



Azerbaijan Alternative Energy and Energy Efficiency Project Development Support

Report to LEAD International and Hayat NNGO

Steven Hunt
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Executive Summary

This report is the output of work undertaken by Practical Action Consulting (formerly ITC) in support of the development of Alternative Energy and Energy Efficiency Projects in Azerbaijan under the BTC funded Environmental Awareness and Improvement Programme (EAIP). It makes recommendations for current and future project development based on surveys, discussions and interviews undertaken in collaboration with Hayat NNGO on a visit by Steven Hunt to Azerbaijan from the 16th to the 26th of April 2006. This visit built on project concepts previously developed by the project partners LEAD International, Hayat and Practical Action Consulting, and was prepared using DEFRA/PECE funding.

After a description of the project context and the approach and methodology undertaken in selecting and developing projects, the report makes the following specific project recommendations for consideration and development by Hayat community liaison officers and community leaders:

- *A project be developed to implement low cost measures to increase building energy efficiency and to use of alternative energy to provide improved services at the Qara Jali community medical centre in Ujar Region*
- *A project be developed to implement environmental improvement and provision of lighting powered using alternative energy sources at the Tovuz City pedestrian railway underpass in Tovuz Region*

These project recommendations include survey and interview information obtained during site visits as well as specific recommendations of measures, technologies and practices for further consideration by communities. Ways forward and outline budgets are also supplied with a view to assisting in proposal preparation by communities for support from BTC through the EAIP Programme.

In addition to these two project recommendations, the report also provides initial assessments of the potential viability of other project concepts developed by the partners including the biomass heating of greenhouses and improved woodburning stoves. It concludes that further work on both of these projects is justified based on the needs expressed and potential seen with respect to the recommendation criteria for EAIP project selection.

Finally, the report also provides feedback on potential projects at other sites assessed during the visit, which although not selected for project development support at this time, would benefit from similar interventions which Hayat and those communities could pursue.

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1. Introduction

1.1 Background and context

Following a tripartite meeting of Hayat, LEAD International and Practical Action Consulting (then known as ITC) at Chatham House in London on 13th December 2005, Practical Action Consulting (PAC) was given the responsibility for developing 6 project ideas for potential implementation in Azerbaijan under the auspices of the Environmental Awareness and Improvement Programme (EAIP). The EAIP is managed by the Azeri national NGO Hayat and funded by the BTC Pipeline Company. PAC developed the proposals in discussion with Hayat and LEAD International and these were subsequently successfully submitted by LEAD International to DEFRA for funding support under the Partners for Environmental Co-operation in Europe (PECE) Programme. The six project ideas initially developed were as follows:

1. Public Building Heating and Insulation
2. Public Lighting
3. Biomass Residue Greenhouse Heating
4. Stimulating Supply of Improved Stoves
5. Domestic Lighting and Electrical Appliance Provision
6. Energy Management Toolkit

An initial visit by Steven Hunt of PAC was scheduled to assist in development of the above projects. DEFRA funding was allocated by LEAD to support development of the first two projects to a position where specific proposals could be submitted for funding to BTC through the EAIP project. This visit was undertaken between 16th April and 26th April 2006 in close collaboration with Hayat staff in Baku, Yevlakh and Tovuz. The following report outlines the results of that visit including specific proposals for projects 1 and 2 for further discussion between Hayat community liaison staff and community leaders. This report also outlines the initial viability and the additional work required to develop the other projects, as well as additional new opportunities identified during the visit.

1.2 Description of Approach

PAC's involvement in the EAIP project is to provide technical assistance in clean and energy efficient technologies in order to support communities in developing projects of suitable quality and focus to meet EAIP objectives. That support is delivered through the participation of PAC staff in capacity building for example through Hayat staff workshops and training sessions on clean energy technologies, as well as direct involvement in project development, site surveys and stakeholder discussions. All PAC's work is in support of the existing efforts of Hayat and seeks to offer additional specialist technical input as well as ideas from Practical Action's international experience in the area.

During the visit in April the focus was on developing proposals at specific locations in collaboration with communities and Hayat field staff, building primarily on the first two project ideas outlined in the introduction, while bringing as much additional value as possible to the Hayat team and assessing options for future projects. Prior to the visit, preparatory tasks were assigned to both Hayat and PAC. Hayat identified communities with specific demand for the types of project envisaged and located potentially suitable local suppliers of equipment for the projects. PAC collated internal and international experience and best practice literature relevant to the projects¹ as well as identifying international suppliers of clean energy hardware which may not be sourced within Azerbaijan.² Additionally PAC sourced a number of pieces of demonstration hardware to illustrate the potential and principles of small scale renewable energy devices and presented them to Hayat staff in training workshops.

The working arrangement for site visits in Azerbaijan was for Steven Hunt to be accompanied by a translator (Rafiq Gurbanzade), a Hayat Engineer (Uzair) and the relevant Hayat community liaison officer where possible. In addition, Steven was accompanied for several days by Eric Lepisto, a consultant working with Hayat and key participant in the development of the initial project ideas.

1.3 Project recommendation selection methodology

It was well known prior to the visit that there were a large number of unmet needs in many areas of rural Azerbaijan which would be deserving of project support. However, for the purposes of PAC's support through DEFRA for the EAIP project it was necessary to focus on specific issues relating to energy provision and energy efficiency. In selecting appropriate communities for project development PAC used the following criteria:

- Strong need expressed by community/municipal leaders
- Capacity for that need to be met by clean energy/energy efficient technologies
- Willingness of community leaders to consider clean/energy efficient solutions
- Strong community benefit able to be shown within project budget of \$10K-\$12.5K
- Complementary to any other project initiatives from other development actors
- Ability to raise general awareness of clean/energy efficient technologies
- Potential for replication

All the sites selected by Hayat staff for consideration were those which were considered "strong" communities in terms of the organisation and enthusiasm of the community committees but who had submitted "weak" proposals which were not approved in the first round of EAIP project selection. The intention of the above criteria was to further assess the most appropriate context for assistance in developing clean/energy efficient projects for support by BTC. After an initial building survey and meeting with community

¹ Appendix 5

² Appendix 4

leaders, those meeting the above criteria were visited again for follow-up meetings, more detailed surveys and solution oriented exploratory discussions with community leaders. Given the limitations of the budget for project development only the two sites which offered the most likely conditions for successful project implementation were taken up and these were as follows:

- Qara Jali Community Medical Centre, Ujar Region
- Tovuz City Pedestrian Railway Underpass, Tovuz Region

Details of all the building surveys are provided in Appendix 2. Recommendations for the two selected project sites as above are developed in the following two chapters, while initial assessments of other projects recommended for further development are supplied in chapter 4.

2. Qara Jali Community Medical Centre, Ujar Region



2.1 Building Assessment and Interview Report³

The Qara Jali Community Medical Centre was built in April 2005 with International Medical Corp and BTC financing. It provides general medical, dental and midwifery services to around 450 community members of two local villages at a rate of around 5-10 persons per day. The centre has a total staff of 15 although typically about 3-4 are present at any one time. The staff live locally and typically occupy the building from around 7.45am to 4 or 5 pm in the evening.

The building as it stands is in fairly good condition as would be expected of a new building, but does not incorporate any energy efficiency measures and is lacking several key services. The following main problems were explained by Dr Matanad Gurbanova who runs the centre:

- *The building is extremely cold in the winter*
- *No refrigeration of vaccines is available*
- *No hot water is available for cleaning*

In the winter, she reported that staff confined their movements wherever possible to the south-easterly room where they kept a wood burning stove lit to keep warm. Where another room was required for example for dental care or delivering a baby, small electric resistance heaters were used when electricity was available or otherwise extremely cold temperatures were experienced. The assessment of the fabric of the building validated the perspective of the staff showing up significant deficiencies in air-tightness, insulation levels and supply of basic services. Figure 1 below shows the basic layout of the building along with notes of key issues.

³ For full report see Appendix 2

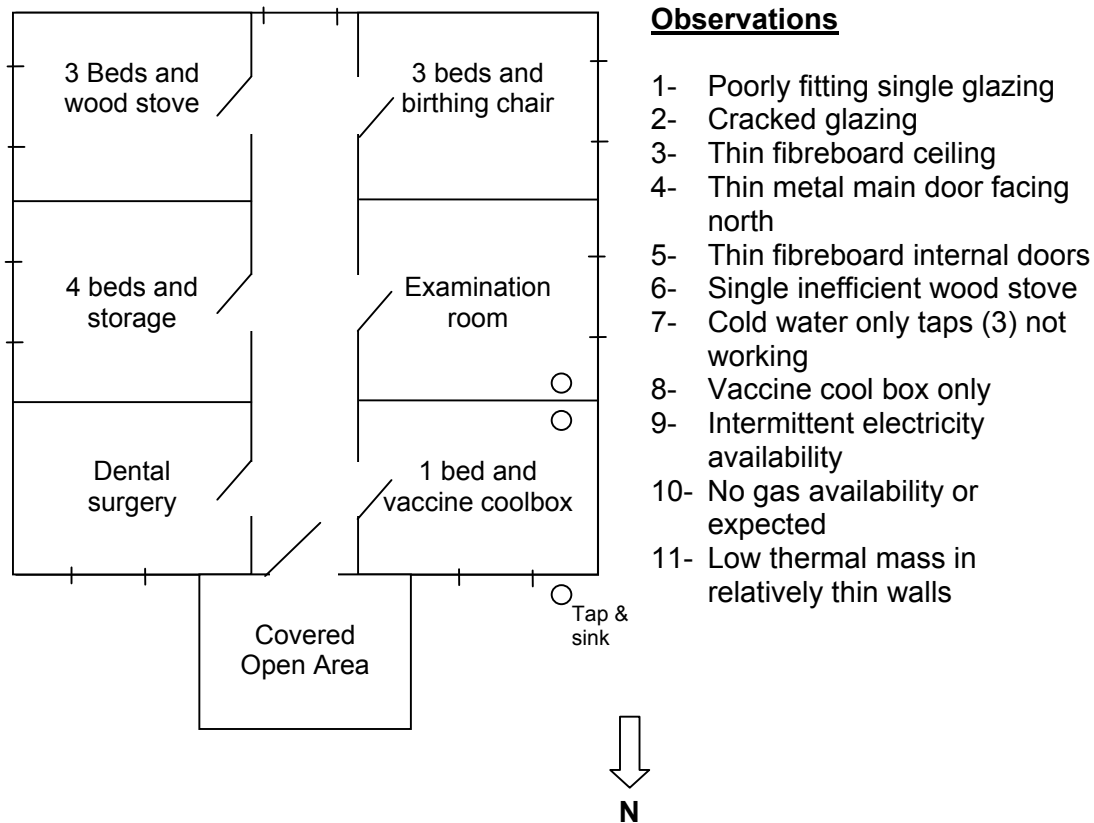


Figure 1 - Qara Jali Medical Centre Building Layout and Observations

As a fairly small community building in fundamentally sound condition with a clear need and demand for energy services, the Qara Jali medical centre was identified after the initial survey and meeting with medical staff as a site with potential for project development. Some initial ideas were developed and a follow-up meeting arranged with the community leaders and the building staff to discuss potential project options. The community leader Mr Visoli Samadov expressed the strong interest of the community in improving conditions in the clinic, showed openness to considering innovative clean energy options for addressing the needs of the clinic, and expressed the willingness and ability of the community to contribute in finance, materials and work. The opportunity is there to build on the previous IMC/BTC financed clinic to significantly improve the service to community members through showcasing low cost and appropriate clean energy and energy efficient technologies.

2.2 Project Recommendations

The following recommendations for the Qara Jali medical centre are made in the light of this initial survey and the discussions with staff and community representatives. The recommendations are structured around an understanding of the building as a complete

system where interventions can be broken down into those on the supply and the demand sides. On the demand side the priority is to ensure that all available energy in the form of heat and light is used as efficiently as possible which in turn minimises the amount of input energy required. On the supply side the priority is to ensure that the maximum benefit in terms of services is obtained from those energy resources available. The main recommendations are therefore for the implementation of the following measures to improve conditions and services at the medical centre:

- *Low cost measures to increase building energy efficiency*
- *Use of alternative energy to provide improved services*

These recommendations are expanded and developed in more detail in the following sections.

2.2.1 Low cost measures to increase building energy efficiency

The current extremely low winter temperatures in the building are mainly due to the draughty and poorly insulated nature of the building. Gaps in the building allow excessive air exchange with cold outside air while the poor insulation allows what heat has built up to conduct quickly away from the building. The first set of recommendations are as follows to address this issue:

- **Installation of ceiling insulation**

The ceiling of the medical centre is made of fibreboard with thickness of approximately 3mm tacked to wooden roof trusses while the roof itself is made of corrugated iron. All the ceiling and roofing materials are in good condition but provide an extremely poor thermal barrier to heat escaping through convection (heat rising) and then conduction through the ceiling into the roof space and out. This is mainly due to the thinness of the fibreboard and the high thermal conductivity of the metal roof especially under high wind chill conditions.

Much of the heat in the building which is built up by body heat, passive solar gain through windows and additional heating sources is lost through the ceiling. Given the good condition of the ceiling and roof it is considered that the addition of ceiling insulation would provide the greatest benefit at minimum cost in comparison to replacing any of the existing materials. The ceiling area is around 115m² although the actual insulation required would be less due to ceiling beams) and would require insulation with a material of as high thermal resistance (U value) as possible.

The most obvious material choice, based on ready availability in local hardware stores and familiarity to local building contractors, would be glass wool on an Aluminium backing. However it is also recommended that consideration be given to using other insulating materials using local resources if possible. One material of particular interest

may be low grade wool associated with the sheep herding business widely practiced in the region. Hayat field staff are currently investigating options for this and will report back to the community on the viability of this material.

- **Application of caulking to window gaps**

The current wooden window frames are in good condition however they are single glazed and the glass, fitted by the community members themselves, is poorly fitting. Nails are used to hold panes in place allowing air gaps to exist between the glass and the frame promoting very significant heat loss in the winter.

Although the most energy efficient solution would come from replacing the windows with double glazing, given the newness of the windows and good condition of the frames, it is recommended that instead particularly poorly fitting panes be replaced and caulking applied to the edges of all window panes to ensure a seal with the frame. This will significantly improve the performance of the windows in resisting heat loss at a fraction of the price of replacing the windows. This will also highlight a simple practice in improving building air tightness to community members visiting the clinic who may also not have the capital to afford full double glazing.

The most appropriate type of caulking which is readily available locally is silicone caulking which comes in tubes using a gun type applicator. The type of seal which may be obtained is as shown in cross section in Figure 2 below.

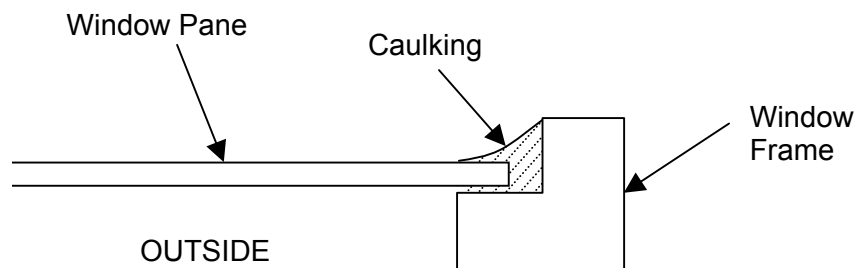


Figure 2 - Caulking Application on single glazed window

- **Replacement of broken/cracked panes of glass**

In addition to poorly fitting glass, at least 8 panes of glass on the building were identified as being cracked or broken. Cracks reduce the ability of the glass to keep in heat and the broken panes should be replaced. Of particular concern should be the window above the main door which is made in several sections having gaps in between them. This should be replaced as a matter of urgency as this north facing window provides a perfect conduit for the ingress of cold air in the northerly wind.

- **Installation of insulation, rubber seals and an additional plate to front door**

As shown in Figure 1, the only access to the building is through a large steel door in the north side of the building. Doors in northern exposures are always vulnerable points as the coldest winds are generally from the north meaning that opening the front door can cause a large amount of cold air to enter the building. In addition the door in place is single sheet steel with steel-on-steel mating when closed providing a very poor seal and leading to cold draughts.

It is recommended that insulation be fixed into the door cavity and a second plate be fixed to the back of the door sandwiching in the insulation. Further it is recommended that rubber gaskets or seals be fixed around the edges of the door so that when it shuts these seals are compressed forming an air tight seal and excluding draughts. These changes will have a very significant effect in reducing the ingress of cold air from the north.

- **Additional measures for consideration by the community**

The measures suggested above have been selected for their high cost-benefit ratio in terms of the amount of difference they will make in keeping the building warm in the winter vs. the cost involved. Other interventions would also have a positive effect on the heat efficiency of the building as described below, and these may be taken up by the community as finances allow:

Fill in porch and put door in west side

The frequently opened front door is a big source of heat loss, particularly when it is north facing as in this case. The first step would be to insulate and seal it as described above however it would also be very beneficial to shield this door from the north wind and provide a buffer against opening directly to the cold air. The most effective way to do this would be by creating a porch vestibule in front of the clinic, filling in the walls under the existing roof section as shown in Figure 3 below:

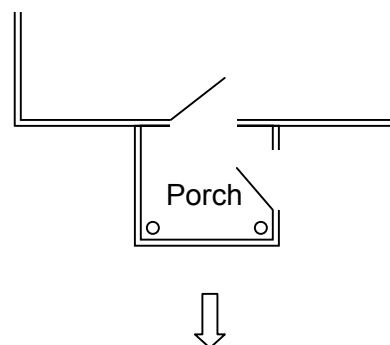


Figure 3 – Existing covered area and diagram of possible added vestibule wall

Filling in the walls of the porch would provide a buffer space “air-lock” so heat in the building would not be lost as the front door is opened into the protected space. Placing the door to the porch on the west side of the porch (where the path currently runs up to the main door anyway) would deflect the worst effects of the cold northerly winds.

Plant trees on northern exposure

Another form of protection from cold northerly winds is to shield the building itself which is most commonly done using coniferous trees which retain their foliage and so wind blocking ability in the winter. There are already some coniferous trees to the north-west of the building and if these could be extended further across the northern side this would have a beneficial impact.

Add another panel on internal doors

The internal doors from the main corridor to the 6 rooms in the clinic use the same thin fibreboard as the ceiling and are thus extremely poor heat barriers. The practice of heating an individual room with a wood burning stove is far less effective as the door to that room will leak a large amount of heat into the cold corridor. Although the aim of the project is to increase the habitability of the whole building, adding an additional layer of fibreboard and considering draught excluders at the bottom of internal doors would keep the heat within individual rooms far better than the existing doors. This gives users flexibility as to which rooms they keep most warm and which will stay warm once heated.

Curtains

The curtains currently provided in the clinic are thin net type curtains as shown in Figure 4. These allow through a lot of light but do not provide any thermal barrier to the heat lost through the windows. If these were replaced by thicker curtains this would provide a valuable, low cost and flexible barrier against heat loss. The effectiveness however of the curtains however would need to be balanced with the proportion of the time with electricity is available since clearly if no light is available thicker curtains would not be useful.



Figure 4 - Curtains and window in the Qara Jali Clinic

2.2.2 Use of Alternative Energy to provide improved services

In addition to reducing the demand for heat through the energy saving methods described in the previous section, the building also requires improved energy services in response to the needs identified by Dr Gurbanova. Having taken into account the existing energy services available to the building and the apparent additional energy resources available at the site, the initial opinion of the consultant is that the most

reliable and energy efficient way to meet these needs is through a combination of the use of solar power and mains electricity.

Electricity is available at the site but is intermittent due in part to poor wiring installation to the clinic and in part to the general limitations in place on electricity availability across the region. The staff at the clinic estimate that electricity is normally available between 6am and 12noon or 1pm and then again between around 6 or 7pm until midnight. The evening supply is not available at the same time as the staff are at the office and supplies to the clinic are interrupted more frequently than general supplies in the area due, in the opinion of the community leaders, to the poor wiring installed when the building was constructed.

Although it was not possible to obtain local data for the solar insolation at the site during the April visit to Azerbaijan, the general levels of solar radiation available are as shown in the graph below:

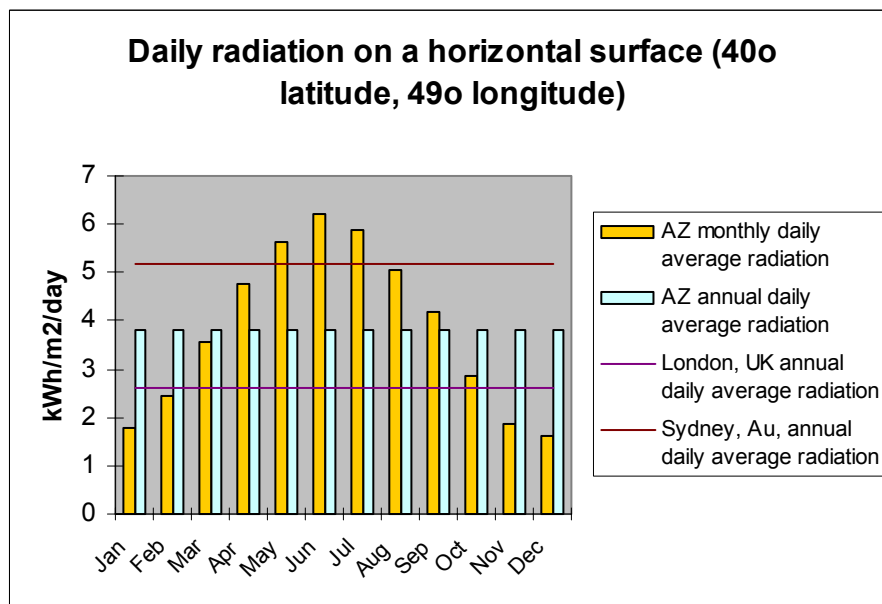


Figure 5 - Average expected solar radiation in Azerbaijan⁴

As can be seen from the graph above, the average radiation levels expected in Azerbaijan on the basis of latitude and longitude compare very favourably with Northern European countries like the UK which have a large number of solar installations, although it is below high insolation countries like Australia. At the time of writing, Hayat staff are attempting to source local weather data for Qara Jali (or at least Ujar region) to provide further information about particular local weather conditions including solar radiation. This information will be very important in understanding the storage and

⁴ ITC 2004

backup requirements of systems incorporating solar photovoltaic (electricity generating) or solar thermal (heat generating) technologies. When the available resource is known it will be possible to compare this with the energy conversion efficiency of the equipment used and with demand patterns in order for suppliers to design reliable systems.

The types of systems which it is recommended are considered for the Qara Jali clinic by the community are as follows.

- **Installation of a solar water heating system, tank, piping and taps (including repair of water pipe)**

The lack of readily available hot water is a serious problem in any medical centre where proper washing of surfaces, equipment and people is very important in promoting a sanitary environment to minimise the spread of infections and diseases. Although the nurses have the facility to boil water when the electricity is available, this is intermittent as previously noted and limits their ability to wash large areas or items with hot soapy water. Currently even the cold water is not working in the medical centre due to a burst pipe from the water tank caused by frost damage.

Given the intermittent supply of electricity and the availability of high levels of solar radiation, it is recommended that a solar water heating system backed up with electric resistance (immersion) heating be installed. The detailed layout of the system would have to be agreed with the chosen supplier however the outline layout would be as shown in Figure 6 showing a cross section of the clinic and water tower.

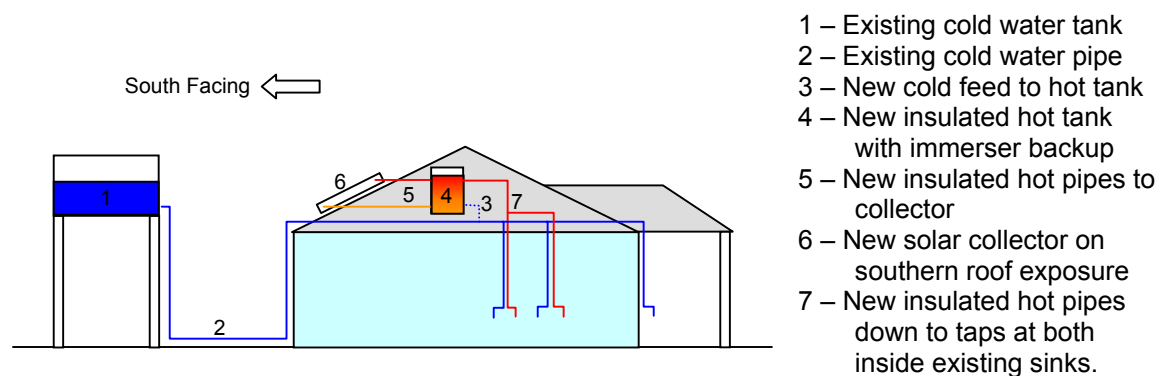


Figure 6 - General layout of clinic solar water heating system

Figure 6 shows a direct solar water heating layout with circulation of the water driven passively by the thermosyphon effect of hot water rising. A direct system is the simplest and lowest cost type of system available however the supplier will have to warrant the design for the specific weather conditions at the site since in extremely low temperatures freezing and damage can occur in the solar collector at night. A thermosyphon based system is also simpler and lower cost than a pumped circulation system but can be

slower in acting and the supplier may recommend a small pump which may be powered from the solar PV panel (see next bullet). Additional design features can include expansion chambers for extremely hot days when the water can boil, and water level float valves to control the cold feed. If, as recommended an electric immersion heater is added as back up, it should only come on as needed and so a temperature sensor and switch would be required. Suppliers of solar water heating systems exist in Azerbaijan and discussions are underway between Hayat staff and Gunas Istisi who provide a range of sizes, prices and capacities of system although the requirement here will be at the low end of the size and cost range.

The existing cold water pipe (2) would have to be repaired at the joint just under the valve on the downpipe from the cold water tank. It is advisable also to lag the existing cold water pipes to avoid a repeat of the frost damage seen currently. The new insulated hot water tank (4) would be installed in the roof cavity of the medical centre, gravity fed from a branch (3) off the pipe from the cold tank (1) which sits slightly higher than the ceiling level. Short insulated pipes (5) would carry the water to the solar collector on the south facing roof. The solar collector consists of high thermal conductivity black metal pipes on an insulated base under a glass screen which rise to a high temperature even under moderate sunlight conditions. New, insulated pipes (7) would then feed from the hot tank down to taps at both the internal sinks in parallel with the existing cold supply.

- **Installation of a Solar PV Vaccine Refrigerator**

The intermittent supply of electricity poses several problems for providing health services to the Qari Jali community particularly in terms of the inability to refrigerate vaccines at the medical centre. Currently a cool box is brought to the clinic often enough to ensure an adequate supply but this means only a small amount of vaccines can be stored for a very limited time, especially in the hot summer months. A vaccine refrigerator was identified by Dr Gurbanova as having important benefit for the community. Given the intermittent access to mains electricity, the most reliable method of refrigerating vaccines would come from the use of solar PV generated electricity to power an efficient and well insulated fridge unit. Units such as this are well developed on the international market although only those tested and approved by the World Health Organisation should be used.⁵ The use of mains electricity when it is available could in principle complement the PV supply, and reduce the numbers of PV panels required by topping up the battery when available. However, WHO standards do not promote this type of system due to the uncertainty over how often the mains power is actually available which must be taken into account in sizing the rest of the system. This should be verified with system providers when they do a detailed system design prior to ordering. Suppliers for vaccine refrigerators and outline quotes from two suppliers are as listed in Appendix 5. A typical system layout for a vaccine refrigerator is as shown in Figure 7 below:

⁵ Details at <http://www.who.int/vaccines-documents> and a list of potential suppliers is provided in Appendix 5

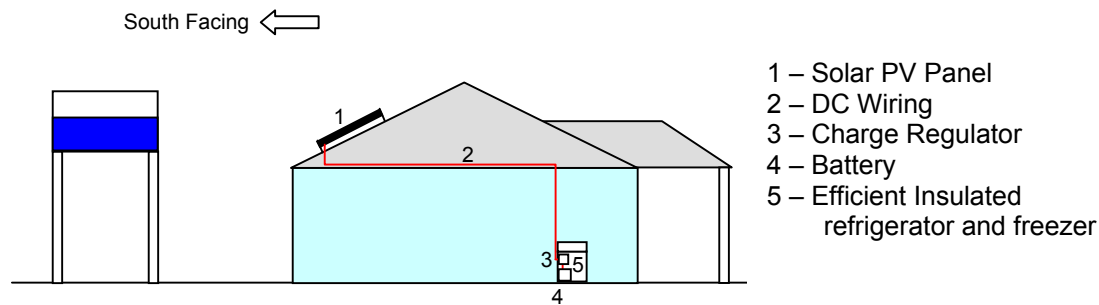


Figure 7 – General Layout of clinic Solar PV Vaccine Refrigeration System

Refrigeration is a particularly good application for solar PV as the system has inherent storage and the greatest need for refrigeration (hot summer afternoons) coincides with the greatest incidence of sunlight. In the clinic therefore, use of solar PV will ensure that even at the height of summer in the afternoon when no mains power is available, the solar PV will be generating to ensure that the vaccines stay within the specified temperatures. Solar PV vaccine refrigerators have no running costs and maintenance requirements are limited to battery changing (after around 5 years).

In the Qara Jali clinic the solar PV panel should be positioned on the south facing roof alongside, but not overshadowing or overshadowed by, the solar water heating collector described in the previous section. The specification of the refrigerator will be proposed by tendering companies and dependent on the local weather conditions, however given the community and building size, the refrigerator is likely to be at the smaller end of the range of system sizes, capacities and costs available.⁶

There are several ongoing initiatives in Azerbaijan regarding vaccine provision including refrigeration. One such project is by the Vishnevskaya-Rostropovich Foundation backed by the US Department of Agriculture which has provided 191 refrigerators and generators in Azerbaijan as well as cool boxes as part of their work to provide the MMR vaccine to 750,000 Azeri children. There was not time during the visit to Azerbaijan to meet with any actor in the health sector involved with those initiatives but co-ordination with them should be sought by Hayat in developing this project along with the community. The use of solar PV technology and improved efficiency fridges represents an important opportunity to show how alternative energy can be used to provide essential services while avoiding increased reliance on diesel (which has increased in price two fold since last year along in Azerbaijan) and protecting the local environment and air quality around the clinic.

- **Installation of electric storage heater or improved wood burning stove**

The energy efficiency measures suggested on the demand side in the previous section will have a very large impact on the temperature in the building in winter even without the

introduction of additional heat sources. However there are also options for providing additional heating in the building as well as improving the efficiency of heating options already utilised. Currently electric resistance bar heaters are used in less frequently used rooms when the electricity is on while a wood burning stove is used in the most frequently occupied room in the South-East corner. In the absence of gas and without the ability to make significant building design changes to maximise solar gain, it is likely that biomass and electricity will remain the most practical heat energy sources.

Taking the wood burning stove first, the stove currently used is a basic type of box stove using thin steel in a folded construction leading to inefficient burning, poor heat conduction into the room and a short lifetime. However this type of stove is extremely cheap and practically ubiquitous in all the parts of Azerbaijan travelled to by the consultant. Section 3.5 of this document refers to the opportunities available for an additional project to develop an improved efficiency wood burning stove, building on the existing manufacturing technologies used and without adding excessive additional cost. The Qara Jali clinic could provide an ideal opportunity to test a prototype design at a location where educated personnel may be able to assist in taking simple measurements over time to provide data on the temperature and wood use differences achieved.

Heating is inherently an inefficient use of electricity which is an extremely flexible energy carrier usually generated itself from burning fossil or biomass fuels. However in the instance where it is one of the few options it may still be used more efficiently and usefully than the current small bar heaters which are used in the medical centre. A particular problem of the bar heaters is that they are only on in the mornings when electricity is typically available and go cold very shortly after the power goes off as they have no heat storage capacity. Similarly electricity availability in the evenings and night are not useful to the clinic staff working during the day. Storage heaters can be used to address these mismatches and gaps by storing heat in high thermal mass energy stores (typically specially formulated bricks) and are commonly used in northern European countries to take advantage of lower cost electricity at night (when demand is typically low) and then to provide heat during the day. Although there does not appear to be any supplier of electric storage heaters in Azerbaijan, it would be possible to import designs for trial and learning in the clinic to assess their appropriateness for replication.

- **Additional measures for consideration by the community**

Gas canisters

Although there is no gas supply to the building it may be viable to consider purchase of a gas heater operating from a gas canister delivered to the clinic periodically. This would provide controllable and efficient heat without the use of wood resources which are shipped in from other regions due to the very small amount of biomass available in Ujar Region.

⁶ ITDG. See Appendix 5.

2.3 Budgetary Estimates for Project Implementation

With the projects at the outline design stage and additional information required it is not possible to provide a firm costing for implementation of the project recommendations at this point. However the table below provides price band estimates where possible to assist communities in selection of elements of the project, in acquiring quotes from suppliers and in proposal preparation for EAIP support. Where stars are shown this item is pending local prices and assistance is sought from Hayat staff and communities in estimating them.

Recommendations	Capital Cost (\$)	Running Cost (\$)	Transport /Installation Cost (\$)	Estimate Source
Ceiling Insulation	150-300	0	*	Yevlakh Hardware
Window Caulking	10-20	0	*	Yevlakh Hardware
Cracked Glass Replacement	20-50	0	*	Yevlakh Glass
Front Door Insulation and sealing	*	0	*	
Building of Porch Vestibule	*	0	*	
Planting Trees on Northern side	*	0	*	
Curtains	*	0	*	
Solar Water Heating System	1000	0 ⁷	*	Gunas Istisi
Water piping, pipe insulation, taps, repair of existing cold pipe	100-200	0	*	Topdan Statis
Solar PV Vaccine Refrigerator	2200-6000	0	*	ITDG Tech Brief
Improved Woodburning stove ⁸	20-40 (prototype)	*	*	Barda Forest Inst.
Night Storage Heater	140-200	*	400	Dealec
Gas Heater	100-150	*	*	Kelkoo

It should be noted that the estimations above do not include any costs for further project development or detail design work which is described in the next section.

⁷ Depending on requirement for electricity backup

⁸ The availability of the improved stove is dependent on an additional project to develop it as described in Section 4.6 of this report.

2.4 Way Forward

Depending on Hayat's assessment of the detail requirements of proposals for EAIP project funding it may be that a proposal can be submitted at this stage or that some more detailed design should be carried out. However, in terms of project implementation the following are the key action items required moving forward.

- Translation of this report into Azeri for reading by Hayat field staff and communities
- Meet with the VRF, UNICEF and other relevant health sector actors in order to co-ordinate with any activities they may be undertaking
- Obtain an architectural drawing of the clinic from IMC/BTC to enable detail design
- Obtain local weather data for the site particularly sun hours, solar intensity and temperature to enable design of the alternative energy systems
- Further investigate the possibility of using wool as the ceiling insulation material
- Further discuss project recommendations in this report with the community leaders and clinic staff to agree on the components of the project to be pursued and the allocation of responsibilities/costs etc in moving forward
- Prepare the proposal for EAIP project funding
- Obtain quotes/start tender process for hardware delivery from potential suppliers
- Carry out detail design as required (although this should largely be carried out by equipment suppliers)

3. Tovuz City Pedestrian Railway Underpass, Tovuz Region



3.1 Assessment and Interview Report

The Tovuz City Pedestrian Railway Underpass was built 25-30 years ago during the Soviet period in Azerbaijan. The underpass links the communities either side of the railway line which was built in 1883, as well as being the main route from the railway station to the amenities and public buildings around about the main square. Prior to the building of the underpass there were a number of fatalities on the line but since its construction there have been none reported. However, although quite grand when opened with many lights, ornate signs and marble cladding, the underpass has fallen into an extreme state of disrepair in the post-soviet era.

Drainage blockages on the railway siding and within the underpass have caused seepage into pools of stagnant water and algae to form on the walls. All the lighting appears to have been removed although some empty fittings and cable routings remain. In the stead of the original cables, newer cables have been jerry-rigged along the ceiling with bare wires showing and bare light bulbs in place. However, on the night the underpass was surveyed there was absolutely no light and local residents said that it had been that way for several months. The lack of light and drainage has promoted extremely unsanitary conditions in the underpass augmented by urination creating a serious health risk. Worried also about personal safety, many people, especially older people and women, are reluctant to use the underpass and choose to cross the 5 unlit railway tracks and sidings. This has obvious safety implications as pedestrians cross the uneven and often slippery track area during the 10pm-12midnight period when the station is most busy with trains, due to the location of Tovuz on the main line between Baku and Tblisi, Georgia.

In addition to the specific problems associated with the underpass, the disrepair of the underpass as the main pedestrian link between the station and the central square is a symbol of the way that infrastructure has crumbled since the end of the soviet period. The underpass is the “most used part of the town” during the day and night according to Mr Fattahou Firdovsi, the deputy head of the municipal government of Tovuz City, and new amenities being built currently around the main square including a wedding building will increase the traffic. It was felt by the municipality that “people very much want lighting in the underpass” and a project focussing on improving the underpass could be

very powerful in “mobilising the community around it”. A project at this location would therefore not only provide an extremely valuable health and safety contribution to the community it could also provide an important focal point to mobilise community action around environmental improvement as well as a symbol of redevelopment in the town. The prospect of using alternative energy such as solar PV was seen by the municipal leaders as an exciting opportunity to showcase a modern type of energy in a prominent location. The association of the underpass with the railway puts it primarily under the jurisdiction of the transport ministry; however the municipal officers were confident of the co-operation of the ministry in a project contributing to improving conditions. It was not possible during the PAC visit to meet with the ministry of transport but a meeting should be sought as soon as possible to clarify details and discuss proposals.

At the time of writing Hayat staff are attempting to obtain an architectural drawing of the underpass from the transport ministry. The general layout of the underpass is as shown in Figure 8 below along with the main problems observed there:

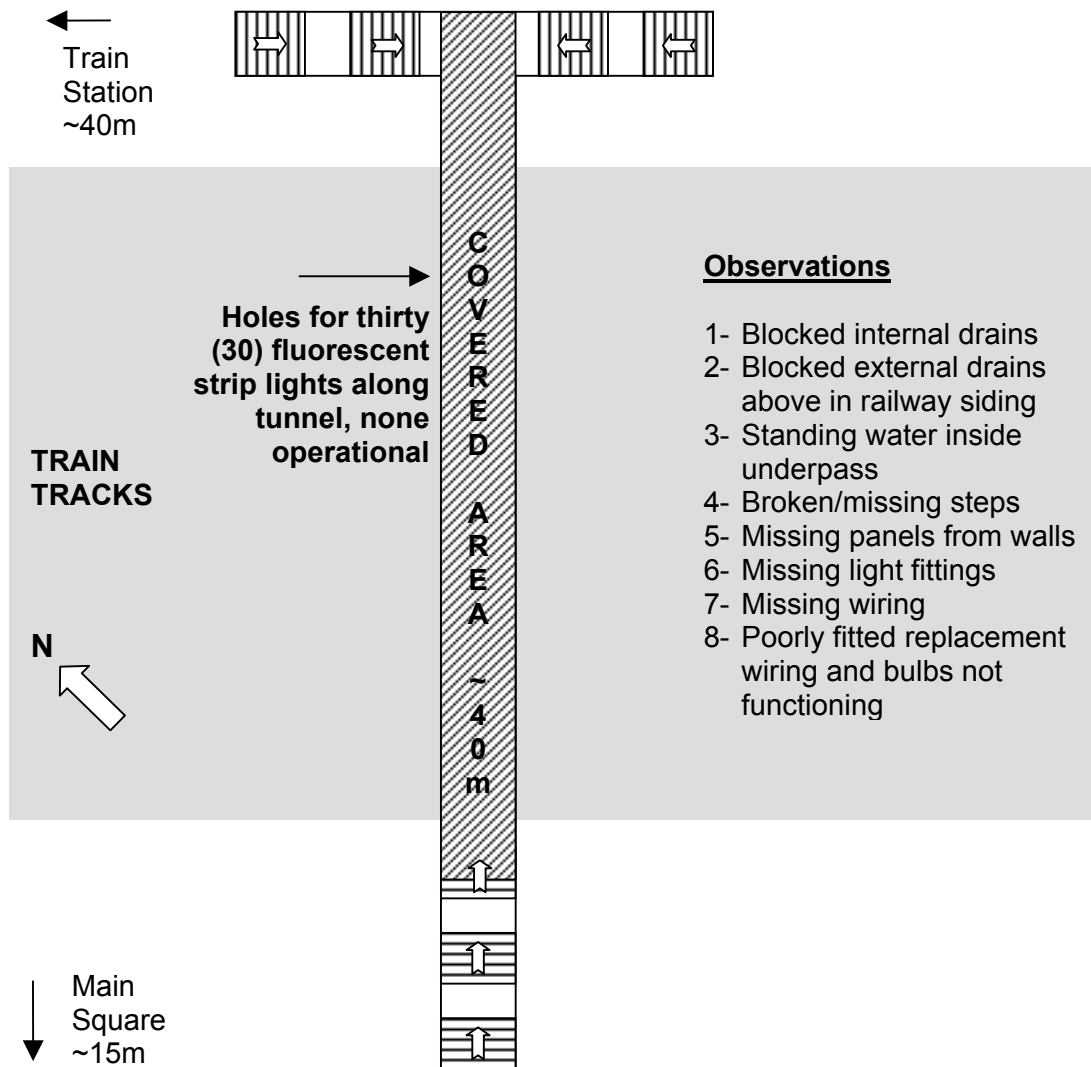


Figure 8 - Tovuz Railway Pedestrian Underpass Layout

The covered area of the underpass is approximately 40m long and even in broad daylight is very dark as shown in the right and left hand pictures at the beginning of this section. At night it is not possible to see your hand in front of your face within the underpass. In both circumstances, in addition to the fear of assault or robbery, it is not possible to see and avoid the many pools of standing water and urine evidenced by the smell in the underpass. Only young men were seen to use the underpass after dark while all other community members were clambering over the railway tracks through wet mud as the trains were passing.

Given the strong need expressed, willingness on the part of community/municipal leaders to consider alternative energy sources which have the capacity to address the need, high potential benefit within the project budget, great awareness raising potential and replication opportunities, it is considered that this site meets the criteria for potentially successful EAIP project implementation. The following section outlines recommendations for consideration by the community and municipality in Tovuz with a view to bidding for implementation support from the EAIP project fund.

3.2 Project Recommendation

The recommended project interventions at the Tovuz pedestrian railway underpass can be broken into three mutually reinforcing types of activity as follows:

- *Environmental Improvement*
- *Provision of lighting inside the underpass*
- *Powering of lighting from alternative energy sources*

Improving the environment in and around the underpass will have a great deal of impact in terms of reducing the health risks associated with the poor current conditions as well as making the underpass more pleasant to use, and encouraging people not to cross the railway tracks. This intervention will be highlighted and reinforced by the provision of lighting in the underpass which will help to reduce misuse of the underpass, such as littering and urination, as well as making the underpass much safer at night. The powering of the lighting from alternative energy sources will provide a focal point for the project in terms of attracting community attention and showcasing the technologies.

It is hoped, based both on experience elsewhere and initial discussions in Tovuz that the combination of these three interventions will significantly raise the sense of ownership, pride and responsibility felt within the community for the underpass and the area around it. It is this type of connection within the community which is crucial if the interventions are to be sustainable and not suffer from abuse, theft, vandalism or breakdown. For example improving the lighting without refurbishing the tunnel (as was done in the previous “jerry-rigging” efforts) simply highlights the dilapidated state of the underpass from which lights “might as well” be stolen or broken, while environmental improvement without lighting would not enable night use and provide cover of dark to those abusing the facility. It is hoped that the inclusion of alternative energy in the lighting will add an

additional powerful element of modern, alternative technology which, in addition to its contribution towards increased environmental sustainability, will help coalesce interest and engagement.

3.2.1 Environmental improvement

Improving the conditions within the underpass is the first step in rehabilitation and an important step in increasing awareness of the importance of taking responsibility for the natural and built environment of the town. Although some of the environmental improvements suggested in this section will require the specialist skills of the municipal engineer, many can be undertaken by community groups in support of the project.

- **Improve drainage above and within the underpass**

The first problem which must be resolved is the drainage issue in the underpass. In addition to the health risk already discussed, water seepage into lighting could damage the system. The two main components of the drainage problem appear to be blocked drains and standing water in the railway siding above the underpass, particularly on the south side of the underpass, and blocked drains within the underpass which are not letting water drain out when it enters through seepage or rain runoff from the stairways.

Figure 9 below shows the water seeping from above into the underpass at the southern end, promoting algae growth and potential damage to the structure of the underpass (left) with a blocked drain in the railway siding directly above (right) which is very likely to be a contributor to the problem.



Figure 9 - Seepage inside southern end of underpass and blocked drain in railway siding above

In addition to the blocked drain above the underpass there is standing water in the siding itself and a former weighing station full of water just to the northeast which may be a contributing factor. It is also possible that a burst buried drain pipe may be contributing to the seepage.

Figure 10 below shows the internal drains at the northern end of the underpass which are blocked with mud and garbage which are leading to water standing at the mouth of the underpass.

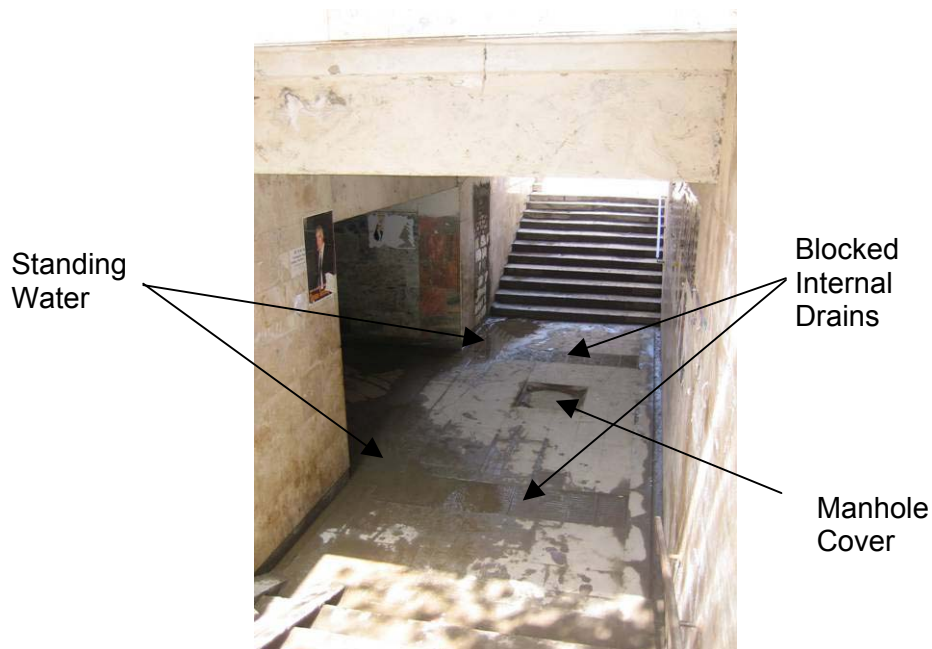


Figure 10 - View of standing water and internal drainage at the north end of the underpass

It was not possible during the visit to obtain drawings of the drainage system around the underpass which should be in the architectural drawings currently sought by Hayat project staff. It is recommended that if possible a drainage or municipal engineer carries out an assessment of the drainage associated with the underpass to ensure that there are no additional factors involved or works required. If not, then pumping out and unblocking of the existing drainage systems above and within the underpass would be the only intervention required to solve the standing water and seepage issues currently a root problem in the underpass. Cleaning, refurbishment and lighting of the underpass could then start without fear of destruction by water ingress.

- **Repair broken steps**

There are several broken steps as illustrated in Figure 11 which present safety hazards to users of the underpass, especially currently given the lack of lighting at night. Broken steps should be replaced to remove this hazard and contribute to the general accessibility and usability of the underpass.



Figure 11 - Broken steps in the underpass

- **Repair broken marble, concrete and plasterwork**

Internal walls and ceilings are damaged in several places (such as that shown in figure 12) where marble is missing, concrete has cracked or plaster has been damaged by water ingress, removal of wiring and lighting fixtures or vandalism. As with the drainage it is recommended that a structural engineer carry out an assessment of the underpass to ensure that none of the damage has structurally undermined the construction. Assuming that this is not the case, replacement of broken wall and ceiling parts should be undertaken to raise the quality of the environment in the underpass and with it hopefully the perception of value in the community.



Figure 12 - Broken walls and ceiling facings

- **Paint internal walls**

In addition to refurbishing the steps, concrete and plasterwork, the final improvement would be to repaint the internal concrete and plaster areas on the ceiling and upper walls of the underpass to seal and protect them. A light coloured paint, with a high reflectivity should be used to maximise the light reflected into the underpass and provided by the lighting provision in the next section.

- **Additional measures for consideration by the community**

In addition to the measures above which are the basic requirements of any project to improve the built environment within the underpass, other activities might also be considered by the community to complement these improvements as follows:

Landscaping of Accessways to the underpass

In addition to the improvement of the actual fabric of the underpass, a significant part of the perception of the underpass occurs as the pedestrian approaches it which may be from any of the three accessways (two on the north, one on the south). The short distance from the underpass accessway on the south to the main square is currently under development to the extent that a public wedding building is being built alongside while a small park is to one side. On the northern side the accessways are close to the train station platform but the paths and general area are in poor condition as shown in Figure 13 below left along with the southern entrance on the right:



Figure 13 - Northern entrances (left) and Southern entrance (right)

Improving the approaches to the accessways would improve perceptions of the underpass, make it more welcoming and offer an opportunity for personal involvement from community members not able to do specialist work like drainage or wiring. It would also provide an improved setting for the solar PV panels which will be discussed later in the section. Approaches might be improved by being cleaned up, having paving added, plants, trees etc. Areas which might benefit particularly from this are as shaded in green in the general layout shown in Figure 14 below:

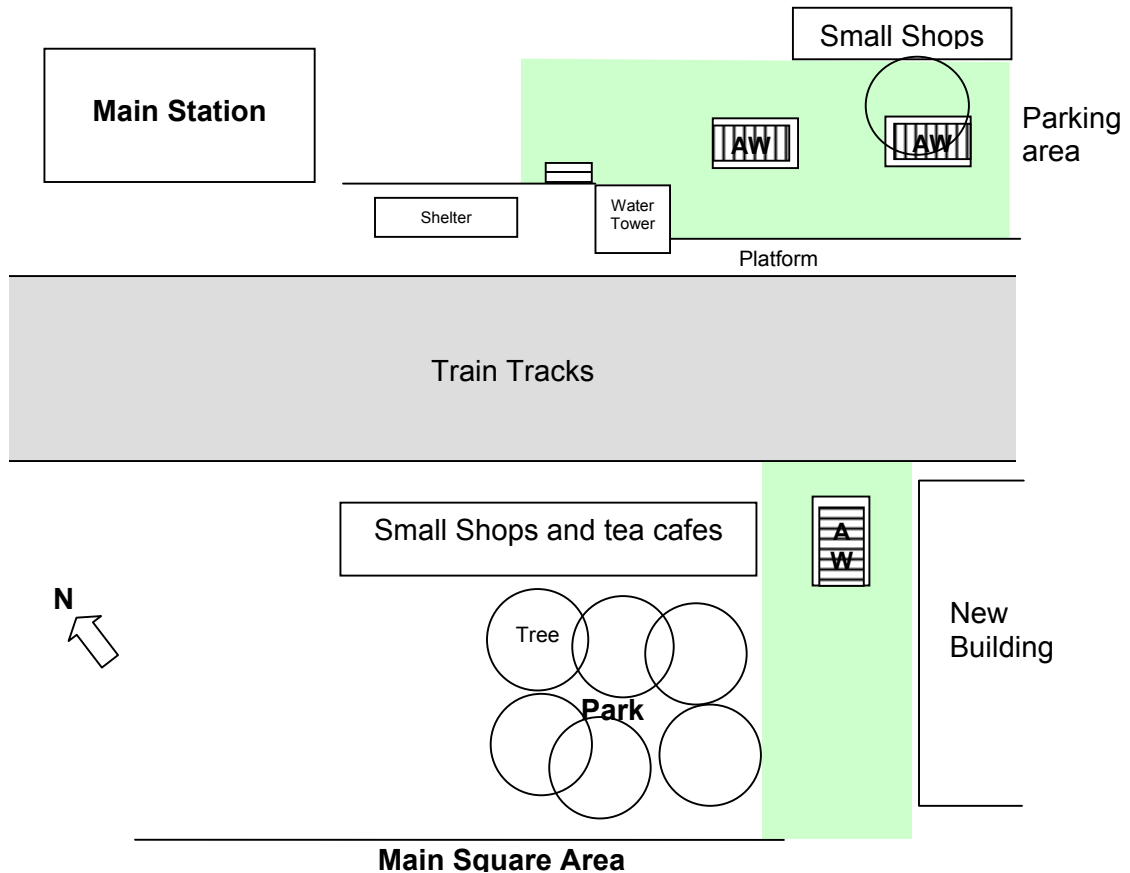


Figure 14 - General site layout and suggested landscaping around Accessways (AW)

Mural Painting

Taking advantage of the improved lighting and general condition of the underpass proposed by this project, there may also be additional opportunities to stimulate other interest and engagement from the wider community. A competition could be organised through local schools for children to design a mural for the large facing wall at the northern end of the underpass or images which could be hung along it. This could both stimulate interest, have a complementary educational function (especially if an environmental or alternative energy theme was used) and provide colourful and attractive wallhangings for the underpass reinforcing the improved environment and value to the community of the amenity.

3.2.2 Provision of lighting inside the underpass

As described previously, lighting in the underpass is the essential energy service affecting the utility and safety of the community using it. There are currently two sets of lighting infrastructure within the underpass neither of which is currently operational. The original soviet-era lighting system is built into the walls using junction boxes and concealed cable conduits while a more recent system of exposed jerry-rigged wiring and bare bulbs was apparently installed after the original system went out of operation. Almost all of the original light fittings which housed fluorescent strip lighting have been removed from the ceilings and the coverings for the wiring junction boxes removed as shown in figure 15 below.



Figure 15 - One of few remaining original light fittings (left) typical wiring junction box (right)

The circumstances behind the breakdown of the soviet-period system, including the removal of the light fittings and the opening of all the junction boxes etc, is not known

and local investigation of this by Hayat staff is recommended. It would be useful to establish whether they were removed maliciously or broke down. The existing soviet-era wiring will certainly not be usable in the future project but it is recommended that an electrician associated with the utility check whether it is possible to reuse any of the conduits which are mounted within the walls. These conduits may be reusable as long as old wiring can be successfully removed and the pipes cleaned out.

The wiring which was introduced, apparently to provide lighting after the previous system stopped working is as shown in Figure 15 below.



Figure 16 - Broken incandescent lightbulb and recent ceiling wiring (left) and recent wiring entering the underpass past soviet-era junction box (right)

This wiring has obviously been very cheaply and quickly installed and it is not known whether it was carried out by anyone associated with the utility or ministry of transport. The system has gone out of service for unknown reasons although this is not surprising given its poor implementation and lack of co-ordination with any other underpass improvement. It is recommended that the utility electrician establish where the grid connection is and ensure that the fault is not in the supply. It is likely that none of this wiring will be reusable on electrical safety grounds and it will have to be removed and new wiring installed with the new lighting system.

If the electrician concludes that the existing soviet conduits cannot be used then new routings will have to be made using appropriate fixings and shielding. The replacement lighting selected should use fluorescent or compact fluorescent to provide efficient lighting at low power consumption relative to incandescent light bulbs. The light housings should be as tamper proof as possible probably involving shatterproof glass and metal mounting boxes. The spacing of the lights should be adequate to light the space according to the specification of the lights selected. The number, type and power of the lights is further discussed in the next section dealing with the power supply to the lights.

3.2.3 Powering of lighting from alternative energy sources

The following table summarises the alternative energy options for the Tovuz underpass where the energy service required is lighting for as many hours per day as possible, but especially after dark.

Potential Alternative Energy Source for Lighting	Applicability (yes/no/maybe)	Reason
Small Wind Turbine	Maybe	Fairly sheltered location, unknown wind resource
Micro-Hydro	No	No appropriate nearby river
Solar Photovoltaic (PV)	Yes	Good annual insolation (see fig 5), can work at night with battery storage
Biomass/biogas	No	Small application without requirement for heat makes biofuel generation inefficient
Wave/Tidal	No	Distance from the sea
Geothermal	No	Unknown resource but even if present, reason would be as for biomass/biogas
Passive Solar Lighting	Yes/Maybe	During the day reflectors or light pipes could be employed but not at night

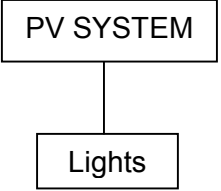
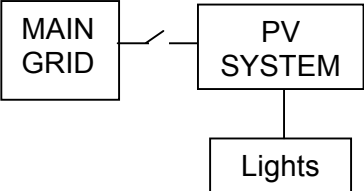
In this context it appears clear that using **Solar Energy** offers the best alternative energy solution for the application given the absence or inapplicability of other alternative energy sources. Although passive solar lighting is an attractive prospect, using light directly with the use of reflectors and light pipes to carry light into the tunnel, given the length of the tunnel it is likely to be very difficult to get light into the middle of the tunnel. Civil works between the railway tracks to create light pipes directly down into the roof of the underpass would solve this but would be likely to encounter significant opposition from the transport ministry as this would disrupt trains and so is unlikely to be approved. This leaves solar PV as the most likely alternative energy option. In order to make a decision about how and if it might be employed, it is important to consider the conventional energy services to the site and the modes in which solar PV can operate in more detail.

According to the municipal officers, mains electricity should nominally be available at the underpass 22 hours a day as it falls under the purview of the transportation ministry which has preferential access to electricity. As long as it is validated by the utility electrician that the current fault in the underpass is due to the recent poorly installed wiring and not a problem in the mains supply, a new lighting system should have access to mains electricity. As mentioned previously, there was not time during the visit to meet with the transportation ministry, but assuming that the power used is the same as that

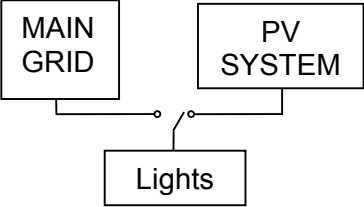
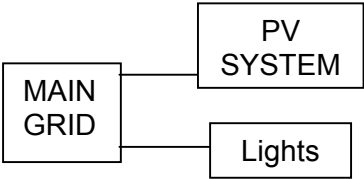
used to run the electric trains, it can reasonably be assumed that this is also more reliable than the general grid.

In this circumstance it can be argued that use of solar PV generated electricity is unnecessary in achieving the end of providing light in the underpass. However, from an environmental perspective taking into account the carbon content of mains electricity⁹ and climate change along with the stated desire of the EAIP to showcase alternative energy technologies, it can also be argued that it is preferable to use a solar PV only system with no mains linkage which would also be possible. This would show how alternative energy solutions can meet energy needs without the assistance of the grid.

In practice, in most countries with widespread grid access, renewables are used in *grid-connected* mode more often than in stand-alone applications even when the target is “renewable energy self-sufficiency” for the generator. Small-scale renewables like solar PV on a building are in fact providing power to the grid and comparing annual renewable supply to household demand in claiming self-sufficiency. These systems effectively use the grid as a storage medium thereby avoiding the need for batteries. In this instance some of the benefits of a *fully autonomous* renewable based system are not realised such as the capacity to continue to have power through a power cut on the main grid by virtue of the battery storage. However if the grid is relatively stable this benefit is usually outweighed by the reduction in system cost and complexity. In a less stable grid or where greater autonomy is desired, it is possible to operate in a *mini-grid* type arrangement where the alternative energy source can power the lighting independently or in parallel with the main grid. These modes can be summarised as in the table below:

Mode	Layout	Additional Equipment in PV System along with PV Panel
Fully Autonomous		Battery + Charge Controller
Conventional Mini-grid		Power Conditioning Unit ¹⁰ + Battery and Charge Controller

⁹ The energy mix in Azerbaijan is XX% Coal, XX% Hydro, XX%

<p>Switched Mini-grid</p>		<p>Power Conditioning Unit¹⁰ + Mains Isolator when solar is available</p>
<p>Grid-Connected</p>		<p>Power Conditioning Unit¹⁰ + 2 Meters for comparison</p>

In the case of the Tovuz pedestrian railway underpass lighting system, given the fact that lighting as many hours of the day as possible would be preferable since the tunnel is dark even during the day due to its length, an autonomous solar PV system would be relatively large and so rather expensive. This is due to the need to capture and store energy during the day at the same time as energy is being used, not just at night such as in a solar streetlighting application. This cost could be justified in a true stand-alone application with no grid available, but is difficult to justify with grid power close by.

The grid-connected mode would be applicable at Tovuz if the utility and/or the ministry of transport did not have any objection or regulation prohibiting small generators injecting power onto the grid. However, this type of arrangement is the least direct in terms of the benefit from the solar power in that one would have to calculate the difference between the solar PV output meter and the lighting input meter (which are not even necessarily connected or needing to be in the same place) in order to see the benefit. This mode would not provide the most useful initial demonstration of solar PV technology.

Either mini-grid system could be applicable at Tovuz. Using the conventional mini-grid “isolate and run autonomously” capability if there is a mains power outage could provide increased system reliability. However, if this mode is to work after dark then a charge controller and battery bank would be required as in the autonomous mode although it could be smaller and cheaper, covering only an hour or two for example of mains outage. However, if the transport grid is as reliable as would be expected in running electric trains, then this may not be a great benefit. This mode also runs into the same potential issue with connecting solar PV generation into the main grid if regulations or ministry of transport conservatism about their supply are an issue.

The switched mini-grid mode is where an isolation switch normally biased towards the solar PV power would bring in the mains power whenever there is insufficient solar

¹⁰ The PCU converts the solar PV panel’s DC output to AC, synchronises it to the grid frequency and controls the injection of power onto the grid, also managing automatic system isolation in the event of either grid or solar PV panel faults.

power (ie after dark). In this mode the PV panel would power the lights during the day and the mains would power them at night avoiding the need for battery and charge controllers but using the PV power directly in the application. This provides increased system reliability protecting against mains outage during the day with the mains available to provide backup if there was any problem with the solar PV system although no backup is available to the mains after dark. ***The switched-mini grid mode is therefore the alternative energy system which is recommended for this application***, providing direct benefit to the community by providing lighting during the day and increasing system reliability. This will also be the lowest cost solar PV option as it does not require batteries, charge controllers or metering. A switched mini grid system will also not run into problems with connecting and synchronising to the main grid as each will be isolated from the other at any one time.

The criteria for optimal location of the solar panels are as follows:

- Maximise their effectiveness in collecting solar energy by avoiding overshadowing by buildings or trees to the south (in the northern hemisphere)
- Maximise the prominence of the panels for the community to demonstrate the technology
- Avoid areas where they panels might be easily damaged by accident
- Avoid areas where vandalism or theft of the panels is concealed
- Locate the panels near to the underpass to avoid long cable runs and to clearly associate the panels with the application in people minds

In the opinion of the consultant the best location for the panels is likely to be as shown hatched in red in the in Figure 17 below with the sun's path shown in yellow.

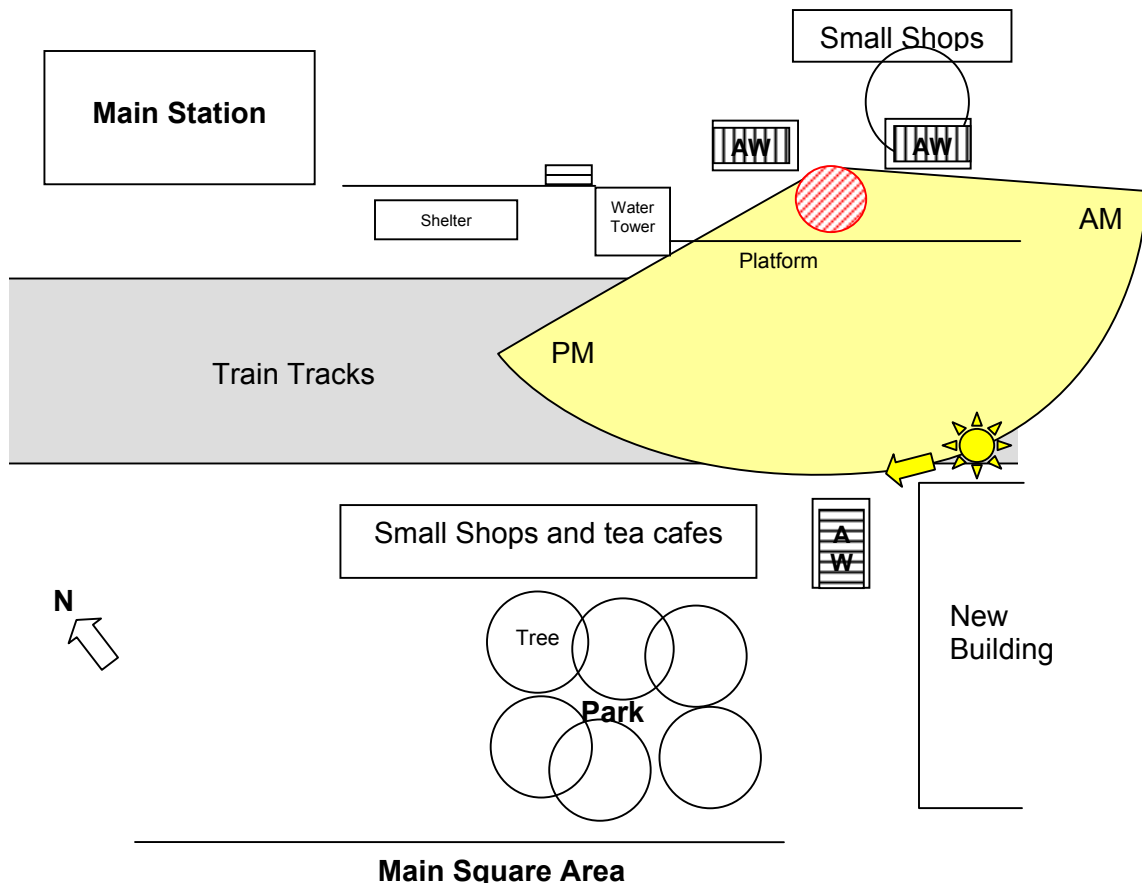


Figure 17 - Proposed location of Solar PV Panels hatched in red on the general layout

The proposed location is not overshadowed to the south due to the open land above the railway lines, is visible to pedestrians from all the accessways into the underpass including the entrance from the main square. The rough land between the two Northern Accessways is also suitable as it is fairly clear of buildings and overhead wiring. Overshadowing by passing trains is possible if the panels are too close to the ground or the platform so they should be stepped back slightly from the platform and raised off the ground on a metal frame up at a height of 3-4m. This also helps avoid vandalism and theft especially if the frames are relatively hard to climb and the panels firmly fixed. It would also make sense to light the area around the bottom of the panels from the same system to both highlight them for passing pedestrians and deny potential thieves the cover of darkness.

The wiring routings will have to be agreed with the transport/utility electrician but in general the arrangement should be as shown in Figure 18 below.

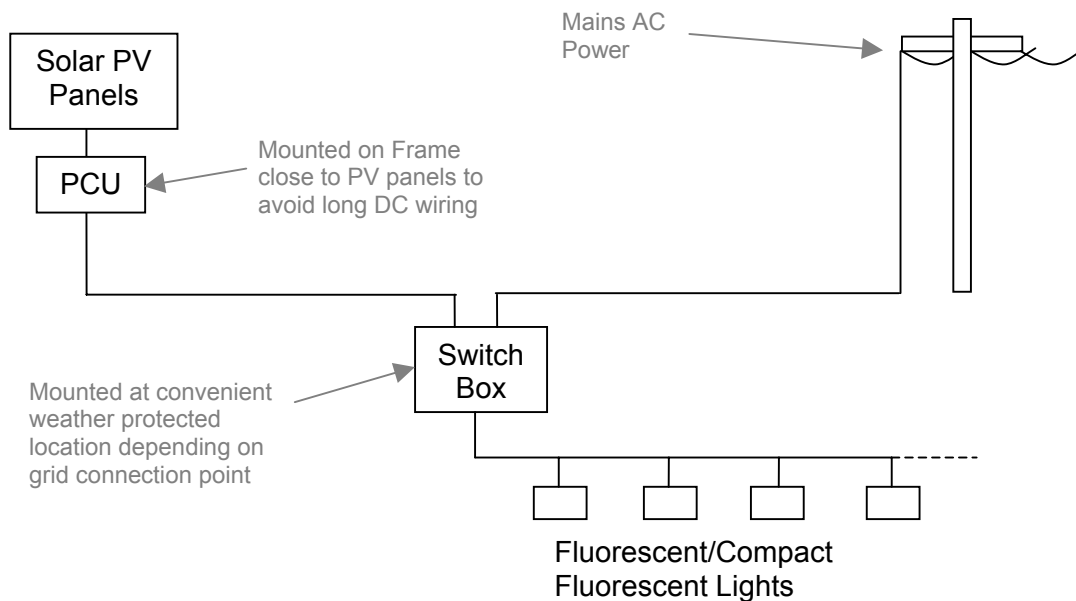


Figure 18 - Wiring Layout proposed for switched minigrid Solar PV system

The number and power of the lights, corresponding size of the solar PV panels and capacities of the wiring, specification of the switch box etc would be decided during the detail design phase in consultation with suppliers of solar PV systems who would be involved in the tendering process.

3.3 Budgetary Estimates for Project Implementation

With the projects at the outline design stage and additional information required it is not possible to provide a firm costing for implementation of the project recommendations at this point. However the table below provides price band estimates where possible to assist communities in selection of elements of the project, in acquiring quotes from suppliers and in proposal preparation for EAIP support. Where stars are shown this item is pending local prices and assistance is sought from Hayat staff and communities in estimating them.

Recommendations	Capital Cost (\$)	Running Cost (\$)	Transport /Installation Cost (\$)	Estimate Source
Improve drainage above and within underpass	*	*	0	
Repair Broken steps	*	0	*	
Repair broken marble, concrete and plasterwork	*	0	*	
Paint internal walls	20-40	0	*	Topdan Statis
Landscaping around Accessways	*	*	*	
Mural Painting	0	0	0	
Lighting and wiring in underpass	1000-2000	* (electricity)	*	
Solar PV Panels	2000-4000	0	300-500	BP Solar
PCU	500-800	0	0	NKF/Dorfmuller
Switch Box	100-200	0	*	
Mains connection	*	0	*	

It should be noted that the estimations above do not include any costs for further project development or detail design work which is described in the next section.

3.4 Way forward

Depending on Hayat's assessment of the detail requirements of proposals for EAIP project funding it may be that a proposal can be submitted at this stage or that some more detailed design should be carried out. However, in terms of project implementation the following are the key action items required moving forward.

- Translation of this report into Azeri for reading by Hayat field staff
- Obtain an architectural drawing of the underpass from the Ministry of Transport to enable detail design
- Arrange a joint meeting between the Ministry of Transport, municipal leaders, community leaders and Hayat to further discuss the project recommendations in this report and agree in principle on the components of the project to be pursued and the allocation of responsibilities/costs etc in moving forward
- Arrange for the assessment of the existing wiring and mains connection by a utility/ministry of transport electrician
- Arrange for the assessment of the drainage above and within the underpass by the municipal engineer
- Arrange for a structural check of the underpass to be made by a structural engineer
- Prepare the proposal for EAIP project funding
- Obtain quotes/start tender process for hardware delivery from potential suppliers
- Carry out detail design as required (although this should largely be carried out by equipment suppliers)

4 Additional Initial Assessments and Project Opportunities

In addition to the projects developed in chapters two and three, several other sites were visited for potential project development although they were not selected for a number of reasons. Additionally the other projects envisioned originally at the Chatham House meeting were initially investigated to assess their potential for further development in the future as well as new possible opportunities identified. The following section outlines these findings and initial suggestions.

4.1 Samadabad School, Yevlakh Region



Figure 19 - Exterior of Samadabad School (left) and view from broken window onto roof (right)

The Samadabad school in Yevlakh region was visited on 18/04/06 and the visit report is contained in Appendix 2. The school is in extremely poor condition and it was felt by the consultant that an alternative energy/energy efficiency based project at the school with a value of \$10-12.5K would only have been able to create a relatively small pocket of improvement in the school which requires a more substantial overhaul. Before any other project is undertaken, the school requires replacement of the roof which is in extremely poor condition and of all the windows in the classrooms virtually all of which are broken and warped (Figure 19 right). There are 21 classrooms (63 windows) while several of the corridors lead directly onto the classrooms and should also have windows replaced (another 20-30 windows). It is expected that the AZRIP Programme will bring gas to the school within the next few months but a boiler and central heating system should not be installed before the roof and windows are fixed or this will result in the waste of a large amount of heat energy without significant benefit to the conditions within the school. Additionally the school currently has no running water which is also a priority intervention for the school.

4.2 Yahdeli School, Yevlakh Region



Figure 20 - Classroom in Yahdeli School showing ceiling (left) and wood burning stove (right)

The Yahdeli school in Yevlakh region was visited on 18/04/06 and the visit report is contained in Appendix 2. A follow-up visit to the school was also undertaken on the 19/04/06 to discuss potential projects at the school. General fabric of the school is in fairly good condition benefiting from intelligent environmental layout with a wood of tall trees to the north blocking cold winds and all the classrooms on the southern exposure of the building to benefit from maximum passive solar gain in the winter. The roof has recently been replaced as part of a BTC funded project and is in very good condition. The main problems at the school are the ceilings which were damaged by rain prior to the roof replacement but not replaced themselves which are very thin, warped and extremely poor insulators, and the windows which are in poor condition showing large gaps and warping. Currently, inefficient woodburning stoves are used in all the classrooms to provide heat in the winter.

This school was selected for follow up as it seemed to offer a good basis for projects involving improved windows, ceiling insulation and alternative heating methods, perhaps using improved stoves. The principal and community leaders were very positive about suggestions relating to the ceilings, insulation and windows however they were unwilling to consider any alternative energy options relating to energy services. Although there has been no gas since 1994, they believe that gas will be coming to the community in the near future and want to use that for heating. There are currently individual gas connections to each classroom intended for individual burners which presents a substantial safety risk. A project could very usefully be carried out here on energy efficiency and safe and efficient use of gas in a central boiler if indeed the supply does arrive.

4.3 Gimli Boluslu School, Goranboy Region



Figure 21 - Gimli Boluslu School newest building (left) and oldest building (right)

The Gimli Boluslu School in Goranboy region was visited on 19/04/06 and consists of three different buildings dated 1924, 1967 and 200X. The newest building shown on the left in Figure 21 was built as part of a BTC financed project and houses the youngest children. The new building is fundamentally sound but lacking in any insulation or energy efficiency measures and in that respect is similar to the Qara Jali Clinic in Ujar. A similar project to that described in chapter 2 could therefore be proposed at Gimli Boluslu. The two other buildings are in poorer condition, similar to the Yahdeli School and would benefit hugely from similar projects in replacement of windows, ceilings/ceiling insulation and improved stoves. As in Yahdeli, the Gimli Boluslu community are expecting gas in the near future and if that is to happen then again a project to implement an efficient gas boiler system or perhaps a flexible fuel boiler using both biomass or gas could be developed.

4.4 Biomass Greenhouses, Dallar Jayad, Shamkir Region



Figure 22 - Greenhouse in Dallar Jayad (left) and oil burning heating system (right)

The initial feasibility of a project using biomass heating of greenhouses was considered in the context of Shamkir which was a region selected by Hayat for its likely match to the project criteria. It was found that there may very well be a high demand and use for a project using agricultural waste for greenhouse heating for a number of reasons. There are large amounts of waste from agriculture in the region mainly in sunflower, potato and corn. Currently the remains of these crops are left or burned in the fields. The cultivation of tomatoes and cucumbers in greenhouses is already a significant industry in Dallar Jayad with many families typically owning one or two greenhouses providing an income from export of tomatoes through family members to Russia while cucumbers are mainly sold in the domestic market.

Although it is possible to grow one crop each of tomatoes and of cucumbers each year in a greenhouse in Shamkir, many farmers did not grow the winter crop last year since the price of diesel, which is typically used as a fuel for the greenhouse heaters, doubled in price from the winter before from around 850 Old Manats to 1700 Old Manats per litre. The typical old style diesel heaters are as shown on the right in Figure 22. More efficient diesel heaters exist but if the high diesel price remains it will not be economic to replace the boilers or grow the second crop. Strong interest was therefore expressed by the greenhouse farmer and community leaders met in Dallar Jayad for the idea of using local biomass residue from crop waste to heat greenhouses and further development of this project is recommended.

One important issue to note is that due to the private ownership of the greenhouses in the post-soviet era, the benefit of this type of project would be to boiler manufacturers, greenhouse owners and the farmers able to get revenue for crop waste rather than the community as a whole as intended by the EAIP. In this instance biomass heating of the local school, wedding house or public bath for example could also be further investigated.

4.5 Improved Woodburning Stoves



Figure 23 – A brand new woodburning stove (left) and the same type of stove after use at Gimli Boluslu School (right)

Woodburning stoves of the type shown in Figure 23 were seen in every school visited during the visit to Azerbaijan (see also Figure 20, right) and a remarkable consistency can be seen in their design across the region. These stoves are of lightweight steel construction, are relatively inefficient, last a maximum of two winters according to school principals and often result in smoke entering the room depending on the chimney output and the wind direction. However they are extremely cheap, retailing at only around \$10 each. Typical failure modes are holes appearing in body of the stove and warping due to heat causing the folded seams to split making the stove unusable. Combustion design issues include the lack of primary air feeding up through fire, the small surface area of heat exchanger (flue) and the lack of insulation to keep burn temperatures high.

A visit to the Forest Institution near the town of Barda where the stoves are made revealed an extremely quick and simple cut-and-fold construction method using 0.4mm thick steel. Thicker steel is not used because of increased material cost and the fact that it would not be workable using the cutting and folding technique and would instead have to be welded, again raising cost and time for manufacture. Some possible improvements to the stove were discussed and it was apparent that the metal workers would be willing and able to fabricate and develop improved prototypes as required.

Some initial ideas on improving the stove include addition of some kind of insulation (possibly fire bricks) around the burn chamber to increase the burn temperature and so increase combustion efficiency of the wood inside as well as giving the stove a longer life. Another avenue for investigation would be to increase the surface area for heat exchange of the hot flue gases with the air in the room. Designs moving away from the current design including air-to-mass heat exchangers or rocket types for examples could also be considered. It is recommended that this project be further developed with a view to developing improved designs and prototypes which may be market tested in schools and public buildings such as those discussed in previous sections.

4.6 Micro-hydro potential in Ujar Region



Figure 24 - Images downstream (left) and upstream (right) of the Ujar canal with micro-hydro potential

A strongly flowing canal in Ujar as shown in Figure 24 was pointed out by the Hayat Project staff as having potential for micro-hydro. Although having low head height, the flow rate, estimated at around 11-12m³/sec, does make it feasible for use in a ***run-of-river*** type system. Local bystanders asserted that the canal was of consistent height and flow all year due presumably due to level control at the inlet further upstream.

In order to develop a pico or micro-hydro project further, better data on the water levels and control of the levels would have to be obtained as well as a better picture of where a micro-hydro installation could be sited. It is recommended however that Hayat community liaison staff first investigate what types of energy needs are present along the waterway which may be met by small-scale generation or even rotational motion for use in machining or milling for example, so that any project is demand rather than resource led. This would enable consideration of what electricity generation or spinning machinery power requirements would be to compare with the maximum extractable resource from the canal.

4.7 Renewable Resource Map of Azerbaijan

During the visit to Azerbaijan it was noted that weather and renewable energy resource maps did not appear to be available for Azerbaijan. These types of maps are usually developed by a collaboration of national meteorological offices who can offer weather data such as windspeeds, temperatures, sun hours etc from their weather stations around the country along with surveyors and renewable energy experts who can model the raw data and compare with maps and physical geography to prepare resource maps of the country for various renewables. These maps can be in the form of individual maps such as of windspeed or combined into Geographical Information Systems (GIS) representations containing layers of data on all the different resources. This map gives an initial understanding to both implementers and policy makers of which areas are likely to be most suitable for the various types of renewable energy devices be they wind turbines, solar PV arrays, hydro sites etc and shows up regional variations in cloud, fog etc due to local climatic conditions. This type of data would be extremely useful in developing further alternative energy systems in Azerbaijan and as such would be a very important project to develop, closely related although perhaps not within the exact remit of the EAIP. As an example, the windspeed map for the UK is given as below with mean windspeeds indicated by colour as shown on the right.

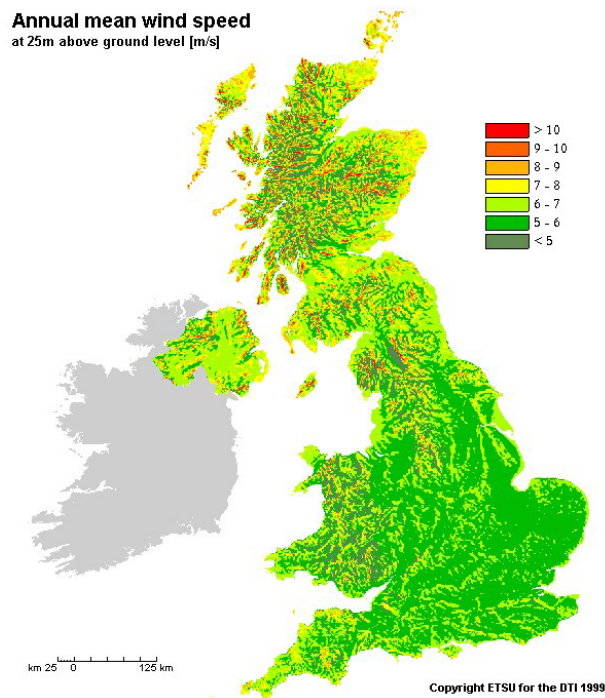


Figure 25 - Windspeed map of the UK (ETSU/DTI) as an example of national renewable resource mapping

5 Appendices

5.1 Schedule of PAC visits, meetings and workshops in Azerbaijan

DATE	APPROX. TIME	LOCATION	PURPOSE OF VISIT/MEETING
17/04/06	10am	Hayat Office, Baku	Start up meeting with Vusal and Eric
	6pm	Hayat Office, Yevlakh	Welcome and meet with field team
18/04/06	9am	Hayat Office, Yevlakh	Workshop on building energy efficiency
	10am	Samadabad School, Yevlakh Region	Building survey and stakeholder interview
	12noon	Yahdeli School, Yevlakh Region	Building survey and stakeholder interview
	2pm	Qara Jali Community clinic, Ujar Region	Building survey and stakeholder interview
	4pm	Canal potential hydro site, Ujar Region	Assessment of canal hydro potential
	5pm	Yevlakh Repair Co-operative	View streetlighting poles and assess metalworking capacity
19/04/06	10am	Ginli Bobuslu School, Goranboy Region	Building survey and stakeholder interview
	12noon	Forest Institution, IDP camp near Barda Town	Assess stove manufacturing capacity
	2pm	Hayat Office, Yevlakh	Training on Solar Lantern and PV panel operation
	3pm	Yevlakh Town bazaar	Assess prices and availability of hardware
20/04/06	10am	Yahdeli School, Yevlakh Region	Follow up visit to discuss project options with community leaders
	12noon	Qara Jali Community clinic, Ujar Region	Follow up visit to discuss project options with community leaders
	3pm	Yahdeli School, Yevlakh Region	Follow up building assessment
	4pm	Yevlakh Town bazaar	Assess prices and availability of hardware
21/04/06	11am	Greenhouses, Shamkir Region	Viewing of greenhouses and interviewing owner on markets, practices + issues
	1pm	Dallar Jayad, Shamkir Region	Meeting community leaders, viewing greenhouses and surveying school.
22/04/06	9.30am	Municipal council office, Tovuz City	Initial meeting with municipal councillors and community leaders
	11am	Road tunnel, bazaar, dumps, Tovuz City	Site assessments and stakeholder interviews
	1pm	Private house, Tovuz City	Viewing of solar water heating installation
	2pm	Baku Aviation Affiliate, Tovuz City	Assessment of metalworking and electrical engineering capacity
23/04/06	10am	Pedestrian railway underpass, Tovuz City	Site Assessment and stakeholder interview
	10pm	Pedestrian railway underpass, Tovuz City	Return visit to assess pedestrian underpass use at night
24/04/06	9am	Municipal council office,	Follow up meeting with municipal council

		Tovuz City	to discuss pedestrian underpass options
	10am	Pedestrian railway underpass, Tovuz City	Site viewing with Hayat team and municipal council officer
25/04/06	9am	Hayat Office, Baku	Workshop on PV technology + assembly of small renewable energy education kits
	2pm	Hayat Office, Baku	Visit wrap-up meeting with Vusal
	3pm	UMID Office, Baku	Co-ordination and information meeting with Rasim Guliyev and Arif Hassanov
	4pm	Hayat Office, Baku	Initial introduction to Junior Education Kit of wind and PV modules.

5.2 Building Assessment Reports

16/04/06 – 10am

Samadabad School, Yevlakh Region

MAIN CHARACTERISTICS	
Children	350 (6-17yrs)
Staff	50
Technical Assistants	15
Classrooms	21 (32 total rooms)
Built in	1984 (not completed)
Opening hours	8am-3am Mon-Fri
BUILDING SERVICES	
Electricity	2-3 hours per day 12noon-2pm (more during 10 day "harvest period")
Gas	Not since 1992 but AZRIP project is due to bring gas (work due to start in May complete 75 days)
Current heating method	Stoves (provided by parents fund) in each class burning fuel wood provided on alternate days by pupils
Current fuel source	Sold by small businesses presumed to bring wood from mountains
Current fuel cost	1m3 of wood is 24 New Manats
Current fuel use rate	10 New Manats worth per classroom per week. Equivalent to a large bushel with 10-15 pieces.
Duration of heating requirement	Oct-Mar
Water Supply	Special supply to school but only to gate. Brought in from there with buckets. Previous reservoir empty and piping removed by residents.
Hot Water	None
BUILDING CONDITION	
Plan of building available	Can't find proper plan. Only IRC sketch
Number of levels	2 + basement
Basement	Yes, unused and full of trash and water
Roof	Corrugated Iron. Extremely poor condition. Many open holes
Ceiling	Concrete. Reasonable condition
Attic Insulation	None
Windows	Single-glazed wood frames. Most in extremely poor condition. Many missing all or some glass. Many frames warped by weather damage.
Floors	Wood covered concrete. A BTC funded project (Sept-Oct 2004) repaired floors in all classrooms but not in many auxiliary

	rooms
Walls	Concrete covered stone but poorly constructed with salty sand probably used in concrete.
Wall Insulation	Not known but unlikely. Wall thickness is
Doors	2 main double doors, south facing
STAKEHOLDER REQUESTS	
Key issue according to Principal	Rehabilitation of gas boiler (in anticipation presumably of reopening of gas supply by AZRIP)
Issues raised by school children in class	New windows, new desks, new chairs
OTHER ISSUES	
Additional Projects	Medical Centre rehabilitated by Save the Children in Feb 2005 Computer Centre provided by Madat in May 2005

18/04/06 – 12noon
Yahdelay School, Yevlakh Region

MAIN CHARACTERISTICS	
Children	178
Staff	28
Technical Assistants	11
Classrooms	16
Built in	1977
Opening hours	
BUILDING SERVICES	
Electricity	7am-9am, 12noon-2pm, 7pm-1am
Gas	Not since 1994 but it is expected by the beginning of next academic year
Current heating method	Wood Stoves
Current fuel source	
Current fuel cost	
Current fuel use rate	
Duration of heating requirement	
Water Supply	
Hot Water	
BUILDING CONDITION	
Plan of building available	No but principal and local leaders promised that they would provide one
Number of levels	2
Basement	None
Roof	Recently replaced as part of BTC project focussed on Alam community. Corrugated iron good condition
Ceiling	Thin wood with severe water damage on 2 nd floor. Not replaced with roof.
Attic Insulation	
Windows	Single glazed. Frames in varying condition. Many gaps in evidence between glass and frame
Floors	Wood
Walls	Concrete covered stone. No concrete cover on Southern exposure
Wall Insulation	Unknown but unlikely
Doors	Two north facing double doors on both floors
STAKEHOLDER REQUESTS	
Key issue according to Principal	Double Glazing, new ceiling
Issues raised by school children in class	
OTHER ISSUES	
Additional Projects	

18/04/06 – 3pm

Qara Jali Community Medical Centre, Ujar Region

MAIN CHARACTERISTICS	
Patients	450 (5-10 per day)
Staff	15
Rooms	6 + hall
Built in	April 2005
Opening hours	7.40am-4 or 5pm
BUILDING SERVICES	
Electricity	Very Irregular (wiring not properly installed). Usually 6am-12noon and 6 or 7 pm until 12 midnight.
Gas	No, not expected
Current heating method	Electric resistance heaters in some rooms and wood stove in back left room where staff gather in winter.
Current fuel source	
Current fuel cost	Electricity cost unknown, paid by local health authority
Current fuel use rate	
Duration of heating requirement	Oct-Mar
Water Supply	Water tank outside but pipe is burst from frost damage so they are currently carrying in water with buckets from the canal.
Hot Water	No, except as boiled in electric kettle
BUILDING CONDITION	
Plan of building available	To be requested by Hayat from *****
Number of levels	1
Basement	No
Roof	Corrugated Iron, good condition
Ceiling	Thin wood panels. Good condition.
Attic Insulation	None
Windows	Single glazed. Frames in good condition but some glass is cracked and poorly fitting
Floors	Concrete with wood covering and linoleum
Walls	Brick and Limestone, 40mm outer wall, 20mm inner wall
Wall Insulation	Unknown but unlikely
STAKEHOLDER REQUESTS	
Key issue according to Doctor	Windows, hot water, vaccine storage
OTHER ISSUES	
Additional Projects	

19/04/06 – 11 am

Ginli Bobuslu School, Goranboy Region

MAIN CHARACTERISTICS	
Children	260
Staff	46
Technical Assistants	1
Classrooms	20
Built in	3 buildings in 1924, 1967 and 200X
Opening hours	8 hours per day
BUILDING SERVICES	
Electricity	Not in most classrooms
Gas	No but expecting supply in the future
Current heating method	Wood Stoves
Current fuel source	Large logs stored at back of school
Current fuel cost	Unknown
Current fuel use rate	
Duration of heating requirement	Oct-Mar
Water Supply	
Hot Water	
BUILDING CONDITION	
Plan of building available	Unknown but school consists of three buildings
Number of levels	1 on two buildings and 2 on one building
Basement	
Roof	Corrugated Iron. Poor condition
Ceiling	In main building extremely poor condition
Attic Insulation	Not known but unlikely
Windows	Made for double glazing but only have single. Many are warped
Floors	Wood but with many gaps
Walls	Stone
Wall Insulation	Unknown but unlikely
Doors	
STAKEHOLDER REQUESTS	
Key issue according to Principal	Windows and ceilings
Issues raised by school children in class	
OTHER ISSUES	
Additional Projects	One of the three buildings for the youngest children was built with BTC funding

5.3 Local hardware availability and price listing (Yevlakh)

ITEM	DETAILS	COSTS (US\$)	SUPPLIER
Street light poles	Various lengths and diameters as required plus foundation rebar	Various	Yevlakh Repair Co-operative
Insulation	Glass Fibre, 10mx1mx50mm thick with Alu backing (density 1kg/m2)	2.20	Yevlakh Hardware Store
	Black Roll sheet, - 1mx8m - 1mx15m	3.40 5.00	Topdan Statis
Window Frame	Wood frame, 1.7x1.7m, 6 part, one opening (no glass)	90	Yevlakh Carpenters
	Aluminium Frame 1.7mx1.7m, 6 part, one opening (no glass)	140	Yevlakh Aluminium Windows
	Plastic Frame 1.7mx1.7m, 6 part, one opening (including double glazed glass)	208	Yevlakh Plastic Windows
Filler	Expanding polyurethane foam can, 750ml	3.20	Yevlakh Hardware Store
Caulking	Silicone Sealant (fixes to glass), 310ml	2.00	Yevlakh Hardware Store
Glass	1mx1.6mx4mm thick	12 (+cutting)	Yevlakh Glass
	1mx1mx5mm thick	4.60	Topdan Statis
	0.9mx1.2mx5mm thick	5.04	
Plywood	1.52mx1.52mx3mm thick	5.04	Topdan Statis
	1.52mx1.52mx4mm thick	5.69	
	1.52mx1.52mx5mm thick	7.22	
	1.52mx1.52mx6mm thick	7.88	
	1.52mx1.52mx9mm thick	10.73	
	1.52mx1.52mx10mm thick	11.56	
	1.52mx1.52mx15mm thick	16.64	
	1.52mx1.52mx18mm thick	19.27	
Fibreboard	1.75mx2.75m (rough one side, shiny other side)	5.25	Topdan Statis
Nails	1kg	1	Topdan Statis
Paint	White ceiling paint, 2.5L (0.14kg/m2 coverage)	5.91	Topdan Statis
Steel Sheet	2.4mx1.2mx3mm thick	49.27	Topdan Statis
	1mx2mx4mm thick	45.99	
	1mx2mx3mm thick	32.85	
Pipe	Corrosion Resistant Steel		Topdan Statis
	- 1mx20mm ID	2.12	
	- 1mx25mm ID	3.28	
	Plastic Pipe		Topdan Statis
	- 1mx10mm ID	0.83	
	- 1mx20mm ID	1.55	
	- 1mx25mm ID	2.56	
Pipe Elbows	Corrosion Resistant Steel		Topdan Statis
	- 25mm ID	0.44	
	- 20mm ID		

	Plastic - 25mm ID - 20mm ID	0.24 0.17	Topdan Statis
Pipe Tees	Corrosion Resistant Steel - 25mm ID - 20mm ID	0.66 0.44	Topdan Statis
	Plastic - 25mm ID - 20mm ID	0.35 0.21	Topdan Statis
Valves	Corrosion Resistant Steel - Gate Valve 25mm ID - Gate Valve 20mm ID	3.28 1.97	Topdan Statis
Taps	Bronze	1.93	Topdan Statis
Pipe lagging	Metal/glass fibre, 3mm thick, 1m2	1.31	Topdan Statis
Light bulbs	Compact Fluorescent, 50W Incandescent, 100W Mounting bracket for bulbs	1.53 0.66 1.31	Topdan Statis

5.4 Solar Refrigeration Suppliers and Initial Quotations

Solar Refrigeration Suppliers

BP Solar Ltd., PO Box 191, Chertsey Road,
Sunbury-on-Thames, Middlesex TW16 7XA,
U.K.

Telephone: +44 1932 779 543

Fax: +44 1932 762 686

Comesse Soudure SA, 88390 Chaumousey,
France

Telephone: +33 3 2966 8548

Fax: +33 3 2966 8094

Note: The unit supplied is solar thermal and not
solar photovoltaic

Dulas Ltd., Dyfi Eco Park, Machynlleth, Powys
SY20 8SX, U.K.

Telephone: +44 1654 705 000

Fax: +44 1654 703 000

Dometic (formerly Electrolux), 14 op der Hei,
L-9808 Hosingen, Luxembourg

Telephone: +352 920 731

Fax: +352 920 731 300

NAPS Norway A/S, Strandvein 50, N-1366
Lysaker, Norway

Telephone: +47 67 112 550

Fax: +47 67 112 545

Norcoast Refrigeration Co, 50 Grigor Street,
Caloundra, Queensland 4551, Australia

Telephone: +61 7 9491 1849

Fax: +61 7 5491 7627

Website: www.norcoast.com.au

Solamatics (Pvt) Ltd., 31 Edison Road,
Graniteside, Harare, Zimbabwe

Telephone: +263 4 749 930

Fax: +263 4 771 212

Sun Frost, PO Box 1101, 824 St Ste # 7,
Arcata, California 95518, USA

Telephone: +1 707 822 9095

Fax: +1 707 822 6213

TATA BP Solar India Ltd., Plot No. 78,
Electronic City, Hosur Road,
Bangalore 561 229, India

Telephone: +91 80 852 1016

Fax: +91 80 852 0116

Solar Refrigerator Initial Quotations

Supplier	Product	Description	Initial Quote
Dulas Solar (UK) http://www.renewable-resources.com/index.htm	V65 refrigeration system with battery charger http://www.renewable-resources.com/pdfs/vc65.pdf	1 3A 24V battery charger 170-260 vc in 2 12V 3OPzS 150, 210Ah Battery 1 VC65 vaccine storage refrigerator 1 System manual 1 30A 12/24V PV Controller with display 8 85 W photovoltaic panel (680 watt) 1 8 module ground/roof support structure 1 Cable set Refrigeration only, supply for 4 days when there is no sun or no power, applicable throughout the year. Additional battery charging from grid is not essential but a charger is supplied. This will be in WHO guidelines.	UK£ 3,401.56 (plus shipping costs)
Sunfrost (USA) www.sunfrost.com	RFVB-134a Solar Powered Vaccine Storage DC http://www.sunfrost.com/vaccine_refrigerators.html	Freezer and Refrigerator Solar Panel (to be specified) Deep Cycle Battery This system has both a refrigerator and freezer requiring more power than the R4 below. It meets WHO standards depending on the system design which Sunfrost would supply.	US\$ 3300-3400 (plus shipping costs)
Sunfrost (USA) www.sunfrost.com	R4 Solar Powered Vaccine Storage DC	4 cubic feet refrigerator 80W Solar PV Panel Deep Cycle Battery This system only has a refrigerator and no freezer capability although it has the same body shape as the RFVB above. It meets WHO standards depending on the system design which Sunfrost would supply.	US\$ 2200-3000 (plus shipping costs)

5.5 Literature References

Technical Brief on Solar Photovoltaic Refrigeration of Vaccines

http://www.itdg.org/docs/technical_information_service/solar_refrigeration_vaccines.pdf

Renewable Energy – Power for a Sustainable Future

G. Boyle et al, OUP, 2004

Renewable Energy Options for Three Communities in the Yevlakh, Aghdash and Ujar
Regions of Azerbaijan

Dulas/ITC, 2005

Designing Improved Wood Burning Heating Stoves

Bryden, Still, Ogle, MacCarty, Approvecho Research Centre,

Checklist to determine energy efficiency of a home

Hawks, L.K., Utah state university, 2005

The Virginia Energy Savers Handbook

2006