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The new series of premium radiator thermostats

living by Danfoss energy simulations

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Documentation: University of Aachen, Germany

- The energy simulation is conducted in 2010
- The simulations have been prepared by University of Aachen in Germany. Mr. Prof Dr.-Ing. Rainer Hirschberg has headed the project at the University.
- Since 1985 Prof. Hirschberg has been public expert for heating, ventilation and sanitary engineering in Germany and since 1999 he has been a professor at the University of Aachen. In 1991, Prof Hirschberg was appointed as member of the Executive Board of the German Society of Engineers (VDI) and he is today still chairman and resource in connection with various VDI guidelines and DIN Standards

Author

Prof. Dr.-Ing. Rainer Hirschberg

Hochschule Aachen

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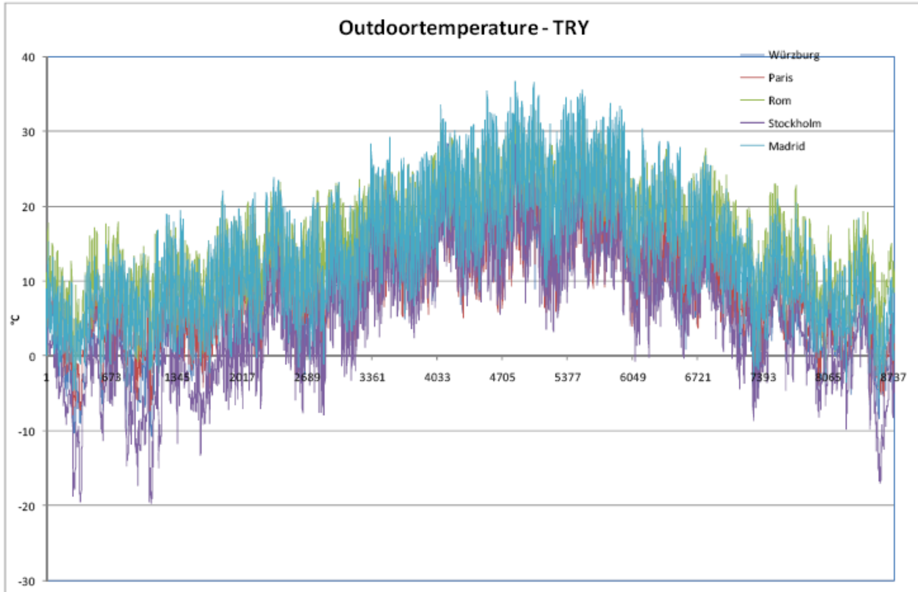
Prof. Dr.-Ing. Rainer Hirschberg

Documentation: Background knowledge

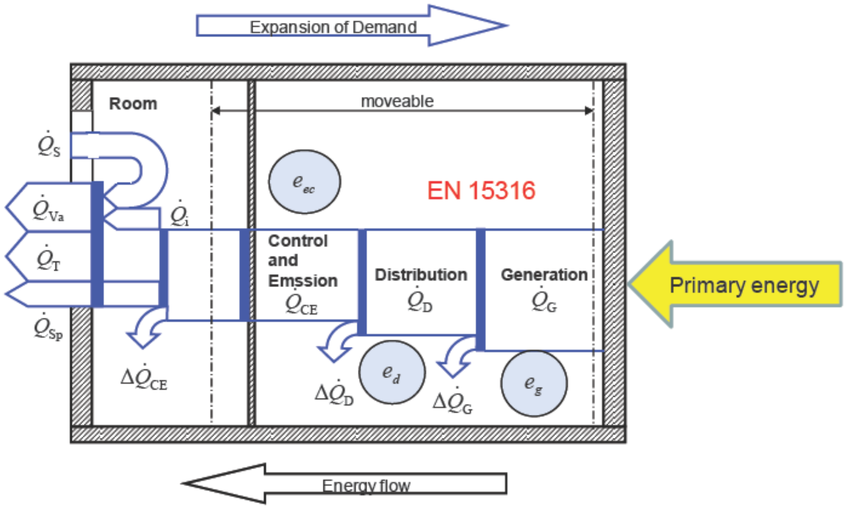
- The results are based on a simulation study, where the energy efficiency of generation and distribution systems are based on European standards
- The remaining components, i.e. pipes, pumps, rooms insulation, TRVs etc are modelled in the well accepted simulation tools TRANSYS and SIMULINK. These simulation programs are both common and found trustworthy within the field of simulation
- When making the simulations, one room (20 sqm) is simulated – this is sufficient for comparing different application setups
- Outside temperatures are taken from the city Würtzburg in Germany. However, the weather conditions can be transferred direct to other countries because of the mean part load of the heating demand. All results in the simulations are therefore relative
- Important to notice is, that the only parameter we change in the simulations is the controls type on the radiator (ie. manual valve, old TRV, electronical TRV etc)

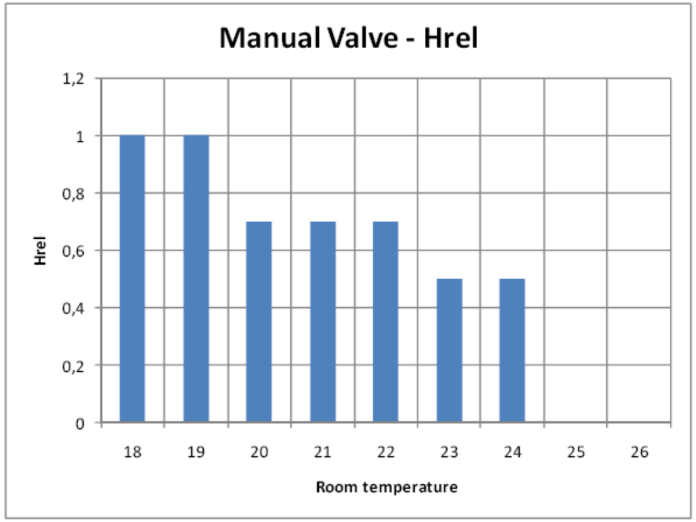


Σ As all figures are relative they are valid for different heat sources and for different geographies.
A simulation study is an appropriate tool to make relative comparisons

Documentation: Definitions

- Generation and distribution expenditure values from EPBD EN15316 standards
- When evaluating the energy efficiency of the different applications, the factor e_{tot} is used. e_{tot} is defined as the energy needed to be generated at the power supply in order to supply 1 unit of heat into the room, i.e. it takes into account all types of heatloss in this process, for instance:
  - energy loss at the power supply
  - energy loss in the pipework
  - energy loss due to the way the TRV performs
  - etc
- In case of use of manual radiator valves, they are operated by the user at 100%, 70%, 50% and 0% open (see graph)





Documentation: Summary of results of e_{tot}

ID	Control type	Energy demand	e_{tot}
1	Manual valves	1,000	2,022
2	Old TRV (15+ years)	1,000	1,401
3	New TRV	1,000	1,293
4	Electronic TRV (no temperature setback)	1,000	1,224
5	Electronic TRV P1	0,959	1,163
6	Electronic TRV P2	0,907	1,099
7	Electronic TRV P2 + holiday	0,894	1,084

- The energy needed to be generated (etot) at the power supply in order to get the needed energy into the room is quite different depending on the controls on the radiator used
- Example: Replacing manual valves (ID1) with new selfacting TRVs (ID3) an energy saving of 36% is expected (2,022-1,293/2,022)

Documentation: Relative comparison of the different control types on the radiator

ID	1	2	3	4	5	6	7
1	0%						
2	31%	0%					
3	36%	8%	0%				
4	39%	13%	5%	0%			
5	42%	17%	10%	5%	0%		
6	46%	22%	15%	10%	5%	0%	
7	46%	23%	16%	11%	7%	1%	0%

Explanation of IDs

ID 1: Manual valves

ID 2: Old TRV (15+ years)

ID 3: New TRV

ID 4: Electronic TRV (no temp setbacks)

ID 5: Electronic TRV P1

ID 6: Electronic TRV P2

ID 7: Electronic TRV P2 + Holiday

- Based on the e_{tot} calculations on the previous slide, we can calculate the energy savings in % when replacing one control type with another
- The table above shows the energy savings at the different replacement options

ΣGoing from one control to another control has quite an impact on energy savings…

Documentation: Where does the energy saving come from?

ID	1	2	3	4	5	6	7
1	0%						
2	31%	0%					
3	36%	8%	0%				
4	39%	13%	5%	0%			
5	42%	17%	10%	5%	0%		
6	46%	22%	15%	10%	5%	0%	
7	46%	23%	16%	11%	7%	1%	0%

Explanation of IDs

ID 1: Manual valves

ID 2: Old TRV (15+ years)

ID 3: New TRV

ID 4: Electronic TRV (no temp setbacks)

ID 5: Electronic TRV P1

ID 6: Electronic TRV P2

ID 7: Electronic TRV P2 + Holiday

- From ID1 to ID2: Automatic and continuous control of room temperature
- From ID2 to ID3: Dirt, wear & agening of plastics all result in increased backlash and friction
- From ID3 to ID4: PID control instead of P control -> faster regulation and less overshoot
- From ID4 to ID5: Temperature set-back during nights (from 22.30 – 06.00)
- From ID5 to ID6: Temperature set-back during days (from 08.00 – 16.00 on work days)
- From ID6 to ID7: Temperature set-back during 1+1 week holiday per year

Documentation: Applications with room reference thermostat – e_{tot} summary

(most relevant for FR, UK, BE, NL)

ID	Control type	Operation modes for rooms R1/R2/R3	Energy demand	e_{tot}
1a	Manual valves	F/A/A	0,882	1,834
2a	Old TRV (15+ years)	F/A/A	0,882	1,318
3a	New TRV	F/A/A	0,882	1,209
4a	Electronic TRV (no temperature setback)	F/A/A	0,882	1,158
5a	Electronic TRV with individual programming	F/G/H	0,851	1,120

- The energy needed to be generated (etot) at the power supply in order to get the needed energy into the room is quite different depending on the controls on the radiator used – also in boiler controlled applications with a room reference thermostat
- Five rooms are simulated: 1xR1, 2xR2 and 2xR3. This can be upscaled to a house.
- The boiler set-back mode is F. When the boiler set-back mode is activated, it applies to all rooms

Operation mode	
A	Continues
F	Night and day set-back (set-back temperature 8C) from 08.00-16.00 (only working days) + from 22.30-06.00
G	Night and day set-back 4K from 08.00-18.00 (only working days) + from 21.00-06.00
H	Night and day set-back 4K from 07.00-21.00 (only working days) + from 22.30-06.00

Documentation: Relative comparison of the different control types on the radiator

ID	1a	2a	3a	4a	5a
1a	0%				
2a	28%	0%			
3a	34%	8%	0%		
4a	37%	12%	4%	0%	
5a	39%	15%	7%	3%	0%

Explanation of IDs

ID 1a: Manual valves

ID 2a: Old TRV (15+ years)

ID 3a: New TRV

ID 4a: Electronic TRV (no temperature set-back)

ID 5a: Electronic TRV (with individual programming (F/G/H))

- Based on the e_{tot} calculations on the previous slide, we can calculate the energy savings in % when replacing one control type with another in a boiler-controlled application
- The table above shows the energy savings at the different replacement options

Σ In boiler controlled applications with a room reference thermostat, the energy savings by using electronic radiator thermostats are lower than in “normal” applications

Σ However, the energy savings are still very attractive

Documentation: Where does the energy saving come from?

ID	1a	2a	3a	4a	5a
1a	0%				
2a	28%	0%			
3a	34%	8%	0%		
4a	37%	12%	4%	0%	
5a	39%	15%	7%	3%	0%

Explanation of IDs

ID 1a: Manual valves

ID 2a: Old TRV (15+ years)

ID 3a: New TRV

ID 4a: Electronic TRV (no temperature set-back)

ID 5a: Electronic TRV (with individual programming (F/G/H))

- From ID1a to ID2a: Individual and automatic control of room temperature in remaining rooms
- From ID2a to ID3a: Dirt, wear & agening of plastics all result in increased backlash and friction
- From ID3a to ID4a: PID control instead of P control -> faster regulation and less overshoot
- From ID4a to ID5a: Individual day set-back in rooms according to F/G/H modes