



Simplified Tools for Evaluation of Domestic Ventilation Systems

Technical Synthesis Report IEA ECBCS Annex 27



Energy Conservation in Buildings and Community Systems

Annex 27 Simplified Tools For Evaluation of Domestic Ventilation Systems

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Preface

International Energy Agency

The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy program. A basic aim of the IEA is to foster co-operation among the twenty four IEA participating countries and to increase energy security through energy conservation, development of alternative energy sources and energy research, development and demonstration (RD&D).

Energy Conservation in Buildings and Community Systems

The IEA sponsors research and development in a number of areas related to energy. The mission of one of those areas, the ECBCS - Energy Conservation for Building and Community Systems Programme, is to facilitate and accelerate the introduction of energy conservation, and environmentally sustainable technologies into healthy buildings and community systems, through innovation and research in decision-making, building assemblies and systems, and commercialisation. The objectives of collaborative work within the ECBCS R&D program are directly derived from the on-going energy and environmental challenges facing IEA countries in the area of construction, energy market and research. ECBCS addresses major challenges and takes advantage of opportunities in the following areas:

- exploitation of innovation and information technology;
- impact of energy measures on indoor health and usability;
- integration of building energy measures and tools to changes in lifestyles, work environment alternatives, and business environment.

The Executive Committee

Overall control of the program is maintained by an Executive Committee, which not only monitors existing projects but also identifies new areas where collaborative effort may be beneficial. To date the following projects have been initiated by the executive committee on energy conservation in buildings and community systems (completed projects are identified by (*)):

- Annex 1: Load Energy Determination of Buildings (*)
- Annex 2: Ekistics and Advanced Community Energy Systems (*)
- Annex 3: Energy Conservation in Residential Buildings (*)
- Annex 4: Glasgow Commercial Building Monitoring (*)
- Annex 5: Air Infiltration and Ventilation Centre
- Annex 6: Energy Systems and Design of Communities (*)
- Annex 7: Local Government Energy Planning (*)
- Annex 8: Inhabitants Behaviour with Regard to Ventilation (*)
- Annex 9: Minimum Ventilation Rates (*)
- Annex 10: Building HVAC System Simulation (*)
- Annex 11: Energy Auditing (*)
- Annex 12: Windows and Fenestration (*)
- Annex 13: Energy Management in Hospitals (*)
- Annex 14: Condensation and Energy (*)
- Annex 15: Energy Efficiency in Schools (*)
- Annex 16: BEMS 1- User Interfaces and System Integration (*)
- Annex 17: BEMS 2- Evaluation and Emulation Techniques (*)

- Annex 18: Demand Controlled Ventilation Systems (*)
- Annex 19: Low Slope Roof Systems (*)
- Annex 20: Air Flow Patterns within Buildings (*)
- Annex 21: Thermal modelling (*)
- Annex 22: Energy Efficient Communities (*)
- Annex 23: Multi Zone Air Flow Modelling (COMIS) (*)
- Annex 24: Heat, Air and Moisture Transfer in Envelopes (*)
- Annex 25: Real Time HEVAC simulation (*)
- Annex 26: Energy Efficient Ventilation of Large Enclosures (*)
- Annex 27: Evaluation and Demonstration of Domestic Ventilation Systems (*)
- Annex 28: Low Energy Cooling Systems (*)
- Annex 29: Daylight in Buildings (*)
- Annex 30: Bringing Simulation to Application (*)
- Annex 31: Energy Related Environmental Impact of Buildings
- Annex 32: Integral Building Envelope Performance Assessment (*)
- Annex 33: Advanced Local Energy Planning (*)
- Annex 34: Computer-Aided Evaluation of HVAC System Performance (*)
- Annex 35: Design of Energy Efficient Hybrid Ventilation (HYBVENT) (*)
- Annex 36: Retrofitting of Educational Buildings
- Annex 37: Low Exergy Systems for Heating and Cooling of Buildings
- Annex 38: Solar Sustainable Housing
- Annex 39: High Performance Insulation Systems
- Annex 40: Building Commissioning to Improve Energy Performance

(*) - Completed Annexes

This summary report concentrates on Annex 27: Evaluation and Demonstration of Domestic Ventilation Systems.

Annex 27 Evaluation and Demonstration of Domestic Ventilation Systems

The choice of ventilation for a dwelling will have a major impact on the energy consumption of the dwelling as well as affecting indoor comfort and possibly the building fabric. The aim of the Annex was to develop a set of simplified tools for evaluating domestic ventilation systems that can be used to identify the most appropriate ventilation system under wide range of operating conditions.

Participating countries

The participating countries in this task were: Canada, France, Italy, Japan, The Netherlands, Sweden, UK, USA.

Summary

The annex's aim was to develop a set of simplified tools for evaluating domestic ventilation systems that can be used to identify the most appropriate ventilation system under a wide range of operating systems. This summary report gives an overview of the project and covers design constraints, user aspects, thermal comfort, noise, building aspects, indoor air quality, reliability, energy, life cycle cost and application.

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1. Introduction

Decisions on ventilation are made in all countries by standards bodies, policy makers, companies involved in the housing industry, and others. Often these decisions are made without comprehensive evaluation of ventilation systems. Research carried out in recent years, and described in the IEA Annexes, now makes it possible to formulate suitable simplified evaluation techniques for domestic ventilation systems.

Dwellings represent about 25 - 30 % of all energy used in the OECD countries, and domestic ventilation will in the future represent up to 10 % of the total energy use. Thus even a relatively small reduction in the overall ventilation levels and improvements in reliability over the life of the building could give significant savings in the total energy use.

The tools developed under the current Annex can be used in the design of new buildings and for renovation projects. They can also be used for detecting, analysing and solving problems connected with the ventilation system.

1.1 Objectives

The overall objective of the Annex was to develop tools to improve the selection of domestic ventilation systems and the prediction of indoor climate.

The work carried out within the Annex included:

- The development of tools for evaluating domestic ventilation systems;
- Validation of the tools developed;
- Demonstration of the tools;
- Provision of guidance on the use of the simplified tools.

1.2 Activities and Products

The Annex was divided into three subtasks relating to the three phases of the research; these were:

Subtask 1: Collection of Background Data

The aim of this subtask was to collect and report background material in a State of the Art Report (Månsson, 1995). This information was used to develop the assumptions needed in the development of the simplified tools.

Subtask 2: Development of Simplified Tools

Simplified tools were developed based on computer models and the assumptions developed from Subtask 1. These tools cover energy, thermal comfort, noise, inside to outside pressure difference, life cycle cost, reliability, user and building aspects, indoor air quality for constant emission sources, CO_2 , tobacco smoke, cooking products, water vapour in habitable rooms and the bathroom. For each of the tools a detailed report has been produced on the work carried out. In addition, a handbook is available presenting the tools and explaining how they can be applied to the selection of domestic ventilation systems (Månsson, 2002), alongside the background reports on a CD.

Subtask 3: Measurement of Real Dwellings

This subtask carried out measurements in a range of dwellings. The data gained was used in two ways, to provide background material on ventilation systems in use and to validate the simplified tools developed in Subtask 2

1.3 Computerised Simplified Tools

Since the completion of the original Annex, the tools have been further developed in an extension to the Annex work in the form of a computer program (de Gids and Phaff, 2002). This accompanies the Handbook and background reports for the tools on the CD.

2. Design Constraints

2.1 Ventilation Systems

t

The simplified analysis tools are applied to four different ventilation systems in typical use. These are defined as:

- Natural Window Airing (NWA) Natural supply and exhaust through windows. Purpose provided openings, inlets, in external walls or windows can be installed.
- Passive Stack Ventilation (PSV)
 Natural supply through windows. Purpose provided openings, inlets, in external walls or windows can be installed. Exhaust through vertical ducts giving the stack effect.
- Mechanical Exhaust Only (MEO) Natural supply through windows. Purpose provided openings, inlets, in external walls or windows can be installed. Mechanical exhaust air by using a fan.
- Mechanical Supply and Exhaust (MSE) Mechanical exhaust and supply by fans. Sometimes a heat exchanger is also installed to recover the heat (MSE-X).

2.2 Dwelling Type

Three types of dwelling were chosen as representative of the main dwelling types across Europe. Each ventilation system was applied to each dwelling type and the results used in the simplified tools. The three dwelling types are:

- D4A ground A four room flat on the ground floor in a four storey building.
- D4A top A four room flat on the top floor in a four storey building.
- D4C A two storey detached single family house with four rooms.

2.3 Climate

External climate will have a significant impact on the energy consumption and appropriateness of ventilation systems. Three climates were chosen to cover a range of conditions:

- Cold climate: Represented by Ottawa,
- Moderate climate: Represented by London,
- Mild climate: Represented by Nice.

2.4 National Codes and Standards

National codes and standards are often used as the design criteria for ventilation systems. However, such documents are commonly intended to be a minimum requirement. Thus ventilation systems could be said to be designed to a minimum standard. The tools developed by this Annex aim to enable ventilation systems to be designed that exceed these minimum regulatory standards.

3. User Aspects

User aspects are defined as the influence the user can have on the ventilation system and are split into three categories; behavioural, life style and user characteristics.

The tool takes the form of a lookup table of warning flags indicating the sensitivity of ventilation system to the different user aspects (${}^{\textcircled{}}$ ${}^{\textcircled{}}$ Very Sensitive, ${}^{\textcircled{}}$ ${}^{\textcircled{}}$ Sensitive, ${}^{\textcircled{}}$ Slightly sensitive, 0 Neutral) for the four different ventilation systems. Thus from a limited knowledge about the potential users of the ventilation system it is possible to obtain an indication of their influence on system performance.

Group	Aspect		Ventila	tion system	
		Natural	Passive	Mechanical	Mechanical
		Window	Stack Venti-	Exhaust	Supply and
		Airing	lation	Only	Exhaust
		(NWA)	(PSV)	(MEO)	(MSE)
Behaviour	User influence	888	8 8	₩.	13
	Maintenance	613	₩.	₹¥	8
	Furniture and decoration	***	****	19 49 19	8 V
	User reaction	0	63	₩¥	
Lifestyle	Cooking	感觉感	10 10 10 10 10 10 10 10 10 10 10 10 10 1	63	1 1 1
-	Smoking	888 B	99 69 69 19 69 69	19 19 19	きき
	Hygiene	888	8 83 83	13 13	1
	Redecoration interval	19 19 I	66	₹¢	*
	Other equipment installed	r.	<u> </u>	0	0
	Pets	奶奶	19 49 19 49	<u> </u>	\$
	Pot Plants	193	197	0	0
User	Involvement	雙膠	10 8 8 W	C'S	₩¥
Characteristics	Knowledge	化化	195 195 197	19 A	an is
	Physical capability,	888	19 19 19 19 19 19 19 19 19 19 19 19 19 1	10 ja	0
	Operation	1			
	Physical capability, main- tenance	Ö	18 18 1	ŧ\$	€.

Table 1: Influence of user on the ventilation systems

4. Thermal Comfort

The supply of outdoor air by a ventilation system to an indoor space can have an impact upon the thermal comfort of the occupant(s) especially in winter. Research performed for this IEA Annex has shown that different methods of air supply have a different impact on thermal comfort, even for the same supply rate and temperature. Thus the risk of draughts due to ventilation can be reduced or eliminated by a careful choice of the method of air supply. Furthermore, thermal comfort and ventilation system performance can be linked. For example, if an occupant feels a cold draught from air coming through an air vent, he or she may close it to avoid poor thermal comfort, even when this has an adverse effect on indoor air quality.

The Thermal Comfort simplified tool allows the user to compare the thermal comfort impact of different types of air inlet or ventilation system. This tool uses the results from an experimental program that was performed for this IEA Annex. Experiments were performed using all the combinations of five input parameters described below. The results were used to provide a simplified tool, giving a rating of five categories from "- -" to "+ +". The score "+ +" means the smallest impact on thermal comfort, and the score "- -" means the severest impact on thermal comfort.

The user is required to select the input parameters from a limited choice.

٠	Ventilation system:	Natural window airing,
		Passive stack ventilation,
		Mechanical central exhaust,
		Mechanical central supply and exhaust;
٠	Method of ventilation supply:	Background leakage (infiltration),
		Windows or low-induction natural supply vents,
		High-induction natural supply vents;
٠	Outdoor temperature/°C:	-15, -10, -5, 0, 5, 10, 15;
٠	Air supply rate:	4 l/s (15m ³ /h), 10 l/s (35 m ³ /h);
٠	Natural ventilation rate from leakage:	$N_{50} = 1.5$ ach, $N_{50} = 2.6$ ach.

These input parameters can be used with the flow chart in Figure 1 to identify the appropriate score from Tables 2 and 3.

Table 2:	Thermal	comfort	impact	of fresh air	• supply Q	$g = 35 m^3$	³ /h (10 Vs)
----------	---------	---------	--------	--------------	------------	--------------	-------------------------

Т	ype of Inlet (Vent)	Outdoor Temperature (°C)										
Generic type	Specific type	-15	-10	-5	0	5	10	15				
High induction	Upward direction flow	- 1	-	0	+	++	++	++				
	Radiant flow			-	-	0	++	++				
	Horizontally straight flow					-	+	++				
Low induction	Horizontal opening, high position		-	-	0	+	+	++				
Or	Vertical opening, middle height						-	-				
Window ajar	Horizontal opening, low position						-	-				
Background leak-	$N_{50} = 1.5$ ach level		-	-	-	-	0	0				
age *	(relatively high speed infiltration)											
	$N_{50} = 2.6$ ach level				-	-	+	++				
	(relatively low speed infiltration)]								

Ту	pe of Inlet (Vent)		Outd	oor T	`empe	ratur	e (°C)	
Generic type	Specific type	-15	-10	-5	0	5	10	15
High induction	Upward direction flow	-	0	+	+	++	++	++
	Radiant flow		-	-	0	+	++	++
	Horizontally straight flow					-	+	++
Low induction	Horizontal opening, high position		-	-	-	+	++	++
or	Vertical opening, middle height					-	-	-
Window ajar	Horizontal opening, low position					-	-	0
Background leak- age *	$N_{50} = 1.5$ ach level (relatively high speed infiltration)			-	-	-	0	+
0	$N_{50} = 2.6$ ach level (relatively low speed infiltration)				-	0	++	+ +

Table 3:	Thermal	comfort i	impact d	of fresh a	air supply	Q =	15 m ³ /h (4 Vs)
----------	---------	-----------	----------	------------	------------	-----	-----------------------------

* equally distributed leakage air flow path on exterior walls Criteria for Scoring the percentage of lattice points satisfying thermal comfort conditions (1) and (2): 100-95% "++"; 95-85% "+"; 85-75% "0"; 75-50% "-"; 50-0% "--".

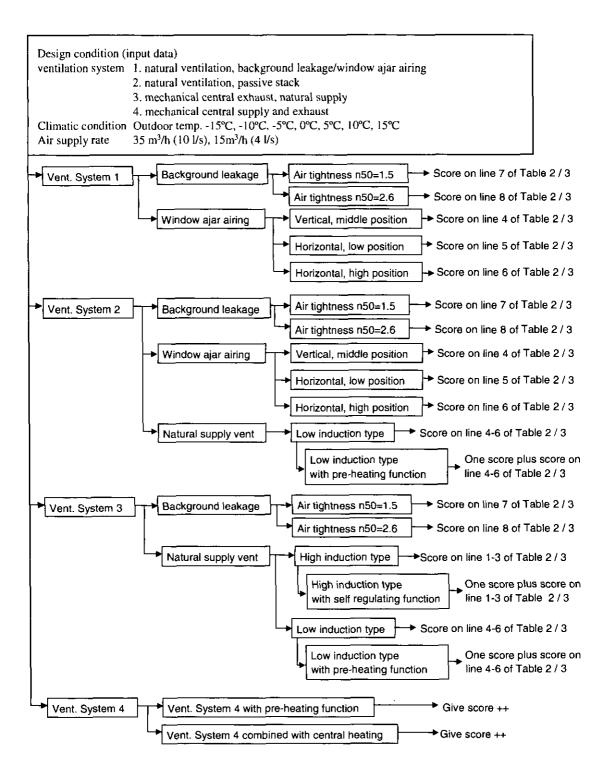


Figure 1: Flow Chart for Thermal Comfort Impact Evaluation of Outdoor Air Supply

5. Noise

Three categories of noise are associated with ventilation systems:

- Outdoor noise (entering the dwelling through ventilation openings, cracks, mechanical supply and exhaust openings etc.);
- Noise generated by components of the ventilation system;
- Sound transported within or between dwellings by the ventilation system.

A separate simplified tool was developed for each of these.

5.1 Outdoor Noise

The first tool makes it possible to select a ventilation principle in a noisy outdoor environment. A number of matrices were developed to select the most appropriate ventilation system for a room when the following parameters are known:

- the area of the façade (5-10, 10-15 or 15-25 m²);
- the required noise reduction of the room (20, 25, 30 or 35 dB(A));
- the required size of the ventilation opening, taking 0 for mechanical supply systems, (0-50, 50-100, 100-200, 200-400 or >400 cm²);
- the percentage inferior sound proofing constructions of the façade (0, <50 or >50 %).

Tables 4, 5 and 6 illustrate the tool. Each matrix will indicate:

- when the system is not applicable;
- 0 when the system is applicable with excellent sound proofing constructions in the facade;
- + when the system is applicable with normal sound proofing constructions in the facade;
- ++ when the system is applicable without extra sound proofing constructions in the facade.

5.2 System Noise

The use of fans in a ventilation system causes a certain noise level in rooms. This noise level is the difference between the total noise production in the system (which is the noise production of the fan, the noise production of the inlet and/or outlet and aerodynamic noise) and the total damping in the system (caused by silencers, cross-talk absorbers, bends, branches etc.). The maximum allowable sound pressure level caused by the ventilation system is 30 dB(A) in most countries. This simplified tool gives the consequences and guidelines for selecting silencers in duct systems depending on the duct length, number of branches and sound power level of the fans. Indications are also given of sound pressure levels in rooms with local fans. The tool is limited to duct air velocities below 3 m/s as this is necessary to avoid aerodynamic noise.

The sound power level of a fan can be determined using the equation:

	$L_{w} = L_{ws} + (10*\log_{10}(q_{v})) + (20*\log_{10}(\Delta P))$
Where:	
L _{ws}	is 1 +/-4 in dB
q _v	is the flow capacity in m ³ /h
ΔP	is the total pressure difference across the fan in Pa

A series of matrices, Tables 7 to 10, indicate the applicability of the ventilation system with or without silencers using the following:

- -- When the resulting noise level in the room is more than 40 dB(A)
- When the resulting noise level in the room is between 35 and 40 dB(A)
- 0 When the resulting noise level in the room is between 30 and 35 dB(A)
- + When the resulting noise level in the room is between 25 and 30 dB(A)
- ++ When the resulting noise level in the room is less than 25 dB(A)

5.3 Cross-talk

The third tool provides some limited guidelines for preventing sound transmission within or between dwellings via the ventilation system (cross talk).

Table 4: Applicability of Ventilation System With External Noise and Façade Area 5 m^2 to 10 m^2

$S_{facade} = 5 - 10 \ m^2$

	on system							G_{ec}	= 20 dF	(A)							
			Р	ercentag 0	e of infe	erior sou	indproof	ing cons		s in the	facade e	exposed to traffic noise [%]					
			А	u net [cm	1 ² 1		<u> </u>	А	< 50 net lcm	2			A	≥ <u>50</u> \ net [cn	1 ²]		
		0-50	50- 100	100- 200	200- 400	≥ 400	0-50	50- 100	100- 200	200- 400	≥ 400	0-50	50- 100	100- 200	200- 400	≥ 400	
	Ventilation opening without soundproofing: R ₁ = -5 dB(A)	Ċ,	3	0	0	•	*	\$	0	•	•	8	\$	+	•	•	
Natural	Soundproofed ventilation opening: $R_a = 0 dB(A)$	τ÷.		8	69	•	60	60	÷ + .	; + ;	+	\$\$	60	\$	+	0	
supply	Soundproofed ventilation opening: $R_a = 10 \text{ dB}(A)$	++	1+++) 1	\$	-	ΦÐ	æ	ç	00	¢¢	¢¢	\$\$	\$\$	\$\$	\$\$	8	
	Soundproofed ventilation opening: $R_a = 15 \text{ dB}(A)$	G	65	8	-	.	\$, C ⊅	\$	⇔	60	8	\$	\$\$	⇔	∞	
Mechania	cal supply and exhaust	8	(45	\$	\$. Ж	60	\$	60	8	\$	\$	⇔	\$	*	¢Ð	
Ventilatio	on system	<u> </u>							= 25 dF								
			Р	ercentag 0	e of infe	erior sou	indproof	ing cons	truction: < 50	in the	facade e	xposed t	o traffic	<u>noise ['</u> ≥ 50	<u>%</u>]		
				net [cn					net (cm		r			net [cn	T	T	
		0-50	50- 100	100- 200	200- 400	≥ 400	0-50	50- 100	100- 200	200- 400	≥ 400	0-50	50- 100	100- 200	200- 400	≥ 400	
	Ventilation opening without soundproofing: R _a = -5 dB(A)			27			•	•	b	•	0	•	°	•	•	•	
Natural	Soundproofed ventilation opening: $R_a = 0 dB(A)$	<u>(</u> ++)	+++	, +		2	¢¢	- +	•	•	•	\$	+.	•	٥	•	
supply	Soundproofed ventilation opening: $R_a = 10 \text{ dB}(A)$	e	₽	ŝ	3	¢	00	⇔	3	3	G	8	\$	\$\$	\$	\$	
	Soundproofed ventilation opening: $R_u = 15 \text{ dB}(A)$			æ		æ	÷	60	8	8	¢Ð,	\$≎	⇔	\$ \$	\$	*	
Mechanic	cal supply and exhaust		Ð	60	60	. €Ð.	œ	CO .	\$	\$	\$	\$		¢\$)	\$	\$	
Ventilatio	on system								<u>= 30 dH</u>								
Ventilatio	up system		P	ercentag 0	e of infe	erior sou	ndproof	G _{ac}			facade e	sposed t	o traffic		<u>۴</u> ۱		
Ventilatio	on system		А	0 . <u>net {</u> ¢m	2			ing cons	tructions < 50 net [cm	in the			A	≥ 50 net [cn	1 ² 1	· · · ·	
Ventilatio		0-50		0		erior sou ≥ 400	0-50	ing cons	tructions < 50	in the	facade c ≥ 400	0-50		≥ 50		≥ 400	
Ventilatio	Ventilation opening without soundproofing: $R_a = -5 dB(A)$	0-50	A 50-	0 . <u>net {</u> ¢m 100-	200-	2		ing cons A 50-	tructions < 50 net [cm 100-	² 200-	2		A 50-	≥ <u>50</u> net [cn 100-	1 ²] 200-		
Ventilatio	Ventilation opening without soundpryofing: $R_{a} = -5 dB(A)$ Soundproofed ventilation opening: $R_{a} = 0 dB(A)$		A 50-	0 net jon 100- 200	200- 400	≥ 400	0-50	ing cons A 50-	truction < 50 net [cm 100- 200	² 200- 400	≥ 400	0-50	A 50- 100	≥ 50 net [cn 100- 200	²] 200- 400	400	
	Ventilation opening without soundproofing: $R_a = -5 dB(A)$ Soundproofed ventilation		A 50-	0 net {cm 100- 200	200-	≥ 400	0-50	ing cons A 50-	tructions < 50 net [cm 100- 200	² 200- 400	≥ 400	0-50	A 50- 100	≥ 50 net [cn 100- 200	2(X)- 4(X)	400 •	
Natural	Ventilation opening without soundproofing: R _a = -5 dB(A) Soundproofed ventilation opening: R _a = 0 dB(A) Soundproofed ventilation		A 50-	0 net {cm 100- 200	200- 400	≥ 400	0-50	A 50- 100	<pre>truction < 50 net [cm 100- 200 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</pre>	in the 1 200- 400	≥ 400	0-50 ø	A 50- 100	≥ 50 net [cn 100- 200	2) 200- 400	400 •	
Natural supply	Ventilation opening without soundproofing: $R_a = -5 dB(A)$ Soundproofed ventilation opening: $R_a = 0 dB(A)$ Soundproofed ventilation opening: $R_a = 10 dB(A)$ Soundproofed ventilation		A 50-	0 net {cm 100- 200	200- 400	≥ 400	0-50 •••••••••••••••••••••••••••••••••••	A 50- 100	tractions < 50 net [cm 100- 200 • •	in the : 200- 400	≥ 400	0-50 • •	A 50- 100	≥ 50 net [cn 100- 200	2(X)- 4(X) 0	400 • •	
Natural supply Mechanic	Ventilation opening without soundproofing: $R_a = -5 dB(A)$ Soundproofed ventilation opening: $R_a = 0 dB(A)$ Soundproofed ventilation opening: $R_a = 10 dB(A)$ Soundproofed ventilation opening: $R_a = 15 dB(A)$		A 50- 100	0 net (em 100- 200	²] 200- 400	≥ 400	0-50 •••••••••••••••••••••••••••••••••••	Ting cons A 50- 100 A 50- 100 A A A A A A A A A A A A A A A A A A	tructions < 50 net [cm 100- 200 0 200 0 200 0 200 0 200 0 200 0 200 0 200 0 200 0 200 0 200 0 200 0 200 0 200 0 200 0 2000 200	s in the s 2 200- 400 0 0 + (A)	≥ 400 • • •	0-50 • • + +	A 50- 100 • • • + +	≥ 50 net [cn 100- 200 0 0 0 +	1 ²] 2(X)- 4(X) 0 0 0 +	400	
Natural supply Mechanic	Ventilation opening without soundproofing: $R_a = -5 dB(A)$ Soundproofed ventilation opening: $R_a = 0 dB(A)$ Soundproofed ventilation opening: $R_a = 10 dB(A)$ Soundproofed ventilation opening: $R_a = 15 dB(A)$ cal supply and exhaust		A 50- 100	0 net (em 100- 200	²] 200- 400	≥ 400	0-50 •••••••••••••••••••••••••••••••••••	A 50-100 100 22+2 + + + +	tructions < 50 net [cm 100- 200 0 200 0 200 0 200 0 200 0 200 0 200 0 200 0 200 0 200 0 200 0 200 0 200 0 200 0 200 0 2000 200	s in the s 2 200- 400 0 0 + (A)	≥ 400 • •	0-50 • • + +	A 50- 100 • • • + +	≥ 50 net [cn 100- 200 0 0 0 + noise [^t	1 ²] 2(X)- 4(X) 0 0 0 +	400	
Natural supply Mechanic	Ventilation opening without soundproofing: $R_a = -5 dB(A)$ Soundproofed ventilation opening: $R_a = 0 dB(A)$ Soundproofed ventilation opening: $R_a = 10 dB(A)$ Soundproofed ventilation opening: $R_a = 15 dB(A)$ cal supply and exhaust		A 50- 100	0 net (cm 100- 200	2) 200- 400	≥ 400	0-50 + _	A S0- 100 F + F Gaz Ing cons	tractions < 50 net [cm 100- 200 • • • • • • • • • • • • • • • • • • •	21 200- 400 0 0 +	≥ 400 • • • • • • • •	0-50 	A 50- 100 • • • • • • • • • • • • • • • • • •	≥ 50 net [cn 100- 200 0 0 0 + noise [f] > 50 net [cn	2 2(X)- 4(X) 0 0 0 + 7 7	400	
Natural supply Mechanic	Ventilation opening without soundproofing: $R_a = -5 dB(A)$ Soundproofed ventilation opening: $R_a = 0 dB(A)$ Soundproofed ventilation opening: $R_a = 10 dB(A)$ cal supply and exhaust		A 50- 100	0 net icm 100- 200 C C C C C C C C	2) 200- 400 200- 400 200- 200- 400	≥ 400 201 201 201 201 201 201 201 201 201 2	0-50 + + +	A 50- 100 22 7 7	tractions < 50 net [cm 100- 200 • • • • • • • • • • • • • • • • • • •	x in the 2 2 2 2 2 2 2 2 2 2 2 2 2	≥ 400 • • • • • • • • • • • • • • • • • •	0-50 0 + + + 0 0-50	A 50- 100 • • • • • • • • • • • • • • • • • •	≥ 50 net [cn 100- 200 0 0 + noise [f ≥ 50	21 2(X)- 4(X) 0 0 0 +	400	
Natural supply Mechanic	Ventilation opening without soundproofed ventilation opening: $R_a = 0 dB(A)$ Soundproofed ventilation opening: $R_a = 0 dB(A)$ Soundproofed ventilation opening: $R_a = 10 dB(A)$ Soundproofed ventilation opening: $R_a = 15 dB(A)$ cal supply and exhaust on system Ventilation opening without soundproofing: $R_a = -5 dB(A)$		A 50- 100 44 44 44 44 44 44 44 44 44 44 44 44 100 100	0 net (cm 200 200 200 200 200 200 net (cm 100- 200	2 200- 400 200- 200- 200- 2 2 200- 2 200-	2 400 2 2 2 400 2 2 400 2 2 400	0-50 + + + + 0-50	A 50- 100 C C C C C C C C C C C C C C C C C C	tractions < 50 net [cm 100- 200 • • • • + + + + + + • • • • • • • • •	200- 400 400 0 0 + 200- 400 0 0 +	≥ 400 0	0-50 	A 50- 100 • • • • • • • • • • • • • • • • • •	≥ 50 net [cn 100- 200 0 0 0 0 0 + + 100- 100- 0 0 0 0 0 0 0 0 0 0 0 0 0	2 2(X)- 4(X)	400	
Natural supply Mechanic Ventilatio Natural	Ventilation opening without soundproofing: $R_a = -5 dB(A)$ Soundproofed ventilation opening: $R_a = 0 dB(A)$ Soundproofed ventilation opening: $R_a = 10 dB(A)$ Soundproofed ventilation opening: $R_a = 15 dB(A)$ cal supply and exhaust on system Ventilation opening without soundproofing: $R_a = -5 dB(A)$ Soundproofing: $R_a = -5 dB(A)$ Soundproofing: $R_a = -5 dB(A)$		A 50- 100 +++++++++++++++++++++++++++++++++	0 net icm 100- 200 C C C C C C C C	2) 200- 400 200- 400 200- 200- 400	2 400 2 2 400 2 2 400	0-50 + - + - + - - + - 50	A 50- 100 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	tractions < 50 net [cm 100- 200 • • • • • • • • • • • • • • • • • • •	x in the 2 2 2 2 2 2 2 2 2 2 2 2 2	≥ 400 • • • • • • • • • • • • • • • • • •	0-50 0 + + + 0 0-50	A 50- 100 • • • • • • • • • • • • • • • • • •	≥ 50 net [cn 100- 200 0 0 0 0 0 0 0 0 0 0 0 0	21 2(X)- 4(X) 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	400	
Natural supply Mechanic Ventilatic	Ventilation opening without soundproofed ventilation opening: R _a = 0 dB(A) Soundproofed ventilation opening: R _a = 0 dB(A) Soundproofed ventilation opening: R _a = 10 dB(A) cal supply and exhaust on system Ventilation opening without soundproofing: R _a = -5 dB(A) Soundproofed ventilation opening: R _a = 10 dB(A) Soundproofed ventilation opening: R _a = 10 dB(A)		A 50- 100 44 44 44 44 44 44 44 44 44 44 44 44 100 100	0 net (cm 200 200 200 200 200 200 net (cm 100- 200	2) 200- 400 200- 400 200- 200- 400	2 400 2 2 400 2 400 2 400	0-50 + + + + 0-50	A 50- 100	truction < 50 net [cm 100- 200 200 200 200 200 200 200 200 200	200- 400 0 0 + (A) 200- 400 0 - - - - - - - - - - - - - - -	≥ 400 0	0-50 • • • • • • • • • •	A 50- 100 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	≥ 50 n net [cn 100- 200 0 0 0 0 0 0 0 0 0 0 0 0	21 2(X)- 4(X) • • • • • • • • • • • • • • • • • • •	400 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1	
Natural supply Mechanic Ventilatic Natural	Ventilation opening without soundpryofing: $R_a = -5 dB(A)$ Soundproofed ventilation opening: $R_a = 0 dB(A)$ Soundproofed ventilation opening: $R_a = 15 dB(A)$ Soundproofed ventilation opening: $R_a = 15 dB(A)$ cal supply and exhaust Ventilation opening without soundproofing: $R_a = -5 dB(A)$ Soundproofing: $R_a = 0 dB(A)$ Soundproofed ventilation opening: $R_a = 0 dB(A)$		A 50- 100 44 44 44 44 44 44 44 44 44 44 44 44 100 100	0 net [cm 200 200 200 200 200 200 200 200	200- 400 201- 400 201- 201- 201- 201- 200- 400 200- 200- 200- 200- 200- 200-	2 400 2 2 400 2 2 400	0-50 + - + - + - - + - 50	A 50- 100 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	truction. < 50 net [central 100- 200 200 	21 200- 400 0 0 + 21 200- 400 0 + 21 200- 400	≥ 400 • • • • • • • • • • • • • • • • • •	0-50 • • + + + + • • 0-50	A 50- 100 • • • • • • • • • • • • • • • • • •	≥ 50 net [cn] 00- 200 0 0 0 + 200 0 0 +	21 2001- 400	400 ○ ○ ○ - - - - - - - - - - - - -	

Table 5: Applicability of Ventilation System With External Noise and Façade Area 10 m^2 to $15m^2$

$S_{facade} = 10 \cdot 15 \text{ m}^2$

Ventilati	on system	- -						6.	c = 20 d	B(A)							
	,				ee of inf	erior so	undproof				facade c	xposed	to traffic	c noise [761		
				0	1.				< 50	7.		≥ 50					
		0-50	50-	Anet fer 1100-	<u>n'}</u> 200-	1	0-50	/ 50-	A net [cn 100-	n ⁴] 200-	1.	0-50	50-	A net [ci 100-		1.	
			100	200	400	≥ 400	0-50	100	200	200- 400	≥ 400	0-50	100	200	200- 400	≥ 400	
	Ventilation opening without soundproofing: $R_{a} = -5 \text{ dB}(A)$	\$	\$	æ	<u> </u>	l °	₿	\$	+	•	•	60	∞	+	•][°	
Natural	Soundproofed ventilation opening: $\mathbf{R}_{\mathbf{s}} = 0 d\mathbf{B}(\mathbf{A})$	\$	8		*	\$	*	*	⇔	*	+	⇔	\$	₩	\$\$	+	
supply	Soundproofed ventilation opening: $R_{II} = 10 \text{ dB}(A)$	\$	\$\$	8	*	*	⇔		l \Leftrightarrow	⇔	*	 	₩	↓ ↔	8	Ĺ	
	Soundproofed ventilation opening: R ₄ = 15 dB(A)	\$	\$	*	\$	8	÷	\$	_ ⇔	⇔	⇔	⇔	\$		⇔	Ê	
Mechanic	cal supply and exhaust	\$	æ	■ ⇔	_ ⇔	**	\$	*	⇔	\$\$	\$	\$\$	\$	⇔	\$	¢	
Ventilatio	on system	- <u>r</u> -						<u> </u>	. = 25 di	3(4)							
			ł		<u>e of inf</u>	erior so	undproof				facade e	xposed (to traffic	noise l	<u>%)</u>		
				0	,				< 50	•		L		<u>≥ 50</u>			
		0-50	50-	<u>A net jen</u> 100-	<u>n"]</u> 200-	1	0-50	50~	<u>x net [cn</u> 100-	1 ⁴] 200-		0-50	50-	<u>A net [cr</u> 100-		E.	
			100	200	400	≥ 400	0-50	100	200	400	≥ 400	0-50	100	200	200- 400	≥ 400	
	Ventilation opening without soundproofing: $R_{\bullet} = -5 dB(A)$	⇔	•	°	°	°	+	°	•	°	°	+	°	°	Ĉ.	C	
Natural	Soundproofed ventilation opening: $R_a = 0 dB(A)$	60	8		°	0	⇔	⇔	0	•	•	\$	+	0	•		
supply	Soundproofed ventilation opening: $R_a = 10 \text{ dB}(A)$	⇔	*	_ ⇔	↔	↔	*	⇔	⇔	**	\$≎	⇔	⇔	*	*	¢	
	Soundproofed ventilation opening: $R_a = 15 \text{ dB}(A)$	\$	\$\$ 		÷	\$	*	¢\$	_ ⇔	*	\$	\$	*	⇔	\$		
Mechanic	cal supply and exhaust	\$\$	\$	⇔	*	\$	\$	÷	⇔	8	\$	⇔	\$\$	*	\$	~~	
Ventilatio	on system	- <u> </u>			_				= 30 dF	3(4)							
			. P	ercentar	e of inf	erior sou	indproof				facade e	xposed (o traffic	: noisę [<u>%</u>]		
				0	2				< 50			ļ		≥ 50			
		0-50	50- 100	<u>net [cn</u> 100- 200	200-	≥ 400	0-50	50- 100	<u>net [cn</u> 100- 200	200-	≥ 400	0-50	50- 100	<u>net (cn</u> 100- 200	200- 400	≥ 400	
	Ventilation opening without soundproofing: $R_{*} = -5 dB(A)$	•	•	•	-00	φ(R) Φ	۰	9	0	0	4(X) O	0	0	0	0	400	
Natural	Soundproofed ventilation opening: R _L = 0 dB(A)	0	•	•	•	°	0	0	•	•	0	•	•	•	0	•	
supply	Soundproofed ventilation opening: $R_{a} = 10 \text{ dB}(A)$	\$	\$	⇔	\$\$	\$	+	+	+	+	0	+	0	0	0	ſ	
	Soundproofed ventilation opening: R ₄ = 15 dB(A)	\$	\$	\$	⇔	⇔	+	+	+	+	0	+	+	+	0	0	
Mechanic	al supply and exhaust	\$	\$	\$ \$	*	\$	+	+	+	+	+	+	+	+	+	+	
Ventilatio	on system								26.00								
- cintilation	11 3J 34-11	—	Р	ercentae	e of infe	erior sou	ndproof		= 35 dE		acade e	roosed t	o testic	noise l	<u></u>		
				0			[< 50					<u>> 50</u>			
		0-50	50-	<u>леt [сп</u> 100-	200-	≥	0-50	50-	net [cm 100-	200-	≥	0-50	50-	<u>net [çn</u> 100-	200-	≥	
		+	100	200 •	400	400 9	o	100	200 •	400 •	400	0	100 •	200	400 •	400	
	Ventilation opening without	•												1	1		
Natural	soundproofing: $R_a = -5 dB(A)$ Soundproofed ventilation	•	•	•	•	•	•	6	•	•	•	•	•	0	•	•	
Natural supply	soundproofing: $R_a = -5 dB(A)$ Soundproofed ventilation opening: $R_a = 0 dB(A)$ Soundproofed ventilation			0	0	•	0	0	0	0 0	•	0	•	0	°		
	soundproofing: R ₂ = -5 dB(A) Soundproofed ventilation opening: R ₂ = 0 dB(A)	•	0													0 0	

Table 6: Applicability of Ventilation System With External Noise and Façade Area 15 m^2 to $20m^2$

$S_{facade} = 15 - 25 \text{ m}^2$

Ventilatio	on system	$G_{ac} = 20 \text{ dB}(A)$								3(A)						
		Percentage of inferior soundproofing constructions in the facade exposed to traffic noise [%]														-
		0							< 50			> 50				
		A net [cm ²]						A	net (cm	121			A	net [cn	1 ²]	
		0-50	50- 100	100- 200	200- 400	≥ _400	0-50	50- 100	100- 200	200- 400	≥ 400	0-50	50- 100	100- 200	200- 400	≥ 400
	Ventilation opening without soundproofing: $R_{a} = -5 dB(A)$		9	69	6		6 3	. 🕬	+	+	•	\$	⇔	60	0	•
Natural	Soundproofed ventilation opening: $R_a = 0 dB(A)$	+++	Ç.	190	4	+++2	60	\$	с ъ	·\$\$	+	€0	\$	\$\$	*	×
supply	Soundproofed ventilation opening: $R_{B} = 10 \text{ dB}(A)$		0	60	œ		60	\$	₩	₩	8	\$	(⇔	€≎	89	 «
	Soundproofed ventilation opening: $R_1 = 15 \text{ dB}(A)$		()	- C.Y.	6 5		6 2	\$	\$	\$	89	¢0	**	€\$	\$\$) œ
Mechani	cal supply and exhaust	.	\$	63	\$	\$ 2	-60	ස	\$	CC	60	⇔	\$	\$	\$	~

Ventilati	on system	$G_{as} = 25 \text{ dB}(A)$														
		Percentage of inferior soundproofing constructions in the facade exposed to traffic noise [%]														
				0					< 50		_			≥ 50		
			Ā	net [en	1 ²			A	net [cn	<u>1</u>			A	net (cn	n²l	
		0-50	50- 100	100- 200	200- 400	≥ 400	0-50	50- 100	100+ 200	200- 400	≥ 400	0-50	50- 100	100- 200	200- 400	≥ 400
	Ventilation opening without soundproofing: $R_a = -5 dB(A)$	+++	60	, 9	e de		3	» O	`	D	٩	æ	0	•	¢	•
Natural	Soundproofed ventilation opening: $R_i = 0 \text{ dB}(A)$.	\$ \$	60		\$ 0-	600	+	0	•	\$	*	+	0	•
supply	Soundproofed ventilation opening: $R_{\mu} = 10 \text{ dB}(A)$	\$	\$	(CD)	ξ¢,		C	÷	89	⇔	\$	8	*	\$	⇔	\$
	Soundproofed ventilation opening: $R_1 = 15 \text{ dB}(A)$	3	8	60	3	\$	80	8	\$	\$	\$	\$; ;	\$	\$	8	\$
Mechani	cal supply and exhaust		3	8	- CQ	3	3	¢	⇔	\$	8	8	8	\$	\$	↔

Ventilati	on system							G	= 30 dl	B(A)						
			Р	ercentar	e of infi	erior sou	ndproof	ing cons	truction	is in the	facade e	xposed t	to traffic	noise [%]	
1				0			-		< 50					≥ 50		
			Α	net len	1^2 l			A	net Jen	a ²]			A	net [en	n ²	
		0-50	50- 100	100- 200	200- 400	≥ 400	0-50	50- 100	100- 200	200- 400	≥ 400	0-50	50- 100	100- 200	200- 400	≥ 400
	Ventilation opening without soundproofing: R ₄ = -5 dB(A)		. U .,	٩	. H	2		0.	. 0	۰	٩	•	•	٥	٥	•
Natural	Soundproofed ventilation opening: $R_a = 0 dB(A)$		\$ \$		•		*+ **	٥	0	•	•	0	•	•	0	•
supply	Soundproofed ventilation opening: $R_s = 10 \text{ dB}(A)$	57).	69	`¢¢`	 .	3	*** **	· +	+	+	+	+ ·	+	+	0	•
	Soundproofed ventilation opening: $R_{B} = 15 \text{ dB}(A)$	ATT I	3	\$	÷		<u>_</u> +	+	+ '	+	+	+ *	+	+	+	0
Mechani	cal supply and exhaust		.	ŝ	, 2 0	6	+ 	· +	+	+	+	+	+	+	+	+

Ventilatio	on system							Gas	= 35 dI	3(A)						
			P	ercentar	c of infe	erior sou	ndproof	ing cons	truction	s in the	facade e	xposed t	to traffic	noise [70)	
				0	-				< 50					<u>≥</u> 50		
			r	<u>net len</u>					net [en	T.		L	/	<u>net len</u>		
		0-50	50- 100	100- 20 <u>0</u>	200- 400	≥ 400	0-50	50- 100	100- 200	200- 400	≥ 400	0-50	50- 100	100-	200- 400	≥ 400
	Ventilation opening without soundproofing: $R_a = -5 dB(A)$			0	ď			°,	0	ō	°	•	•	•	°	•
Natural	Soundproofed ventilation opening: $R_{4} = 0 dB(A)$		1		•		5	đ	2	•	°	°	0	•	°	°
supply	Soundproofed ventilation opening: $R_a = 10 dB(A)$	(1)	3	0	°0,	8	0	0	0	٥	•	· •.	•	٥	0	•
	Soundproofed ventilation opening: $R_a = 15 \text{ dB}(A)$	+++			9		• 0	0	0	0	•	0	0	٩	٥	°
Mechanie	cal supply and exhaust	++			++	++	. 0	0	0	0	0	0	0	0	0	0

Table 7: Applicability of Ventilation System with Fan Power Level of 70 dB(A)

$L_w = 70 \ dB(A)$

Duct length \Rightarrow		< 5 meter			\geq 5 meter	
Number of branches \Rightarrow	0	1	2	0	1	2
No silencer	~~					
Silencer 1000 mm	0	0	0	0	0	0
Silencer 1000 mm and cross-talk absorber 500	0	+	+	0	+	4 7
mm						

Table 8: Applicability of Ventilation System with Fan Power Level of 65 dB(A)

 $L_w = 65 \text{ dB}(A)$

Duct length \Rightarrow		< 5 meter			\geq 5 meter	
Number of branches \Rightarrow	0	1	2	0	1	2
No silencer					•	
Silencer 1000 mm	+	\$ \$ \$		+	+	410
Silencer 1000 mm and cross-talk absorber 500 mm	\$ \$	 \$#}	\$ \$	44	4 4	\$ \$ \$

Table 9: Applicability of Ventilation System with Fan Power Level of 60 dB(A)

$L_w = 60 dB(A)$

Duct length \Rightarrow		Not applicable	
Number of branches \Rightarrow	0	1	2
No silencer		~	
Silencer 1000 mm	0	0	+
Silencer 1000 mm and cross-talk absorber 500	+	\$ \$	 ትት
mm			

Table 10: Applicability of Ventilation System with Fan Power Level of 55 dB(A)L_w = 55 dB(A)

Duct length \Rightarrow		Not applicable	
Number of branches \Rightarrow	0	1	2
No silencer	Ð	œ	0
Silencer 1000 mm	64		
Silencer 1000 mm and cross-talk absorber 500 mm	\$ \$	\$ \$	**

6. Building Aspects

Ventilation systems both interact and influence the building in which they are installed. This tool is given in three tables, each one dealing with a particular building aspect. The impacts are given as weighted judgement and are based on technical conclusions of an analysis procedure.

The tool is in the form of three tables that show the impact of the chosen type of ventilation system on the various building aspects. Each table covers different building aspects, Table 11 covers building structure, Table 12 covers architecture and services, while Table 13 covers building construction and use.

Four categories of influence are given, ****** Very high impact, ***** High impact, ***** Low impact, **0** No impact

System	Inner Elem	ents	Enve	elope
Window Airing	Wall	0	Wall	0
-	Slab	0		
	Corridor	0	Window	<u>888</u>
	Doors	175 (P3	Roof	0
Passive Stack	Wall	₩¥	Wall	1
	Slab	WS.		
	Corridor	0	Window	1995 - 1905 - 19
	Doors	19 13	Roof	19 19 19
Mechanical exhaust only	Wall	6 9	Wall	C.
	Slab	Ref.	-	
	Corridor	0	Window	61 <u>7</u>
	Doors	鬯	Roof	10%
Mechanical supply	Wall	17 F 17	Wall	10%
and exhaust	Slab	5°% 5°%		
	Corridor	₩3	Window	0
	Doors	W.	Roof	Ψ¥.

Table 11: Building aspects. Ductwork and flow influence

Table 12: Building aspects, architectural, building service

System	Archited	tural					Buildin	g services	
	Sp	atial	Replac	cement	В	uilding	Elect-	Plumb-	Control
	Opera-	Mainten	Same	Other	Lay out	External	ricity	ing	system
	tion	-ance	system	system		appearance		_	
Window Airing, NWA	0	0	0	888	0	0	0	0	0
Passive Stack, PSV	0	*	***	19 13 19 19	****	营营	**	****	0
Mechanical exhaust only, MEO	refer	۴۶	₩.	40 <u>9</u>	₩¢	*0.VP	÷.	€¥	₩,
Mechanical supply and exhaust, MSE	19 93 19 93	19 19 19	193	63	19 19 19	P S	49 <u>5</u>	19 12 19	eje

Systems		Construct	ion – at sit	te	Building	g in use	Ot	hers
	Con- struction	Bldg services	Decora- tion	Commis- sioning	Mainte- nance	Fire	Building Age	Furnish- ing
Window airing	0	0	0	**	0	0	世世	苦苦
Stack	193 193	ey.	193	营营	193	er.	营营营	1
Mechanical exhaust	**	**	1975	**	1	witz.	<u> </u>	1 75
Mechanical supply and exhaust	83 83	r S	***	9 7	495 1	est.	÷.	ن ې

Table 13: Buildingaspects, at building site and usage

The tool can be usefully applied in the whole process of building evaluation both for new constructions and renovation work. The tool can also be used as part of the total quality assurance procedure, thus avoiding mistakes and facilitate the circulation of information to various experts and managers.

7. Indoor Air Quality (IAQ)

This tool estimates the effect of the choice of ventilation system, together with the air-tightness of the dwelling, on the indoor air quality. The user selects values for basic input parameters related to the ventilation system, building envelope and climate. The user then refers to simple, easy-to-use matrices to obtain a rating for:

- The indoor air quality
- The level of condensation
- The energy required to heat the indoor air

The results from this tool are based on computer simulations and the background material contains sufficient data to allow the user to perform their own computer simulations if required.

IAQ

Indoor air quality was based on three common pollutant sources in dwellings, CO_2 from human metabolism, water vapour from cooking and pollutants from passive smoking. For each pollutant an exposure is calculated and a relative rating given in the tables provided (-- corresponds to the higher exposures and ++ corresponds to the lower exposures).

Condensation

This output is related to the hours of condensation in habitable rooms (a single glazed window is used as the reference) and in wet rooms (an internal wall is used as a reference).

Heating Energy

The heating tool is intended as a comparison between ventilation systems rather than as a measure of actual energy consumption. The Energy Tool deals with energy consumption in more detail. Energy is assessed in the IAQ tool by comparing the heat loss due to ventilation for each set of parameters investigated.

Warning Flags

In addition to the three IAQ issues discussed above, matrices are provided showing warning flags for long periods when:

- The indoor air is dry;
- The indoor air is humid (which can increase the level of house dust mites);
- The outdoor pressure is significantly greater than the indoor pressure (which can be a problem in high radon areas or during the use of combustion appliances).

Tools

The IAQ tools are illustrated in Tables 14 to 16. The following conventions are used in these tables:

- Areas of supply openings are given in cm²
- Extract (and supply) rates for mechanical systems are given in l/s
- Warning flags are highlighted 💭 orange shaded

Extended Applicability

The tool was produced on the basis of a four room dwelling and a four person family. Its application can be extended to larger or smaller dwellings by adding or removing one bedroom with one person. The results are then less precise, but the ranking would remain quite the same. It is not, however, possible to use the tool for single room dwellings.

Table 14: Indoor Air Quality for Ventilation Systems in Nice

climate : NICE

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Table 15: Indoor Air Quality for Ventilation Systems in London

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climate : OTTAWA

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	add fan ->	Ν	Υ	Ν	Υ	Ν	ΙY	Ν	Y	Ν	Υ	N	Y	Z	Υ	z	Υ	N	Υ	Ν	Υ	Ν	Y	Ν	Y	z	Y	N	[Y	Ν	Y
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top	5	•	-	-	+	-	-	-	+	o	0	0	++	0	0	0	0	+	+	0	0	0	+	+	+	0	+	0	++	+	++
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ground	5	I	-	-	+	-	-	-	+	+	+	+	++	0	0	0	0	+	+	0	0	0	+	+	+	0	+	0	++	+	++
D4c	1			0	Q			0	0	-		+	+	•		0	-	+	1	-	•	Ò	-	+	0	١	١	0	+	+	++
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ground	5		+		++		+		++	0	++	L+	++	-	++	0	++	+	++	-	++	0	++	+	++	-	++	0	++	+	++
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	10 case b	-	++	0	++	-	++	0	++	++	++	++	++	0	++	+	++	++	++	0	++	+	++	++	++	¢	++	+	++	++	++

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	add fan ->	Ν	Y	Ν	Y	N	Y	N	Y	Ν	Y	N	Y	Ν	Y	Ň	Y	N	Y	Ν	Y	Ν	Y	N	Y	Ν	Y	N	Y	Ν	Y
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	2.5	++	++	+	0	++	++	+	0	+	0	•	• •	++	+	+	0	٠	۲	++	+	+	0	-	•	++	+	++	+	+	0
top	5	++	+	0	-]++	+	0	-	0	-	I	 	÷	0	0	0	-	•	+	0	0	-	-	••	++	+	+	0	0	0
D4a	1	++	++	+	0	++	++	+	0	+	-			++	+	+	0	-	1	++	+	+	0	-	+	++	++	++	+	++	+
	2.5	++	++	+	0	++	++	+	0	0				++	+	+	0	-	-	++	+	+	0	-	-	++	+	++	+	+	0
ground	5	++	+	0	•	++	+	0	•					+	+	0	0	-	•	+	0	0	-	-		++	÷	+	0	+	0
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Table 16: Indoor Air Quality for Ventilation Systems in Ottawa

climate : OTTAWA

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8. Reliability

This tool estimates the reliability of ventilation systems. While the reliability of achieving good indoor air quality is the real concern, for practical reasons two different reliability tools have been produced:

- Reliability as indicated by air flow rate stability;
- Reliability as indicated by performance over time i.e. systems and components reliability.

8.1 Air Flow Rate

The tool for airflow rate stability is based on computer simulation results using a multi-zone airflow model. The assumed target for ventilation flow rate was 4 l/s per person or more in the bedrooms. The relative performance of the different ventilation systems, as indicated in tables 17 to 19, is based on the fraction of the time that the target flow rate is achieved or exceeded.

The user must choose values for a number of input parameters from the limited options in the simplified tool. These are:

- The appropriate climate relating to the location of the dwelling;
- Type of dwelling;
- Type of ventilation system;
- Airtightness of dwelling;
- Supply openings for natural ventilation;
- Mechanical extract flow rate for mechanical extract (including MSE) systems.

The user can then read off from the appropriate table the reliability of the ventilation flow rates for the chosen case.

8.2 System Reliability

Component reliabilities and life can be estimated using probability of failure with time. By building up fault trees from the component models whole systems have been modelled. Three standards of components are offered for which three standards of maintenance can be applied. These nine options have been analysed in a detailed spreadsheet tool for three building types and the results presented in the simplified tool as a series of tables. The tables indicate reliability based on average and minimum reliability over the life of the system.

System Quality

- Poor: Aimed at minimising capital costs with no attention to future maintenance;
- Average: Relatively good components but reducing capital costs still dominate;
- Best: The best available components with little attention to initial capital cost.

Maintenance Standards

- High: Maintenance is approximately 50-100 % more intense than normal practice;
- Medium: Maintenance is performed according to normal practice;
- Low: Maintenance is approximately 30-50 % less intense than normal practice practice.

System	Airing	Inlet	Exhaust	Extra	8.2.1.1	Dwellin	σ		<u> </u>	
	-	area	fan flow	fan	0.2.1.1		tment		Ho	use
	1	(cm ²)	rate		D4a	top		round	D	
		()	(l/s)	1		(ach)	¥	(ach)	n50 (
			(~~)		1	5	1	5	2.5	10
NWA	No	0		N		-		-		
		1		Y		-		-		
		410		N	0	0	0	0	-	0
				Y	0	+	0	0	-	0
	Yes	0		N	-	0	-	0	-	-
				Y	-	0	-	0		-
		410		N	+	+	0	0	0	0
				Y	0	+	0	+	0	0
PSV	No	100		N	+	+	0	+	0	0
				Y	+	+	0	+	0	0
		400		N	+	+	+	+	+	+
				Y	+	+	+	+	+	+
MEO		0	15	N		0		0		0
				Y		0		0		0
			45	N	0	+	0	+	-	0
				Y	0	+	0	+	-	0
		100	15	N	-	0	0	0	0	0
				Y	0	+	0	0	0	0
			45	N	+	+	0	+	0	0
				Y	+	+	+	+	0	0
MSE			15	N	0	+	0	+	0	+
				Y	0	+	0	+	0	+
			30	N	++	++	++	++	++	++
		ļ		Y	++	++	++	++	++	++
			45	N	++	++	++	++	++	++
				Y	++	++	++	++	++	++

Table 17: Reliability flow rate stability. Climate Nice

System	Airing	Inlet	Exhaust	Extra	8.2.1.2	Dwellin				····
		area	fan flow	fan			tment		Ho	use
		(cm ²)	rate		D4a	top	D4a g	round	D	
		· · · · ·	(l /s)			(ach)		(ach)	n50 (
			(= /		1	5	1	5	2.5	10
NWA	No	0		N	-	-	-	-		-
				Y		-		-		-
		410		N	0	+	0	0	0	0
				Y	0	+	0	0	0	0
	Yes	0		N	0	0	0	0	-	0
				Y	-	0	-	0	-	0
		410		N	+	+	0	+	0	0
				Y	+	+	0	+	0	+
PSV	No	100		N	_ +	+	0	0	-	0
				Y	+	+	0	0	-	0
		400		N	+	+	+	+	0	0
				Y	+	+	+	+	0	0
MEO		0	15	N		0		0		0
				Y		0		0	-	0
			45	N	0	+	0	+	-	0
				Y	0	+	0	+	-	0
		100	15	N	0	+	0	0	0	0
				Y	0	+	0	0	0	0
			45	N	+	+	+	+	0	0
				Y	+	+	+	+	0	0
MSE			15	N	0	+	0	+	0	+
				Y	0	+	0	+	0	+
			30	N	++	++	++	++	++	++
				Y	. ++	++	++	++	++	++
			45	N	++	++	++	++	++	++
	<u> </u>			Y	++	++	++	++	++	++

Table 18:	Reliability flow	rate stability.	Climate	London
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System	Airing	Inlet	Exhaust	Extra	9212	Dwallin			•	
		area	fan flow	fan	8.2.1.3 Dwelling Apartment House					
		(cm ²)	rate	1411	D/19	D4a top D4a ground				4c
	<u> </u>	(((11))				(ach)		(ach)	n50	
	·				1	5	1	5	2.5	10
NWA	No	0	<u> </u>	N		0	-	0		0
NWA				Y	_	0	-	0	-	0
	<u> </u>	410	·	N	0	+	0	+	0	0
		-10		Y	0	+	0	+	0	0
	Yes	0		N	0	0	0	0	0	0
	1.00	· · · · · · · · · · · · · · · · · · ·		Y	0	0	<u> </u>	0	0	0
		410		N	+	+	+	+	0	+
			·····	Y	+	+	+	+	0	+
PSV	No	100		N	0	0	0	0	-	0
	- <u> </u>		1	Y	0	0	0	0		0
	1	400		N	+	+	0	0	0	0
	-		t	Y	+	+	0	0	0	0
MEO		0	15	N		0		0	_	0
				Y		+	-	0	-	0
			45	N	0	+	0	+	-	0
				Y	+	+	0	+	0	0
		100	15	N	0	+	0	0	0	0
				Y	0	+	0	+	0	0
			45	N	+	+	+	+	0	0
			<u> </u>	Y	+	++	+	+	0	0
MSE			15	N	0	+	0	+	0	+
				Y	0	+	0	+	0	+
			30	N	++	++	++	++	++	++
				Y	++	++	++	++	++	++
			45	N	++	++	++	++	++	++
		<u> </u>		Y	++	++	++	++	++	++

Table 19:	Reliability flow	rate stability.	Climate:	Ottawa
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Table 20: Reliability as indicated by performance over time is shown in the set of tables on this page

Apartments

Passive stack ventilation system											
Technical	Technical Maintenance level quality of										
system	High	Medium	Low								
Poor	Ingn	Weddum									
system	++	++	-								
Average											
system	++	++	+								
Best											
practice	++	++	++								

Central exh	Central exhaust ventilation										
Technical	Mai	intenance le	evel								
quality of											
system	High	Medium	Low								
Poor											
system	++	-									
Average											
system	++	++									
Best											
practice	++	++	+								

Central supply and exhaust ventilation											
Technical quality of	М	laintenance le	vel								
system	High	Medium	Low								
Poor											
system	+										
Average											
system	++	+									
Best											
practice	++	++	0								

Single family houses

Passive stack ventilation system										
Technical quality of	Mainte	nance level								
system	High	Medium	Low							
Poor										
system	++	+	-							
Average										
system	++	++	+							
Best										
practice	++	++	+							

Central supply	Central supply and exhaust ventilation										
Technical	Mainter	ance level									
quality of											
system	High	Medium	Low								
Poor		Γ									
system	+										
Average											
system	++	0	-								
Best											
practice	++	++	-								

For	natural	window	airing
ventila	ation strate	gy, only	openable
windo	ows, and	sometimes	natural
supply	y air devic	es in the	façades,
consti	tute the ven	tilation system	stem. For
this c	ase, the sco	ore "++"	could be
used.			

Central exhaust ventilation					
Technical quality of	Maintenance level				
system	High	Medium	Low		
Poor					
system	++	-			
Average					
system	++	++	-		
Best					
practice	++	++	+		

For natural window airing ventilation strategy, only openable windows, and sometimes natural supply air devices in the façades, constitute the ventilation system. For this case, the score "++" could be used.

9. Energy

The energy use due to ventilation and infiltration can be divided into two parts, the energy to heat the infiltration and ventilation air and the energy used for the transport of air through the ventilation system.

Due to the interactions between infiltration and ventilation it was impossible to create a paper based simplified tool. The Simplified Energy Tool is therefore a computerised nomogram with a single zone ventilation model behind it to calculate the lines of the nomogram instantaneously. This single zone model is based on the conservation of mass. The user has to provide input data to define the dwelling, the ventilation system and the climate. The tool is called Enervent 2, which is available on the Annex 27 'Simplified Tools' CD.

The energy tool can be applied to the four generic ventilation systems previously described for almost all types of dwelling in any location, due to the flexibility of the input data. More detailed information on the tool can be found in the background report [1].

Input

The require input data can be entered via a set of input screens accessed by selecting the appropriate button on the input menu. These input screens enable data to be entered to define the dwelling, the ventilation system, its use and the climate. From this information the nomogram calculates and displays on the computer screen the energy consumption to heat the ventilation and infiltration air and the fan energy used to transport the ventilation air.



A description of the dwelling and ventilation system can be entered into the tool using the input menu options:

number of levels 3	rewind aspect	awanna	eventilation sys		i asara	an an an an an an an an an an an an an a
	C city centre	and the second	Ino ductays		sl +windows	1070
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level volume m3 125	O open country	TO TO THE REAL PROPERTY AND A DESCRIPTION OF THE PARTY OF				
level height m 2.8	Con and a second second		11111111111111	11111	1000	000
attic height m 2.8	Cilet terrain		C balanced supply llowrate m3/s 20.042			
and the second		a an an an an an an an an an an an an an				戶 Fan 🗤
leakage distribution	Fini of facade compone		andoor temper.	atures		
	inlets	window		al. 3.1, C	at 14 C o	utside
tool 0.0	altic / rool 0	0	attic / rool	9.0	14.8	11 - C - S
level 3 0.0	level 3 2	2	level 3	9.0	14.8	
level 2 23.5	level 2 3	2	lovel 2	15.0	17.0	
level 1 23.5	level 1 3	3	level 1	15.0	17.0	
floor leakage 53.0		8 <i>- 20</i>		and	a and a constant	
alla and and and and and and and and and an	opening per cm2		degraedays	base ten	perature T	15.5
nomalize	inlet and per 50.0 window	0.60	outside temp	1.199.2	10119-10	
to 100%	Use	Use	1111AC			14.0

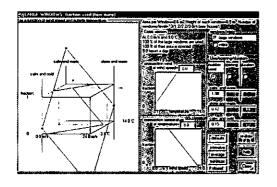
Ventilation Flow Rates

Ventilation rates for mechanical systems are relatively simple to provide and these can be input using the "house" input sheet.

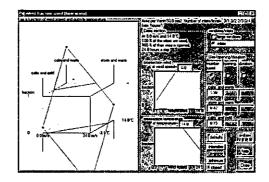
Ventilation rates for natural ventilation systems are harder to specify. For such systems information is provided on openings under the input sheet "house" and on the use made of these openings by occupants in the input sheets "inlets" and "win-

dows". Default occupant behaviour is available in the tool based on work carried out under Annex 8. The single zone simulation model calculates ventilation rates from this information.

Information on fans can then be input using the "fan" input sheet.



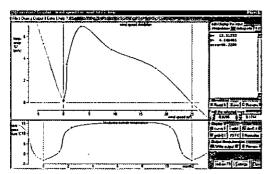
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Infiltration

Information on dwelling air leakage is entered on the "house" input sheet. This includes leakage distribution, overall leakage rate (N_{50} value).

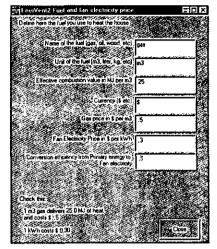
Climate



The internal-external temperature difference and wind speed are needed to calculate energy consumption. Internal temperatures for each floor are entered by the user under the "house" input sheet for two external temperatures. Default external climate data exists for a cold, moderate and mild climate but the user can enter their own data if required under the "V-wind " and "temp" input sheets.

Fuel

The Fuel button allows the input of information on heating fuel and electrical energy, including costs.



Output

On entering the necessary data the tool will draw a line through the fields of the nomogram ending in a red and a blue arrow. The blue arrow gives the total annual energy consumption in GJ while the red arrow is the heating energy required in GJ.

In addition the output menu provides the facility to:

- Redraw: redraws the final result and erases the previous ones;
- Print: prints the nomogram on a default printer;
- Report: open a text file and print a report with explanation about current input and output data, including some warnings;
- Help: open the help file;
- "p" house: which gives information about the weighted average pressure.



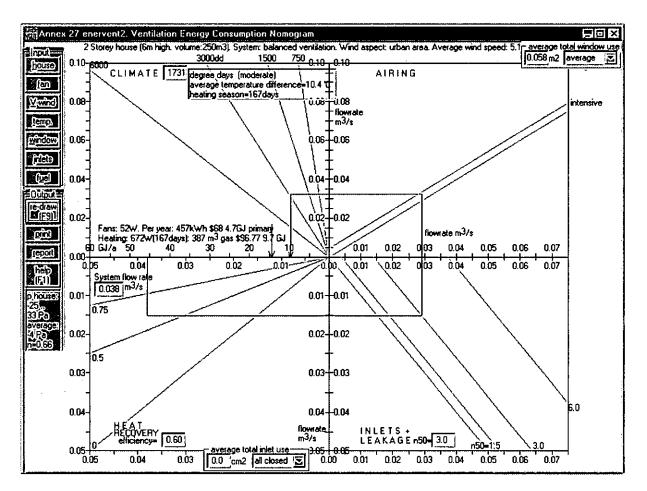


Figure 2: Example of Energy Nomogram

IEA Annex 27. EnerVent2. Calculation of the energy used to warm up the ventilation air for a house during the heating season. ======I n p u t====== The example house is a 3 Storey house (11m high. volume: 438m³). System: Exhaust Ventilation (MEO). Wind aspect: urban area. Average wind speed: 9.8m/s n=0.71 Files used: House House.txt Wind wind.txt Temperature temp.txt Fan: exhaust high= $0.020m^{3}/s$ efficiency= 0.10 - System pressure= 90.0 Pa. Fan: time high= 24:00hours Average system flow rate = $0.020 \text{ m}^3/\text{s}$ Air leakage value, n50 =1.6 Air Changes per Hour at 50 Pa giving: 0.1944 m³/s at 50 Pa; 0.0615 m³/s at 10 Pa; 0.0320 m³/s at 4 Pa; 0.0119 m³/s at 1 Pa. The estimated envelope area is 288.2 m^2 . The flow rate per m^2 is: 6.75-4m/s at 50 Pa; 2.14-4 at 10 Pa; 1.11-4 at 4 Pa; 4.12-5m/s at 1 Pa. The total opened area of large windows (averaged over the heating season)= 0.446 m^2 The total opened area of inlets (averaged over the heating season) = 142 cm^2 The number of degree-days is: 1488 dd =====Calculation====== This run considers heating during the heating season and fan energy during the whole year. The heating season is the period with outdoor temperatures below 14.0 °C which occurs at the degree-days base temperature inside (15.5 °C). The pressure in the house ranges from =-4.3 to -1.2 Pa The weighted average pressure in the house is -2.8 Pa. The weighted average system flow rate = $0.020 \text{ m}^3/\text{s}$ There is no heat recovery. The air leakage of the house (n50=1.6) results in an extra ventilation flow rate of $0.018 \text{ m}^3/\text{s}$ The ventilation inlets that have an average area of 141.6 cm² result in an extra ventilation flow rate of $0.018 \text{ m}^3/\text{s}$ The average use of 0.446m2 windows results in an extra flow rate of 0.017 m^3/s The total air flow rate is 0.074 m3/s The average temperature difference is 10.0 K and the duration of the heating season is 150 days. The energy used for Heating: 836W (150days): 432 m³ gas, \$216.01, 10.8 GJ The energy for the whole year for Fans: power = 13W. Per year: 114 kWh, \$34, 0.8GJ primary.

10. Life Cycle Cost (LCC)

Cost is one of the main influencing factors when selecting a domestic ventilation system. This often leads to a ventilation system that just meets the requirements of building regulations at the lowest initial costs. Decision makers are often not aware of the impact of the quality of the ventilation system on life cycle costs (LCC), not only for the ventilation system itself but also for the building, as a result of complaints or even damage due to a poor functioning ventilation system. The objective of a tool for LCC is to compare the total costs of ventilation systems and to make selections based on a cost comparison. The costs include initial investment costs, system maintenance costs and building maintenance costs. A fourth component could be included for energy costs, however, these are dealt with in more detail by the energy tool.

All estimated costs are averages from several EU countries (the Netherlands, France, Sweden, Germany, Denmark) and Canada, material and labour costs have a limited spread for most western and northern European countries and are expressed in ECU. Material and labour cost are included but location dependent costs are excluded.

The tool covers seven combinations of dwelling and ventilation system. For each of these there are four pages to the tool which contain:

- 1. a description of the ventilation system and building type. This includes specific qualities of concern.
- 2. a table from which the basic quality and initial costs can be estimated based on some qualitative descriptions of the installation and building qualities and properties.
- 3. a table from which the system loading can be estimated, again based on qualitative descriptions of the way the system and building are used. The maintenance class can then be read off a graph from the previously estimated basic system quality and system load.
- 4. two tables from which the maintenance cost and planned maintenance activities can be read based on the previous identified maintenance class. The expected costs are expressed as Net Present Values (NPV).

The total Life Cycle Costs can then be estimated by summing the initial capital costs with the maintenance costs.

The seven combinations covered are: a single family dwelling with passive stack (PSV), mechanical exhaust (MEO) and mechanical supply & exhaust with heat-recovery (MSE-X), and a multifamily dwelling with passive stacks (PSV), central mechanical exhaust (MEO), individual mechanical exhaust (MEO-local) and mechanical supply & exhaust with heat-recovery (MSE-X). No maintenance costs are available for Window Airing.

An example of the tool is given for a single family dwelling with mechanical exhaust and natural supply (MEO) on the following pages.

② Type of building:Single family houseType of ventilation system:Mechanical extract, natural supply (MEO)

Specific qualities that are of concern for assessment:

Ventilation system, installation Unit:

- Location
- Accessibility
- Devices

Duct and duct work:

- Layout of the system
- Devices
- Quality of design
- Quality of execution

Grilles, devices:

- Control possibilities
- Cleaning possibilities

Building

Purpose provided openings:

- Presence
- Design, according to building regulations
- Accessibility
- Control possibilities
- Cleaning possibilities

Building envelope:

- Air tightness

② Type of building:Single family houseType of ventilation system:Mechanical extract, natural supply (MEO)

STEP 1: Estimate the basic quality by Table 21A

Table 21A: Basic quality

	Best practice	Average	Poor
	Inst	allation	
Unit	• Easily accessible Mounted on construction with special sound proofing provi- sions	 Accessible Flexible mounting on construction 	 Difficult to access No sound proofing provisions for mounting
Ducts	 Straight duct layout Short duct lengths No sharp bends, flexible tubes Air tight sealing of ducts and connections Sound proofing provisions as silencers and flexible mounting on unit 	 Limited flexible bends No special sealing of ducts; connections sealed with tape 	 Excessive duct lengths Many bends Flexible tubes Leaky ducts No sound proofing provisions
Commission- ing and ad- justment	 Adjustment and commissioning in every dwelling Completion reports of commissioning required 	 Adjustment in limited number of test dwell- ings Completion report of test dwellings re- quired 	 No measurements and/or completion reports required
Grilles, devices	 Cleaning possibilities without disorder the ad- justment (marking or se- curing) (???) Self regulating inlets (pressure and temperature) 	 Cleaning possibilities with limited chance of disorder the ad- justment Good quality grilles (controllable, airtight when closed) 	 No cleaning possibilities or cleaning possi- bilities with chance of disorder No special requirements
		ilding	· · ·
Air tightness Initial costs	• n50 = 35 • 1200	• n50 = 56 • 900	No requirements800

Explanation:

Classification in category "best practice" or "poor" if most of the aspects are applicable for that specific category, otherwise category "average".

② Type of building:

ding: Single family house

Type of ventilation system: Mechanical extract, natural supply (MEO)

STEP 2: Estimate system loading by Table 21B

Table 21B: System loading

	Low	Average	Intensive
	Use of ins	tallation	
Instructions for use, control, maintenance etc.	Personally addressed	Written instructions are present	No instructions
Cleaning grilles, unit	Monthly cleaning	Cleaning 4 times/year	No cleaning
Use	In accordance with manual and instructions	Mostly in accordance with manual and in- structions	Disordering system
Building		<u></u>	
Ventilating, airing	Conscious use of provi- sions	Alternating use of pro- visions	Incidental, very alter- nating or no use at all
Cleaning vents	Regularly	Occasionally	No cleaning

STEP 3: After estimating the basic quality and expected system loading the most suitable maintenance class can be established by Figure 3

Figure 3: Maintenance classes

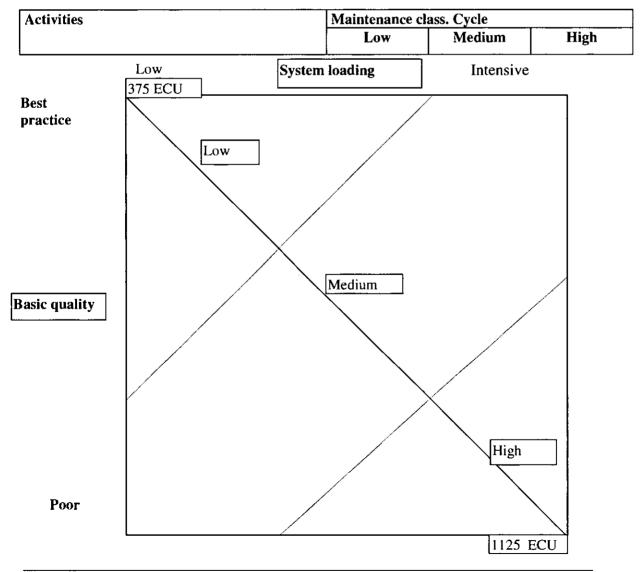
② Type of building:	Single family house			
Type of ventilation syst	em: Mechanical extract, natur	al supply (MEO)		

STEP 4: After estimating the most suitable maintenance class the expected maintenance costs can be estimated by Table 21D and the planned maintenance activities by Table 21E

Table 21D: Expected costs of maintenance expressed as LCC over 30 years (ECU)

Maintenance costs	Planned maintenance	Complaints	Total
Low	300	75	375
Medium	550	150	700
High	900	225	1125

Table 21E: Planned maintenance activities



Installation						
Measuring flow capacity	9	6	• 6			
Cleaning grilles/devices	*	6	6			
• Inspecting ducts	9	9	6			
Cleaning ducts	9	9	6			
• Cleaning extraction fan unit	3	3	3			
Replacing grilles/devices		18	18			
Cleaning kitchen hood	*	6	6			
Replacing kitchen hood		18	15			
Replacing extract fan unit	18	15	12			
Checking control system	9	6	6			
I	Building	l	L			
Cleaning vents/grilles/devices	* *	6	6			
Repairing vents/grilles/devices		12	12			
• Repairing ventilation windows	6	6	6			

activity carried out by residents

STEP 5: Estimate the total LCC by summarising initial from step 1 and maintenance costs from step 4

11. Application

A worked example is provided to illustrate how each tool can be used to compare different ventilation systems.

Often the case to be investigated will not exactly match those covered by the simplified tools. In such circumstances it is necessary to use the values that most closely match the real case.

The date defining the example is given in Table 1 below. This also illustrates the nearest option for each parameter to be used in the simplified tools. For individual tools additional data is used and this is presented with each tool.

Table 22: Case for Investigation – The alternatives for use in the tools that best fit the case under investigation are marked in **Bold**.

Parameter	Present Case		Alterna	tive	
	Tresent Case	1	2	3	4
Dwelling type	2 storey 4 room detached house	De- tached	Apartment ground floor	Apartment top floor	
Location/Climate	Amsterdam, NL	Cold	Moderate	Mild	
Ventilation System	All to be investigated	NWA	PSV	MEO	MSE
Leakage Detached n50 (ach) Apartment	6 for NWA, PSV & MEO. With 3 for MSE]	2.5 (MSE) 2.5	5(other) 5	10
Mechanical exhaust flow rate (l/s)	35 l/s	15	30	45	
Natural supply inlet area (cm²)	70 cm ² /inlet NWA & PSV 20 cm ² /inlet MEO	0 100 0	410 400 100		
Supply flow rate per inlet (l/s) 1/bedroom, 2 in living room. Only MSE	7 l/s per inlet	3 (15 l/s per dwelling)	6 (30 l/s per dwelling)	9 (45 l/s per dwelling	
Outer wall characteristic	Brickwork	Light	Heavy		
Local extra exhaust fans in kitchen and/or hathroom	Kitchen fan No bathroom fan	No	Yes (As given)		
Window airing	Average	No (win- dows closed)	Yes (As given)		
Technical quality of ventilation system	Average	Роог	Average	Best Practice	
Maintenance level	Medium	High	Medium	Low	

12. References

De Gids W and Phaff J (2002), VenSet v1.0 User Manual, TNO, Delft, The Netherlands.

Månsson L-G, Editor (1995), IEA ECBCS Annex 27 Evaluation and Demonstration of Domestic Ventilation Systems - State of the Art, Report A12:1995, Swedish Council for Building Research, Stockholm, Sweden.

Månsson L-G, Editor (2002), IEA ECBCS Annex 27 Handbook: Evaluation and Demonstration of Domestic Ventilation Systems, FaberMaunsell Ltd, St Albans, UK.

The above reports and software may be purchased from:

ECBCS Bookshop C/o FaberMaunsell Ltd 94/96 Newhall Street Birmingham B3 1PB United Kingdom Tel: +44 (0)121 262 1900 Fax: +44 (0)121 262 1994 Email: bookshop@ecbcs.org Web: www.ecbcs.org

The International Energy Agency (IEA) Energy Conservation in Buildings and Community Systems Programme (ECBCS)

The International Energy Agency (IEA) was established as an autonomous body within the Organisation for Economic Co-operation and Development (OECD) in 1974, with the purpose of strengthening co-operation in the vital area of energy policy. As one element of this programme, member countries take part in various energy research, development and demonstration activities. The Energy Conservation in Buildings and Community Systems Programme has sponsored various research annexes associated with energy prediction, monitoring and energy efficiency measures in both new and existing buildings. The results have provided much valuable information about the state of the art of building analysis and have led to further IEA sponsored research.

