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# Vacuum insulation panels – A promising solution for high insulated tanks

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**Abstract**

Thermal energy storage (TES) devices, especially hot water tanks lose energy through the surface. To keep the energy loss low, TES are insulated with materials like expanded polystyrene or mineral wool. However, the insulation of small and middle-sized TES is not as good as it should be. With Vacuum Insulation Panels (VIPs), it is possible to reduce these losses by a factor of 6 to 10, compared to conventional insulation materials. This paper describes the possibility of using VIP for insulating TES. This leads to a reduction of the energy loss.


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*Keywords:* Thermal storage, vacuum, insulation

## 1. Introduction

Nowadays, conventional insulated small- and middle-sized thermal energy storage devices are not as good as they should be for long-term storage [1]. Even though owing to their surface area to volume ratios small- and middle-sized hot-water storages should be insulated better than huge thermal storages, the overall heat transfer coefficient (U-value) declines with smaller tanks [2]. Beside economic reasons, an important factor that causes this problem is the technical limits in the diameter of the insulation layer. Hot-water storage uses nearly the same insulation materials as in building construction. Especially, passive houses need highly insulated walls and roofs to achieve the required small energy losses over the envelope [3]. The thickness of insulation layers for passive houses can be reduced by the use of vacuum insulation panels (VIPs) and, today they are well known in building insulation [4]. This research project explores the feasibility of using VIPs for small- and middle-sized thermal hot-water storages. The advantage of using VIPs lies in their small thermal conductivity, which is about 6 to 10 times lower compared to conventional insulation materials like expanded polystyrene (EPS) or mineral wool. [5, 6]. Further information about the physics of vacuum insulations is given in the contribution, “On Vacuum Insulated Thermal Storage,” found in this proceedings volume.


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## 2. About the need for highly insulated thermal storage

Nowadays long-term storage is done with large-sized thermal tanks with volumes of up to 10,000 or even more [7]. Beside other things, the surface-–volume ratio is the major advantage. Because surface–volume ratio declines with increasing volume, huge thermal storages can be insulated with smaller U-values [6]. Therefore, the small- and middle-sized hot-water storages have to be insulated more than the larger ones. Compared with a 10,000 m³ of long-term storage, the U-value of a 100 m³ storage should be 4 times higher and for a 10 m³ storage the it should be 8 times higher [6]. As shown in figure 2, more insulation layers cause a tremendous decrease in the net volume. For example, the volume share of the insulation layer of the storage with a net volume of 10 m³ and an insulation thickness of 50 cm is about 48 %. That is to say, that only half of the available volume could be used for storing energy. By using vacuum insulation panels with a thermal conductivity that is about five times smaller compared to conventional insulation materials, the share of the insulation layer could be reduced to 14%. The outcome of this is the possibility to use small- and middle-sized tanks with a low U-value with technically feasible insulation thicknesses.

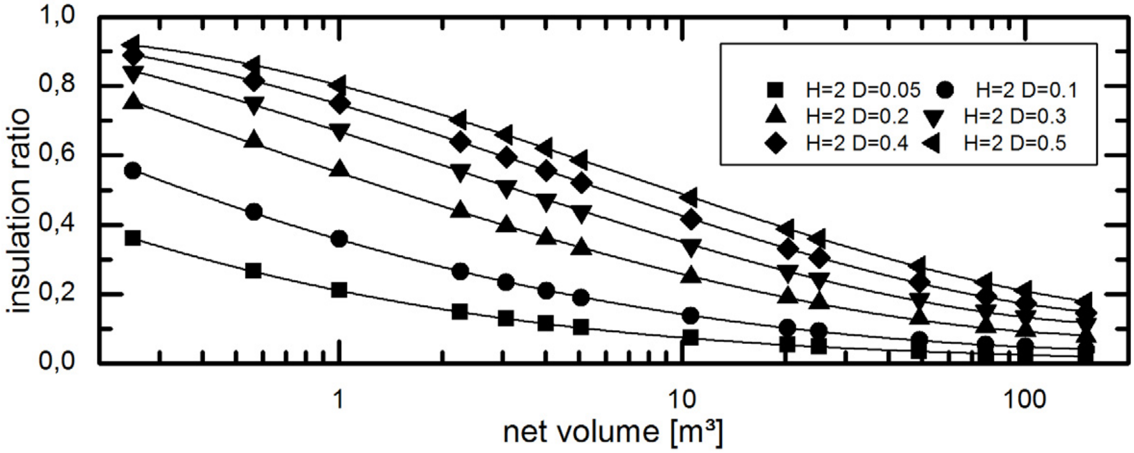


Fig. 1. Ratio of the insulation layer relating to the cross volume, which is the usable net volume of the tank plus the volume of the insulation layer.

## 3. The usage of vacuum insulation panels for thermal energy storage

Today, many technical applications use vacuum insulation panels. Contiguous to the use of VIPs in the insulation of buildings [8], they are also used for the insulation of fridges [9]. Theoretically, a VIP can be produced in every imaginable structural shape. However, the production of complex structures is very expensive due to the low number of items required. Currently only flat panels are produced through a nearly bulk mode of production. Therefore, the use of flat VIPs is more cost efficient than using, for example, radial VIPs resulting in a concept of using flat VIPs [10]. Besides the concept of using flat VIPs, the Technical University of Illmenau [11] and the Institute of Sustainable Technology [12] are using radial VIPs.

## 4. Challenges of VIP-insulated hot-water storage

The lifetime of thermal storage for the heat supply of buildings is scheduled as 20 years [13]. Therefore, the increase in the thermal conductivity has to be lowered to a minimum within this period. Two physical processes are known, which are limiting the service lifetime of vacuum insulations. On the one hand, the increase in pressure has to be smaller than the breakeven point of the Knudsen number. With an increase over this specific pressure, the main effect of the VIP is disabled [14]. On the other hand, an increase in water intake due to the permeation of water vapor through the envelope foil over a percentage of about 8% causes an unacceptable increase in thermal conductivity [14]. Schwab et al. found that the main process relating to the service lifetime is the permeation of water vapor [14]. They also found that this process is linear over time and the rate of mass increase depends on the temperature and humidity [14]. Nevertheless, new and highly efficient metalized laminates for high temperatures and for a service lifetime of up to 60 years have been developed [15]. In addition, the thickness of VIPs for insulating hot-water storage is about two to three times higher than in the insulation of passive houses. To estimate the service lifetime of VIPs used for thermal-energy storage, further calculations and experiments will be conducted.

## 5. Conclusion

The use of vacuum insulation panels are a promising solution for insulated thermal storage on a high level. With VIPs, it is possible to use small- and middle-sized hot water tanks for long-term storage in an efficient way. Different concepts in the usage of VIPs are being developed currently. Owing to the high temperature and high humidity of thermal storages, it is estimated that the service lifetime of 20 years could be reached. Further simulations and calculations have to be executed to estimate the potential of VIPs for thermal storage. Experimental analyses are being conducted to get more operational experience in the use of highly insulated small- and middle-sized thermal storages.

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