Individual solar and smart energy systems

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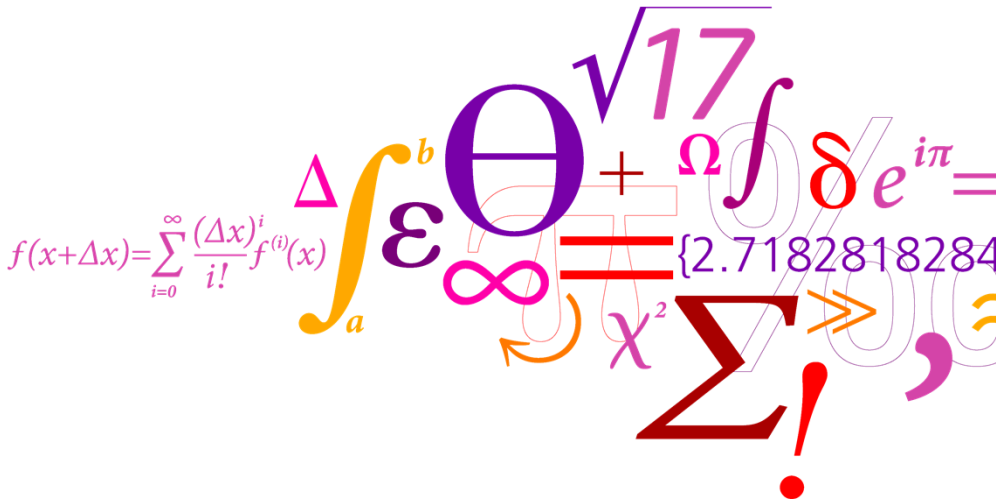
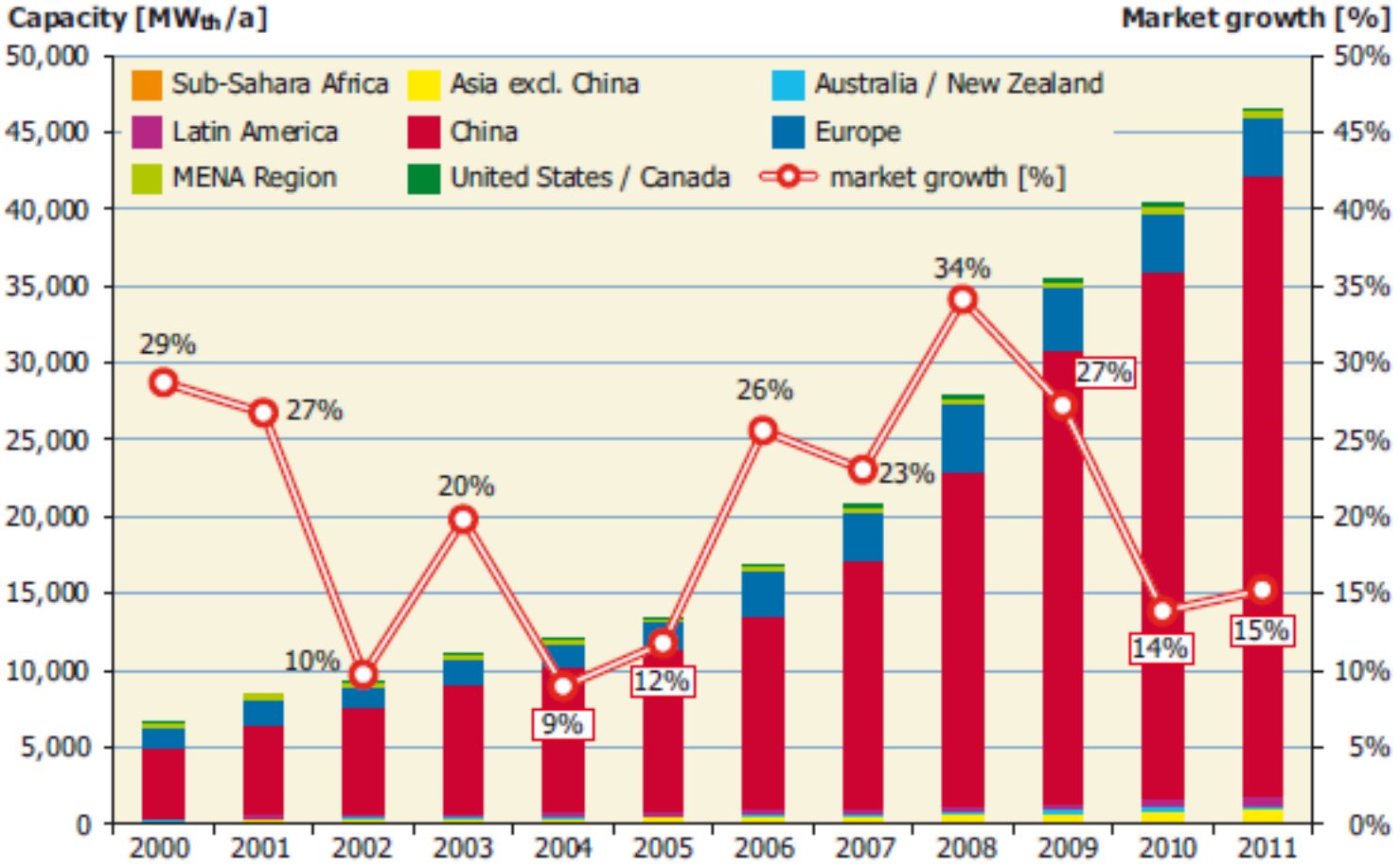


DTU Civil Engineering
Department of Civil Engineering

World solar heating market 2000 - 2011



Sub-Sahara Africa: Mozambique, Namibia*, South Africa, Zimbabwe
Asia excluding China: India, Japan, Korea South, Taiwan, Thailand**
Latin America: (Barbados**), Brazil, Chile, Mexico, Uruguay**
Europe: EU 27, Albania, Macedonia**, Norway, Switzerland, Turkey
MENA Region: Israel, Jordan, Lebanon, Morocco*, Tunisia

* 2011 estimated / ** 2010 and 2011 estimated

Figure 19: Annual installed capacity of flat plate and evacuated tube collectors from 2000 to 2011

Chinese and European markets 2000 - 2011

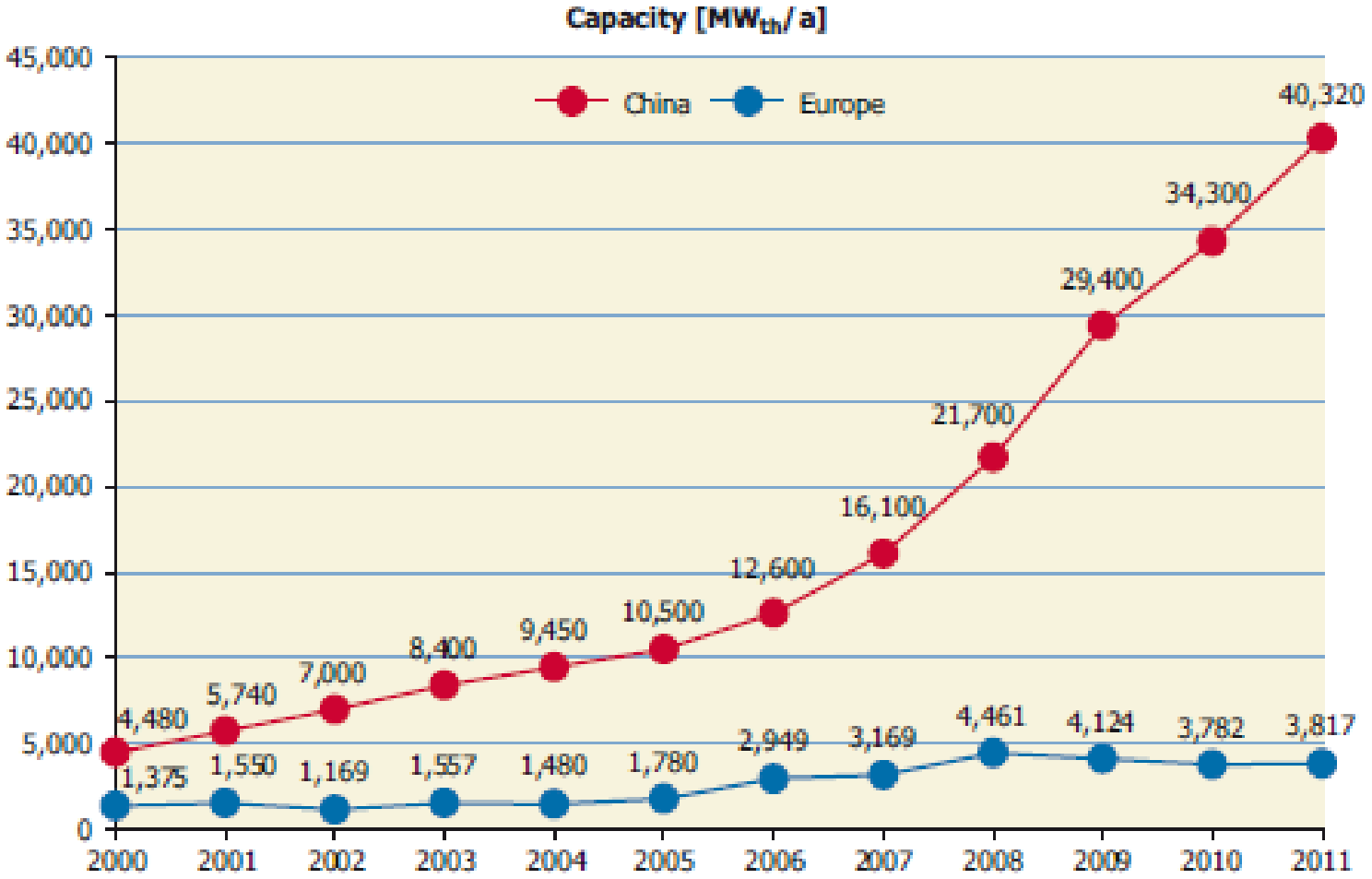


Figure 20: Annual installed capacity of flat plate and evacuated tube collectors from 2000 to 2011 in China and Europe

Installed solar heating power per person, end of 2011

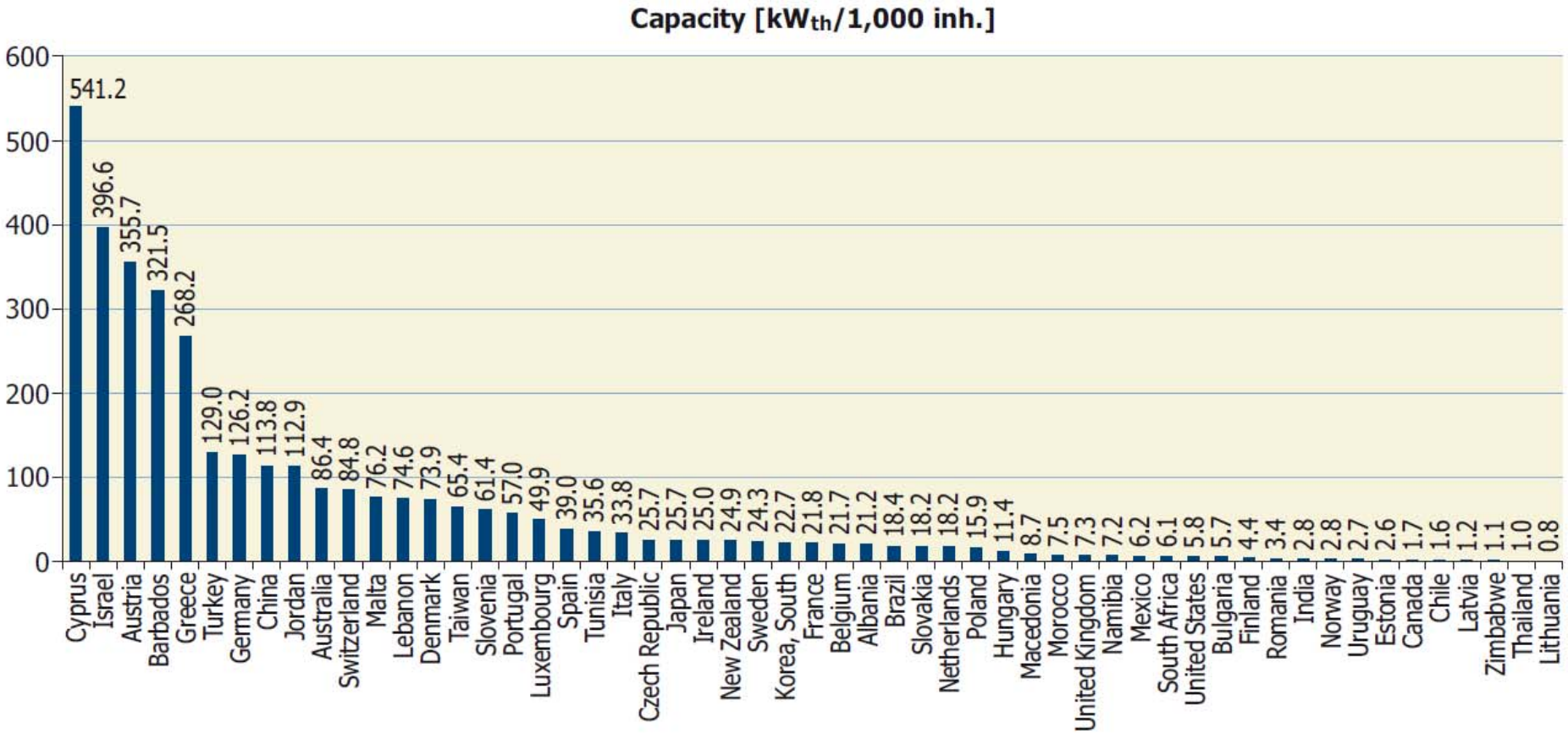


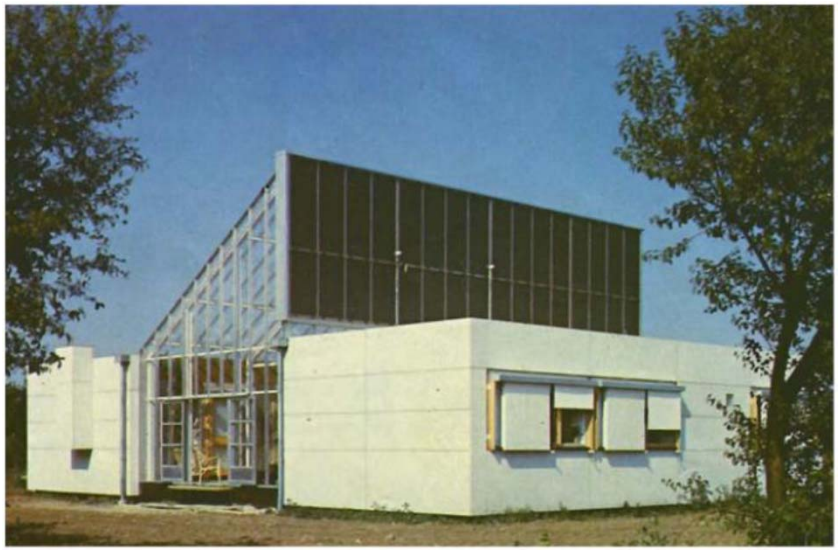
Figure 7: Total capacity of glazed flat plate and evacuated tube collectors in operation in kW$_{th}$ per 1,000 inhabitants by the end of 2011

ESTTP vision for solar heating 2050

50% of Europe's heating and cooling demand covered by solar thermal

New buildings: Heating and cooling demand fully covered by solar thermal

Zero energy house, DTU 1975

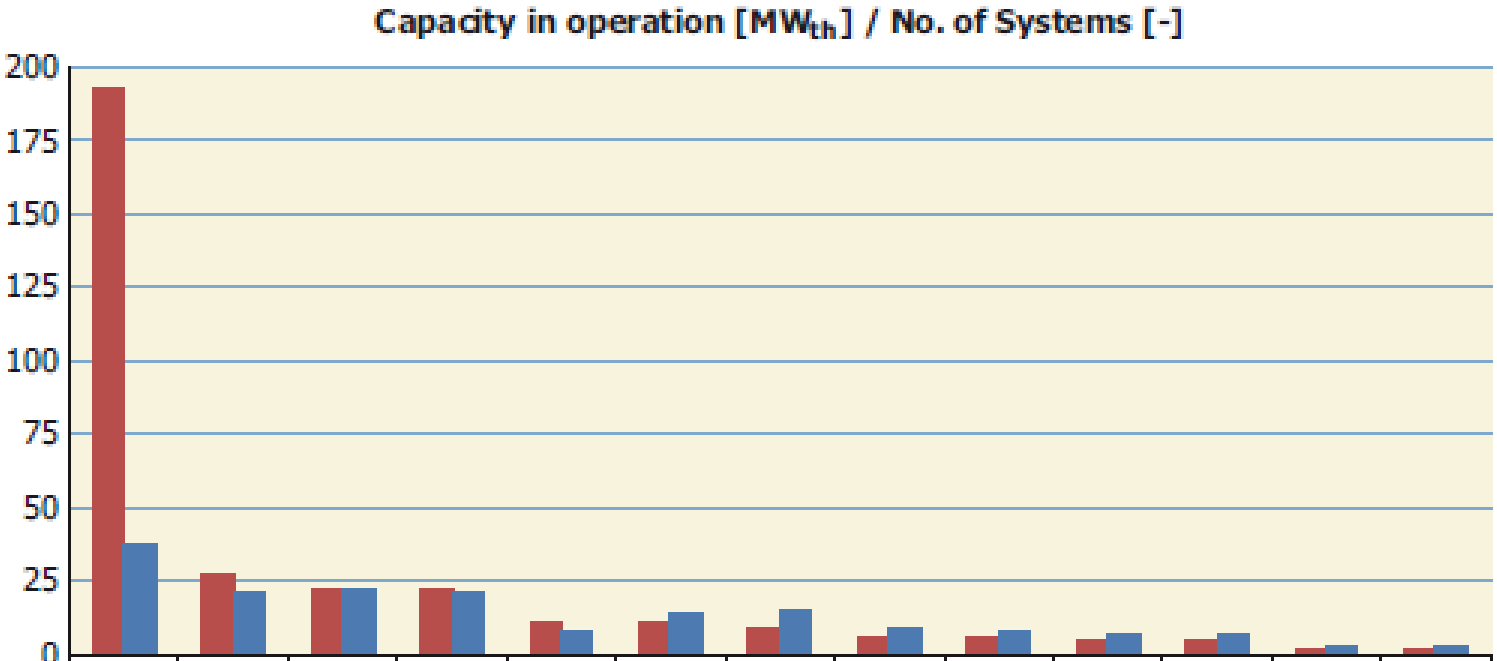


Renovation of buildings: More than 50% of heating and cooling demand covered by solar thermal

http://www.estif.org/fileadmin/estif/content/esttp/downloads/SRA/ESTTP_SRA.pdf

Need for education, research, development and demonstration now!

European large scale solar heating plants, end of 2012

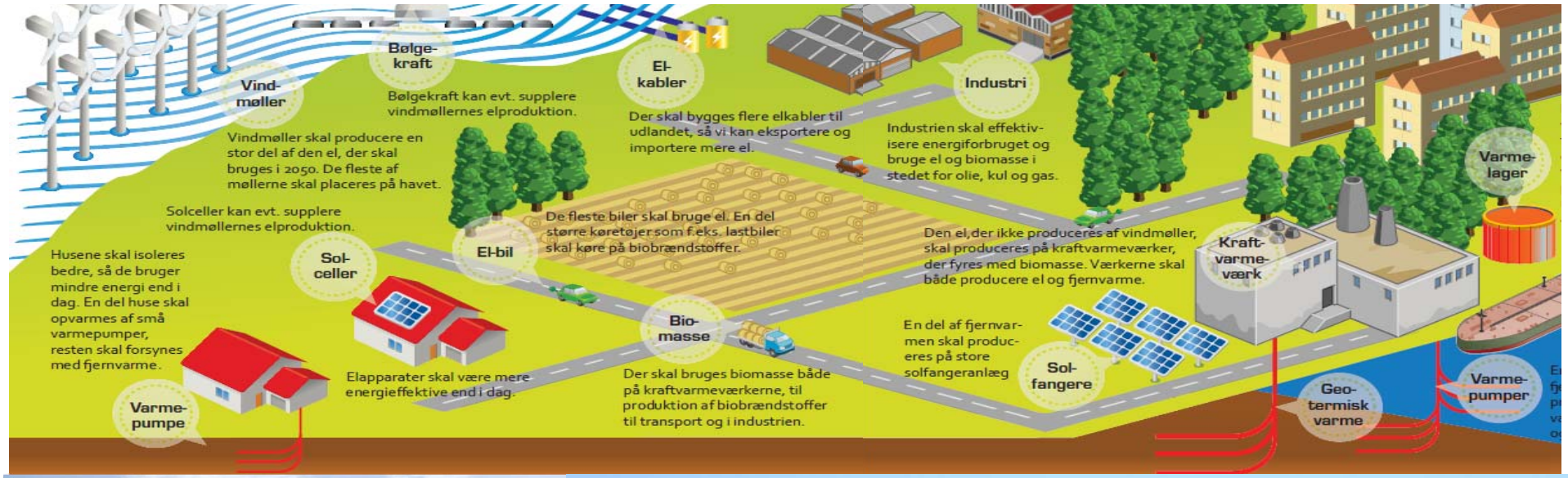


	DK	DE	AT	SE	NL	GR	ES	CH	PL	Oth.	IT	FR	CZ
Capacity [MW_{th}]	193.0	27.3	22.0	21.8	11.4	11.0	8.5	5.8	5.7	5.2	4.5	2.0	1.3
No. of Systems [-]	37	21	22	21	8	14	15	9	8	7	7	3	3

Figure 45: European large-scale solar heating systems by the end of 2012

(Source: Jan-Olof Dalenbäck - Chalmers University of Technology)

Denmark: Phase out all fossil fuels before 2050



<u>Wind energy:</u>

2012: 30% of electricity

2020 → 50 % of <u>increased</u> electricity consumption (incl. transport, heat pumps, …)

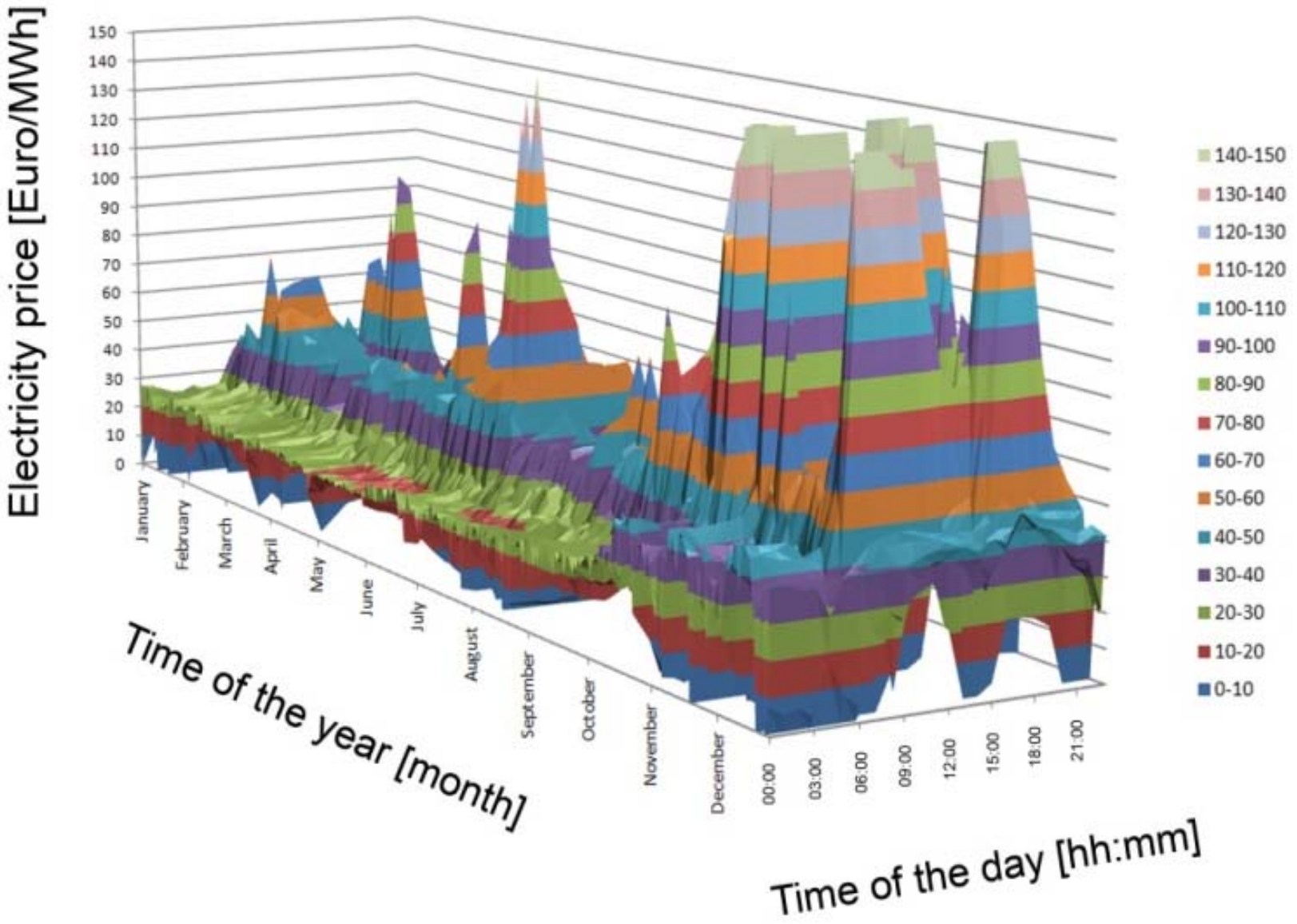
<u>Solar heating:</u>

2030: 15% of decreased heating demand

2050: 40% of decreased heating demand – 80% of this by district heating & 20% individual systems

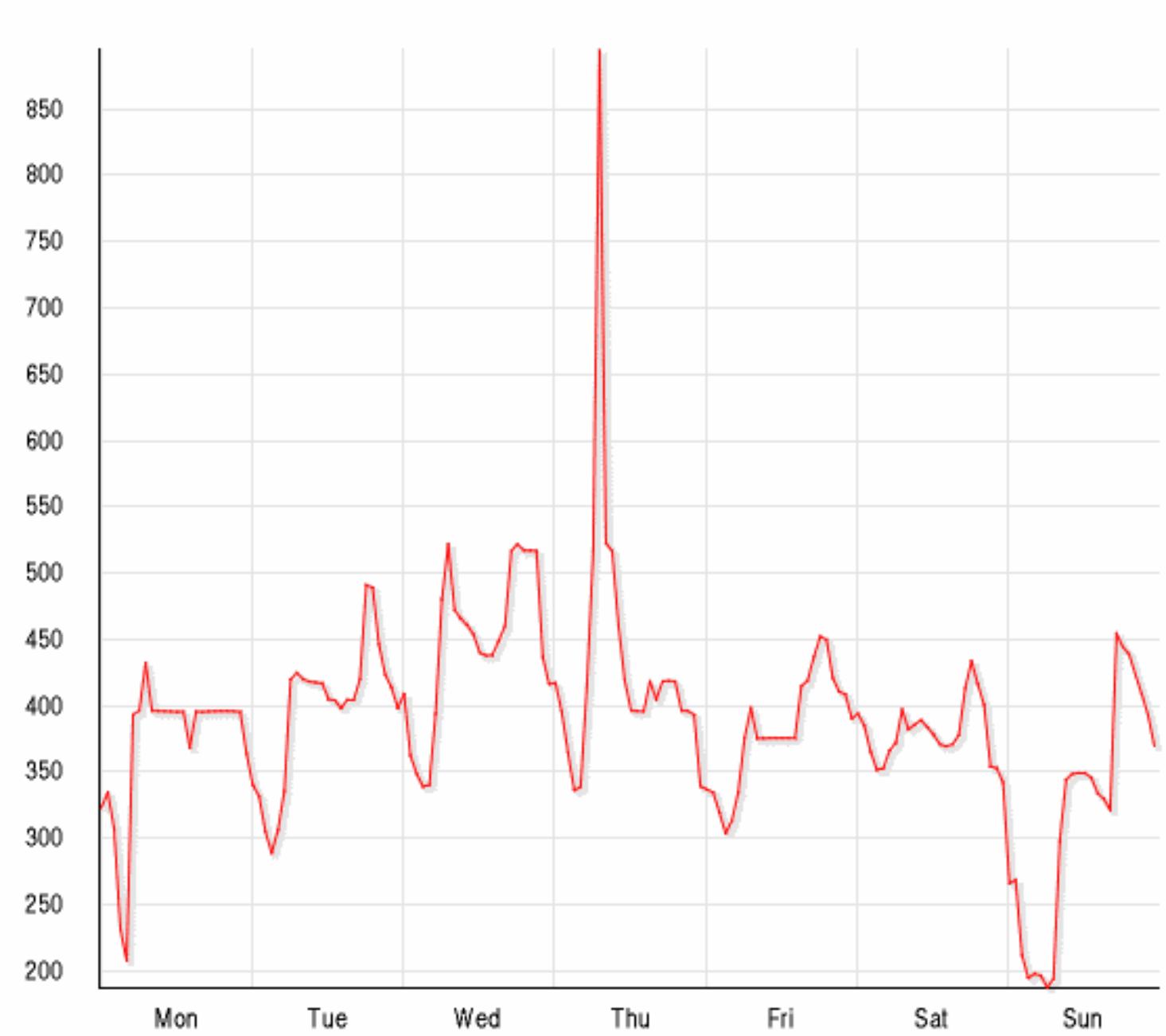
Danmark west, 2007 - from Nordpool

Electricity price variations during one year



Electricity price, DKK / MWh

Denmark west, November 3.-9., 2008



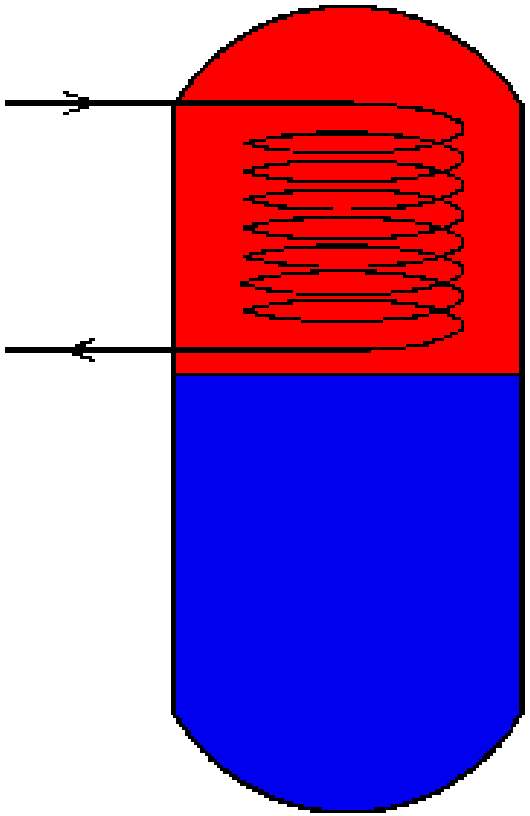
Individual solar/electric heating system for the future smart energy system

Individual solar/electric heating systems with smart heat storages, which can be heated by solar collectors and by electricity in periods with low electricity prices

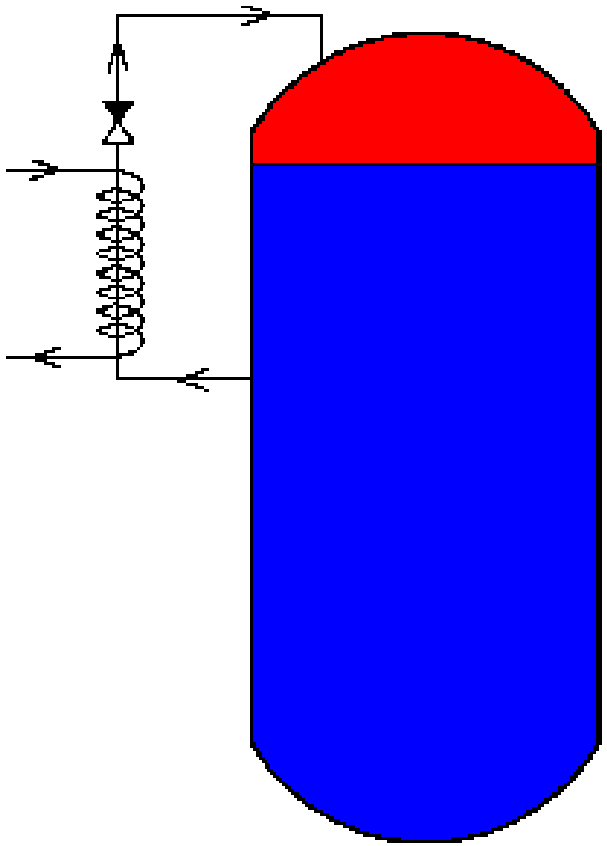
- Heat is produced by solar collectors and by electric heating elements or a heat pump
- Electric heating elements/heat pump if possible only in operation in periods where solar heat can not fully cover heat demand and where the electricity price is low
- System equipped with a smart heat storage (variable auxiliary volume) and a smart control system based on prognoses for:
  - heat demand
  - solar heat production
  - electricity price

Smart solar tanks for solar heating systems

MARKETED SOLAR TANK



SMART SOLAR TANK



TANK HEATED FROM THE TOP

INDIVIDUAL FLEXIBLE TIMER/ENERGY CONTROL SYSTEM

Solar heating systems with smart solar tanks

Increased thermal performance by up to 35% due to:

☺ Decreased tank heat loss

☺ Increased solar heat production

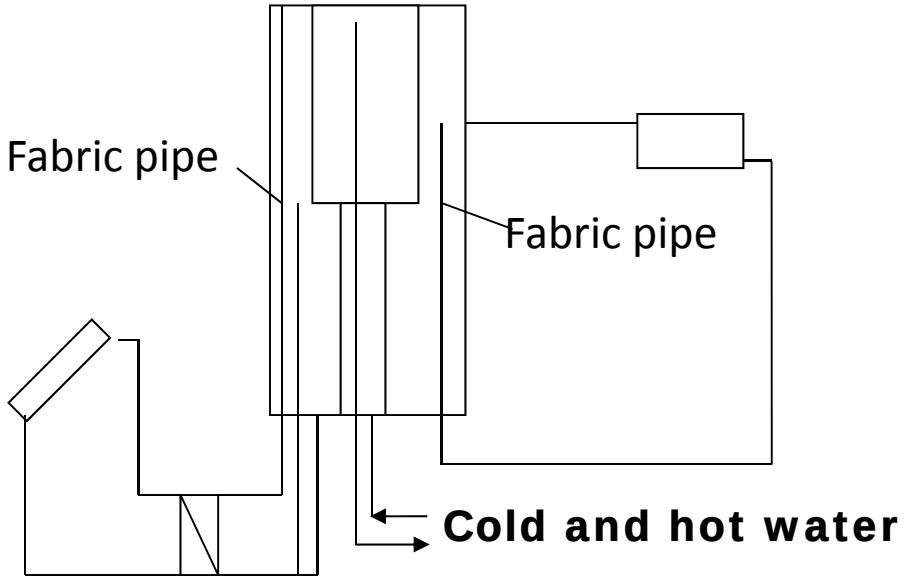
Further, also additional improved cost efficiency due to:

☺ Use of low electricity price

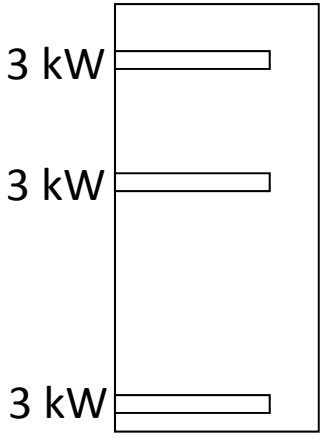
Three systems tested side by side

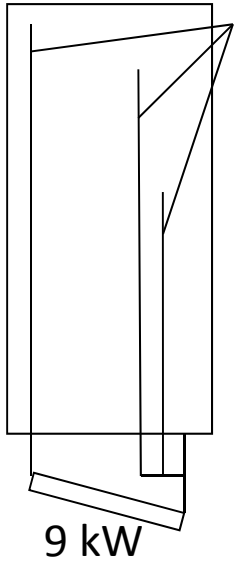
- 9 m² solar collector
- 735 l smart solar tank. Auxiliary: One electric heating element, three electric heating elements, heat pump
- Smart control system - heat content in tank, weather forecast, coming heat demand, coming solar heat production, coming electricity prices from NORDPOOLSPOT

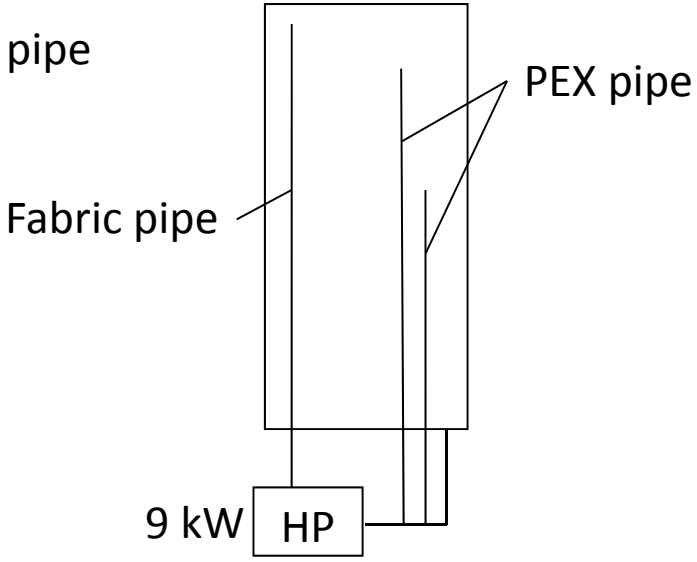
Solar collector loop & discharge loops



Auxiliary heating principles







Measured results for spring 2013

- Heat price for two systems based on one electric heating element and three electric heating elements almost the same
- Heat price for systems with electric heating element(s) = 2 x Heat price for system with heat pump

Information available in report ”Solar/electric heating systems for the future energy system”, Department of Civil Engineering, Technical University of Denmark, report R-288. Can be downloaded from: http://www.byg.dtu.dk/~/media/Institutter/Byg/publikationer/byg_rapporter/byg-r288.ashx

Theoretical calculations - results

Home owner

- Heat price for house: 100%
- Heat price for house with 10 m² solar combi system: 70-80%
- Heat price for house with 10 m² smart solar heating system with electric heating elements and variable electricity price: 30-50%
- Heat price for house with 10 m² smart solar heating system with heat pump and variable electricity price: 15-25%

Society

- Socio-economic benefit of smart solar heating systems compared with a reference scenario with oil and gas boilers: The total benefit: 2200 - 6100 DKK per system per year

Conclusions

- Individual smart solar heating systems with electric heating elements/heat pump and variable electricity price are more cost-effective than traditional solar heating systems
- Individual smart solar heating systems with electric heating elements/heat pump can help integrating wind power in the energy system and contribute to an increased share of renewable energy
- For houses with low heat demand a smart solar heating system with electric heating elements is most attractive
- For houses with normal or high heat demand a smart solar heating system with a heat pump is most attractive

Recommendations

Development of individual solar heating systems for the future

General:

- Low flow systems: Serial connected solar collectors of different types, small all in one solutions for solar collector loops including hot and cold pipes, small low energy circulation pumps with variable flow rates
- Heat stores: Low heat losses from pipe connections and thermal bridges, good thermal stratification (tank design, inlet stratifiers), discharge from different levels, smart tanks with variable auxiliary volumes, new insulation materials
- Good interplay between solar collectors and auxiliary energy supply system
- Smart control systems
- Prefabricated easy to install solar tank/energy system units
- Drain back systems using water as solar collector fluid
- Compact seasonal heat storage: PCM heat storage, chemical heat stores

Specific:

- Heating systems based on solar collectors, a smart tank with electric heating element(s) and a smart controller for houses with low heat demand
- Heating systems based on solar collectors, a heat pump, a smart tank and a smart controller for houses with normal or high heat demand

Perspectives

- Individual smart solar/electric heating systems for buildings outside district heating systems can in the future play an important role for home owners and for the energy system

- Individual smart solar/electric heating systems combines in an excellent way solar and wind energy