Correction of collector efficiency depending on fluid type, flow rate and collector tilt

Subject:	**Correction of collector efficiency** depending on variations of collector type, solar collector fluid, volume flow rate and collector tilt
Description:	Influence and importance of variations of collector type, solar collector fluid, volume flow rate and collector tilt on the efficiencies and thermal performances of collectors
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Intro

The efficiency of a solar collector is influenced by the solar collector fluid, flow rate and collector tilt. However, test institutes usually determine the collector efficiency for only one combination of fluid type, flow rate and tilt angle. This fact sheet describes investigations on the influence and importance of variations of solar collector fluid, flow rate and collector tilt on the efficiency and thermal performance of different solar collectors. Additionally, the effect of a fluorinated ethylene propylene foil used as convection barrier between glass cover and absorber is investigated.

Guidelines for collector design, installation and operation - with respect to collector tilt, mass flow rate and fluid type

Regarding the influence of the collector **tilt** on the efficiency coefficients, the results of all tests agreed on the fact that the major effect is on the heat loss coefficient, which decreases if the tilt angle increases. On the other hand, the zero-loss efficiency is not significantly affected by the tilt angle. Consequently, in mere terms of efficiency, a higher tilt positively affects the solar collector efficiency. However, a much stronger influence on the collector performance is played by the total solar radiation which reaches the collector throughout the year. For this reason, the tilt angle should be chosen in order to maximize the solar radiation and minimize the shadow effect from one collector row to the next. As the collector efficiency stated in the technical datasheet is usually obtained for a tilt angle of 60°, correction of the heat loss coefficient should be introduced if the collector is installed with a lower tilt, in order to size properly the installation without overestimating its yearly thermal performance. In the Canadian study of the effect of tilt angle, a single-glazed flat plate collector with a selective surface on the absorber had a 7% lower collector heat loss coefficient at a 90° tilt (vertical collector) than the same collector at a 60° tilt. In the Danish investigation, assumed 45° tilt as reference, the variation of tilt angle by ±15° caused a relative variation of the heat losses by 5-8%.

Concerning the **flow rate**, its influence on the efficiency parameters is more or less significant depending on whether it entails a different flow regime in the absorber pipes. The collector design and the control strategy should be such that the fluid velocity is high enough to guarantee turbulence most of the time. As higher fluid velocity entails both better heat transfer from pipe walls to solar collector fluid and higher pressure drop across the collector, a compromise between these two aspects should be reached. When carrying out an efficiency test, the flow rate should be chosen in such a way that the fluid does not experience regime transition within the tested temperature interval, as this will most likely cause a discontinuity in the efficiency trend and cause a poor interpolation of the single data points. Additionally, transitional flow regime may cause the results to be difficult to reproduce, so compromising their reliability.

Water should be used as **solar collector fluid** whenever possible, as it presents better characteristics from both the thermophysical and economic points of view. However, depending on the climate and on the risk of freezing, propylene glycol (PG)/water mixtures may be necessary. As higher concentrations of glycol entail poorer fluid properties in terms of specific heat and heat transfer, a lower concentration assuring anti-freezing protection only at a certain extent may be preferred. Then, if the fluid temperature approaches its freezing point, the pump of the solar collector loop can be started and the fluid circulated and warmed up. This approach makes the control strategy a bit more complex and requires more temperature sensors, but can enhance the solar collector performance on a yearly basis. As the collector efficiency stated in the technical datasheet usually refers to water as solar collector fluid, correction should be introduced if a glycol/water mixture is used, in order not to overestimate the yearly performance and to size properly the installation. In the Canadian study, using a 50% PG/water mixture instead of pure water resulted in up to a 5% reduction in zero-loss efficiency and up to a 9% reduction in collector heat loss coefficient. Similar effect (-4%) on the zero-loss efficiency was found in the Danish investigations when comparing pure a 40% PG/water mixture and pure water. On the other hand the heat loss coefficients were reduced by 2% when using water as solar collector fluid

An effective way of reducing the heat losses was found in the installation of a **convection barrier**, such as a thin fluorinated ethylene propylene (FEP) foil between the glass cover and the absorber. On the other hand, the presence of the FEP foil negatively affects the transmittance of the collector cover, causing a decrease in the zero-loss efficiency. So, when supplied with a relatively cold fluid, a collector without foil performs better than one with foil. However, at sufficiently high temperatures, as those reached in solar collector fields, the decreased heat losses play a more significant role than the reduced zero-loss efficiency, so that the presence of the foil is advantageous.

Regarding the **incidence angle modifier** (IAM), no significant influence of the operating conditions (fluid type, flow rate and tilt angle) was found. Only the presence of the FEP foil had a negative effect on this parameter.

References

Get all details from the corresponding FACT SHEET on correction of collector efficiency IEA-SHC TECH SHEET 45.A.1, http://task45.iea-shc.org/fact-sheets and from the report "Canadian and Danish investigations on corrections of collector efficiency depending on fluid type, flow rate and collector tilt", report Byg R-326, Department of Civil Engineering, technical University of Denmark, 2015., ISBN=9788778774163.