each project with its respective insulation technical sheets. A critical analysis is made of each building's context, design, orientation, insulation and chosen heating system.

Technical sheets present the principal characteristics of each specific insulation system with a comprehensive "step-by-step" implementation diagram.

The technical sheets on wall insulation are:

- Earth and straw wall (Technical sheet W1)
- Double wall (W2)
- External Polystyrene System Wall (W3)
- Sto wall (W4)

The technical sheet on roof insulation is:

- "Cold roof and glass wool (R1)

Project 1: Bioclimatic school

Context

Following a thermal insulation operation involving ten schools in Kabul, the MoE asked GERES to develop solutions for a bioclimatic design suitable for rural areas using natural local materials. About 80% of the school construction programme is being implemented in rural areas. TMF had developed technical knowledge of construction using local materials. The design of a new standard and its implementation has been possible thanks to the involvement of TMF and its architect Graham Hunter.

Design

The MoE asked for a design developed on the basis of a standard 3-classroom school for rural areas. This design, widely implemented in Afghanistan, involves building schools using raw clay construction techniques. GERES, the MoE and TMF agreed on a design of two blocks of two classrooms, each one facing south and reinforced for earthquake resistance.

Orientation (cf. Annexe 4)

The building is to be oriented south-east (10° to 20°) to get early morning (south side) sun in classrooms. This also avoids overheating on summer afternoons (the South face will be in the shade earlier). For ultimate comfort in the building, its occupation must therefore be planned taking account of these remarks.

Insulation (cf. Technical sheet W1)

Full insulation has been implemented (wall, roof and windows) using the "distributed insulation" technique (cf. Part I, Insulation: state of the art). The insulation technique is based on the substantial mass and high thermal inertia of the materials used (mud, clay and straw). Because of this high inertia, the technique provides particularly good summer comfort. This technique is recommended for hot climates with high thermal amplitude. It is suited to rural contexts due to the availability and low cost of such materials. A large, low-cost labour force with good supervision is necessary.

Heating system

Two integrated stoves will produce the heat required for the building. Wood and charcoal can be used as fuel. As the drawings and plans show, stoves constitute internal walls between the four rooms. Hot smoke circulates inside the wall and diffuses heat into rooms. This configuration is much more efficient that conventional "bukharis" or individual heaters (cf. Part I, Heating: state of the art) mainly due to the thermal mass of the stove and the longer distance to the smoke outlet.

Khoja Hassan school


New	Bioclimatic School
Location	Khoja Hassan Village, Istalif district, Kabul province
Climate zone	2
Rural/urban	Rural
Use	Secondary school (4 classes = 150 children)
Building cost	US$46,000 (not finished)
Floor surface	213 m²
Floors	Single storey
Donor	TMF and GERES
Implementer	Local community supervised by TMF, GERES and MoE (cf. Annexe 2)
Owner	Ministry of Education (MoE), Islamic Republic of Afghanistan (cf. Annexe 2)
Thermal insulation	Roof: mud and straw block + cotton on one classroom
	Wall: mud and straw blocks (cf. W1 + Annexe 5)
	Foundation: (cf. Annexe 6)
	Windows: Wood, double glazing (cf. Annexe 7)
Thermal insulation cost	The thermal insulation cost is included in the building cost. Mud and straw are both construction and insulation materials.
Orientation	South-East
Heating	Integrated stove (cf. Annexe 5)
Detailed plans	Floor plan, elevation South, Vertical section (cf. Annexe 4)

Main advantages: Made with free, locally available materials (mud and straw). Job creation for the community. The insulation is fitted in accordance with traditional Afghan architecture and knowledge. Training has been provided to the community and good overall community involvement has been seen.

Main difficulties: building follow up, knowledge transfer (both directions), expensive if natural materials are not available on site.

Table 11: Bioclimatic School


Project 2: Afshar school

Context

In April 2007, the MoE asked GERES to improve energy efficiency in 10 ongoing school construction projects. In order to compare various kinds of improvement solutions for standard design schools, it was proposed to improve two schools with full insulation, one of them with external wall insulation and the second with internal insulation. The eight other schools were treated with roof insulation and efficient windows only.

Some of the insulated schools have two floors and their orientation varies. Following a comparative study on the comfort and usage of these schools during spring and summer 2008, it appears that roof and window insulation is the most pragmatic and useful improvement on existing design. In this case schools are not used during the winter, so the main issue for comfort was in summer when the temperature in classrooms can go very high due to hot weather and pupil density (more than 40 per class).

Design and orientation (cf. plans, Annexe 8)

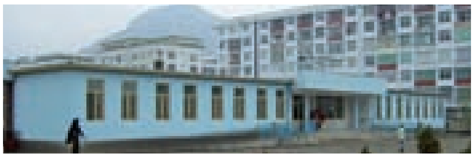
The comfort survey revealed that the standard design is not adapted to the Afghan context and school requirements. Due to the design with classes on both side of the corridor, if the building is oriented south/north, classes on the north side are too cold and the south ones are too warm. If the building is oriented east/west, classes on the west side cannot be used during afternoons in summertime due to overheating (sun). With this design, users mostly complained of a lack of access to water, no rest room (staff and teachers) and no private toilets for teachers. A more suitable design would be a multi-storey building with the corridor on the north side and all classes facing south (or south-east) with window overhang or solar protection.

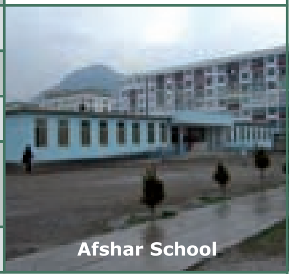
Insulation (cf. technical sheet R1)

As already stated, schools are not heated and not used in winter in Kabul so roof insulation with double glazing (semi-insulated option) could be sufficient to improve summer and acoustic comfort. As buildings are not heated and not used, wall insulation does not improve comfort in a significant way during mid-seasons and winter. Wall insulation is therefore not cost effective (fuel savings). Investment should be devoted to bioclimatic design (mentioned above).

Heating systems

There are no heating devices in "standard design" schools located in Kabul.

New	Afshar School	
Location	District 5, Kabul, Afghanistan	
Climate zone	2	
Rural/urban	Urban	
Use	Girls' public primary school Eight classrooms (300-400 pupils)	
Building cost	US$90,000	
Floor surface	600 m²	
Floors	Single storey	
Donor	Ministry of Education (MoE), Islamic Republic of Afghanistan	
Implementer	Itifaq Faqiri Construction Company (IFCC) (cf. Annexe 3)	
Owner	Ministry of Education (MoE), Islamic Republic of Afghanistan (cf. Annexe 2)	
Thermal insulation	Roof: Glass wool (10 cm) (cf. Technical sheet R1)	
	Wall: none (bricks with cement plaster only)	
	Foundation: none	
	Windows: Wood, double glazing	
Thermal insulation cost	US$7.4 /m²	
Orientation	South	
Heating	none	
Detailed plans	Ground floor plan, section, Front elevation (cf. Annexe 8)	

Main advantages: As the school is not used in winter, wall insulation is not cost effective. Roof insulation helps to stabilize building temperature in summer. Double glazing is particularly appreciated.

Main disadvantages: With this design, the north side is colder (due to south solar gains), creating an uncomfortable area. Buildings should therefore have corridors on the north and classrooms only on the south side.

Table 12: Afshar School

Project 3: Rural basic health centre

Context

Following earlier work on clinic construction, the international community and Afghan government established health facilities based on a standard design which did not include any specifications for energy efficiency. These clinics are difficult to heat in winter. Hundreds of clinics are now used during winter. Some rooms are closed, available wood is only sufficient to heat one or two rooms. Even in rooms that are used, the temperature is sometimes below 5 degrees.

The technique described here has been added to the standard design of basic and comprehensive health centres in 2008. The clinic described as an example is one of the first buildings implemented according to the improved design. From now on, new clinics may all follow these technical specifications for insulated walls, roof and windows.

Orientation (cf. Annexe 9)

As with any building, the largest face of the BHC faces south with a substantial overhang (50 cm). South-east orientation (10° to 20°) is recommended to get early morning sun and also prevents overheating on summer afternoons.

Insulation (cf. Technical sheets W2 and R1)

Any changes to the existing design approved by the Afghan government would delay its implementation on site. Therefore, the technical choice for envelope thermal insulation did not alter the architectural layout and engineering design of the structure.
This rural building in climate zone 2 has intermittent occupation and is heated with low efficiency equipment (wood bukharis). There is therefore high temperature amplitude between seasons. As it is a health centre, a minimum comfort level is required (5 to 10°C at least), so very efficient insulation is required to keep as much heat as possible inside.

Roof

As the clinic has a Galvanized Iron (GI) cover roof, the simplest insulation technique available was to lay down glass wool under the GI cover. The vapour barrier was laid on the concrete slab.

Walls

A polystyrene layer covers the standard clinic walls from outside. A brick wall protects the polystyrene. This solution has no impact on the existing structure of the building and does not alter the size of rooms. In the case of an overall integrated design, the double wall thickness could be reduced.
As the building is temporarily heated in only a few rooms and may sometimes be used at night, efficient insulation is required to allow rapid heating as well as the possibility of conserving heat (overnight) by using high thermal inertia materials. The best compromise is "cavity wall insulation", i.e. a double brick wall with polystyrene inside. GERES had to produce special detailed insulation plans for this building to allow fitting on site with remote supervision from Kabul.

Windows

As it is a new building, the plan called for purchase and installation of double-glazed windows. These windows are particularly appreciated by medical staff in other clinics for their thermal and acoustic comfort gains in comparison with single-glazed windows.

Heating systems (cf. "Building and energy data" section, part 1)

Heating is provided by individual heaters.


Sapahi Khil Clinic

New	Sapahi Khil Clinic
Location	Sapahi Khil village, Gardiz, Paktia province
Climate zone	2
Rural/urban	Rural
Use	Basic health centre (under construction), Open during the day only (closed at night)
Building cost	US$90,000
Floor surface	280 m²
Floors	Single storey
Donor	Ministry of Public Health
Implementer	Ilias Ariobi Construction Company (IACC) (cf. Annexe 3)
Owner	Ministry of Public Health (MoPH), Islamic Republic of Afghanistan (cf. Annexe 2)
Thermal insulation	Roof: Glass wool (cf. Technical sheet R1)
	Wall: Double wall (polystyrene 5 cm) (Ref. To technical sheet W2)
	Foundation: refer to design (insulation 3 cm) (Ref. Annexe 9)
	Windows: Wood, double glazing
Thermal insulation cost	US$20.5/m²
Orientation	South
Heating	Bukhari/wood/gas stoves
Detailed plans	Ground floor, sections, side elevations (Annexe 9)

Main advantages: The building is more comfortable than a conventional one. Double glazing is very much appreciated by users.

Main difficulties: Still under construction; supervision and monitoring of the project is difficult because it is a remote area with a poor security situation.

Table 13: Sapahi Khil Clinic

Project 4: Ana dormitory rehabilitation

Context

An important part of the rehabilitation of Afghan institutions involved the reconstruction of army buildings. With support from the international community, especially the US government, a programme of compound construction is ongoing. The Ministry of Defence, supported by the US Government, decided to shift from wood stoves to combined heating and cooling systems (electrical heat pumps). In 2007, three compounds, built four years ago in Herat, Mazar and Gardez, shifted from wood stoves to heat pumps (air-air). At the same time, it was decided to insulate all buildings in order to improve energy efficiency. A network of contractors (NCDC) was appointed to do the work and asked GERES to support them with implementation and knowledge transfer between the Afghan insulation contractors and NCDC. Training was provided in Kabul and on site. Thermal calculations were checked to validate the chosen technical solutions.

The advantage of this project is to demonstrate to other Afghan institutions that energy efficiency is relevant in the country and this issue is taken seriously into account by reliable and professional stakeholders. Secondly, in ecological terms, the shift from Afghan wood to electricity is a significant benefit for the remaining forest.

Design and orientation (cf. plans, Annexe 10)

GERES could not have any input on these two subjects because the buildings were already built and in use by the Afghan army. As already stated, the largest face of the building should be oriented south to maximize solar gains in winter.

Insulation (cf. Technical sheets R1 and W3)

The Afghan military authorities, with US government support, wanted to adapt Afghan National Army buildings to US building standards. After calculation it appeared that buildings were not sufficiently insulated (only 10 cm glass wool layer in the roof). The main task of GERES was to identify an insulation technique that was easily replicable and met US insulation standards. To comply with US insulation standards, full insulation was recommended (roof, walls and windows).

Roof

As buildings already had a 10 cm glass wool layer in the roof, the easiest and the most cost-effective solution was to add a new glass wool layer (10 cm) without a vapour barrier over the existing one. This technique is simple and can be adopted without heavy renovation work. With 20 cm of glass wool in the roof, US construction standards are fully reached.

Walls

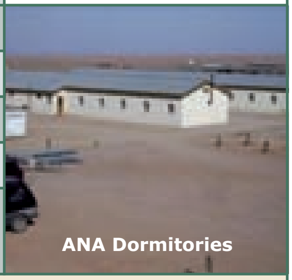
The dormitories were already in use by the Afghan army, so internal insulation was not convenient. Without the possibility of working inside, external insulation was a more suitable technique. In order to replicate the solution in all buildings all over the country, the contractor chose a well-known standard technique to undertake the insulation of more than 200 buildings around the country. The EWIS system (polystyrene boards added to the existing wall with a covering of cement plaster over a steel mesh) has been implemented by the Network of Construction and Development Companies (NCDC) working with GERES support.

Windows

Despite GERES recommendations, single-glazed windows have been retained for all buildings.

Heating systems (cf. "Heating systems" section)

Buildings are heated by air/air heat pumps. This kind of equipment can blow hot and cold air. One of the problems is that it does not work properly when outdoor conditions reach very high or low temperatures (-5; +30 °C). Even if their coefficient of performance is high (2 to 4), these systems, if they are in permanent use, can consume a lot of electricity. A good, permanent electrical grid connection is therefore required.

Rehabilitation	ANA Dormitories	
Location	ANA dormitories	
Climate zone	Herat, Gardiz and Mazar-e-Sharif	
Rural/urban	2	
Use	Urban	
Building cost	Dormitories for Afghan National Army (9000 people in 161 dormitories in 3 compounds)	
Floor surface	Not available	 ANA Dormitories
Floors	435 m² (per barrack)	
Donor	Single storey	
Implementer	US Government	
Owner	Network of Construction and Development Companies (NCDC) (cf. Annexe 3)	
Thermal insulation	Ministry of Defence (MoD), Islamic Republic of Afghanistan (cf. Annexe 2)	
	Roof: Glass wool (20 cm) (cf. Technical sheet R1)	
	Wall: External Wall Insulation System (EWIS) with steel mesh and cement plaster. (10 cm) (cf. Technical sheet W3)	
	Windows: PVC single glazing	
Thermal insulation cost	US$12/m² (wall + roof)	
Orientation	South or East	
Heating	Electrical heating and cooling A/C units (heat pumps)	
Detailed plans	Floor plan, elevations, cross sections (cf. Annexe 10)	

Main advantages: The building is well insulated and more comfortable than non-insulated buildings based on the same design. Dormitories are used by 9000 persons, there is a 50-70% saving on fuel consumption and 100% of wood is saved.

Main difficulties: Thermal insulation was not included in the original project and was applied after completion of construction works. Small cracks appeared after completion of plastering on walls. Unfortunately, it is still a single-glazed building despite GERES advice.

Table 14: ANA Dormitories


Project 5: MSCC Clinic

Context

This clinic is owned by the MoD but the principal donor is the US government. The building is situated in an urban environment close to Kabul airport in climate zone 2. As the clinic is able to admit patients for several days and perform surgical operations, it may be considered as a small military hospital. Construction was 60% completed when GERES was contacted to improve thermal efficiency. This clinic is used by more than 300 students and 100 staff of the military academy.

Design and orientation (cf. plans, Annexe 11)

GERES could not have any input on these two subjects because the building was already built. As already stated, the largest face of the building should be oriented south to maximize solar gains in winter. Unfortunately, the building's orientation is east, meaning that high solar gains are obtained in the morning on the east side and in the afternoon on the west side. Consequently, substantial temperature differences will occur during the day inside the building, creating uncomfortable areas. There is also a risk of overheating in summer on the west side.

Insulation (cf. Technical sheets R1 and W4)

This is a rehabilitation project, but the building is not yet in use, so all rehabilitation techniques could be considered for this project. More than 400 military academy students will use the building and it is in a very sensitive (airport) public zone, so the visibility and social impact of the building are important. Consequently, this building is an opportunity to show an example of energy-efficient construction techniques. As it is planned to heat the building 24 hours a day in winter (using a central heating system), full external insulation seems the most appropriate because it is the most efficient for this type of use in this climate zone (high temperature amplitude). It will also significantly compensate for the building orientation problem.

Roof

As the building was already built, the easiest and the most cost-effective solution was to lay a glass wool layer (15 cm) under the GI cover. This technique is simple and can be adopted without heavy renovation work. Glass wool is readily available in Kabul.

Walls and Foundations

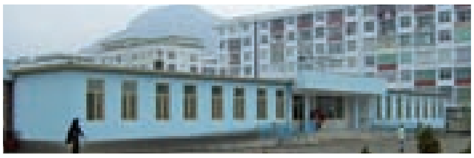
Two external insulation techniques are available in Kabul for walls: the EWIS system already presented and the Sto technique. The second is German and follows European standards. It is an expensive external insulation technique because all construction materials are manufactured in and imported from Germany but also the most efficient. The Sto system uses only a specific wall adhesive to fix polystyrene boards on the supporting wall and a light fibre mesh to fix the final coating. The same technique is used for foundations with higher density polystyrene. The MSCC company did the work with support from GERES and AEP.

Windows

Despite GERES recommendations, single-glazed windows have been retained for all buildings.

Heating systems

At this point, a central system is planned, which is a good solution if the regulation system is efficient.

Rehabilitation	Military Clinic
Location	Airport road, in front of Kabul international airport, Kabul, Afghanistan
Climate zone	2
Rural/urban	Urban
Use	Health clinic (350-450 persons) for military academy of Afghanistan. Open 24/24h.
Building cost	US$500,000 (Approximately)
Floor surface	576 m²
Floors	Two storeys
Donor	US Government
Implementer	Mustafa Sahak Construction Company (MSCC) (Annexe 3)
Owner	Ministry of Defence (MoD), Islamic Republic of Afghanistan (cf. Annexe 2)
Thermal insulation	Roof: Glass wool (15 cm) (cf. Technical sheet R1)
	Wall: Polystyrene EPS Sto (10 cm) (cf. Technical sheet W4)
	Foundation: Polystyrene XPS (10 cm) (cf. Annexe 11)
	Windows: PVC single glazing
Thermal insulation cost	US$22/m²
Orientation	East
Heating	Central heating
Detailed plans	First and second floor plan, elevation N/South, insulation vertical and horizontal section. (cf. Annexe 11)

Main advantages: The building is fully insulated and more comfortable than non-insulated buildings based on the same design. Thermal performance is better with multi-storey rather than single-storey buildings. The second floor provides good insulation for the ground floor. The clinic is used by more than 300 students and 100 staff of the military academy.

Main difficulties: Thermal insulation was not included in the original design of this project. The insulation has been added after 60% of construction work was complete. Unfortunately, it is still a single-glazed building despite GERES advice.

Table 15: Military Clinic

Insulation system technical sheet: W1

Earth and straw wall

Nature/ Description	This is a monolithic wall composed of soil, clay and straw. Adobe blocks are made up and put together with mud mortar to build a wall. The straw ensures distributed insulation.
Thermal conductivity λ (W/m°C)	0.1-0.25 (for a density of 300-800 kg/m³). The mix density in volume is 50% straw and 50% clay.
Cost ($/m²)	$60/m². Complete wall estimate.
Implementation time	13 hours/m² to build the complete wall for one skilled and two unskilled workers (including bricks manufacturing time)
Distributors	Turquoise Mountain Foundation
Implementers	Turquoise Mountain Foundation. Any skilled workers can do it but special training is necessary.
Plan and details	cf. Annexe 5
Criteria for choice	Building used all year around, very frequently and as many hours per day as possible (more than 10 hours). Rural area, community with available free workers.
Advantages	Good thermal efficiency if the mix has low density; minimal ecological impact, traditionally used materials, easily maintained, no foreign labour/machinery required, highly sustainable crop; and maximizes use of local materials.
Disadvantages	Limited straw availability (alternative fibres can be used), building blocks require preparation, time to dry before being used in construction, must be plastered, requires skills and training. Expensive due to extensive labour.
Feedback	Communities are highly satisfied; thermal inertia is much appreciated. It is a long process to complete a building but the knowledge transfer is very efficient. This technique can easily be reproduced anywhere in the country because the materials used are local and available. The technique is adapted to Afghan knowledge and construction habits.

Earth and straw walls (adobe blocks)

Fig 51
Step-by-step implementation
1-Adobe block 2-Mud mortar 3-Lime plaster

Implementing technique details are shown in Annexe 5.
A mud and straw wall of 30 cm with 400 kg/m³ mix density has the same thermal resistance as 10 cm of polystyrene.

For further information, contact: Turquoise Mountain Foundation or GERES Kabul.

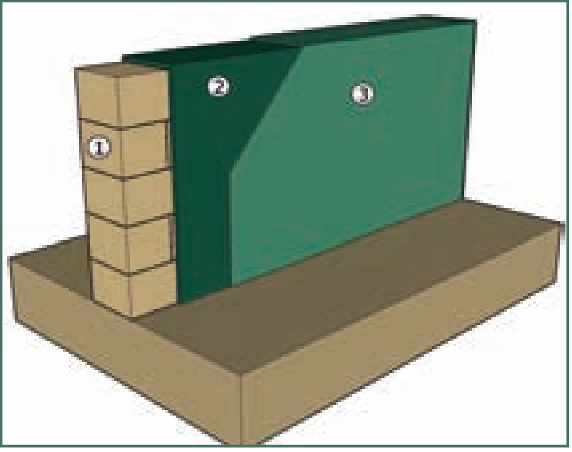


Table 16: Earth and straw wall

Insulation system technical sheet: W2

Double wall

Nature/ Description	A double wall is a polystyrene board (5 cm thickness minimum) between two brick walls.
Thermal conductivity λ (W/m°C)	0.04 (Polystyrene, at least 15 kg/m³)
Cost ($/m²)	16 (including second brick wall)
Implementation time	1-1.5 Hours/m² for one skilled and two unskilled workers
Distributors	Polystyrene: Yarash Huma, Kabul Interiors Co. Ltd, Murad limited
Implementers	Ilias Ariob Construction, Himat Mangal construction company
Plan and details	Not available
Criteria for choice	Only for new buildings, daily or 24/24h use, public or domestic
Advantages	Efficient insulation, high thermal inertia, stock and support available in big cities, easily implemented by Afghan companies, steady room temperature, cheaper than external insulation.
Disadvantages	Detailed, accurate design required, imported product, manufacturing polystyrene is a polluting process (hydrocarbon source), requires training for workers, new buildings only.
Feedback	Polystyrene boards of 10 cm (thickness) are required. Polystyrene particles can pollute the work site during implementation. An air gap is recommended between the polystyrene and brick walls.

Double wall insulation

Fig 52

Step-by-step implementation

1- Reinforced concrete base
2- First brick wall (2 bricks wide, 1 m high)
3- Polystyrene panel (leave an air gap with bricks)
4- Second brick wall (1 brick wide, 1 m high)
5- Steel bars 6- Layer of cement plaster
7- Smooth cement coating

For further information, contact:
Ilias Ariob Construction, Himat Mangal Construction, GERES

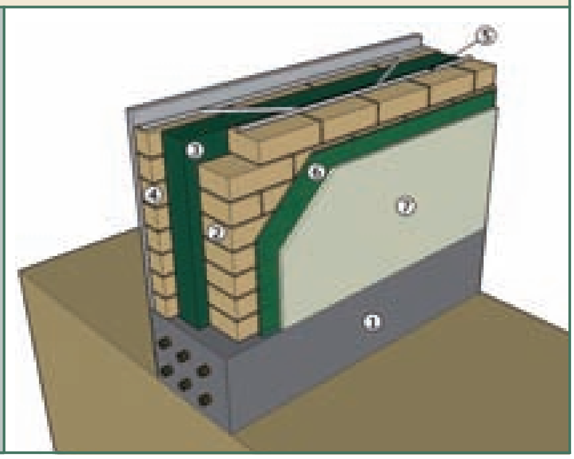
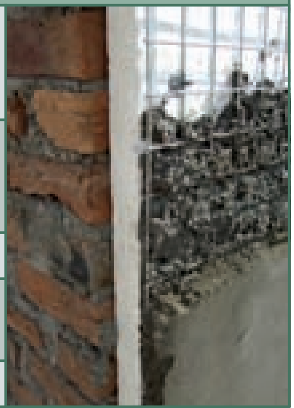


Table 17: Double wall

Insulation system technical sheet: W3

External wall polystyrene system (EPS)

Nature/ Description	The principle of external wall insulation is to fix polystyrene boards (10 cm thickness minimum) on the wall using a metal frame. It also provides support for the cement plaster.
Thermal conductivity λ (W/m°C)	0.04 (Polystyrene, at least 15 kg/m³)
Cost ($/m²)	25 to 28
Implementation time	2 Hours/m² for 1 skilled and two unskilled workers
Distributors	Yarash Huma, Kabul
Implementers	Yarash Huma, Kabul
Plan and details	Cf. ANA dormitories section (Annexe 10)
Criteria for choice	External wall insulation for public building rehabilitation or construction (new), used all year around, 24h/24h and heated in winter (e.g. hospitals, clinics, military barracks, etc.)
Advantages	Very effective insulation, stock and support available in Kabul, implemented by an Afghan company, cheaper than Sto insulation.
Disadvantages	High risk of cracks, even a short time after implementation of the technique, durability not assessed. Imported product, requires trained workers, polluting manufacturing process (hydrocarbon source). Not recommended for multi-storey buildings.
Feedback	Effective wall insulation requires 10 cm thickness minimum for polystyrene boards. Cracks may appear in the plaster if it is not done properly.



External wall insulation EPS system

Fig 53

Step-by-step implementation

1- Smooth cement coating
2- Second layer of cement plaster
3- First layer of cement plaster (ratio cement / sand 1:3 and water ratio in the cement: W/C=0.6)
4- Polystyrene panel with its metal frame (dowels)
5- Structural wall, brick, block, timber, etc.

For further information, contact:
Yara shuma or GERES Kabul

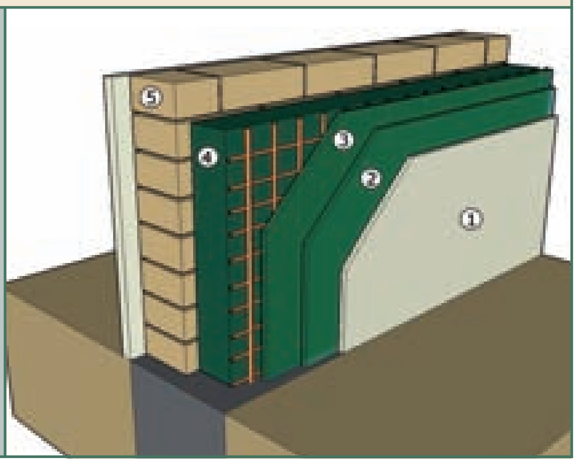
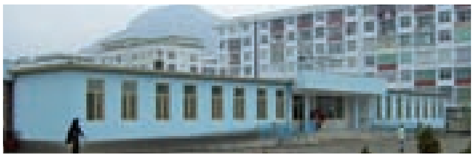


Table 18: External wall polystyrene system



Insulation system technical sheet: W4

External wall organic system (STO)

Nature/ Description	The principle of external wall insulation is to fix polystyrene boards on the wall using a special adhesive and fixation system.	
Thermal conductivity λ (W/m°C)	0.04 (Polystyrene, 20 kg/m³)	
Cost ($/m²)	36 to 42	
Implementation time	3 to 4 Hours/m² for 1 skilled and two unskilled workers	
Distributors	AEP, Kabul	**External wall insulation STO system**
Implementers	AEP, MSCC, etc.	
Plan and details	Cf. MSCC clinic plans, horizontal section of organic insulation system	
Criteria for choice	External wall insulation for public building rehabilitation or construction (new), used all year around, 24h/24h and heated in winter more than 8 hours per day (e.g. hospitals and clinics)	
Advantages	Effective insulation, crack free, stock and support available in Kabul	
Disadvantages	Expensive, imported product, requires trained workers, polluting manufacturing process (hydrocarbon source)	
Feedback	Polystyrene particles can pollute the work site during implementation, requires special Sto adhesive and own fixation system. Effective wall insulation requires 10 cm thickness minimum for polystyrene boards	

Fig 54

Step-by-step implementation

1- Structural wall, brick, block, timber, etc.
2- STO adhesive compound
3- Polystyrene panel (1 x 1 m)
4- STO cement–free reinforcing coat
5- STO glass fibre mesh
6- STO cement–free reinforcing coat
7- STO finish coat.

For further information, contact:
AEP, GERES, STO (www.sto.com)

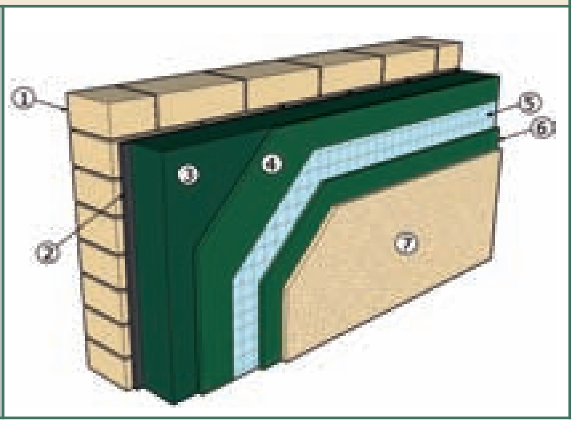


Table 19: STO wall insulation

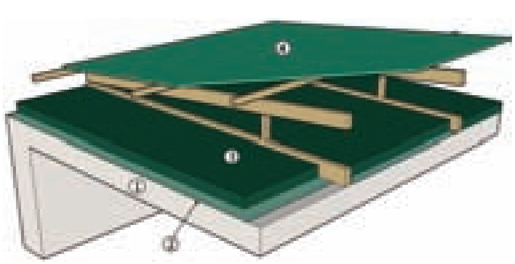
Insulation system technical sheet: R1		
Glass wool for "Cold roof" design		
Nature/ Description	Recycled glass, siliceous sand. The manufacturing process requires a lot of energy (Fusion 1500°C).	
Thermal conductivity λ (W/m°C)	0.04	
Cost ($/m²) (Thickness=10 cm)	4	
Implementation time	Very quick (½ hour /100 m²) if the surface is flat, clean, dry and protected from outdoor conditions. One or two unskilled workers maximum needed.	
Distributors	Ayanda Sazan Sabaz, Dahsabaz Pipe, Murad Limited.	
Implementers	No special skills or equipment are required (except gloves and mask)	
Plan and details	Unroll it onto the surface to be insulated. Vapour barrier on the warm side of the insulation.	
Criteria for choice	Flat roof insulation in renovated or new buildings. Appropriate for an urban environment.	
Advantages	• Cheap • Rolls are very light and handy to install • Available in big cities	
Disadvantages	Skin and respiratory tract irritation during implementation • Electrostatic fields • Environmental impact during production process • Non-renewable resources • Imported product	
Feedback	• Requires gloves and mask for implementation due to volatile fibres which are very irritating for the skin and respiratory tract • Shrinks after a long period (can lose half of its thickness in 10 years) • Rolls must have a moisture barrier included (Aluminium sheet) • For efficient insulation, the minimum required thickness is 10 cm (or 2 layers of 5 cm)	
Fig 55 **Glass wool roof insulation** 1- Flat roof (concrete slab) 2- Vapour barrier (aluminium) 3- Glass wool 4- GI cove		

Table 20: Glass wool for "Cold roof" design

Raising awareness and user behaviour

Part 5

Raising awareness

As part of the Afghan/French/German Energy Initiative, GERES and GTZ have worked together with the MoEW to set up three energy information centres in the North-East. The Faizabad and Talokan centres have been rehabilitated and opened to the public (see map below). Energy centre contacts and details are available from GERES and GTZ Kabul (cf. List of partners, Annexe 2). Unfortunately, the Kabul centre has suffered collateral damage due to the local conflict so it is closed to the public.

The three information centres aim to inform and raise awareness of energy efficiency and renewable energies amongst the public, contractors, decision-makers and stakeholders. The centres have an office permanently staffed by a technician to answer and guide visitors.

Centres sell solar electrical appliances (photovoltaic panels, batteries, lamps, etc.) and solar heaters. They also present energy-efficient building principles such as insulation, double glazing, south orientation, etc.

All these notions are summarized and displayed on sixteen thematic posters (attached as Annexe 12) given to the public at each centre.

Fig 56: Energy centre location

User behaviour

How users behave can dramatically change energy consumption in a building. Energy efficiency in a building consists of reducing energy needs (lighting, heating) for the same level of comfort. Once a building is built or rehabilitated and heating or cooling systems have been fitted, only half of the work is done. Users' energy behaviour has a heavy impact on energy consumption.

This remark is particularly true in public buildings, due to the wide diversity of users (e.g. in clinics, there will be doctors, nurses, administrative staff and patients). For instance, an employee may leave the light on all day even if nobody is using the room. Some unused rooms may also be heated unnecessarily. This simple example shows that, if users have not been educated, the energy assessment of even the best bioclimatic building with the most economic heaters can be dramatic.

The two main energy expenses are heating and lighting. As described previously, heating devices are inefficient and their heating period is very limited. For example, a sawdust bucket in a bukhari lasts for 6 hours maximum and can heat a room not exceeding 15 to 20 m². Most heating devices in Afghanistan have no regulation systems. Afghan households burn what they can afford on a daily, weekly or monthly basis. The budget available is the first factor of comfort. Even windows are in very poor condition (broken glass or plastic, closing badly, etc.). Sometimes doors do not close properly or are broken, etc. All this (especially in cities) could be changed to make more efficient use of the fuel people can afford.

For lighting, electricity is not available 24h/24h on the grid in Afghanistan. Consequently, many shops, offices and houses have their own generators. There are also many clandestine grid connections, so people do not pay for their electricity. Anyway, as soon as the grid is operating, Afghans

consider it as a godsend so they use electricity as much as possible; they light up everywhere even when it is not necessary and leave lights on until the power cuts out. For those who have a generator, it is very common to see one generator working for one or two bulbs, so people are not using their generators according to their needs. They are satisfied if it works, irrespective of efficiency.

However, whether or not energy supply is sufficient, it is essential to use it in the most effective way. Afghans can make savings and improve their day-to-day comfort significantly by changing some habits.

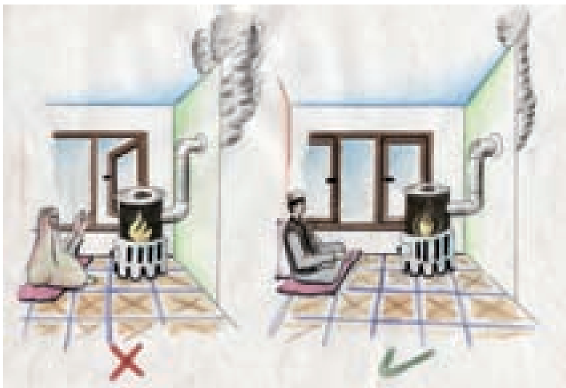
GERES therefore decided to launch a sticker campaign, in parallel with thematic posters on energy efficiency and renewable energy, on 10 simple energy-saving measures. The drawings were designed by Afghan technicians to ensure that they would be understood by the population.

Stickers have been distributed in schools and hospitals and we had good feedback. The messages are understood and appreciated by building managers and users. The stickers are presented below:

Turn off light whenever you don’t need it.

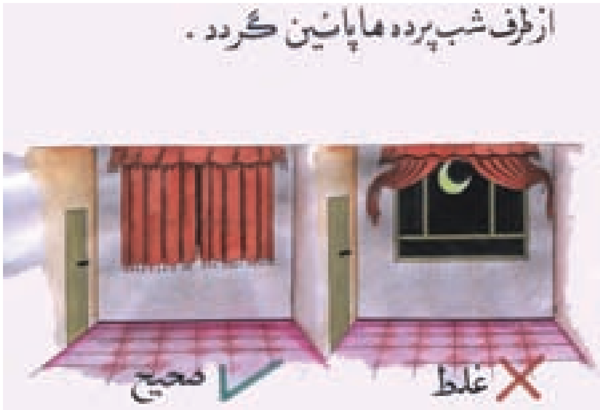
Try to use low-consumption bulbs.

Heat buildings reasonably.
19°C is a comfortable temperature.



Do not open windows while the bukhari is on.

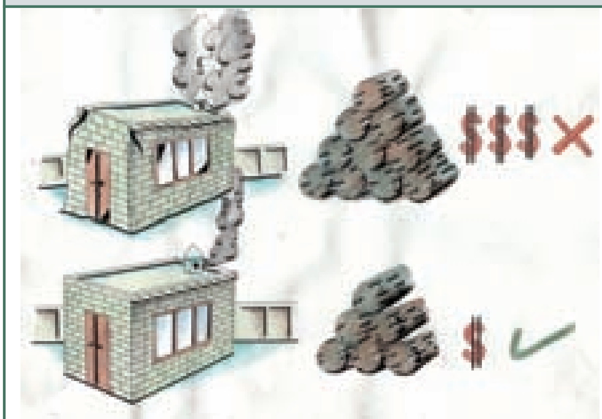
To save energy, close doors.



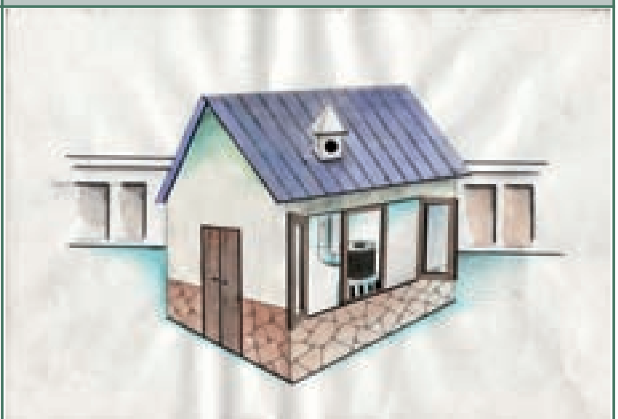
At night time, curtains must be closed.

Turn off the water tap
whenever you don't need it.

Report technical problems
to the maintenance team.



A well-maintained building
helps to save fuel – and money.



For hygiene purposes, open windows 5-10 min.
per day but do not forget to turn bukharis off.

Table 21: Energy behaviour stickers

Project feedback

Part 6

Expectations and results

The project's objective was to demonstrate to the Afghan government and its partners the financial, environmental and comfort benefits of thermal insulation in one hundred buildings. A second objective was to evaluate and measure energy efficiency benefits. Indicators are necessary for any evaluation, so we chose the following ones for our building energy efficiency assessment:

- Energy efficiency: Heating needs (theoretical calculations) or fuel consumption (real data) in kWh/m²/year
- Ecological impact: CO_2 emissions
- Economic impact: Payback time

We then decided to evaluate the comfort benefits for users. This indicator is much more difficult to estimate due to the many criteria governing a person's perception of comfort in a building (light, room size, colour, humidity, temperature, etc.). As Afghan comfort is far below European standards, we considered only buildings' average indoor temperature in this survey. In fact, a comfortable temperature in Afghan public buildings is the principal improvement required by users.

Comfort evaluation: indoor temperature

Theoretical calculations give the following results if buildings are heated at 18 °C in climate zones 1 and 2. There are no results for climate zone 3 because, as the climate is "semi-arid", most of the time buildings are not heated even in winter. These results are based on daily use only.

All results are in comparison with a non-insulated building.

18 °C Climate Zone 1	Heating Needs kWh/m²/year	CO_2 Emission Reductions	Payback Time (years)
New building partially insulated (wood only)	95	49%	Less than 1
New building fully insulated (wood only)	60	77%	2 to 3

Table 22: Indicator summary for zone 1 (18 °C)

All results are in comparison with a non-insulated building.

18 °C Climate Zone 2	Heating Needs kWh/m²/year	CO_2 Emission Reductions	Payback Time (years)
New building partially insulated (wood only)	65	48%	Less than 1
New building fully insulated (wood only)	40	70%	3 to 4

Table 23: Indicator summary for zone 2 (18 °C)

If we assume that the level of comfort for insulated and non-insulated buildings is 18°C:

- Partially insulated buildings could reduce CO_2 emissions by 50%
- Fully insulated buildings could reduce CO_2 emissions by 70%
- In theory, the projects implemented in Afghanistan with FFEM support between 2006 and 2009 could save 18,000 tonnes/CO_2/year for 170,000 m² insulated.
- The payback time for insulation of new buildings is less than 4 years anywhere in Afghanistan.

Unfortunately, these are theoretical assumptions and such results are not realistic in Afghanistan. A second study has therefore been set up to evaluate the real benefits of building insulation. Temperatures have been measured inside different kinds of buildings over the same period of time. The main findings are presented here. GERES organized temperature measurements in three Comprehensive Health Centres (CHCs) over three days in mid-January 2008. In order to evaluate the effectiveness of insulation, one centre is not insulated, one is partially insulated and one is fully insulated. They also have similar sizes.

Health Centres	Climate Zone	Use	Insulation	Outside T (°C)
Sang Takht	1	Daily	Fully insulated	-15.5
Gosfandi	2	Daily	Partly insulated	-11.5
Suzma Qala	2	Daily	None	-11.5

Table 24: Health centre data results

Health Centres	Insulated	Average Indoor T (°C)
Sang Takht	Fully	14.8
Gusfandi	Partly	11.4
Suzma Qala	No	5.6

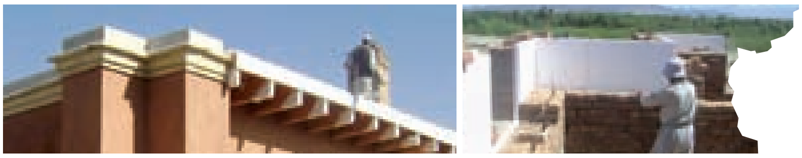
Table 25: Health centre heating consumption

The effectiveness of the insulation appears clearly. All health facilities are using wood and diesel for heating. For the heated rooms, average temperatures are much higher in the insulated building (+5 to 10°C) than in the conventional one, where the temperature barely reaches 6°C on average.

Conclusions

- Insulation brings greater comfort in buildings. Average indoor temperatures are higher in insulated buildings.
- Heating needs (fuel consumption) are not limited by the level of comfort but more by the "heating budget" allocated per building.
- Heated Afghan public buildings have an average indoor temperature between 5 and 15 °C in winter (more investigation is necessary).

Consequently, at the moment there are no, or barely measurable, real savings on budgets and CO_2 emissions in insulated buildings in Afghanistan. However, comfort is certainly increased (+5 to 10 °C) for the same amount of fuel used. Savings and lower CO_2 emissions from heating public buildings will occur when the Afghan standard of comfort (15° to 18 °C) is reached. Savings will then be made in insulated heated buildings.



In theory, if the comfort level was even throughout the building (18 °C), in zone 2 (most projects), we could expect the following results:

Heating / Cooling	Building type	Insulation recommended	Insulation additional cost $/m²	Payback time	CO_2 emission savings	Comfort gain
No	Schools	Partial insulation	6.8	None	None	2 to 5 °C, hotter in winter and cooler in summer
Yes	ANA	Full insulation	12	3 years	70%	18 °C even throughout
Yes	Health centres	Full insulation	20.5	3 years	70%	18 °C even throughout

Table 26: Theoretical results summary

In reality, at the moment, the comfort level of Afghan public buildings is very low, especially in winter (5° to 15 °C), and buildings are only partly heated. Comfort gain is the principal advantage at this point. Savings cannot occur with such a low comfort level.

We assume that renovated Afghan National Army buildings (18 °C all year around) will be an exception in comparison with other public buildings because the heating/cooling devices/equipment planned for next year will be modern and very effective.

Heating / Cooling	Building type	Insulation recommended	Insulation additional cost $/m²	Payback time	CO_2 emission savings	Comfort gain
No	Schools	Partial insulation	6.8	None	None	Slight, depends on occupancy ratio, user behaviour, architecture and orientation
Yes	ANA	Full insulation	12	3 years	70%	18 °C even throughout
Partly heated	Health centres	Full insulation	20,5	none	none	+ 5 to 10 °C

Table 27: Field results summary

Design and insulation recommendations

To obtain a similar level of comfort while saving energy, energy-efficient buildings must be adapted to their environment, use and users. Before any new building project is undertaken, the building's situation must first be examined. Its design and orientation must then be carefully studied with users and decision-makers. Finally, adapted insulation techniques and heating systems must be planned. The following table presents GERES's main recommendations for different types of building depending on their location, use and users.

Climate Zones	Uses		
	Not heated (not used in winter; schools)	**Intermittently heated (days only; offices)**	**Constantly (24h/24h) (hospitals, rural clinics)**
Zone 1	• **Orientation:** South • **Specific design:** Multi-storey, corridors north side, classrooms south facing only. South face higher than North face. • **Insulation:** External roof insulation and double-glazed windows. • **Heating systems:** None	• **Orientation:** South-east if the building is mostly used in the morning; South-west if mostly used in the afternoon (to get solar gains in winter). • **Specific design:** Multi-storey. • **Insulation:** External roof and wall insulation with double-glazed windows. • **Heating systems:** Individual gas heaters or heat pumps in permanent staff offices.	• **Orientation:** South • **Specific design:** Multi-storey. • **Insulation:** External roof and wall insulation with double- or triple-glazed windows. • **Heating systems:** Central heating (gas or fuel oil)
Zone 2	• **Orientation:** South • **Specific design:** Multi-storey, corridors north side, living rooms south facing only. South face higher than North face. • **Insulation:** Building with a high thermal mass (heavy materials), external roof insulation and double-glazed windows. • **Heating systems:** None	• **Orientation:** South-east if the building is mostly used in the morning; South-west if mostly used in the afternoon (to get solar gains in winter). • **Specific design:** Multi-storey. • **Insulation:** External roof and wall insulation with double-glazed windows. • **Heating systems:** Individual gas heaters or heat pumps in permanent staff offices.	• **Orientation:** South • **Specific design:** Multi-storey. • **Insulation:** External roof and wall insulation with double- or triple-glazed windows. • **Heating systems:** Central heating (gas or fuel oil)
Zone 3	• **Orientation:** South • **Specific design:** Multi-storey, corridors north side, living rooms south facing only. South face higher than North face. Large overhang. • **Insulation:** Building with a high thermal mass (heavy materials) and double-glazed windows, roof insulation. • **Heating systems:** None	• **Orientation:** South-west if the building is mostly used in the morning; South-east if mostly used in the afternoon (to avoid solar gains in summer). • **Specific design:** Multi-storey. • **Insulation:** External roof with double-glazed windows. • **Heating systems:** A/C heat pumps in permanent staff offices.	• **Orientation:** South • **Specific design:** Multi-storey. • **Insulation:** External roof and wall insulation with double- or triple-glazed windows. • **Heating systems:** A/C heat pumps

Table 28: Energy-efficient building recommendations

Conclusion

The Afghan building sector is expanding every day and construction projects are under way all over the country; however, most of the buildings are heated with wood and are not thermally insulated.

The exhaustion of natural resources, especially wood, is forcing Afghanistan to establish a sustainable, conservative energy policy. Energy supply must be boosted and diversified (gas, solar technologies, hydro-power, etc.) to ensure the sustainable economic growth necessary for the country's development. During winter, the population has a vital need of energy resources to heat homes and other facilities. However, the country has a limited stock of natural energy and wood resources. Forests represent the main access to energy for heating purposes and the resource is going to be exhausted in the near future.

Between 2006 and 2009, with support from the FFEM, energy efficiency has been implemented in hundreds of buildings in Afghanistan. The results demonstrate the feasibility of energy-efficient building techniques in the country.

This book has shown how these projects have been implemented in practice and how to replicate them in new operations. With the help of all the partners involved, Afghan contractors and ministers have made this demonstration possible in schools, clinics, barracks and even a museum and university. Implementers have been villagers, small contractors or bigger companies. But they were all Afghans and quickly learned appropriate thermal insulation techniques.

The materials needed for thermal insulation are easily available in big cities, while local natural materials like cotton or wool are local alternatives for very remote locations. The cost of materials is affordable or at least has a short payback time and remains under 12% of the total cost of the building. The cheap or more costly solutions presented in this book are suited to most kinds of projects and budgets in Afghanistan.

The feedback from projects shows the positive impact of thermal insulation comfort, energy saving and environmental protection.
In winter, the indoor temperature in improved clinics is higher and buildings are more comfortable for the same amount of fuel used. Users are spending the entire heating budget anyway because they can barely reach a reasonable level of comfort inside buildings (18 °C). This is mostly due to bad building conditions and the very low efficiency of the current heating devices used in Afghanistan (wooden bukharis).

For buildings heated at 18 °C, 70% energy savings can be achieved with thermal insulation.

General results

- Most “energy-efficient" projects in Afghanistan achieve greater comfort in buildings rather than savings (CO_2, heating budget).
- Heating needs (fuel consumption) are not limited by the level of comfort but more by the “heating budget” allocated per building.
- Significant savings and lower CO_2 emissions from heating public buildings will occur when the Afghan standard of comfort (15 ° to 18 °C) is reached.
- For summer comfort, bioclimatic architecture and suitable building orientation with a good natural ventilation system are prerequisites.
- The standard design of Afghan public buildings is not always adapted and must be improved.

Key figures

If we assume the same level of comfort for insulated and non-insulated buildings:

- Partially insulated 22 buildings reduce CO_2 emissions by 50%
- Fully insulated 23 buildings reduce CO_2 emissions by 70%
- The payback time for new partially insulated buildings is around one year anywhere in Afghanistan (at 18 °C)
- The payback time for new fully insulated and rehabilitated partially insulated buildings is less than 5 years (at 18 °C).
- In the coming thirty years, the comfort level in Afghanistan buildings will hopefully be higher, so energy savings will increase with time in insulated buildings.

Main recommendations

- **Insulation** is required only in climate **zones 1 and 2**.
- **Partial insulation** is recommended **for schools**.
- **Full insulation** is only recommended for buildings where **the level of comfort is over 15 °C** (high heating budget).
- **Summer comfort is as important as winter comfort** (5 months summer, 4 months winter), so it must be carefully studied (ventilation, solar gains, building architecture, roof insulation, etc.)
- Standard **Public building design and orientation** must be **reviewed** first, before implementing costly insulation techniques.

Partners

Coordinator

Groupe Energies Renouvelables, Environnement et Solidarités (GERES)

Coordinator of the project, GERES is a French non-profit NGO created in 1976 after the first Oil Shock. Its works on innovative and sustainable development projects in France and in eight countries. Environmental conservation, climate change mitigation and adaptation, reducing energy poverty, and improving livelihood of the poor are the main focus areas for GERES. The GERES team is particularly involved in the implementation of engineering solutions for development and providing specific technical expertise. Activities include conducting energy efficiency programs, providing decentralized energy services for local economic development, supporting and developing renewable energies and promoting waste management. These activities are implemented in partnership with local stakeholders and communities on the basis of collaborative experience sharing.
Having worked in Afghanistan since 2002, GERES is acknowledged as a major player in the country. It focuses on promoting energy efficiency through setting up projects in partnership with local and national institutions aimed at making public buildings warmer and more comfortable.

www.geres.eu

Main partners

The French Global Environment Facility (FFEM)

The French Global Environment Facility (FFEM) was created in 1994 by the French government, in continuation of the Earth summit in Rio de Janeiro in 1992, to facilitate the environmental protection in developing countries. Abounded by the public budget, from the envelope of the development help, its resources amount to 277,5 ME on period 1994-2010. It is added to the contribution of France to the Global Environment Facility (GEF). The FFEM is placed under the supervision of the Ministries of Economy and Finance, Foreign and European Affairs, Environment, Research as well as the French Development Agency (AFD). The Ministry of Economy assures the FFEM presidency and the management of FFEM is assured by AFD. The FFEM contributes, in the form of subsidies, to the financing of sustainable development projects having a significant impact on the world environment domains: the biodiversity, the greenhouse effect, international waters, ozone layer, grounds degradation including the desertification and the deforestation, and the persistent organic pollutants.

www.ffem.fr

The French Environment and Energy Management Agency (ADEME)

The French Environment and Energy Management Agency (ADEME) is active in the implementation of public policy in the areas of the environment, energy and sustainable development in France. As part of this work the agency helps finance projects, from research to implementation, and collaborates on specific projects with GERES to support its activities in the field.

www.ademe.fr

The Mission of the Ministry of Public Health (MoPH)

The Mission of the Ministry of Public Health, Islamic Republic of Afghanistan, is committed to ensuring the accelerated implementation of quality health care for all the people of Afghanistan, through targeting resources especially to women and children and to under-served areas of the country, and through working effectively with communities and other.

Values and principles embody the essential ideals of the Ministry of Public Health and offer a moral and ethical code that guides decision making to achieve success. Values are also useful in communicating the reasoning behind decision-making. The Ministry of Public health believes in the following values, all of which are equally important: Right to a healthy life, compassion, Honesty and Competence, equity, pro-rural.

www.moph.gov.af

The National Environment Protection Agency (NEPA)

The National Environment Protection Agency has been created in 2005. Its serve to elaborate environmental, economic.and social policies, and as statutory and regulting institution. As such, it regulates, coordinates, control and applies the laws on the environment and plays a major role in the environment protection and management. In 2009, under its authority, has been created the first national park in Afghanistan (Band-e Amir)

The tripartite initiative AFGEI (Afghan-French-German Energy Initiative)

In 2004, the tripartite Initiative AFGEI (Afghan French German Energy Initiative) in the energy field was signed in Kabul between three countries to develop the renewable energies and the energy efficiency in Afghanistan. The German cooperation concentrates its interventions mainly on the renewable energies sector in the remote regions (hydroelectric power plants, distribution of lamp, solar ovens and boiler, rural decentralized electrification grid). The French help is targeted at the energy efficiency in buildings.

www.afghanistan.ded.de

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)

As an international cooperation enterprise for sustainable development with worldwide operations, the federally owned Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH supports the German Government in achieving its development-policy objectives. It provides viable, forward-looking solutions for political, economic, ecological and social development in a globalised world. Working under difficult conditions, GTZ promotes complex reforms and change processes. Its corporate objective is to improve people's living conditions on a sustainable basis.

www.gtz.de

Abbreviations

ADEME	French Agency for the Environment and Energy Management
AEP	Ansari Engineering Products and Services
AEIC	Afghan Energy Information Centre
AFA	Afghanis, Afghan currency
ANA	Afghan National Army
ANDS	Afghanistan National Development Strategy
BHC	Basic Health Centres
BTU	British Thermal Unit
CHC	Comprehensive Health Centre
COP	Coefficient of Performance
EPS	Expanded polystyrene
EU	European Union
FFEM	French Global Environment Facility – FGEF
GERES	Renewable energies, environment and solidarities group
GDP	Gross Domestic Product
GNP	Gross National Product
GTZ	German Technical Cooperation
IACC	Ilias Ariobi Construction Company
IEA	International Energy Agency
IFCC	Itifaq Faqiri Construction Company
LPG	Liquefied Petroleum Gas
MAEE	French Ministry of Foreign and European Affairs
MoD	Afghan Ministry of Defence
MoE	Afghan Ministry of Education
MoEW	Afghan Ministry of Energy and Water
MoPH	Afghan Ministry of Public Health
MSCC	Mustafa Sahak Construction Company
NEPA	Afghan National Environmental Protection Agency
NCDC	Network of Construction and Development Companies
NGO	Non-Governmental Organizations
PVC	Polyvinyl chloride
Sto	German manufacturer and leading specialist in wall insulation systems
TMF	Turquoise Mountain Foundation
UNODC	United Nations Office on Drugs and Crime
US	United States
UXO	Unexploded Ordnance

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Figures

Tables

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Based upon a 3-year project (and 7 years' experience) in Afghanistan, this technical guide to energy-efficient public buildings has been designed for implementers and decision-makers.

The experiments detailed in the guide were carried out between 2006 and 2009 as part of the "Dissemination of best energy efficiency practice in the public building construction sector in Afghanistan" project. The aim was to demonstrate that the energy performance of public buildings can be sustainably improved.

The project was endorsed by the French Ministry of Foreign and European Affairs in 2004. It is the successor to pilot operations carried out in Afghanistan between 2002 and 2005 by GERES (Renewable Energies, Environment and Solidarities Group).

The guide aims to facilitate the construction of energy-efficient buildings. It provides decision-makers with practical information, databases and energy efficiency guidelines for various types of buildings. Technicians and engineers will find detailed insulation systems with their implementation criteria. Detailed technical sheets help in choosing the most suitable thermal insulation depending on the public building concerned (use, location, investment, etc.).

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