Aga Khan Planning and Building Services, Pakistan
Building and Construction Improvement Programme - BACIP

Research Report on the

ROOF-HATCH WINDOW

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Abstract

Organisational and technical details of the development of the Roof-Hatch Window (RHW) for the installation in the open roofs of traditional houses in the remote mountain areas of the Northern Areas in Pakistan. Traditional and modern building materials and construction techniques are incorporated in low-cost but durable roof window design, which can be locally replicated with the available skills. The roof-hatch window design provides control of ventilation and smoke when combined with a metal stove and chimney, greatly increased thermal insulation and enhanced passive solar energy intake. These combinations lead to very high firewood savings of over 40% per winter season, reduced Indoor Air Pollution (IAP), reduced drudgery for women in firewood collection and cooking, and substantially increased comfort and illumination.

The design has been further developed since 2000 and is now commercially available from several carpenters in the Gilgit-Baltistan Province and Chitral.

Note:

This document reflects the findings and opinions of the author. It is not an official publication of the Aga Khan Foundation or the Aga Khan Planning and Building Services, Pakistan.

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FOREWORD

The development of the roof-hatch window (RWH) was initiated by BACIP in November 1998 as the first and most needed house improvement. The roof-hatch window provides the villagers with an affordable and effective improvement to their comfort in traditional houses (central room). In particular the RWH conserves the generated warmth in the traditional room and avoids low inside temperatures during the winter. With the realisation of a RHW, the house occupants receive the following benefits:

- Conservation of the warm (heat-generated) inside temperature of the house in the winter.
- Increased illumination level of the traditional house.
- Protection against rainwater entering the house through the roof opening.
- Controlled ventilation of the house according to the needs of the occupant.
- Increased aesthetics of the house and social status for the house owner.

The disadvantage is that they have to purchase a stove with a chimney to evacuate the smoke, but:

- Strongly reduced Inside Air Pollution (IAP) for the cook (women) and all others.
- No more open fire which is a considerable risk for the children.
- Reduced time for collection of firewood and space saving for firewood storage.

The development of the three roof-hatch window versions (small, medium and large) is a concerted effort made under the direction of the BACIP Programme Director and implemented by the Manager Field Operations, Engineer Qayum Ali Shah, during 1999-2000.

Initially, local carpenters in Gilgit, Skardu and Chitral were approached to manufacture the first 20 prototype models of the large version of the roof-hatch window. These roof-hatch windows were installed on houses in 20 villages and the occupants were requested to provide feedback to BACIP.

The methodology of developing a product for household improvements is described in the BACIP publication, *BACIP PRODUCT DEVELOPMENT (June 1999)*. The process for arriving at a suitable RHW model has taken slightly more than one year (two winter seasons) with several upgraded versions being placed in the villages after a recall.

Sjoerd Nienhuys, BACIP Programme Director, May 2000

> The Building and Construction Improvement Programme (BACIP) finds appropriate solutions taking into consideration the local economy of its clients and entrepreneurs, as well as the available skills, tools, materials and other resources, to create affordable products for an improved living conditions and livelihood.

This paper describes some of the issues involved in the development of the first RHW product. These developments have continued since based on feedback from the users, including lack of maintenance. The thermal insulation of the design could be substantially improved. By the year 2010, over 2500 RHW had been installed, mainly self-financed by the house owners. The improvement process continues with new materials coming into the market and local craftsmen obtaining skills.

Sjoerd Nienhuys, Technical Advisor, March 2011

1. INTRODUCTION

The Building and Construction Improvement Programme (BACIP) is implemented by the Aga Khan Planning and Building Services, Pakistan (AKPBS,P) and financed by PAKSID, a joint venture of the Canadian International Development Agency (CIDA) and the Aga Khan Foundation, Pakistan (AKF,P). The Programme Director is financed by the Netherlands International Technical Assistance Programme (DGIS). BACIP works in co-operation with other Aga Khan Development Network Institutions (AKDNI) in the Northern Areas and Chitral of Pakistan. Presently 35 staff members are involved in the BACIP programme, consisting of architects, engineers and social workers. In addition, 200 village-based male and female resource persons assist on a voluntary basis in the implementation of the programme.

The present programme (until December 2000) consists of house improvements in the domestic environment (2500 households), new house design models, introduction of model improvements in existing houses, technology and skills development among local entrepreneurs, and participatory cluster and village planning for determining appropriate housing sites to avoid hazardous areas.

The suggested house improvements need to be financed by the house owners themselves. To achieve this, various demonstration models and examples of different types of improvements have been realised by BACIP in several houses in each of the 35 selected villages. In some villages where new houses are planned to be built during the 1999/2000 season, various BACIP-suggested improvements will be incorporated.

House improvements focus on thermal issues and earthquake engineering aspects. The thermal issues include: smoke control, ventilation, illumination, wall and roof insulation, leakage and dampness control. Earthquake engineering solutions are being developed for traditional stone, soil block and cement block constructions. Especially in mountain villages with little land availability, two- and three-storey housing and building in stages is being encouraged. BACIP has developed new and improved building materials and realises the distribution thereof using existing market mechanisms. Training for local craftsmen is realised through short "hands-on" internships with host entrepreneurs on the new designs. In addition, exchange visits are organised between villages to view and discuss improvements.

An important aspect of the programme is that the house owners have to understand the reasoning behind the improvements that have been installed in their village and subsequently finance the realisation of their own house improvements with their own funds, labour and materials. Essential building materials which are unavailable in the remote villages can be bought through a BACIP trading network.

Community participation is needed in the shape of financial and organisational involvement to make the activity sustainable. Therefore group action is necessary for the purchase of essential materials and services. BACIP gives high priority to the involvement of women in the decision-making process as household improvements particularly affect the living and working conditions of the women and children.

To promote BACIP improvements, Road Shows have been organised under the slogan:

"WITH BACIP PREPARE FOR THE COLD"

2. ROOF-HATCH WINDOW – RESUME

Most of the traditional houses in the villages of the Northern Area have an 18-inch square-shaped opening in the middle of the ceiling of the main living quarters. The purpose of the opening is twofold: to allow the smoke produced from the open cooking/heating fire to escape and to let sunlight and fresh air into the room. While the roof opening does allow for the smoke to escape, it takes along with it the heat (warmth) from the room and lets in cold drafts and rain. The cold air then mixes with the warm smoky air of the room and deposits black soot on the walls and ceiling. With the living quarters painted in black soot, the hole is ineffective in illuminating the area. All of which leads to extremely unhealthy and unpleasant living conditions, especially during the cold winter months.

Typical situation where the roof is used for stacking hay and drying fruit.
The wooden plank is used to close the roof hatch in the event of severe cold or rain.
The chimney is sticking out of the hole.

The BACIP roof-hatch window does not disturb the overall traditional layout of the house, yet is efficient in terms of heat insulation and provides better illumination.

When we showed the drawings of a roof-hatch window to a carpenter in Skardu, he commented:

"This construction I remember from my grandfather's time."

This remark showed that it might be possible to find good traditional solutions in some of the older houses. Unfortunately many of the older practices are no longer being applied by local craftsmen and without documentation may soon be forgotten by future generations.

To record the impact of this intervention, the villagers with the first 15 models were provided with a maximum-minimum thermometer (along with training) and a registration table to record the temperature variance. Findings showed that the average temperature inside the room had improved by 4-6 degrees Celsius, resulting in more comfort and a considerable reduction in firewood consumption (30% or more). In one house only one quarter of the former year's quantity of firewood was used (four tractor loads a season). In autumn and spring no additional heating was required.

Characteristics of the BACIP Roof-Hatch Window

- ◊ The full-size roof-hatch window has four glass panes (18" x 18"). Being four times as large as the traditional hole in the roof, it provides four times the amount of light.
- ◊ For optimal illumination and heat-generating effect, the roof-hatch window should be placed facing south and the glass kept clean.
- ◊ In the vertical rear side of the roof-hatch window there is a pivoting shutter for ventilation that can be operated with a string from inside the house.
- ◊ The roof-hatch window keeps the rain and snow out, avoids mixture of cold and warm air, and reduces smoke.
- ◊ The traditional 3-inch chimney pipe has been repositioned and fitted with a pivoting hood (*feri-feri*) to avoid back-draft.
- ◊ A standard BACIP blanket attached to the top of the roof-hatch window frame can be rolled down to provide better insulation in the winter and protect the glass when the window is open.
- ◊ Alternatively an optional single GI flat sheet shutter can be fitted to close over the top of the roof-hatch window with a single movement, providing additional insulation and protection at night.
- ◊ An optional glass window can be placed on the east side of the roof-hatch window to allow light to enter when the insulation blanket is rolled down or the shutter is closed.
- ◊ An optional wire-mesh screen can be placed to protect the glass. Children tend to throw stones into nearby trees to collect fruits and cricket is actively played in villages.

Size Variations in the Roof-Hatch Window

Different size variations of the roof-hatch window have been made to accommodate the wishes of the villagers. A medium-size window has been developed with glass panes of two times 18" x 24" each, fitted into a single glass frame. This is the most popular model. The smallest size measures only 18" x 18", just big enough to cover the existing traditional roof hole.

Note: The designs with the side supports were no longer made after 2002. Instead a single laminated glass sheet is being used which can be replaced by a fly screen for the summer period.

3. PROBLEM IDENTIFICATION

During the issue mapping exercise conducted by BACIP in mid-1997, cold houses in the winter were identified as the main discomfort among the people.

In older traditional houses the cause of the problem was the 18" x 18" centrally located roof opening at the highest point in the main traditional room. The purpose of the roof opening was for ventilation and access to light, but it also allowed the warm (smoky) air to escape freely.

In the more modern houses people tend to add additional spaces for bedrooms, bathrooms and kitchens, but omit the anterooms that are so important for controlling the airflow and temperature. They do this to offset the cost of the additional rooms. Following examples from the cities, new houses are being constructed with cement blocks, cement plastered walls, rooms with higher ceilings, larger windows with more glass surface and cement flooring.

All of the following create a cold house:

- ◊ Houses without anterooms that prevent wind drafts from entering directly into the house.
- ◊ Increased floor to ceiling heights, allowing the warm air to settle higher.
- ◊ Large windows with single glass and poor joinery work, allowing extra cooling and ventilation.
- ◊ Lack of curtains or shutters that would provide additional thermal insulation.
- ◊ Massive stone walls that absorb the heat from the room.
- ◊ Lack of insulating mud plaster work on the walls or cloth wall hangings that would create an insulation effect.
- ◊ Cement floors without wooden planking or grass mats.
- ◊ Cement block walls (plastered), having high conductivity and heat absorption capacity.

An objective of the BACIP programme was to find solutions for existing houses, in particular for the older traditional houses. The closing of the roof hole by means of a window was therefore given the highest priority as it was estimated that this would be the most effective measurement.

Village people have little theoretical understanding about the thermal physics of their immediate environment, but are quite aware that traditional houses are warmer than the more modern houses. The fact that most heat is lost through the open hole in the roof is apparently not perceived by the average villager. Education at school does not deal with these practical issues.

Warm air, being lighter in weight than cold air, rises to the roof area. Upon opening a door, the cold air that enters the room pushes the higher warm air out through the roof hole. If the door is kept closed, then the warm air tries to get out, while at the same time cold air falls into the roof hole. The result is that the cold (fresh) air and the smoke-laden warm air mingling together to fill the entire room with smoke. This traditional roof design with the smoke circulation near the ceiling causes the entire roof construction to become blackened with soot.

The open roof hole also allows rainwater and snow to fall directly into the house. The raindrops mix with the ever-present smoke, causing a layer of dirt and soot to cover the floor, bedding, utensils and food. The blackened surfaces make the house exceptionally dark inside. Keeping the house clean is virtually an impossible task.

Various Benefits of the Roof-Hatch Window

- By closing the roof opening and controlling ventilation, the average temperature can be drastically increased. In several houses separate ventilation openings were installed.
- By improving the stove and chimney outlet, the entire room can be kept smoke free. One of the improvements consists of a chimney roof passage that is waterproof and continuously ventilates the room.
- The increased size of the opening (36" x 36" instead of 18" x 18") allows nearly four times the amount of light into the room.
- The associated sunlight in mid-day provides additional heat intake. Once the sunlight has entered the room and hits a surface, the light converts into heat that warms the air.
- Together they can improve the living condition in the room by 400%.
- In many cases the house owner started to further clean and improve the room.

The following pages give an overview of the research activity.

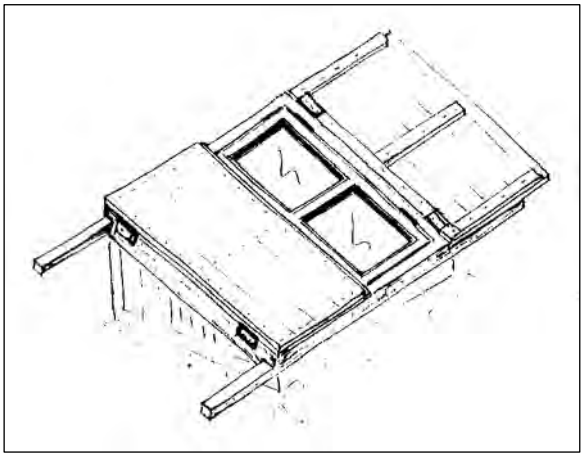
Carpenter Noor making the first series of Roof-Hatch Windows.

Note: The designs with the side supports were no longer made after 2002. Instead a single laminated glass sheet is being used which can be replaced by a fly screen for the summer period.

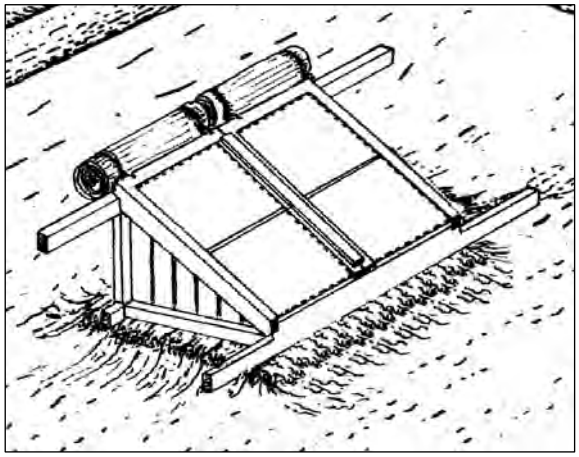
4. RESEARCH ACTIVITIES

The research activities on the roof-hatch window are listed in chronological order.
The process demonstrates the difficulties in arriving at a product that can be locally manufactured considering local materials and the skills and tools of the local craftsmen.

Month	Activity	Observations	Actions
16 Oct. 1998	Sketches made by director and discussed.	BACIP staff unable to make sketches or suggested perspective drawings.	Need for drawing staff – draftsman or architect.
17 Nov. 1998	Carpenter Mr. Shah Dil Khan was approached for making the hatch window.	After two days the Mr. Shah Dil Khan returned the papers as he was unable to understand the sketches.	Course on "how to read a drawing" for entrepreneurs.
19 Nov. 1998	Carpenter Mr. Mirbaz Khan (Nagar Valley) was approached to make the roof-hatch window, although he could not read the technical drawings and was illiterate.	Mr. Mirbaz Khan finished the window on 19.12.98 with frequent supervision. Finished work was reasonable.	Frequent visits to the workshop to explain all steps.
21 Nov. 1998	Carpenter Mr. Faqir Zaman (from Punjab) near Airport gave assurances that the window would be ready on 28.11.98 and that there was no need of any supervision from BACIP side.	Mr. Faqir Zaman completed the window on 28.11.98 but missed several things and he was unable to understand the drawings. Sizing of glass was wrong. Work was of poor quality.	Meeting between carpenters to discuss results.
23 Dec. 1998	Meeting with Mr. Faqwir Zaman and Mr. Mirbaz Khan at BACIP office to discuss the two roof-hatch windows prepared by them. Mr. Faqir Zaman admitted he initially thought the drawings were simple but later it appeared that they were rather difficult. Discussion points were: - Design should minimise amount of timber. - Thickness of pivotal shutter planks should be ½" instead of 1" (lighter). - Width of sash bar of glass frame should be increased from ¾" to 1". - Mr. Mirbaz Khan: cover the top wooden shutters with metal sheets to protect them from rain. He suggested deleting both the diagonal and the two horizontal planks.	Section of all the frame planks were too thick, causing high wood consumption and making transport difficult. The diagonal (inclined) frame was not necessary. Glass frames of 2" was too thick.	Diagonal or inclined frame removed. Glass frame now 1½" pieces. Top shutters with 30-gauge tin sheets. Main frame reduced to 2". Pivotal shutter now ½" thick.



Old Roof-Hatch Window

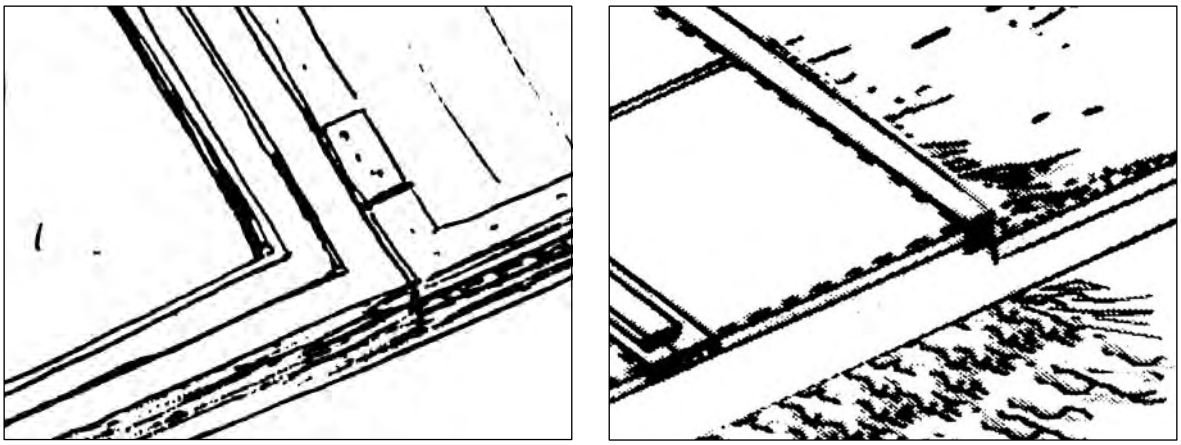


New Roof-Hatch Window

Note: The designs with the side supports were no longer made after 2002. Instead a single laminated glass sheet is being used which can be replaced by a fly screen for the summer period.

Month	Activities	Observations	Actions
23 Dec. 1998	Drawings for third window with adjusted dimensions was given to Carpenter Mr. Barkat Ali near Kohistan Transport Agency.	Mr. Barkat Ali did not make the window, kept drawings for more than two months.	Drawings were taken back from this carpenter.
08 Jan. 1999	First hatch window was realised in Datuchi. The house owner was appointed by the village committee as being very poor and having a very dark house. The window was installed in a corner of the room as that was the only place where direct sunlight would enter.	The house became well illuminated and warmer. The house owner experienced increased warmth but wanted the window in another corner.	Placement of the window and its consequences must be better discussed with the house owner.
Jan/Feb 1999	**Monitoring.**	1) String and eyes of the pivotal shutter were not functioning very well. 2) Rubber profile of glass was not fixed properly. 3) The length of the main supports for the open glass frames was not sufficient. 4) The timber sections again looked too big. 5) The trapezoidal section plank of the pivotal frame was not necessary. 6) The 2" hinges for folding the pivotal frame to the main frame during transportation did not work.	1) Eyes for pulling the string were improved. 2) Improved. 3) The length of projected planks increased to 18". 4) Thickness of frame reduced to 1½". 5) Trapezoidal plank was removed from the design. 6) 2" wide strips of 28-gauge GI sheet were fixed for folding.

Window Frame Wooden Shutter Window without Shutter

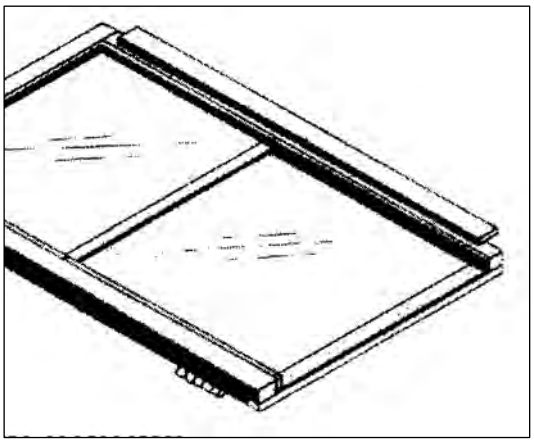


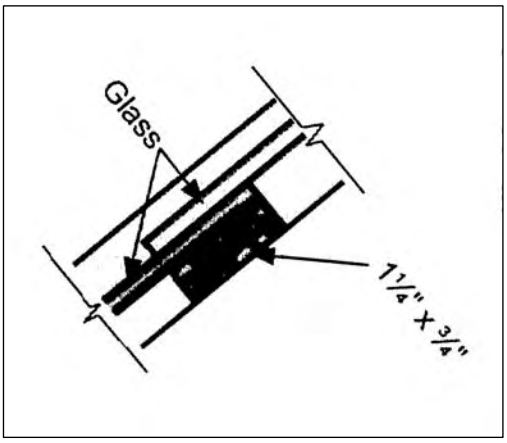
In the old design (left) the glass frame was inside the main frame, creating a joint and leakage. In the new design (right) the glass frame lays on top of the main frame.

Note: The designs with the side supports were no longer made after 2002. Instead a single laminated glass sheet is being used which can be replaced by a fly screen for the summer period.

In addition, the wooden or metal winter insulation shutter was not reproduced later. New solutions need to be found to improve the overall insulation value of the RHW and reduce the ventilation between the glass and the frame or around the ventilator (shutter) in the rear.

Month	Activities	Observations	Actions
Dec. 1998	**Testing durability.** In the BACIP office, several models manufactured by the carpenters were purposely roughly mishandled by slamming the glass shutters closed, standing on the supports and dropping the frame.	Elements would break at places where there were knots or too many nails.	Manuals should be precise as to the location of nails and design of junctions.
Feb. 1999	**Testing for leaks.** Buckets of water were poured over the window. The window was sprayed with a garden hose.	Water leaked into three sides of the glass frame and around the middle sash of the glass frames.	Notches in the sashes were made to avoid standing water.
23 Feb. 1999	One roof-hatch window was installed in Mayoon. It was fixed by a local carpenter. The triangular sides were closed with timber panels by the owner, as advised by BACIP.	Making the sashes with chisels is laborious work and makes the design weaker.	New design to be made that allows better run-off of water.
25 Feb. 1999	One hatch window was installed in Gulmit.	Similar leaking problems occurred as experienced during testing.	Temporarily solved.
March 1999	**Monitoring.**	Local comments: (a) Window size was too large. (b) Placement of the window destroyed the traditional roof design and hence contrary to the local culture.	BACIP needed to better explain the advantages and disadvantages before installation.

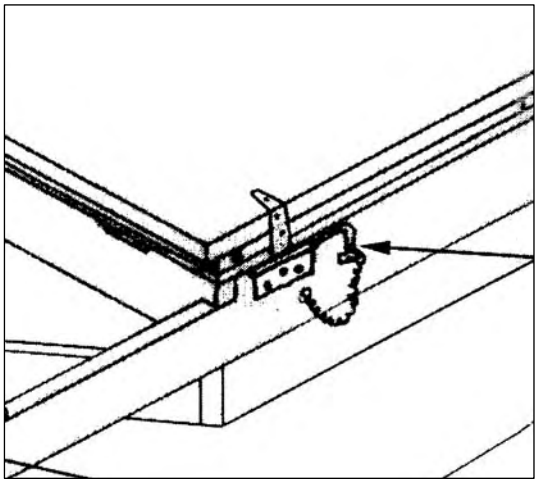




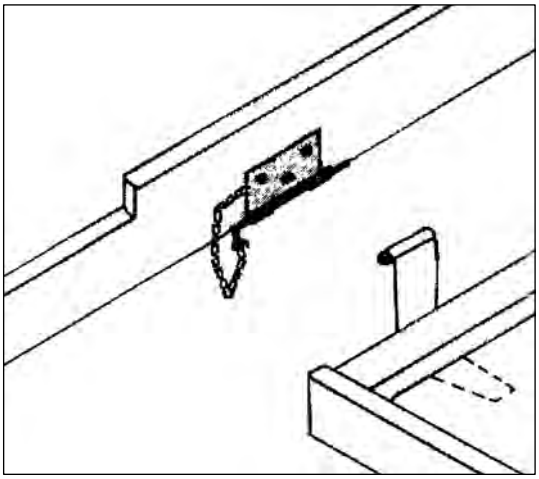
Note: the two single glass sheets have been replaced with one larger laminated glass sheet.
The hinged windows have been abandoned as being too vulnerable over many years of use.

Month	Activities	Observations	Actions
April 1999	**New design of glass frames.** Glass frames now placed on top of the main frame. New glass frames also allowed the main frame to be slightly smaller. Middle and lower sash bars in the glass frames were removed. Glass panes now placed overlapping. Possibility existed of leakage from the top or from the middle joint. A flat GI sheet strip was tried. Finally a wooden strip was placed over the middle joint.	Leakage control: The new design worked well. Design looked better. The work required to make the sashes with a plane and by hand was time-consuming. The tested GI sheet strips were found dangerous when the glass frame was opened as it could cut into the legs of persons walking on the roof.	All installed roof-hatch windows to be modified with new glass frames. Sashes were made with ½" x 1¼" wooden strips nailed to the glass frames (faster work). The glass frames were extended ½" on the upper side.

Month	Activities	Observations	Actions
April/ May 1999	**Reducing possible damage.** In the new design, when the glass frames were open, the bottom parts of the frames with the glass sheets were not supported.	Support needed to be made of a soft material to absorb the opening impact on the glass frame.	A rubber hose was fixed onto the lower supports of the main frame.
April/ May 1999	**Modifying the top insulation shutter.** A single top shutter with ¾" frame and covered with one tin sheet was developed. The top shutter became very light in weight, economical and easy to make.	The former design was too heavy and needed a separate action to open each shutter. The galvanised nails became loose and came out of the shutter.	A rubber hose was used to close the space between the glass and the shutter. Galvanised screws were used.
April/ May 1999	**Modifying the pivotal shutter.** Two 3" galvanised nails were used at each side of the frame. Shutter now filled with wood shavings for insulation**.**	Tin sheets on the pivotal shutter was up to the edge, making minor adjustments (reduction) impossible.	Sheet on shutter was fixed, leaving a margin of 3/8" from the edges.
June 1999	**Making top insulating shutter detachable.** Metal shutter was not needed in the summer and in the way for other roof-top activities.	Shutter was laying in the way and collecting rainwater.	Detachable T-hinges were made.



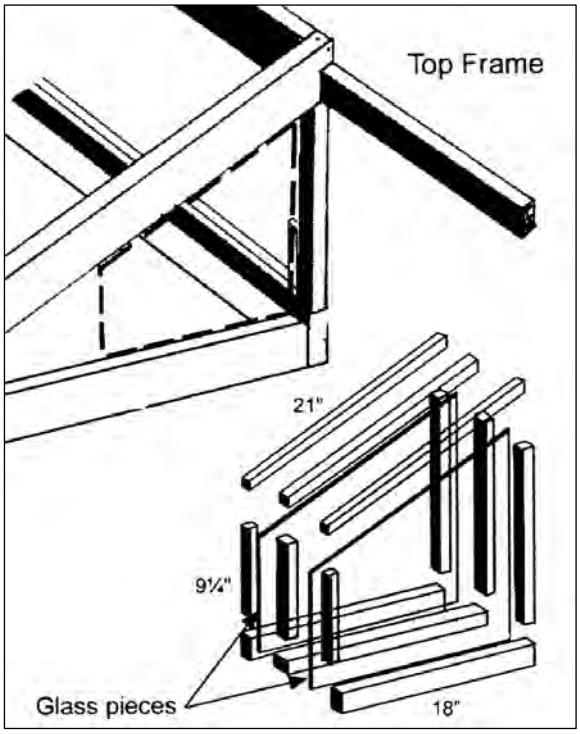
Closed and open T-hinges on GI metal shutter.



Note: The metal shutter was seldom used for insulation, but often for drying fruits in the summer. Better thermal insulation has been developed for cold winter periods.

Month	Activities	Observations	Actions
June 1999	**Flies in the summer.** People from villages asked for fly screens for the roof-hatch window.	People were drying fruits on the roofs, an activity which attracts a large number of flies.	A white mosquito mesh was fitted in the hatch window.
August 1999	**A new model.** A small-size window was installed in Gindai at the house of Mr. Mohd Faqir.	The house became too dark. The former hole size of this house was 28" x 27", larger than the new hatch window.	This was replaced with the medium-size roof-hatch window.
October 1999	**Testing fruit dryer with meat.** By using the existing metal sheet top shutter, along with an additional light GI sheet shutter and a mesh frame, a fly-proof fruit dryer was developed.	1000 gram of buffalo meat was reduced to 350 gram after 4 days in October.	Fly-proof fruit dryer to be tested in the coming season.
October 1999	**Small-size roof-hatch window** with single shutter equivalent to one quarter the size of large roof-hatch window was placed in Gojal (Upper Hunza).	The middle 3/8" x 1¼" strip seemed too weak to support the glass sheets.	The section of the strip was made 1½" x 1¼".
October 1999	A **medium-size roof-hatch window** was prepared using 24" wide glass sheets.	Because of the high cost of the large glass sheets, people wanted a smaller size.	Smaller size gives less heat-intake in winter.

Month	Activities	Observations	Actions
Nov. 1999	**Monitoring.** Most of the people do not use the top shutter during night-time. They complained that with closing the shutter the house became too dark.	The shutters made the house very dark as there were usually no other windows in the traditional houses.	Fixing double-glazing in the eastern triangular side of the roof-hatch window to receive morning sunlight.
	After installation of the roof-hatch window, people added soil on the roof that caused the shutter to get stuck and deform the hinges.	Many top shutters were not opening flat as these were jammed on the lower side due to soil fill.	A bottom plank was introduced elevating the window.
	Several glass sheets were broken caused by kids throwing stones to collect fruits from the trees. The breaking of the glass was a recurrent issue. The glass sheets needed to be 5mm thick and kept small (18" x 18" maximum).	In some cases the broken glass pieces fell into the house. This was a potential risk for accidents. Transparent security adhesive was found but was rather expensive and difficult to keep clean.	Kids should be educated. Optional wire-mesh or strong transparent adhesive film could be purchased for summer use.



In traditional houses the roof hole was the only light intake.

During a monitoring visit the house owner complained that "since installing the roof-hatch window his house was not only warm but also very dark". After some further questioning it appeared that he had never opened the metal insulating hatch!

Another house owner said that when it snowed during the day, the house became very dark as the thick layer of snow blocked out the light.

A third house owner observed that in the warmer house he did not wake up in the morning as there was no biting cold nor morning sun to awaken him.

The third person's observation (complaint) was a remark also received from other villagers, especially in the winter period. Responding to the above observations, BACIP introduced the optional side window.

Month	Activities	Observations	Actions
Dec. 1999	A BACIP blanket was fixed to a medium-size hatch window in such a way that it could be used both in the night-time for insulation (with the window closed) and during the daytime for glass protection (window open).	In Gulmit the house owner did not like the BACIP blanket and was happy with the GI sheet shutter.	A blanket was tested and subsequently fitted to a roof-hatch window in Passu.
Jan/Feb March 2000	Working on the final drawings of the **large roof-hatch window manufacturing manual**.	Total process of designing and field testing with entrepreneurs and villagers took more than one year.	Finalising installation manual.
March 2000	Start with the design drawings of the **medium-size roof hatch window manufacturing manual.**	Variations of glass windows were developed.	See Annexe II. Glass size selection matrix.

Note: The side insulation and the insulation of the pivoting shutter has been further improved. By 2010, a first model was made of a fully plastic RHW with all double glass (expensive).

5. DEVELOPMENT CYCLES

The research and development of the roof-hatch window followed a series of cycles that finally resulted in an acceptable product with limited manufacturing or user problems.

Phase 1: DEVELOPMENT

– Trying to manufacture the design.
– Making the design lighter and therefore reducing the amount of wood and cost.
– Testing the design on strength, rough treatment and transportability.
– Installing the design in the village. Adapting the connection to the roof.
– Improving the design in operational aspects, opening and closing window and shutter.
– Changing the design to control leakage (technical aspects).
– Calling back existing roof-hatch windows or repairing on site at the houses.
– Improving manufacturing and insulation aspects (technical).
– Improving the design based on user comments (light from the sides, fly-screen).
– Making adjustments to hinges and fittings on installed roof-hatch windows.
– Changing the cover construction to reduce glass breakage and lower cost.
– Making smaller variations to adjust to cost and user requests.
– Inclusion of a support plank to avoid future problems when extra layers of roof topsoil are added.
– Repainting the BACIP installed and improved roof-hatch windows after final upgrading.

Phase 2: MANUAL AND MARKETING

- Developing the manufacturing manual for the largest size.
- Develop manufacturing manuals for the smaller sizes.
- Make pictures or photographs of the manufacturing and installation processes for the manuals.
- Develop a roof installation manual for the different sizes.
- Publish roof-hatch window designs in the village information catalogue, with price indications.
- Sell the roof-hatch manufacturing and roof installation manuals.
- Market the orders that are made through BACIP with local entrepreneurs.
- Make a quality control check-list for the manufacturing of the roof-hatch window.
- Establish a quality control system among the entrepreneurs.
- Organise "host training" visits between entrepreneurs for other village craftsmen to learn the same.
- Develop a roof-hatch window package that can be assembled in the village by the local carpenter.
- Make an assembly manual for the Assemble-It-Myself (AIM) method.
- Market the roof-hatch window package with a detailed assembly manual.

Phase 3: PROMOTION AND REPLICATION

◊ Develop mini-models for explaining the design and principle to the public.
◊ Realise temperature measurements and wood consumption measurements with the users.
◊ Demonstrate the roof-hatch windows to new villages by means of Road Shows.
◊ Organise that satisfied customers come to the Road Shows to explain the benefits.
◊ Organise informative visits for the villagers and between villages to view the roof-hatch windows.
◊ Make a research report on the effects of the roof-hatch window on firewood savings and improvement to the quality of life in the village.

Phase 4: FUTURE PLANS

∗ Make a radio programme on the benefits of the roof-hatch window.
∗ Make a video programme on the installation of the roof-hatch window.
∗ Rent out the videos from the BACIP video library.

6. OBSERVATIONS FROM THE VILLAGERS

Datuchi: The house owner (teacher) has much more light. He first thought that the winter was not that cold, but later realised that the house was much warmer because of the roof-hatch window. He noticed that he was using much less firewood.

Mayoon: The lady of the house commented that they were not using the stove anymore in the spring (April) as the house was warm by itself. Estimated firewood savings was about 30%.

Sherquilla: Very satisfied, the house is warmer and much less firewood is being used. Not only the firewood consumption is less but the average room temperature has risen by 3 - 4 degrees Celsius.

Hasis Bala: Very satisfied. Mr. Shukarat has used half the amount of firewood during this season.

Gindai: Very satisfied. Mr. Gul Azam, who has realised the medium-size hatch window at his own expenses, has saved an amount of Rs. 5,000 in terms of firewood. In another house the traditional room became so light that it inspired the house owner to clean the layers of black soot off a beautifully carved wooden cabinet.

Moorkhun: The lady of the house said that she has saved one tractor trolley of firewood by the end of January 2000. (That is about 25% of all fuel consumption or Rs. 1,500)

Parkusap[1]: House owner Zar Wali measured the impact from 21 January to 17 February 2000.
The outside average temperature was minus 2 degrees Celsius (-7 at night to +3 in the day).
With the roof-hatch window closed, he could obtain an average inside temperature of 12 degrees Celsius (+7 to +17). With the hole in the roof (as in the past), in order to obtain an inside average temperature of 10 degrees Celsius (+6 to +14), he would have to use 30% more firewood as compared with the closed roof-hatch[2].

Rehsun: House owner Khun Bakhs measured the impact from 18 January to 14 February 2000.
The outside average temperature was minus 2 degrees Celsius (-6 at night to +2 in the day).
With opening the shutter only when there was sun, the average maximum temperature in the room raised by two degrees (from +10 to +12). With the hole in the roof (as in the past), in order to obtain an inside average temperature of only 8 degrees Celsius (+5 to +9), he would have to use 30% more firewood as compared with the roof-hatch closed.

Dirbarkulti: Mr. Jaffer Ali said that the roof-hatch window extensively increased the illumination in the room and his children could now easily read a book. In addition, he used only one tractor trolley of firewood as compared to two trolleys in the past. Before the installation of the roof-hatch window, the rainwater was falling directly into the house through the roof opening and the wind brought along with it dust and dirt. Now the house is clean and dry during the rainy season.

[1] The temperature research was applied in several houses.
[2] From a close analysis of the supplied temperature charts, it appears that the house owner closed the roof-hatch glass after three days as it became too cold in the house.

7. REGIONAL IMPACT ASSESSMENT

In the Northern Areas the 1.400.000 inhabitants occupy about 160.000 housing units, considering the average sizes of the combined families. Roughly about half of the houses (80.000) still have the open hole in the roof as the central point in the traditional house design. These holes are usually covered with thin plastic sheets in the winter, but this measure still allows the room warmth (and smoke) to escape. In several houses a second hole is located over the adjacent storerooms.

If one quarter of the houses with traditional roof holes place a roof-hatch window, 20.000 roof-hatch windows would be needed. If each roof-hatch window results in a firewood saving of 25% (the lowest value measured), as well as an increase in comfort[3] due to the higher temperature, the following estimates can be made:

Annual Calculations

- ♦ 25% of four tractor loads is one tractor load or $1m^3$ firewood per family (kg 750 = Rs. 750).
- ♦ 20.000 times 750 kg = 15.000.000 kg or 15.000 ton or 30.000 large trees annually.
- ♦ 20.000 times Rs. 750 = Rs. 15.000.000 in economic savings within the Northern Areas annually.
- ♦ Collection of 750 kg firewood, including all labour time in cutting and transport, requires one week.
- ♦ Total primary time savings would be 20.000 weeks or over 60 men-year annually.

Investments and Benefits

- ◊ Average cost of a locally manufactured roof-hatch windows is Rs. 2500.
- ◊ Cost of 20.000 roof-hatch windows is Rs. 50.000.000 (recovered in about three years).
- ◊ Improvement in forestry reserve, reduction of soil erosion and improved water management.
- ◊ Reduced health expenses due to reduced sickness caused by humidity and cold.
- ◊ Improved light levels in the houses allowing domestic production of handicrafts. The 60 man-year can then be invested in productive activities.

Currently in the largest villages about Rs. 100 is paid per 100 kg of firewood, being the value quoted above. It can be assumed that with the reduction of the availability of firewood, the time to collect the required amounts will increase, as well as the cost/value of the firewood.

In general terms the thermal benefit per family will be greater in the higher regions (over 7000 ft.) than in the low regions. However, most people are living below 7000 ft. in the main valleys.

The economic impact and savings will be the largest in the lower valleys (from 5000 ft. to 7000 ft.) as here the people need to buy most of the firewood. The ecological, social and comfort impact will, however, be the largest in the higher regions as people there need to go ever higher into the mountains to collect firewood.

To date 50 roof-hatch windows have been realised by BACIP and individual house owners, providing a substantial house improvements for about 500 persons. Activities will be undertaken to promote the roof-hatch windows and to engage more local entrepreneurs in the manufacturing of the design.

Approximate costs of the basic roof-hatch window (normal 5mm glass):
Large-size roof-hatch window with 4 x 18" x 18" glass panes: Rs 3,500
Medium-size roof-hatch window with 2 x 24" x 18" glass panes: Rs 2,500
Small-size roof-hatch window with 1 x 24" x 24" glass panes: Rs 1,500 (with triplex glass: Rs 2,000)

[3] Minimum average increase is 2 degrees Celsius. Increments of 6-8 degrees have been measured.

ANNEXE I TEMPERATURE CHART

During the winter season of 1999-2000 temperature records were taken in a number of houses that were fitted with the first series of large-size roof-hatch windows (3 ft. x 3 ft.). These roof-hatch windows had a galvanised sheet metal shutter that provided additional insulation when closed. Measurements were taken during a four week period following the schedule below:

Week 1 Glass closed, shutter left open at night. To measure the effect of glass closure alone.
Week 2 Glass closed, shutter closed when there was no sun or at night. Optimum insulation.
Week 3 The rear vent hatch or one glass pane was kept fully open all the time, day and night. This situation represented the old situation when the permanent (traditional) hole was open all the time.
Week 4 Same as during week 2, fully insulated.

From the 15 measurements obtained, it was noted that some of the villagers did not measure the outside temperatures and others did not measure the corresponding firewood consumption for each week.

From the measurements obtained, the following are two typical examples over the same time span:

A. In **Parkusap** the house owner realised a high maximum room temperature of about 17-18 degrees Celsius, whereas the minimum early morning temperature dropped to about 6-7 degrees Celsius. The lowest wood consumption was 128 kg per week or 18 kg per day.
B. In **Rehsun** the house owner heated only to a rather low room temperature of about 11-12 degrees Celsius, whereas the minimum early morning temperature dropped to 4-7 degrees Celsius. The lowest wood consumption was 73 kg per week or 10.5 kg per day.

Parkusap	Week 1 (Jan. 2000) Glass only	Week 2 Insulated	Week 3 (Feb. 2000) Open	Week 4 Insulated
Maximum average	14 to 19º Celsius	16 to 18º Celsius	12 to 17º Celsius	16 to 19º Celsius
Minimum average	6 to 10º Celsius	8 to 9º Celsius	5 to 8º Celsius	6 to 7º Celsius
Outside max. average	+2 to 4º Celsius	+1 to 5º Celsius	+3 to 5º Celsius	+3 to 5º Celsius
Outside min. average	-10 to -6º Celsius	-8 to -4º Celsius	-9 to -5º Celsius	-9 to -6º Celsius
Firewood per week	128 kg	139 kg	190 kg	155 kg

From the detailed measurements in the Parkusap house, it appeared that the house owner closed the roof-hatch in the middle of the third week as he/she could not get the house warm again. If the house owner would not have closed the glass, the maximum temperature in the third week would have been no higher than 14 degrees Celsius, whereas the wood consumption would have been far over 200 kg in the third week.

Rehsun (same climate region)	Week 1 (Jan. 2000) Glass only	Week 2 Insulated	Week 3 (Feb. 2000) Open	Week 4 Insulated
Maximum average	9 to 12º Celsius	11 to 12º Celsius	8 to 9º Celsius	9 to 12º Celsius
Minimum average	5 to 7º Celsius	7 to 8º Celsius	4 to 7º Celsius	6 to 8º Celsius
Outside max. average	+2 to 4º Celsius	+1 to 5º Celsius	+3 to 5º Celsius	+3 to 5º Celsius
Outside min. average	-10 to -6º Celsius	-8 to -4º Celsius	-9 to -5º Celsius	-9 to -6º Celsius
Firewood per week	105 kg	87 kg	113 kg	71 kg

The occupants of the Rehsun house were obviously taking a lower average day and night temperature than the occupants of the Parkusap house. The substantial difference in firewood consumption shows the effect of the higher maximum temperatures.

The following observations can be made about the above two measurements:

- There is a substantial difference in firewood consumption between the houses with the open hole and the houses with the roof-hatch windows.
- The firewood saving for the closed window amounts to 30% or more (50%), thus making the roof-hatch window one of the most effective temperature controllers.
- The firewood saving applies to both situations where the people maintain a low maximum temperature as well as where people maintain a high maximum temperature.
- The "comfort temperature" of the people in the Northern Areas appears to be lower than the "comfort room temperature" of people in more temperate climate zones. This is obviously related to their habits, amount of clothing worn and their frequent movement from inside the house to outside. It can be expected that with improved thermal insulation, the local "comfort temperature" may increase for those who can afford to buy firewood.
- Firewood consumption reduces considerably and the average temperature in the room increases with about two degrees Celsius, thus increasing comfort.
- The roof-hatch window reduces the differences between minimum and maximum temperatures, stabilising the temperatures at a more even level, thus increasing comfort.
- The proper use of the shutter (closing it at night or when there is no sunshine) raises the minimum inside temperature with an average of 2 degrees Celsius.
- When the shutter is used properly (closed at night and open when there is sun intake), the saving in firewood can amount to 50% and higher as compared with the traditional open hole.
- The firewood saving in kg per week will be the highest in the coldest period of the winter.
- People at high altitudes (+7000 ft.) have more benefit from the thermal control by the roof-hatch window than people in the lower altitudes.
- Reduced need for firewood for room heating will reduce the work of the women.

In addition to the above observations, the firewood saving effect of the roof-hatch window is further demonstrated in the autumn and spring when no (additional) firewood was necessary for room heating as the period for cooking the meals was adequate enough for keeping the house comfortable.

In many villages it was observed that during the cold months in the winter, the roof hole was partly covered with a plank or plastic sheet, thus reducing the draft, but also reducing light levels.

Charts with Average Temperature Curves

The chart on the following page gives an indication of the firewood consumption and temperature curve during a single day in an average house. The table presents the average of the two measured houses: Parkusap with a rather high maximum temperature (18 degrees Celsius) and Rehsun with a rather low maximum temperature (12 degrees Celsius).

The chart is based on the combination of the real total measurements (per day). An estimation has been made of the hourly temperature curve and the hourly firewood consumption based on verbal information from the occupants.

The first chart shows the situation with the roof hole open and the second chart with the roof-hatch window properly operated with the shutter closed at night.

ANNEXE II WOOD CONSUMPTION CHART

Wood Consumption and Temperature Chart Average two houses Jan. 2000

Hourly wood consumption and related temperatures in traditional house with roof hole open

Degrees Celsius	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	per day temp.
15																										
14																										
13																										average
12														+	+					+	+	+				max=12
11							+	+	+							+							+			
10										+							+	+	+					+		
9						+					+	+	+												+	
8	+	+																								average
7			+	+	+																					min=7
6																										
5																										
KG of wood 5																										total kg average
4																										0
3						3	3								3					3						12
2								2								2					2					6
1									1	1	1	1					1	1								6
0	0	0	0	0	0								0	0					0			0	0	0	0	0
Per hour	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	24

Fire starts Fire dies out

Doors are regularly opened during the day

Morning 04:30 hrs is the coldest. Evening 19:00 hrs is the warmest.

Same house with roof-hatch window functioning properly.

Degrees Celsius	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	per day temp.
15														#					#	#	#					max=15
14							#	#	#						#	#						#	#			
13										#							#	#						#		
12	#					#					#	#	#	+	+					+	+	+			#	max=12
11		#	#				+	+	+							+							+			
10				#	#					+							+	+	+					+		min=10
9						+					+	+	+												+	
8	+	+																								
7			+	+	+																					min=7
6																										
5																										
KG of wood 5																										total kg average
4																										0
3																										0
2						2	2							2	2				2	2						12
1								1								1					1					3
0	0	0	0	0	0				0								0	0				0	0	0	0	0
Per hour	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	15

Wood consumption is 55% from former amount.

Average temperature up with 3 degrees Celsius, thus increasing comfort.

ANNEXE III GLASS TYPE SELECTION MATRIX

The following matrix will assist the house owner to make the best selection of the type of glass for the roof-hatch window. This is especially important when the risk of breakage is high. The risk of breakage depends on the habits of the children and neighbours and the amount of stone throwing, cricket playing and other sport activities in the area.

Type of Protection	1. None, with 5mm Glass Sheets	2. Wire-mesh Cover for the Summer	3. Wire 5mm Glass	4. Triplex Shatter-proof 6mm Glass	5. Anti-shatter Foil 0.3mm
Description	Clear sheet glass, comes in a few qualities. The lowest quality may encounter difficulties in straight cutting.	A light wooden frame with 21-22 gauge expanded metal wire-mesh. Normal wire-mesh or double galvanised mesh.	Clear glass with thin metal wires in the middle of the glass. Glass does not allow clear sight as it is not flat.	Consisting of two layers of clear sheet glass with a clear plastic foil in-between. Same as car wind screens but flat.	A clear plastic anti-shatter foil can be pasted on the inside of the glass.
Breakage Risk	Fairly easy, with torsion of frame or throwing stones (cricket).	Very small as ½ inch wire-mesh covers the whole window.	Slightly stronger than the clear 5 mm glass.	Rather strong against impact of small stones.	Rather strong against impact of small stones.
Cost	Low cost: Rs. 10 / sq. ft.	Low cost: Rs. 20-25 / sq. ft. Galvanisation Rs. 30-35 / sq. ft.	Medium cost: Rs. 40-50 / sq. ft.	High cost: Rs. 60-80 / sq. ft.	High cost: More than Rs. 100 / sq. ft.
Advantages	Easy to make, low cost and easy to replace. Clear view, good solar heat intake.	When placed the risk of the glass breaking is small. In summer it can reflect solar heat. Made locally.	When the glass cracks, it does not fall down into the room. It can be cut to size.	When the glass cracks, it does not fall down or leak. Glass does not fully break.	Light in weight. When the glass breaks, it does not fall down or leak.
Disadvantages	When it breaks, the pieces fall down into the room below. For large RHW four glass sheets 18" x 18" required.	Needs to be placed timely outside on the window and removed for the winter. Needs to be painted.	When it breaks, it may leak a bit. Not fully transparent (can be an advantage). To be brought from main town.	Expensive, to be ordered and transported from Karachi. Cannot be cut to size once made.	Very expensive. Smoke and dust will adhere on inside. Difficult to apply.
Sizes	Not recommended for dimensions over 24" x 18" or 18" x 18".	Can be made for all sizes of roof hatches.	Not recommended for sizes over 24" x 18" (medium RHW) or large 18" x 18"	Sizes 24" x 24" for special RHW. Glass sheet can be removed and stored in summer.	Up to 5 ft. wide, but large sizes very difficult to apply.
Recommended	Small sizes and with neighbourhood control against stone throwing.	For all areas with fruit trees, birds and playing children. Recommended.	When risk of breaking is large and investment can be made.	For special size 24"x 24" RHW with removable glass sheet.	Not recommended.
Needed Developments	Education of neighbourhood to stop stone throwing.	Education of neighbourhood to stop stone throwing.	Education of neighbourhood to stop stone throwing.	Education of neighbourhood to stop stone throwing	Education of neighbourhood to stop stone throwing.
Order Forms	See manual and standard order form.	See manual and standard order form.	Special order. Two months minimum.	Special order. Three months minimum.	Not available from BACIP.

Note: After 2004, the triplex glass of one size was used as the only standard in BACIP.
The smallest version of the RHW was soon abandoned as an option due to lack of demand.

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