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Heat Output from Space Heating Radiator with Add-on-fan Blowers

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Background

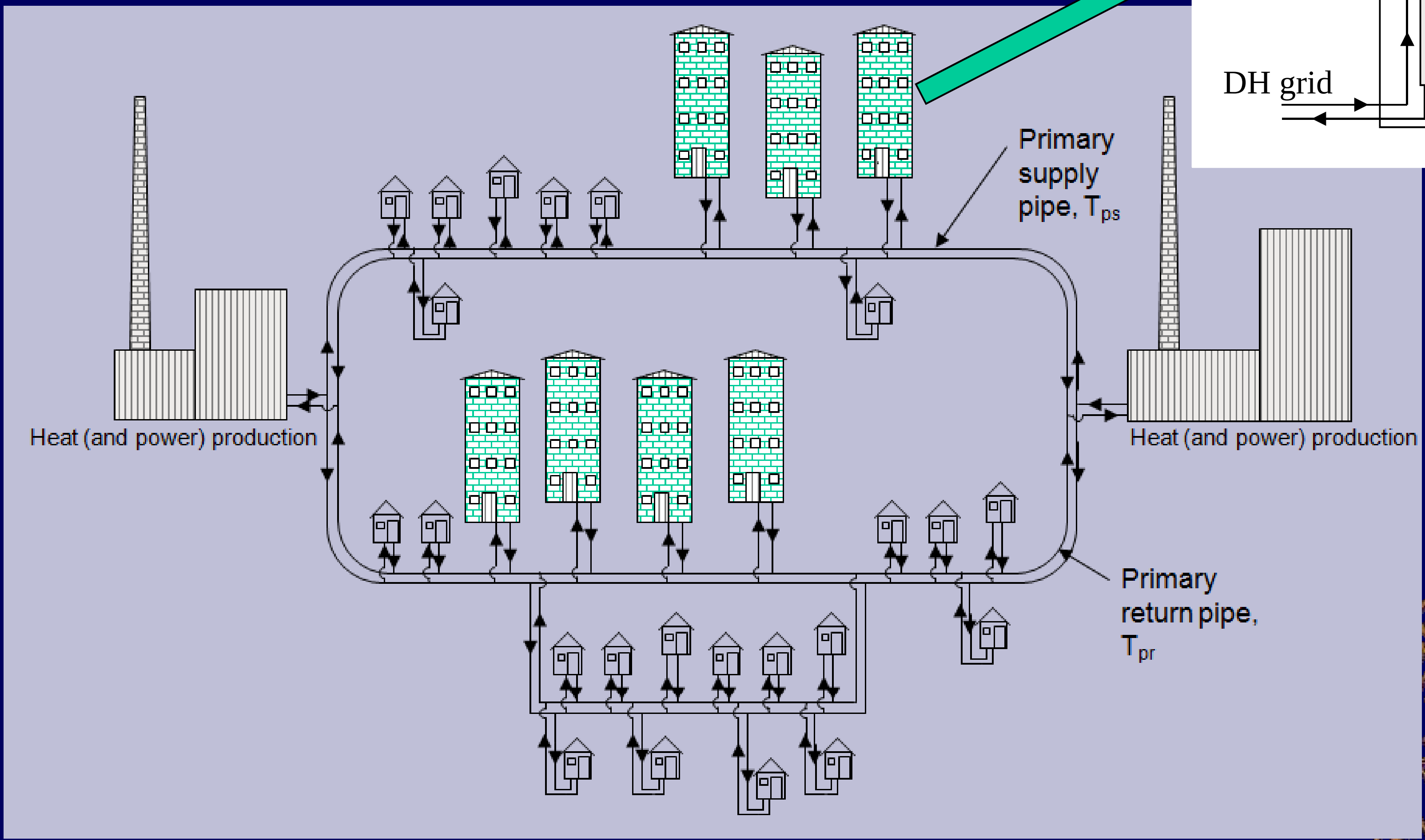
DH temperatures are dependent on the temperature demand in the connected buildings

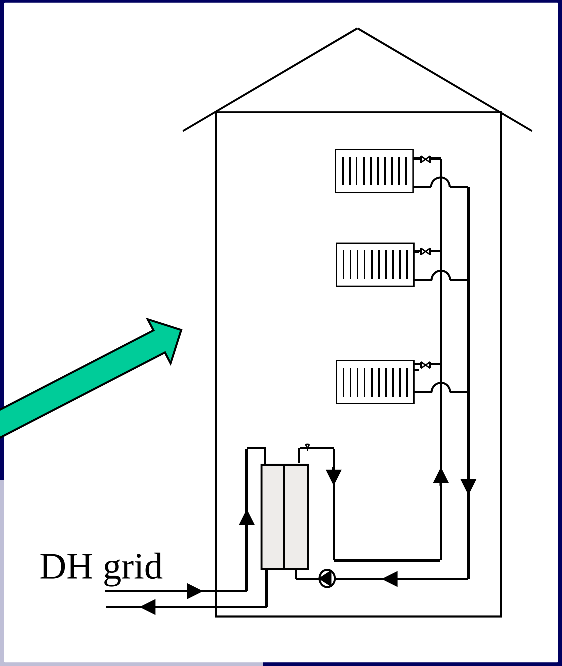
Space heating return temperature describes the District Heating (DH) return temperature

Low temperature heating systems leads the way towards a reduced DH temperature

Improved heat output without changing exciting space heating system by using add-on-fan blowers

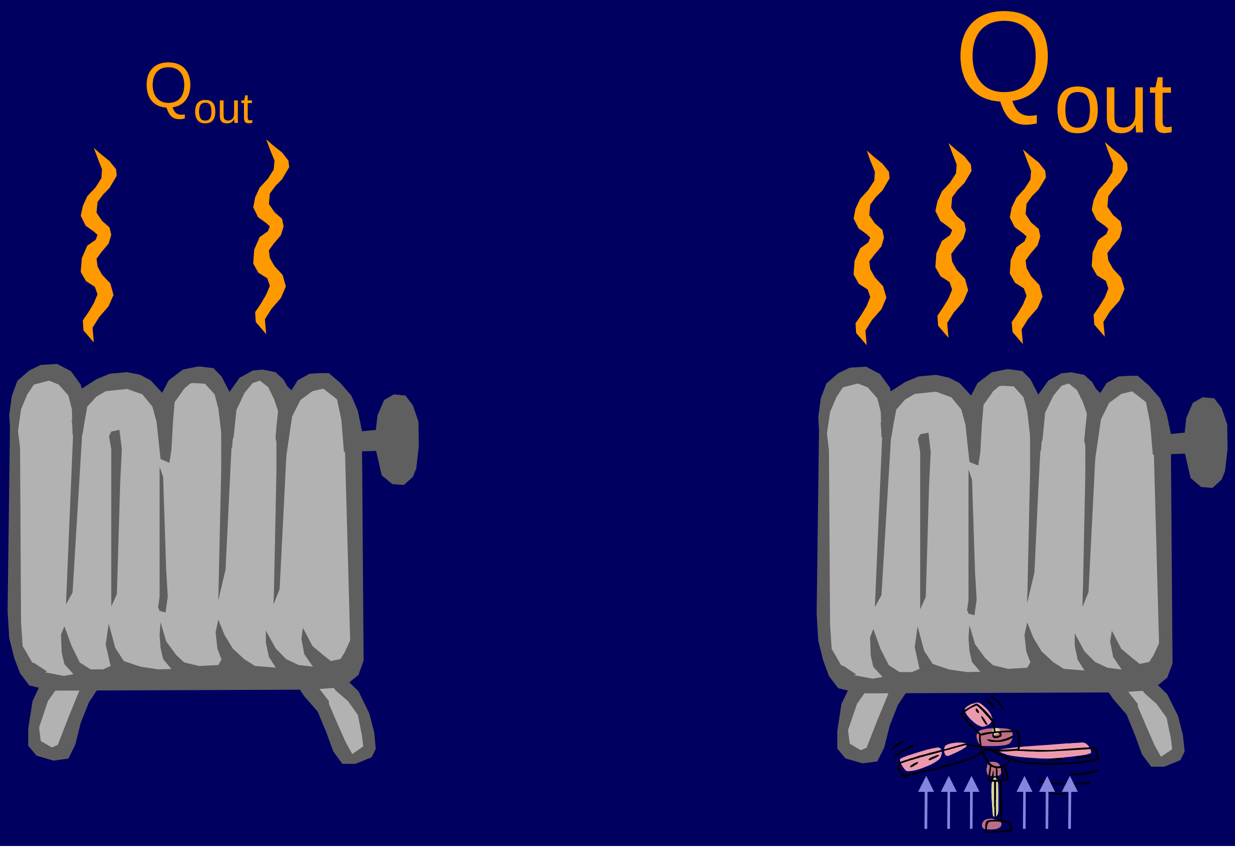
District Heating





Add-on-fan blower

Increased forced convection to increase the heat output from the space heating system



Objective

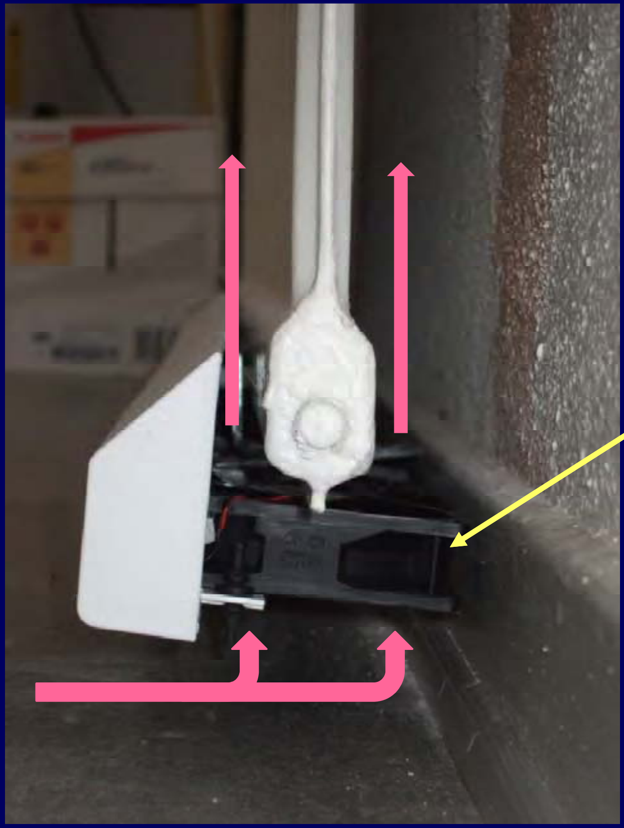
Simulate the affect of add-on-fan blowers at different fan speeds

Derive new space heating temperature program

Complement to a field study

Add-on-fan blower – Field study

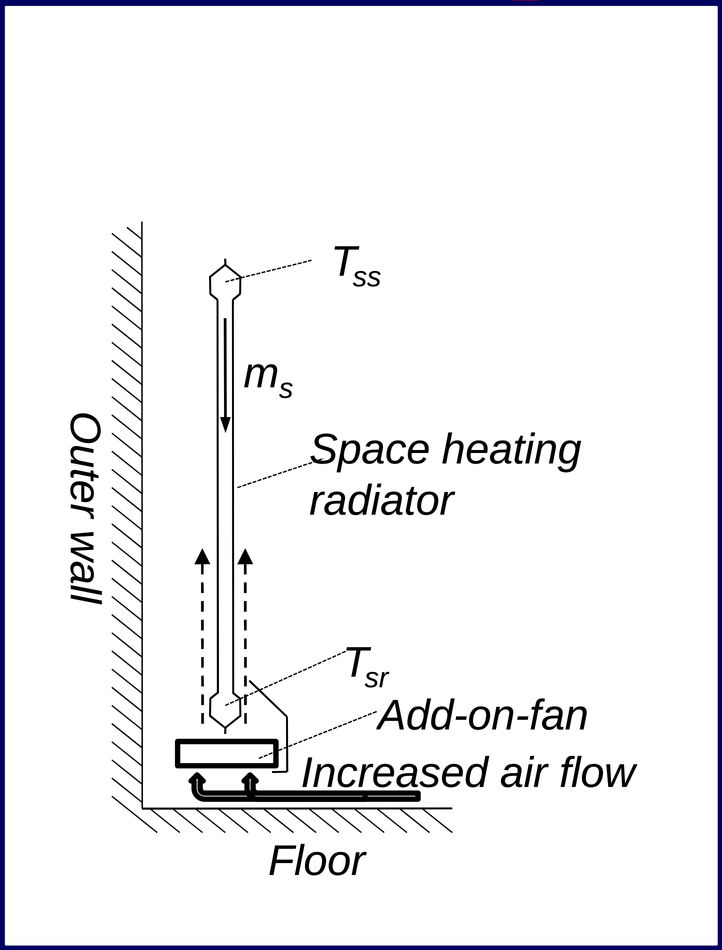
Test setup

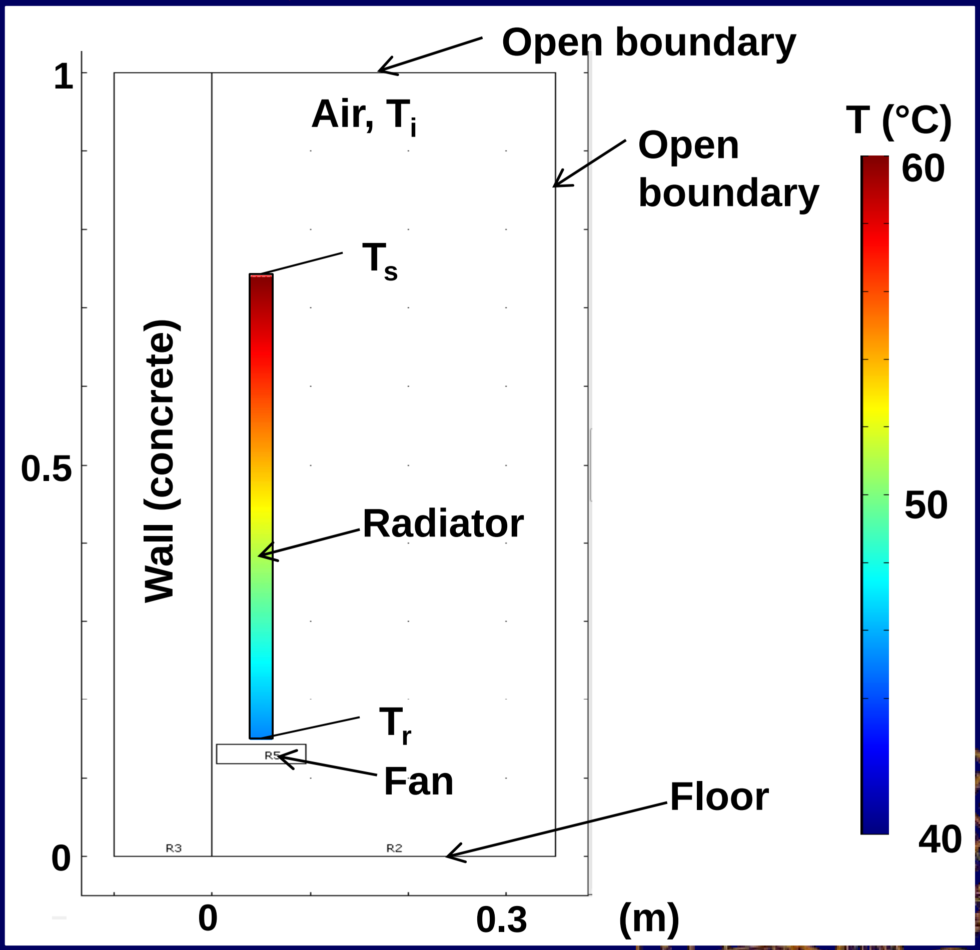


Additional add-on-fans

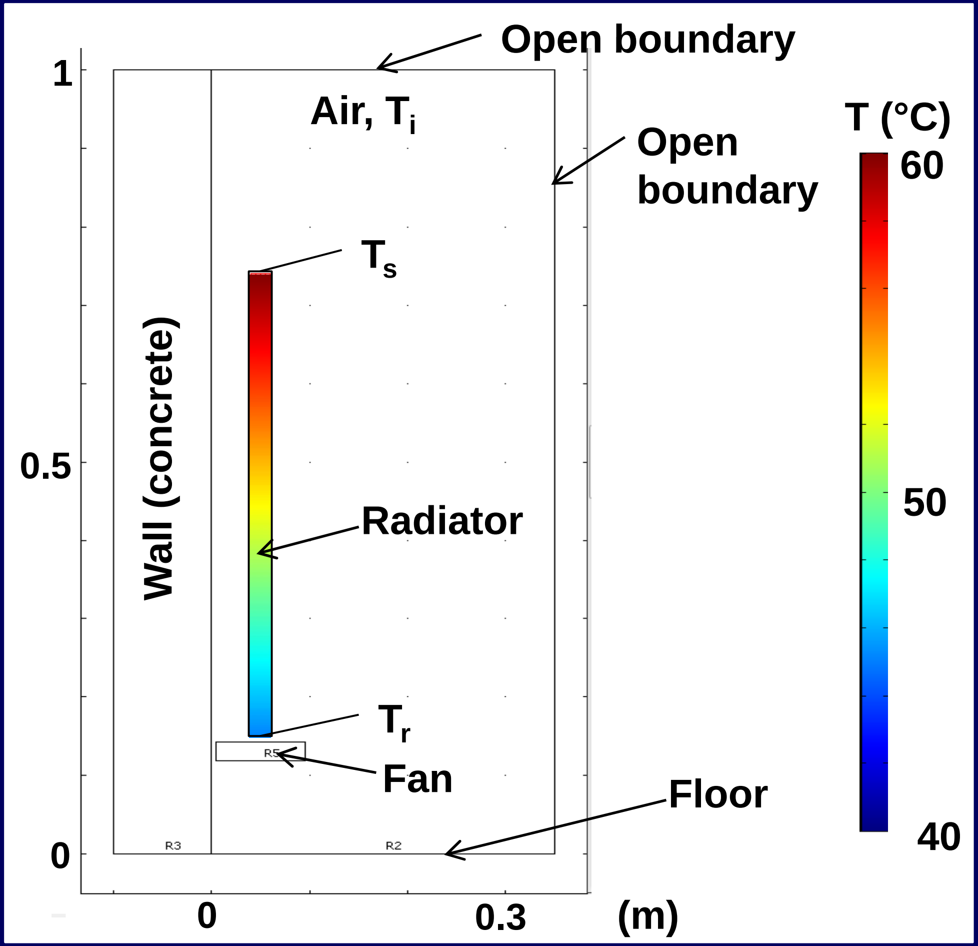
Add-on-fan blower – Simulation

COMSOL 2-D model





COMSOL-model



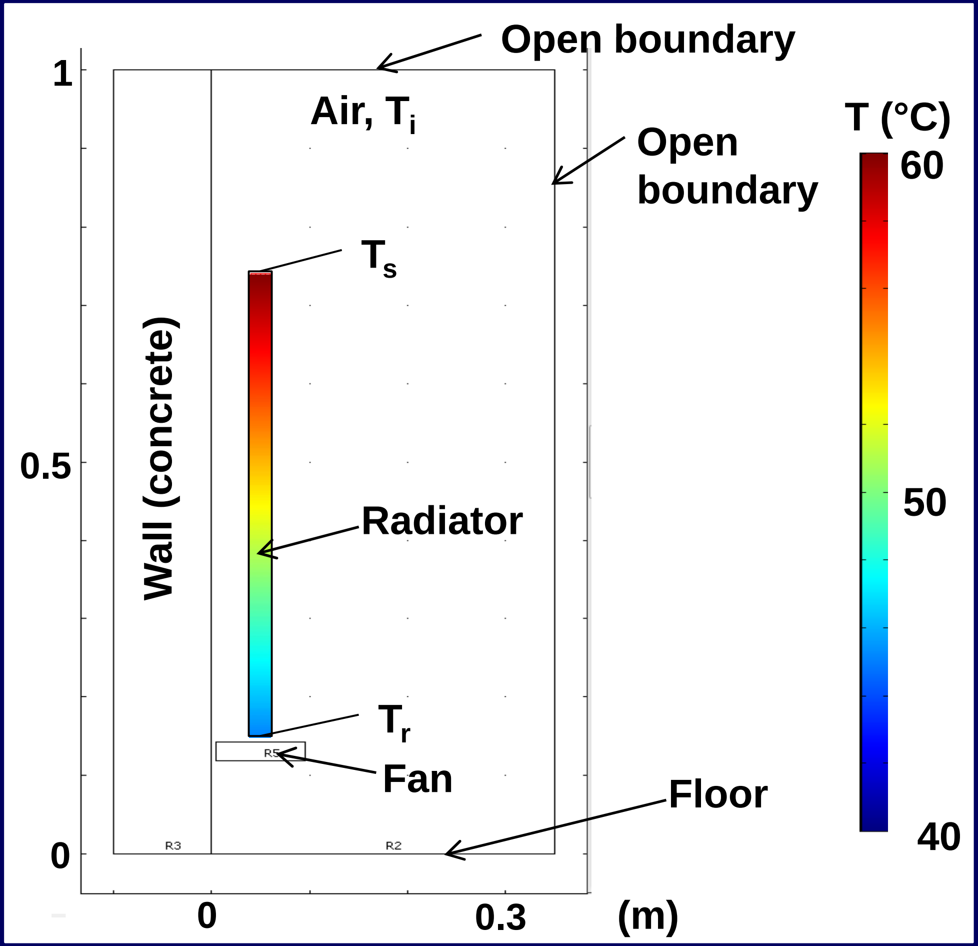
Limitations and assumptions:

No water flow in the radiator

A linear temperature in the middle of the radiator is assumed

No heat losses in the outer wall

COMSOL-model



The model is using:

General Heat Transfer toolbox

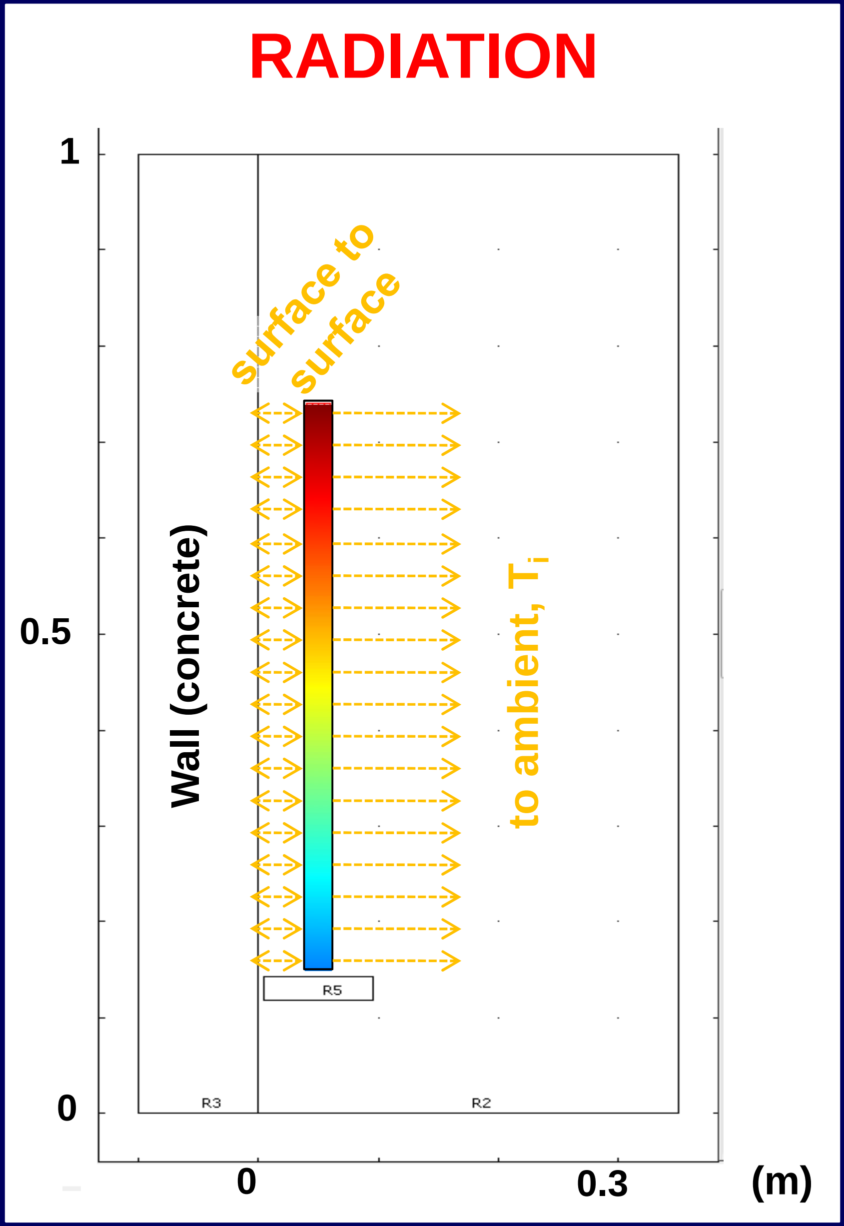
Navier-Stokes toolbox (Weakly Compressible and Incompressible)

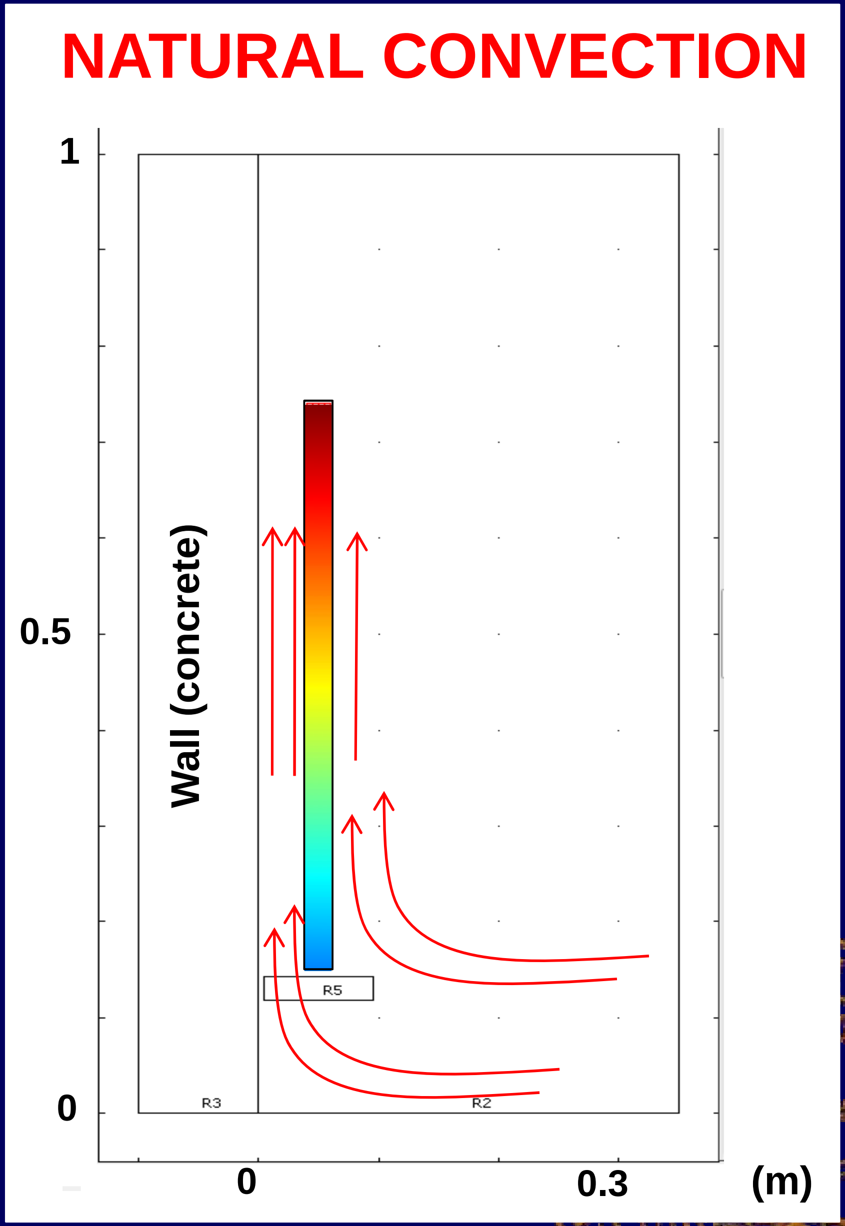
The model is dealing with:

Convection (natural and forced)

Radiation

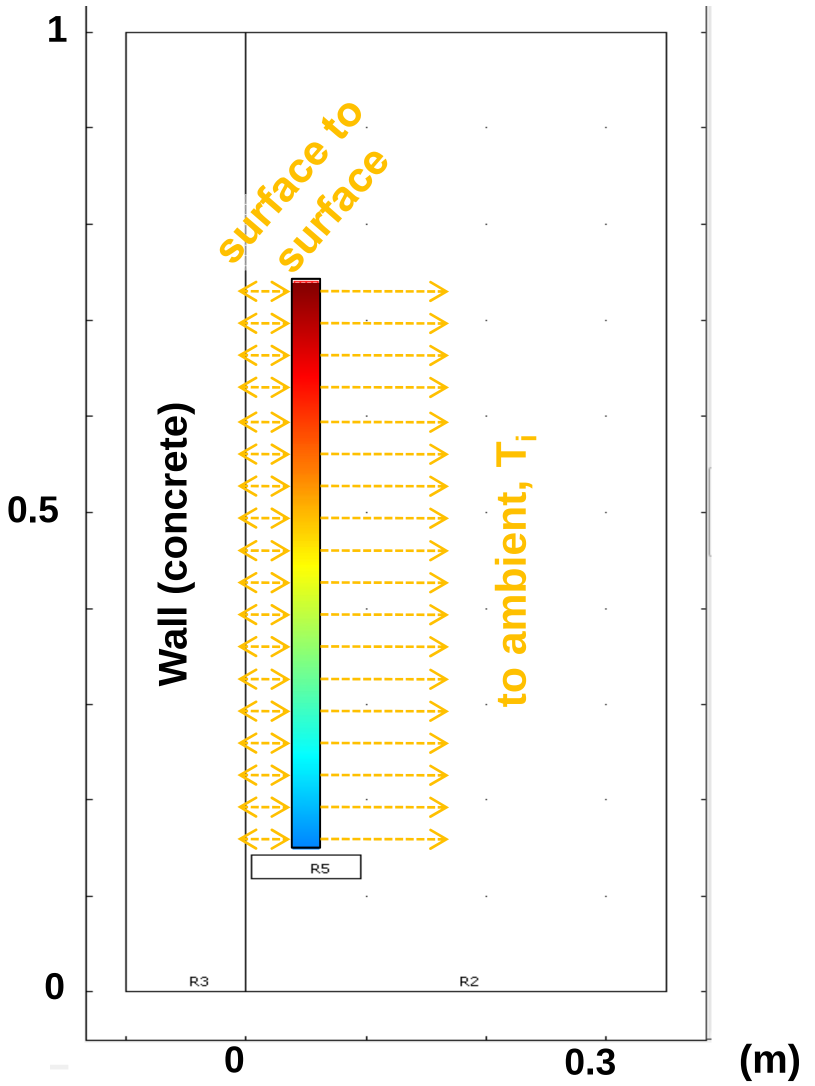
COMSOL-model





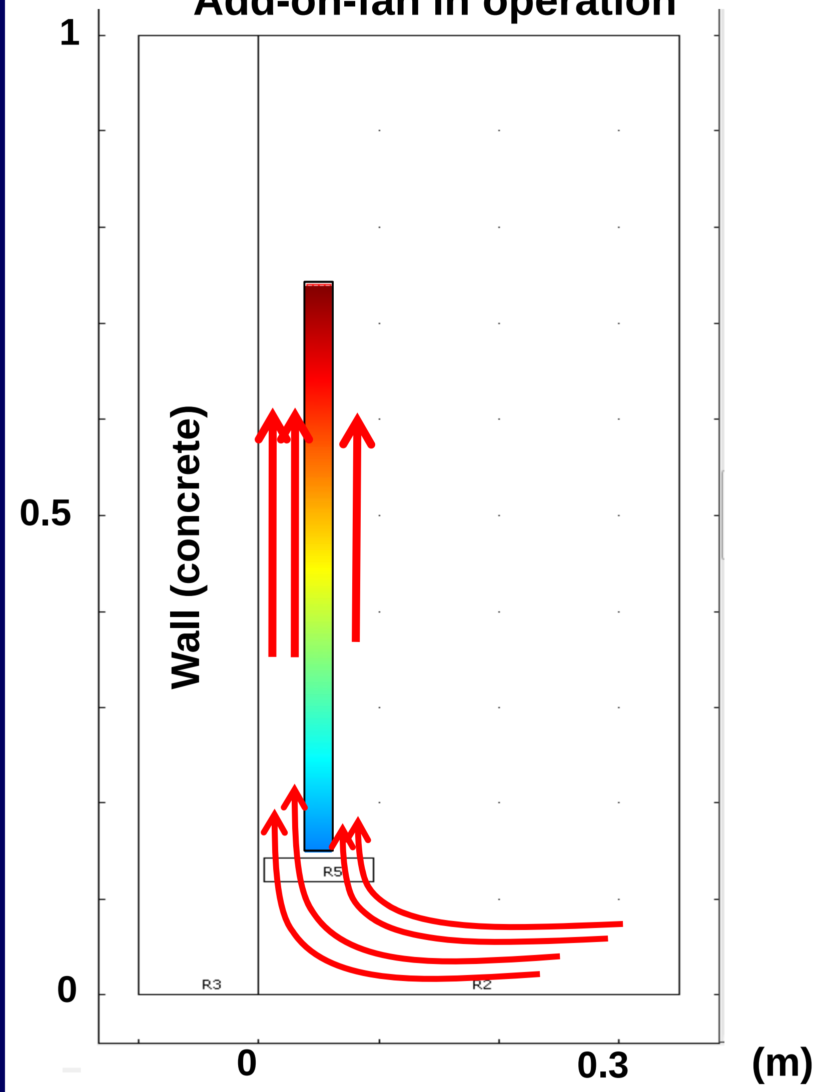
COMSOL-model

RADIATION

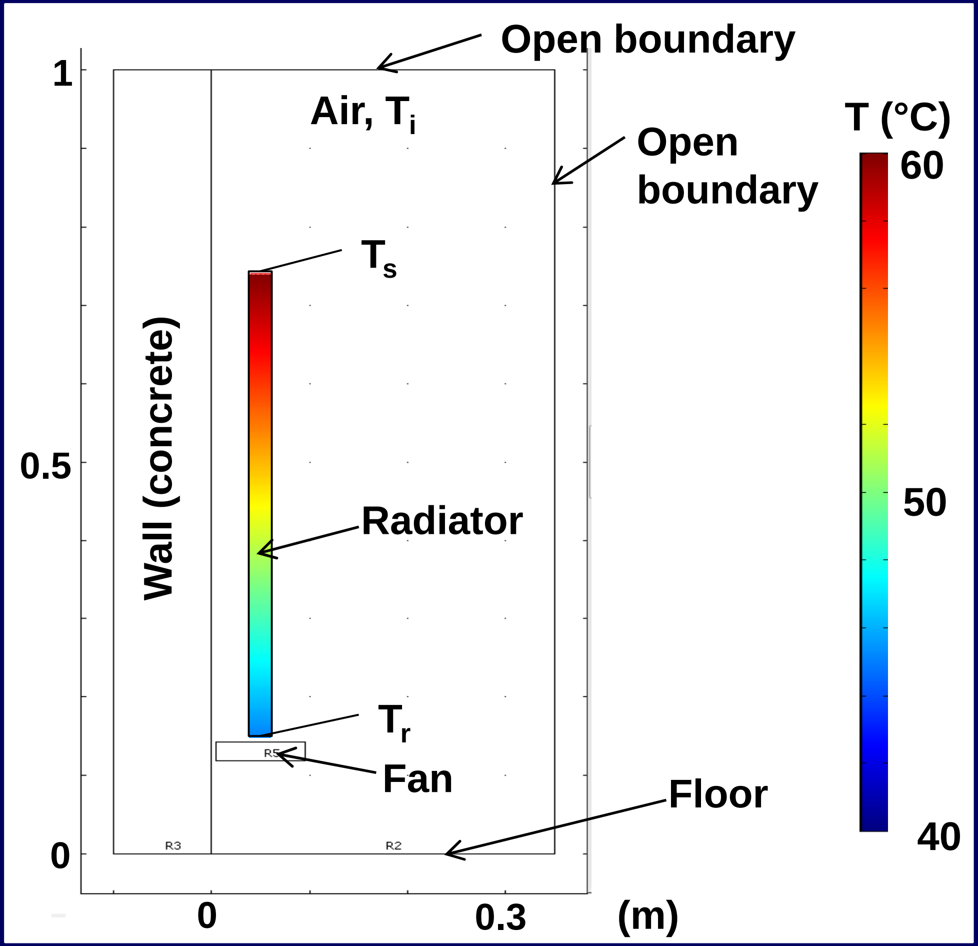


FORCED CONVECTION

Add-on-fan in operation



COMSOL model



The model is validated for

Natural convection

Forced convection

Parameter test:

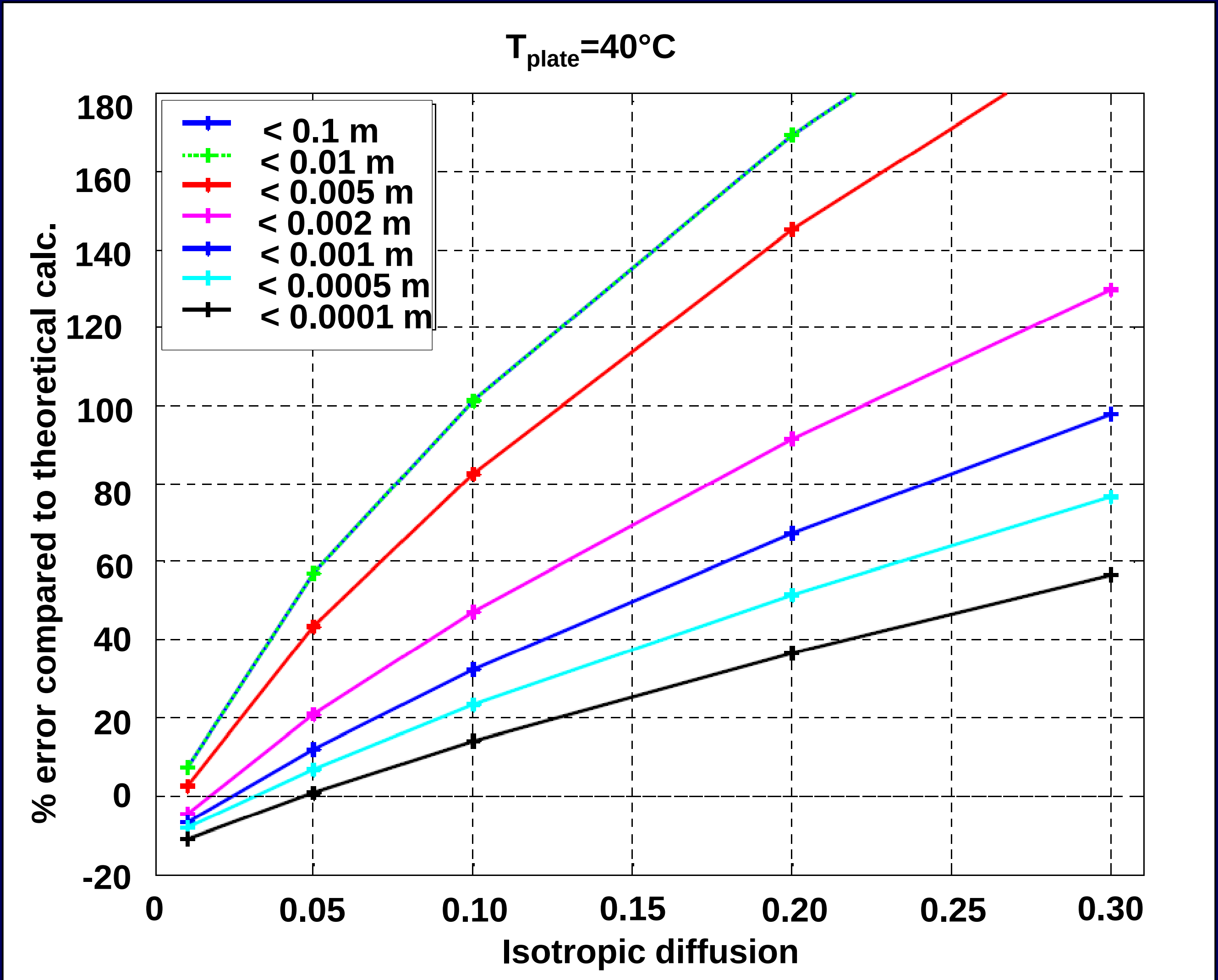
Mesh size

Isotropic diffusion

COMSOL-model

- validation

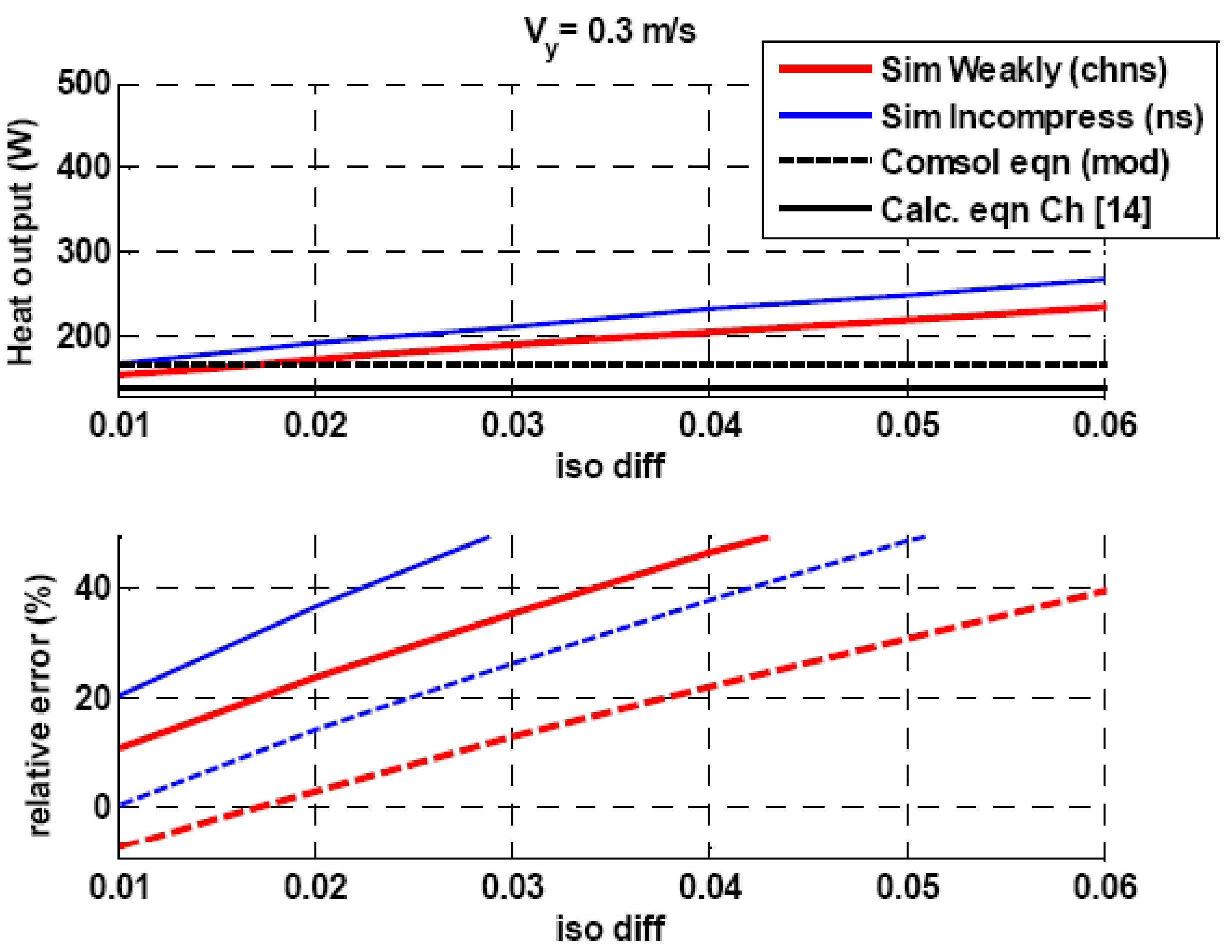
Natural convection

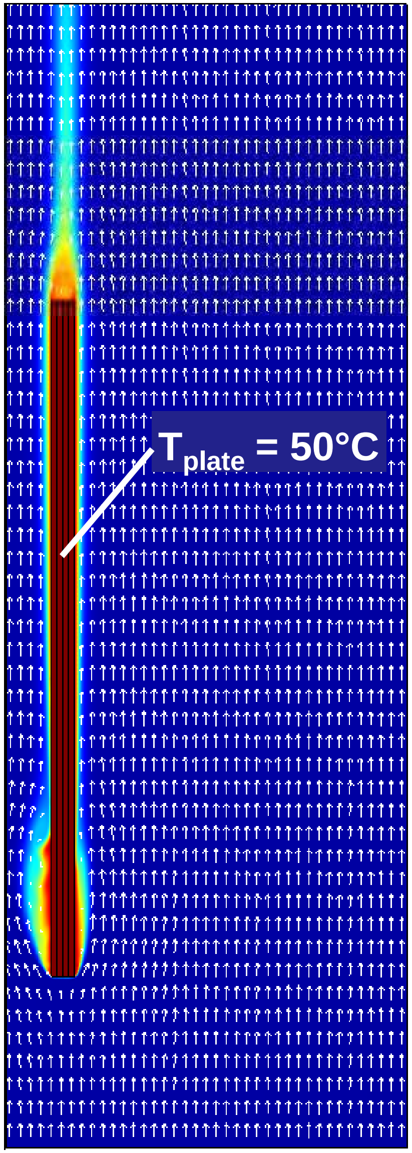


COMSOL-model

- validation

Forced convection



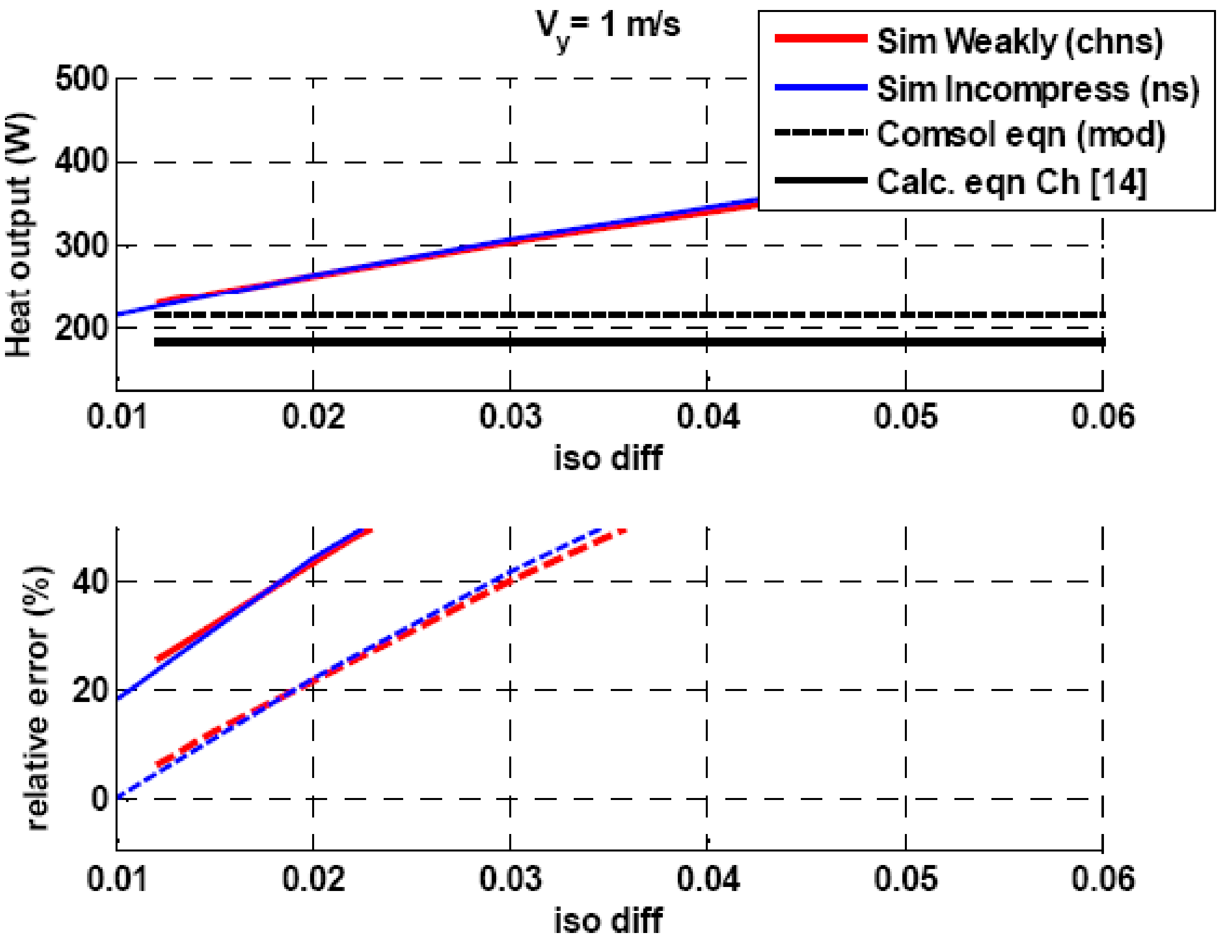


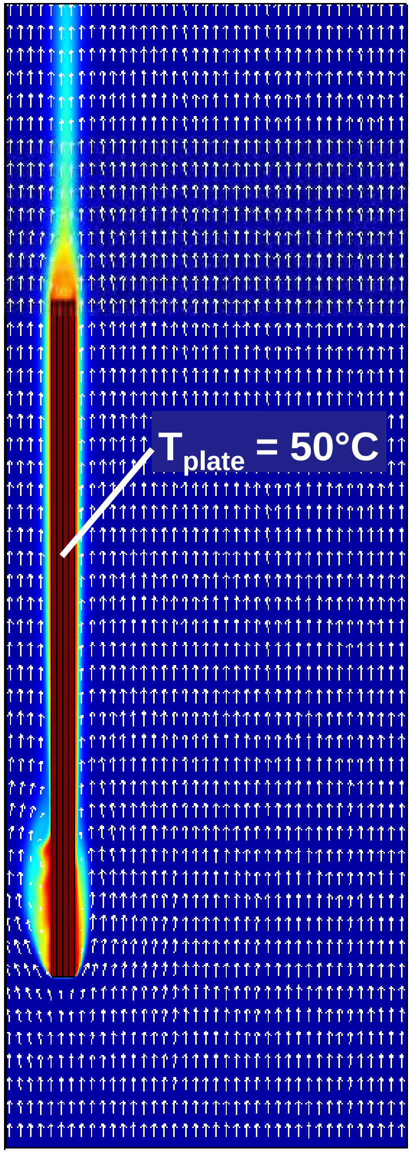
Constant velocity, inlet

COMSOL-model

- validation

Forced convection





Constant velocity, inlet

COMSOL-model

- Deriving new temperature program

To derive new temperature program the heat output should be the same as in the reference case without add-on-fan blower

$$Q = \dot{m}_s \cdot c_p (T_s - T_r) = k \cdot A \cdot \Delta\theta$$

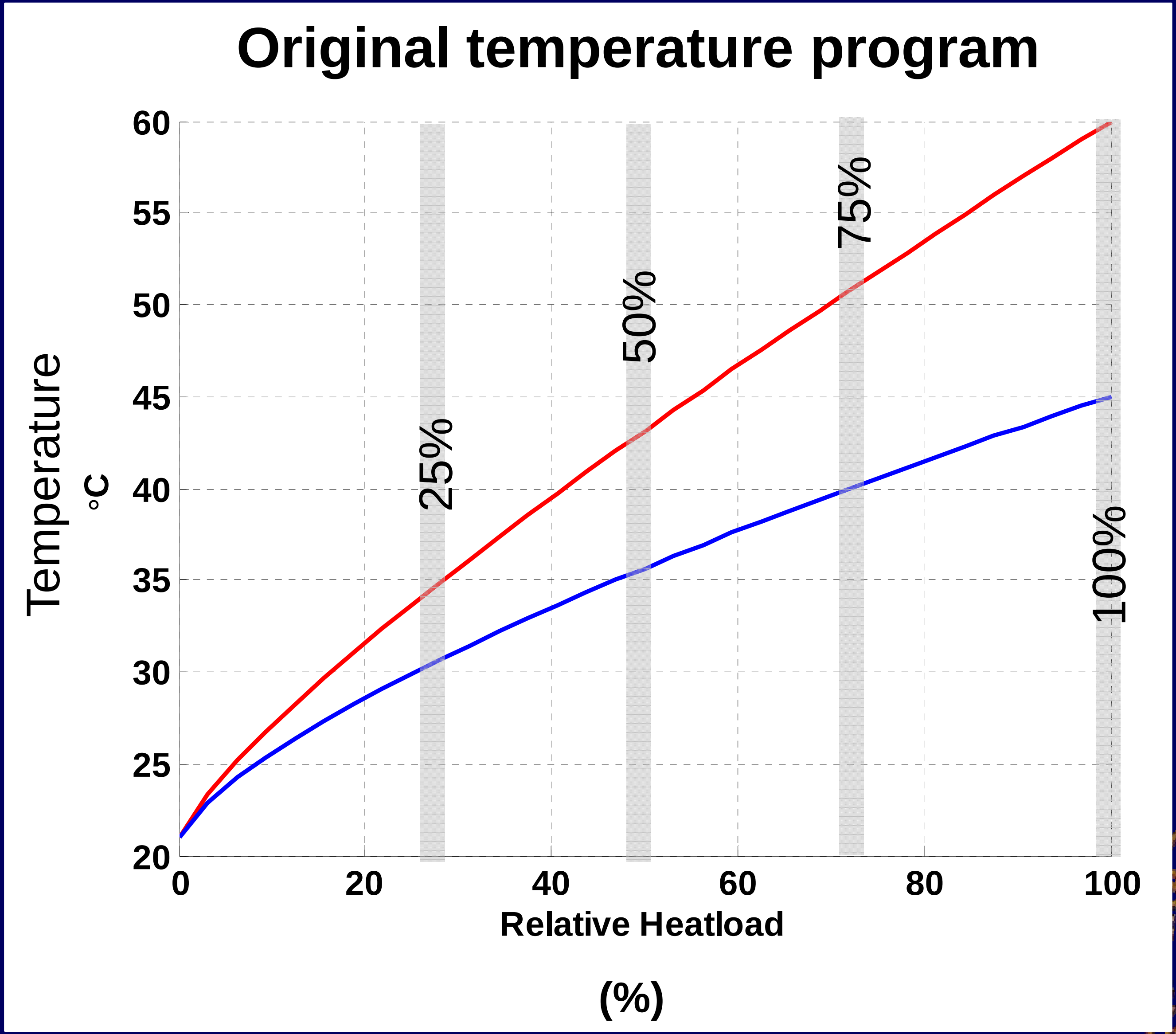
Two control strategies is considered:

$$\Delta\theta = \frac{T_s - T_r}{\ln \frac{T_s - T_i}{T_r - T_i}}$$

1. Constant mass flow (m_s) through the radiator → T_s is reduced and (T_s-T_r) is constant
2. Constant T_s → m_s is reducing and (T_s-T_r) is increasing

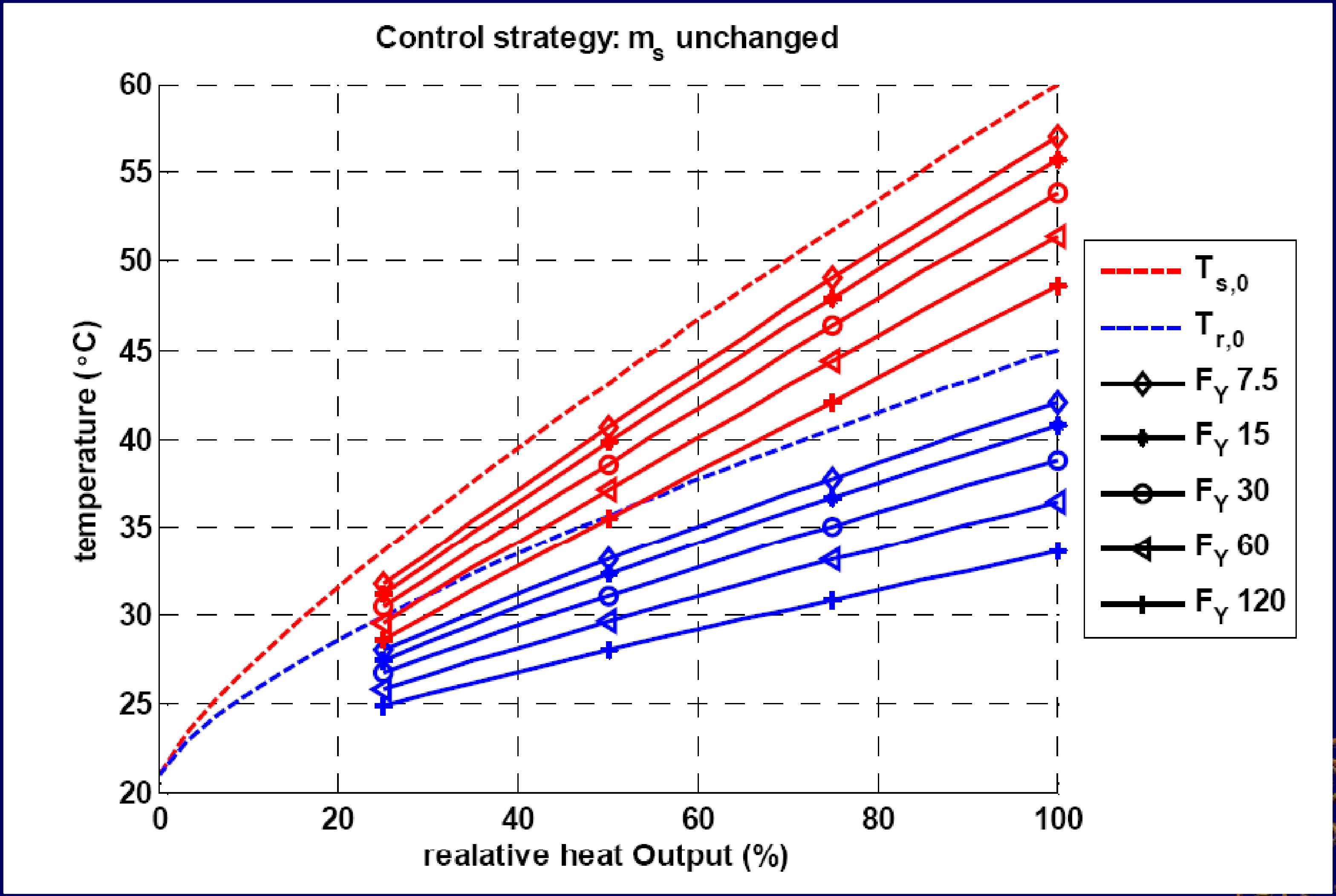
COMSOL-model

- Deriving new temperature program



COMSOL-model

- Deriving new temperature program, Results

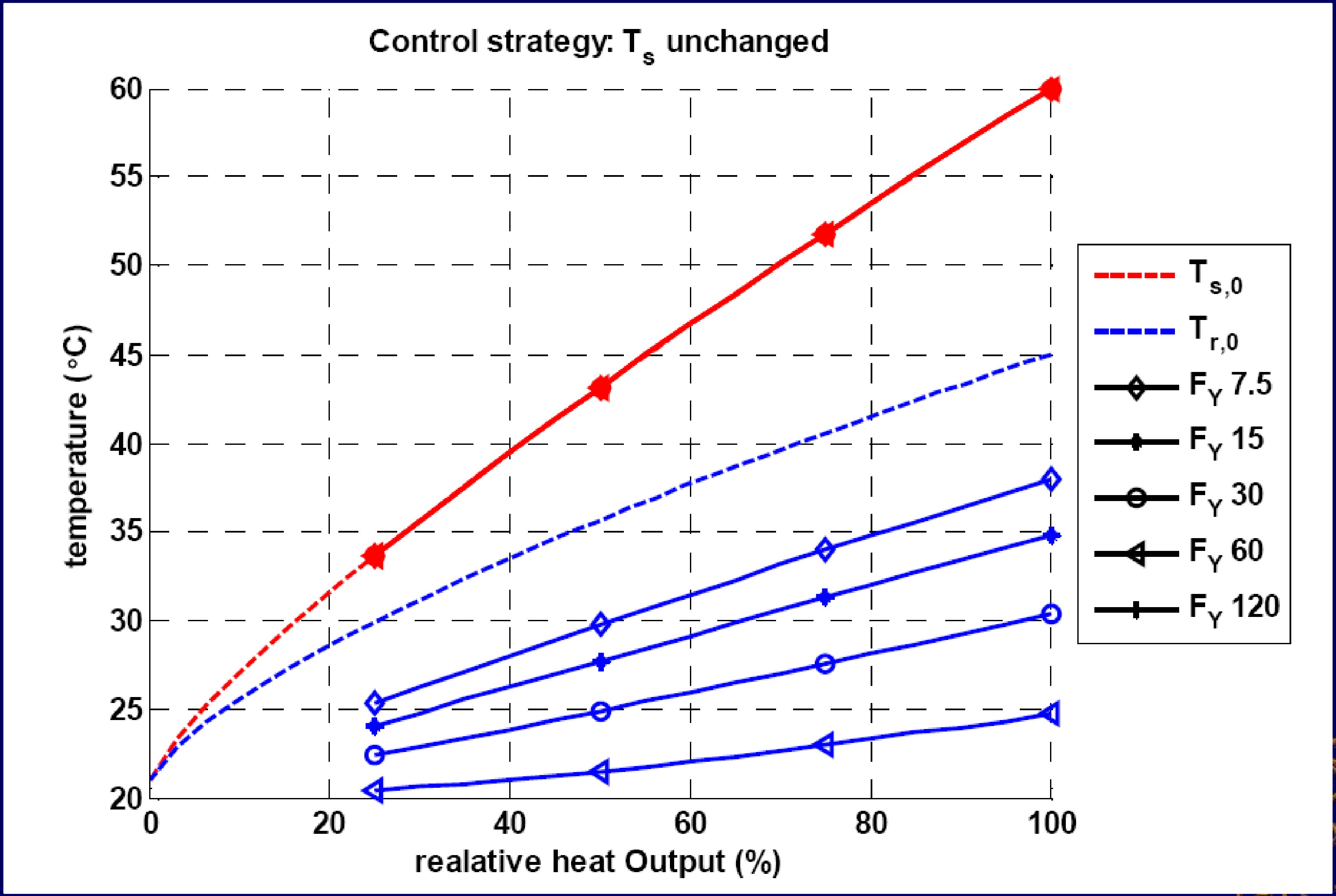


SOLVER: Time dependent Direct UMFPACK

Simulation time: 259200 sec (=3*24h)

COMSOL-model

- Deriving new temperature program, Results



SOLVER: Time dependent Direct UMFPACK

Simulation time: 259200 sec (=3*24h)

COMSOL-model

- Deriving new temperature program, Results

Vertical force F_y (N/m³)	Air volume flow V_{air} (m³/s)	Δp (N/m²)	P_{fan} (W)	P_{fan} η=0.1 (W)
7.5	0.025	0.11	0.003	0.03
15	0.036	0.26	0.009	0.09
30	0.051	0.55	0.028	0.28
60	0.073	1.12	0.081	0.81
120	0.104	2.23	0.231	2.31

Conclusions

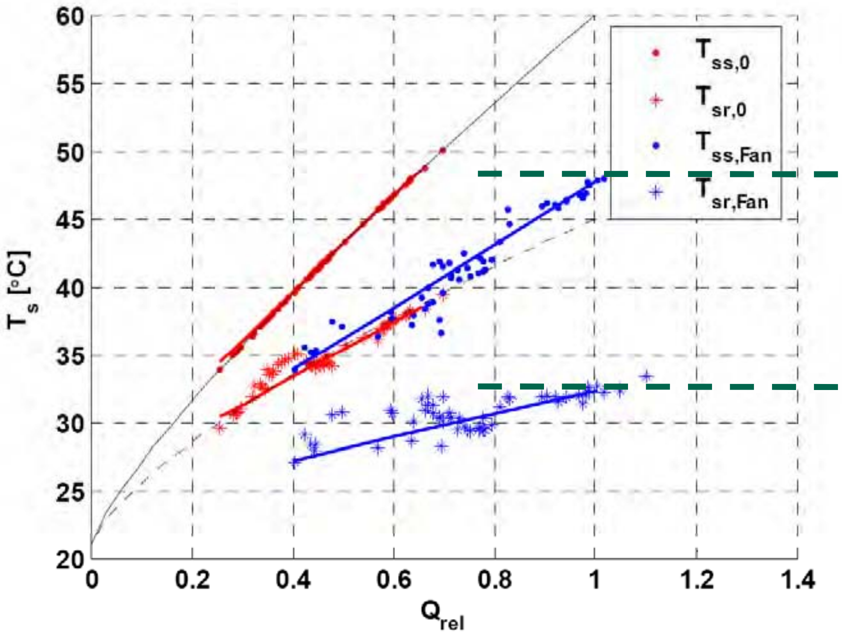
- A significant reduction of space heating temperature program is possible with add-on-fan blowers
- The model shows good correspondence to theoretical calculations within simulated range
- It is possible to derive new temperature program for a variation of fan speeds
- The model shows good correspondence to field study

COMSOL-model

- Results, Field study V.S. Simulation

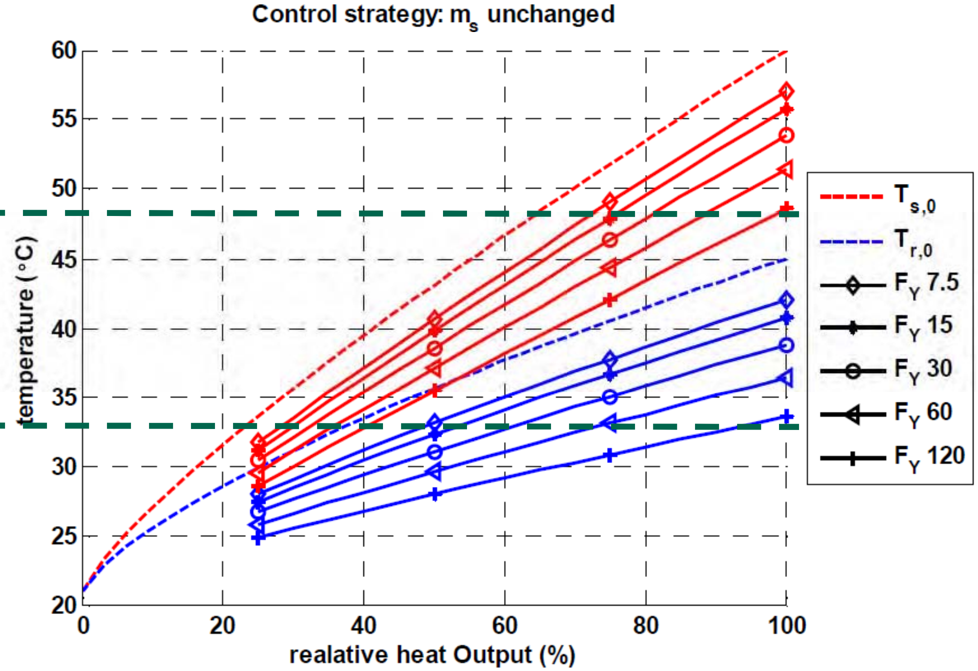
Field study

Panel radiator P_{fan} = 2.7 W



Δp ≈ 2 Pa → V = 0,074 m³/s

Simulation



F_y=60 → V = 0,073 m³/s P = 0,081 W P_{fan}=0.8 W

F_y=120 → V = 0,104 m³/s P = 0,231 W P_{fan}=2.3 W

Thank you for your attention

This work is part of the Primary Energy Efficiency project of Nordic Energy Research.

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