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ENERGY SAVING POTENTIAL WITH DEMAND CONTROLLED VENTILATION IN HOSPITALS

Focus on clinical areas

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Background

- Official policy in Norway is to require passive house standard for new hospitals within 5-10 years and for retrofitted hospital within 10-15 years.
- Passive house criteria's for hospitals will most likely be based on maximum utilization of available energy efficient technology like demand controlled ventilation (DCV).
- DCV has proven to reduce the ventilation airflow rate and energy use for fans, heating and cooling compared to constant air volume (CAV) ventilation without compromising functionality and indoor air quality but
- The potential for energy reduction in clinical areas in hospitals has not yet been evaluated
- DCV was used in only 0.4% of the hospital areas (Enova, 2008)

Use of clinical areas

Real use registration at Bispebjerg hospital

- Average use per building (n=40) of waiting-areas, meeting rooms, offices and other areas during daytime:

0	-	10%	n=5
10	-	30%	n =33

Maximum: 52%

Real use registration at Fredriksberg hospital

- Average use per building (n=19) of waiting-areas, meeting rooms, offices and other areas during daytime:

0	-	30%	(n=18)

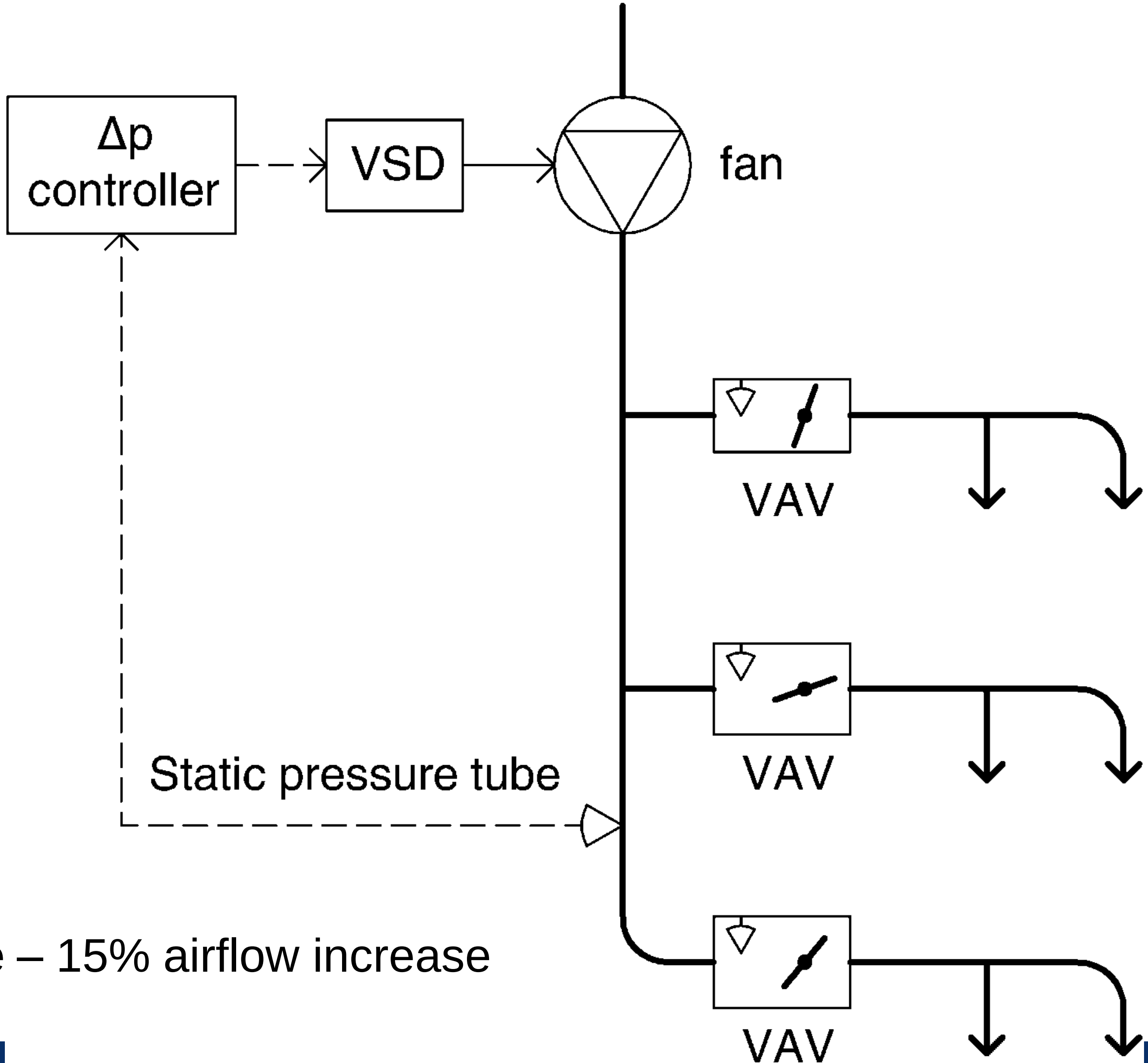
Maximum 34%

Use of clinical areas

	Hospital 1						
	net area	%share og total	Hours/day	Days/week	Hours per year	% use per yera	Weighted use
	(1000*m2)						
Use ordinary hours	32,2	47 %	9	5	2340	27 %	12 %
Use extended hours	2,0	3 %	12	6	3744	43 %	1 %
Use except night	10,7	16 %	16	7	5824	66 %	10 %
Use 24/7	24,1	35 %	24	7	8760	100 %	35 %
In total	69,0						**59 %**
	Hospital 2						
Use ordinary hours	39,7	46 %	9	5	2340	27 %	12 %
Use extended hours	1,8	2 %	12	6	3744	43 %	1 %
Use except night	26,2	30 %	16	7	5824	66 %	20 %
Use 24/7	19,3	22 %	24	7	8760	100 %	22 %
In total	87,0						**55** %

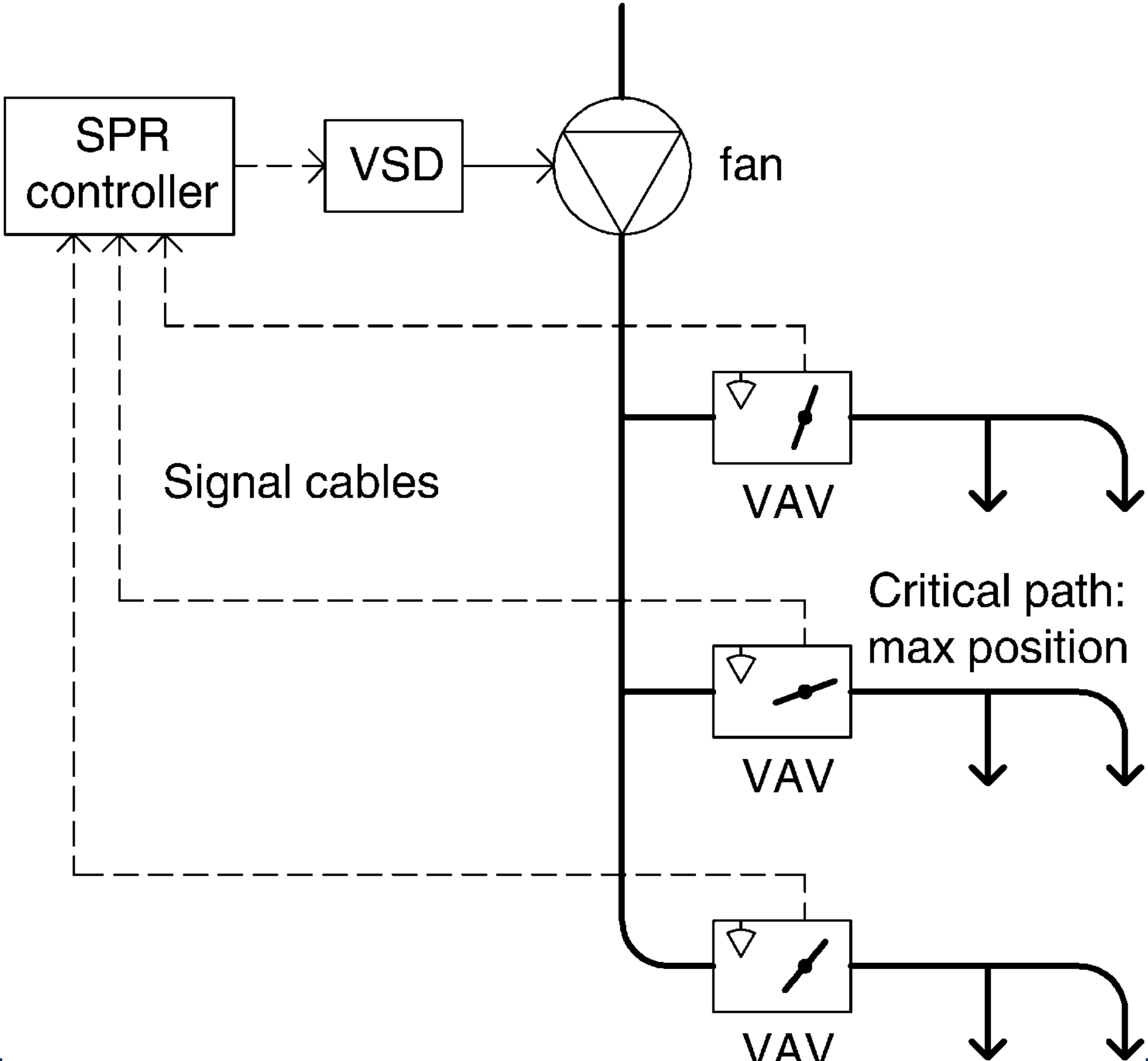
Source: Martinez et al. R&D-project LowEnergyHospital, Report phase 1, 2011

Constant Static Pressure controlled DCV

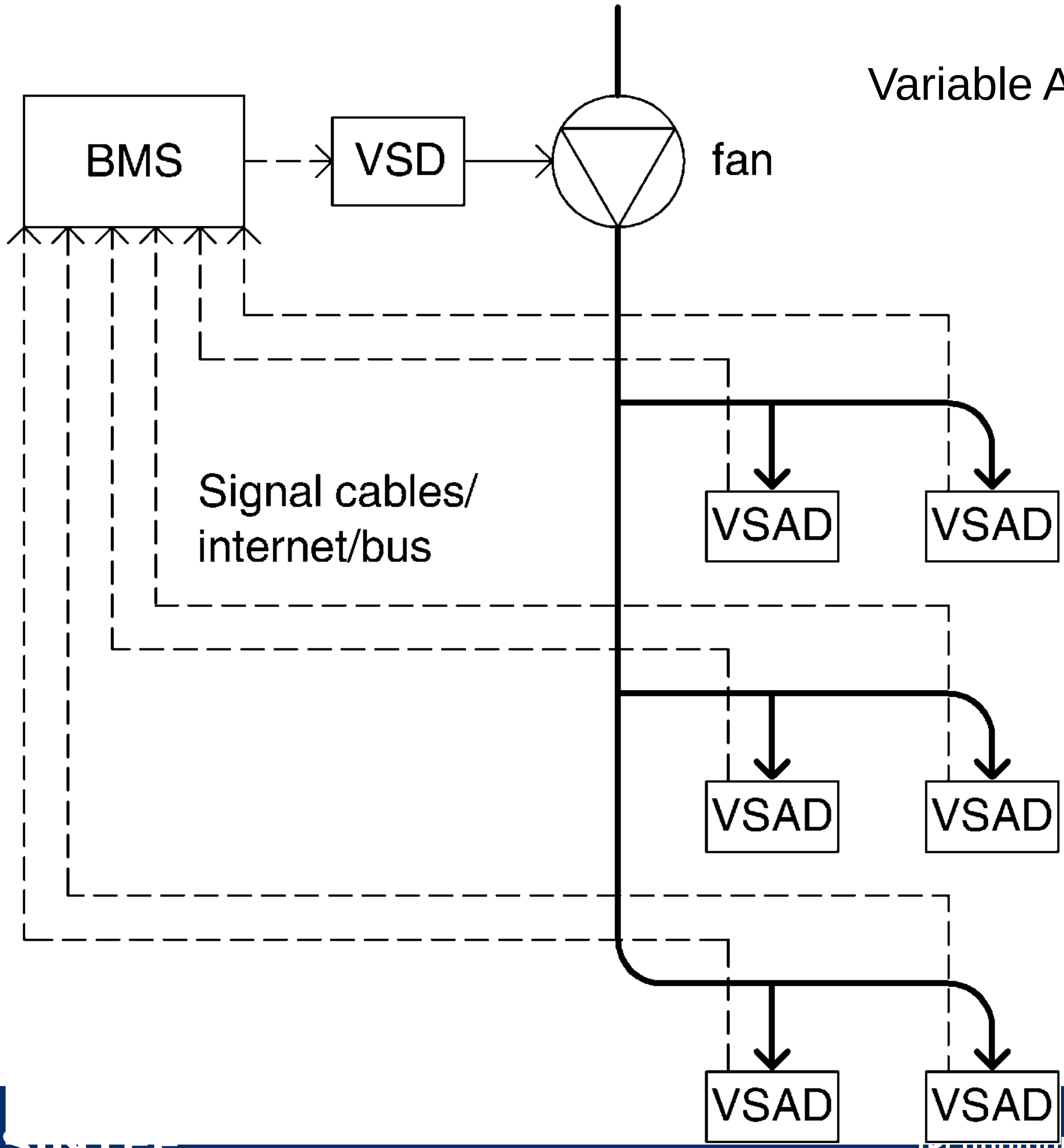


Inaccurate – 15% airflow increase

Damper Controlled or Static Pressure Reset DCV

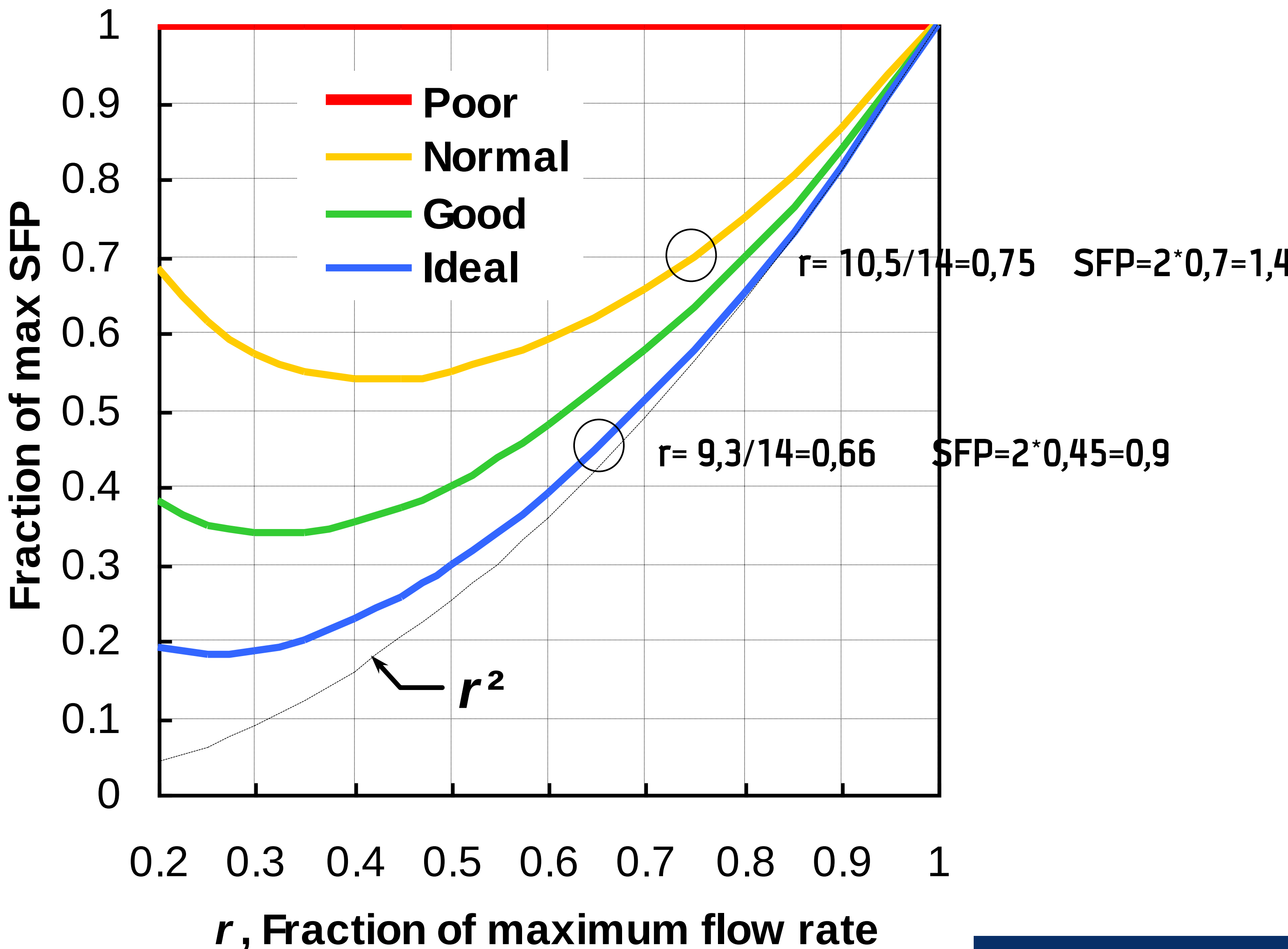


Variable Air Supply Diffusor



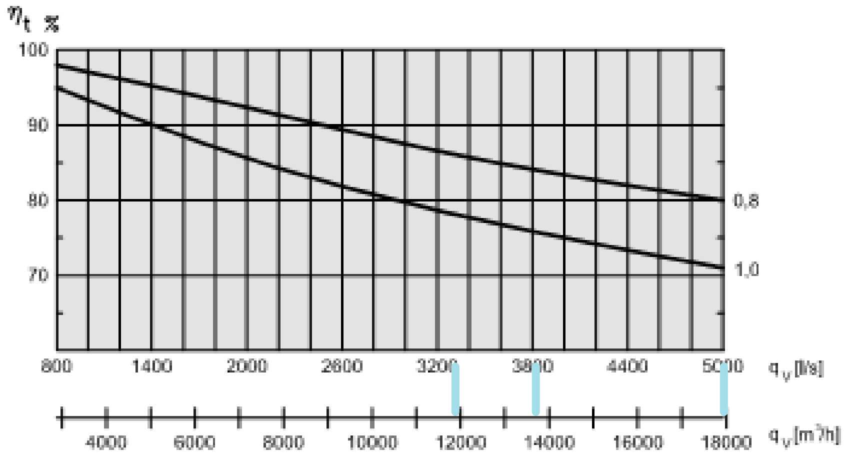
Use, ventilation system and airflow rates

Use % and airflow rates (m^3/hm^2)	Areas in use	Areas not in use	Average air flow rate
Time of use	57 %	43 %	
Reference model	14,0	14,0	14,0
Constant P DCV	16,1	3,0	10,5
Energy optimal DCV	14,0	3,0	9,3



Fraction of max SFP
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Poor
Normal
Good
Ideal
r= 10,5/14=0,75 SFP=2*0,7=1,4
r= 9,3/14=0,66 SFP=2*0,45=0,9
r²
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
r , Fraction of maximum flow rate

VEX280 Temperature efficiency



Temperature efficiency increases with reduced airflow

q=14   n=80%

q=10,5 n›83%

q= 9,3 n›85%

The VEX unit temperature efficiency is shown at different volume flow ratios, calculated as:

$$\frac{\text{Supply air}}{\text{Extract air}} = 0.8 \text{ and } 1.0$$

Temperature efficiency is stated for dry heat recovery and is increased by condensation.

$$\eta_t = \frac{t_{22} - t_{21}}{t_{11} - t_{21}} = \text{Temperature efficiency}$$

t_{21} = Temperature of outdoor air

t_{22} = Temperature of supply air

t_{11} = Temperature of extract air

Extract air = 25 °C

Outdoor air = 5 °C

The assumptions

No	Description	Airflow rates	SFP	Ventilation system	Average temperatur efficience
1	Reference case	14 m^3/hm^2	2	CAV	65%
2	Building code case	14 m^3/hm^2	2	CAV	70%
3	Constant Static Pressure controlled DCV	10.5 m^3/hm^2	1.4	Constant P - DCV	a) = 73% b) = 83%
4	Energy optimal DCV	9.3 m^3/hm^2	0.9	SPR - DCV	a) = 75% b) = 85%

a) Average annual temperature of cross counter heat exhanger
b) Average annual temperature efficiency of rotating wheel heat exchanger

Energy use, SFP and airflow-rates

$$14\,\frac{\mathrm{m^3/h}}{\mathrm{m^2}} \times \frac{1\,\mathrm{h}}{3600\,\mathrm{s}} \times 2\,\frac{\mathrm{kW}}{\mathrm{m^3/s}} \times 8760\,\frac{\mathrm{h}}{\mathrm{yr}} = 68\,\frac{\mathrm{kWh}}{\mathrm{m^2\,yr}}$$

No	Description	Airflow rates Annual avg	SFP Annual avg	Fan energy use (kWh/m2)
1	Reference model	14 m^3/hm^2	2	68
2	Building code case	14 m^3/hm^2	2	68
3	Constant Static Pressure controlled DCV	10.5 m^3/hm^2	1.4	36
4	Energy optimal DCV	9.1 m^3/hm^2	0.9	20

In addition: local heat, central heat and central cooling

Model simulation tool

- Simien (www.programbyggerne.no) .
- Made for calculations of energy use and thermal climate
- Validated according to NS-EN 15625:2007

Calibration of model with measured values

	Measured values*	Calibrated model
	kWh/m²	kWh/m²
1a Local heating	52	59
1b Central heating	111	110
2 Hot water		30
3a Fan		68
3b Pumps		0
4 Artificial ligting		47
5 Techn. eq.		47
6b Central cooling		34
Total net energy demand	417	395

*Source: Martinez et al. R&D-project LowEnergyHospital, Report phase 1, 2011

Annual average air flow rate: 14 m^3/hm^2
Heat exchanger efficiency: 65%
Supply air temperature: 18.5 ^oC

Results

Specific energy (kWh/m²)	Reference model	Building code - model		Constant Pressure DCV	Constant Pressure DCV	Energy optimal DCV	Energy optimal DCV
Heat exch. type		Counterflow	Rot. wheel	Counterflow	Rot. wheel	Counterflow	Rot. wheel
1a Local heating	**59**	**59**	**59**	**33**	**33**	**26**	**26**
1b Central heating	**110**	**85**	**36**	**55**	**20**	**45**	**14**
2 Hot water	30	30	30	30	30	30	30
3a Fan	**68**	**68**	**68**	**36**	**36**	**20**	**20**
4 Artificial ligting	47	47	47	47	47	47	47
5 Techn. eq.	47	47	47	47	47	47	47
6b Central cooling	**34**	**35**	**35**	**25**	**25**	**21**	**21**
Total net energy	**395**	**370**	**321**	**272**	**237**	**235**	**205**
Rel reduction, total		0 %	13 %	26 %	36 %	36 %	45 %
Net energy 1a,1b,3a,6b	**272**	**246**	**198**	**149**	**114**	**112**	**81**
Rel reduction 1a,1b,3a,6b		0 %	20 %	40 %	54 %	55 %	67 %

Summary and conclusion

- The potential for energy reduction related to DCV in clinical areas in hospitals has been evaluated based on a calibrated reference model adjusted to meet current norwegian building code
- Constant pressure controlled DCV can potentially reduce energy use   for local heating, central heating, fan energy and central cooling with about 40% (97 kWh/m^2) using counterflow heat exchanger
- Corresponding energy reduction potential with energy optimal DCV is 55% (134 kWh/m^2)