Standard Operating Procedure (SOP)
Designing, Fabrication and Installation of Mountain Solar Water Heating System for Domestic Water Heating

NMHS Project: Innovative Technologies for Climate Change Mitigation and Biodiversity Conservation with alternate livelihood opportunities for mountain communities in North Western Himachal Himalayas

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Rural areas in Indian Himalayan Mountains are facing grave energy crisis and high dependence on fuel wood and dung due to cold climate poses a potential threat to the ecology, health of household inmates and involve women drudgery in fuel wood and dung collection. Collection of dung and extraction of forest biomass in mountains as fuel accelerate forest degradation and agriculture which directly reduce forest/ agriculture productivity with direct contribution to climate change and affect livelihood dependence of local communities and sustenance of local fauna species as well. Therefore, HRG developed local cost effective systems for utilization of solar energy in domestic water and space heating keeping in view the >60% conventional fuel consumption in these two activities. 307 mountain solar water heating systems were installed in three remote and high altitude locations of Himachal Pradesh under NMHS MG project (ID NMHS/2016-17/MG16/09).During 2017-18. Installation of these solar water heating systems on average achieved saving of 31.47% and 45.41% fuelwood at selected villages of Kullu and Mandi sites respectively under this project. Maximum fuel wood saving was through solar water heating was observed in winter season. This resulted in time saving of women and visible improvement in their health and hygiene through availability of hot water. Fabrication of solar water heating systems provided new skills and avenues to the rural artisans. This initiative of solar energy use in water heating resulted in significant environmental, social and economic benefits. Local inhabitants preferred solar water heating systems keeping in view the high requirement of hot water in different household activities during the day and have option to sit in sun during the day to avoid space heating investments. Solar hot water systems commercially available in the market are cost intensive and require specialized installations as well as post installation maintenance. These features are major constraint in popularization of commercial solar water heating systems in remote and difficult areas. Therefore HRG mountain solar water heating systems was developed as per specific requirement of rural households having high dependence on fuel wood with least installation and post installation maintenance. System having provision of manual filling and night drainage to prevent freezing make this most suitable for the Himalaya landscape.

Step 1: Desing of mountain solar water heating system

Mountain Solar Water Heating System is based on flat plate design and work on solar thermal technology principle. System design is simple box type which can easily be installed and shifted from one place to the other with changing sun direction and additional construction in the house. Name Mountain signifies the importance of the design suited to specific requirement in hilly and difficult terrain of the Indian Himalayan Region from the point of simplicity, capacity, maintenance and usage with different set of water supply ranging from manual, piped and from storage tank. Further system design facilitates night drainage during freezing winter time to avoid cracking of pipe and high efficiency of water heating. Above all system is quite cost effective with present market cost nearly about 12000/- unit ex HRG field station at Mandi in H.P. Design of the system is such that it requires no investment for installation after purchase and can be directly kept in the premised Wood Frame nearer to the place of use (Bathroom or Kitchen) in sun for disbursing hot water during the day. Complete layout of the Mountain Solar Water Heating System design is presented in Fig.1.

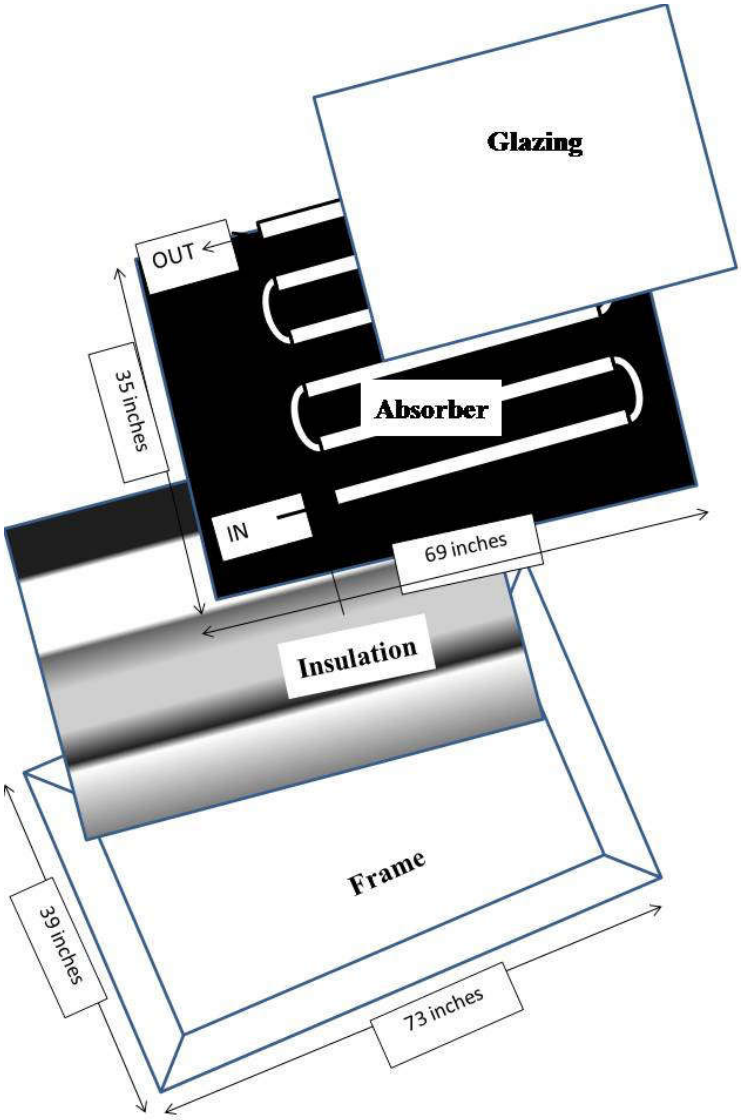

Fig.1. Design of HRG Mountain Solar Water Heating System

Step 2: Fabrication of mountain solar water heating system

Solar water heating system is simple innovation done with locally available material to tap maximum solar energy for water heating backed with scientific principle. This system is evaluated in great detail for performance and durability and under NMHS 307 systems were fabricated and installed in three remote locations situated in District Mandi, Kullu and Shimla of H.P. Systems were also installed under different programme of the central and state departments in last 5 years in HP and Ladakh. Mountain solar water heating system of 180 cmX90cmX12.5 cm dimension wood frame having glass glazing on solar side and GI sheet painted black as absorber next to glazing face as heat absorber. On the back side of GI heat absorber sheet will be insulated with 3.75cm thick thermocol sheet to prevent heat loss. Coil of Aluminum alloy 3.75 cm between glazing and absorber sheet painted black to absorb maximum sun energy during day time. Wood frame is coated green with underlying layer of wood primer to prevent rotting. Absorber sheet, water coil coated black after coating with steel primer. Black paint contains special coating agent for maximum absorption of solar energy for water heating. Two ends of water coil are fitted with GI reducer which connects to the ½" GI nipple protruding through the wood frame. These nipples at the bottom side of the erected system is fitted with GI ½" T to make passage for night drainage tap on side and upright GI inlet pipe connection. On top side of the system ½" GI albo is fixed to contain flow of hot water downward in the bucket. Backside of the black absorber sheet thermocol sheet is fixed in 1.5" groove in the wood frame as insulation which is covered with aluminum sheet.Sun facing side of the system above water coil is covered with three pieces of window glass glazing fixed with wood beading fixed with fine nails. At every joint of wood and space between glass, wood frame and beading is filled with fevicol to prevent energy leakage for achieving maximum efficiency of the system. System is filled with cold water manually or with pipe fitting as most of the household have public tap. On inlet side night drainage outlet is kept to flush out silt and keep coil empty during night to prevent freezing in winter. Detail of items required for fabrication of one system is presented in Table-1.

Wood Frame

Fixing of GI Absorber Sheet in Wood Frame

Coating and Fixing of Water Coil on Absorber Sheet

Fixing of Glazing

Step 3: Table-1. List of items required for fabrication of One Unit of Mountain Solar Water Heating Systems

- Wood Frames 72”X5.5”X2” = 2 No., 39”X5.5”X2” =2 No, 39”X2”X2” =3 No
- Beading of fixing of Glazing 1/2" X1/2”X1/2” = 36 feet
- Wood Primer =1 liter
- Steel Primer =1 liter
- Black paint with coating =2 liter
- Green Paint =1 liter
- T- oil =1 liter
- Galavanized Sheet 72”X36”X0.35 mm = 1No
- Water Coil 69”X37”X1.5” =1 No.
- Reducer 1/1/2 X 1.5” =2 No.
- GI Nipple 12” X 1/2” =2 No.
- GI Socket 1/2” =2 No.
- GI-T 1/2” =1 No
- Tap 1/2” =1 No.
- GI Pipe 30”X½”with both side thread =1 No.
- GI Albo ½” =1.No.
- Window Glass Glazing 30”X22.5” =3 No
- Nails 4” =50 g
- Nails 1/2”(16 No) =50g
- Nails for fixing of beeding of glazing =100g
- Fevicol =100g
- M-seal =1 Packet
- Thermocol sheet 36 density 40”X20”X1.5” =4 No.
- Aluminum sheet (Thin) 72”X39” =1 No.
- Paint Brush 4” =1 No.

All these items can be easily sourced from the hardware shop in any semi urban area or town except for the water coil which is made customized and made on order by the HRG with advance order in bulk in one of the industrial unit.

Step 4: Model and technical description of mountain solar water heating system

Model No. MSWHS-01
MSWHS Technical Description

- Suitable for water heating with simple and high efficiency coating of absorber and water coil
- Dimension 90 cm (height) X180cm (length)X12.5 cm (thickness) without cold and hot water tanks.
- 18.5 litres aluminum alloy (code6063-T4) water coil with tensile strength 170 Min MPa and thermal conductivity 200 W/mK
- 1.54m² GI flat plate collector with innovative coating Households using respective Systems Systems Installation with Data Loggers
- High-transmissivity with 4 mm window glass
- Free of complicated features and systems for easy maintenance after installation
- 18 litres/batch with 100 lpd hot water with maximum > 80°C during the sunny day.
- Dual option for manual filling in winter freezing temperature and piped supply.
- System save average 40% fuel wood/annum with mitigation of 2.5-2.7 MT Household Carbon emission in mountain households above 2000 m altitude and can replace 2 KW electric geysers to save up to 1500 electricity units/annum
- Unique feature of night drainage and anti freezing outlet
- Pressure and air-release during heating
- Require 1.825 sq. m surface area to install
- Average system life 10-12 years and more with maintenance and care.

Step 5: Installation mountain solar water heating system

System is fixed at 45-48o angle with two side legs to tap maximum sum energy during the day in premises of the household to provide hot water for different activities of bathing, cleaning and washing. System installation requires no extra fitting, stand or storag e tank. This is like 'hamam' and on filling cold water will dispense hot water. No special post installation maintenance is required except for the safety of glazing glass which can easily be replaced by the household members without any specialized skills and tools.

Systems Installation with Data Loggers

Step 7: Usage mountain solar water heating system

Hot water for bathing, cleaning, washing and cattle feeding is required round the year in Himalayan Mountains. Mountain solar water heating system addresses all these requirements in mountain households. Fill the system manually or with pipe connection having control on supply side in the morning through inlet. First batch of 15-18 liters takes about 40 min in full sun to heat and successive batches can be withdrawn in a gap of 15- 20 minutes and this way 100-110 liters hot water is dispensed during the day. This hot water dispensing schedule of system matches with requirement of the rural households. In the morning members get engaged with activity of livestock and agriculture and return back around 9-10 AM by the time first batch is heated for washing of hands and taking bath. After this woman prepare food for serving between 11-11.30 AM and stack utensils for cleaning. Cleaning of utensils and cloths is carried out after lunch and then woman take bath with hot water. Last batch of the system is drawn through night drainage tap late in the evening for cleaning of utensils after dinner. In some of the households cattle are also provided lukewarm hot water in winter months and system deliver for that as well without burning fuel wood. System save women time in fuel collection and also improves their health and hygiene with regular bathing reduced level of indoor pollution in the kitchen.

Households using respective Systems

Step 8: Do's & Dont's

- Check leakage in water tube before fixing in frame and glazing
- Apply M-seal kind leak proof plumbing adhesive on threaded ends and pipe fittings joints to prevent leakage
- Keep away from hot water outlet to prevent burn injuries
- Always fix system away from the reach of children
- Drain water of coil every evening during winter season to prevent freezing to avoid damage to the coil and better efficiency
- Do not fix stopper or tap on hot water outlet to prevent pressure building which can result in cracking or sudden burst of water coil with increasing pressure.

Step 9: Discussion

Fuel wood or dung (in cold desert) will continue to be the major source of energy in domestic sector of the Himalayas and need immediate technology interventions like solar water heating systems for efficient use to conserve forests and achieve sustainability. If the quantum of utilization continues with estimated volume and rate of deforestation, it will make life tuff for mountain communities not in next generation but in late stages of this generation as well. Saving with local made mountain solar water heating systems is the fine example of customizing the technology to the location specific need and to be encouraged through policy instruments and financial incentives for effective field popularization. This will reduce women drudgery, conserve forests, mitigate household Green House Gases (GHGs) and provide employment to rural artisans. Indian Himalayan Region is inhabited by around 7.0 million households. Implementation of initiatives with reduction of average 2.0 t CO_2 emission/household/annum as estimated with our study under this NMHS project only installation of cost effective locally fabricated solar water heating systems will contribute significantly to the national agenda on climate change mitigation.