Climate control for high productive pigs in hot climate

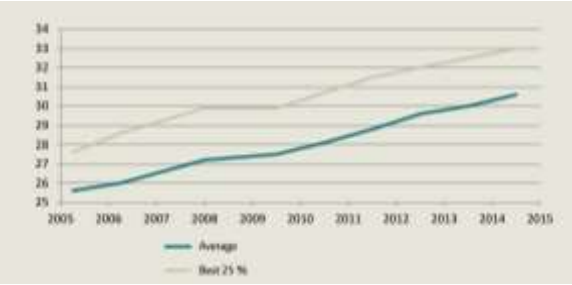
AMVEC 20-23th of July 2016

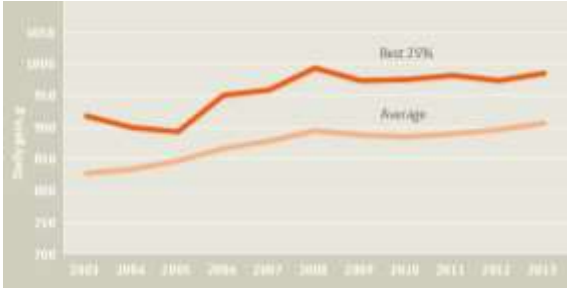
M.Sc. Agriculture - Poul Pedersen

Agenda

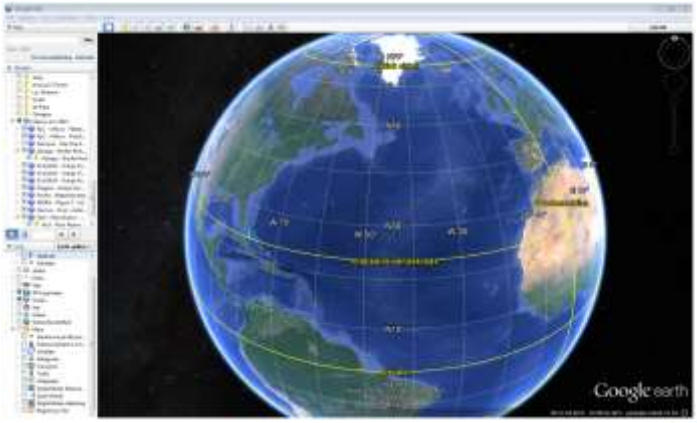
- Potential in high productive pig production
    - Production results in Denmark
- Climatically challenges in Mexico
    - Climate profiles from various locations
- Pigs reaction to hot climate
    - Farrowing and gestating sows
    - Grower-finishing pigs
- Influence of well-insulated houses
- Climate systems for reducing heat stress
    - Side ventilation with high pressure cooling
    - Tunnel ventilation with pad cooling
    - Combi tunnel systems

Potential in high productive pig production

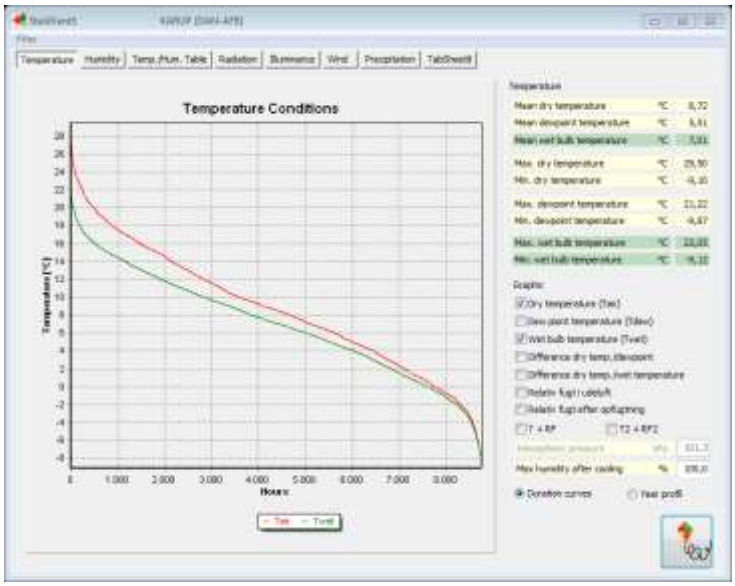




Mexico ensures good climate condition in Denmark

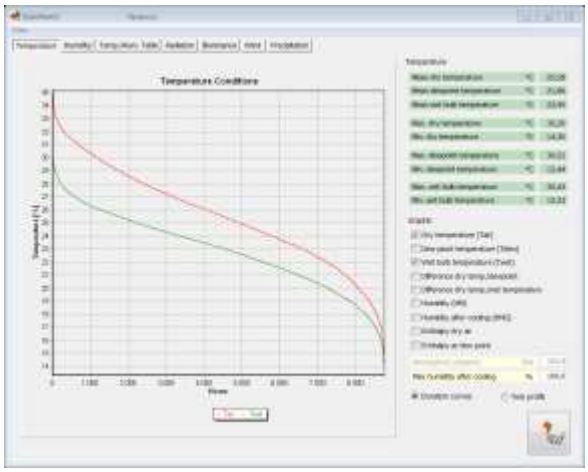


Denmark

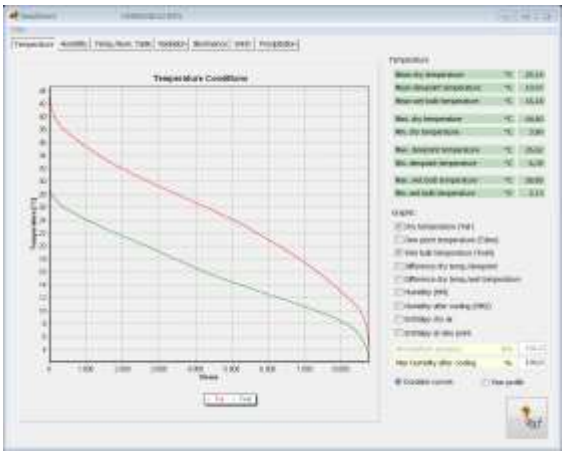


Meteonorm climate profiles for Mexico

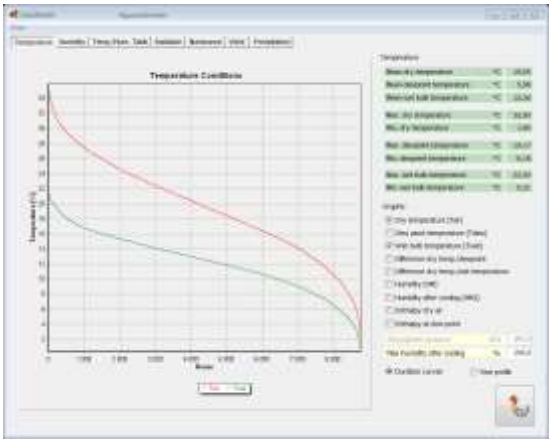
Vera Cruz 33 m above sea level



Hermosillo 210 m above sea level



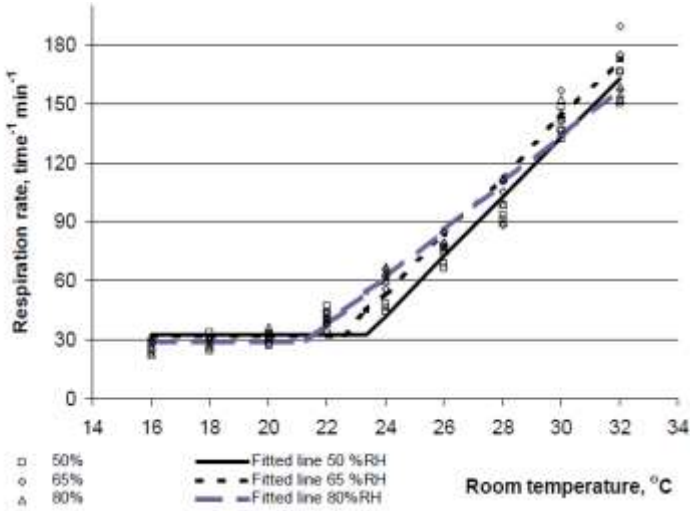
Jalisco app.1885 m above sea level



Cooling of pigs is essential in Mexico

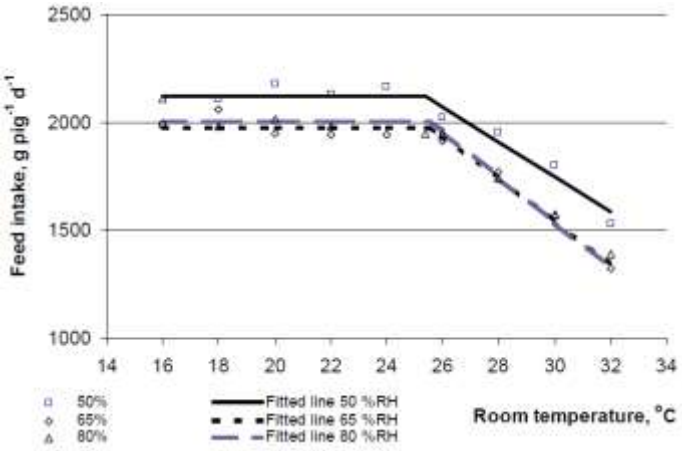
- Sensible heat
    - Conduction
    - Convection
    - Radiation
- Latent heat
    - Evaporation

Effect of climate on respiration rate (60 kg pig)

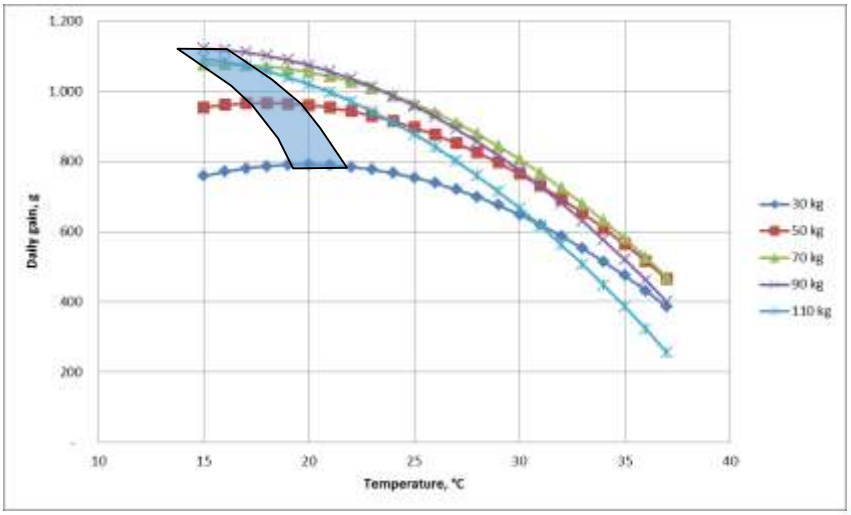


Reference: Aarnink et al, 2006

Effect of climate on feed intake (60 kg pig)



Effects of high ambient temperatures on pig growth



Farrowing sows in hot climate

Table 6. Effect of farrowing house temperature on sow and litter performance [a]			
Item	Temperature, °C (°F)		
	18 (64)	25 (77)	30 (86)
Litter weaning wt, kg	63[b]	61[b]	53[c]
Weaning number	8.1	8.9	8.3
Pig weaning wt, kg	7.8[b]	6.9[b]	6.4[c]
Mortality, %	20[b]	12[c]	19[b]
Sow feed intake, kg/d	6.5[b]	6.1[b]	4.2[c]
Sow wt change, kg/lactation	-3.1[b]	-7.9[b]	-24.2[c]

[a] Stansbury et al. (1987). 29 or 30 litters per treatment.
[b,c] Means in the same row with different superscripts differ (P<0.05)

Gestating sows in hot climate

Table 5. Effect of temperature on reproductive performance in sows[a]			
Item	26 - 27°C (80° F)	30°C (86° F)	33°C (92° F)
No. of sows	74	80	80
No. in oestrus	74	78	73
No. in anoestrus	0	2	7
No. returning to oestrus	2	8	8
No. of sows that conceived	67	67	62
Conception rate, %	90	85	78

[a] From Serres (1992).

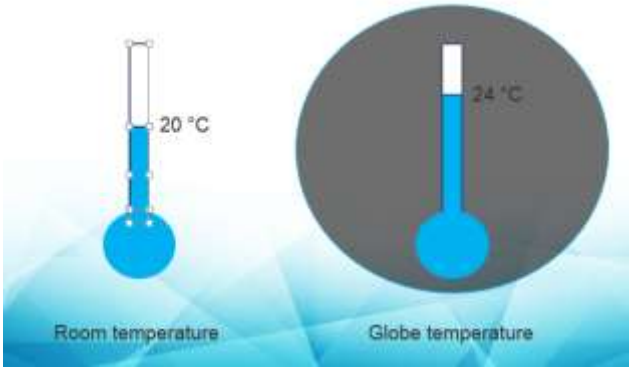
Heat radiation from uninsulated roof

Short wave solar radiation: Colour is important

Long wave heat radiation No influence of colour

Heat radiation is important in both cold and hot climate

Measurement of heat radiation – globe thermometer



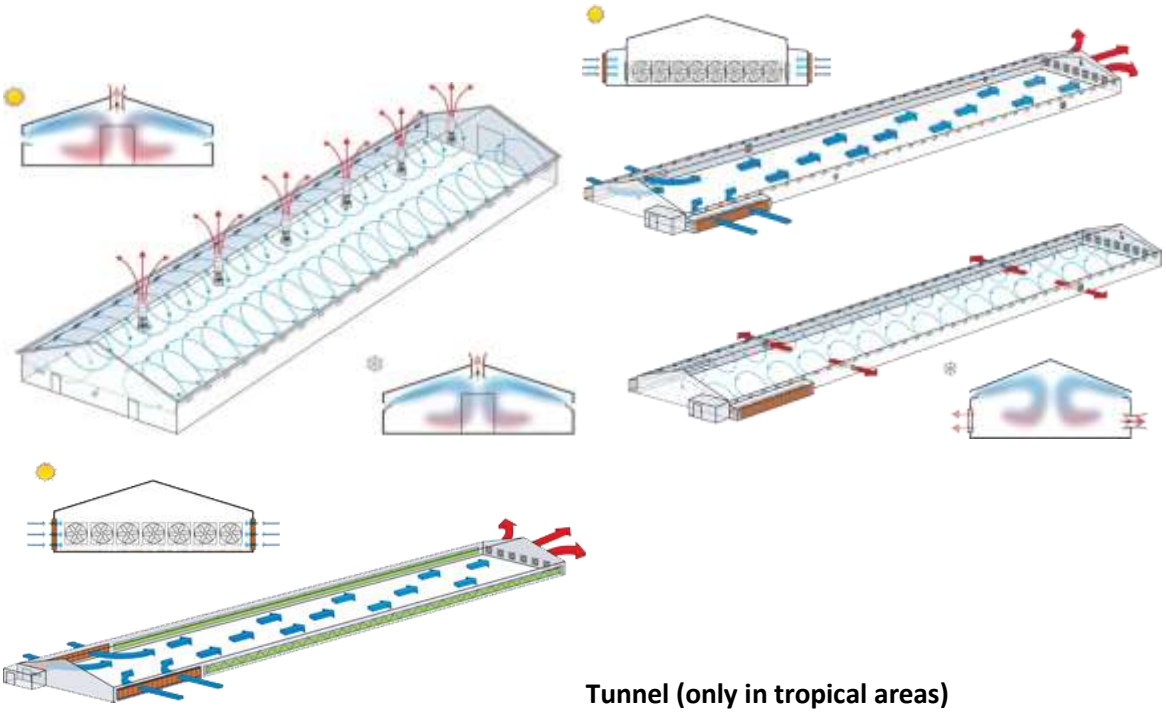
High productive pigs need well-insulated houses

Insulation equal to at least 5 cm sandwich is recommended

Ventilation systems for pig production

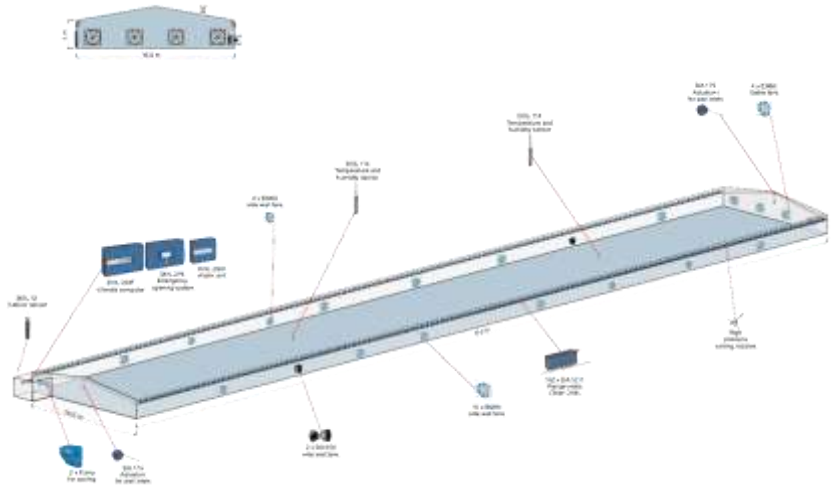
Low **P**ower **V**entilation (**LPV**)

Combi-Tunnel



Tunnel (only in tropical areas)

LPV ventilation with high pressure cooling

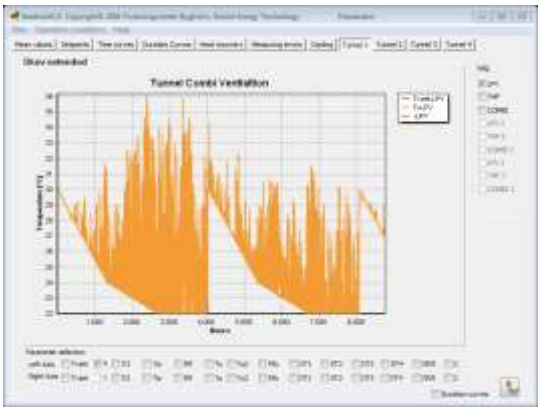


High-pressure cooling – pump and nozzles

Placement of high pressure cooling

- **Wall placement**
- **Ceiling placement**

Analysis for Wean to finish house in Jalisco



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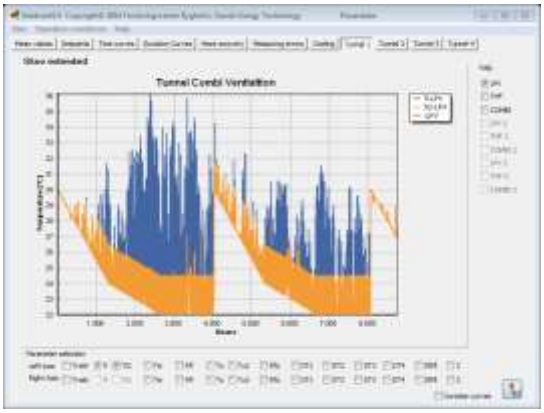
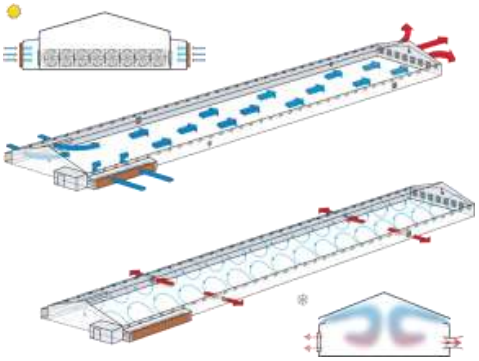
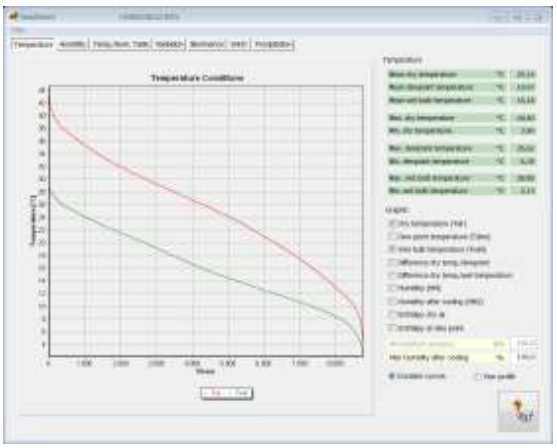
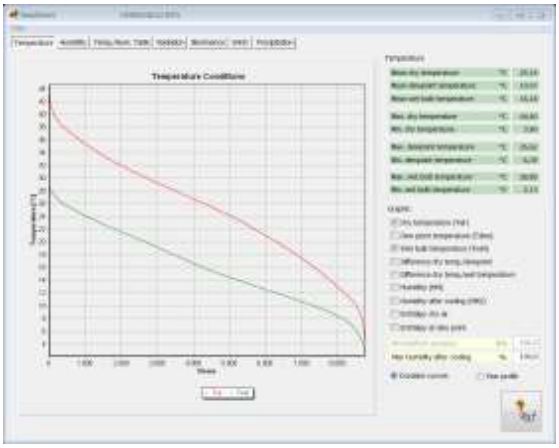


Combi tunnel with pad cooling

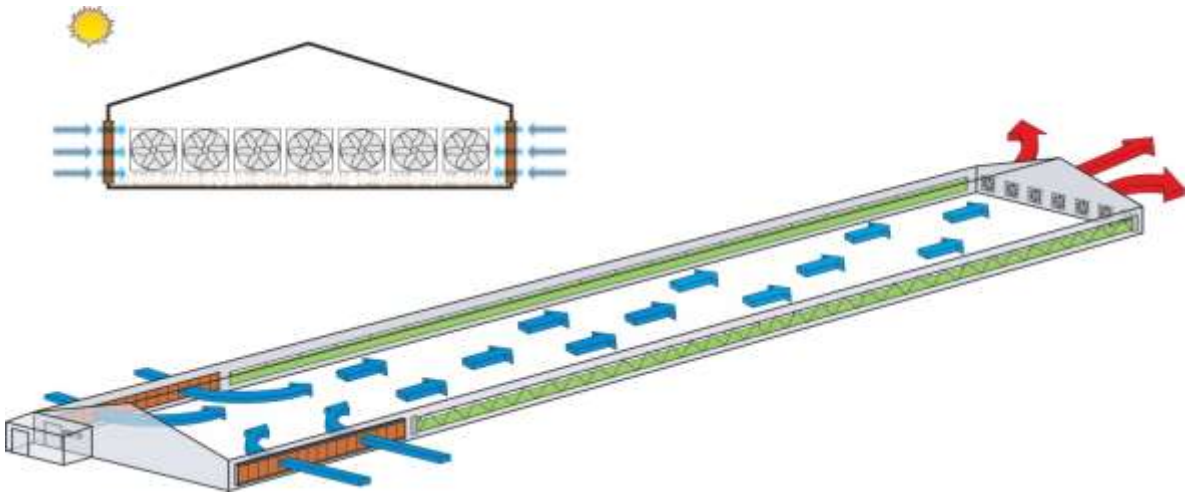


Hermosillo 210 m above sea level

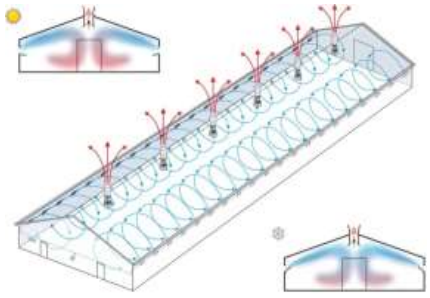


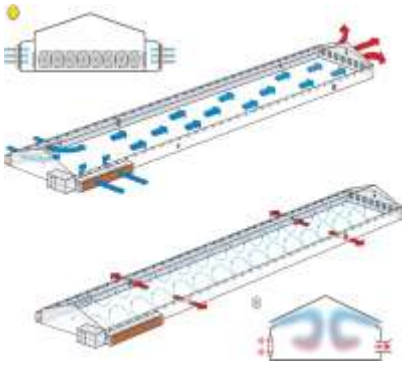


Combi-tunnel or Tunnel



Recommended systems for pigs in Mexico





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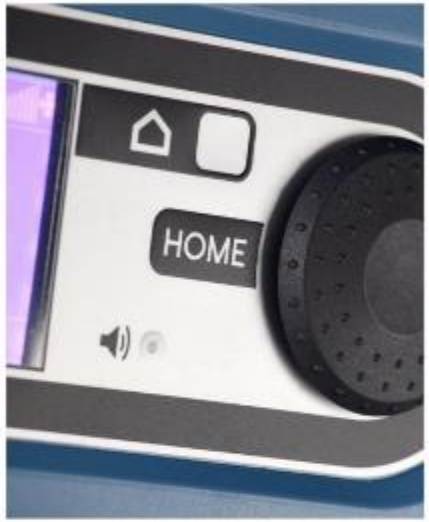

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CV for Poul Pedersen

- 1987-1992 Agricultural University in Copenhagen: M.Sc. Agriculture. Specialised in pig production
- 1992-2012: Project manager at the “Danish Pig Research Centre”: Development and test of climate systems, housing systems, systems for reduction of ammonia and odour, etc.
- 2012: System Developer at R&D & Pig Specialist at SKOV

World pig meat production and pig population

	Pigmeat production 1,000 tonnes		Pig population M head	
	2010	2011 [1)]	2010	2011 [1)]
Germany	4,941	5,035	26.5	26.7
Spain	3,527	3,527	24.7	25.5
France	2,312	2,301	14.1	13.8
Poland	1,811	1,783	14.0	13.1
Italy	1,577	1,570	9.3	9.3
Denmark	1,888	1,931	12.2	11.9
Netherlands	1,800	1,818	12.3	12.4
Belgium/Luxembourg	1,114	1,127	6.4	6.3
UK	771	803	4.5	4.5
Austria	507	519	3.1	3.1
Hungary	340	322	3.2	3.1
Rumania	393	378	4.7	4.6
Portugal	310	315	2.3	2.2
Czech. Rep.	267	258	1.9	1.8
Sweden	264	262	1.6	1.5
Finland	197	195	1.4	1.3
Ireland	219	221	1.5	1.6
Greece	115	115	1.1	1.1
Bulgaria	69	69	0.7	0.7
Other EU-27 countries	350	334	3.0	2.9
EU-27 total	**22,772**	**22,883**	**148.5**	**147.2**
China (incl. Hong Kong)	51,070	49,700	470.0	477.2
USA	10,177	10,289	64.9	64.9
Brazil	3,220	3,260	39.5	39.6
Russia	2,331	2,400	17.2	17.2
Canada	1,926	1,136	11.8	11.9
Mexico	1,175	1,180	15.3	15.4
Japan	1,291	1,260	10.0	9.8
Rep. Of Korea	1,110	835	9.6	9.9
Ukraine	630	650	7.6	7.9
Total selected countries	**95,702**	**93,593**	**794.3**	**800.9**

[1)] *Provisional figures* *Source: GIRA*

- Million piglets 2012
  - D: 45.8
  - E: 41.1
  - DK: 29.2
  - F: 24.4
  - NL: 24.1

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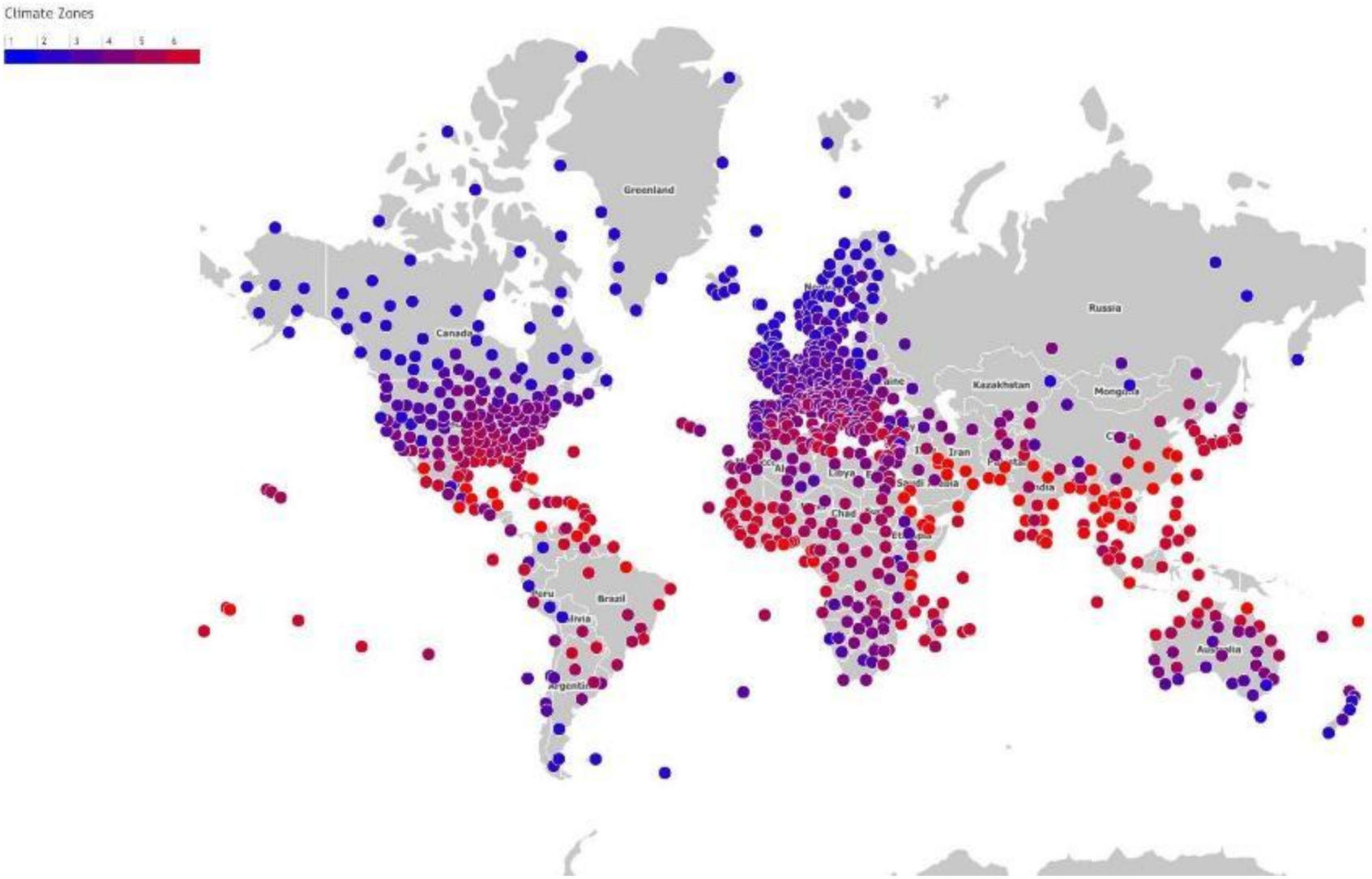
Climate zones



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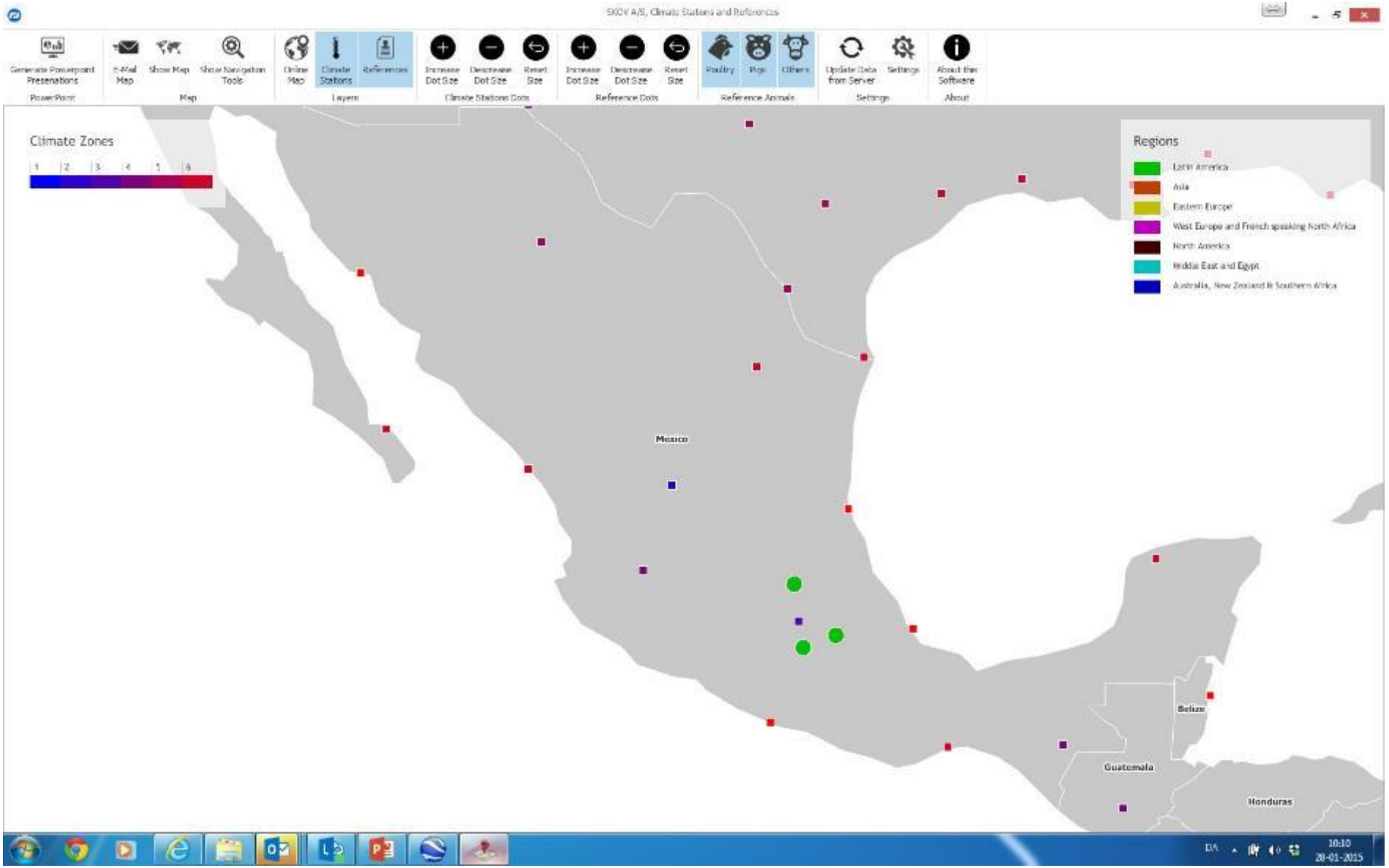
Climate zones in Mexico



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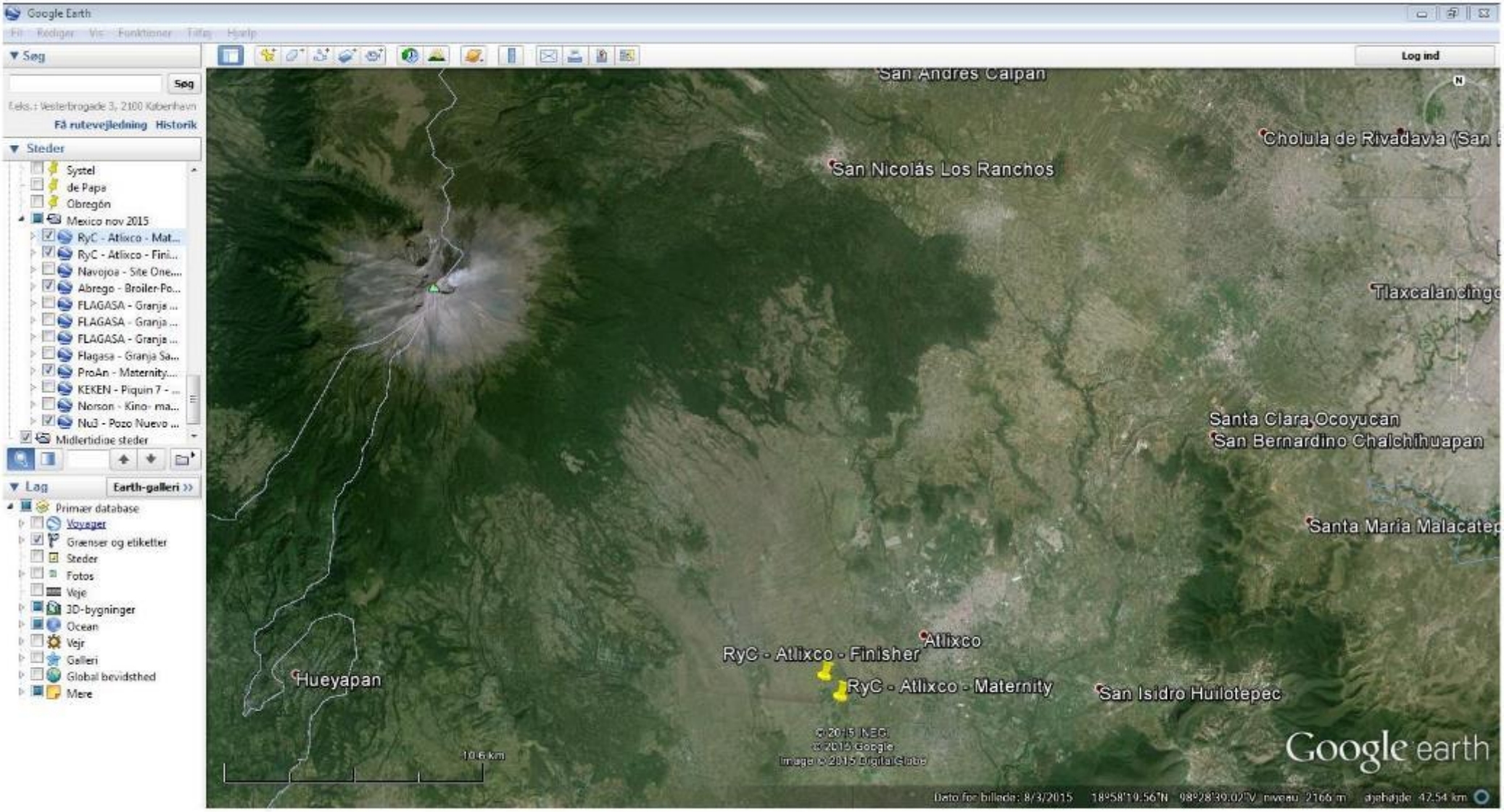
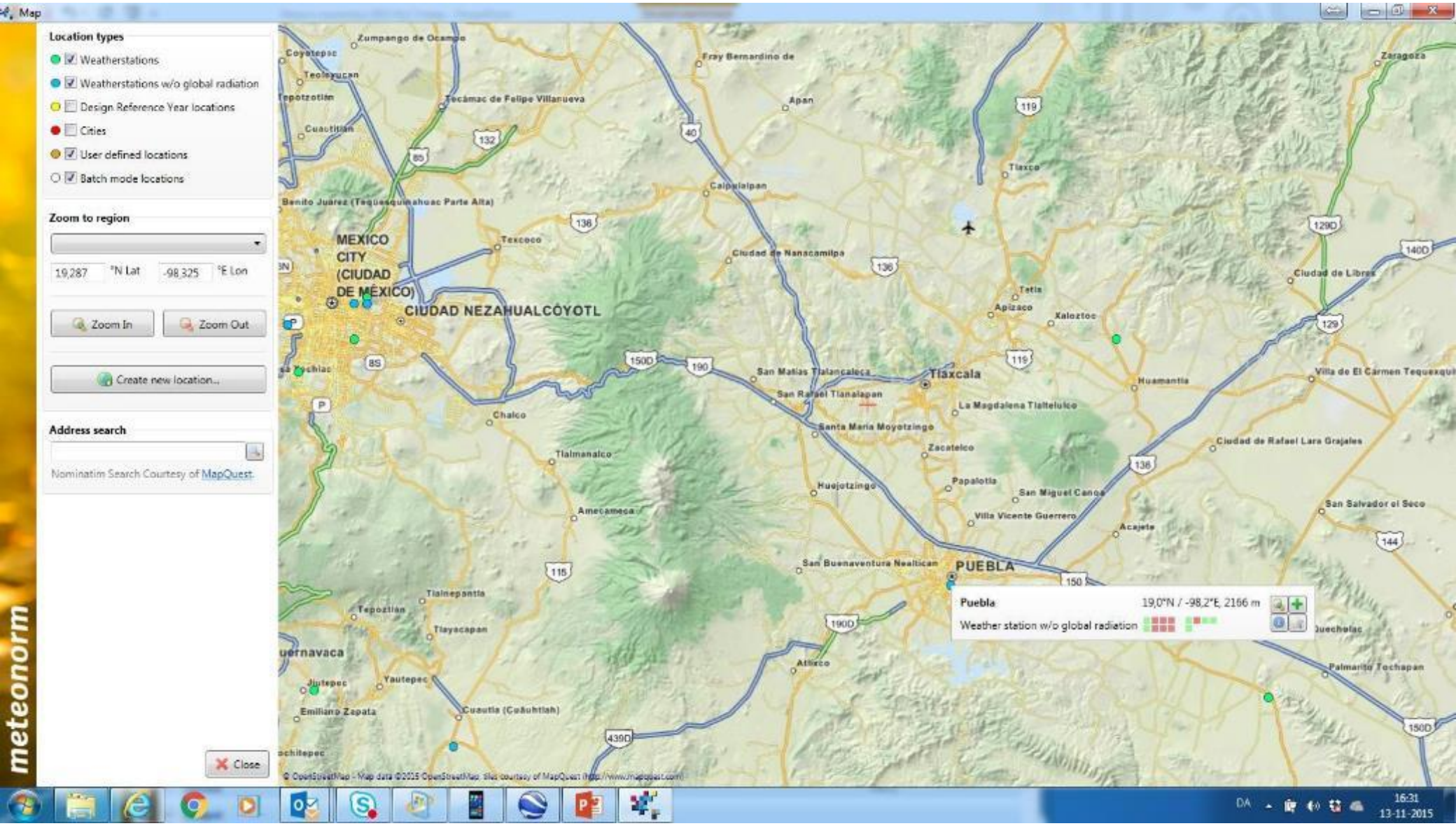
Climate profile for RyC Atlixco 1899 m above sea level



Climate profile for Puebla 2166 m above sea level



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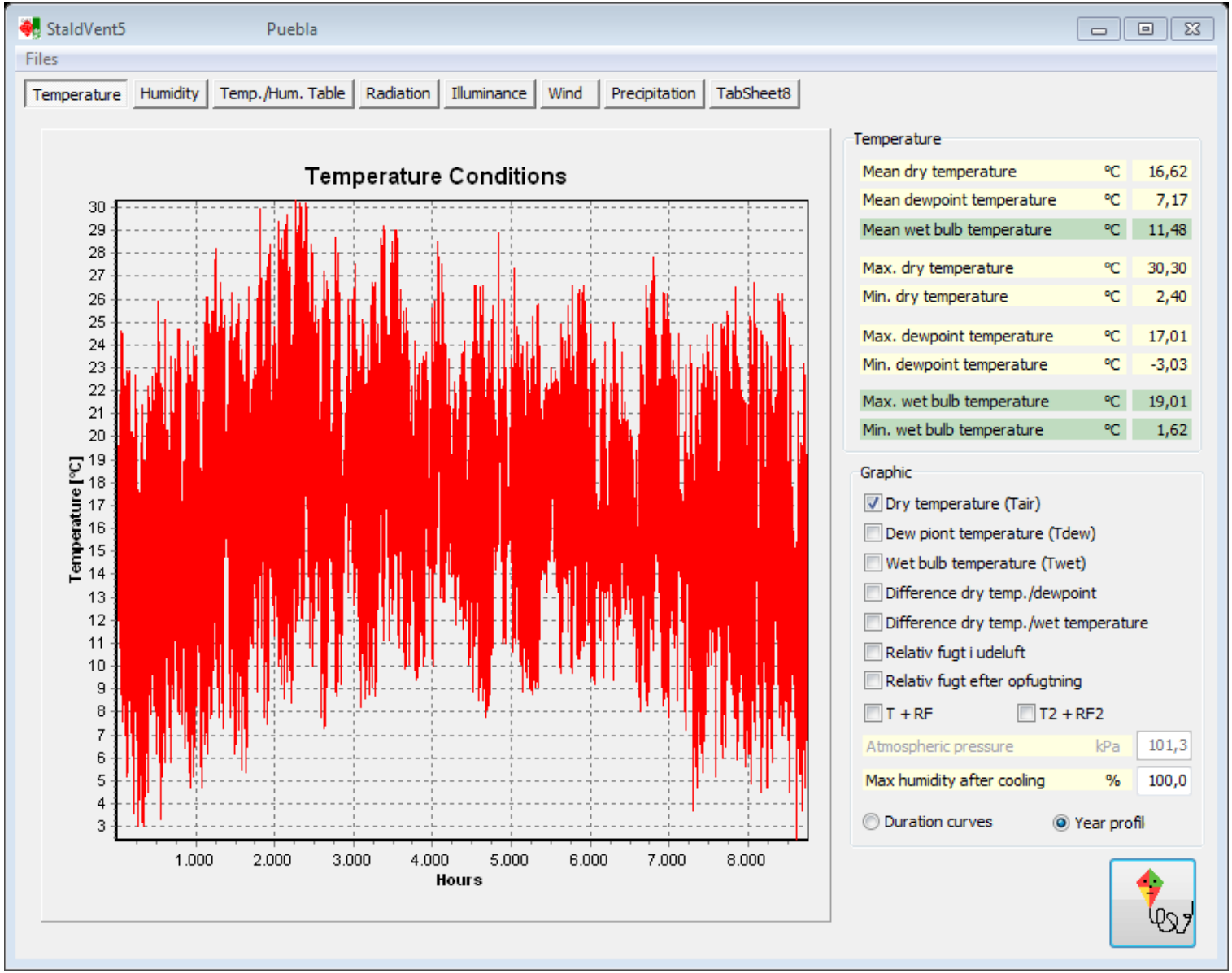

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Climate profile for Puebla 2166 m above sea level

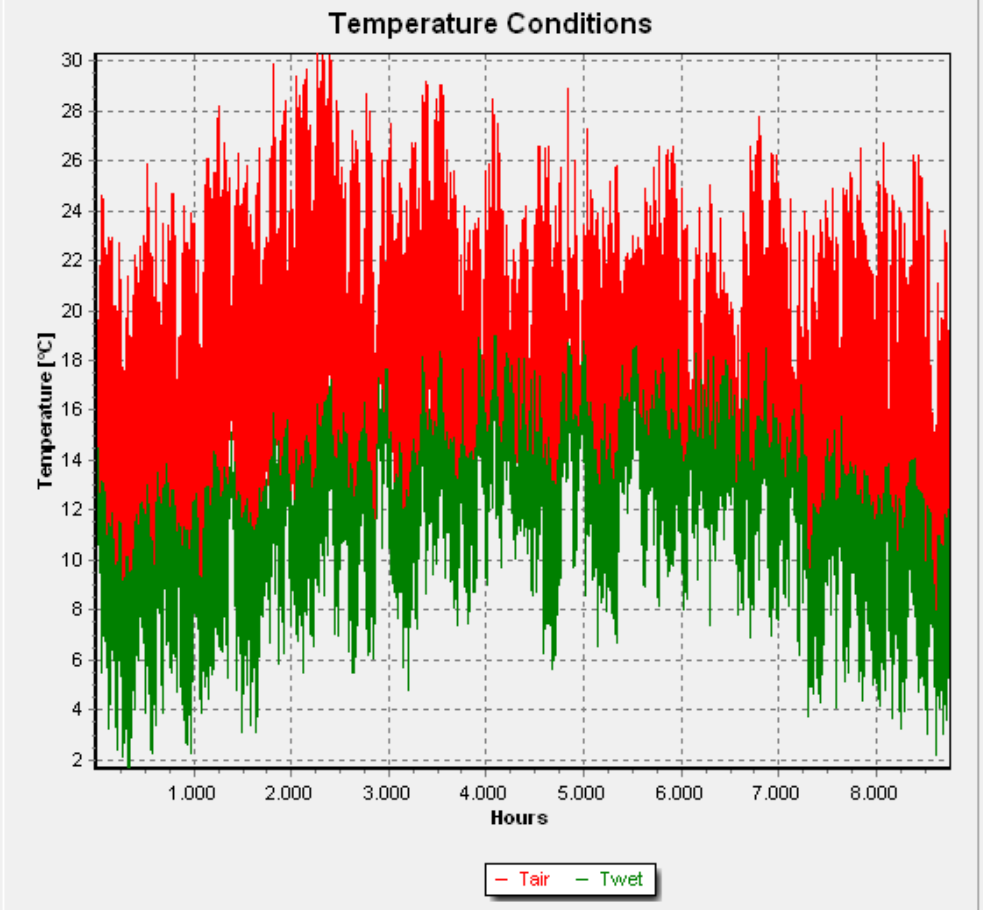
Dry bulb

Wet bulb

StaldVent5 Puebla

Files

Temperature | Humidity | Temp./Hum. Table | Radiation | Illuminance | Wind | Precipitation | TabSheet8



Temperature

Mean dry temperature	°C	16,62
Mean dewpoint temperature	°C	7,17
Mean wet bulb temperature	°C	11,48
Max. dry temperature	°C	30,30
Min. dry temperature	°C	2,40
Max. dewpoint temperature	°C	17,01
Min. dewpoint temperature	°C	-3,03
Max. wet bulb temperature	°C	19,01
Min. wet bulb temperature	°C	1,62

Graphic

- [x] Dry temperature (Tair)
- [ ] Dew piont temperature (Tdew)
- [x] Wet bulb temperature (Twet)
- [ ] Difference dry temp./dewpoint
- [ ] Difference dry temp./wet temperature
- [x] Relativ fugt i udeluft
- [ ] Relativ fugt efter opfugtning
- [ ] T + RF
- [ ] T2 + RF2

Atmospheric pressure	kPa	101,3
Max humidity after cooling	%	100,0

( ) Duration curves (•) Year profil

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Climate profile for Puebla 2166 m above sea level

Dry bulb

Wet bulb

StaldVent5 Puebla

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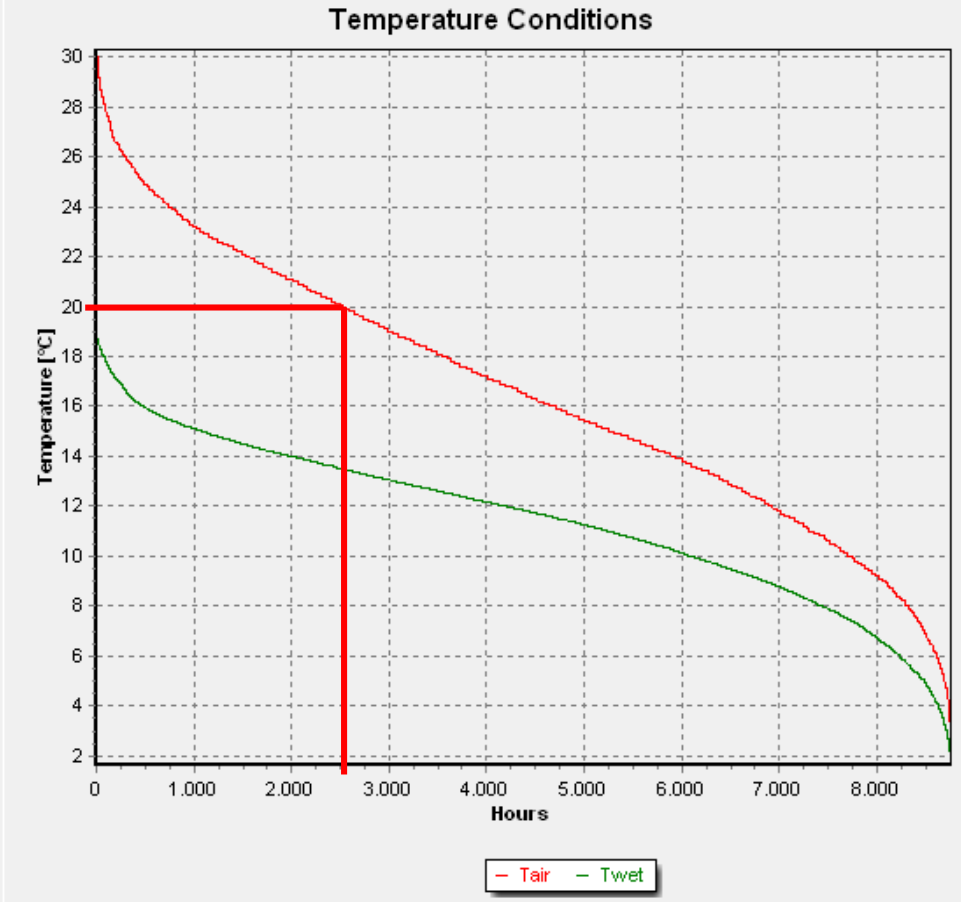

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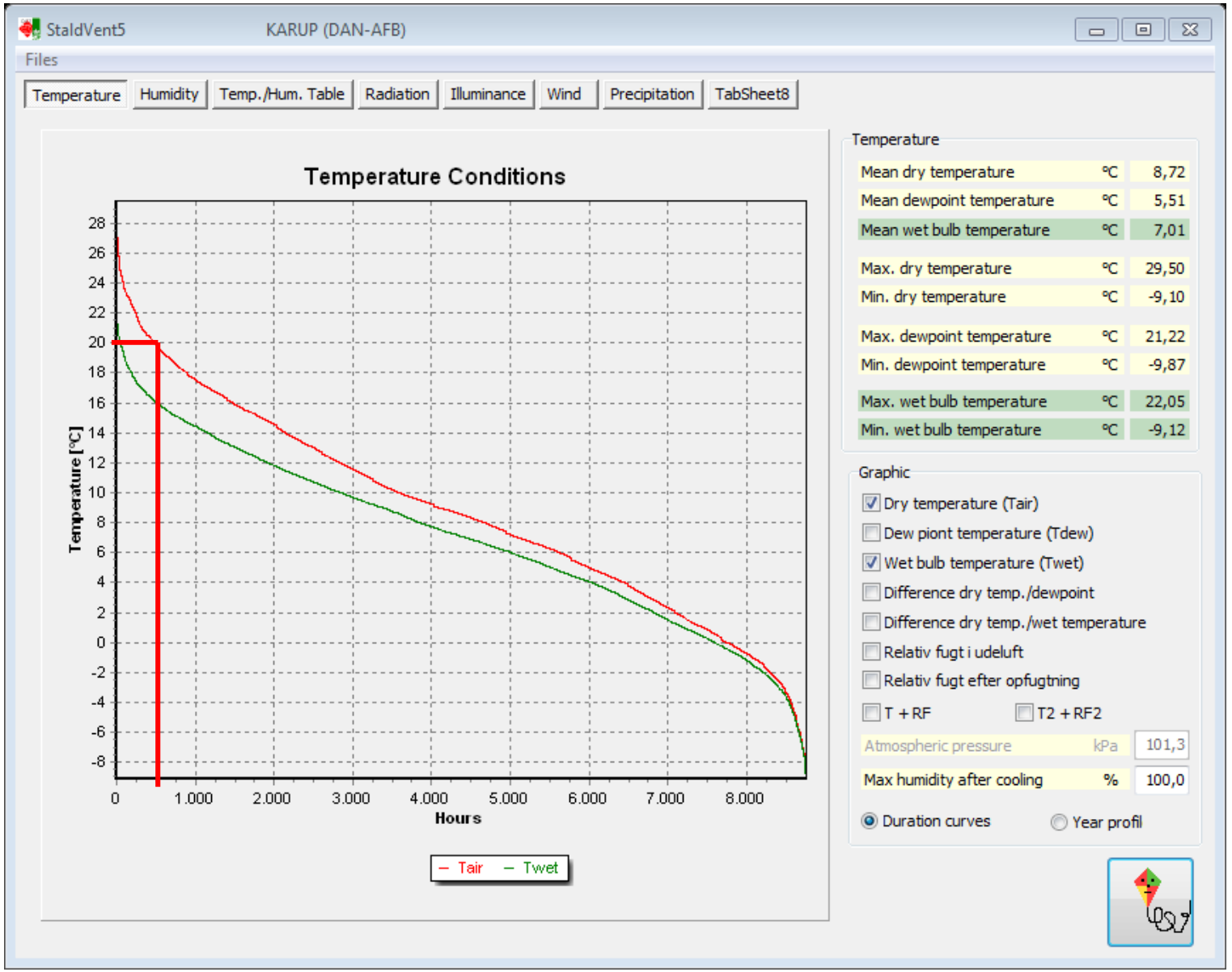
Denmark



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Cooling is important – three ways of doing it

- Ventilation capacity
- Evaporative cooling
  - Sprinkling system
  - High-pressure cooling
  - Pads
- Increasing air velocity
  - Wall and ceiling inlets
  - Tunnel ventilation

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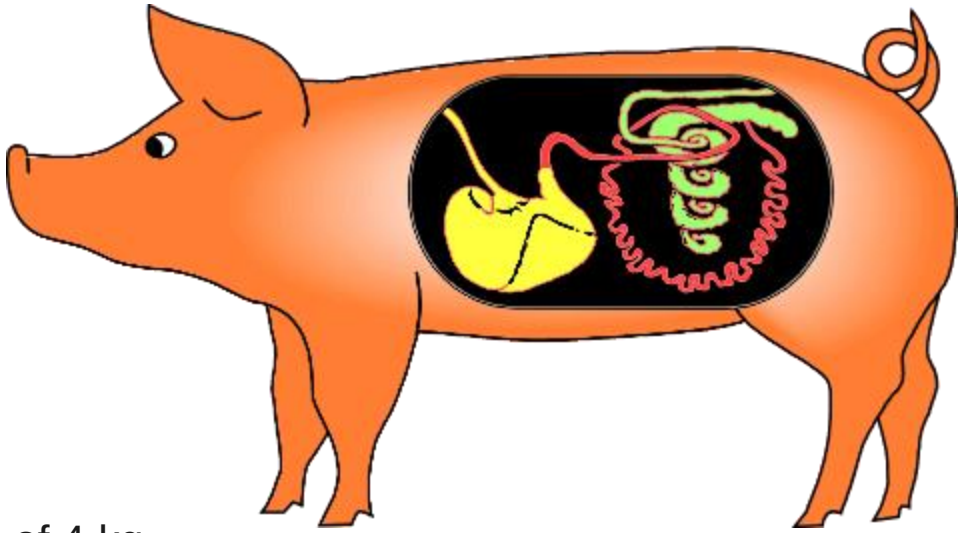
Pigs can’t sweat

But as a pig producer, you don’t want to sweat like a pig

Heat production of the pigs

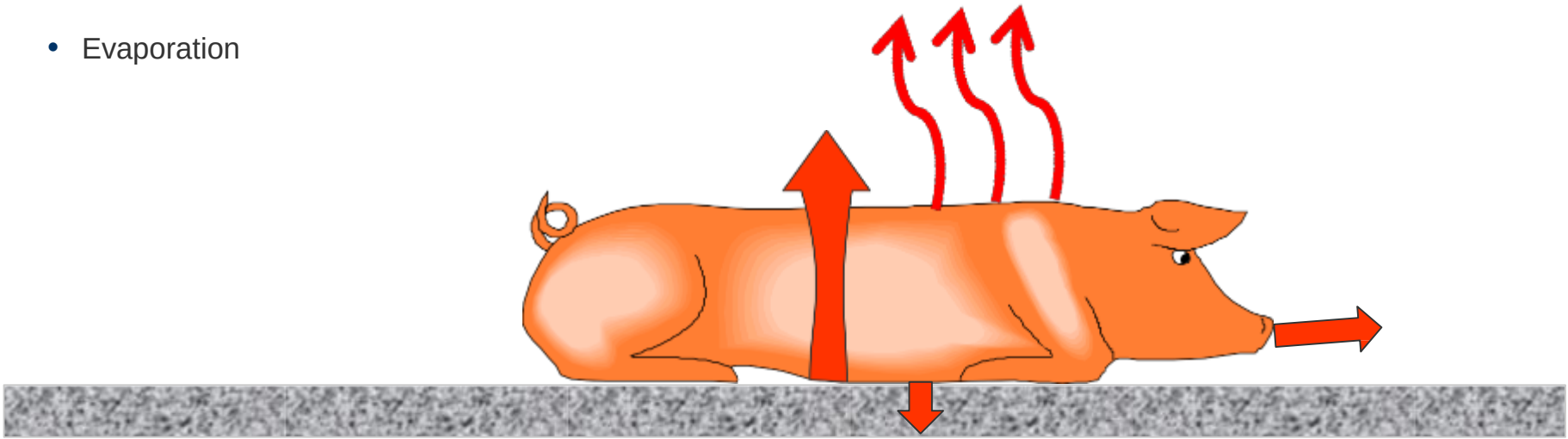
1 Heat **P**roduction **U**nit
Total heat: 1000 W
Sensible heat: 650 W
Moisture production: 0.50 kg/h
Carbon dioxide production: 0.35 kg/h



1 HPU = 4 finishing pigs at 98 kg
8 weaning pigs at 30 kg
3 pregnant sows of 270 kg
1 farrowing sow of 270 kg + 12 piglets of 4 kg

Heat loss from a pig

- Sensible heat
  - Conduction
  - Convection
  - Radiation
- Latent heat
  - Evaporation



Naturally ventilated pig houses in Spain

Pigs reaction to hot climate

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Heat stress – respiration rate increases

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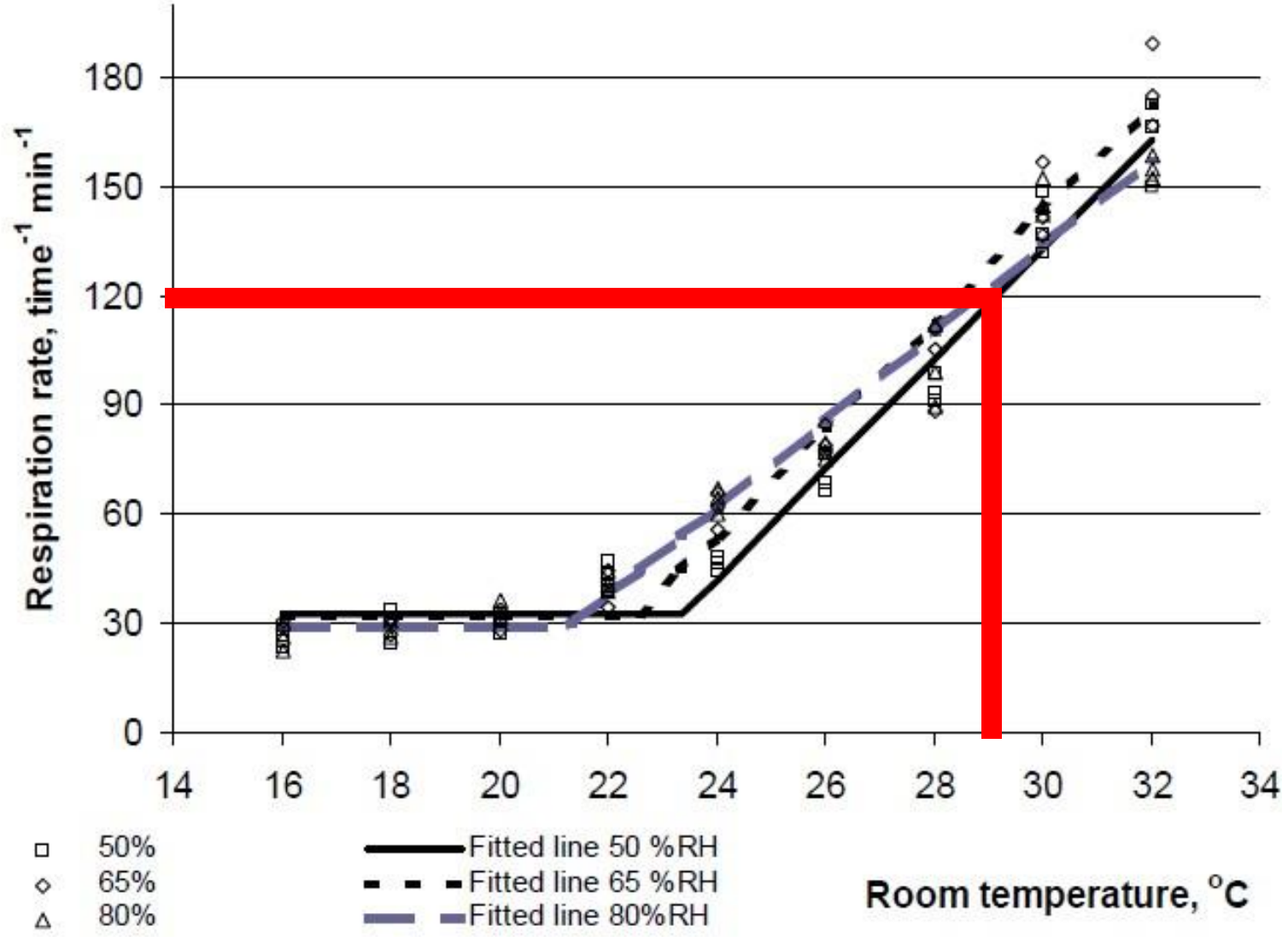
Effect of climate on respiration rate (60 kg pig)



Source: Aarnink et al, 2006

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Effect of temperature on water to feed ratio

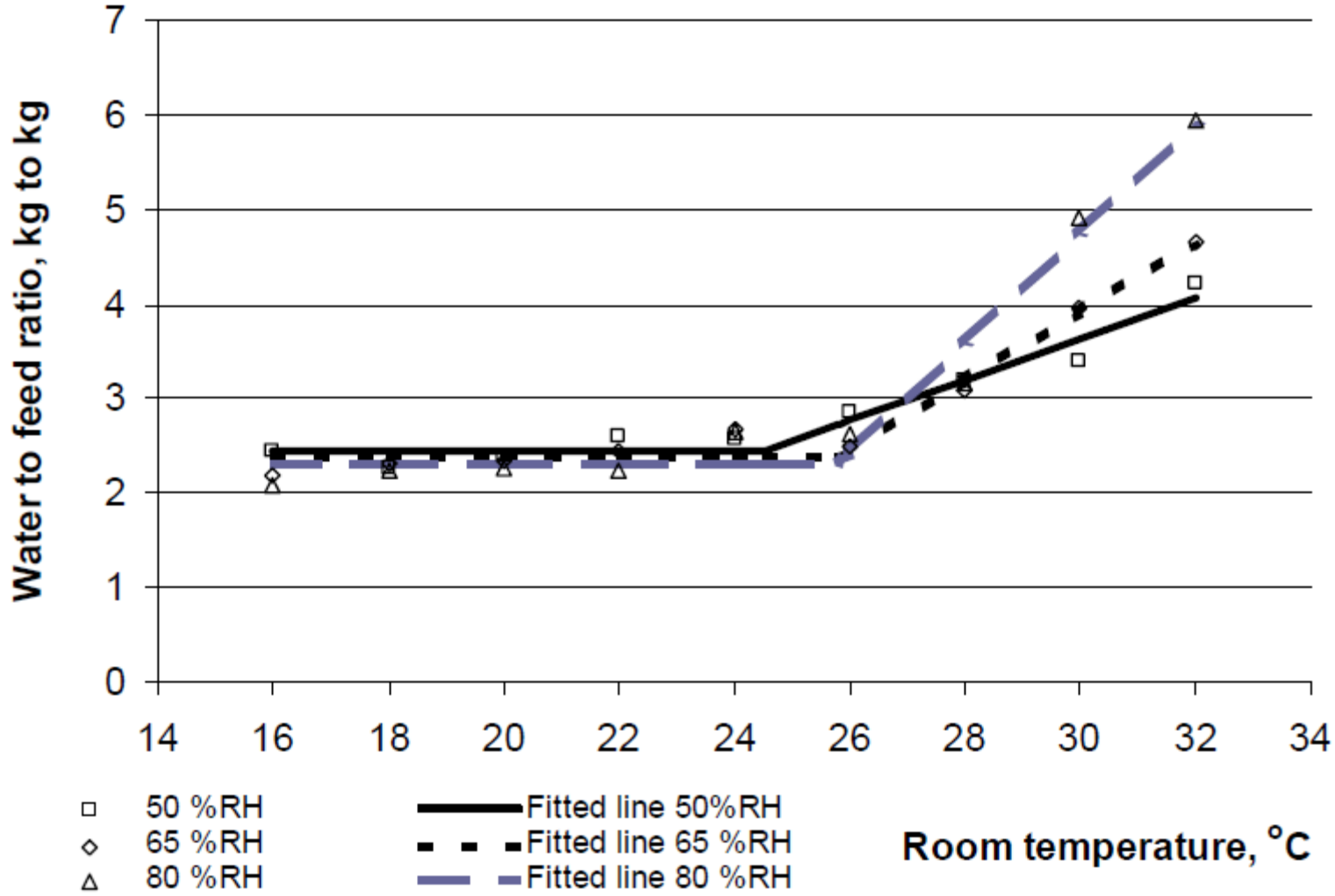

Figure 4. Broken line relationship between ambient temperature and water to feed ratio; □ ◇ Δ are means of measured data.

Effect of temperature on skin temperature

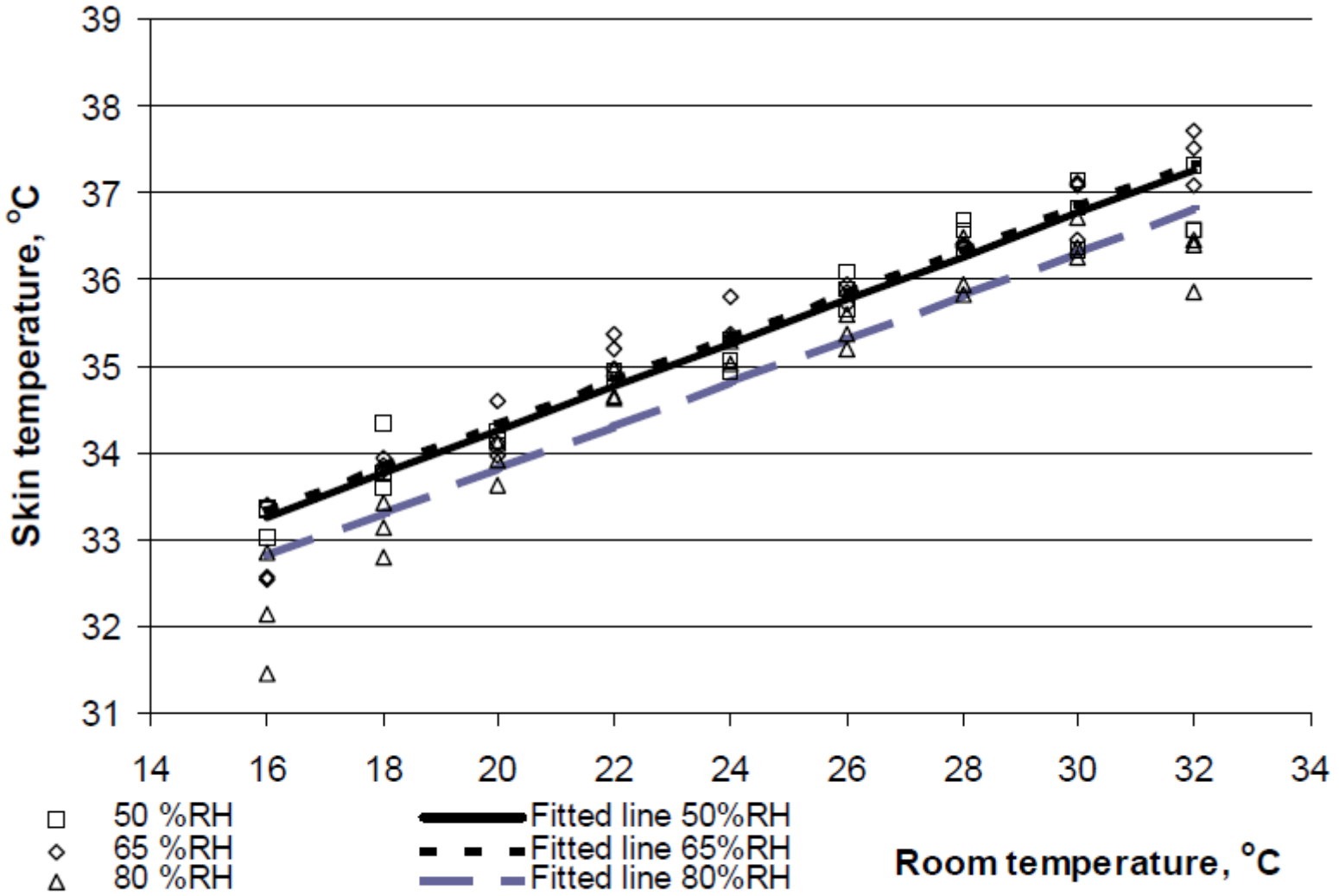

Figure 5. Linear relationship between ambient temperature and skin temperature;
□ ◇ Δ are means of three marked pigs.

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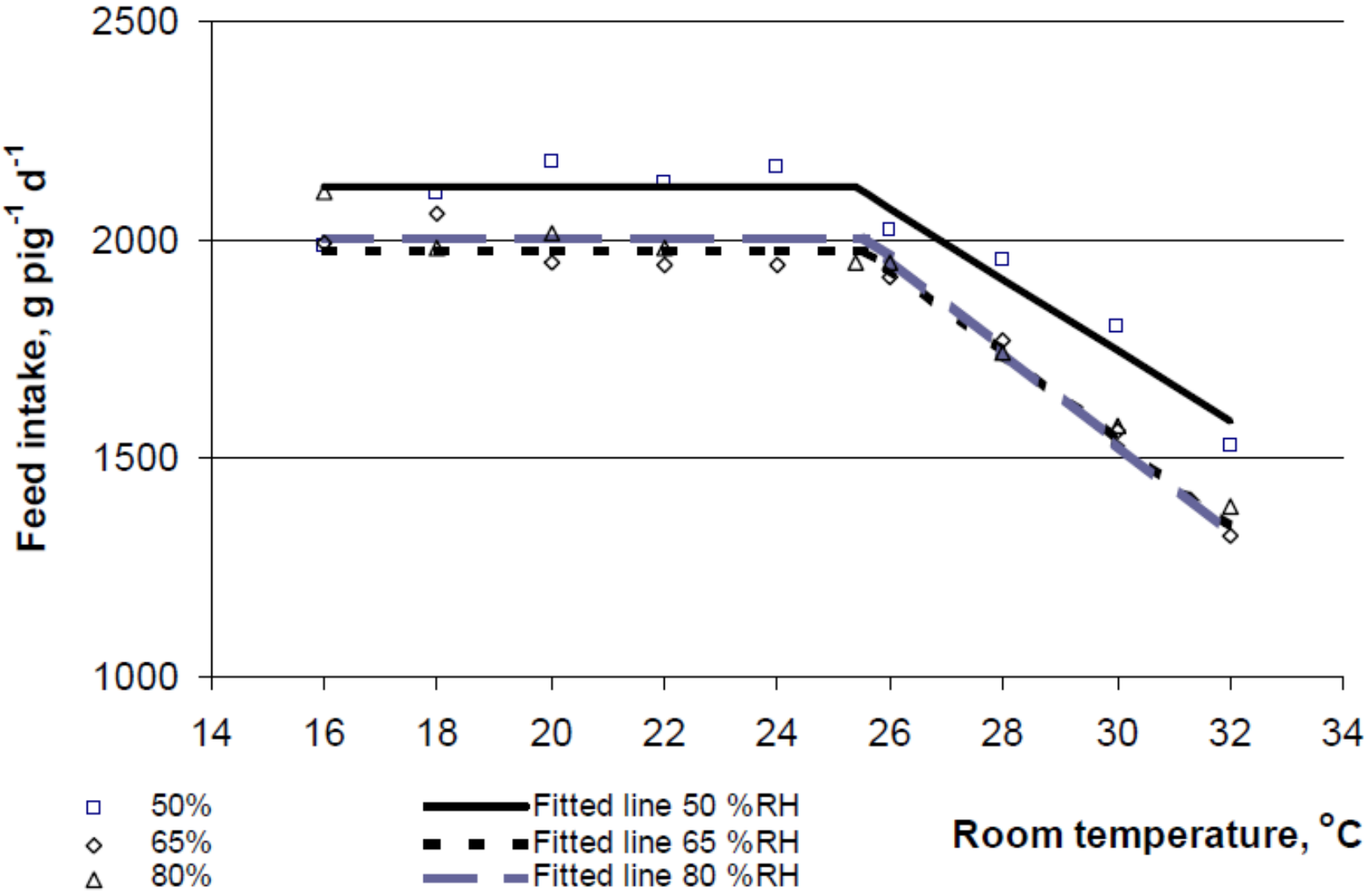
Effect of climate on feed intake (60 kg pig)



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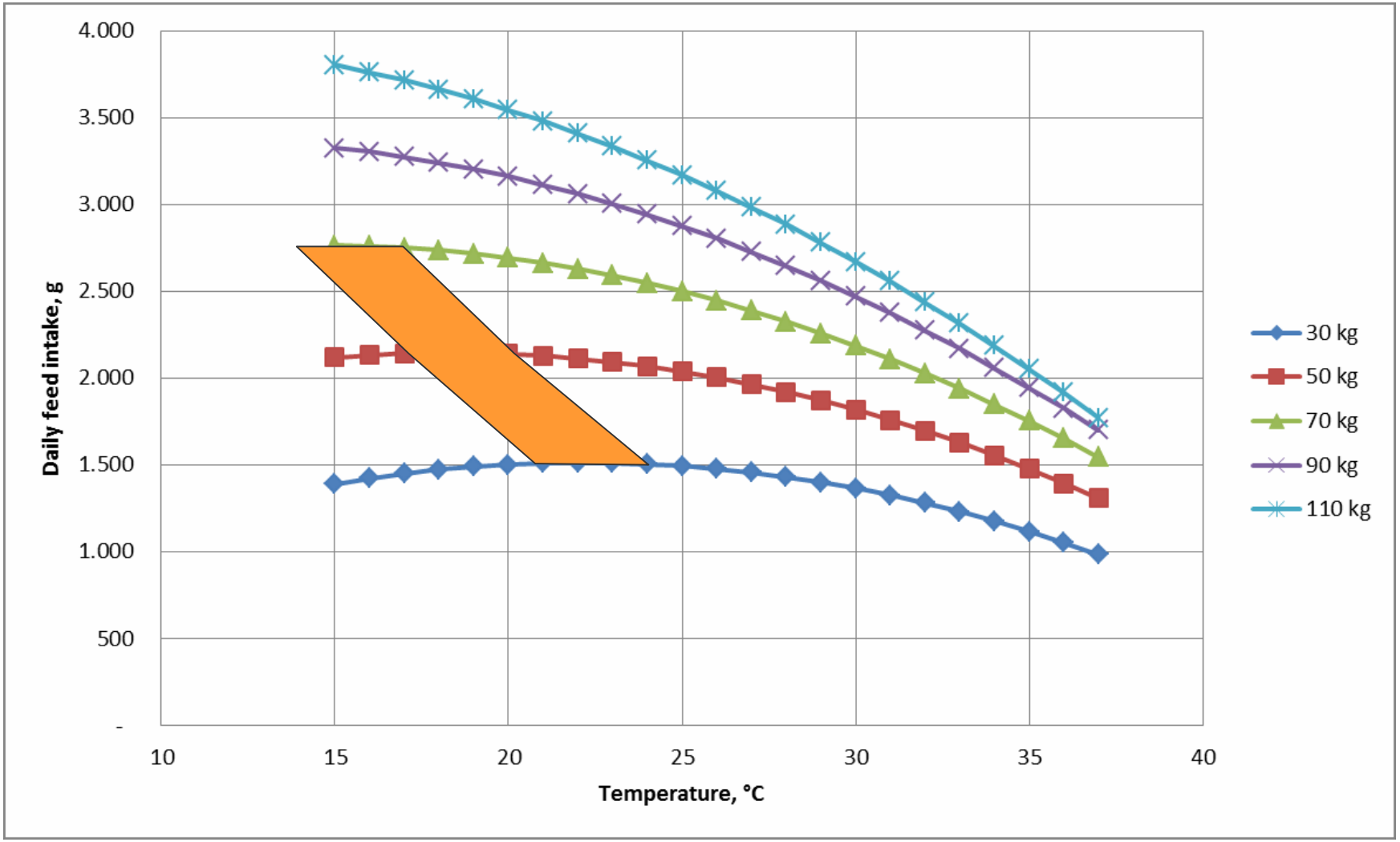
Effect of heat stress on pigs

- Behavioural change starts at approx 20°C
- Productivity drop starts at approx 25°C
- Sensitivity to heat stress depends on the category of pigs
  - Most sensitive: Finishing pigs and lactating sows
  - Less sensitive: Weaning pigs and gestating sows

Effects of high ambient temperatures on pig growth



A meta analysis of effects of high ambient temperature on growth performance of growing finishing pigs
Rendaudeau et. Al., 2011

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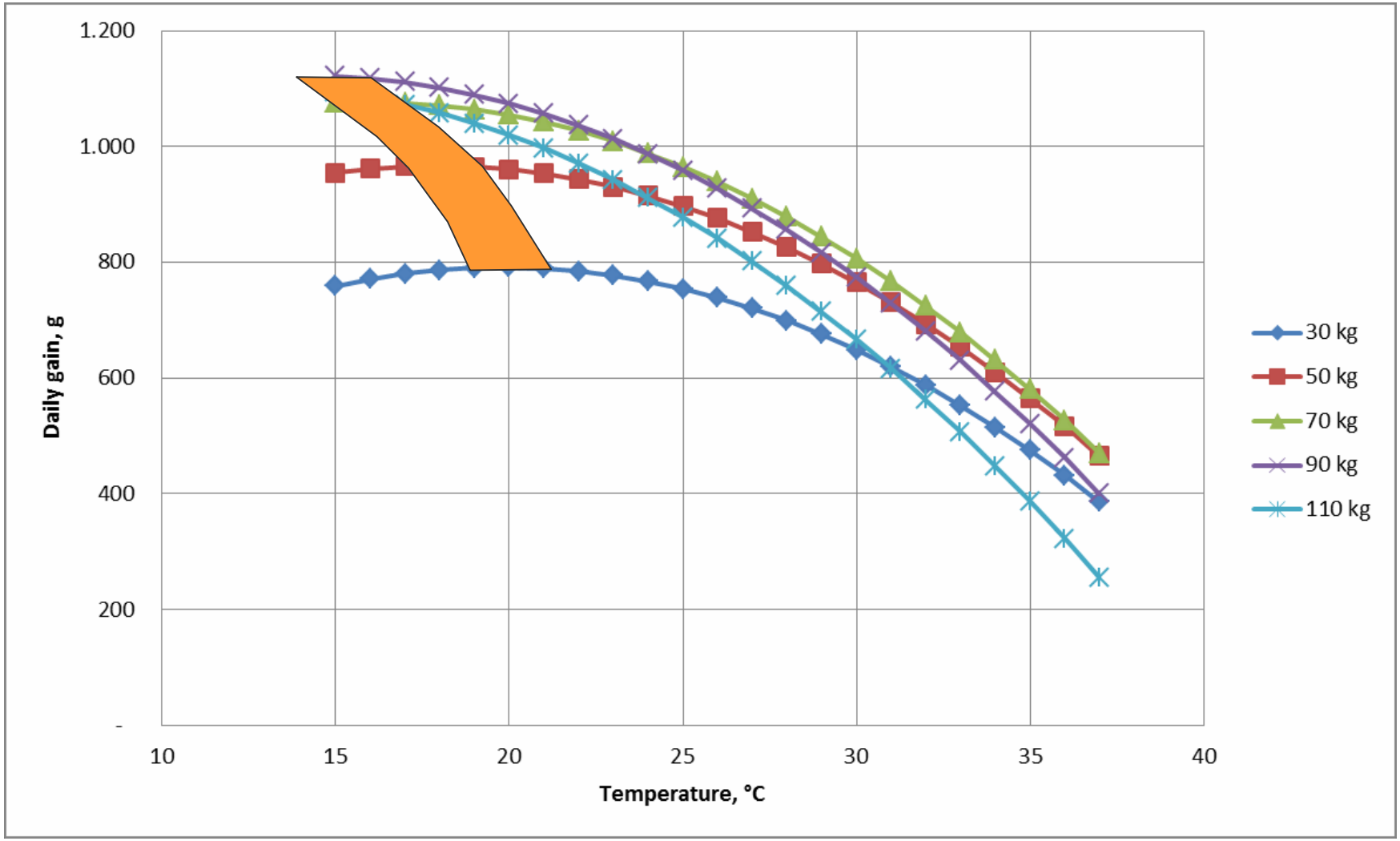
Effects of high ambient temperatures on pig growth



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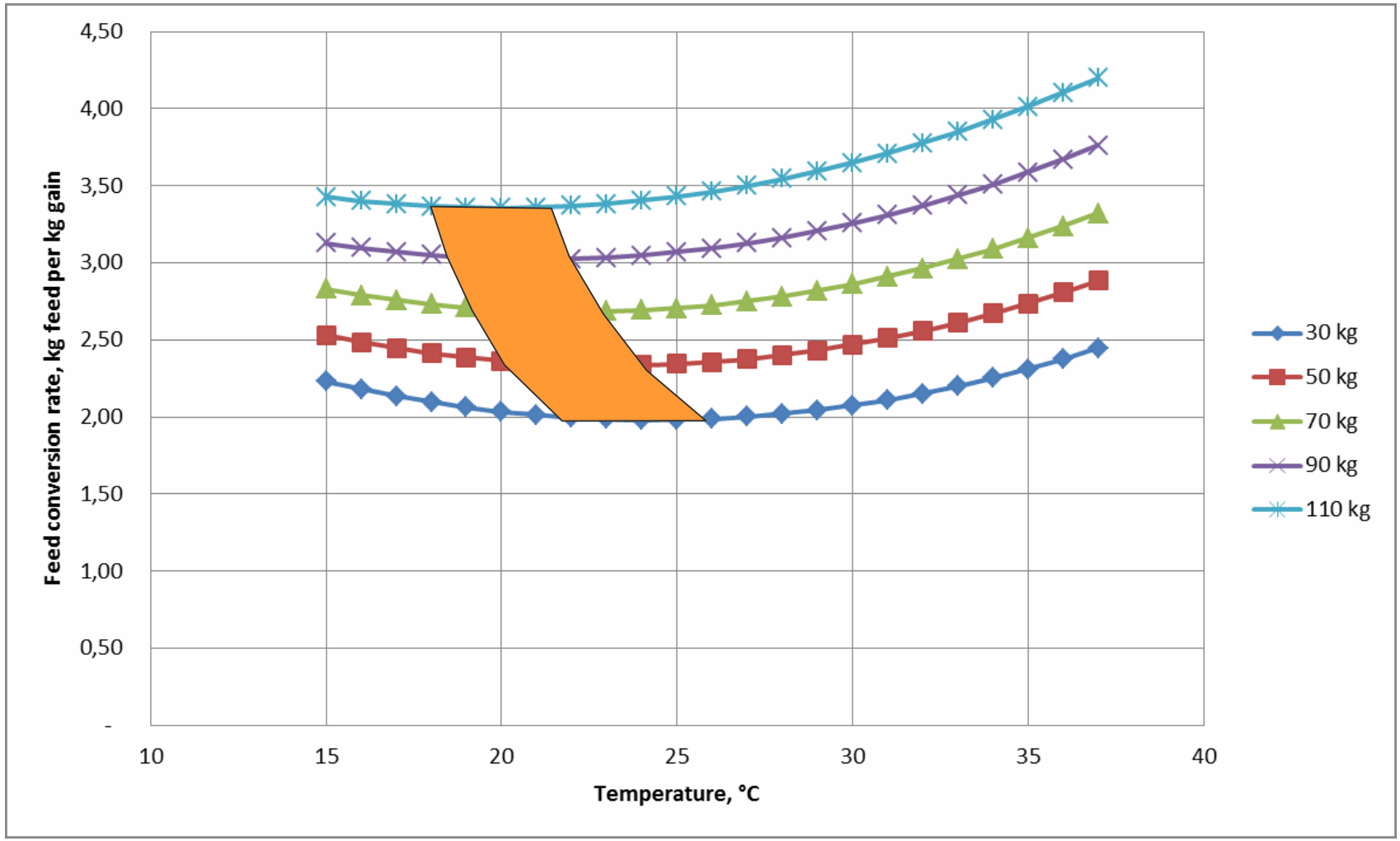
Climate for Growth

Effects of high ambient temperatures on pig growth



A meta analysis of effects of high ambient temperature on growth performance of growing finishing pigs
Rendaudeau et. Al., 2011

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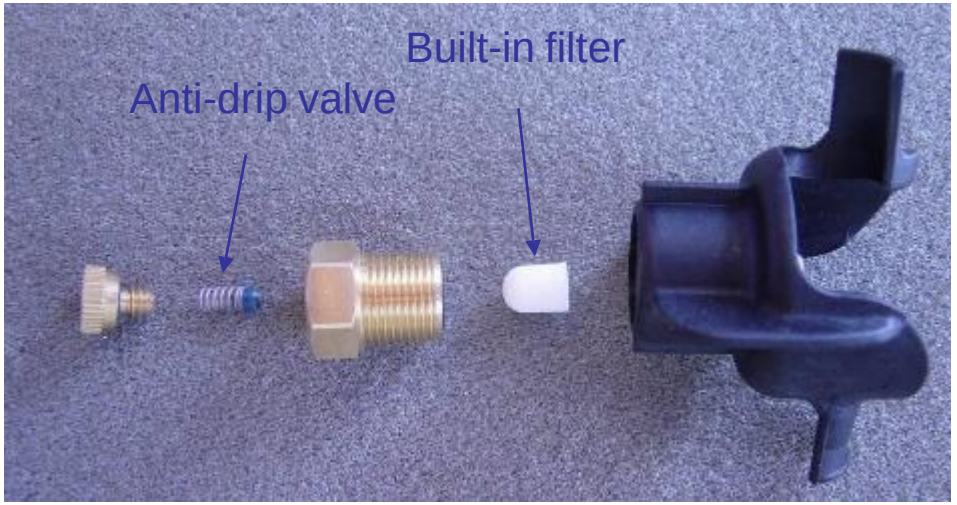
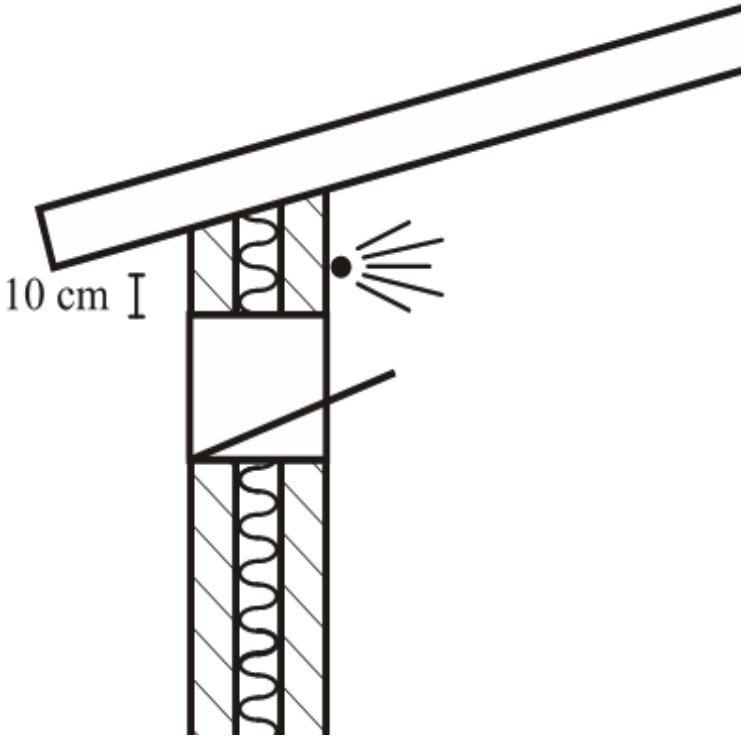
Climate for Growth

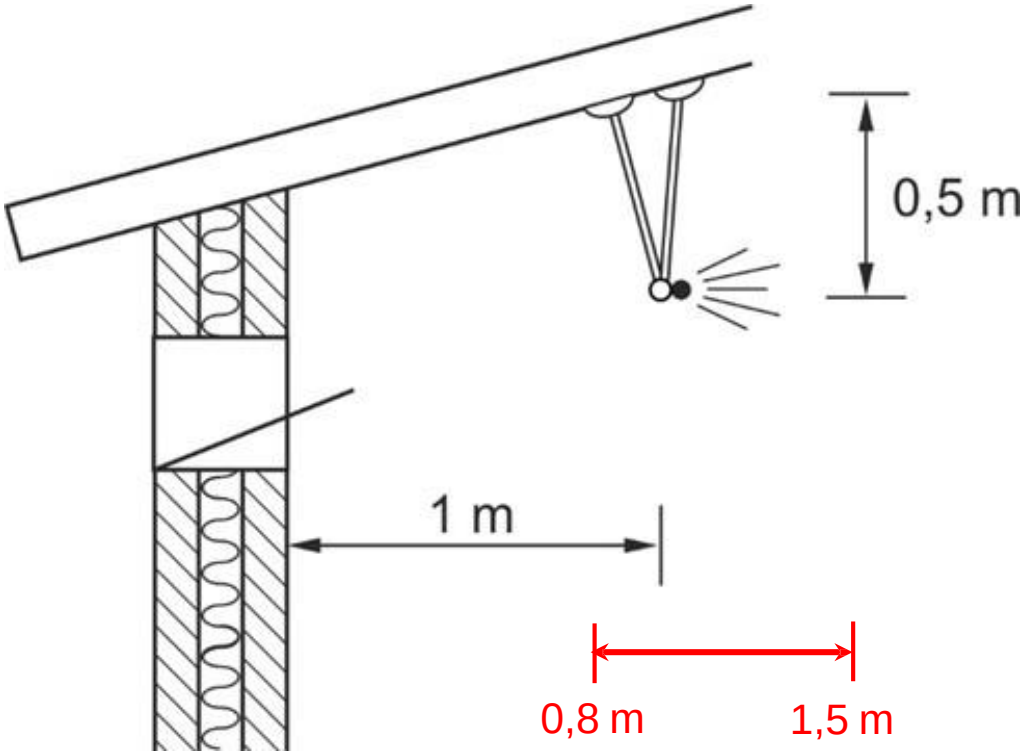
High-pressure cooling – pump and nozzles



New placement of high pressure cooling – why?

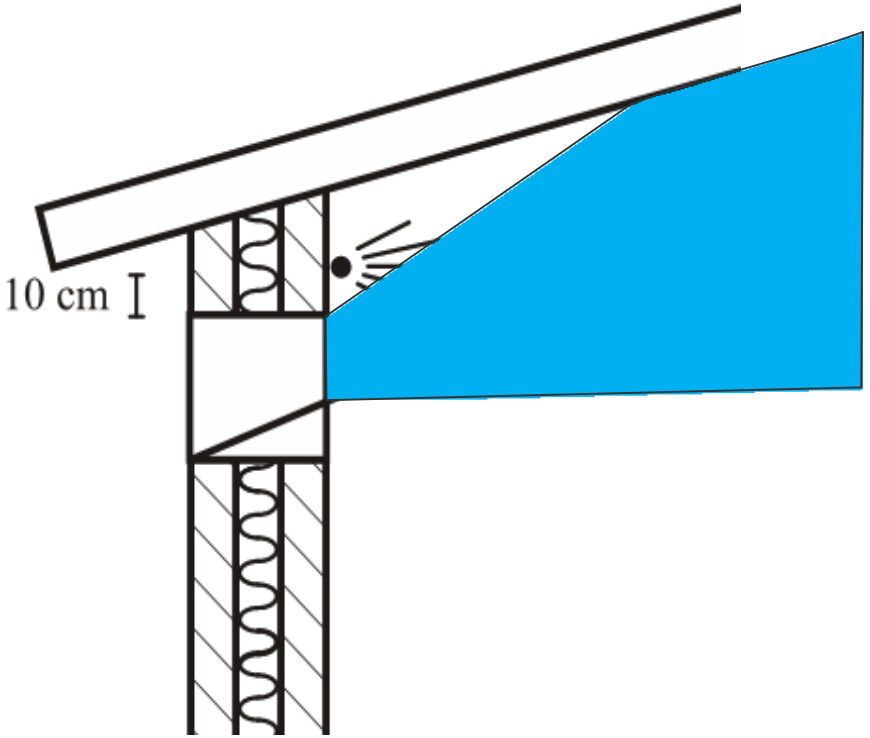


Wall placement

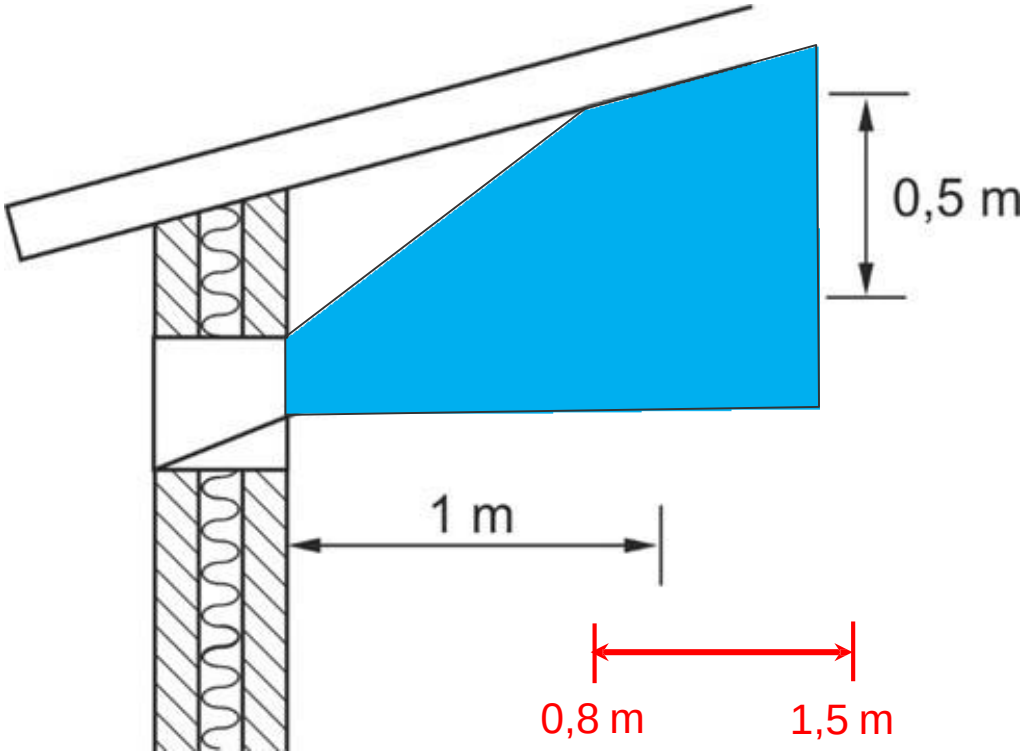


Ceiling placement

New placement of high pressure cooling – why?

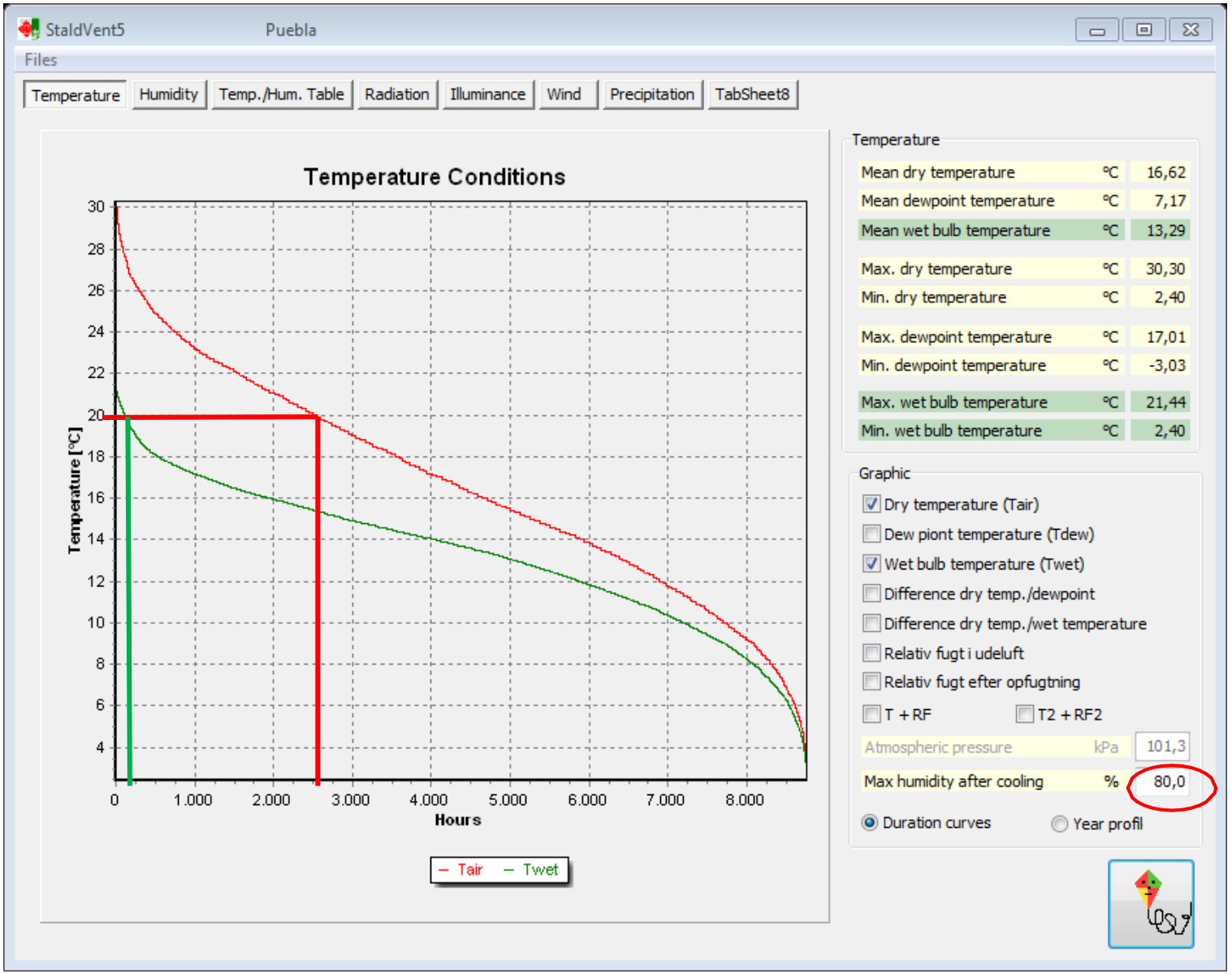


Wall placement



Ceiling placement

Climate profile for Puebla 2166 m above sea level



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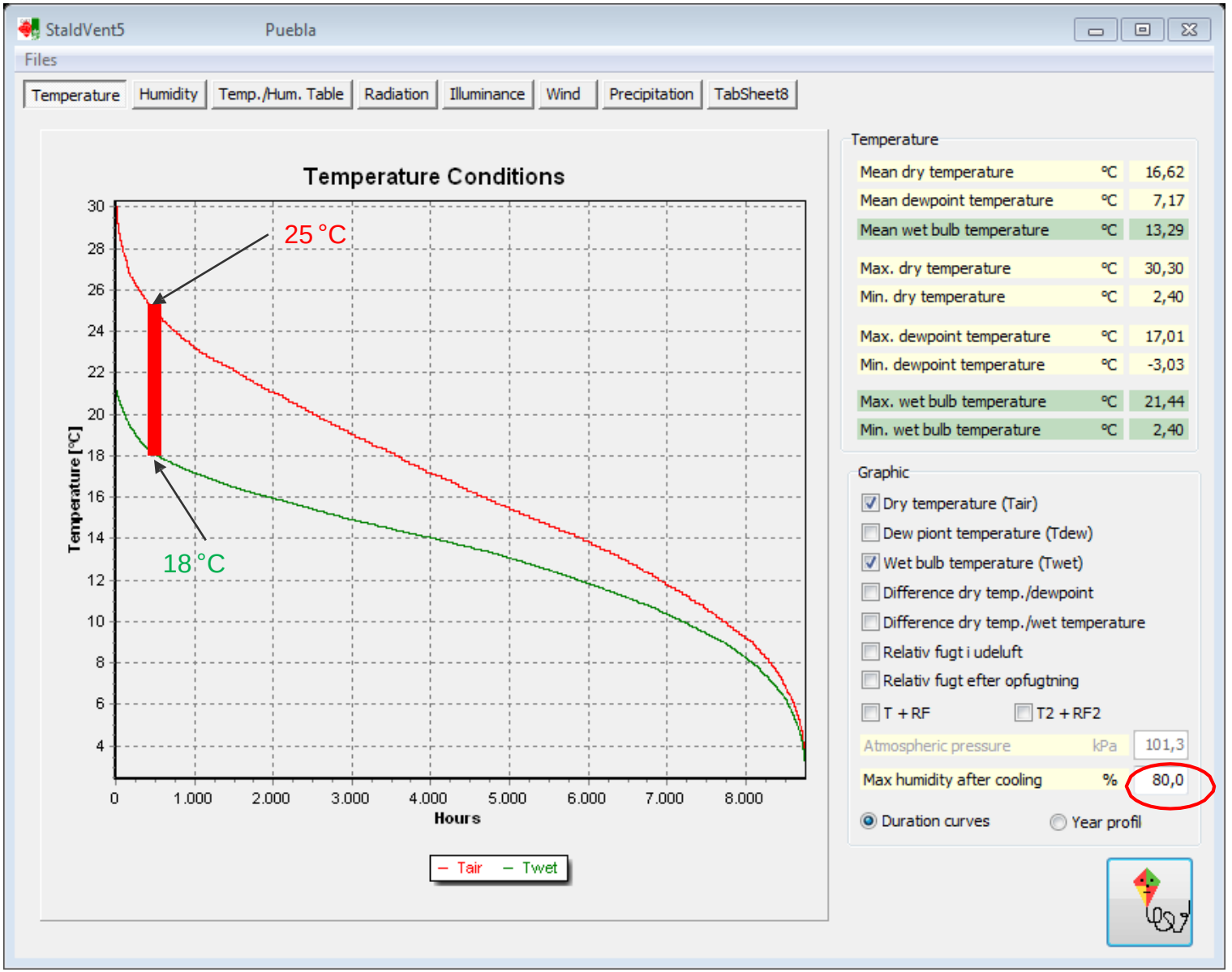
Climate profile for Puebla 2166 m above sea level



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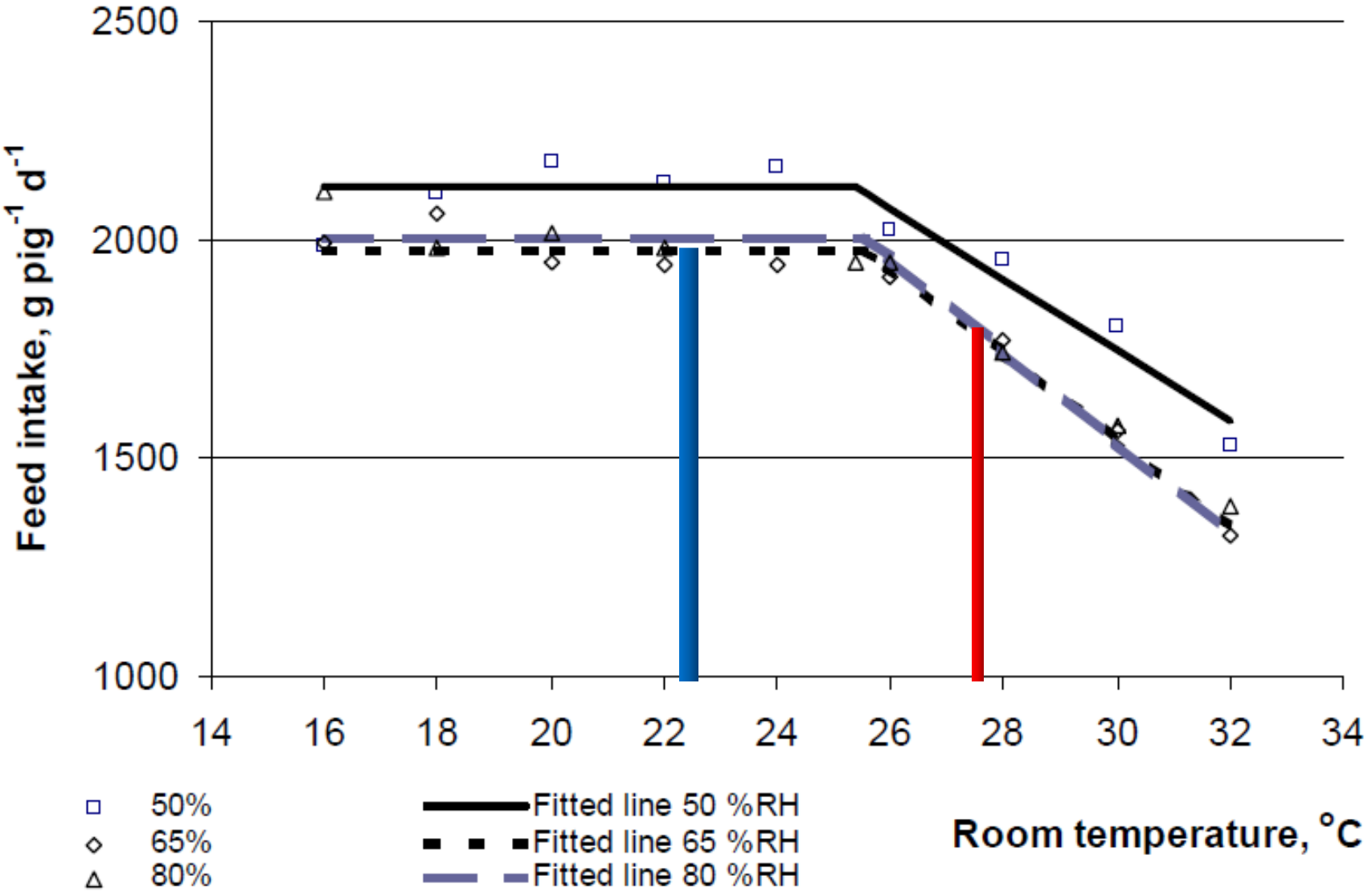
Natural versus mechanical ventilation with cooling

	Natural ventilation	Mechanical ventilation
Ambient temperature, °C	25	25
+ pigs heat production, °C	+2.5	+2.5
÷ cooling, °C		-7.5
÷ chill effect, °C		0
Experienced temperature, °C	**27.5**	**20**

Effect of climate on feed intake (60 kg pig)



Source: Aarnink et al, 2006

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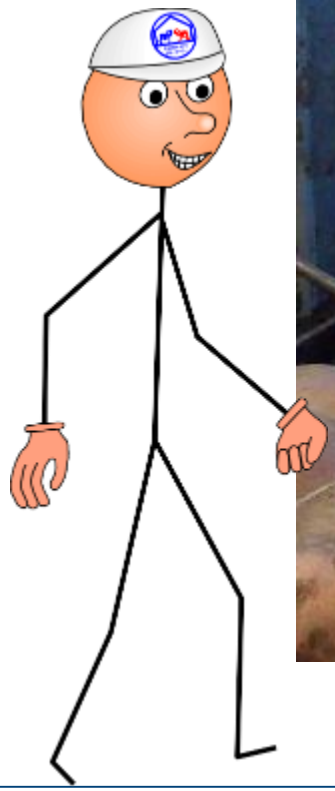
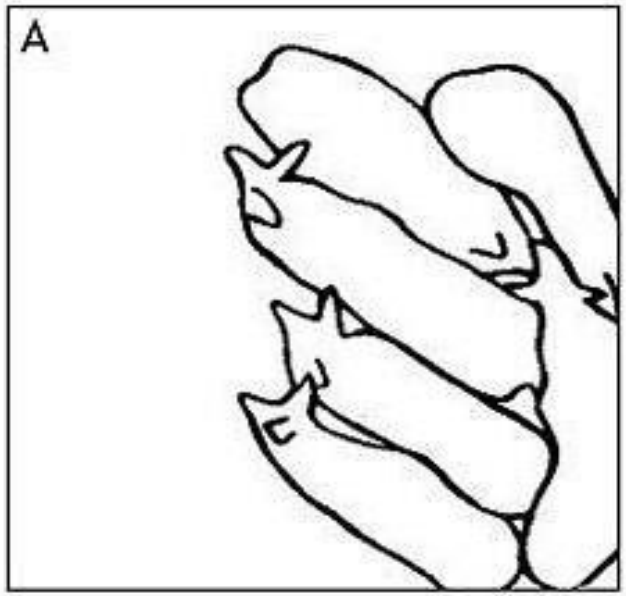
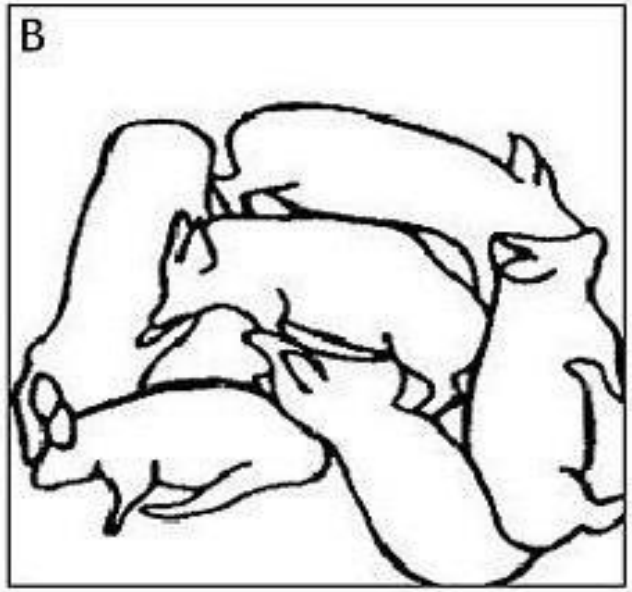
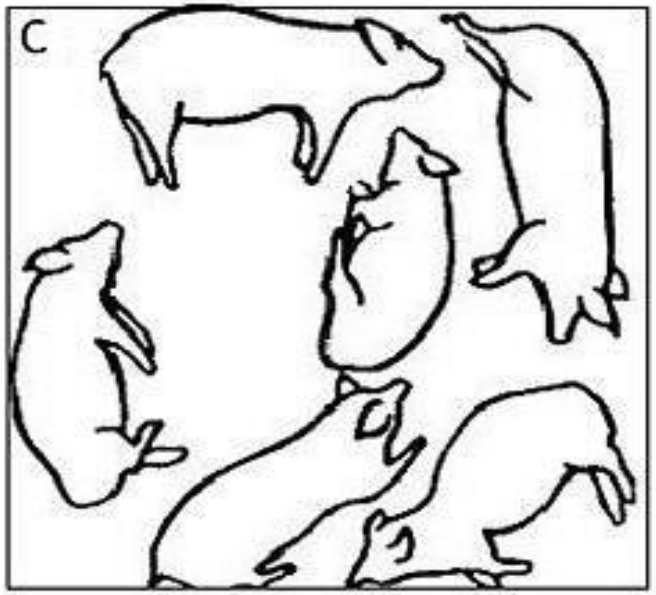
Climate condition in the zone occupied by the pigs



Pigs behavioural reaction to temperature







Always look at the pigs!

Source: Model after Baxter, M. og Inns, T. (1993) The Biological Basis for Pig Space Requirements

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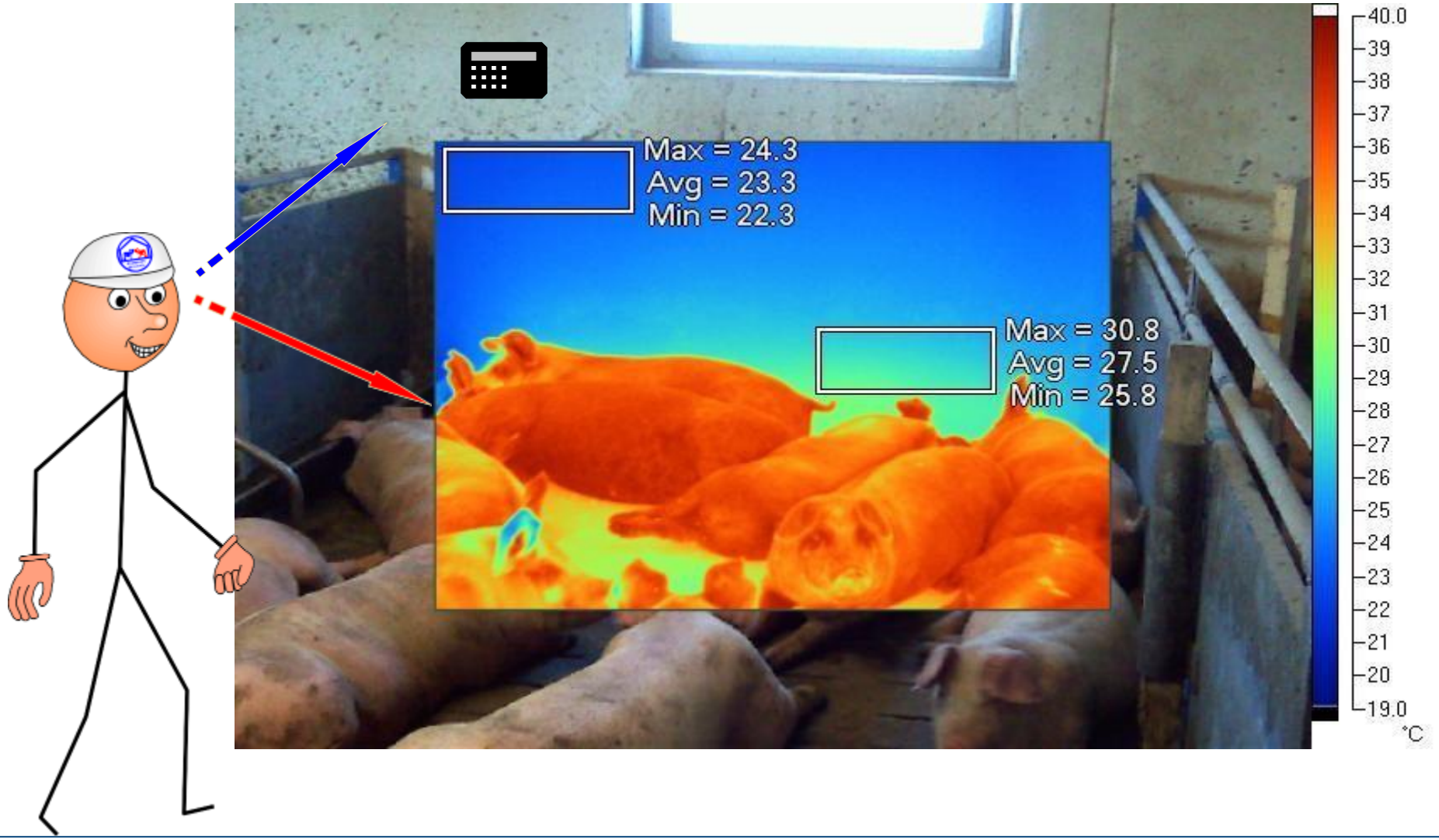
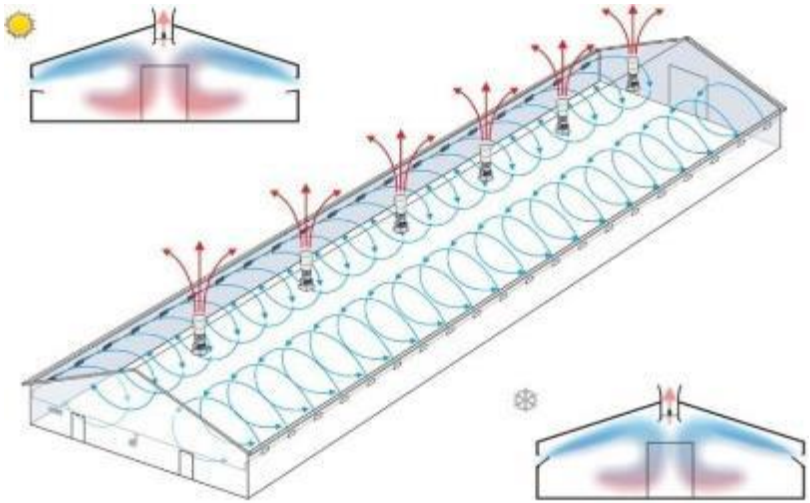
Climate condition in the zone occupied by the pigs

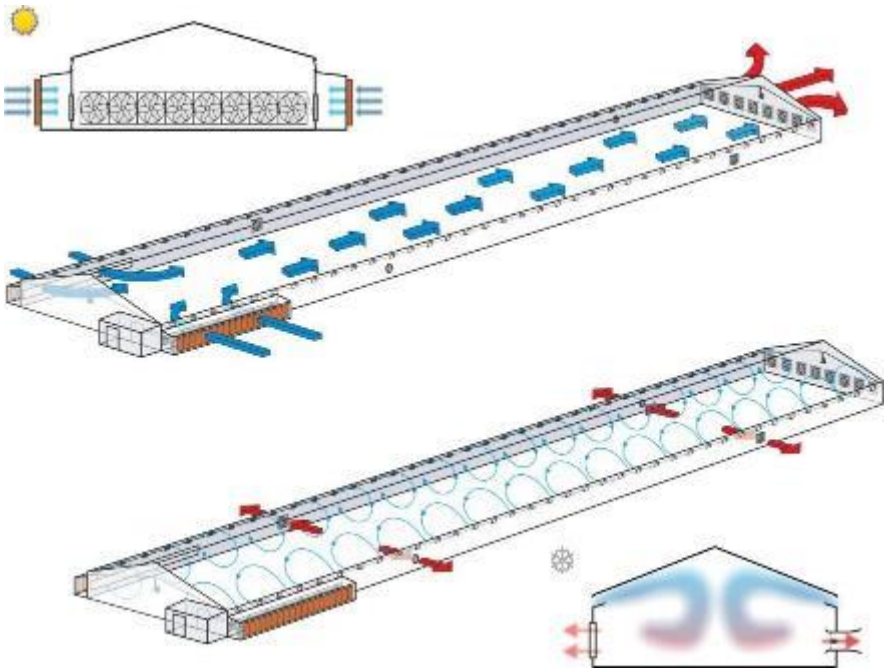


SKOV ventilation systems for pig production

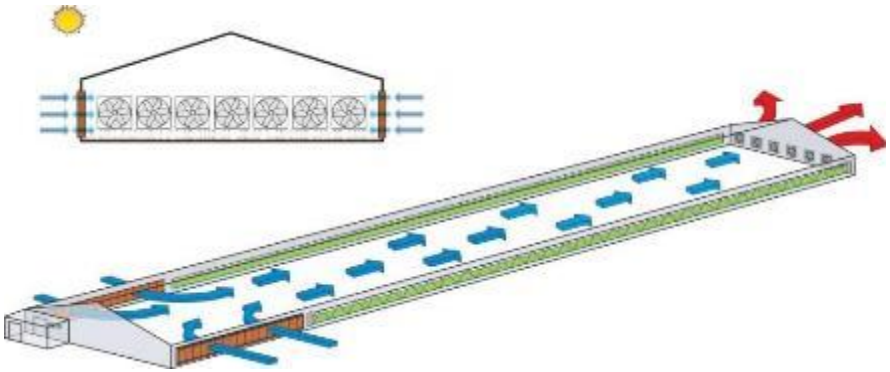
Low **P**ower **V**entilation (**LPV**)



Combi-Tunnel



Tunnel (only in tropical areas)



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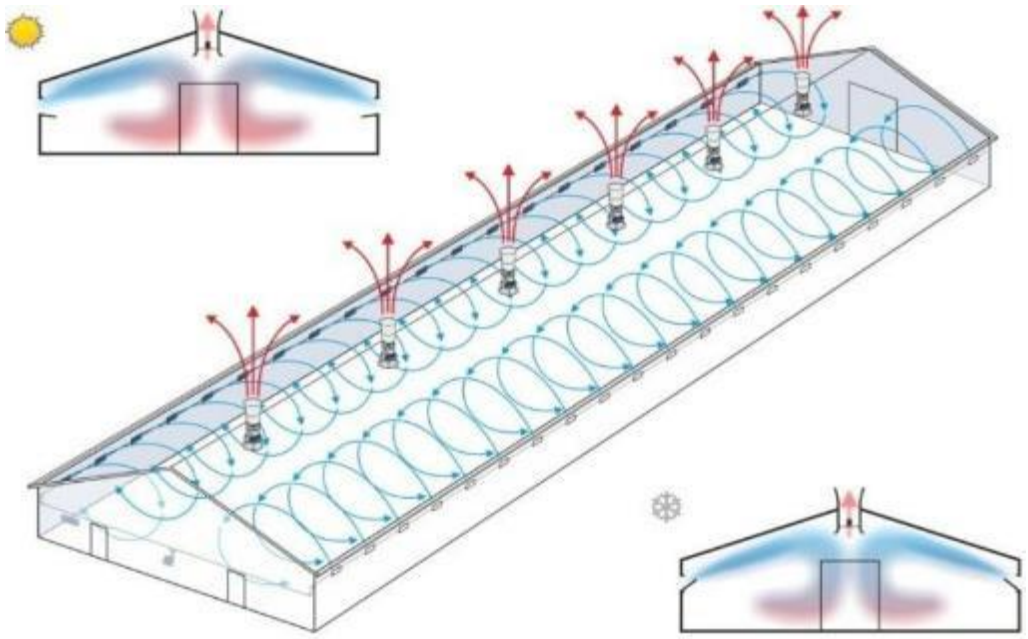
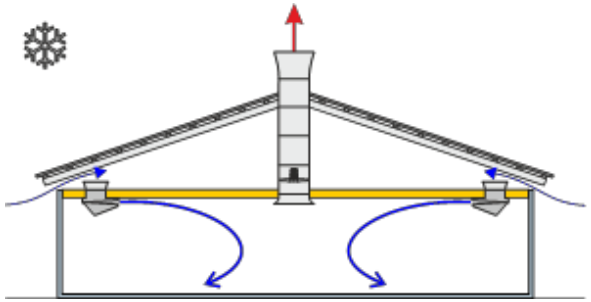
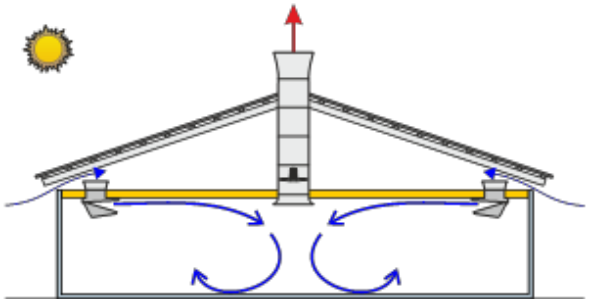
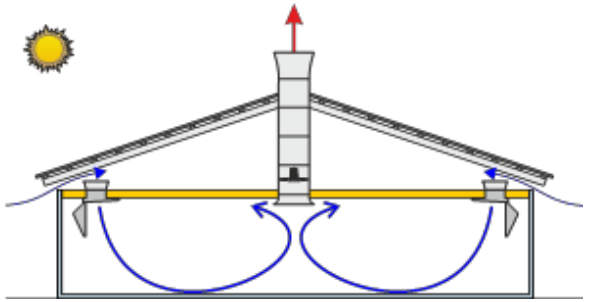
LPV as much as possible



- LPV advantages
  - Identical climate conditions in all pens
  - Control of the air flow pattern within the pen







Identical climate conditions in all pens

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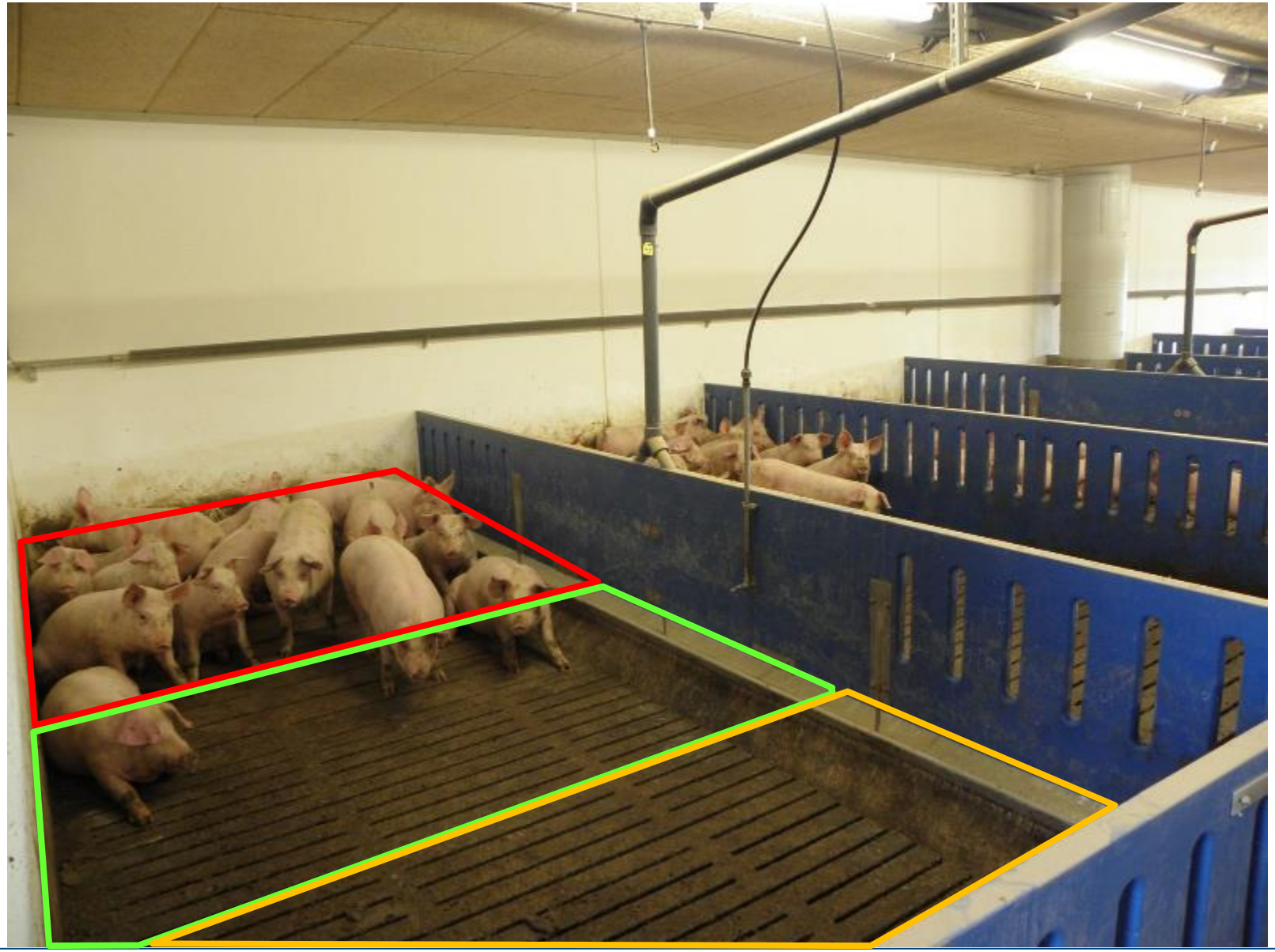
Different climate conditions within the pen is optimal



Resting area

Activity area

Dunging area

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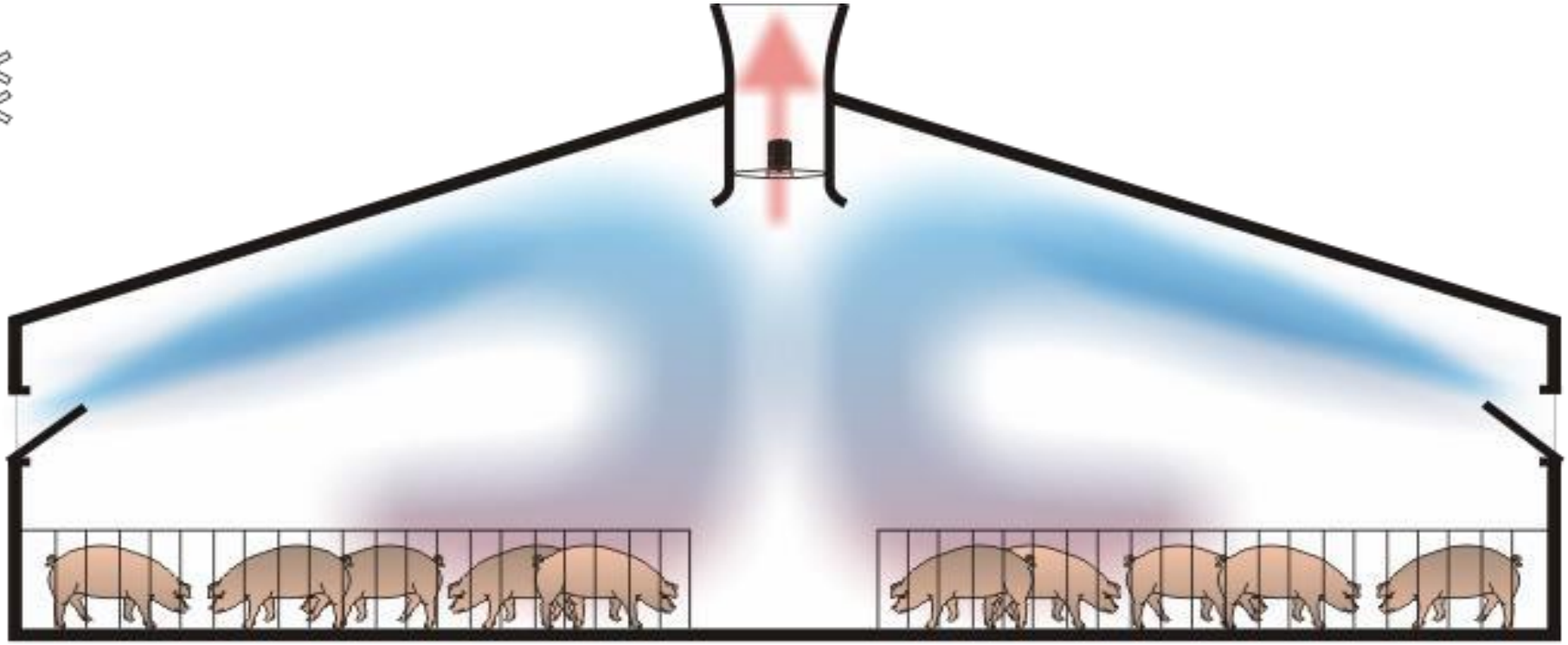
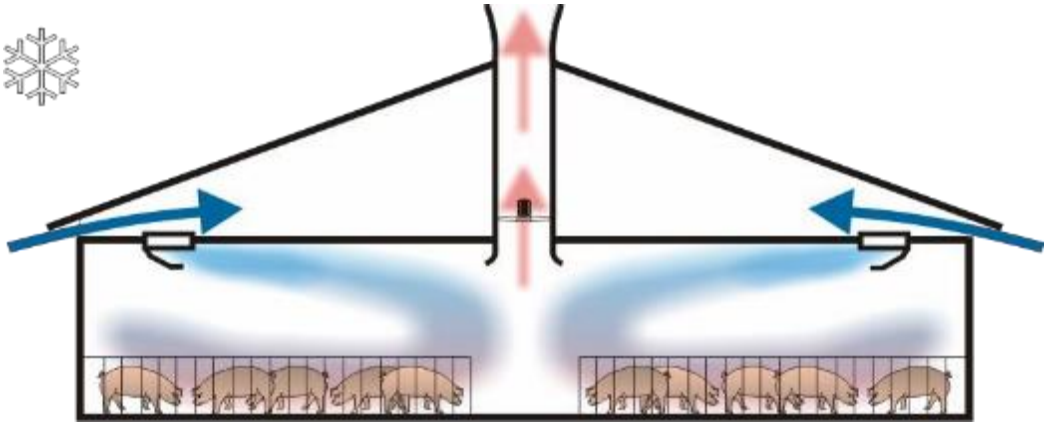
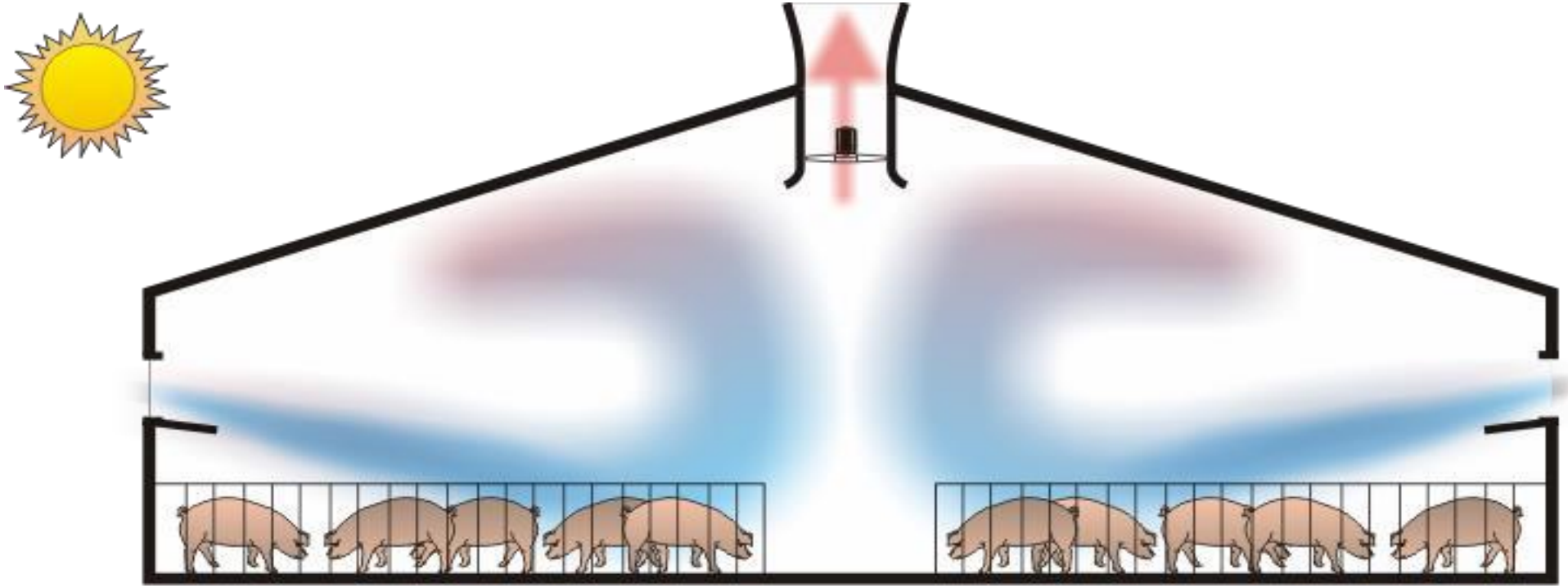
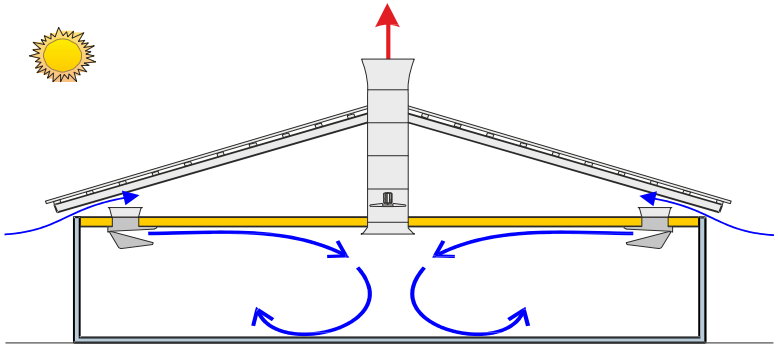
Air distribution in cold periods

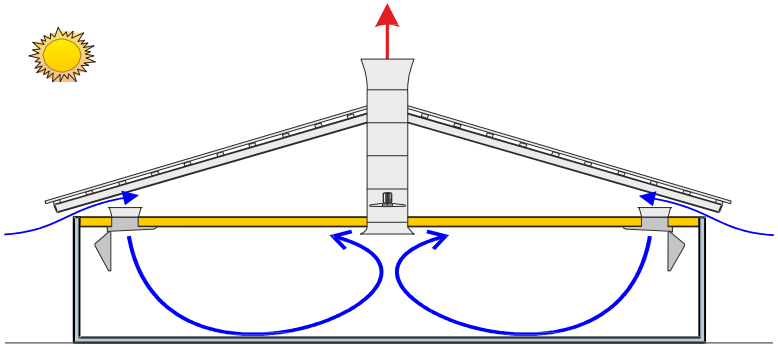




Air distribution in hot periods

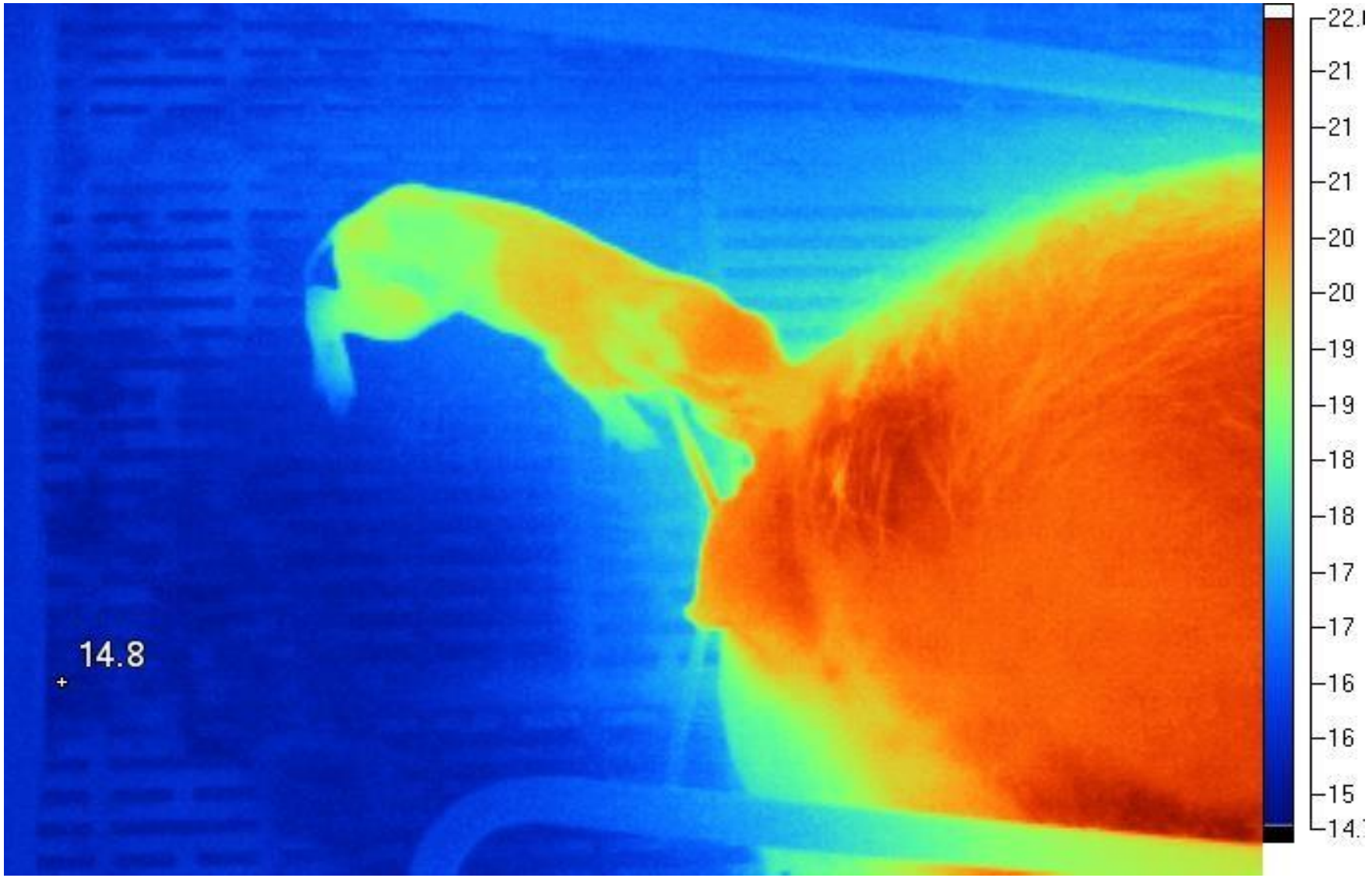






Farrowing pen – micro climate is important

Farrowing pen – micro climate is important



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Piglet nest – micro climate is important

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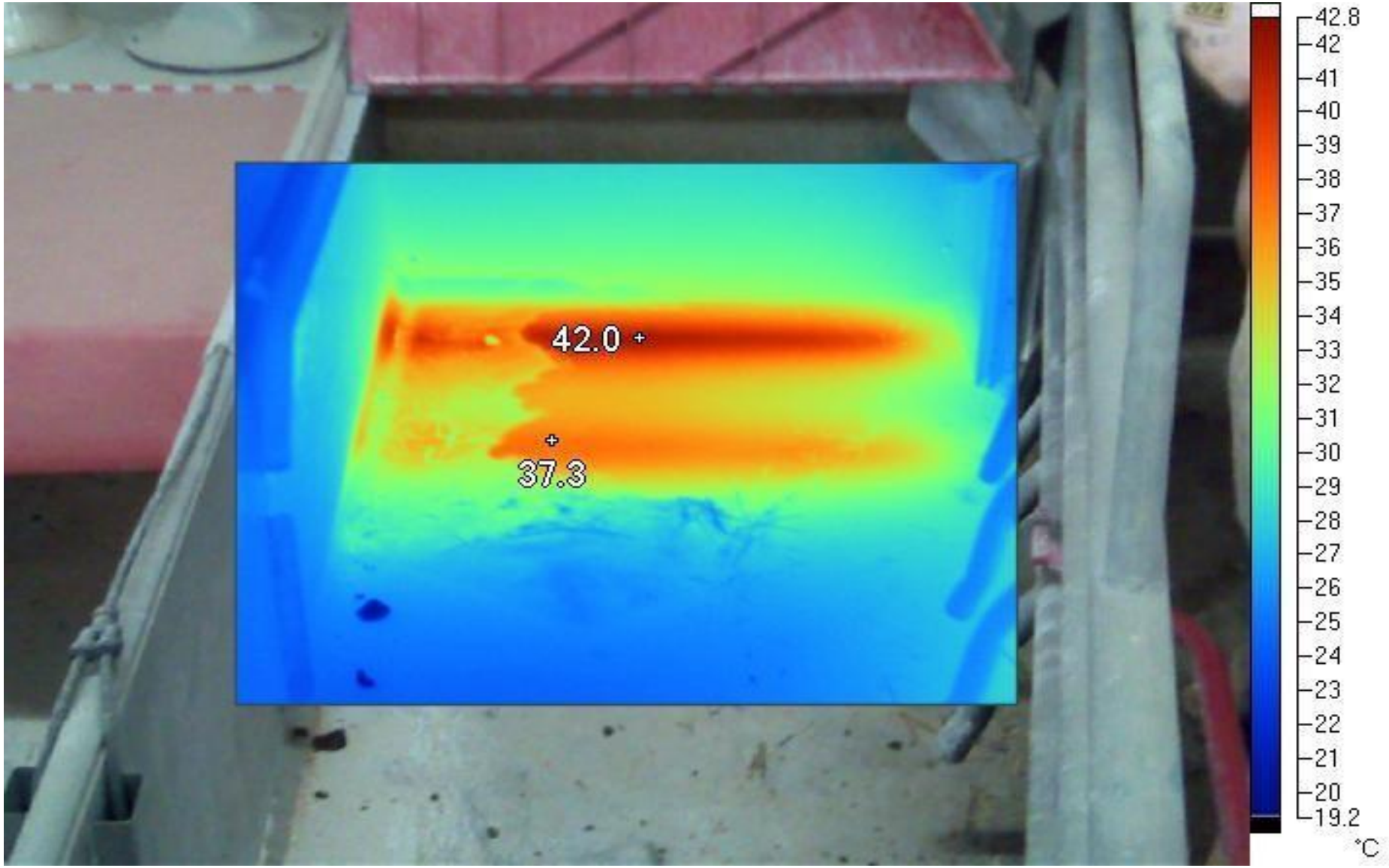
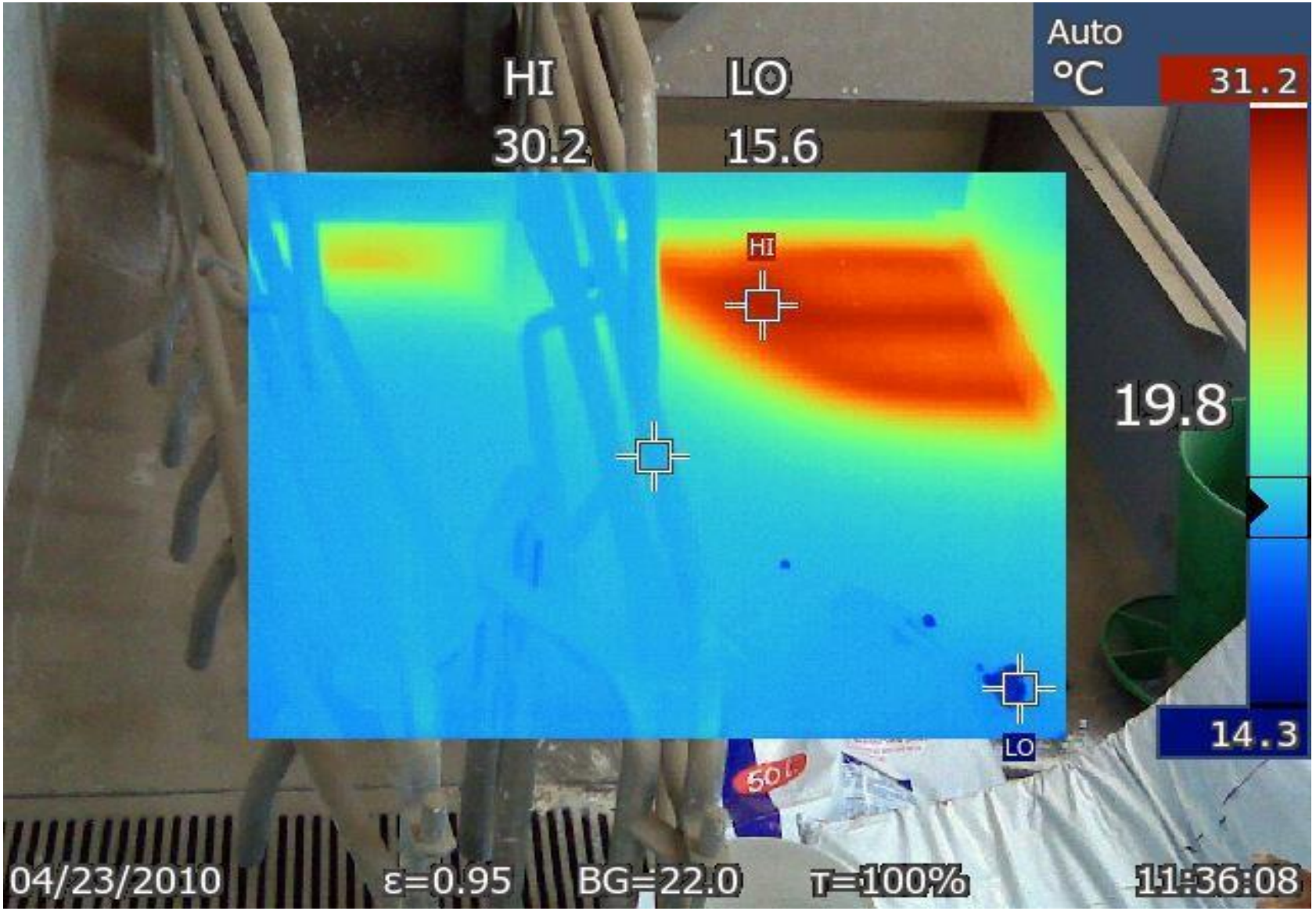
Floor heating – heating tubes in installation tubes



Floor heating – heating tubes cast in concrete



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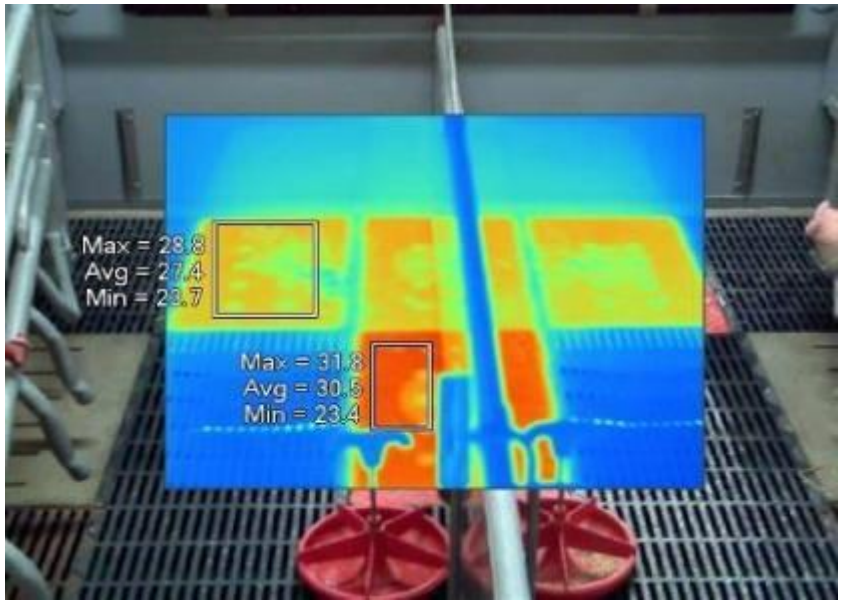
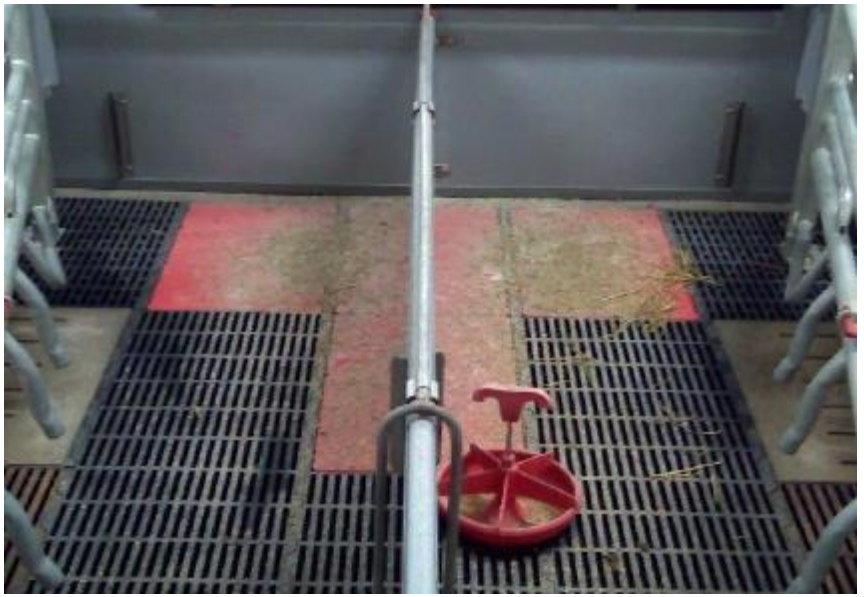
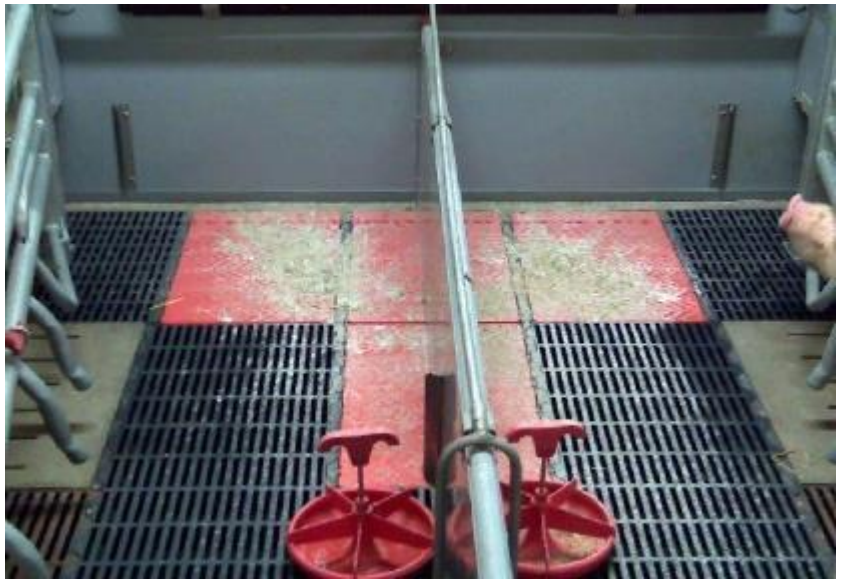
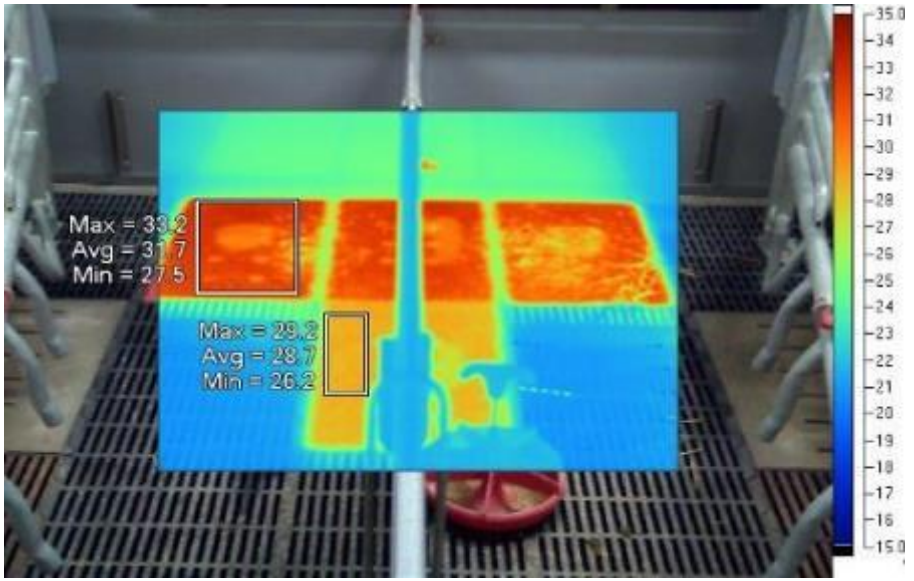
Design and control of heating plates are important









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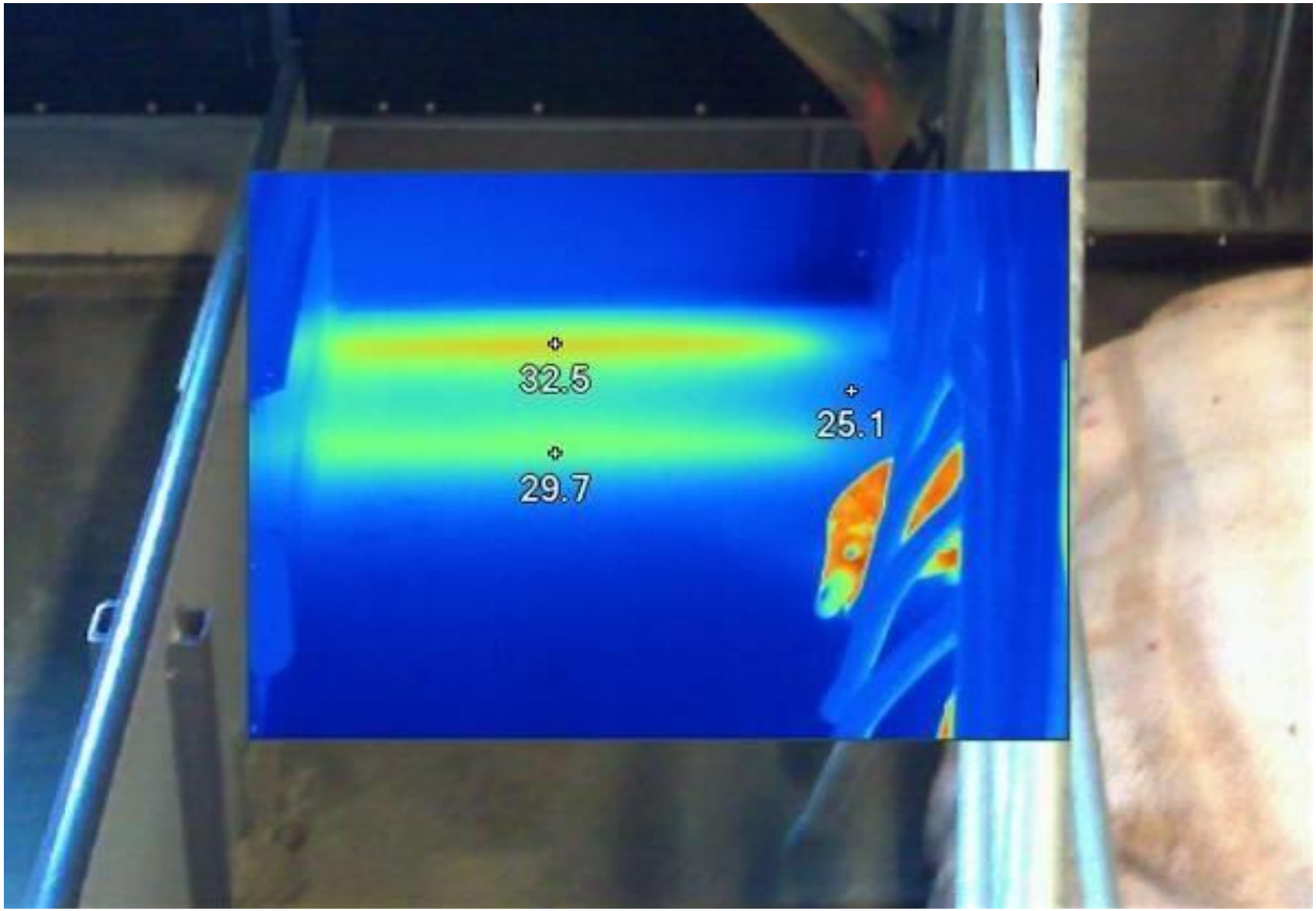
Design of heating tubes – max 2-3 °C difference



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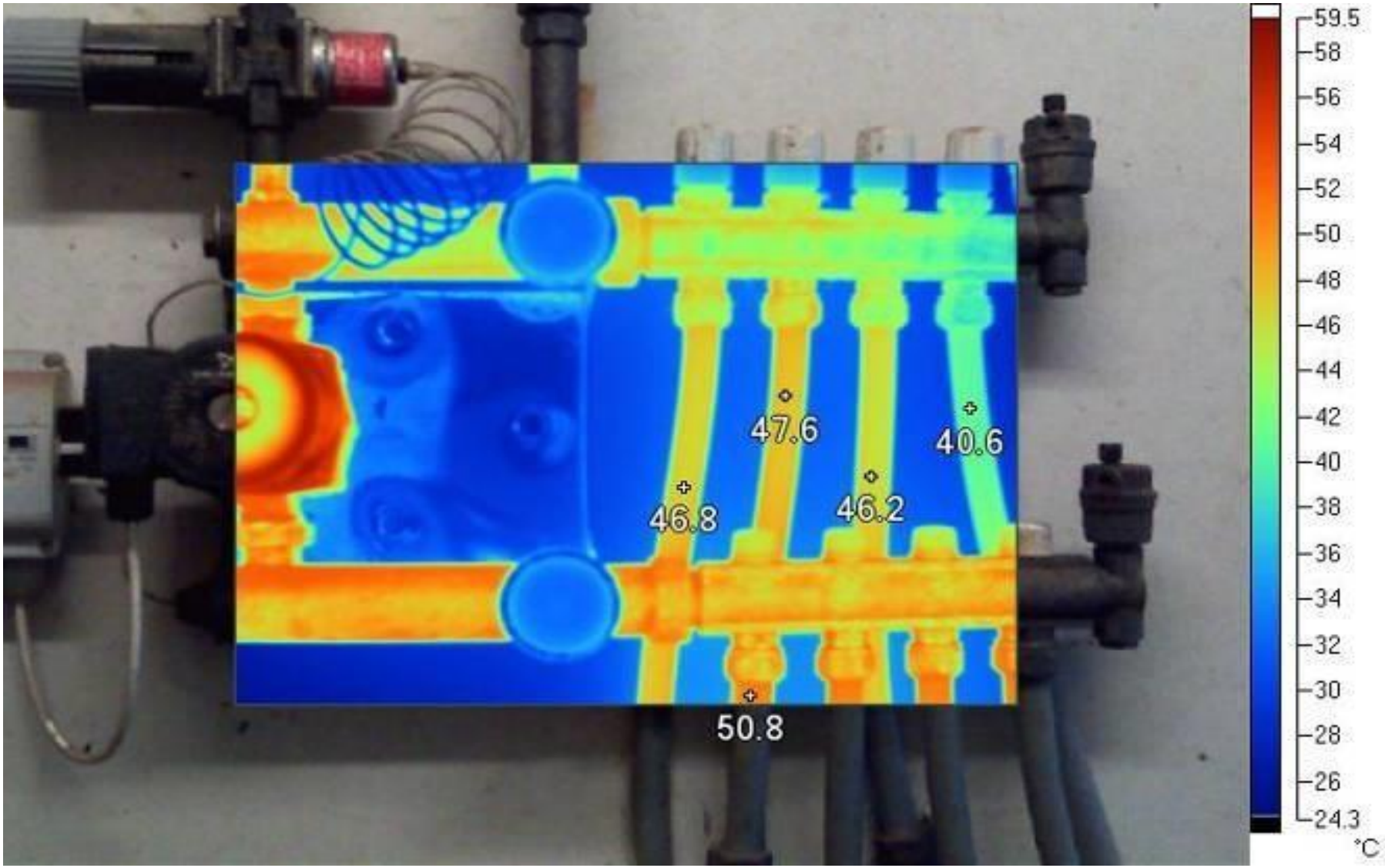
Adjustment of floor heating system is important



Important with a manifold with adjustable valves

Two-climate versus one-climate systems in DK

- Two-climate system
  - Start temperature: 22-24°C
  - Heating capacity: 20 W/pig
  - Heat consumption: 3 kWh/pig
- One-climate system
  - Start temperature: 28-30°C
  - Heating capacity: 100 W/pig
  - Heat consumption: 15 kWh/pig
  - Slurry curtains should implemented

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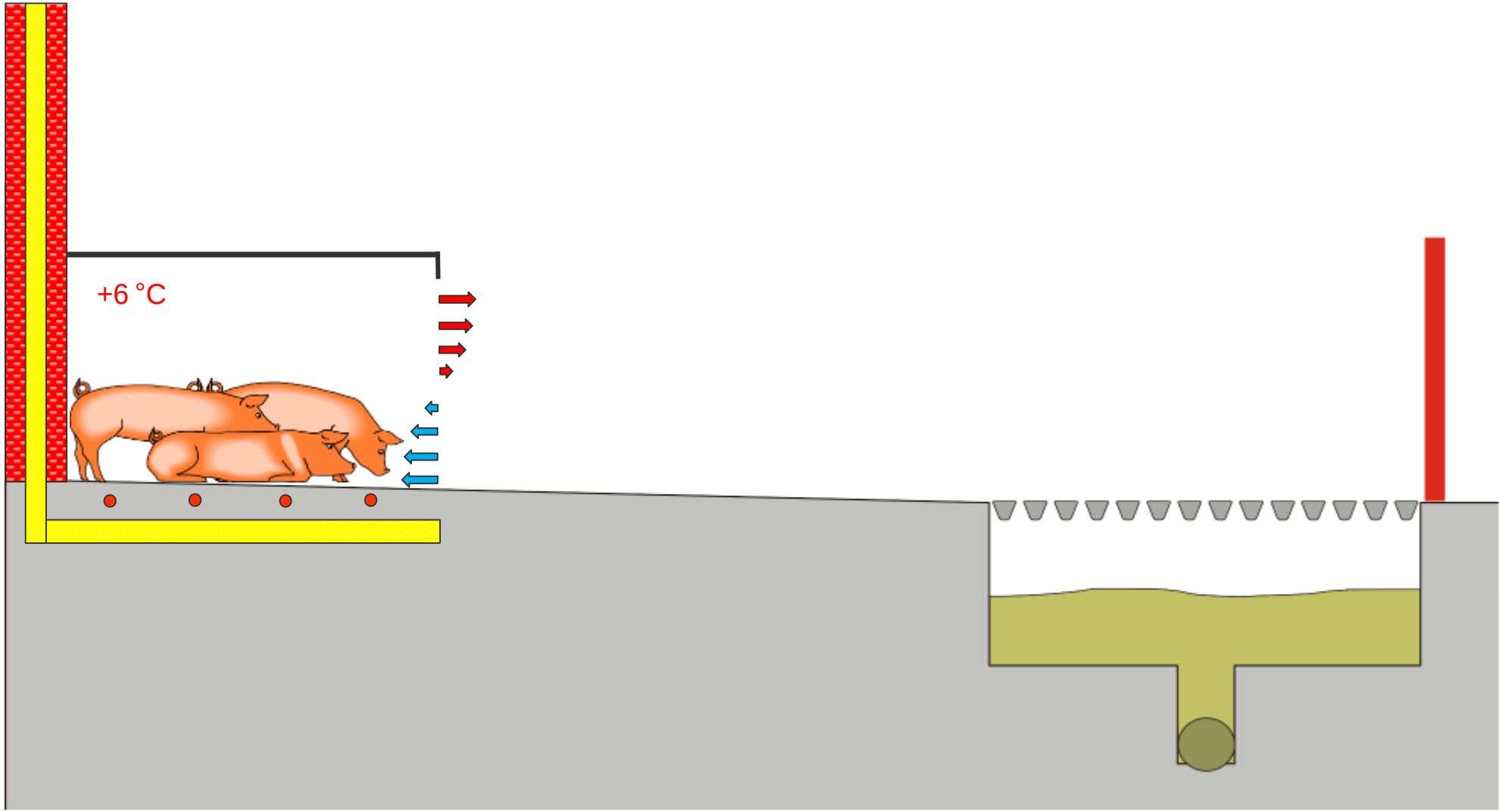
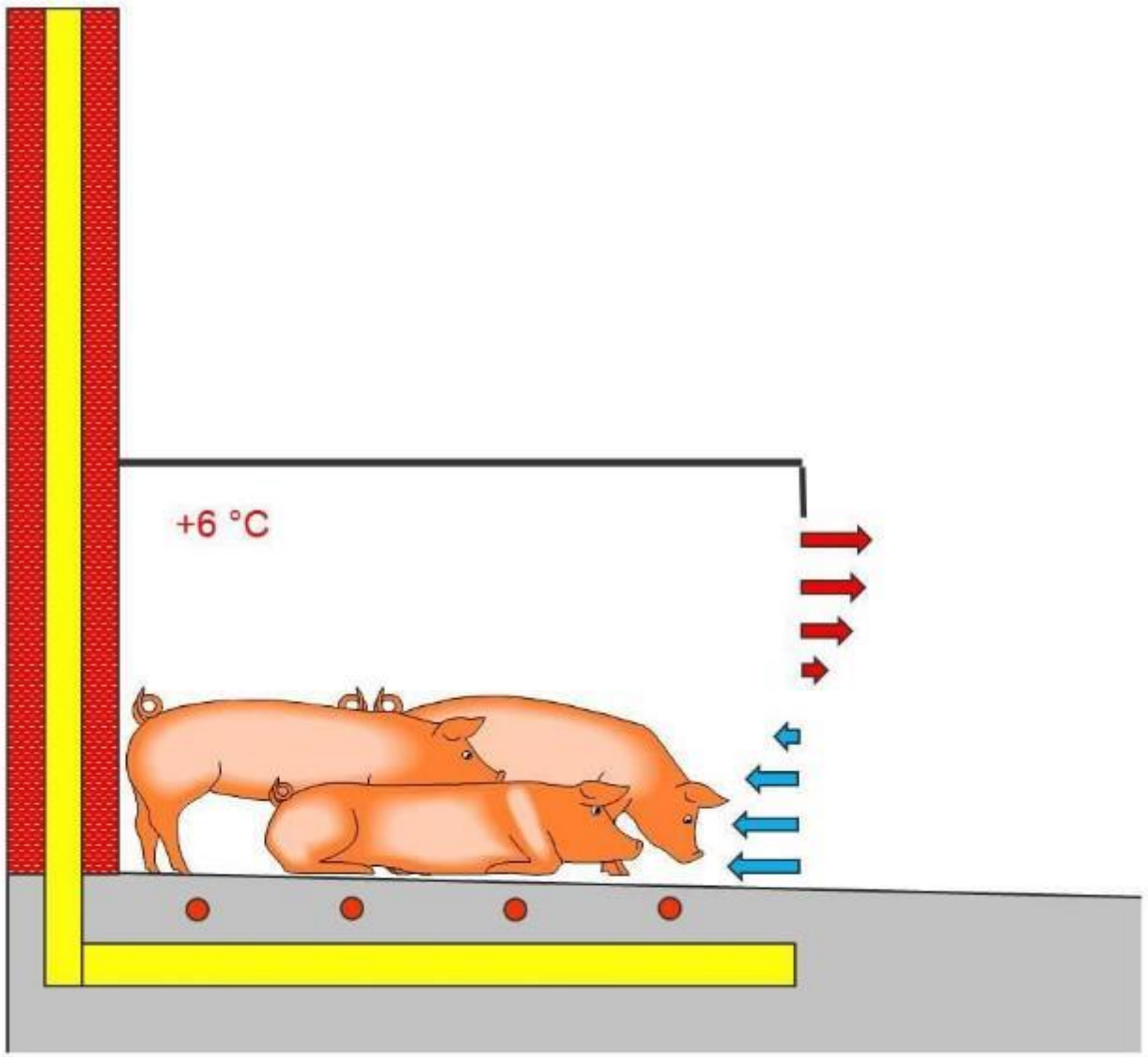
Principle in two-climate systems

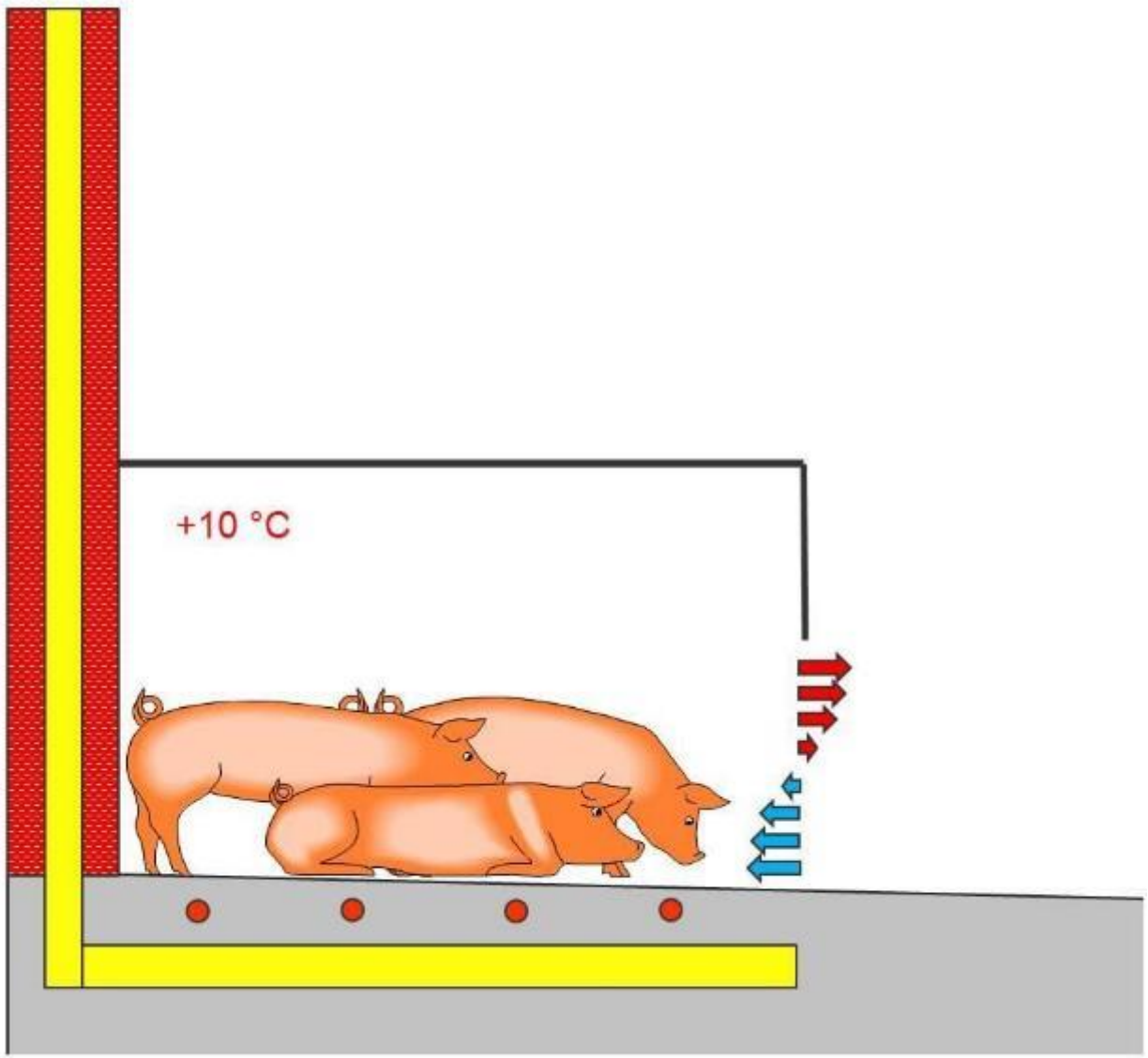


Principle in two-climate systems



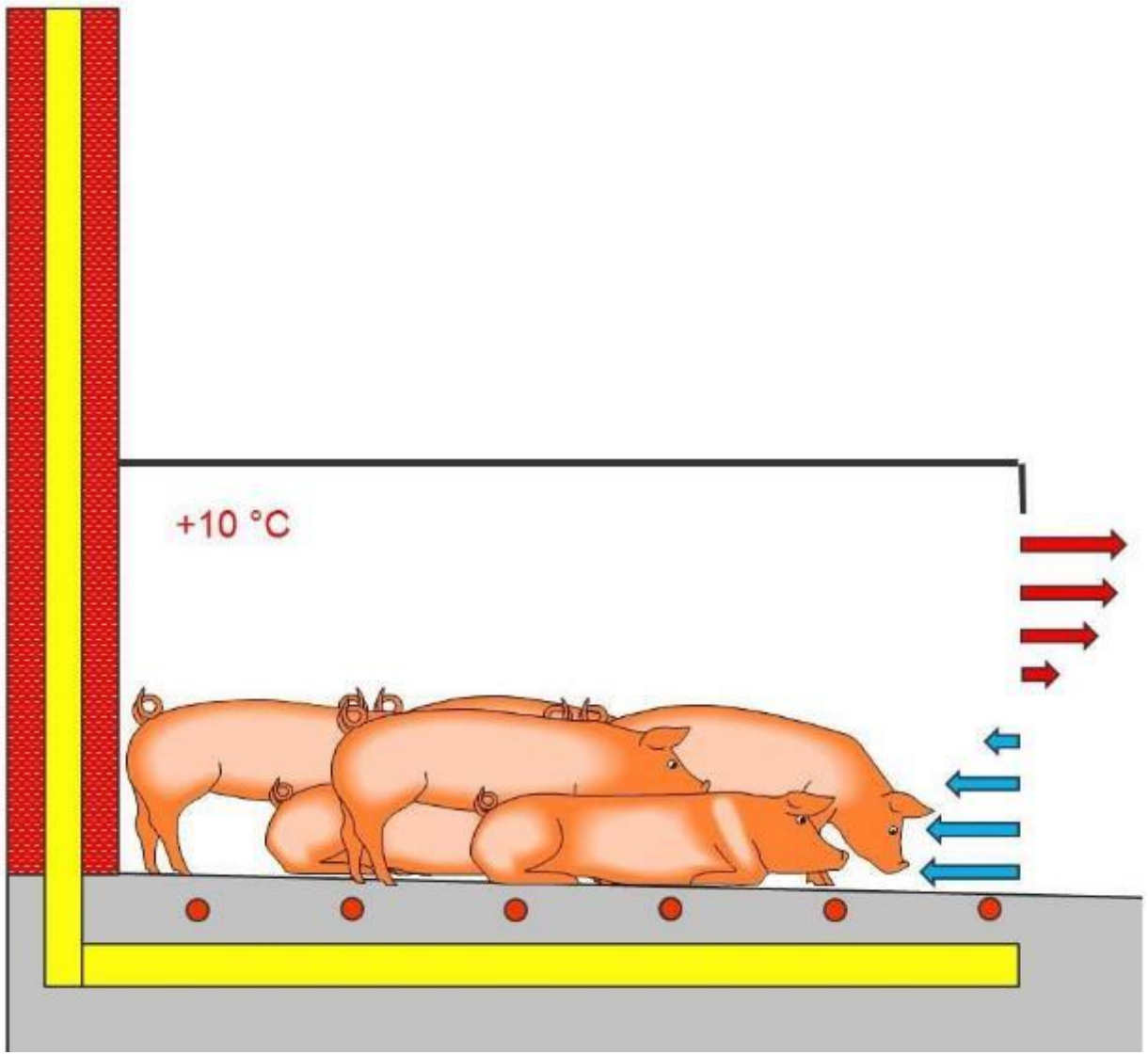
- Optimal design
  - Comfortable for the pigs
  - Up to +6 °C

Two-climate system



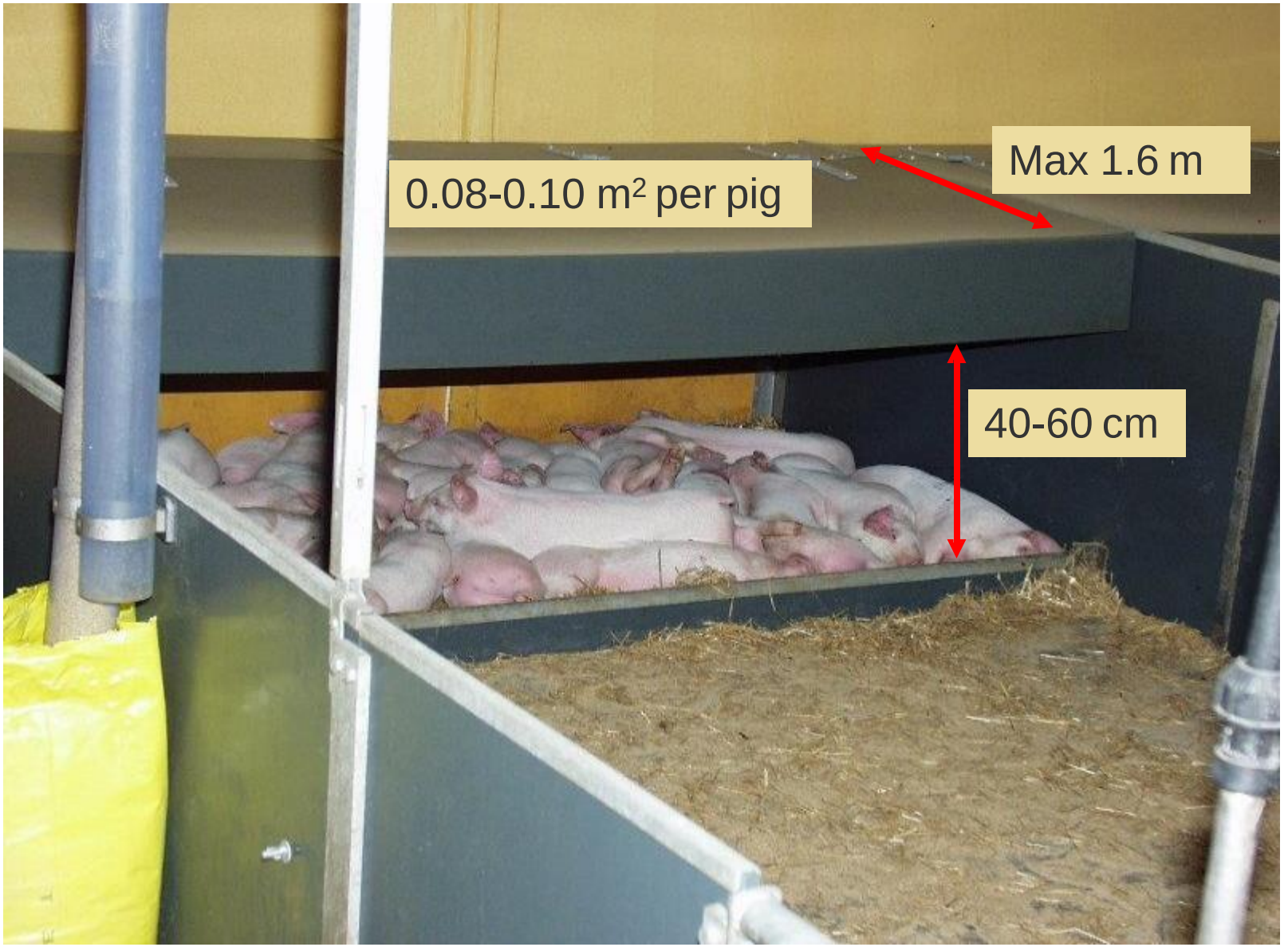
- Not comfortable
  - Opening reduced too much
  - Too hot and humid
  - Too bad air quality
  - Too big temperature variation

Two-climate system



- Not comfortable
  - Too deep two-climate system
  - Too hot and humid
  - Too bad air quality
  - Too big temperature variation
  - Too high air speed

Two-climate system for weaning pigs - design



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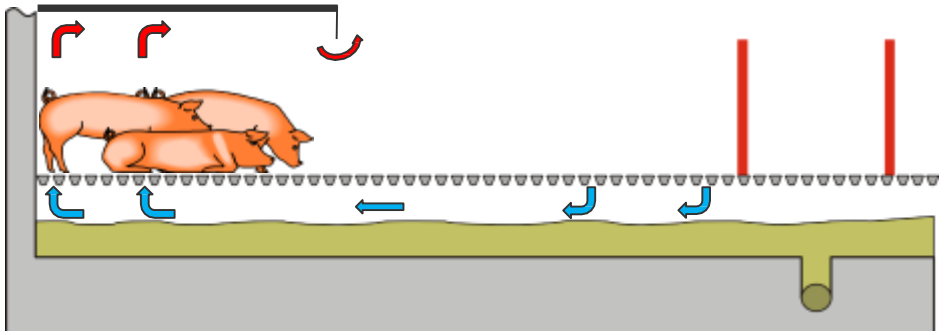
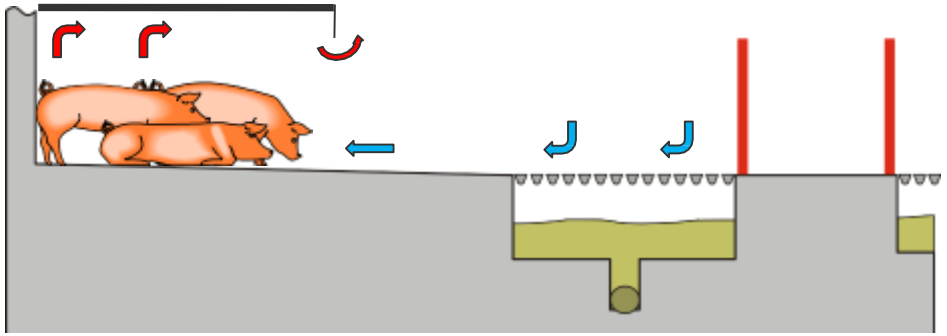
Two-climate – reduced opening height the first weeks

Two-climate system only with solid floor



- Fully slatted flooring
  - Risk of draft and bad air quality in the resting area under two-climate system



- Solid flooring
  - Eliminates the risk for draft from the slurry pit

Houses for high performance pigs must be insulated

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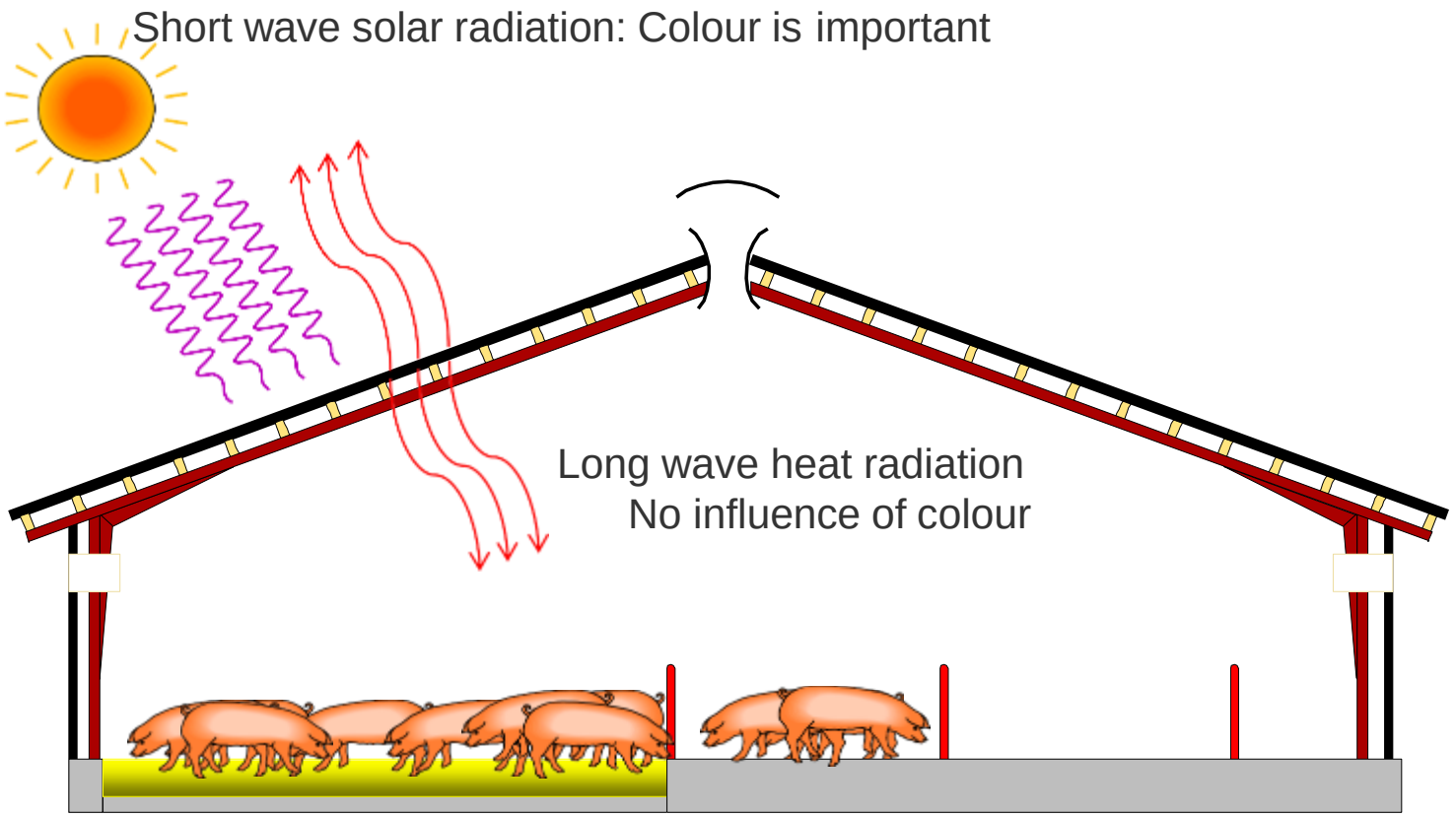
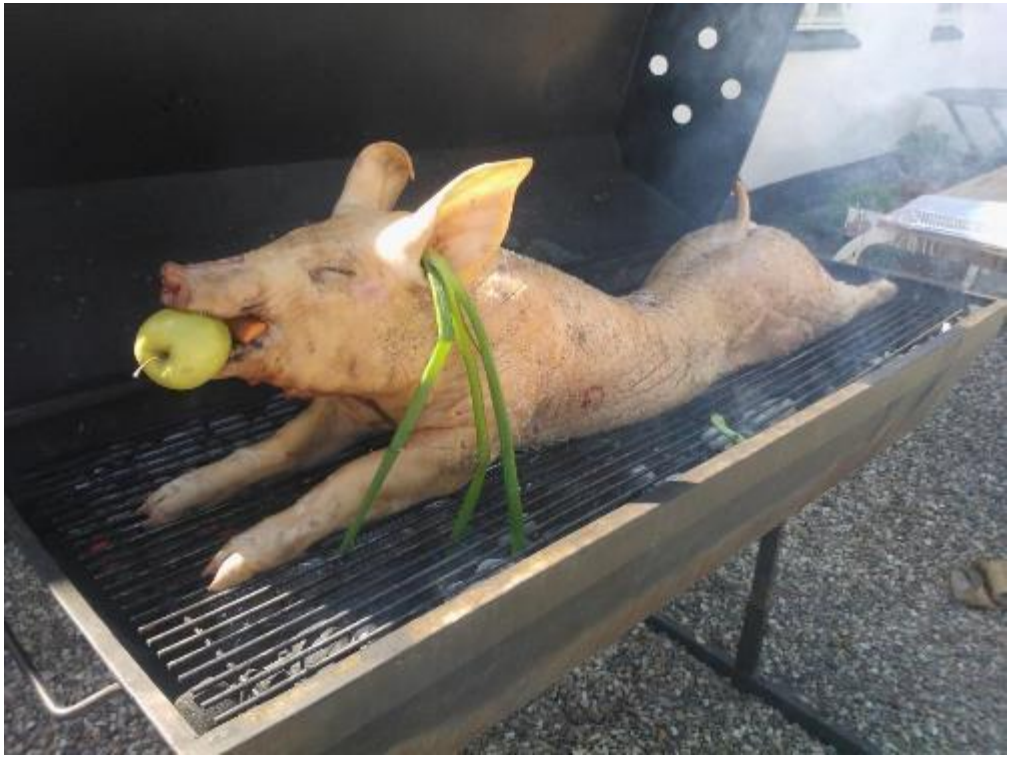
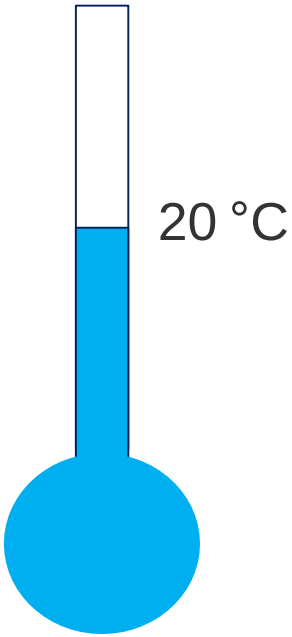
Heat radiation from uninsulated roof



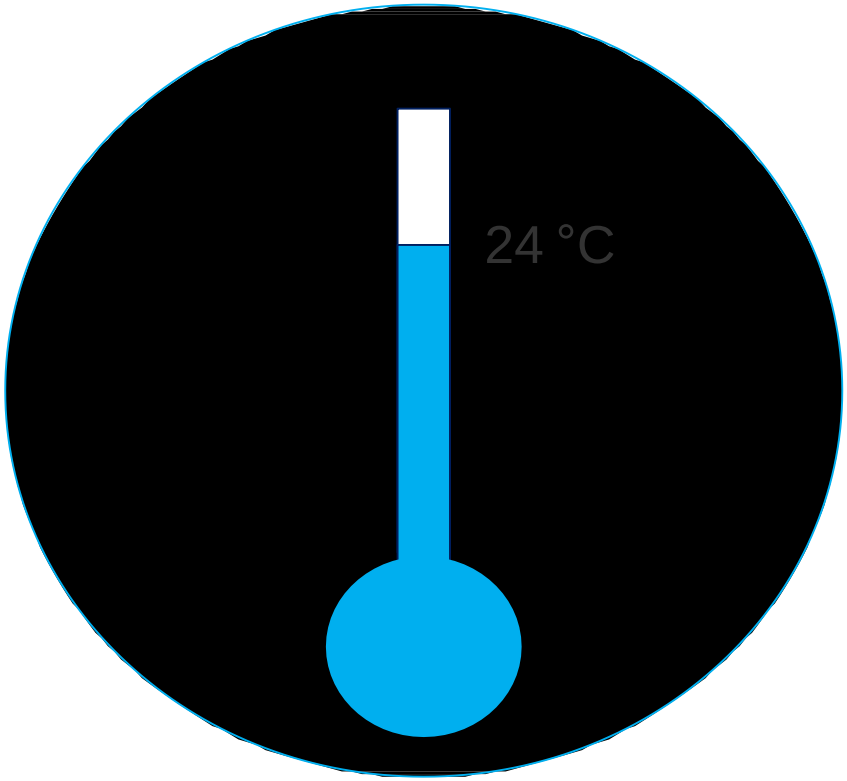
Heat radiation is important in both cold and hot climate



Measurement of heat radiation – globe thermometer

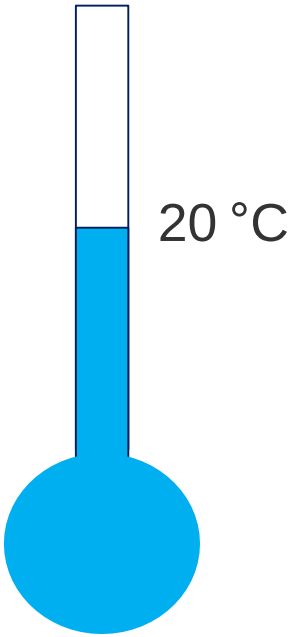


Room temperature

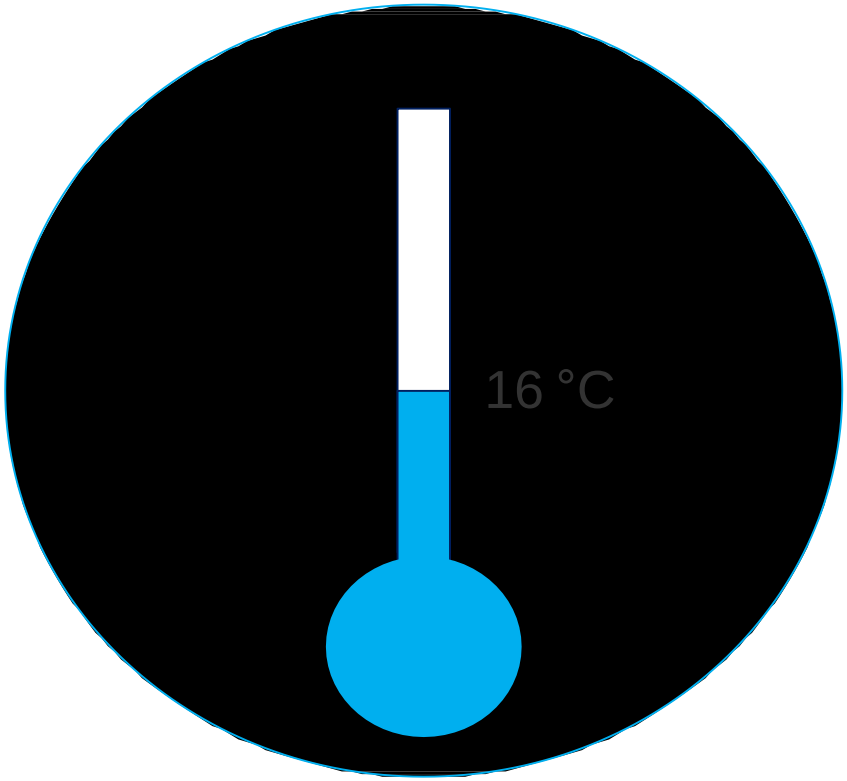


Globe temperature

Measurement of heat radiation – globe thermometer

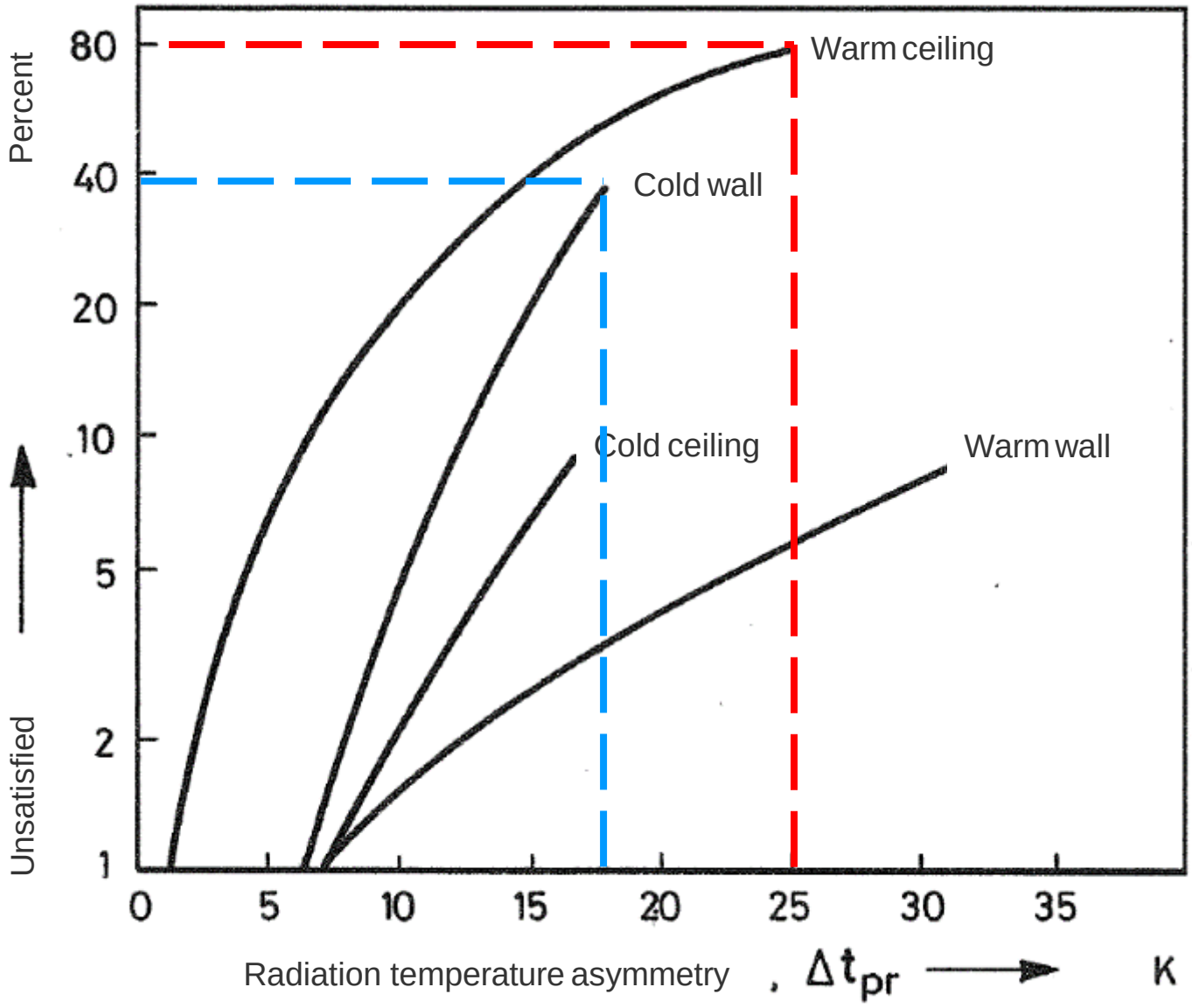


Room temperature



Globe temperature

Radiation – discomfort for human beings



Benefits of insulation

Example: Outside 0 °C, inside 20 °C & 70 % RH

Insulation	None	1 cm	3 cm	5 cm	10 cm
U-value, W/m²/°C	5.9	2.4	1.1	0.70	0.37
Surface temp., °C	4.7	13.8	17.2	19.0	19.5
Condensation, %RH	36	67	84	94	97

- Insulation equal to at least 5 cm of mineral wool insulation is needed

Questions?

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