DEMONSTRATION OF A SOLAR THERMAL DIRECT HEATING SYSTEM IN COLD CLIMATES – A NEPALESE RETROFIT CASE STUDY

Summary

The EU-funded BEEN project promotes energy efficiency in Nepal, including alpine regions like Mustang, where heating is often absent or relies on wood stoves. This study presents a retrofit of a 25 m^2 reception room in Jomsom (2,750 m elevation), retrofitted with a solar thermal direct heating system. On-site assessments and TRNSYS simulations guided the design, with insulation (sheep wool walls, XPS floor) and double-glazing reducing the heating load by 50% for a 15°C target. The system features two vacuum tube collectors (4.66 m^2), a 200-litre buffer tank, and radiant floor/ceiling panels for low-temperature operation. Installed in May 2025, it now maintains 18.5°C in winter, significantly improving comfort. Ongoing data and feedback collection will evaluate long-term performance. This case demonstrates the viability of solar thermal heating in cold climates, offering a scalable, renewable solution for Nepal's alpine buildings.

Keywords: Solar thermal, direct space heating, cold climate, Nepal

Field of application for the findings: Space heating in office building

Addressed audience: Building operators, researchers

1. Introduction

Solar thermal systems are widely used for domestic hot water generation (DHW), particularly using solar thermal syphon systems. Additionally, solar thermal energy is a promising energy source for space heating of rooms and buildings. However, in most cases, solar thermal collectors are often an additional energy source to a heating system. Direct solar thermal systems, characterized by only one heat transfer medium directly coupled to the heat distribution system (e.g. floor heating system), are not widespread in the field.

The EU-funded SWITCH-ASIA project BEEN (Building Energy Efficiency in Nepal) increases awareness about energy efficiency measures (EEM) in Nepal. The project ran from March 2022 until February 2026 and included trainings and workshops for local experts in the construction sector and provided guidelines on relevant topics, such as Heating, Ventilation, and Air-Conditioning (HVAC) (Streicher et al., 2026) or the installation of insulation. The project activities include retrofit and planning support activities (Strobel and Jakob, 2024). The area of application ranges from hot and tropical regions in the Tarai region up to cold and alpine regions such as Mustang region. The winter their lasts from October until April and the daily average ambient temperature ranges from 1.6°C to 3.0°C. Both historical and modern buildings in this region are either have no heating system or heated only via wood-fired stoves. Insulation of freshwater pipes is not applied, due to additional costs and as insulation is locally seen as a non-proven technology.

One of the retrofit activities conducted under the BEEN project in Nepal was carried out for the registration office room of the Gharapjong Municipality Office building in Jomsom at an elevation of 2,750 m above sea level. The office building was completed in 2023 and primarily used in the summertime. However, the reception of the office building located in a 25 m^2 room in the ground floor is occupied all year. The building has no central heating system and does not include EEMs, such as double glazing, wall or roof insulation, nor does it have any sealings to reduce air infiltration. This retrofit activity targets to create a case study of solar thermal heating in the Mustang region. The aim is to identify most cost-effective EEM and draft a concept of solar thermal heating. The room is located on the ground floor facing South-East and is neighbouring on the building internal side both the lobby, the hallway and an office. Figure 1 shows the floor plan of the room.

Fig. 1: Frontview of the Gharapjong municipality office building in Jomsom, Mustang, Nepal. (Source: Michael Strobel)

2. Preparation and planning

The investigation of existing infrastructure and construction was the very first step. Construction details and building plans were collected and reviewed and multiple site-visits were undertaken. The collected information and the feedback from the local staff members and municipality directors led to the decision to retrofit the reception room, as the office room being used most frequently and throughout winter times. The local demand and requirements on the room were identified. Before a solar heating system was planned and designed, the EEM optimization of the reception was investigated. The optimisation of the room was investigated via dynamic simulations in TRNSYS. The insulation reduced the calculated maximum heating load for the room for a desired room temperature of 15°C from 200 W/m² to 100 W/m² (2.5 kW for the whole room). The course of annual load and accumulation of heating demand for both the baseline (as it is) and optimised are presented in Figure 2.

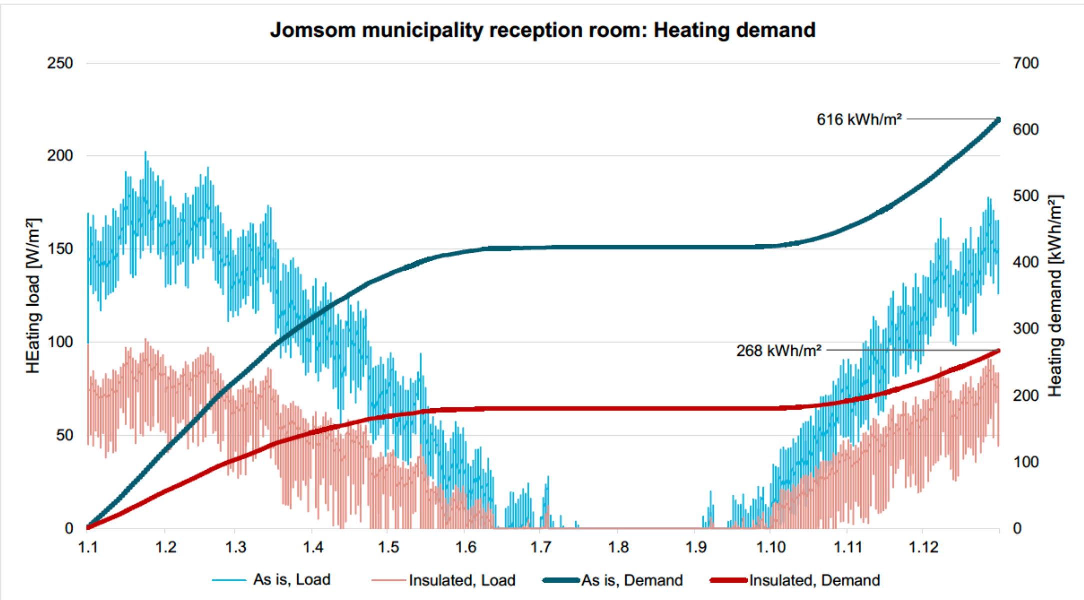

Fig. 2: Simulation results showing the area-specific heating load and heating demand for the room, as is and insulated.

The optimisation includes the implementation of passive measures to reduce heating losses to the environment, both outside and neighbouring rooms within the building, and the installation of a solar thermal direct heating system. The system consists of two hydraulic loops connected via a hot water buffer tank. Water is used as heat transfer medium circulating from the solar thermal collectors through the buffer tank to the floor and ceiling heat supply surfaces and backwards. Instead of radiators or convectors, the BEEN experts propose to operate heating elements with large surfaces. Large surfaces are more effective to heat the room with relatively low hot water temperatures even of 30°C. This will secure that heating is available even at less solar radiation, increasing the annual hours of solar operation and comfort. Furthermore, these systems are saving space in the room. The heating system includes a 200 litres buffer tank with a air-water heat pump as a back-up heater.

A feedback survey is ongoing and will be finished once the system is operating more than one year. Data collection is also ongoing at the time of extended abstract submission.

3. Installation and results

As a result of the assessment and the analysis on-site, a solar thermal direct heating system was fully planned and installed. All equipment was transported from Kathmandu to Mustang, a 360 km travel. The installation activities took place in May 2025. During this time, the room was internally insulated with a 40 mm layer of sheep wool on all four walls, covered by 12 mm plywood. The floor was insulated by a layer of 25 mm XPS mats, on top of which the floor heating pipe system embedded in aluminium sheets (see Figure 3 right). Radiant ceiling panels were installed on the ceiling of the room to increase the area of heat dissipation. Additionally, the single-glazed windows were replaced air-filled double-glazed windows. The solar thermal direct heating system was installed in the same period. Two vacuum tube-collectors with an aperture area of 2.33 m² each in a 30° slope facing South were installed on the flat roof of the building (Figure 3 left).

Fig. 3: Installation of solar thermal collectors (left) and of the floor heating system (right). (Source: Dibya Acharya)

The system was commissioned in end of May 2025 and is operating since. The system works and provides solar heat to the room, increasing comfort to local staff. This demonstration of solar thermal direct heating system in cold climate in Nepal can serve as a best practice for simple and renewable heating solutions. The room now provides 18.5 °C during cold time in January.

4. References

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