# STOCKTAKING OF ENERGY-EFFICIENT TECHNOLOGIES IN TAJIKISTAN

## GERES, TAJIKISTAN

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# 1. INTRODUCTION

Geres has been working in Tajikistan since 2011 to increase access to clean energy and improve the living conditions, livelihoods and wellbeing of the most vulnerable populations. In rural areas, the majority of houses are built without insulation. To cook food and heat up the house during the cold season, households use large quantities of wood, dung and coal. This provides only very limited thermal comfort on one hand and on the other hand create a significant pressure on a household's budget and daily workload. Additionally, excessive use of biomass fuel and coal leads to increase of indoor and outdoor air pollution and deforestation. Based on Geres experience, multiple assessments and other existing studies, energy-efficient solutions proved to be effective in improving the quality of life of households and contributing to mitigation of the consequences of climate change.

In the framework of the pilot project « Sustainable Housing Solutions for Scale-Up » that is funded by the Government of Switzerland - Swiss Agency for Development and Cooperation (SDC), by "La Fondation Abbé Pierre pour le logement des défavorisés", and being implemented in partnership with BASE (the Basel Agency for Sustainable Energy), Geres will be testing different energy-efficient solutions in various combinations and individually. Through this work Geres on one hand, will support the most vulnerable population in 4 districts around Dushanbe – Vahdat, Hisor, Faizobod and Rudaki and contribute to improving their livelihoods through providing access to sustainable energy efficient solutions. On the other hand, together with its implementing partner BASE, Geres also will work to explore potential financial mechanisms that could facilitate a broader uptake of the energy-efficient technologies in the future.

To move towards achieving these goals Geres has undertaken stocktaking study among development partners in Tajikistan (WHH, Acted, WB, Habitat for Humanity, CESVI, AKAH, etc.) to better understand what type of energy-efficient and habitat improvement technologies have been piloted in the past. It was also important to gather information on lessons learned, bottlenecks and success stories to learn and get inspired by them.

Ultimately, the objectives of this study are to inform Geres current and future programs and to create a catalogue of the solutions and recommendations that could be useful for development partners when making decisions about specific technology. The report also provides testimonies of beneficiaries, drawing upon their applied experiences with the solutions and some of the impact on their day-to-day life

Geres worked on identifying as many as possible solutions that were implemented in Tajikistan and further documented them in this report. As a result, 21 energy-efficient, renewable energy and housing improvement solutions were identified and will be further presented in this report.

## 1.1. METHODOLOGY

Information gathering consisted of several stages. As a first stage, Geres conducted thorough desk research to identify all development partners in Tajikistan who worked in the past or still are working with energy efficient/renewable energy technologies. As a result, 9 organizations, both international and local were identified and invited to take part in the survey. Geres team in Afghanistan was also invited to participate, as their experience is very relevant to Tajikistan context. The organizations that took part in the survey are as follows: Welthungerhilfe, ACTED, CARITAS SWITZERLAND, Geres Afghanistan, Bargi Sabz, Youth Ecological Center, Little Earth, CAMP Kuhiston, Cooperative Zindagi and Systemavtomatika.

As a second stage, Geres developed a comprehensive questionnaire that aimed at gathering information about the type of technology, distribution mechanisms, impact assessment, potential innovative elements and lessons learned. All organizations were offered either to take part in face-to-face interviews or to fill in the questionnaire and send it back to Geres. Additionally, Geres conducted short interviews with beneficiaries of each technology presented in the report to gather their feedback with regards to affordability, practical aspects and final benefits that the technology brings. During the final stage, the incoming data was analyzed and complemented with Geres experience in Tajikistan to date. This report is a summary of this analysis that provides an overview of all the technologies documented during the survey, with focus on both technical and practical aspects as well as the testimonies from beneficiaries.

To assess the amount of fuel saved, the following approach was put in place. First of all, the data provided by partner organizations that promote specific technology was taken as a basis. If such information was not provided, then Geres's data was taken as a basis (if available). In the absence of the mentioned data, the data provided by the beneficiary was used for the calculations. Here, of course, it is important to be careful with using this data as averages, since the numbers might be different depending on the geographic location of households / beneficiaries.

In order to identify the potential amount of fuel savings for the thermal insulation solution, a theoretical calculation was carried out, since there is no fuel saving data for individual solutions (wall insulation, ceiling insulation, etc.)

In terms of carbon dioxide reduction, the calculations are based on the amount of fuel saved and for coal only. Wood used as fuel for each solution is disaggregated from other fuel types. For the purpose of this stocktaking, we limit ourselves to the assumption that woodfuel is carbon neutral and do not estimate the carbon positive aspect of having energy not produced by other carbon negative fuels (coal, LGP, other), following the principles highlighted below:

“The implications of woodfuel use for the global environment can be evaluated by estimating the associated greenhouse gas emissions. As CO2 is the main greenhouse gas, it only (carbon-dioxide) will be considered here, leaving aside gases like methane and other carbon-hydrogens. Any emissions caused by woodfuels can be compared with emissions from alternative fuels.

Though combusting wood emits CO2 into the atmosphere, regrowth of wood captures CO2 from the atmosphere. As a first approximation it can be stated that woodfuel use is carbon neutral, i.e. there is no net emission of carbon into

the environment. The approximation is supported by the evidence of two dominant mechanisms. First, most woodfuel use takes place on a sustainable basis. This applies to the use of virtually all woodfuels originating from non-forest land (e.g. agriculture land, plantations and home gardens), and to the use of most of the woodfuels from forest land. Sustainability implies carbon neutrality, because the same amount of CO2 emitted by wood combustion, is recaptured from the atmosphere by regrowth of wood. Second, leftovers from non-sustainable logging and land conversion, if not used as fuel (or for other purposes) would simply decompose by natural processes, and lead to the same amount of carbon emitted in the atmosphere if the woody material were to be combusted (though not necessarily distributed amongst CO2, methane and other greenhouse gases in the same way)." (https://www.fao.org/3/w7744e/w7744e0c.htm ).

It is important to note that this statement is supported by the fact that forests/ trees stock is managed sustainably and is allowed to regrow. Further specific study would be needed to confirm/infirm this in the case of Tajikistan and its different geographies.

While the report has a lot of potentially valuable information for practitioners, it has its limitations and represents only the experience of development partners and beneficiaries which are subjective in its nature and doesn't provide a holistic picture, nor scientific evidence on various aspects of identified technologies.

## 1.2. BRIEF STRUCTURE OF THE REPORT

For the sake of clarity, the identified solutions were divided into 5 main categories:

- Thermal insulation
- Improved heating solutions
- Improved cooking solutions
- Solar systems
- Other technologies improving the habitat /other innovations

Each category includes profiles of equipment that belongs to this category. The profile structure is consistent for all technologies and include:

- Summary of its key characteristics
- Picture of the technology
- Brief description
- Potential non-material value to households
- Solution cost
- Requirements and precautious
- Ecological and economic benefits
    - Energy/fuel savings
    - GHG emission reduction
    - Operating costs
    - Pros and cons
- Social acceptance
- Testimonies of beneficiaries

In the end of the report there is an evaluation table that helps to assess each technology against specific criteria. Finally, the report concludes with a list of recommendations that could be considered by development partners when making decision about piloting technologies that are new to them or to beneficiaries that they work with.

# 2. PROFILES OF ENERGY-EFFICIENT TECHNOLOGIES

## 2.1. THERMAL INSULATION

The solutions that are gathered in this section are following:

- Wall insulation
- Ceiling and/or floor insulation
- Double glazed windows

### 2.1.1. WALL INSULATION

(IMPLEMENTED/PILOTED BY GERES, ZINDAGI COOPERATIVE, CAMP KUHISTON)

## WHAT IS THIS ENERGY EFFICIENCY SOLUTION?

The main heat losses (45%) in residential buildings occur through the walls, regardless of what materials they are made of. This is due to the fact that the walls have large surface areas. Thermal insulation of the walls is one of the most effective ways to reduce heat losses to a minimum.

Four main types of exterior wall insulation are normally placed on the facade of the building:

- **Spraying method** (hydraulic coating)
    - Hydraulic binder and coating compound of loose insulating material, manually or mechanically sprayed into the structure. This method allows to adapt the coating thickness to the required thermal conductivity.
- **Wet facade method.**
    - There are two types - light plastering system and heavy plastering system. This is the most common external wall insulation system.
- **Ventilated facade.**
    - This type of facade is called ventilated due to the presence of an air gap between the insulation and the cladding. Consists of horizontal and vertical guide profiles, insulation (mainly mineral wool for fire safety purposes).
- **Well masonry**.
    - This insulation system is the cheapest of all of the above. It consists of three layers - a load-bearing wall, insulation (any insulation can be used, like expanded polystyrene, mineral wool, straw, sawdust etc.), a decorative and protective layer (mainly facing brick). It is performed with a height of no more than 15 m.

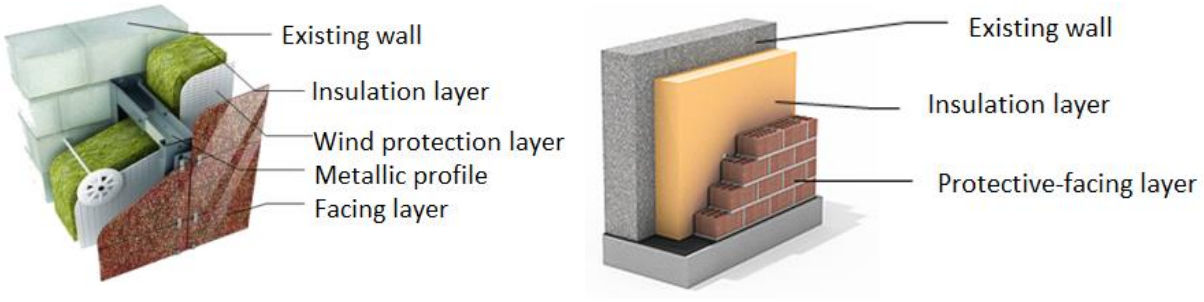



Figure 1. Details and concept of wall insulation

## Why choose this energy efficient solution?

Wall insulation performs the following roles:

- Reduces heat loss through walls;
- Increases thermal comfort in the room;
- Saves money on fuel when heating during the winter season.

## Solution cost

The cost of insulating 1 m2 of a wall with various thermal-insulating materials, including installation work:

- Mineral wool 50mm thick - >130 somoni;
- Expanded polystyrene 50mm thick -> 80 somoni;
- Extruded polystyrene 30mm thick - >130 somoni;
- Facade decorative thermal panels 30mm - >200 somoni;

# REQUIREMENTS AND PRECAUTIONS

When doing wall insulation, follow these requirements:

- If possible, use local and environmentally-friendly materials.
- Wall insulation materials should be non-flammable.
- Selected materials should not have a significant impact on the process of natural air circulation.
- Be aware of the moisture and make sure that the insulation materials remain dry.
- Wall insulation requires a trained specialist who can calculate the thickness of the insulation for various designs and perform the work correctly layer by layer.

## ECOLOGICAL AND ECONOMIC BENEFITS

### Energy / fuel savings

According to thermal calculations, insulating the exterior walls of the winter room with one or another solution (the cost pictured above) the **energy saving**s during the heating season represents **approximately 1100 kWh**[1] per year.

### GHG emission reduction

By saving fuel, the insulated wall **reduces CO2 emissions** by **0,7**[2] **tons per year**.

### Operating costs

Operating costs for this solution are very small. A cosmetic repair of the facade might be needed every 10 years.

## PROS AND CONS

- Optimal insulation: external insulation eliminates most thermal bridges.
- Can be used to insulate balconies and loggias.
- Provides a good protection against climate changes, walls are less susceptible to changes in outdoor temperature.
- Provides a comfortable indoor temperature in hot weather.
- Allows optimal use of thermal inertia. The walls capture and retain heat in the house at night during the cool part of the day.
- Does not decrease the living area.
- Provides a good sound proofing effect.
- High cost of thermal insulation materials.
- Requires trained specialists.
- It is necessary to protect the wall from precipitation when using mineral blocks.

## SOCIAL ACCEPTANCE

### Beneficiary feedback

Based on the feedback from beneficiaries, insulated houses provide a high level of thermal comfort in the house, are warmer in winter and cooler in summer. Fuel consumption in winter is reduced by three times. When the facade is finished the house looks more esthetic.

*"I am Sharipov Kurbonali Rachabovich. I live in Barakat village, Mirzo Tursunzoda`s jamoat city of Hisor together with my parents. I insulated the walls of my house. We used to burn 30 kg of coal a day in winter, but the rooms remained cold, now we burn 10 kg of coal and the rooms are warm and cozy. The air is clearer. Now I buy a ton of coal for 900 somoni and use 500 pieces of dung. Previously, we bought 3 tons of coal and 800 pieces of dung."*

[1] Thermal calculation is made for the climate of surrounding Dushanbe districts and for the 15m2 of winter room, which has 35m2 of external walls with R-value 0,75 m²K/W.

[2] It is considered that the heating system of the room is a metal stove with 35% of efficiency and coal represents 55% of the total fuel. Same data will be used for further estimation as well

### 2.1.2. CEILING INSULATION

(IMPLEMENTED/PILOTED BY GERES, WHH, ACTED, BARGI SABZ, ZINDAGI COOPERATIVE, CAMP KUHISTON, LITTLE EARTH)

## WHAT IS THIS ENERGY EFFICIENCY SOLUTION?

There are two ways to insulate the ceiling:

- From inside of the room.
- In the attic (top of the ceiling).

As a rule, the insulation from inside of the room is combined with the construction of suspended or stretch ceilings. In this case, the insulation is placed in the space between the ceiling slab and the covering to be installed or between wooden beams. For insulating the ceiling from inside of the room, most homeowners choose mineral insulation, which is available in the form of rolls or mats.

## Why choose this energy efficient solution?

The insulated ceiling performs the following roles:

- By adding 5cm of mineral wool, the heat losses through the ceiling could be halved.
- Prevents the penetration of heat from the attic in the summer.
- Helps to save fuel and family budget.

**Solution cost:** The cost of insulating 1 m2 of the ceiling depends on the thermal insulation materials and varies from 10 somoni to 100 somoni.

## REQUIREMENTS AND PRECAUTIONS

To insulate the ceiling, follow these requirements:

- If possible, use local and environmentally-friendly materials.

- Ceiling insulation materials should be non-flammable.
- Selected materials should not significantly impact the process of natural air circulation.
- Be aware of the moisture and make sure that the insulation materials remain dry. For some material (glass wool, mineral wool) it is necessary to add a vapor barrier.
- Ceiling insulation requires a trained specialist who can calculate the thickness of the insulation for various designs and performs the work correctly layer by layer.

## ECOLOGICAL AND ECONOMIC BENEFITS

### Energy / fuel savings

According to thermal calculation the ceiling insulation with 5cm of mineral wool allows to save **approximately 450 kWh of energy** used to heat the room per year.

### GHG emission reduction

By saving fuel, the ceiling insulation **reduces CO2 emissions by** 0,3 tons during the heating season.

### Running costs

No running costs for this solution.

## PROS AND CONS

- Prevents heat losses during the heating season through limiting heat leakage through ceiling.
- Can be easily applied with alternative biomaterials such as straw, sawdust, reeds, flax and rice straw.
  - Special solution against rodents is needed, if biomaterials used.
  - The insulation material loses its properties, if moisture gets on it.

## SOCIAL ACCEPTANCE

### Beneficiary feedback

According to beneficiaries, ceiling insulation is indeed a very effective technology for insulating houses, especially if performed with locally available biomaterials thus reducing the price significantly.

*"Our house was poorly insulated, single windows, doors with cracks, and no ceiling. In winter the room was very cold, cold air came from all directions, we used a lot of fuel sparingly and the whole family was often sick. Every year I bought 1000 kg of coal and 450 kg of dung for 850 somoni. When the ceiling of the winter room was insulated and a plastic window was installed, we felt a big difference. This year, the winter was very cold, but our house was much warmer, less fuel was consumed and we did not use an electric heater at all".* - Gulrakat, 40 years old widow from Mekhrobod village, B.Burunov jamoat, Vakhdat.

### 2.1.3. INSULATION OF THE FLOOR

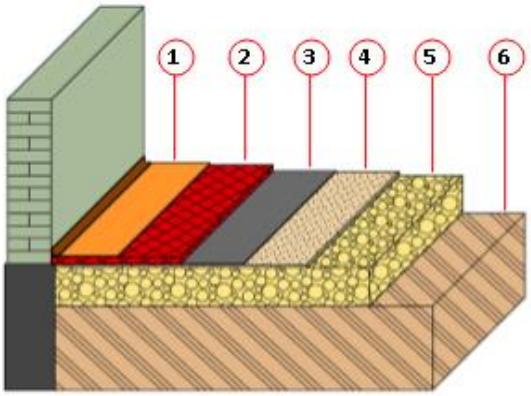
(IMPLEMENTED/PILOTED BY GERES, WHH, ACTED, BARGI SABZ, ZINDAGI COOPERATIVE, CAMP KUHISTON, LITTLE EARTH)

## WHAT IS THIS ENERGY EFFICIENCY SOLUTION?

Floor plays quite a central role in houses of Central Asia and Tajikistan. It is habitual to sit, eat family meals and even sleep on the floor. In rural areas, the floors are usually directly on the ground or on the layer of concrete. In such cases, it is recommended to heat-insulate the floors with 4 mm foam over the entire floor surface and to perform the floor covering itself with laminate or linoleum. If the wooden floors are raised on posts, a waterproofing layer, insulation material, vapor barrier and floor covering are laid along the beams before installing the planks. If the house is built with a basement, then it is possible to insulate the first floor from the basement side using a hinged method with tiled thermal insulation materials.

Expanded polystyrene Styrofoam | Expanded clay | Polyethylene | Felt Glass | Wool

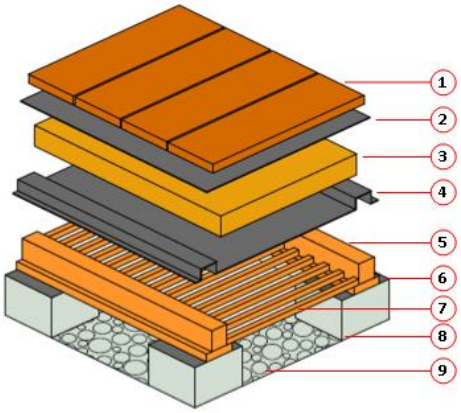
Figure 1. Types of materials for floor insulation




1. Laminate or linoleum; 2. Insulation layer made of clay; 3. Waterproofing layer; 4. Levelling layer of sand

5. Filling made of sand and clay

6. Compacted soil base




*1. Floor; 2. Vapor barrier; 3. Insulation block; 4. Waterproofing layer; 5. Wooden beams; 6. Rough floor; 7. Wooden floor racks;*

*8. Concrete or bricks; 9. Compacted soil ground*

Figure 2. Details and concept of floor insulation

## Why choose this energy efficient solution?

Floor insulation performs following roles:

- Provides high level of thermal comfort in the house.
- Contributes to improvement of children's health, as they usually play on the floor.

## Solution cost

The cost of insulating 1 m2 of floor depends on thermal insulation materials and varies from 5 somoni to 35 somoni.

# REQUIREMENTS AND PRECAUTIONS

Follow these requirements for floor insulation:

- If possible, use local and environmentally-friendly materials.
- Floor insulation materials should be non-flammable.
- Selected materials should not significantly impact the process of natural air circulation.
- Be aware of the moisture and make sure that the insulation materials remain dry.
- Floor insulation requires a trained specialist who can calculate the thickness of the insulation for various designs and performs the work correctly layer by layer.

# ECOLOGICAL AND ECONOMIC BENEFITS

## Energy / fuel savings

If floors are on the ground or concrete, the heat losses are around 4% of the total heat losses in the house. Therefore, the impact of floor insulation on the overall energy-saving is very low. If the floor is lifted or with a basement and covered with planks or chipboard only, then the heat losses is around 20% (almost the same as ceiling). Insulation of the floor with 5cm of mineral wool, can result in 450 kWh of energy saving per heating period.

## GHG emission reduction

By saving fuel, thermal insulation of the basement floor will avoid emissions of 0,3 tons of CO2 per heating period.

## Running costs

No running costs for this EE technology solution.

# PROS AND CONS

- Increased thermal comfort.
- Fuel savings, especially if there is a basement in the house.
- The price can be reduced significantly if local materials are used for thermal insulation of the floor such as straw, reeds, flax, wool, rice straw, etc.
  - Special solution against rodents is needed, if biomaterials used.
  - The insulation material loses its properties, if moisture gets on it.
  - For some material (glass wool, mineral wool), it is necessary to add a vapor barrier.

## SOCIAL ACCEPTANCE

### Beneficiary feedback

*"I am 35 years old, I work part-time at construction sites. During the winter period, no matter how much we heat, the floor is cold all the time. I have small children and they get sick very often. After insulation of the floor, we felt a great deal of comfort especially in the colder months of the year".* – Safarov Amridin Mukhridinovich, resident of the Manas village, Jamoat Sharora city of Gissar.

### 2.1.4. DOUBLE GLAZED WINDOWS

(IMPLEMENTED/PILOTED BY GERES, WHH, ACTED, BARGI SABZ, ZINDAGI COOPERATIVE, LITTLE EARTH)

## WHAT IS THIS ENERGY EFFICIENCY SOLUTION?

How is a plastic window with a glass unit arranged?

- Raw materials and additives directly impact the quality of PVC (plastic) which depends on the amount of phenol and vinyl added to it. This can make the plastic hard, brittle or soft.
- Glass unit (double glazing) - depends on the number of chambers (single-chamber, two and three chambers, in rare cases four-chambered), the material of the framing and sealing of the chambers: an aluminum spencer filled with silica gel granules. Glasses can be ordinary or energy-saving, with sputtering that improves the thermal resistance of the glass.
- Fittings - the more openings in the plastic window, the more expensive the window is.

Figure 1. Details and concept

## Why choose this energy efficient solution?

Double glazed window performs the following roles:

- Retains the heat.
- Helps to insulate the house due to the fact that the windows are two-layered
- Can protect from drafts if installed properly.
- Serves for over 20 years.
- Esthetic and easy to install.
- Wooden windows with double-glazing can serve as more environmentally-friendly alternatives.

## Solution cost

The average cost of 1 m2 of a double-glazed plastic window is 500 - 1000 somoni. The price includes measurement, delivery and installation. Some carpentry shops with specially trained artisans produce high-quality wooden windows using German technology with a double-glazing, but they are 1.5 times more expensive than plastic windows.

# REQUIREMENTS AND PRECAUTIONS

For plastic insulating glass units, follow these requirements:

- For windows installed on the south side of the house, it is necessary to protect the plastic from solar radiation with an additional overhang.
- Pick the fittings of a good quality to ensure long-term use.
- The windows in winter room should have an optimal size (approximately 20% of the total area of the floor).
- Ensure to have air vents on the windows for room ventilation.

# ECOLOGICAL AND ECONOMIC BENEFITS

## Energy / fuel savings

Double glazed windows can ensure approx. 200 kWh of energy savings per heating period.

## GHG emission reduction

Due to the savings, plastic windows with double-glazing will avoid the emission of 0.2 tons of CO2 during the heating season.

## Running costs

No running costs for this solution.

# PROS AND CONS

- Increased thermal comfort and fuel saving.
- Esthetical design.
- Easy to install.
  - Tolerates poorly solar radiation, the plastic becomes fragile and changes its color.
  - Over time, deformations and cracks can appear in the rabbets.
  - Expensive, not everyone can afford.

## SOCIAL ACCEPTANCE

According to the reviews of the beneficiaries, double glazed windows are comfortable, and easy to use. The downside of this technology is that white color fades in a couple of years. However, on other aspects, the reviews of the beneficiary Badalova Kholniso, a 35-year-old homemaker, a resident of the Tubek village of Lohur jamoat, Rudaki district, is very positive:

## Beneficiary feedback

*"After insulating the room, my family and I significantly feel the warmth in the room and the savings in fuel consumption. It's nice when the windows are beautiful and do not require painting. I have small children that I am raising by myself. I probably would not have been able to install double glazed windows myself".*
- Badalova Kholniso, 35-year-old resident of the Tuberk village of Lohur jamoat, Rudaki district

## 2.2. CONCLUSION ON THERMAL INSULATION

The above analysis shows that thermal insulation is one of the main measures to reduce heat energy and greenhouse gases. To prove this, we summarized the details and benefits for each of the building envelopes (walls, ceilings, etc.) in a table (see table below).

| № | Building envelope | Total area, m2 | Heat losses before the thermal insulation, kWh/season | Thermal insulation measures | Approx. cost of the thermal insulation, TJS | Heat losses after the thermal insulation, kWh/season | Heating energy saved, | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | kWh/ season | % |
| 1 | Exterior walls | 35 | 1915 | 5cm of mineral wool | 4500 | 815 | 1100 | 57 |
| 2 | Ceiling | 15 | 725 | 5cm of mineral wool | 1500 | 260 | 465 | 64 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 3 | Window | 1,7 | 470 | PVC double glazed window | 1000 | 280 | 190 | 40 |
| 4 | Earth floor (no basement) | 15 | 235 | 0,5cm of foamed polyethylene (mainly to avoid the cold effect) | 100 | 215 | 20 | 8,5 |
| | **Total** | | **3345** | | **7100** | **1570** | **1775** | **53** |

The table shows that the loss of heat energy in one season (110 days for the surrounding districts of Dushanbe) is equal to 3345 kWh before and after 1570 kWh, i.e. 1775 kWh (53%!) saved in one heating season.

However, it is not always possible to keep a room or a building fully insulated. What should be done in such case? Which part of the room / building should be insulated first?

To answer this question, several factors must be taken into account:

- the potential amount of energy saved.
- the cost of thermal insulation measures.
- technical requirements.
- the availability of knowledge and skills in thermal insulation, and so on.

If we look at the amount of energy saved (the last column of the table), the heat energy gain is the highest when external walls are insulated. At the same time, the external walls insulation is very expensive (about 60% of the total cost of thermal insulation). Geres Tajikistan field experience on housing insulation shows that the most appropriate combination of solutions, both for financial and energy saving is ceiling, floor and windows. It amounts to roughly 30% energy savings while costing 40% of all 4 solutions.

It should be noted that thermal insulation increases the internal surface temperature of the building envelope, resulting in the decrease of comfortable temperature that people feel. For example, in a non-heated room, the indoor air temperature should be raised (up to 23-25 0C) so that people feel comfortable. In thermally insulated rooms, when the temperature is 18-20 0C, people already feel comfortable. Note that reducing temperature by 1 0C can save up to 7% of heat energy! In this instance 3 degrees less amounts to 20% savings.

Another point is that the heat-insulated room needs more ventilation. Along with the thermal insulation, the air permeability of the building envelope is also reduced. The most air permeable structures are ordinary windows and wooden doors because of their air gaps (recall your doors and windows!). In rooms that are insulated with plastic doors and windows, the air is heavy if the room remains closed. This indicates that there is not enough ventilation in the room (for this reason some people wrongly think that plastic doors and windows are harmful), so it is necessary

to consider additional ventilation (through the ceiling, walls, etc.) when insulating. It is best if the ventilation system is adjustable (e.g. an adjustable grille during natural ventilation) depending on the season. It is recommended to have a thermometer/hygrometer unit installed in the house. It is not expensive, easy to find and very useful for controlling heat and humidity. Optimal relative humidity for residential buildings is 50-60% and when it is more than 70% (except when raining) the house should be ventilated.

# 3. IMPROVED HEATING SOLUTIONS

## 3.1. IMPROVED HEATING STOVE "ETERNAL FIRE" (ACTED)

### WHAT IS THIS ENERGY EFFICIENCY SOLUTION?

High fuel prices in winter cause a financial burden for the rural population. The prices go up as the demand for firewood increases. In rural areas, people need stoves not only for heating purposes but also for cooking food. Having an energy-saving stove tackles both issues, as families can perform these tasks simultaneously. This contributes to decreasing fuel consumption and supports families with savings. It also results in lowering pressure on natural resources such as forests.

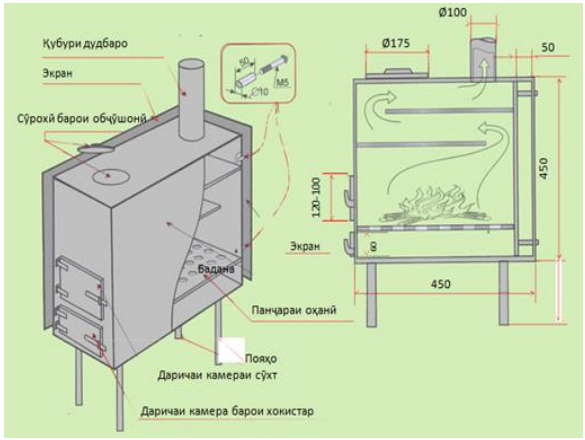



Figure 1. Stove details and concept

### Why choose this energy efficient solution?

The main features of the modified furnace are:

- It has a protective shield installed from the side of the room. The screen acts as a heat exchanger.
- The combustion chamber is fenced from above with two tiered partitions that retain heat.
- It performs 2 tasks at the same time: heating the room and cooking.
- Suitable and effective for use in large rooms (over 300 m3).

### Solution cost

It can be purchased on average for 1400 somoni.

## REQUIREMENTS AND PRECAUTIONS

When using improved heating stove, follow the requirements:

- The base of the floor in the room should not be wooden; if wooden, then it is necessary to secure the floor with a piece of tin.
- For safety install the stove at a distance from the front door (usually done in households).
- The screen should be facing the room, not the wall, to ensure circulation of the air.
- To build and assemble the stove a welder needs technical knowledge.

## ECOLOGICAL AND ECONOMIC BENEFITS

### Energy / fuel savings

An improved heating stove will save up to 50% of the fuel used to heat the room. According to the beneficiary from Ayni district, who uses this stove, the savings are up to 2000 kg of coal and 200 kg of wood. In monetary terms, the savings are up to 1200 somoni per year.

### GHG emission reduction

Based on fuel savings mentioned above, the stove will avoid emission of 5,5 tons of CO2 per year.

### Running cost

No running costs for this stove. Maintenance costs are practically zero. For the long-term service of the stove, it is advisable to use metal sheets larger than 3 mm.

## PROS AND CONS

- Thermal comfort and fuel savings.
- Possibility to cook.
- Compact design.
- Decrease in indoor pollution.
  - The cost of an EE Stove is much higher than usual. The most vulnerable households cannot afford it.
  - Difficulty of heat regulation with high and low temperature variation = effect on thermal comfort.

## SOCIAL ACCEPTANCE

According to the feedback of beneficiaries, the “Eternal Fire” heating stove is in great demand among residents of the Ayni district. At the same time, the high cost of the solution makes it inaccessible for many families.

## Beneficiary feedback

*"Due to the harsh, cold climate in the mountain villages in our area, the rural population uses more natural resources - forest trees, coal and other fuel sources - to keep their homes warm and to cook food. These resources are being depleted, including the forests. Therefore, technologies like this heating stove are very much needed as they reduce the fuel consumption.*

*We installed a stove in 2019. The stove significantly saves fuel consumption (wood, manure, coal). Before we installed this stove, we used up to 4 tons of coal. Over the last two years (winter period) we used only 2 tons. Besides savings, thermal comfort is much better and it heats up faster. The stove also does not produce as much smoke as an ordinary one."*

- Abdurakhmonova Abdukaroma, a resident of Ayni district, Rarz jamoat, Soyrokh village.

## 3.2. IMPROVED 2 ROOMS HEATING STOVE (IMPLEMENTED/PILOTED BY CAMP KUHISTON)

## WHAT IS THIS ENERGY EFFICIENCY SOLUTION?

In Tajikistan, numerous organizations have done significant work to design and improve energy efficient stoves. One of the energy efficient stoves is a two-room stove (interroom) using German technology, which has proven to be effective in cooking and keeping heat in the house. This stove can be installed in households and for spacious buildings, for example in schools, hospitals, mosques, etc. The stove is normally used to heat the house. Due to the smoke-circulation in the wall, two rooms can be heated in parallel. Moreover, this is a multifunctional stove that can be used for cooking and baking bread in the built-in oven.

### Why choose this energy efficient solution?

The 2 rooms stove has several functional roles:

- Heats houses during the winter time (2 rooms simultaneously)

- Provides opportunity for families to cook in their homes rather than outside during winter.
- Provides a reliable source of heating for around 12 years.
- Oven function for bread baking can be included.

### Solution cost

Average cost of 2 rooms stove is 4500 somoni

## REQUIREMENTS AND PRECAUTIONS

For the construction of the 2 rooms stove, the following requirements are necessary:

- Prepare the base. Solid base is needed. The weight of the stove is more than 1 tone (around 400 pieces of brick (each 3,5 kg) are needed).
- The 2 rooms stove requires 2 times more space than traditional stove.
- It is not removable, once built. It cannot be removed during summer time (traditional stove is removed off season)

## ECOLOGICAL AND ECONOMIC BENEFITS

### Energy / fuel savings

According to the beneficiary from Faizabad district, the 2-room stove saves 30% of fuel. The average savings are 1050 kg of coal and 1350 kg of wood per year. In monetary terms, the savings are approximately 1200 somoni per year.

### GHG emission reduction

Based on amount of saved fuels mentioned above the stove will prevent emission of 2,9 tons of CO2 per year.

### Running cost

No running costs for this EE solution. The stove is long lasting if properly maintained - whitewash in the spring after the heating season.

## PROS AND CONS

- The thermal mass of the unit distributes the heat uniformly and adds better thermal comfort.
- Increased thermal comfort and fuel savings.
- Offers additional functions such as cooking, baking bread.
- Heats two rooms in parallel.
  - Due to a thermal mass (bricks or stone) it takes up a lot of space in the rooms and a long time to heat it up.
  - Very expensive.

## SOCIAL ACCEPTANCE

According to the feedback of beneficiaries, constructing a stove like that is much more expensive than buying a conventional one. In addition to that, the stove takes up a lot of indoor space. At the same time some beneficiaries praised it for reducing the amount of fuel and heating up a large area in the house.

## Beneficiary feedback

*"The winter climate is very harsh and windy in our area. Our heating season lasts from October until May. We use about 3 tons of wood and 3.5 tons of coal per year to heat our house. Our family of 8 people uses about 1.5 tons of firewood for cooking and heating water for domestic needs. However, after the 2 room stove was installed, it saves about 30% in fuel every season. When there is a power outage, we use this stove to cook food and bread during the fall / winter season. We are very glad that we have this stove in our house, as it helps us to save our heating and cooking costs." –*

Salimova Asliya, a resident of the village of Durakhshon, Jamoat Chashmasor, Faizabad region

### 3.3. METALLIC STOVE WITH INTEGRATED HEAT-EXCHANGER (IMPLEMENTED/PILOTED BY CARITAS SWITZERLAND)

## WHAT IS THIS ENERGY EFFICIENCY SOLUTION?

This multifunctional stove allows you to cook, heat, boil water and heat water for home cooking and bathing. Additionally, it can provide a hot water heating system in the house. Thanks to these measures, the modified stove consumes 33-40% less fuel. The modified stove can be made from metal sheets of different sizes and thickness, depending on the expectations for the durability of the stove and the price that the customer is ready to pay.

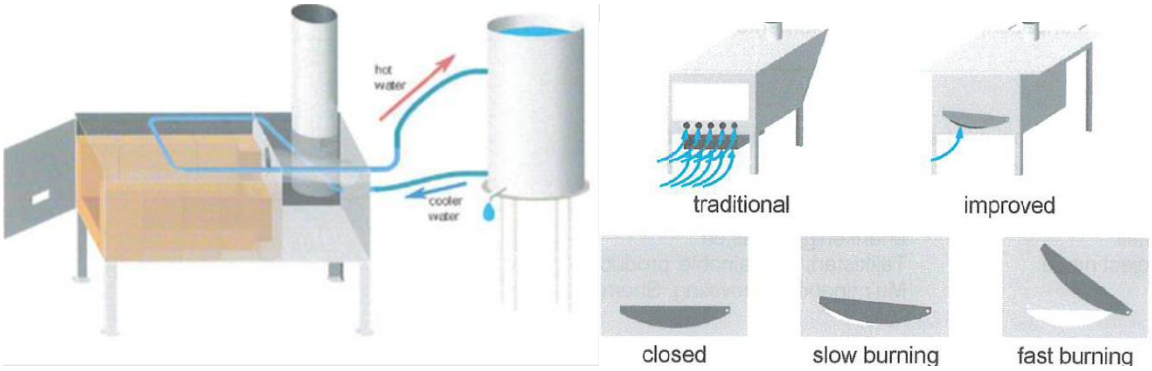



Figure 1. Stove details and concept

## Why choose this energy efficient solution?

The main features of the modified stove are:

- The shortened combustion chamber reduces energy losses and optimizes the use of raw materials during the production stage, which reduces the cost of the stove.
- The draft regulator allows you to control the heat and keep the oven of the heat exchanger warm.
- Two burners of different diameters, adjustable with the help of the ring, increase the functionality of the stove and shorten the cooking time by about 10%.
- Burnets have a lid to prevent smoke escaping.
- Double ring pipes for faster water heating.
- The wire structure around the oven increases the space for the cookware and increases the efficiency of the heating surface.
- To ensure the service life of 3-5 years, it is recommended to use metal sheets with a thickness of at least 3 mm, and for better quality - up to 5 mm.

## Solution cost

Average cost of the metallic stove with integrated heat-exchanger depends on the thickness of the metal sheet and varies from 800 to 1100 somoni.

# REQUIREMENTS AND PRECAUTIONS

For the design of a stove with integrated heat-exchanger, the following requirements are necessary:

- Room floor should not be wooden.
- Install on a distance from the front door to ensure safety related to hot water tank.
- It is necessary to control the water levels in the water heating tank.
- The distance of the heat exchanger from the stove should be exactly 40 cm.
- Can be built by the blacksmith and tinsmith with the help of drawings and photographs.

## ECOLOGICAL AND ECONOMIC BENEFITS

### Energy / fuel savings

A metallic stove with an integrated heat exchanger will save up to 40% of the fuel used for the winter room. According to the beneficiary from Muminabad district, on average, the savings are up to 1000 kg of coal and 500 kg of wood and dung per year. In monetary terms, the savings are up to 1000 somoni per year.

### GHG emission reduction

Based on fuel savings mentioned above, the metallic stove with integrated heat exchanger will save 2,75 tone of CO2 per year by saving fuel.

### Running cost

No running costs for this EE solution. Maintenance costs are equal to zero. In case when container remains without water, the pipes melt at a high temperature and must be replaced.

## PROS AND CONS

- Thermal comfort and fuel savings.
- Cooking possibilities.
- Heating of water for households use (washing clothes, dishes, etc).
  - High prices of materials and labor cost.
  - Might not be fully safe for households with small children due to a tank with hot water.

## SOCIAL ACCEPTANCE

According to residents, a metallic stove with an integrated heat-exchanger is well appreciated by the population but not all families can afford to purchase this stove because of the cost.

### Beneficiary feedback

*"We installed a metallic stove with an integrated heat-exchanger six years ago. All this time (winter period) we use less fuels (firewood, manure, etc.). I can say with confidence that the savings are around 40%. The water that heats up in the tank helps us a lot in the household. Muminabad has very cold winters. We often use hot water to unfreeze water in livestock drinkers as well." –*

Gesh Kurbonova Olambi, resident of the Muminabad

## 3.4. "VULKAN" HEATING STOVE (IMPLEMENTED/PILOTED BY ZINDAGI COOPERATIVE)

## WHAT IS THIS ENERGY EFFICIENCY SOLUTION?

The furnace of the "Vulkan" stove is reduced in size due to heat accumulators from firebricks, which protect the metal body of the stove from overheating. The stove has a pass-through oven with two doors. If you open both doors, you get a heat exchanger, and when used as an oven, one door is open only. In addition, to regulate the temperature of the oven, there is an adjustable valve above the oven that directs heat flows around the oven.

For cleaning the chimney, there is a removable galvanized sheet cup at the bottom of the outlet pipe. The outlet pipe has a valve for keeping the heat of the stove. A removable ash collector is provided for ash removal. The top plate has a round hole with removable rings for the diameter of a large and medium pot.

The "Vulkan" stove is, first of all, an energy-saving stove and is very convenient to use. The stove meets the requirements of the quality standard and provides the home with warmth and comfort.

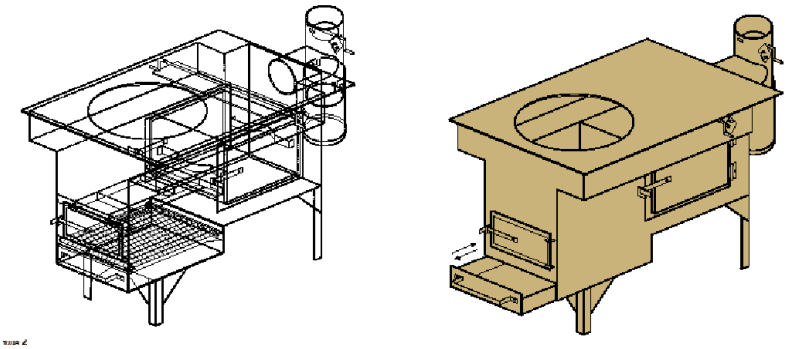


Figure 1. Details of the "Vulkan" stove

### Why choose this energy efficient solution?

"Vulkan" stove fulfills several functional roles:

- Heats the house in winter.
- Provides opportunity to cook food, boil water, heat up food and bake cakes.
- Can function as a heat exchanger, you can dry firewood and save fuel.

### Costs of the solution

Average cost of the "Vulkan" stove is 1300 somoni

## REQUIREMENTS AND PRECAUTIONS

- Fire safety rules should be considered when installing the “Vulkan” stove.
- If the floors are wooden, it is necessary to protect the floors with metal sheet at the place where the stove is installed.
- The chimney pipe must comply with fire safety requirements. It should be tightly attached to the body, making sure that there are no gaps at the joints.
- Before lighting a fire in the firebox, open the valve on the pipe and the valve for the oven so that the fire ignites easily and the stove does not smoke.
- It is necessary to pull out the ash drawer a little so that air enters the combustion chamber.
- If you heat the stove with coal, be sure to install a special steel basket for coal in it. It protects the stove from direct contact with hot coal. Thus, the stove will last longer.
- To use the oven, close the oven valve. In this way, warm air is directed around the oven chamber. When you are not using the oven, leave both oven doors open to allow the oven to generate more heat like a heat exchanger.

## ECOLOGICAL AND ECONOMIC BENEFITS

### Energy / fuel savings

The “Vulkan” stove saves about 40% of the fuel used for heating. Based on a Geres fuel consumption monitoring report from Asht district, the average savings are 600 kg of coal and 400 kg of wood per year. In monetary terms, the savings are 510 somoni for coal, 400 somoni for firewood, for a total of 910 somoni per year.

### GHG emission reduction

Based on the amount of saved fuel the “Vulkan” stove will avoid emissions of 1,65 tons of CO2 per year.

### Running cost

If you use coal, there might be a need to change the grate of the ash collector every two years, which costs 70 TJS.

## PROS AND CONS

- Heats the house.
- Provides possibility to cook food.
- The “Vulkan” stove has an oven in which you can bake or use it as a heat exchanger.
- The stove cools down slowly, because there is a heat accumulator inside from firebricks.
- Easy to get ash out thanks to the removable ash collector.
- The temperature is regulated by a valve (gate) in the chimney.
  - The cost of the stove is rather expensive for vulnerable households.
  - The stove is very heavy.
  - The stove can only be made by a trained craftsman.

## SOCIAL ACCEPTANCE

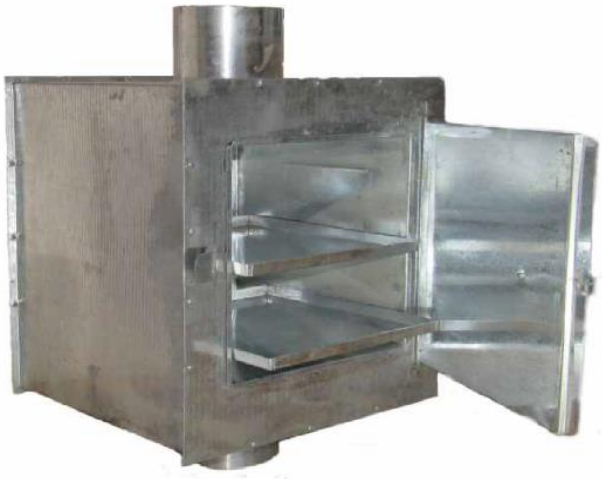
According to the reviews of the beneficiaries, the “Vulkan” stove is very massive and heavier than traditional stoves. The stove is expensive, not everyone can afford to buy a “Vulkan” stove. It is impossible to buy a stove on a free sale, one can only order it. The stove requires special instruction for use. At the same time, some households found it extremely useful.

## Beneficiary feedback

*As a user of the “Vulkan” stove, I constantly recommend the others to buy this stove. " Vulkan " is a very good helper not only for heating the house, but also in cooking. For the last few months we have been baking bread in the oven, and this does not require additional expenditure of firewood. According to my calculations and thanks to the improved combustion chamber, the stove saved 30-40% of my firewood. In addition, this winter we saved 40 bundles of firewood that we used to make bread in a separate oven. In this oven, bread is baked without the use of additional fuel. Due to this, we saved 120-160 somoni. Thus, the “Vulkan” stove saved 910 somoni out of 1500 somoni that we spent in previous years. –*

Shoira Sotiboldieva, a resident of the jamoat Oshoba, Oshoba village, Asht district, 52 years old.

### 3.5. “AIR-AIR” HEAT EXCHANGER (IMPLEMENTED/PILOTED BY WHH, ACTED, BARGI SABZ, CARITAS SWITZERLAND)



## WHAT IS THIS ENERGY EFFICIENCY SOLUTION?

The heat exchanger is designed to increase the heating efficiency of homemade steel stoves, and at the same time it is a multifunctional equipment. It is made of 0.5 mm thick metal sheet and is installed on the chimney 40 cm above the stove. Depending on the type of heat exchanger, it can also be used as an oven for baking. At the beginning of firing up the stove, use less wood. The heat exchanger must be installed vertically on the chimney.

### Why choose this energy efficient solution?

Heat exchangers fulfills several roles:

- Heats the house in winter.
- Heats up the food.
- The heat exchanger can be used as an oven for baking purposes.

### Costs of the solution

The average cost of the “air-air” heat exchanger is 185 TJS. More accurate prices can be collected from local markets according to the US dollar exchange rate. The price of a heat exchanger depends on its size and type.

## REQUIREMENTS AND PRECAUTIONS

To use the heat exchanger, the following requirements are required:

- The use of coal in the stoves equipped with a heat exchanger is strictly prohibited.
- If a heat exchanger is installed, the use of elbow pipes (chimney bends) is not recommended.
- The stove must be heated with a moderately small amount of fuel.
- If over time the draft disappears and the stove starts to smoke, it is necessary to clean the heat exchanger and the pipe from the accumulated soot.
- The heat exchanger is installed on the chimney about 40 cm higher from the stove plate.

## ECOLOGICAL AND ECONOMIC BENEFITS

### Energy / fuel savings

The heat exchanger saves approximately 25% of the fuel used to heat the room. According to data from partner organisations in some districts of Khatlon oblast, on average, one household buys 8 $m^3$ of firewood in winter. The cost of 1 $m^3$ of firewood is about 200 somoni (depending on the region), and the total amount of firewood is 1600 somoni. 25% of the total amount is 400 somoni. Thus, a heat exchanger saves more money in one heating season than its cost.

### GHG emission reduction

Based on the amount of saved fuels, the heat exchanger will avoid 0 tons of CO2 emissions per year.

### Operating costs

No running costs for this EE solution.

## PROS AND CONS

- Increased thermal comfort and fuel savings.
- The “Rohati Jon” heat exchanger has an oven which can be used for baking and warming up food.
- Can be easily cleaned of the soot.
  - Coal cannot be used as fuel with heat exchanger.
  - Only trained craftsmen can manufacture it.

## SOCIAL ACCEPTANCE

According to beneficiaries, the heat exchanger cannot be used when burning coal in the stove, because of carbon monoxide emissions. Beneficiaries found it difficult to buy a heat exchanger at an affordable price on a free market.

## Beneficiary feedback

*“I am one of the users of the “Rohati Jon” heat exchanger. Before the installation of the heat exchanger, our living room was difficult to heat, consumed a lot of fuel, and the children slept with thick blankets. Previously, my husband and I collected firewood from the slopes of mountains and valleys all summer and autumn until winter. After installing the heat exchanger, we only collect firewood from September to October and still reserves remain for the next year.*

*By opening the oven door, we heat the room, we can heat food and cakes. Another nice feature is that the chimney is cleaned less often and the heat exchanger is easy to clean from the soot. We used to clean it 4-5 times a winter, but now we clean it only once.*

*The heat exchanger is installed 40 cm above the plate on the chimney. One disadvantage of the heat exchanger is that it is strictly forbidden to heat the stove with the coal.”*

# 4. IMPROVED COOKING SOLUTIONS

## 4.1. EFFICIENT COOKING STOVE (IMPLEMENTED/PILOTED BY WHH, BARGI SABZ)

### WHAT IS THIS ENERGY EFFICIENCY SOLUTION?

In order to reduce the cost of fuel and dung, it is proposed to use an Efficient cooking stove, which is easy to use and reduces the cost of fuel by up to 50%. The efficient energy-saving cooking stove was invented by specialists from Welthungerhilfe. This cooking stove is similar to traditional stoves, however has higher performance. It saves a lot of fuel, allows cooking comfortably and quickly. The smoke is discharged through the chimney thus making a positive impact on people's health through reducing indoor pollution. The food preparation area remains clean and nice.

Figure 1. Details and concept of the Efficient cooking stove

## Why choose this energy efficient solution?

The Efficient cooking stove has several functions:

- It is used for cooking as a primary purpose.
- Can be used for boiling water at the same time near the firebox.

## Solution cost

The Efficient cooking stove, together with metal elements, costs on average 600 somoni.

Prices are approximate. A more accurate price can be established after monitoring local markets in accordance with existing prices. It can be built without firebox shape. The price of a cooking stove without mold and cement is 472 somoni. The price is indicated for a pan of 20 liters.

# REQUIREMENTS AND PRECAUTIONS

To construct an Efficient cooking stove, following requirements should be met:

- There should be no flammable or explosive substances near the cooking stove.
- It is important to follow fire safety rules.
- The chimney must be led out beyond the roof slope.
- Firewood must correspond to the size of the cooking stove firebox.
- The place of construction of the cooking stove should be sheltered from the ingress of precipitation.
- The firebox of the cooking stove is made of welded metal so that the cooking stove will serve for a long time.

# ECOLOGICAL AND ECONOMIC BENEFITS

## Energy / fuel savings

According to the beneficiary from Vahdat city, the Efficient cooking stove saves 50% of the fuel used for cooking. The average savings are from 700 kg to 1000 kg of wood per year. In monetary terms, the savings will amount to 333 somoni per year.

## GHG emission reduction

The Efficient cooking stove will avoid emissions of 0 tons of CO2 per year.

## Running cost

Every 5 years, you need to change the tin chimney, elbows and umbrella. The cost will be 135 somoni.

# PROS AND CONS

- Improving the ignition of fire inside the furnace due to proper smoke removal.
- The fire is evenly distributed under the pan if correctly placed in the Efficient cooking stove.
- Less smoke due to better combustion of fuel inside the stove.
- Food is cooked in a short time and remains hot for a long time.

- Households can cook in a clean and hygienic environment.
- The process of fuel combustion is improved.
- The stove does not lose heat, saves about 50% of fuel.
- Collecting fuel takes less time.
  - The mold for the furnace must be ordered from the welder.
  - Firewood must be chopped.
  - Requires a skilled craftsman to build a cooking stove.

## SOCIAL ACCEPTANCE

According to beneficiaries, the Efficient cooking stove is very economical. The villagers liked this type of cooking stove and adapted it in households, because it looks like a traditional cooking stove, only with changed form.

### Beneficiary feedback

*"I learnt how to make Efficient cooking stoves and built two stoves for myself and over 45 Efficient cooking stoves for others. The advantage of this cooking stove is that food is cooked quickly, and during cooking, the water in the barrel, which is installed on the chimney, boils in a short time. Every year I bleached the walls of my kitchen with lime 4-5 times, now I paint the walls once a year. The most important thing is that I use less firewood and dung when cooking, there is no smoke in the kitchen, clothes do not smell like burning. I use this Efficient cooking stove every season. Save up to 50% of fuel when cooking. It takes 2 to 4 hours to build an Efficient cooking stove, it depends on what building material is used. People are also very fond of these stoves. " –*

Latipova Gulzira, resident of Romit jamoat, Romit village of Vakhdat city.

## 4.2. MODERNIZED COOKING STOVE (IMPLEMENTED/PILOTED BY WHH, ACTED, CARITAS SWITZERLAND, BARGI SABZ)

## WHAT IS THIS ENERGY EFFICIENCY SOLUTION?

Rural residents in Tajikistan usually use all kinds of cooking stoves made of stone and clay, most of which are not built properly. In these cooking stoves, there is usually no special place for a chimney and an exhaust pipe, the fire seeps through the gap and the heat is wasted. As a result, not only the interior of the kitchen turns black from soot and smoke, but cooking on such stoves is dangerous, you can burn yourself with an open flame. Thus, cooking uses a lot of firewood and other fuels, which is detrimental to the household budget and reduces the forest area across the country.

In order to reduce the cost of fuel and reduce deforestation, it is proposed to use a modernized cooking stove. It is easy to use and lowers the cost of fuel by up to 50%.

The modernized cooking stove differs from the traditional ones in that it has a side steel door and one chimney for two cooking stoves.

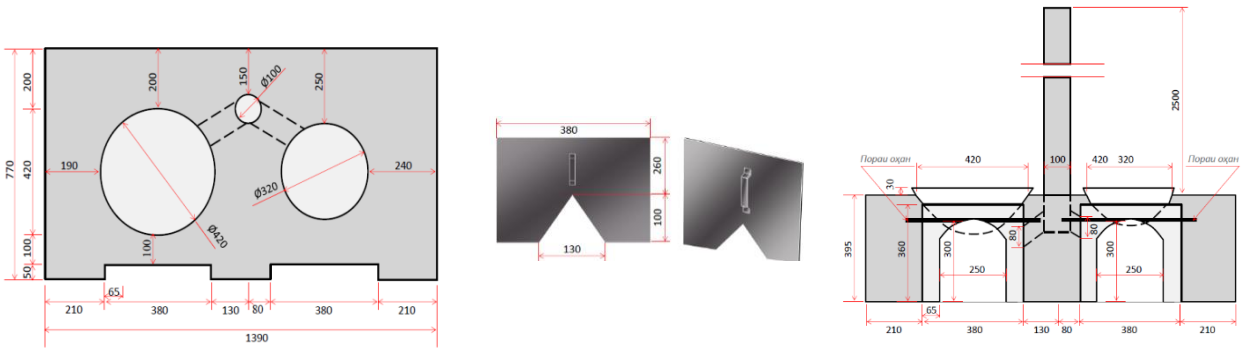



Figure 1. Details and concept of the retrofitted furnace.

### Why choose this energy efficient solution?

Modernized cooking stove fulfills several functions:

- The main purpose is to cook food.
- Food can stay hot for a long time, so there is no need to heat it often.

### Solution cost

The cost of the stove, with two burners including an exhaust pipe, 2 doors and the services of a master, will be 385 somoni. The price depends on its size and type.

## REQUIREMENTS AND PRECAUTIONS

When using modernized cooking stoves, follow these requirements:

- Chimneys less than Ø 100 are not recommended.
- It is recommended to cover the firebox with removable doors during cooking.
- In case of smoke and loss of traction, it is necessary to clean the chimney.
- The installation of a chimney pipe and a door is required, and the installation of an ash collector is optional.

## ECOLOGICAL AND ECONOMIC BENEFITS

### Energy / fuel savings

According to the Geres fuel consumption monitoring report from Asht district, the modernized cooking stoves save up to 50% of the fuel used in cooking. Depending on the area, on average, 3.5 $m^3$ of firewood is collected per household. The cost of 1 $m^3$ of firewood is about 200 somoni (depending on the region), and the total amount of firewood is 700 somoni. Thus, the stove pays off in one season.

### GHG emission reduction

The modernized cooking stoves will avoid 0  tons of CO2 emissions per year.

### Running cost

If it is a close kitchen, the modernized cooking stoves serve long time. No need for renovation, some households plaster the surface or decorate with tiles.

## PROS AND CONS

- Relatively low cost.
- Long service life.
- Esthetic design.
- Energy efficient (fuel consumption is 50% less than that of the traditional one).
- Fast food preparation (time is saved by 30%).
- Fire safe and hygienic (smoke goes up through the chimney and does not harm health).
- The large hob allows for using of more than two cooking pots.
  - When installing the oven, it is necessary to undergo training / consultation.
  - The cost is higher than a traditional stove.

- Wood has to be chopped to match the size of the combustion chamber.

## SOCIAL ACCEPTANCE

Many beneficiaries emphasized the easiness of implementation and quite high level of fuel savings.

### Beneficiary feedback

*"I am one of the users of the modernized cooking stoves. Before the construction of this stove, it was difficult to collect firewood in our household. I used to spend a lot of firewood for cooking, about 6 kg, and now I consume 2.1 kg. Consequently, during the season we used to consume about 2040 kg and now it is 720 kg. When I was taught how to build this stove, I got the impression that it wasn't very difficult and therefore anyone can build it. Finally, we also noticed that the taste of plov (national rice meal) is much better when cooked on this stove." -*

Yusupov Abdufayoz, a resident of the Ivan Tojik jamoat,Dashti Oburdon village, Mastchoh district.

## 4.3. PRESSURE COOKER (IMPLEMENTED/PILOTED BY WHH, BARGI SABZ)

### WHAT IS THIS ENERGY EFFICIENCY SOLUTION?

The pressure cooker is a spherical aluminum cauldron with a tight-fitting lid. The cauldron has two clamps for securing the rocker arm with a clamp for sealing the lid of the pressure cooker. There are two holes on the lid of the pressure cooker, where a safety valve and a branch pipe are installed to release excess steam during boiling. The safety valve is adjusted to a specific pressure inside the cooker. It works when the pressure rises above normal and protects against an explosion. Put the pressure cooker on medium heat. When food is cooked over medium heat, it is harmless and tastes better.

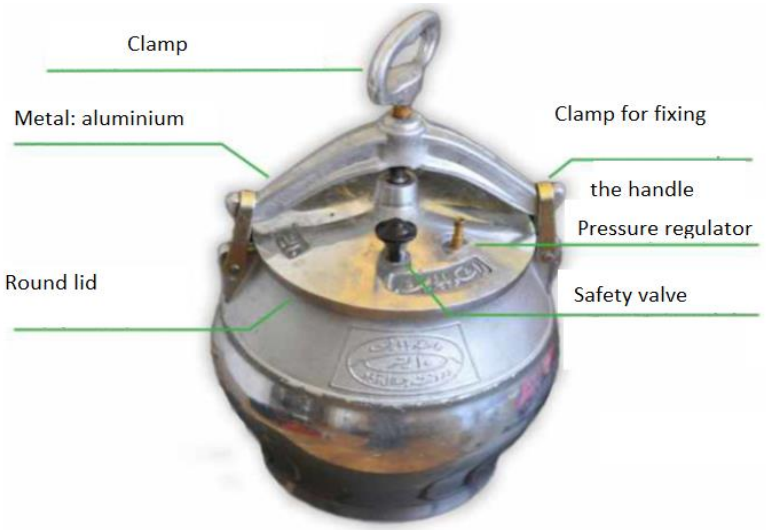



Figure 1. Details and concept of the pressure cooker

## Why choose this energy efficient solution?

- The solution is easy to use, no additional skills needed.
- The main purpose of the pressure cooker is for cooking food.
- Reduces cooking time.
- Helps to save fuel and family budget.

## Solution cost

The cost of a pressure cooker, depending on its capacity, ranges from 100 somoni to 170 somoni. There are various sizes of pressure cookers on sale: 5, 8, 10 and 15 liters.

# REQUIREMENTS AND PRECAUTIONS

Requirements and precautions for using the pressure cooker:

- The pressure cooker should be disinfected before the first use. To do this, it is necessary
    - to boil 2 liters of milk and 0.5 liters of water in it to clean the residual slags from production.
    - Pour away the liquid from pressure cooker and rinse it thoroughly with warm water.
- When cooking in a pressure cooker: add oil, water and food and cover the pressure cooker tightly.
- It is recommended to cook on low heat.
- When the dish is ready in the pressure cooker, you do not need to open the lid right away, you have to wait until the steam stops coming out of the signal valve.
- When cooking, be sure to monitor the temperature of the fire and the safety valve of the pressure cooker.
- The safety valve must be inspected periodically, otherwise the pressure cooker may explode if the valve is faulty.

# ECOLOGICAL AND ECONOMIC BENEFITS

## Energy / fuel savings

According to the beneficiary from Romit jamoat of Vahdat city the pressure cooker saves about 70% of the fuel used for cooking. On average, the savings are 1050 kg of coal and 700 kg of firewood per year. In monetary terms, the savings are 653 somoni per year.

## GHG emission reduction

The pressure cooker will avoid the emission of 0 tons of CO2 per year.

## Running costs

There is no running cost for this solution.

# PROS AND CONS

- Saves cooking time thus saving fuel.
- Hygienic food preparation.
- When cooking, all the vitamins of the products remain in food and make the dish tastier.
    - If the safety valve is not cleaned on time, the pressure cooker may explode.

## SOCIAL ACCEPTANCE

According to the feedback from beneficiaries, the pressure cooker is not very adaptable for households needs. For example, while it can cook liquid dishes well, it is not suitable for making plov, the dish essential for Tajik households.

## Beneficiary feedback

*"The advantage of this pressure cooker is that the food is prepared quickly. I usually use a pressure cooker on a gas or electric stove, the food is also tasty and quickly cooked. When the food is ready, the pressure cooker makes a sound. There is a small nuance that during cooking, you need to wait a little until the weight of the steam evaporates. The pressure cooker should always be controlled. If you use it for a long time without cleaning the safety valve, the steam cooker can explode. The advantage of this pressure cooker is that it saves fuel." –*

Latipova Gulzira, a resident of Romit jamoat, Romit village, Vakhdat city says

### 4.4. NEPALESE COOKING STOVE (IMPLEMENTED/PILOTED BY LITTLE EARTH, GERES, YEC)

## WHAT IS THIS ENERGY EFFICIENCY SOLUTION?

This type of cooking stove is used for cooking and, depending on the design, can accommodate several large small pots. The stove is made from local materials using wool, straw, fresh manure and it is highly energy-efficient. These stoves are commonly referred to as "Nepalese" cooking stoves.

In practice, there are several types of economical stoves, which have two goals: to reduce the amount of fuel used by improving the combustion process, which leads to the preservation of trees and shrubs, and solves the problem of reducing emissions and smoke inside the kitchen.

Nepalese stoves are built in home conditions in the kitchens using the same local materials as traditional stoves. However, unlike traditional stoves, Nepalese stoves reduce environmental pollution, save fuel and reduce the risk of illnesses caused by smoke in the room.

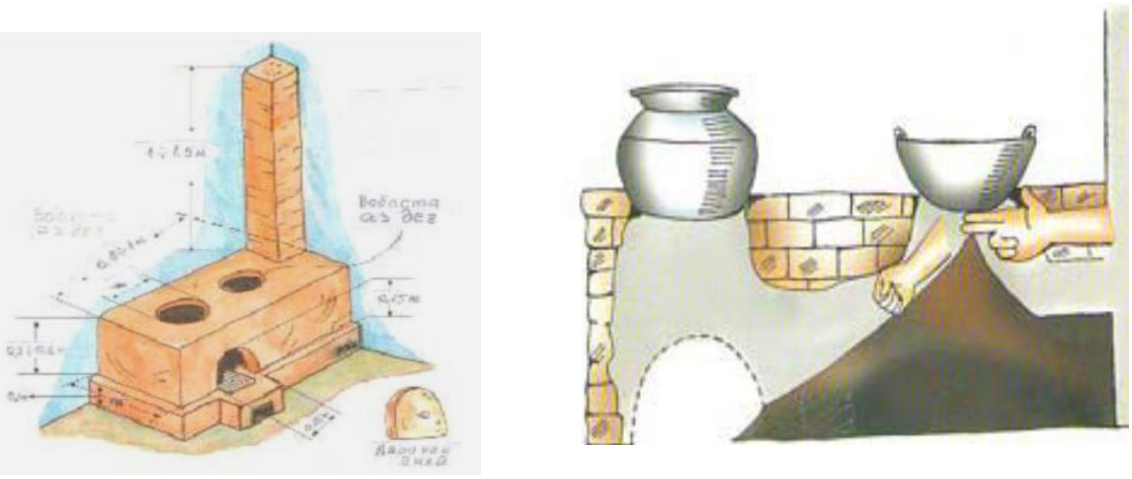


Figure 1. Details and concept of the Nepalese cooking stove

## Why choose this energy efficient solution?

The Nepalese stove fulfills several functional roles:

- Used for cooking and boiling water for household needs.
- It has two slots for cooking pots, so two dishes can be cooked simultaneously.
- It saves up to about 20% fuel and keeps the kitchen clean.

## Solution cost

Average cost of a Nepalese cooking stove is 536 somoni.

# REQUIREMENTS AND PRECAUTIONS

To build a Nepalese stove, you must follow these requirements

- These stoves are usually built in the corner of the kitchen to save space.
- There should be no flammable or explosive substances near the furnace.
- Follow fire safety rules.
- The chimney must be extended beyond the roof.
- These cooking stoves should only be installed by a trained technician.

# ECOLOGICAL AND ECONOMIC BENEFITS

## Energy / fuel gain

According to Geres fuel consumption monitoring report from Asht district, the Nepalese stove saves 20% of fuel used for cooking and boiling water for household needs. A Nepalese stove saves up to 0.7 $m^3$ of firewood or 420 kg of firewood per year. In monetary terms, it is 137 somoni, at the rate of 1 $m^3$ = 200 somoni

### GHG emission reduction

The Nepalese stove will avoid the emission of 0 tons of CO2 per year.

### Running cost

Operating costs for this solution. Once a year, cosmetic repairs and maintenance are required (cleaning the soot of the chimney).

## PROS AND CONS

- Up to 20% fuel savings when using Nepalese stoves compared to traditional stoves.
- The Nepalese stove improves sanitary and hygienic conditions in the kitchen - it does not smoke and it is safe to use.
- Building a stove requires a simple learning curve and these stoves are very popular.
- These cooking stoves are designed for one, two or more small and large cauldrons.
- It takes little time to cook.
- Cooking pots and other utensils do not turn black from the soot.
  - Must have the skills to build a furnace.
  - Tin chimneys and a steel door must be ordered from craftsmen.
  - The chimney must be cleaned of soot every three months because the stove is made of mud bricks.

## SOCIAL ACCEPTANCE

According to beneficiaries, the Nepalese cooking stove looks unusual. At the same time, it is a very efficient stove, saving time and fuel. Keeps the warmth for a long time.

## Beneficiary feedback

*My name is Shahri and I am one of the community's active craftsmen. I have built over 20 Nepalese stoves. The advantage of the Nepalese cooking stove is that two cauldrons are cooked on the same fire, in the first one is cooking food, and in the second there is always hot water. I use the Nepalese cooking stove myself. Before I used about 4-5 kg of firewood and dung (dried or processed manure) in a traditional stove. Now for cooking, I spend only 1kg of firewood + 0.5kg of dung. My kitchen is clean, I spend less time cooking, I constantly have boiling water. I am very glad that they taught me how to build Nepalese stoves with this. They are very pleased with the ones I built." –*

Sharipova Shahri from the village of Pinyon, jamoat Fondaryo, Ainy district of the Republic of Tajikistan.

## 4.5. IMPROVED COOKING STOVE "«TEZPAZ»" (IMPLEMENTED/PILOTED BY ZINDAGI ZOOPERATIVE, GERES)

## WHAT IS THIS ENERGY EFFICIENCY SOLUTION?

In order to reduce the need for firewood and dung, it is recommended to use the energy-saving mobile cooking stoves «Tezpaz». The «Tezpaz» furnace body is made of galvanized sheet and consists of two parts of a cubic-shaped firebox compartment and a round-shaped stove with a chimney, designed for different cauldrons. The combustion chamber is made of steel in the form of a knee. The cavities between the firebox and the tin case are filled with expanded clay or agloporite. The «Tezpaz» cooking stove kit includes a stand for supporting the firewood of the combustion chamber which is made of smooth fittings. The body has handles for easy portability.

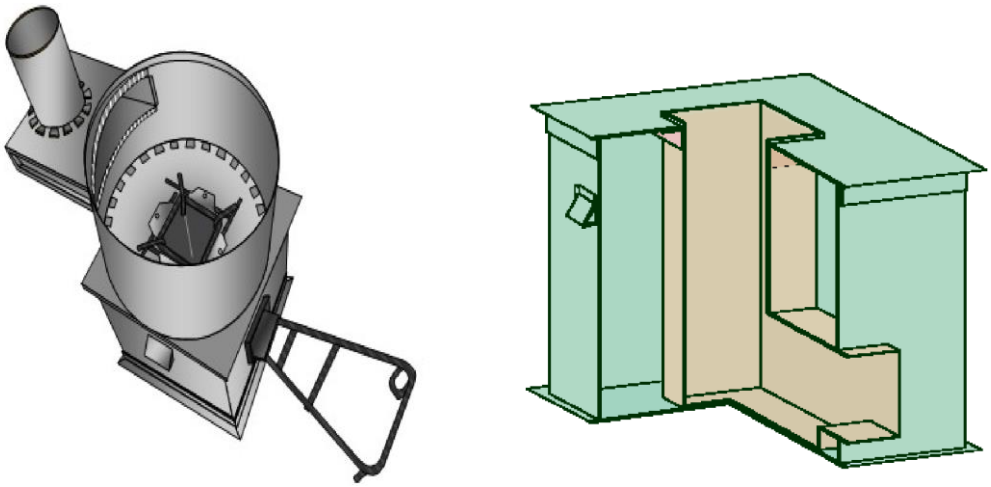


Figure 1. Details and concept of the «Tezpaz» cooking stove

### Why choose this energy efficient solution?

- «Tezpaz» stove is mobile and can be easily relocated.
- It cooks food very quickly.
- The stove is economical and saves fuel.

### Solution cost

Average cost of «Tezpaz» stove is 450 somoni

## REQUIREMENTS AND PRECAUTIONS

- There should be no flammable or explosive substances near the stove.
- Follow fire safety rules.
- Choose a cauldron according to the upper ring of the stove.
- Use wood chips and chopped wood as fuel.

## ECOLOGICAL AND ECONOMIC BENEFITS

### Energy / fuel savings

According to Geres fuel consumption monitoring report from Asht district, the «Tezpaz» cooking stove saves 50% of the fuel used for cooking. On average, the saving is 600 kg of firewood per year (for 7 months of the summer season of using the fireplace). In monetary terms, the savings are 300 somoni per year.

### GHG emission reduction

The "«Tezpaz»" stove will avoid the emission of 1.08 tons of CO2 per year.

### Running costs

The corps and chimney of the «Tezpaz» stove are made of galvanized material. The material of corps will serve for the last 5 years, and the costs will be 200 somoni.

## PROS AND CONS

- Using the «Tezpaz» stove for cooking saves about 50% of fuel.
- If the stove is used once a day during a 7-month season you can save 1 $m^3$ of firewood per year.
- The area around the combustion chamber is filled with thermal insulation material "Agloporit" or "Ceramzit" and provides a high temperature of the combustion chamber and slow cooling.
- Food is quickly prepared.
- The stove is mobile and easy to carry.
- Collecting fuel takes less time.
- Insulation material is difficult to obtain in rural areas such as agloparite or expanded clay (ceramzit)
- The wood needs to be chopped because the firebox is too small.
- Requires a skilled craftsman to build a hearth.

## SOCIAL ACCEPTANCE

According to beneficiaries, the «Tezpaz» stove is not habitual to use, the firewood must be chopped, which takes more time. The stove is not well accepted by the population. Those who want to have such a stove should order the master, since there is no free sale.

### Beneficiary feedback

*"I have been using the «Tezpaz» stove for almost a year now and I see the advantage as our fuel costs have dropped twice, and I can protect myself from toxic smoke while cooking. With the help of «Tezpaz», I saved 300 somoni, which is 50% of last year's expenses. The disadvantage of this stove is that the wood has to be chopped, it takes a lot of time." –*

Gulsara Rakhimova, 58 years old, resident of the Oshoba jamoat, the village of Markhamat, Asht region.

# 5. SOLAR SYSTEMS/SOLUTIONS

## 5.1. SOLAR PHOTOVOLTAIC SYSTEM (IMPLEMENTED/PILOTED BY SYSTEMAVTOMATIKA, BARGI SABZ - GREEN TECHNOLOGIES)

## WHAT IS THIS ENERGY EFFICIENCY SOLUTION?

A photovoltaic solar installation is designed to produce electricity using solar radiation. The batteries generate up to direct 40 V current when in operation. To use it for domestic purposes, a number of transformations are required. The following equipment is responsible for this:

- The battery pack allows you to use the generated energy at night and at low intensity hours. Helium batteries are used with a voltage of 12, 24 or 48 V.
- Charge controllers maintain optimal battery life and transfer the required power to consumers.

- A voltage inverter converts DC to AC. Hybrid inverters also allow the surplus generated energy to be fed to the city grid.

1 - city network 220 V;

2 - solar panels 12 V;

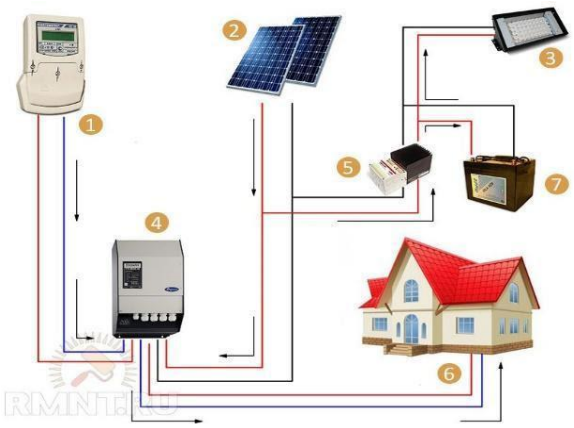
3 - 12V lighting;

4 - inverter;

5 - charge controller;

6 - main consumers of 220 V;

7 - rechargeable batteries.




## Why choose this energy efficient solution?

- Can be used in remote mountainous villages where there is no access to a centralized power supply network.
- Can be used as a back-up system during a power outage.
- The solar photo panel inverter sets the priority of the voltage source. In case of lack of power, it switches to another source automatically.
- It can support households in saving money, as it decreases the electricity bills.
- It provides an opportunity to use free solar electricity for your private business (sewing workshop or bistro cafe).

## Solution cost

The price of such energy systems is determined based on 1 watts' x 3 US dollars. If the photo panel equipment is designed for 100 watts, then all the components together will cost a little more than 3000 somoni.

# REQUIREMENTS AND PRECAUTIONS

Things to keep in mind when installing a solar power device:

- Solar panels should be installed facing south.
- There should be no obstacles shading the panels (trees, buildings, mountains etc.).
- The panels are installed at an angle of 380 - 420 (average working angle for summer and winter) to the horizon, so that the sunrays hit the panel perpendicularly.
- It is necessary to use a combined scheme for connecting the equipment, for example to have a backup power generator.
- The inverter must, if necessary, switch to recharging the batteries from the city network.

## ECOLOGICAL AND ECONOMIC BENEFITS

### Energy / fuel savings

Solar photoelectric panels can save 30-50% of electricity when used for house lighting, a small refrigerator, audio and video equipment with a total power of up to 1 kW connected to the device. On average, the savings will amount to 250 somoni per year.

### GHG emission reduction

Saving electricity from a centralized grid by a solar installation does not affect the reduction of CO2 emissions, since energy is generated by a hydroelectric power station thus it is environmentally friendly.

### Running costs

The solar photo electric panel does not require additional costs, only once every 5 years it is necessary to replace the helium rechargeable batteries. The cost of one battery is 1000 somoni.

## PROS AND CONS

- Uninterrupted supply of electricity in the absence of a centralized power grid.
- Saving family budget on lower electricity bills.
- A good option for starting a small business.
  - Lack of qualified technicians for the repair and maintenance of equipment.
  - In cloudy weather, the efficiency drops to 40%, as well as in hot climate.
  - The high cost of a solar installation.

## SOCIAL ACCEPTANCE

According to beneficiaries, the solar photo-electric installation is indispensable in rural areas, especially where power outages are common.

## Beneficiary feedback

*"Five years ago, when I was finishing the construction of my house, I didn't have a connection to the power supply. My neighbors and I did not have access to the power grid. I was offered to become a participant in the project and purchase a solar uninterruptible power supply system with a subsidy. The system consists of three panels with a total power of 300 watts, an inverter with a charge controller for 1 kW and two helium batteries (total cost of 10,000 somoni). I connected to the system up to 15 x 5-Watt LED lighting lamps, a Samsung TV (60 Watt), a small refrigerator (70 Watt) and in the summer 2 x 80-Watt fans. In addition, two of my neighbors asked me to connect them to this system as well to use lighting in the home and to watch TV. When we were connected to the power grid and centralized network at home, I decided to use the solar system to support my small business. I rent a space in the city market as a fast food cafe, where I cook hot dogs, pies, shaurma, rice and sell ice cream. As there are constant power outages in the market and food can get spoiled very quickly. I reinstalled the solar system on the roof of the cafe. I was able to connect 2 refrigerators to this installation for storing food and ice cream. Thanks to solar photo panels and installation, my business started to develop. Thanks to everyone who supported me with this."*

- Safarov Kurbonjon from the Barakat village, Mirzo Tursunzoda`s jamoat, Hissar city.

## 5.2. SOLAR WATER HEATING UNITS (SWHU) (IMPLEMENTED/PILOTED BY SYSTEMAVTOMATIKA, BARGI SABZ - GREEN TECH.)



### WHAT IS THIS ENERGY EFFICIENCY SOLUTION?

Solar water heating units (SWHU) are designed for the production of hot water by absorbing direct and scattered solar radiation, converting it into heat, and accumulating warm water for consumers. Infrared radiation that goes through clouds is also absorbed and converted into heat by the unit. Solar water heaters can be active or passive. The active system uses an electrical pump to circulate liquid through the collector. The passive system has no pump and relies only on thermal transfer (the water tank must be placed above).

According to the type of coolant, SWHU are divided into 2 types: water and antifreeze. If the coolant is antifreeze, the collector does not freeze in winter, and there is no need for additional heating with electric heaters. Most systems here use that option because it is rare to have a nonfreezing climate. Note that external tanks system can work in mild climate (cannot go below 5 degrees Celsius)

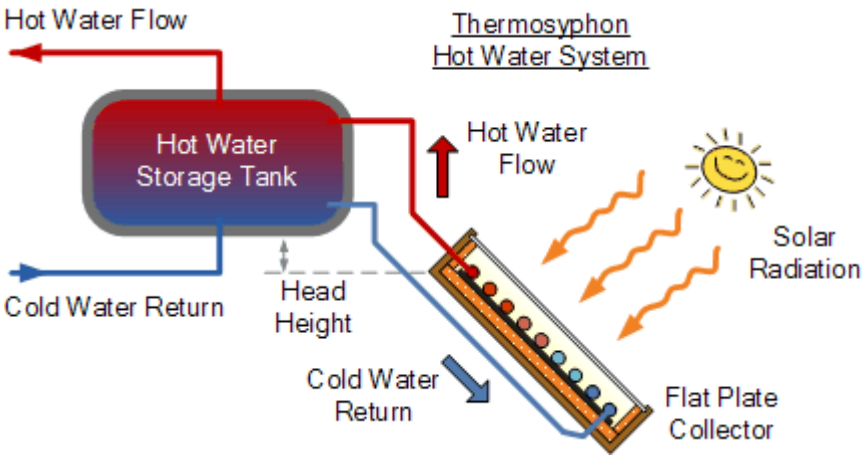



Figure 1 Working principle of solar water heating system

## Why choose this energy efficient solution?

- Provides an alternative to traditional ways of heating water for domestic purposes which requires a lot of fuel. SWHU doesn't require fuel.
- Helps to save the family budget.
- Reduces CO2 emissions and is an environmentally friendly product.

## Solution cost

The solution cost 12800 TJS and includes: Solar water heater itself, pipes, pump and metal frame.

# REQUIREMENTS AND PRECAUTIONS

Things to keep in mind when installing a solar water heater:

- The SWHU collector must be facing south (+/- 15 degrees);
- There should be no obstacles in front of the unit (trees, buildings, mountains and ...);
- SWNU is installed at an angle (the angle of inclination is determined by the solar diagram) to the horizon, so that the sun's rays fall on the collector perpendicularly;
- Better to use a combined scheme for connecting the SWNU, meaning additional electric heating of water in the winter. Combining a secondary electric heated tank will guarantee hot water in winter. The electric heater can also ensure thermal shocking in case of legionellosis
- The calculation of the area of the SWHU should be made based on the daily consumption of hot water (based on the composition of the family) with a double reserve.

# ECOLOGICAL AND ECONOMIC BENEFITS

## Energy / fuel savings

To heat 170 liters of water in SWHU storage tank up to 70 ° C (per daylight hours) requires 10 kWh with a collector area of 2.3 m2. If to transfer this value equivalent to coal in the winter and firewood in the summer the calculations will be as follows. Coal consumption for 170 liters of water (daily) will amount to 906 kg in the period from November to March, and the consumption of firewood in the summer period from April to October will amount to 1712 kg. It can be seen from the calculations that using the SWHU can save 1,450 somoni per year.

## GHG emission reduction

The SWHU will avoid the emission of 0 tons of CO2 per year.

## Running costs

The SWHU does not require additional costs.

## PROS AND CONS

- The advantage of modern collectors in rural areas is to ease the needs of households when doing laundry, dishwashing, cooking and bathing children.
- Eliminates the need to use firewood, dung and coal to heat water.
- Modern SWNU operates in any weather, the productivity is very high.
- Saves the family budget when buying coal and firewood.
- Ecologically friendly installation and reduces CO2 emissions.
- Lack of qualified technicians for the repair and maintenance of equipment.
- The high cost of SWHU, not everyone can buy.

## SOCIAL ACCEPTANCE

According to beneficiaries, SWHUs are indispensable in rural areas, especially when there are power outages (there is a limit on electricity). The use of solar energy for heating water is very beneficial and can save up to 60% of electricity, used mainly for heating and boiling water for domestic purposes.

# Beneficiary feedback

*"We are a young family, who installed a water heater with a volume of 80 liters. It's so convenient and economical. It can be of great use, especially in the villages, where there is a limit on electricity in winter.*

*I have small children who wash in warm water in the morning, and use warm water at home almost all the time. Due to this technology, children get less sick. We spend less time on household work such as washing, preparing food and washing dishes. The only drawback is the cost of the equipment. It is very expensive. On the other hand, it can pay off in the shortest possible time. In the future, you can experience significant savings in your family budget. " –*

Murodov Mukhsin from the village of Yavroz, Romit`s jamoat of Vahdat city is very positive:

## 5.3. SOLAR KITCHEN (IMPLEMENTED/PILOTED BY LITTLE EARTH, YEC, BARGI SABZ)

## WHAT IS THIS ENERGY EFFICIENCY SOLUTION?

A solar kitchen is a device for cooking and boiling water using the energy of the sun. The solar kitchen consists of a simple, segmented (parabolic) base of light metal or plastic on the inside, in which pieces of mirror or aluminum foil are pasted over, and which collects the sunrays at a focal length in the center. A feature of such kitchens is the high heating temperature in the center, where the pan is fixed on the base. The base of the solar kitchen has a horizontal and vertical rotation mechanism for easy guidance in the direction of the sun.

Solar kitchens are convenient to use when you need to quickly cook a small amount of food, like in a conventional oven. When using the solar kitchen for cooking or boiling water you don't need fire, gas, or electricity. There is a variety of food that can be cooked using solar kitchens such as meat, fish, cereals, noodles, cabbage soup, soup, scrambled eggs and so on. The cooking time depends on the type of food, its quantity, the outside temperature and the position of the sun.

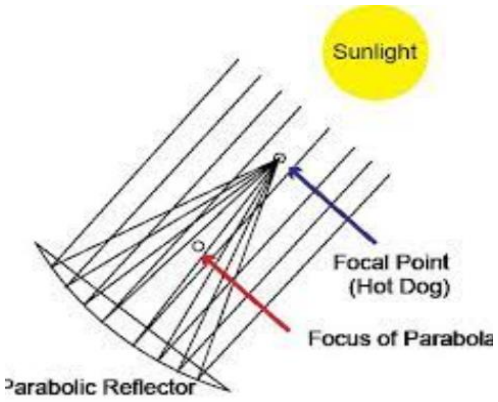



Figure 1. Details and concept of a solar kitchen.

## Why choose this energy efficient solution?

Solar kitchens fulfill several functional roles:

- Can be used for cooking and boiling water.
- Solar kitchens are mobile, the design is very simple, you can assemble it yourself.
- The solar kitchen can be used in pastures, in camps and when going out of town.

## Solution cost

Average cost of a solar kitchen: 1000 somoni

# REQUIREMENTS AND PRECAUTIONS

To use a solar kitchen, you need to follow some requirements:

- Constantly observe the focusing of the sunrays on the center of the burner (dish supports).
- The temperature in focus reaches thousands of degrees and can easily ignite a wooden block (the ignition temperature of a tree is more than 300 degrees).
- For safety, you must wear sunglasses and cook with gloves.
- Keep small children out of the solar kitchen.

# ECOLOGICAL AND ECONOMIC BENEFITS

## Energy / fuel savings

A solar kitchen saves 100% of cooking fuel. According to the beneficiary from Shahrinav district it give the average saving around 1000 kg of wood per year. In monetary terms, the savings are 333 somoni per year.

## GHG emission reduction

A solar kitchen will avoid 0 tons of CO2 emissions per year.

## Running costs

You would need 2 rolls of silver tape every year. The cost is 30 somoni.

# PROS AND CONS

- The energy of sun is free and easily available. By using solar kitchen, you save money that you spend otherwise on gas, electricity, firewood.
- Food cooked in the solar kitchen retains all the nutrients and is saturated with solar energy.
- Food cooked in the sun has a "sunny taste" and a unique smell.
- It is mobile and can be taken with you wherever you go.
- The disadvantage of a solar kitchen is the necessity to rotate the kitchen to follow the sun's movement every half hour during the entire cooking time.
- Solar kitchens are very expensive, not everyone can afford it, and difficult to find in Tajikistan;
- Doesn't work in cloudy weather, rain and snow.

## SOCIAL ACCEPTANCE

According to beneficiaries, the solar kitchen could be best used on pastures and in camps. This will save time, effort and natural resources as there is no need to use wood. At the same time, there are households who put it to a good use to address some day to day needs.

## Beneficiary feedback

*"I received the solar kitchen as a gift and it is used in our household nearly every day. Our household budget has decreased greatly. Before we started using the solar kitchen, my overall monthly spending was 400-500 somoni, now it is 200-300 somoni. I can easily boil water, cook eggs or bake potatoes and it doesn't take a long time. In the winter time, I use the solar kitchen to heat the water for the cattle. Every day we heat more than 30 liters of water for washing, livestock, bathing and making tea. This solar kitchen is also very useful for people who are working on fields and pastures."*

Sirodzhev Kamoliddin, a resident of the Shakhrinav district of the Sabo jamoat,village Kadijuibor.

## 5.4. SOLAR VERANDA (IMPLEMENTED/PILOTED BY GERES)

## WHAT IS THIS ENERGY EFFICIENCY SOLUTION?

The Solar Veranda is a structure attached to the house with the same principle as a solar greenhouse. Based on the available constructive solutions, there could be several variations of solar verandas. The veranda frame can be made of wood or metal. The covering material could be a polyethylene sheet of 0.4 microns, glass 4 mm, plexiglass of 5 mm or polycarbonate sheets of various thicknesses and interlayers. The structural and cover materials should be selected based on the financial capacity of the customer and availability of the materials in the market. During the warm season (April – October) the covering material should be removed (or an opaque layer can be added to create shade?). The structure will remain and could be used as vine-prop for growing different type of flowers and thereby provide shade

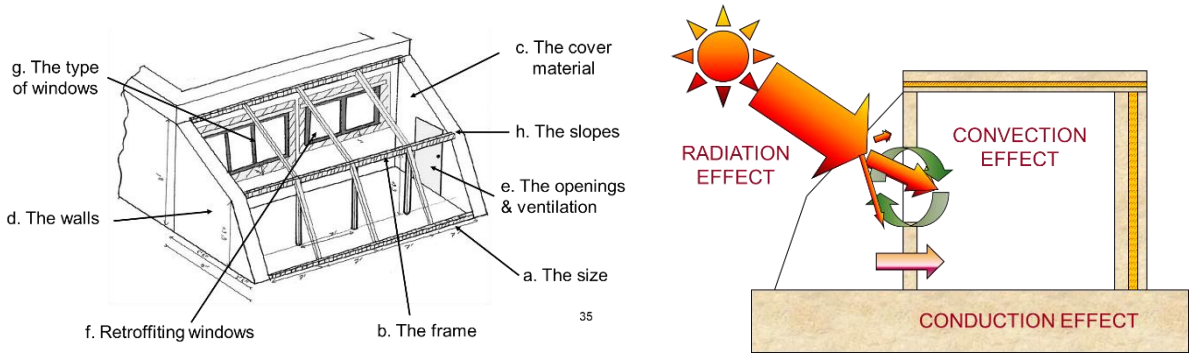



Fig.1. Solar Verandas' details & concept

## Why choose this Energy Efficient solution?

Solar verandas fulfill several functional roles.

- Solar Veranda is used to heat the house in winter, during the day when the sun is shining.
- It provides additional insulation for the house. The front door is protected from drafts, and the room that is connected with the veranda will require less energy for heating than the others.
- Solar veranda can be used as an additional room during the day.

## Costs of the solution

The average area of the solar veranda is 15 m2. Usually the length of the veranda is equal to the length of the winter room 5-6 m, and the width is 2.5 m.

The average cost of a solar veranda of this size:

- with polyethen sheet 2,500 somoni
- with polycarbonate sheet 7,000 somoni,

## REQUIREMENTS AND PRECAUTION

- To build solar veranda its important to consider following requirements:
- The windows of the winter room of a residential building should be oriented to the south. Deviation up to $50^0$ SE or SW is allowed;
- In front of veranda there shouldn't be any barriers, buildings or trees that might overshade it;
- The windows of the winter room should have an optimal size (1/4-1/6 of the size of the room) and with double glazing;
- The windows in the winter room should open easily, so warm air from the veranda can go inside the house and heat it up.
- Solar veranda can be built either by carpenter (wooden frame) or by welder (metal frame).

## ECOLOGICAL AND ECONOMIC BENEFITS

### Energy / fuel savings

According to the Geres' fuel consumption report from Asht district the solar veranda can save 40% of the fuel used for heating the winter room. On average, savings represent 600 kg of coal and 400 kg of wood per year. In monetary terms the savings are 570 TJS per year.

### GHG emission reduction

Based on the amount of saved coal, the Solar Veranda would lead to 1,7 tons of CO2 avoided per every year.

### Running cost

No running costs for this EE solution. The maintenance costs are almost zero for veranda with polycarbonate. In case of the use of polyethen, it has to be changed every 1-2 years. The cost will be around 500 TJS.

## PRO AND CONS

- Increased thermal comfort and fuel savings.
- Additional activities like growing flowers in pots, tubers and seedlings.
- Can be used for drying washed clothes.
  - Poor, limited view if cover material is polyethylen.
  - High cost if cover material is polycarbonate.

## SOCIAL ACCEPTANCE

According to beneficiaries the Solar Veranda made of polyethen doesn't look esthetic and prevents from seeing outside view. At the same time, other aspects of the veranda were praised by many beneficiaries as per below feedback:

## Beneficiary feedback

*«Thanks to veranda, we managed to save almost half of the fuel this winter. Now on sunny winter days we do not light up the stove. In the past when opening the front door, cold air would enter the room, but now we leave the door open to heat the room with the warm air coming from veranda. Solar veranda protects our shoes from rain and snow, and dust from the street does not get into our house. By using solar veranda this year, we saved 750 somoni on fuel, which is 50% of the overall amount we paid last year. –*

Kushnazar and Salima Samievs, Residents of the Oshoba jamoat, Asht district.

## 5.5. TRANSFORMING OVERHANG (NEW TECHNOLOGY, TO BE PILOTED BY GERES)

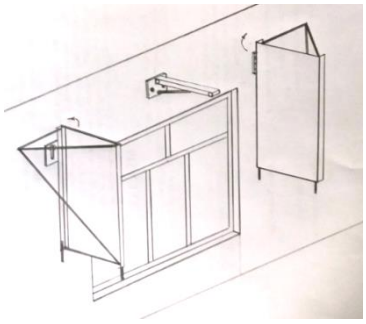
## WHAT IS THIS ENERGY EFFICIENCY SOLUTION?

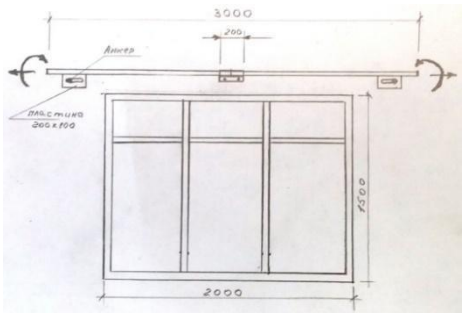
The purpose of the standard overhang: installed above the window, it provides shade in the summer, reducing the amount of direct sunlight entering the building while it also provides protection from wind, rain/hail and from icicles in winter.

To improve its efficiency a pivoting mechanism that transforms the overhang into guide mirrors on both sides of the window opening is proposed so to direct extra sunrays into the window and into the living room. It is called transforming overhang.

The frame of such an overhang consists of two halves, when these halves are above the window opening, they work as an overhang in the summer, but in winter they are separated in the center and rotated by 90 degrees at the ends of the window opening downward via a hinge - an anchor bolt for fastening the elements of the overhang to the wall. As a result, the cover of the overhang turns into guide mirrors which are adjustable in the vertical plane, directing the morning and evening sunrays into the surface of the window.

The frame of the overhang is made of spatial smooth reinforcement with a diameter of 12 mm.





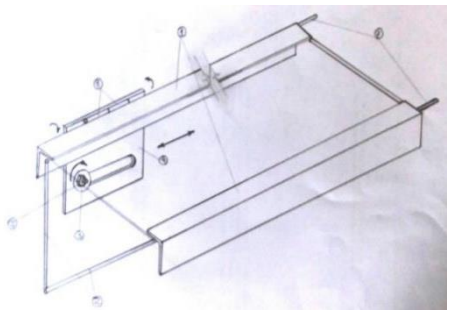



Figure 1. Scheme of the turning mechanism of the transforming overhang

## Why choose this energy efficient solution?

- To increase the solar gain in the morning and evening.
- To shade the window during hot months.

## Solution cost

The Estimated cost is 700 somoni.

### REQUIREMENTS AND PRECAUTIONS

- Windows shouldn't have other type of overhang
- Walls should be strong enough in order to fix the overhang

### ECOLOGICAL AND ECONOMIC BENEFITS

#### Energy / fuel savings

Not calculated yet

#### GHG emission reduction

Not calculated yet

#### Running cost

No cost expected

### PRO AND CONS

- Shades the windows in summer to keep summer thermal comfort inside.
- In winter, increase the warming effect of the sun, in the morning and evening, hence more energy gathered.
  - Difficult manufacturing.
  - Expensive, as particular metal parts and hinges are used that differ from conventional overhangs.

## 5.6. SOLAR DRYER (IMPLEMENTED/PILOTED BY LITTLE EARTH, YEC, ZINDAGI COOPERATIVE)

### WHAT IS THIS ENERGY EFFICIENCY SOLUTION?

Solar dryer is a structure that can be used for drying certain types of food. Normally, the temperature of a solar dryer exceeds the air temperature in the shade by 15–20 ˚C, and can reach 50 ˚C, on average. This means that a solar dryer can be used from early spring to late autumn. Over the years, various types of solar dryers were developed: large stationary, small mobile (portable) devices.

The dryer consists of a heating zone (solar air collector) and a drying chamber above the collector. There are several metal drying trays inside the drying chamber. The air passes through the solar collector and heats up. The heated air is directed by the fan into the drying zone and blows onto the fruits and vegetables located on the pallets. The fan is powered by a 220 V power supply or a photovoltaic panel (if available).

Figure 1. Solar dryer

## Why choose this energy efficient solution?

The solar dryer can perform the following functions:

- Preservation of taste, color, valuable properties.
- Drying speed - 1 day;
- Protection from rodents, insects, birds, dust and precipitation;
- Reducing the area for drying by 10 times;
- Can be used from March to October.

## Solution cost

The average cost of a Solar Dryer (size 1.5 X 1.5 X 1.5 m) is 770 somoni

## REQUIREMENTS AND PRECAUTIONS

The design of a solar dryer requires the following requirements:

- The front part should be inclined at 45 degrees for better sunrays intake.
- Protect the ingress of water or other liquid on the glass surface of the dryer.
- The legs of the structure should be stable and firm enough to sustain a strong wind.
- Keep surface glass clean to not hinder the drying process of food.
- The dryer can be assembled by a trained master or carpenter based on the design.

## ECOLOGICAL AND ECONOMIC BENEFITS

### Energy / fuel savings

The technology of a solar dryer is simple and the essence of the work is that the technology works only with solar energy and does not require additional costs for heating (coal, firewood, etc.).

### GHG emission reduction

This technology does not emit greenhouse gases as it works purely with solar energy.

### Running costs

The glass surface is fragile, sometimes it might break and will require a substitute. It might be necessary to paint the dryer or to change the nylon mesh for the pallet. The operating costs are approximately 100 somoni per year.

## PROS AND CONS

- The dryer is easy to install, easy to make from available materials.
- It is used to preserve the fruits, nuts, as well as harvesting seeds.
- The technology is relevant everywhere, but especially where the population is traditionally engaged in the procurement of dried fruits: dried apricots, raisins, prunes and others. It can accommodate up to 20 kg of food at once.
- It allows for expanding the family's food ration (especially in winter).
- Makes it easier for households to work on drying products.
- The dryer does not work in winter or when the weather is cloudy.
- For commercial purposes, it is necessary to make large stationary dryers.

## SOCIAL ACCEPTANCE

According to the beneficiary in Bartang district, the solar dryer is not very comfortable in terms of volume, it is considered too small. However, if you enlarge the size, it becomes inconvenient, not mobile and very expensive.

## Beneficiary feedback

*"We have built several units and waited for warm days to experiment with the results of our work. When the season came it turned out that this technology was unprofitable. The shelves were rather small in size and only 1.5 buckets could be loaded at a time (15 kg). Lower shelves are shaded by the upper once, so the fruits won't dry. It's not convenient to turn when the sun moves. Finally, it is not resistant to strong wind and can easily fall and break the glass. Therefore, we used these dryers for other household needs."*- Olimova Savribegim, a resident of the village of Nisur, Bartang district of GBAO.

# 6. OTHER TECHNOLOGIES IMPROVING THE HABITAT/OTHER INNOVATIONS

## 6.1. RAINWATER COLLECTION (IMPLEMENTED/PILOTED BY WHH, BARGI SABZ)

## WHAT IS THIS SOLUTION?

The main task of a rainwater collecting system is to collect as much rainwater as possible and transfer it to a storage tank. Having a large reservoir and sump allows access to water during the water shortage. The easiest and most traditional way is to place the barrel under the roof spillway. To build a rainwater collection system one requires roof drain kit, filter, water tank, short hose and connecting hardware. For a simple pitched roof, it is recommended to install an open drainage system. When installing the gutters, they should be inclined towards the intake pipe. The filter is installed in a branch pipe that connects to the drain from the roof. The gutter consists of the following elements:

- water intake gutter installed along the perimeter of the roof canopy.
- funnel for collecting waste water from the gutter.
- pipe connecting the funnel to the water tank.

The purpose of the reservoir is to collect water from atmospheric precipitation for irrigation. The accumulated water can be effectively used for watering the garden and vegetable garden. Using water for drinking and household needs requires disinfection.

### Why choose this solution?

- Rainwater collector is especially relevant in rural areas, with little or no access to drinking water.
- Can be used for various household needs: irrigation, hygienic purposes, watering livestock.
- It allows household to save money on buying water.
- It does not contain any chemicals. If the water is diluted with river water and disinfected, then it can be used for drinking and cooking.

- Collecting rainwater can save about 500 somoni. The exact amount varies depending on the size of the reservoir. The larger the tank, the greater the savings.

### Solution cost

The average cost of collecting 1m3 of rainwater is 1770 somoni

## REQUIREMENTS AND PRECAUTIONS

The rainwater collector requires the following:

- Make a hatch in the tank in order to have access to inside the tank.
- You can use either polyethylene around the walls and floor of the tank or concrete.
- Before connecting the hose to the tank make sure the roof is cleaned by heavy rain (5-10 min should be enough).
- Rainwater cannot be used for food without being purified. Installing a filter can be one of the solutions.
- It is not recommended to store rainwater for a long time as it provides a hospitable environment for worms and microorganisms that can lead to various infectious diseases.

## ECOLOGICAL AND ECONOMIC BENEFITS

### Energy / fuel savings

N/A

### GHG emission reduction

N/A

### Running costs

If the walls of a 1m3 tank are made with plastic wrap, it will require substitution every 2 years. The cost is around 40 somoni.

## PROS AND CONS

- Rainwater not only saves water, but also reduces the cost of maintenance and cleaning of pumping equipment, thereby saving the family budget;
- It can be effectively used for watering the garden and vegetable garden;
- Rainwater is oxygen rich and chlorine free.
  - Rainwater in the tank should not congest as it may lead to infectious disease;
  - Be sure to empty the rain tank when the water supply is used up;
  - It is not recommended to drink rainwater without mixing with river water and specific cleansing treatment.

## SOCIAL ACCEPTANCE

The Rainwater collection system “Havz” has been used on the territory of Tajikistan since ancient times. The earthen reservoirs were filled with melt and rainwater. Over time, when water mains with clean drinking water appeared, the "havz" became a thing of the past.

In recent years, when developing new lands where the infrastructure is not developed, it has become urgent to return to the construction of reservoirs for water storage. Beneficiaries give positive feedback on the accumulation tanks.

### Beneficiary feedback

*“I use a rainwater tank to water the trees. Rainwater is usually clean and we use it for gardening and animal husbandry. To use rainwater for cooking and drinking, I pour 1 ton of river water onto 5 tons of rainwater and treat it with chlorogam (manganese, furacillin, lime). We clean the tank and decontaminate it once a year. Before collecting rainwater into the tank, we always pour the rainwater into the ground for 5-10 minutes to keep the rainwater clean of roofing dust, and then plug it into the tank. There are only 16 households in the village, 10 of them have already built rainwater reservoirs.* - Boydokov Boymurod, a resident of the Farkhor district, Zafar jamoat, the Khoja dekhkan farm.

# 7. EVALUATION OF THE SOLUTIONS

For the purpose of choosing preliminarily best practices, an evaluation process and subsequent table is presented below. The evaluation process of the solutions is based solely on the information that was provided by development partners, feedback of the beneficiaries and Geres previous experience. Thus, the evaluation is rather indicative and is meant to provide some initial information to be used for further exploration and analysis. In order to evaluate the solution following criteria are used:

- Financial investment from 1 - complex (need of trained professionals, hard to get material or product...) to 10 - easy (can be done by HH owner, material or product easily found...)
- Reproducibility from - 1 specific design to 10 - standard measures or design
- Energy and GHG saving from 1 - low savings to 10 - high savings
- Running cost from 1 - high cost to 10 - low cost
- Acceptability by household from 1 - difficult or not ready to 10 - widely accepted

The table below provides an evaluation of the technologies that were described in the report.

| Solutions' category | Solutions' types | Evaluation criteria | | | | | | | Total scores |
|---|---|---|---|---|---|---|---|---|---|
| | | Cost investment | Ease of implementation | Reproductibility | Energy saving | Greenhouse gas reduction | Running cost | Social acceptance | |
| THERMAL INSULATION | Ceiling insulation with local materials (10cm straw or reeds) | 10 | 10 | 7 | 6 | 4 | 10 | 3 | 50 |
| | Ceiling insulation with 5cm mineral wool | 10 | 5 | 10 | 6 | 3 | 0 | 10 | 44 |
| | Floor insulation with foamed polyethylene (1cm thickness) | 10 | 10 | 10 | 1 | 1 | 0 | 10 | 42 |
| | Floor insulation with 5cm mineral wool | 10 | 5 | 10 | 6 | 3 | 0 | 10 | 44 |
| | Wall insulation with 50mm EPS | 5 | 1 | 1 | 8 | 3 | 10 | 5 | 33 |
| | Wall insulation with 50mm mineral wool | 4 | 1 | 1 | 8 | 3 | 10 | 5 | 32 |
| | Wall insulation with 40mm XPS | 3 | 1 | 1 | 8 | 3 | 10 | 5 | 31 |
| | Wall insulation with 30mm Thermal panels | 2 | 1 | 1 | 8 | 3 | 10 | 5 | 30 |
| | Wooden DG windows | 5 | 2 | 6 | 1 | 1 | 10 | 10 | 35 |
| | PVC DG windows | 6 | 8 | 10 | 1 | 1 | 10 | 10 | 46 |
| HEATING SOLUTIONS | Imrpoved heating stove "Eternal Fire" | 5 | 4 | 10 | 10 | 10 | 9 | 9 | 57 |
| | Improved 2 rooms heating stove | 2 | 5 | 1 | 10 | 10 | 10 | 6 | 44 |
| | Metallic stove with integrated heat exchanger | 7 | 5 | 10 | 9 | 10 | 10 | 9 | 60 |
| | "Vulkan" heating stove | 6 | 2 | 4 | 9 | 8 | 9 | 5 | 43 |
| | AIR-AIR" heat exchanger | 10 | 6 | 5 | 7 | 6 | 7 | 8 | 49 |
| COOKING SOLUTIONS | Efficient cooking stove | 6 | 7 | 8 | 10 | 7 | 6 | 8 | 52 |
| | Modernized cooking stove | 8 | 5 | 6 | 10 | 7 | 8 | 8 | 52 |
| | Pressure cooker | 9 | 10 | 7 | 10 | 10 | 10 | 5 | 61 |
| | Nepalese cooking stove | 7 | 5 | 7 | 5 | 3 | 10 | 5 | 42 |
| | Improved cooking stove "Tezpaz" | 9 | 5 | 6 | 7 | 3 | 4 | 1 | 35 |
| SOLAR SYSTEMS | Solar photovoltaic | 1 | 5 | 1 | 5 | 1 | 8 | 3 | 24 |
| | Solar water heater unit | 1 | 3 | 6 | 10 | 10 | 7 | 9 | 46 |
| | Solar cooking | 7 | 5 | 5 | 10 | 5 | 10 | 7 | 49 |
| | Solar dryer | 7 | 8 | 9 | 0 | 0 | 3 | 2 | 29 |
| | Plastic Solar Veranda | 8 | 8 | 3 | 7 | 8 | 3 | 3 | 40 |
| | Glass Solar Veranda | 4 | 5 | 3 | 8 | 9 | 9 | 8 | 46 |
| | Transforming overhang | 9 | 5 | 8 | n/a | n/a | 10 | n/a | 32 |
| OTHER | Rainwater harvesting | 6 | 8 | 8 | 10 | 10 | 10 | 9 | 61 |

**COMMENT: HIGHLIGHTED SOLUTIONS ARE SELECTED FOR FURTHER IMPLEMENTATION AND TESTING**

The table result helps evaluate which solution stands out from others. The rating for each solution is a joint effort from all partners. Considering the context, needs and priorities of the households, the past experience of Geres and partners' experts, some of the solutions could have been more or less appropriate. For example, wall insulation has a low score but it is a crucial solution when trying to achieve high energy savings.

## 7.1. OVERALL RECOMMENDATIONS:

- It's necessary to consider previous experience of other organizations and their lessons learned when working with certain EE technologies. This report can serve as a starting point.
- It is always a good idea to solicit information from other people who used those technologies first, to make sure their experience was satisfactory (feedback)
- As some technologies are very expensive, consider offering some financial mechanisms in parallel to make it more affordable.
- Carefully assess the needs and priorities of the beneficiaries before offering the solutions to them: some might prioritize heating over fast cooking or having a warm floor rather than double-glazed windows.

## 7.2. THE CHOSEN SOLUTIONS:

The purpose of this stocktaking has been primarily to create an inventory of existing technologies and solutions to allow Geres to tentatively identify existing solutions for further piloting under SDC financial support. Geres does not pretend to select the theoretically best-in-class solutions (savings, GHG reduction, affordability, acceptance) and further work should be done to understand better the advantages and disadvantages of each, especially when working in combination with a sustainable housing concept.

When choosing solutions for further piloting, Geres used a holistic and nuanced approach that rests upon 11 years of its experience in the field, engagement with the beneficiaries, experience of partners and outcomes of the stocktaking survey. Additionally, for this pilot project Geres looked at prioritizing solutions for which the organization doesn't yet have substantial data to explore possibilities for scaling up in the future.

The preliminary list of solutions to be implemented is briefly described below, together with elements for their selection. The final impact and monitoring analysis will be gathered and presented to the donor at the end of the project, when sufficient data and understanding will be gathered.

### House improvement solutions:

The benefits of insulation, apart from obvious environmental reasons, have many other arguments for improving the current insulation standard.

- Before implementing any other type of solutions like better heating equipment, energy production, etc..., it is crucial to reduce the energy demand. Limiting the heat loss in the house is the priority number one.
- When installing heat equipment, it is necessary to size its thermal power to match the house's heat loss. By insulating the house first, this will reduce the equipment size and heat demand, generate energy and financial savings both in daily consumption and equipment investment.
- Investment on insulation will allow money savings every year in the long term and even growing savings if we consider the planned continuous increase of energy cost. This will allow the household to reallocate the savings in additional solutions for even more savings.
- As expressed in earlier chapters, insulation will improve thermal comfort and not the other way around. It means that installing a better heating equipment without insulation does not lower the cold surface effect. Therefore, to compensate for the coldness effect the household will need to raise the temperature inside the house.
- As also mentioned earlier when insulating a house, the ventilation that controls air quality and humidity, will have to be implemented simultaneously.

To conclude, **insulation needs to be implemented first and preferably in a full insulation** package (wall, ceiling, floor and windows).

## Heating solution: “Air-Air” heat-exchanger.

“Air-Air” heat-exchanger is the most affordable and yet quite efficient solution that has a great level of social acceptance, it is easy to implement and it does not require any running costs. Those factors are essential when exploring strategies and potential financial mechanisms for broad uptake among vulnerable populations.

## Cooking solution: efficient cooking stove.

Efficient cooking stove proved to have a very high level of social acceptance, easiness in implementation and a big potential for wide dissemination. It does not require much investment and it helps households to significantly reduce fuel consumption at the household level.

## Solar/passive solutions: solar water heater, solar veranda, transforming overhang:

## Solar water heater.

A solar water heater is a good choice for producing hot water. Compared to other types of solutions, the SWH is fairly easy to install, requires no electricity, breakdowns are also almost impossible, need very little maintenance and most of all it is environmentally sound equipment. Through testing and monitoring of the technology, Geres will be able to gather more solid data in terms of the potential and strategies for promoting it among the rural population.

## Solar Veranda.

The Solar veranda has multiple benefits for the households: i) it contributes to saving heating fuel, as it is attached to the winter room and heats it during the sunny days; ii) it acts as an extra heated room during the sunny days, where different household works can be done (children can play or do their homework, family can do washing etc.). This is very important as households normally can heat only one room during the winter time due to limited financial resources. iii) veranda can be used for small agriculture (dry fruit during the season, grow seedlings, flowers etc.). Considering all of the arguments Geres decided to test this solution and its impact on daily life of the households.

## Transforming overhang.

In the frame of its projects Geres promotes Low Energy Consumption Houses, where one of the requirements is south oriented windows of the winter rooms. Windows oriented to the south increase solar gain into the rooms during the sunny days and decrease fuel consumption by 10-15%. Although, in the mornings and evenings the efficiency is very low due to the location of the sun compared to windows (very few sunrays go inside the room). Transforming overhangs will be installed in a vertical position on both sides of the window, reflecting the sunrays and directing them into the room. Thus, thermal comfort will be increased in the winter room. In the summer it transforms into horizontal overhang above the windows, protecting the room from overheating. This low-tech solution is a Geres innovation, quite prospective considering its relatively low cost and potential benefits. Geres will test this solution from technical viewpoint (how realistic it is to make it) and socio-economic viewpoint (what will be the impact for the households).