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Department of Civil Engineering

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Heat storage for solar heating systems

Now and in the future

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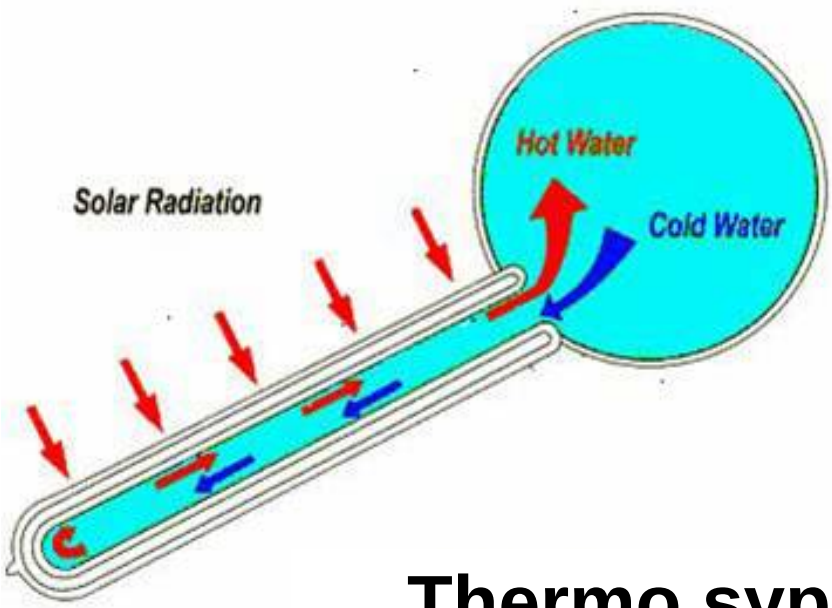
Solar tanks for

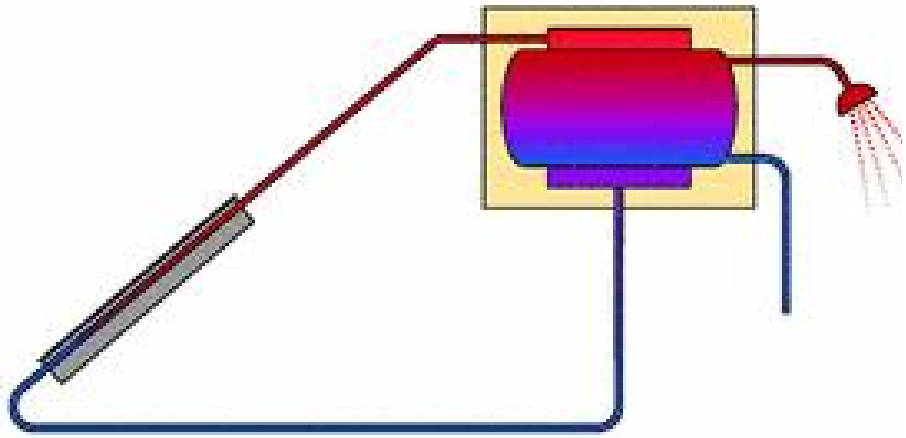
- **Solar Domestic Hot water Systems**
- **Solar Combi Systems**

Small
Solar Domestic Hot Water Systems

China

Southern Europe

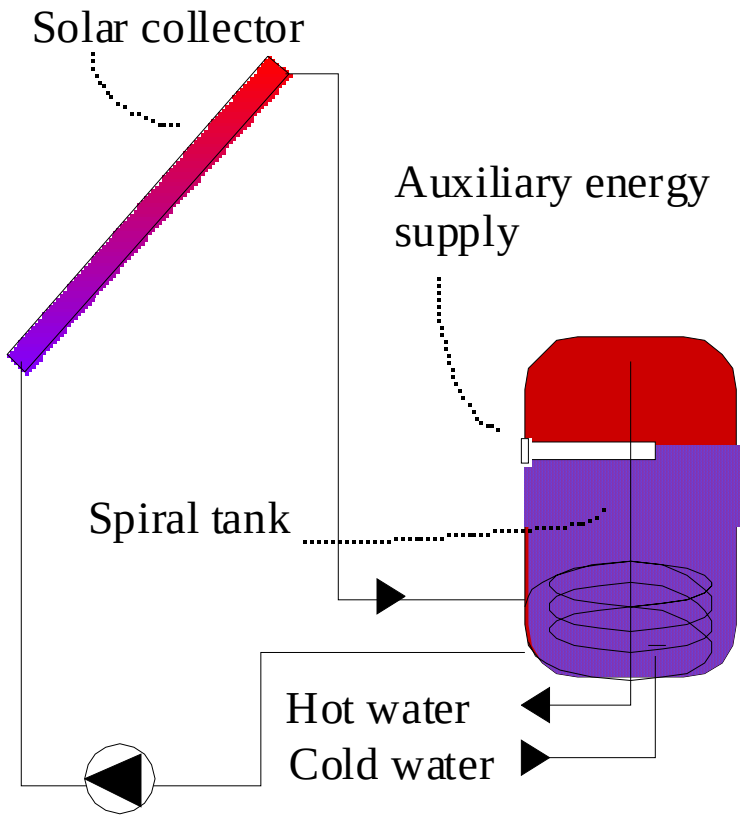




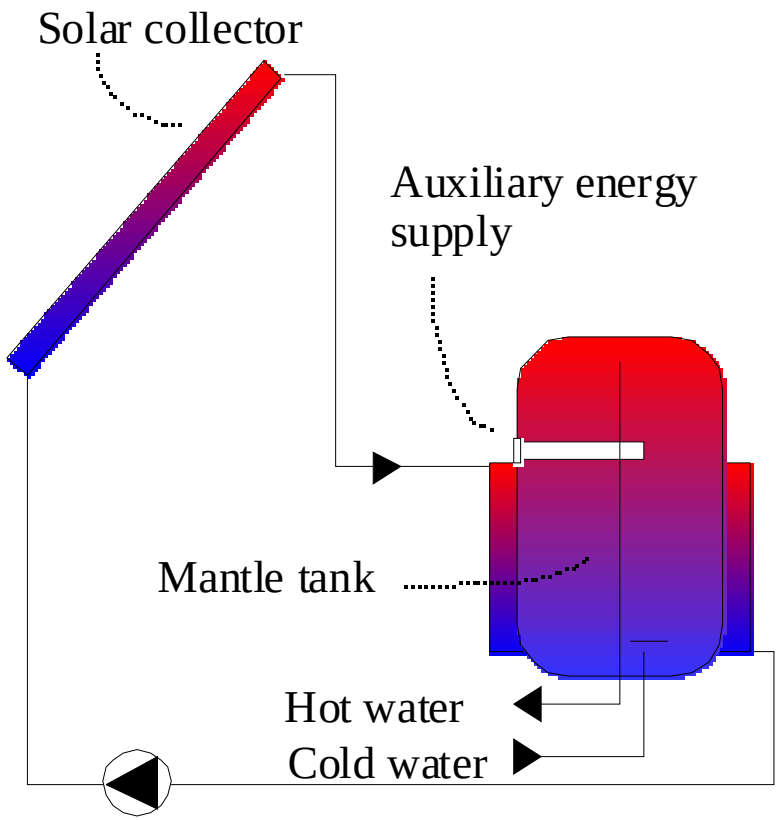
Thermo syphon systems

Central & northern Europe

High flow
Spiral tank



Low flow
Mantle tank



Pumped systems

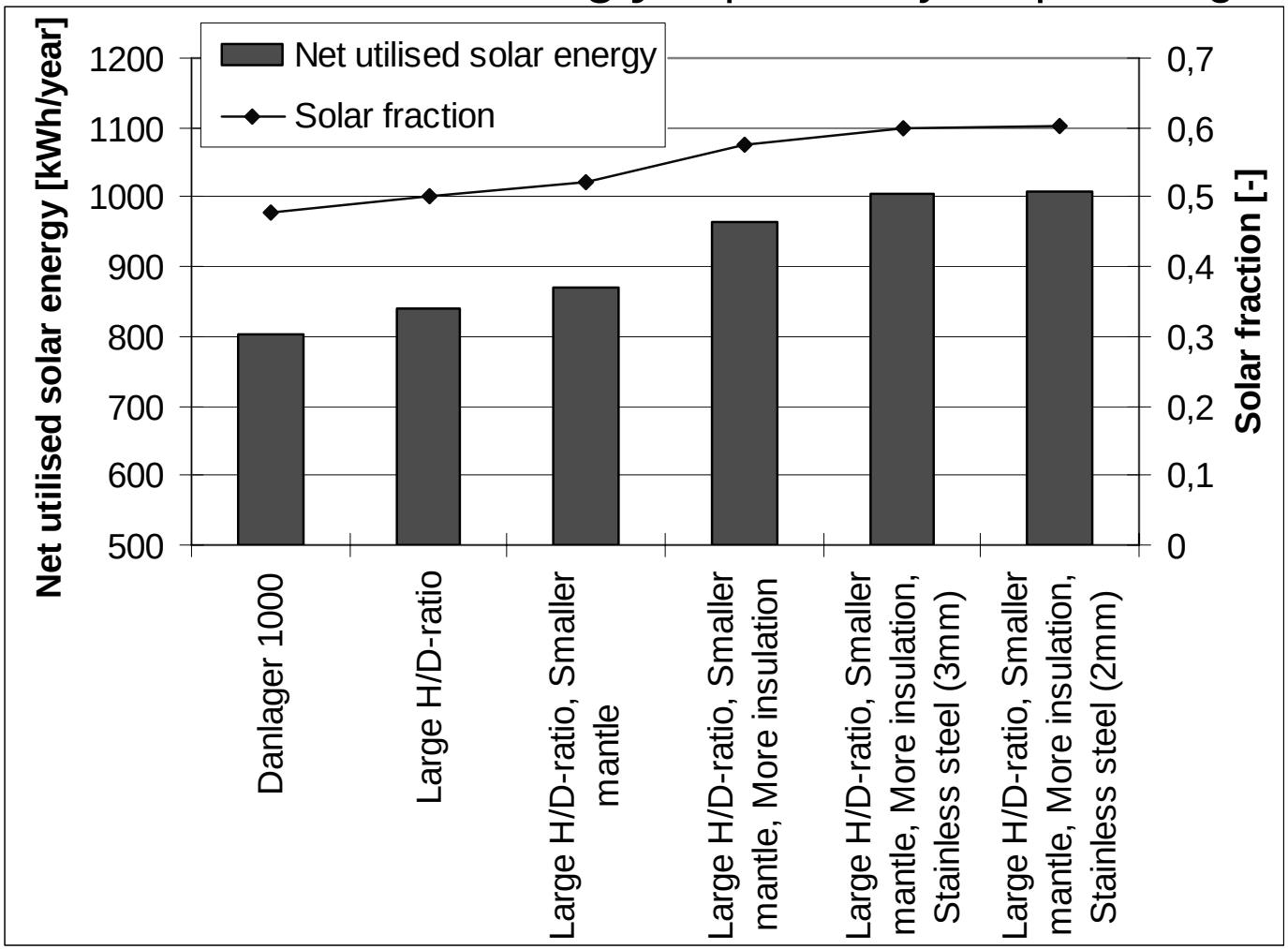
Advantages by low flow mantle tank systems compared to high flow spiral tank systems

- Extra thermal performance: 10-25%
- Improved performance/cost ratio: 39%
- Reduced lime deposits: 2.5 times

Lime in tank after 3 years of operation

Spiral tank Mantle tank

Marketed mantle tanks can be **strongly** improved by simple design changes

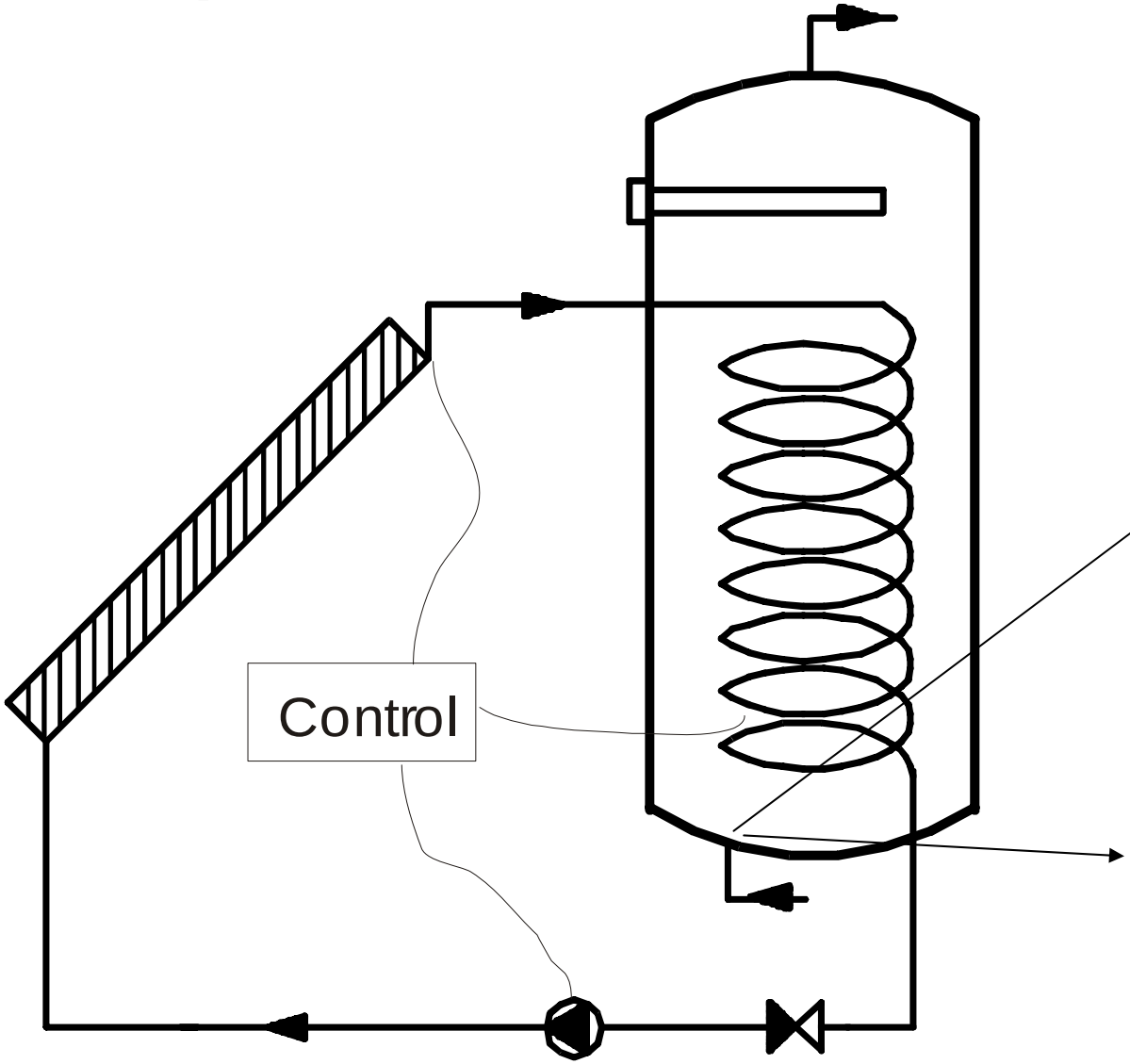


20% extra thermal performance by:

- Increased height/diameter ratio
- Reduced mantle height
- Lowering the position of the mantle inlet
- Increased insulation thickness on the sides of the tank

Further improvements by use of tank material with low thermal conductivity

Improved cold water inlet design

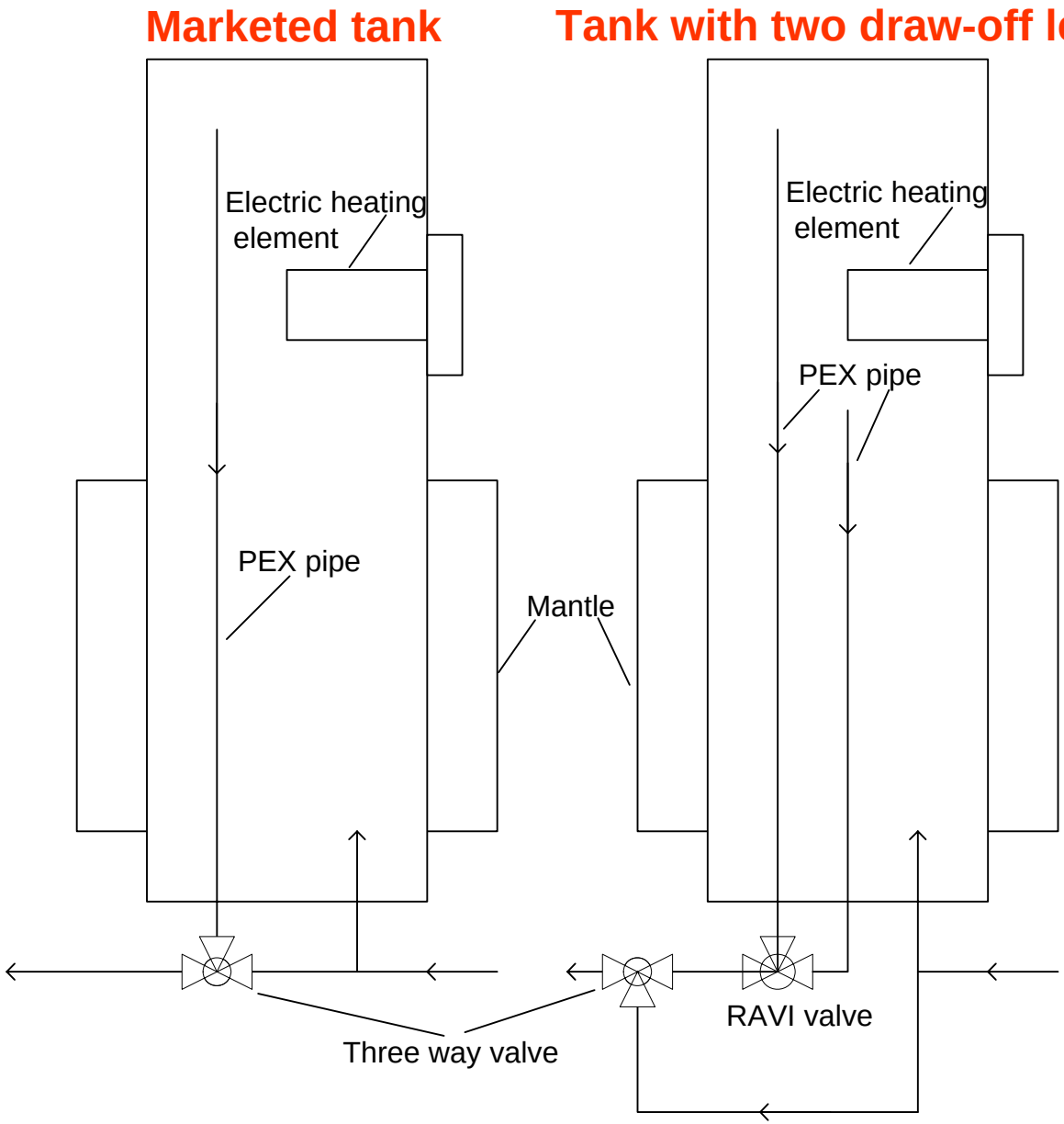


Standard cold water inlet

Cold water inlet with reduced mixing during draw-offs

Extra thermal performance: 5%

Hot water tank with hot water draw-off from two levels



Extra thermal performance: 5%

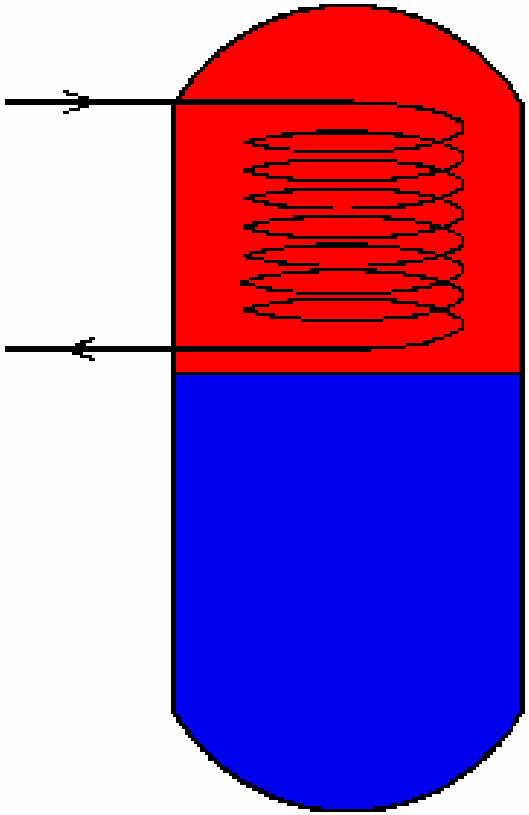
Boiler/hot water tank unit

Potential advantages:

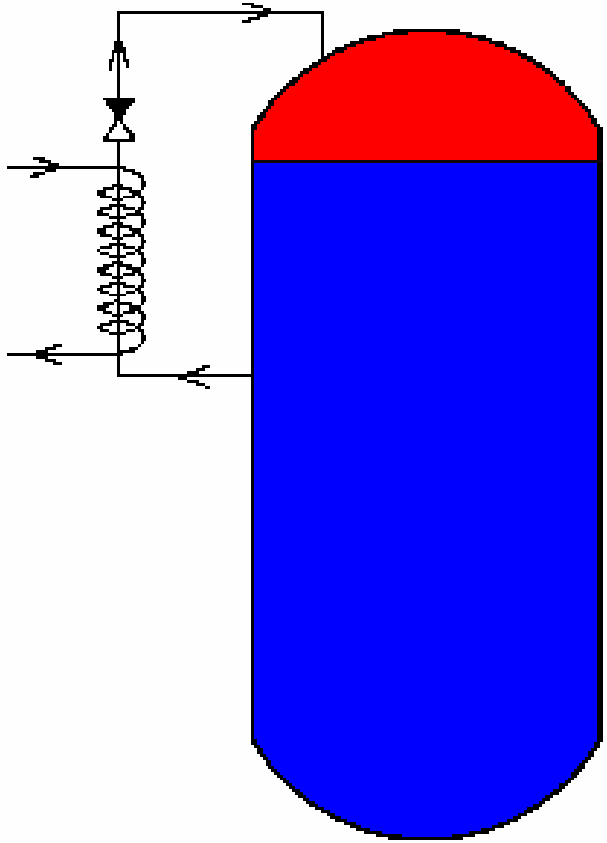
- Increased efficiency of natural gas boiler/oil boiler
- Increased thermal performance of solar heating system
- Increased energy savings
- Reduced space demand
- Easy to install
- Easy to sell

Smart hot water tank

Marketed solar tank



Smart solar tank



Tank heated from the top

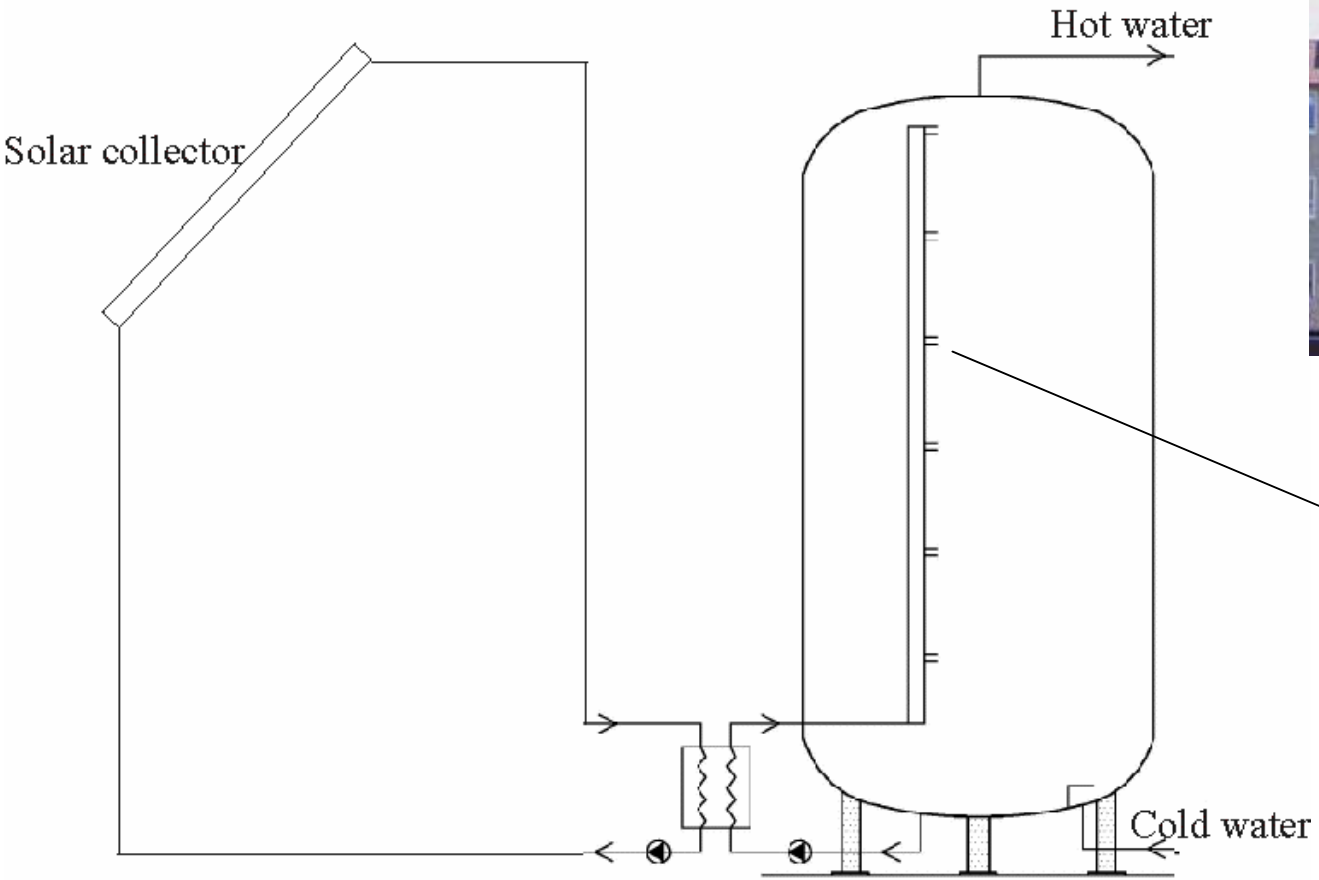
Individual variable auxiliary volume

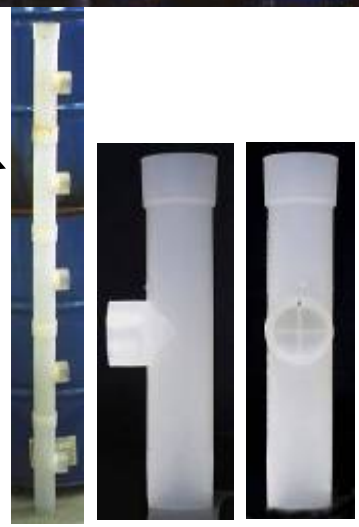
Auxiliary energy supply fitted to heat demand

Extra thermal performance: Up to 35%

Cost/performance improvement: Up to 25%

Large Solar Domestic Hot water Systems





Collector area: 336 m², partly facing east, partly facing west

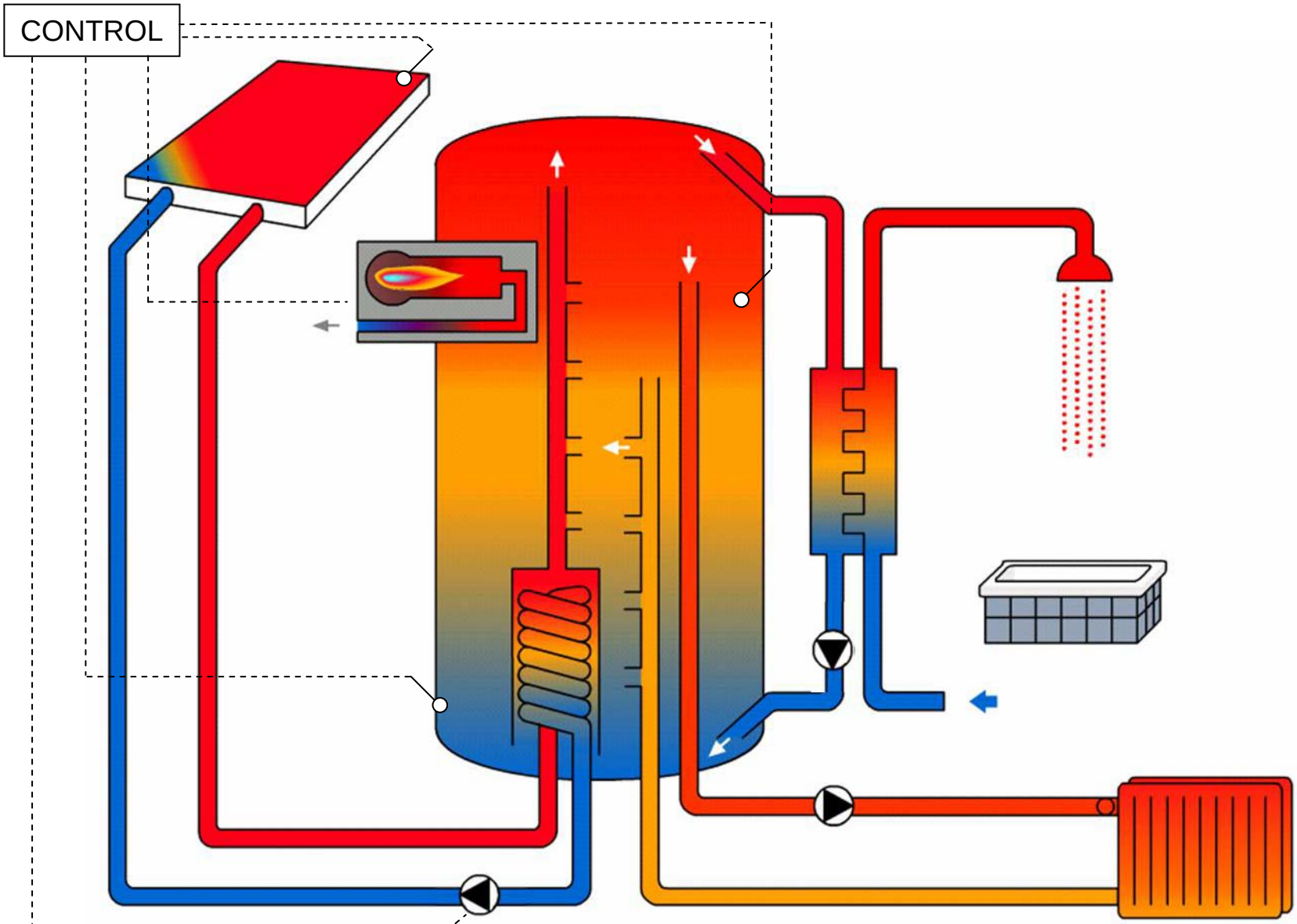
Collector tilt: 15°

Tank volume: 10000 l

Measured net utilized solar energy (2001-2002): 455 kWh/m² year; solar fraction: 21% (10%)

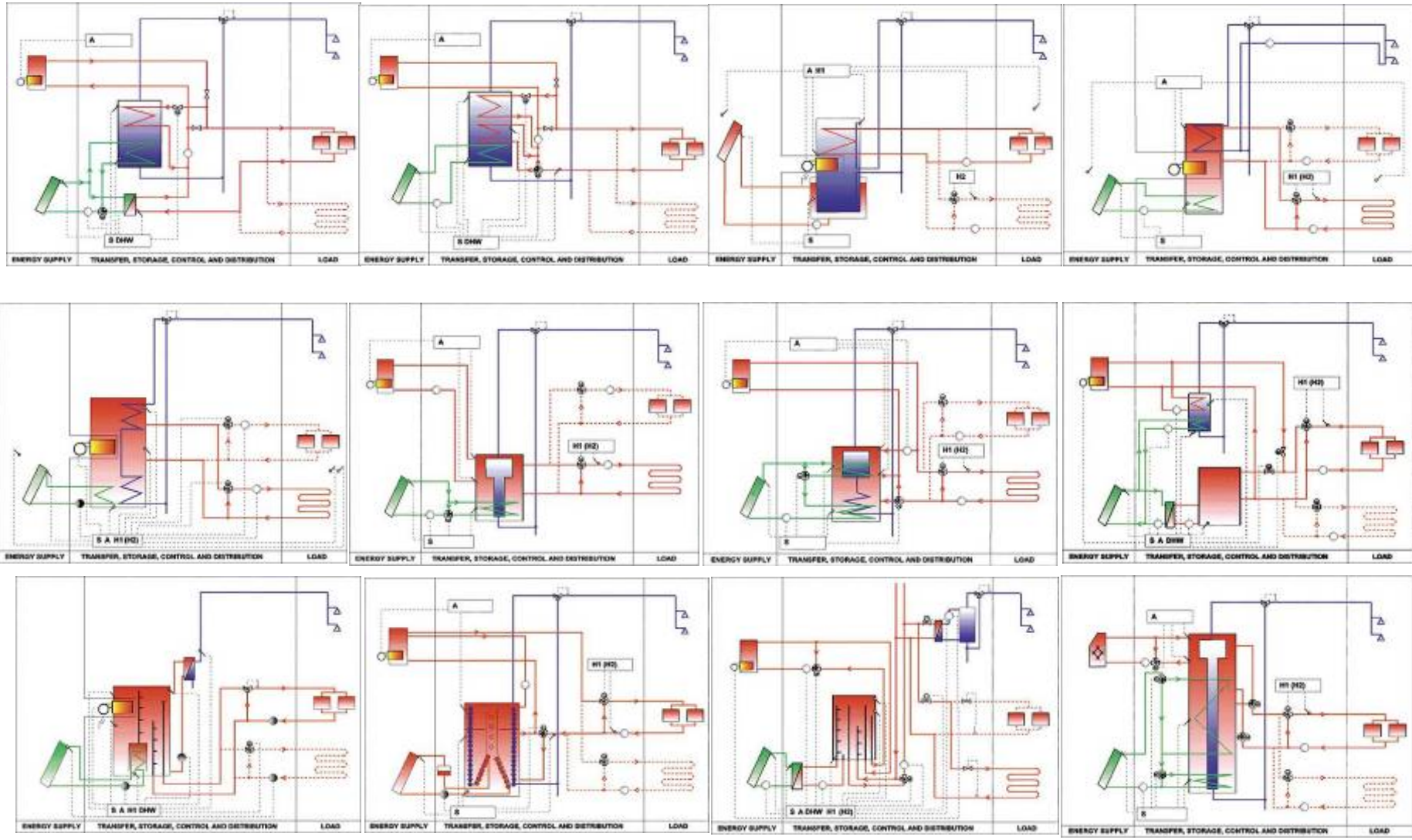
Utilization of solar radiation: 46%

Solar combi systems



Solar tanks for solar combi systems

A huge variety of designs exist:



and so on ……

Important for a well performing system

- Good interplay between solar collector and auxiliary energy supply system
- Small auxiliary volume in top of tank
- Low temperature level of auxiliary volume
- Low heat loss from heat storage

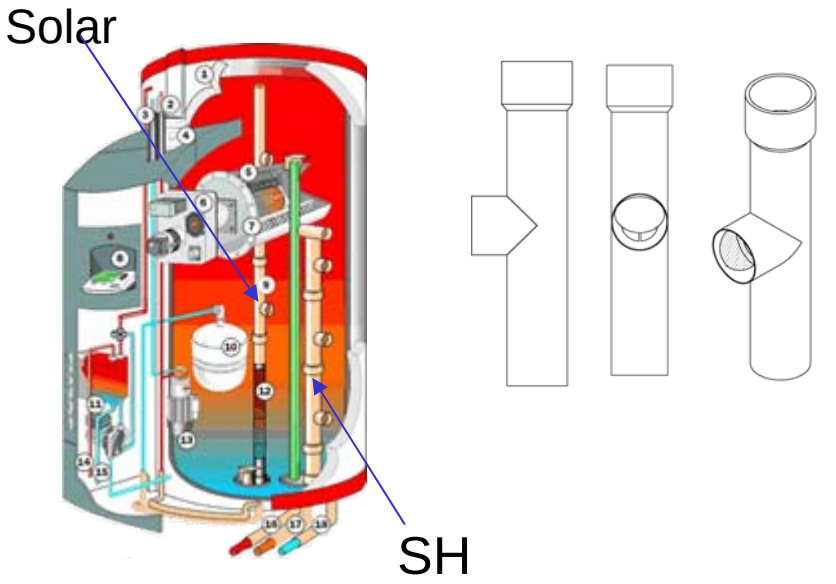
- Good thermal stratification in heat storage
- Independent of operation/installation conditions

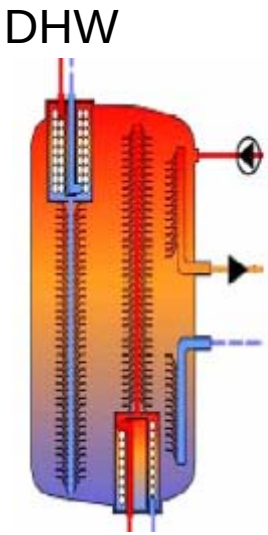
Increased thermal performance due to increased thermal stratification. Why?

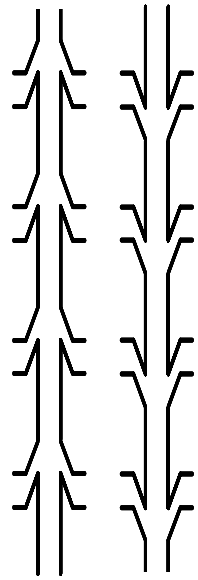
- Low temperature in lower part of tank results in longer operation periods for the solar collector and thus increased collector performance

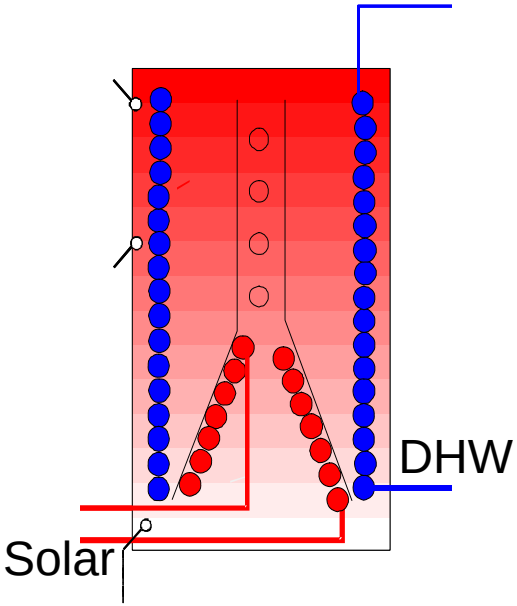
- High temperature in upper part of tank will meet the heat demand and/or turn off the auxiliary energy supply system

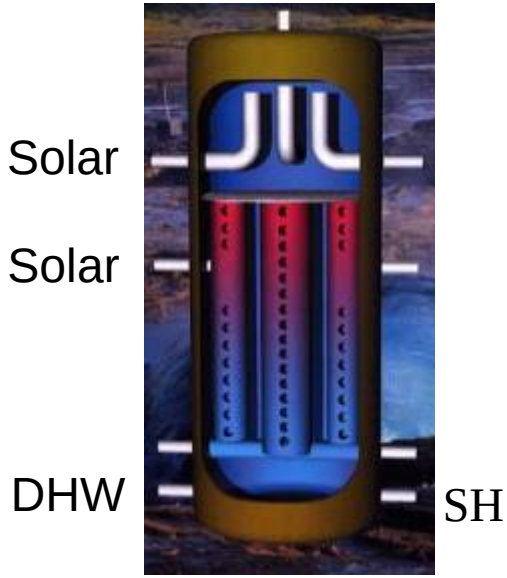
Inlet stratifiers for thermal stratification

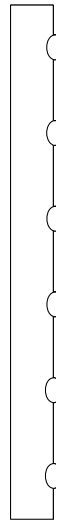








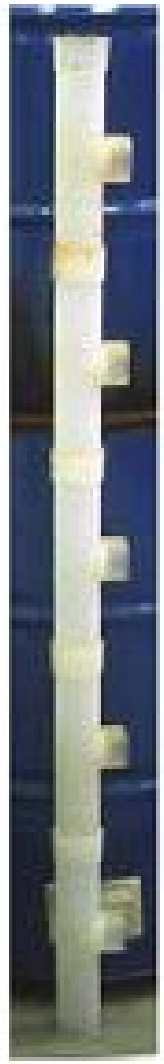




DHW = ***D***omestic ***H***ot ***W***ater

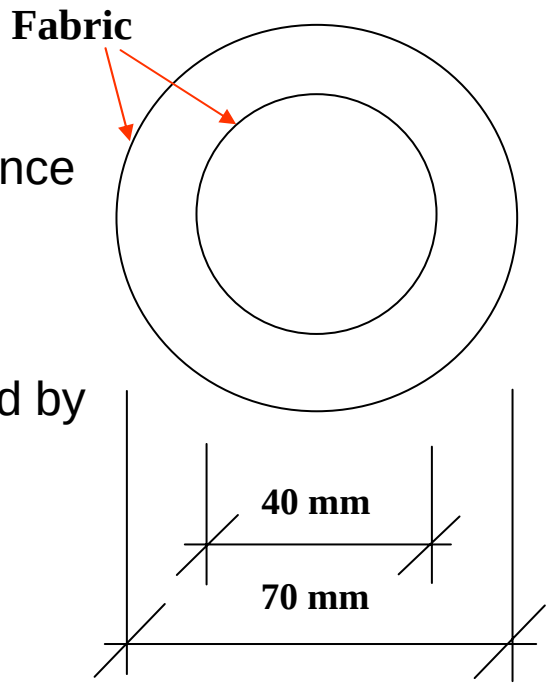
SH = ***S***pace ***H***eating

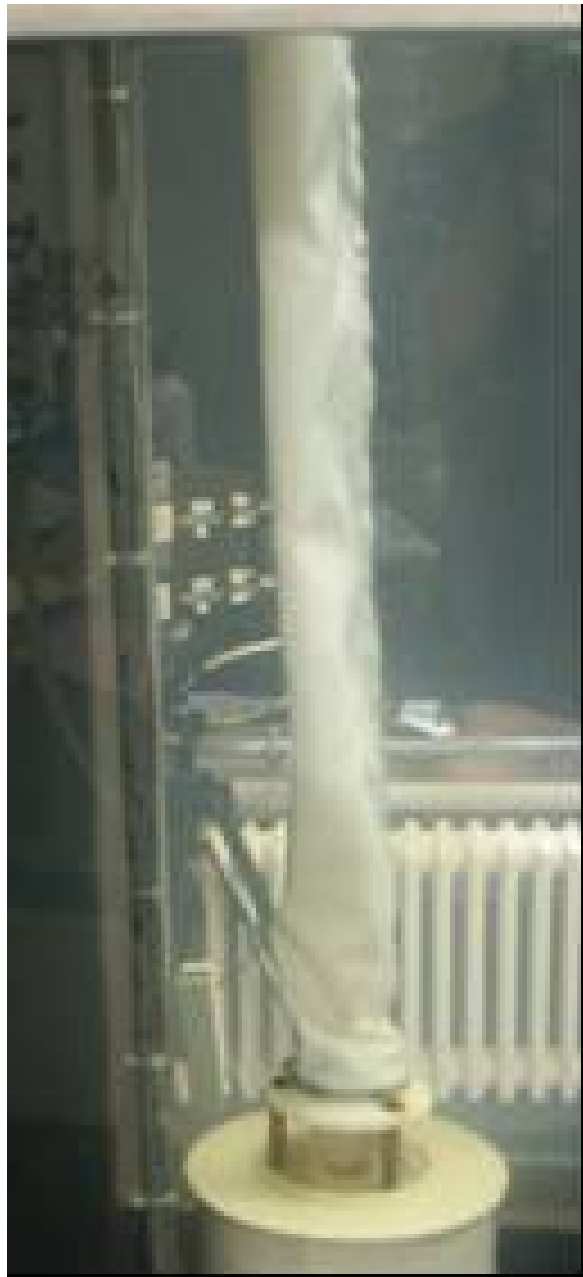
Solvis inlet stratifier



New fabric inlet stratifier – stratifier of the future?

Stratifier with two fabric layers





Status

- Excellent thermal performance
- Water inlet in all levels
- Inexpensive
- Easy to transport and store
- Optimal diameter influenced by flow rate

Future investigations

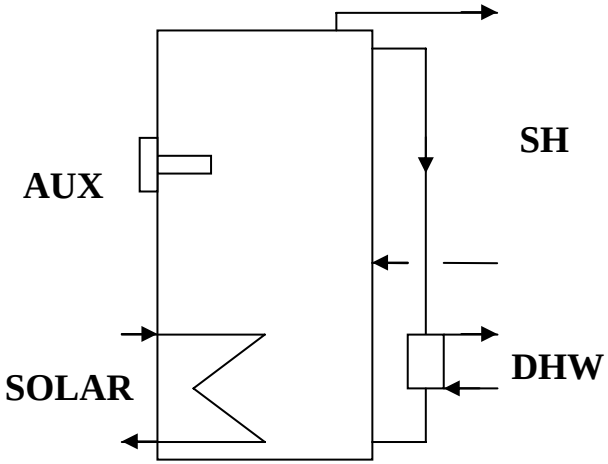
- Long time durability
- Experience from practice

Theoretical investigations of solar combi system with different solar tanks

Collector area: 20 m²

Solar tank volumne: 1000 l

Danish weather data

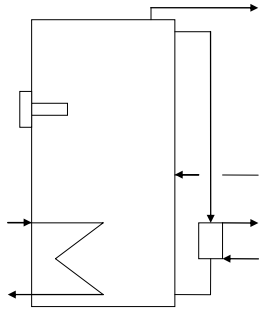


SH: Space heating

DHW: Domestic hot water

AUX: Auxiliary energy

SOLAR: Solar energy



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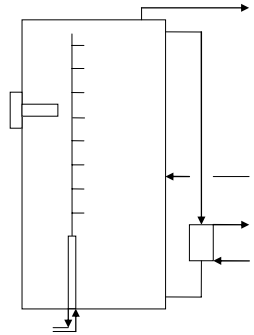

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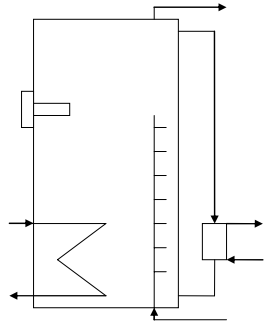
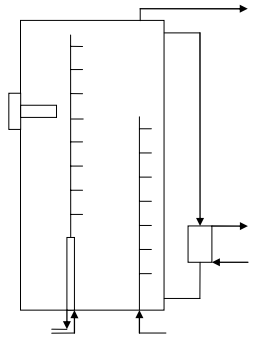
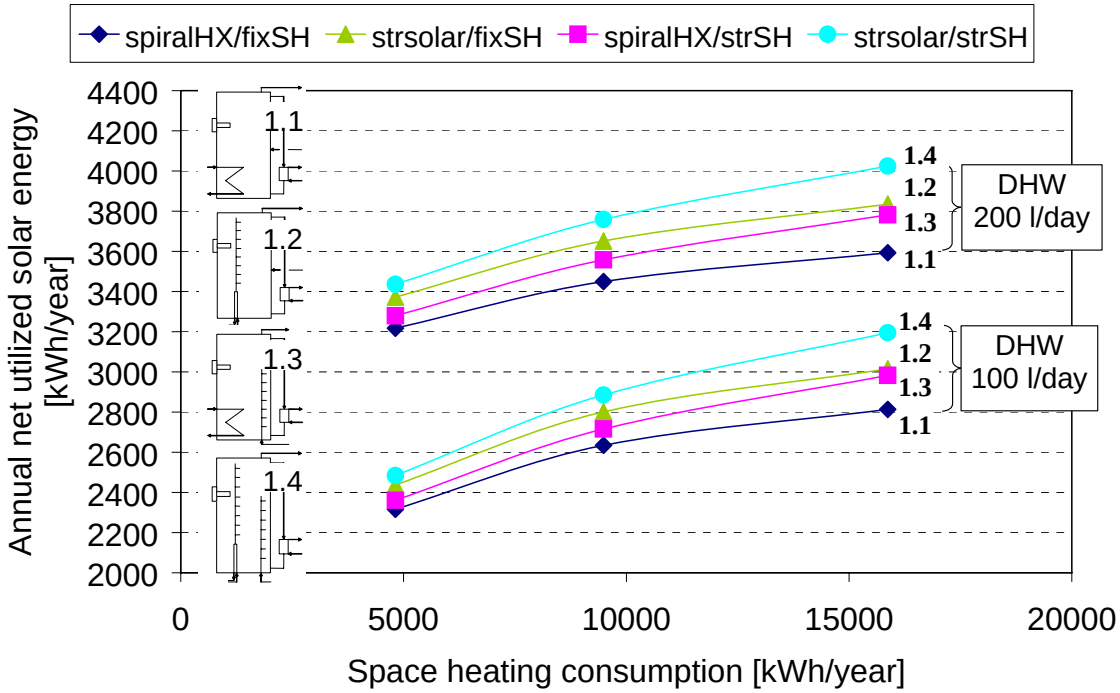


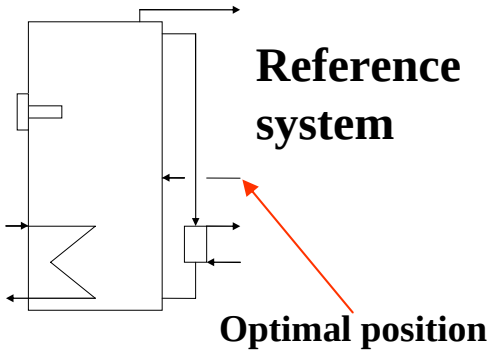
1.3

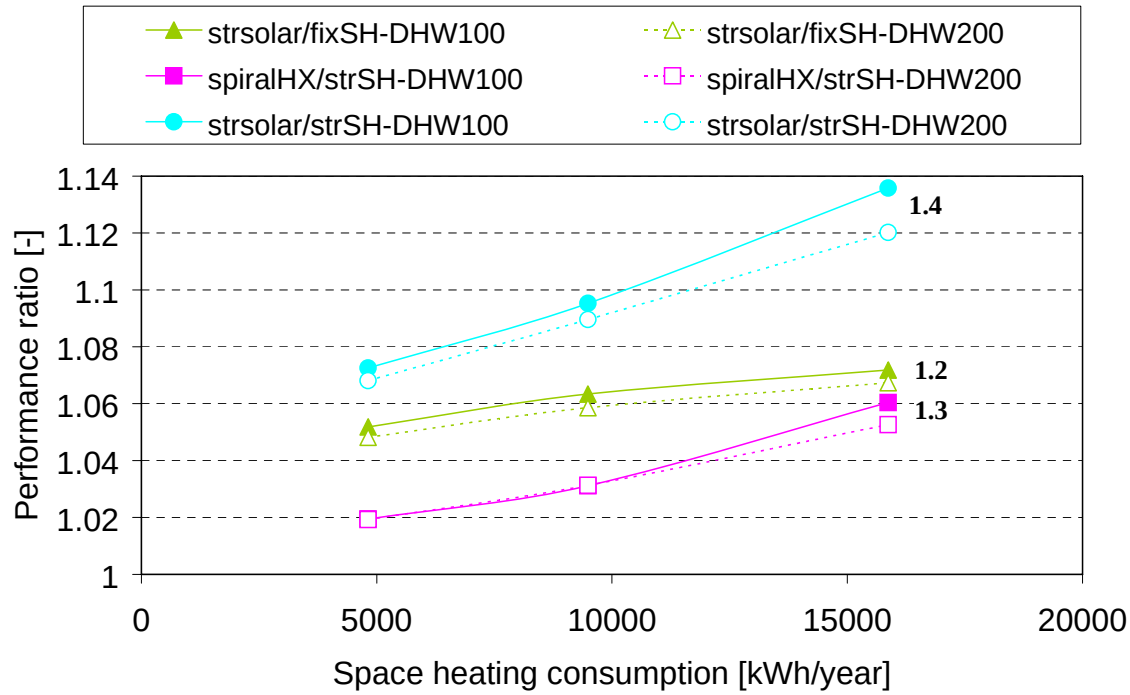


1.4

Step by step improvement







Theoretical investigations

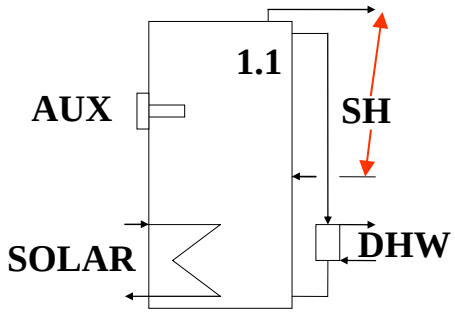
Reference systems

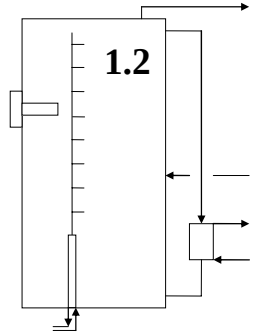
Stratifier in solar collector loop

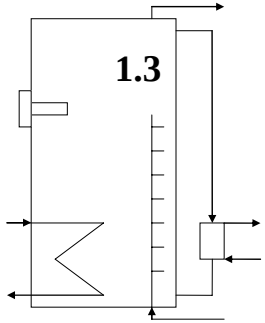
Stratifier in space heating loop

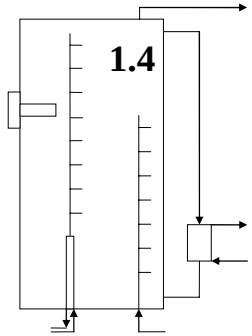
Stratifier in solar collector loop and in space heating loop

Heat storage with side-arm

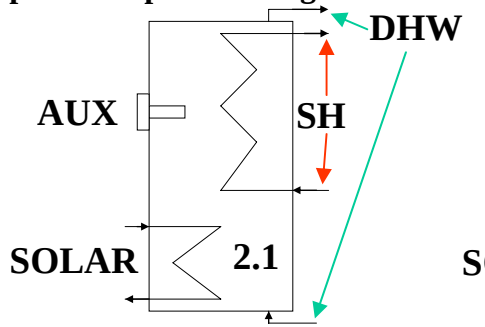


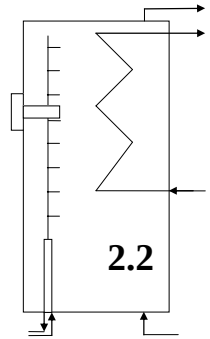




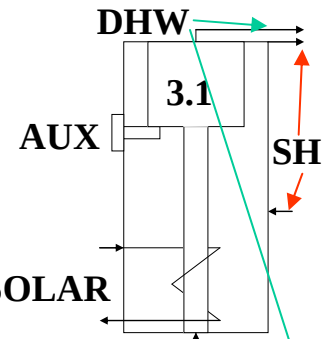


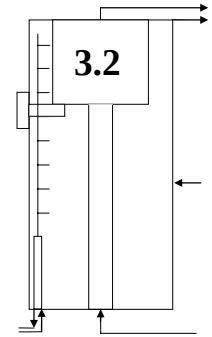
Hot water tank with heat exchanger spiral for space heating

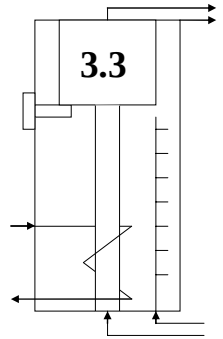


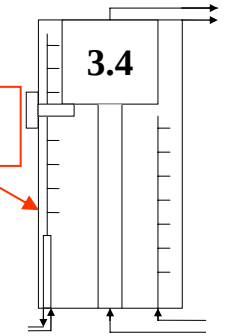


Tank in tank









Best tank ☺

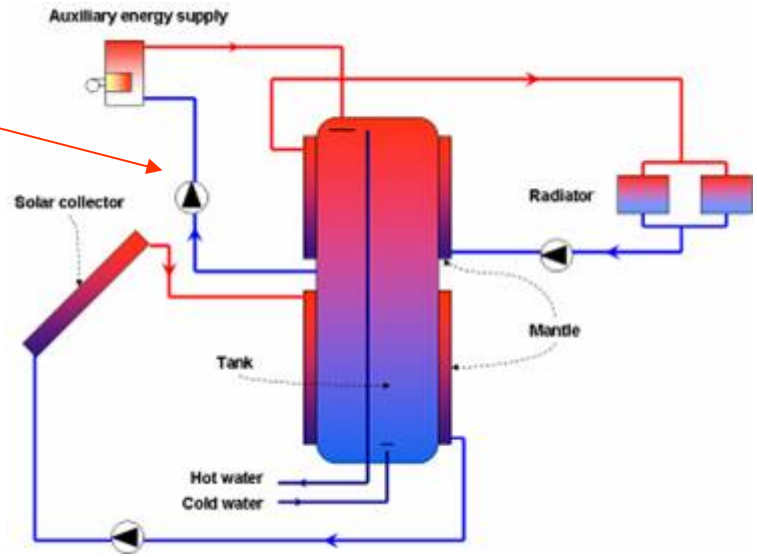
Future heat stores for solar combi systems

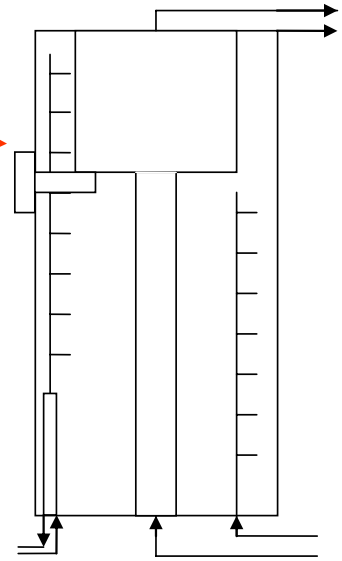
General:

- Tank/auxiliary energy supply system unit
- Smart tanks/smart control systems
- Solar/electric heating systems based on heat from wind turbines in windy periods; advanced control based on weather forecast

Tank types:

- Tank in tank storage with inlet stratifiers
- Bikini mantle tanks





- Seasonal PCM heat storage based on material with stable super cooling

Conclusions

- Possiblities for huge improvements of marketed solar tanks!

Future solar tanks

General

- Solar tank/auxiliary energy supply system units
- Low tank heat loss
- No thermal bridges/pipe connections in upper part of tanks
- Variable auxiliary volume fitted to heating demand
- Smart control of auxiliary energy supply system
- Highly stratified solar tank: Limited mixing, low downwards heat conduction, stratified charge and discharge

SDHW systems

- Mantle tanks
- Hot water tanks with inlet stratifier(s)

Solar combi systems

- Tank in tank heat storage with inlet stratifiers
- Bikini tanks
- Seasonal PCM stores

BYG·DTU Department of Civil Engineering

Ph.D. Course
Thermal stratification in solar storage tanks

September 27 – October 17, 2007

Kgs. Lyngby, Denmark: October 10-17, 2007

Organized by:
Department of Civil Engineering
Technical University of Denmark, DTU

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Thermal stratification in solar storage tanks

Department of Civil Engineering at the Technical University of Denmark, DTU, is hosting this Ph.D. course on Thermal stratification in solar storage tanks.

For small solar heating systems the heat storage is the most important component, both from a thermal and economical point of view.

The thermal performance of solar heating systems is strongly influenced by the thermal stratification in the heat storage. The better thermal stratification in the solar tank is built up and maintained the higher the thermal performance of the solar heating system. Consequently, it is very important that solar tanks are designed in such a way that thermal stratification is built up in the best possible way.

Further, in order to develop optimum designed solar tanks and evaluate differently designed solar storage tanks it is important to be able to model, measure and characterize thermal stratification in solar storage tanks.

The course is focused on all aspects of thermal stratification in solar storage tanks