International Energy Agency

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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Annex 27 Synthesis Report based on
IEA ECBCS Annex 27 Handbook: Evaluation and Demonstration 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.

Contents

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

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 (✋✋✋ Very Sensitive, ✋✋ Sensitive, ✋ 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.

Table 1: Influence of user on the ventilation systems

Group	Aspect	Ventilation system			
		Natural Window Airing (NWA)	Passive Stack Ventilation (PSV)	Mechanical Exhaust Only (MEO)	Mechanical Supply and Exhaust (MSE)
Behaviour	User influence	✋✋✋	✋✋	✋	✋
	Maintenance	✋	✋	✋	✋
	Furniture and decoration	✋✋✋	✋✋✋	✋✋	✋✋
	User reaction	0	✋	✋	✋✋
Lifestyle	Cooking	✋✋✋	✋✋	✋	✋
	Smoking	✋✋✋	✋✋✋	✋✋	✋✋
	Hygiene	✋✋✋	✋✋✋	✋✋	✋
	Redecoration interval	✋✋	✋✋	✋	✋
	Other equipment installed	✋	✋	0	0
	Pets	✋✋	✋✋	✋	✋
	Pot Plants	✋	✋	0	0
User Characteristics	Involvement	✋✋	✋✋	✋	✋
	Knowledge	✋✋	✋✋	✋	✋
	Physical capability, Operation	✋✋✋	✋✋	✋	0
	Physical capability, maintenance	0	✋✋	✋	✋

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.

- Ventilation system: Natural window airing, Passive stack ventilation, Mechanical central exhaust, Mechanical central supply and exhaust;
- Method of ventilation supply: Background leakage (infiltration), Windows or low-induction natural supply vents, High-induction natural supply vents;
- Outdoor temperature/°C: -15, -10, -5, 0, 5, 10, 15;
- Air supply rate: 4 l/s (15m³/h), 10 l/s (35 m³/h);
- 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 = 35 m³/h (10 l/s)

Type of Inlet (Vent)		Outdoor Temperature (°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 Or Window ajar	Horizontal opening, high position	--	-	-	0	+	+	++
	Vertical opening, middle height	--	--	--	--	--	-	-
	Horizontal opening, low position	--	--	--	--	--	-	-
Background leakage *	N_{50} = 1.5 ach level (relatively high speed infiltration)	--	-	-	-	-	0	0
	N_{50} = 2.6 ach level (relatively low speed infiltration)	--	--	--	-	-	+	++

Table 3: Thermal comfort impact of fresh air supply $Q = 15\ m^3/h$ (4 l/s)

Type of Inlet (Vent)		**Outdoor Temperature (°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 or Window ajar	Horizontal opening, high position	--	-	-	-	+	++	++
	Vertical opening, middle height	--	--	--	--	-	-	-
	Horizontal opening, low position	--	--	--	--	-	-	0
Background leakage *	N_{50} = 1.5 ach level (relatively high speed infiltration)	--	--	-	-	-	0	+
	N_{50} = 2.6 ach level (relatively low speed infiltration)	--	--	--	-	0	++	++

* 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% "- -".

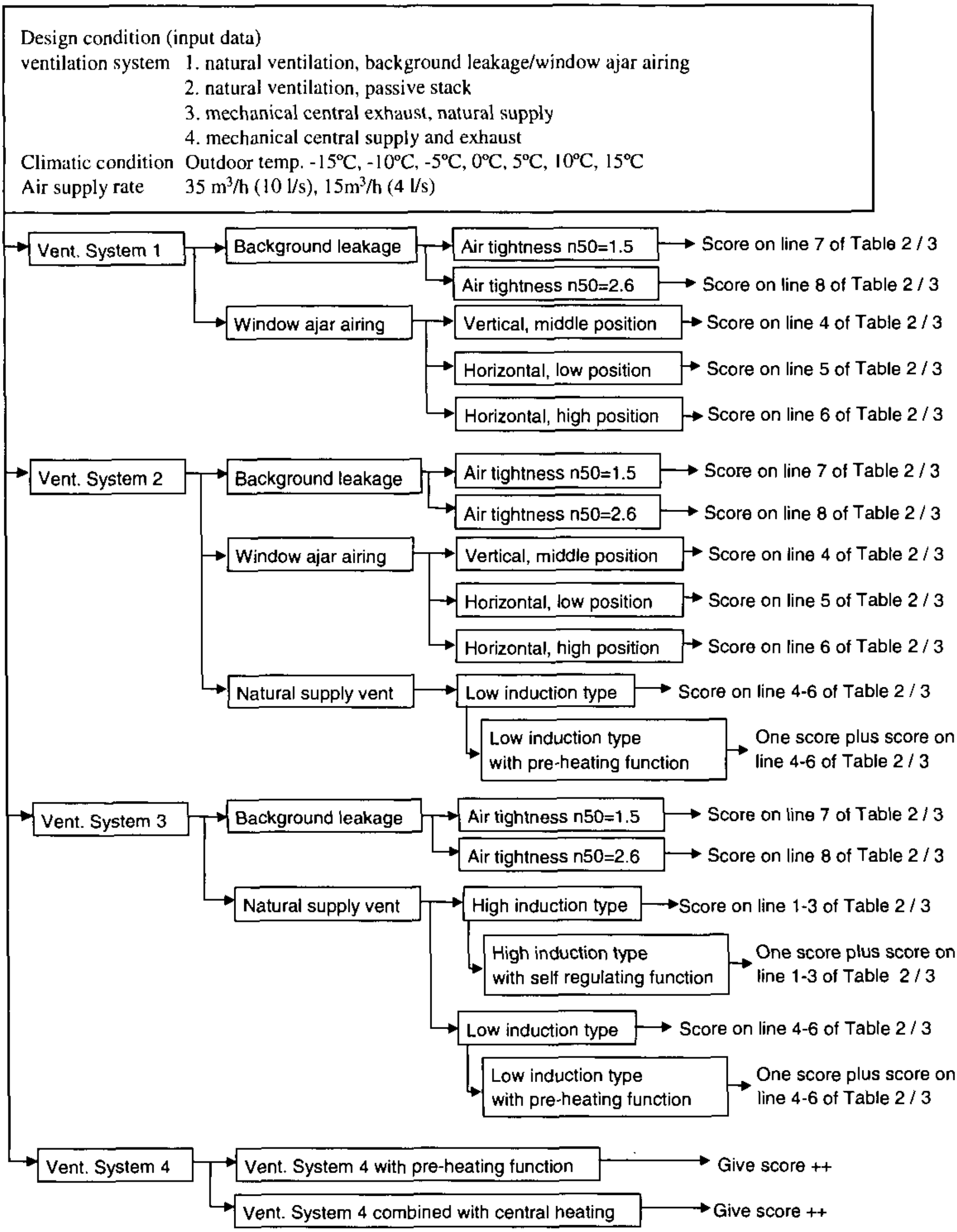


Figure 1: Flow Chart for Thermal Comfort Impact Evaluation of Outdoor Air Supply

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 m^2);
- 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 cm^2);
- 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

Ventilation system		$G_{a,c}$ = 20 dB(A)														
		Percentage of inferior soundproofing constructions in the facade exposed to traffic noise [%]														
		0					< 50					> 50				
		A net [cm^2]					A net [cm^2]					A net [cm^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
Natural supply	Ventilation opening without soundproofing: R_a = -5 dB(A)	++	++	o	o	o	++	++	o	o	o	++	++	+	o	o
	Soundproofed ventilation opening: R_a = 0 dB(A)	++	++	++	++	o	++	++	+	+	+	++	++	++	+	0
	Soundproofed ventilation opening: R_a = 10 dB(A)	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++
	Soundproofed ventilation opening: R_a = 15 dB(A)	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++
Mechanical supply and exhaust		++	++	++	++	++	++	++	++	++	++	++	++	++	++	++

Ventilation system		$G_{a,c}$ = 25 dB(A)														
		Percentage of inferior soundproofing constructions in the facade exposed to traffic noise [%]														
		0					< 50					> 50				
		A net [cm^2]					A net [cm^2]					A net [cm^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
Natural supply	Ventilation opening without soundproofing: R_a = -5 dB(A)	+	o	o	o	o	o	o	o	o	o	o	o	o	o	o
	Soundproofed ventilation opening: R_a = 0 dB(A)	++	++	+	o	o	++	+	o	o	o	++	+	o	o	o
	Soundproofed ventilation opening: R_a = 10 dB(A)	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++
	Soundproofed ventilation opening: R_a = 15 dB(A)	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++
Mechanical supply and exhaust		++	++	++	++	++	++	++	++	++	++	++	++	++	++	++

Ventilation system		$G_{a,c}$ = 30 dB(A)														
		Percentage of inferior soundproofing constructions in the facade exposed to traffic noise [%]														
		0					< 50					≥ 50				
		A net [cm^2]					A net [cm^2]					A net [cm^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
Natural supply	Ventilation opening without soundproofing: R_a = -5 dB(A)	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
	Soundproofed ventilation opening: R_a = 0 dB(A)	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
	Soundproofed ventilation opening: R_a = 10 dB(A)	++	++	++	+	o	+	+	+	0	o	+	o	o	o	o
	Soundproofed ventilation opening: R_a = 15 dB(A)	++	++	++	++	++	+	+	+	0	o	+	+	0	o	o
Mechanical supply and exhaust		++	++	++	++	++	+	+	+	+	+	+	+	+	+	+

Ventilation system		$G_{a,c}$ = 35 dB(A)														
		Percentage of inferior soundproofing constructions in the facade exposed to traffic noise [%]														
		0					< 50					> 50				
		A net [cm^2]					A net [cm^2]					A net [cm^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
Natural supply	Ventilation opening without soundproofing: R_a = -5 dB(A)	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
	Soundproofed ventilation opening: R_a = 0 dB(A)	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
	Soundproofed ventilation opening: R_a = 10 dB(A)	++	o	o	o	o	0	o	o	o	o	o	o	o	o	o
	Soundproofed ventilation opening: R_a = 15 dB(A)	++	++	++	o	o	0	0	0	o	o	o	o	o	o	o
Mechanical supply and exhaust		++	++	++	++	++	0	0	0	0	0	0	0	0	0	0

Table 5: Applicability of Ventilation System With External Noise and Façade Area 10 m² to 15m²

S_{facade} = 10 - 15 m²

Ventilation system		$G_{a,c}$ = 20 dB(A)														
		Percentage of inferior soundproofing constructions in the facade exposed to traffic noise [%]														
		0					< 50					> 50				
		A net [cm²]					A net [cm²]					A net [cm²]				
		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
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 opening: R_a = 15 dB(A)	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++
Mechanical supply and exhaust		++	++	++	++	++	++	++	++	++	++	++	++	++	++	++

Ventilation system		$G_{a,c}$ = 25 dB(A)														
		Percentage of inferior soundproofing constructions in the facade exposed to traffic noise [%]														
		0					< 50					> 50				
		A net [cm²]					A net [cm²]					A net [cm²]				
		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
Natural supply	Ventilation opening without soundproofing: R_a = -5 dB(A)	++	-	-	-	-	+	-	-	-	-	+	-	-	-	-
	Soundproofed ventilation opening: R_a = 0 dB(A)	++	++	++	-	-	++	++	0	-	-	++	+	0	-	-
	Soundproofed ventilation opening: R_a = 10 dB(A)	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++
	Soundproofed ventilation opening: R_a = 15 dB(A)	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++
Mechanical supply and exhaust		++	++	++	++	++	++	++	++	++	++	++	++	++	++	++

Ventilation system		$G_{a,c}$ = 30 dB(A)														
		Percentage of inferior soundproofing constructions in the facade exposed to traffic noise [%]														
		0					< 50					> 50				
		A net [cm²]					A net [cm²]					A net [cm²]				
		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
Natural supply	Ventilation opening without soundproofing: R_a = -5 dB(A)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Soundproofed ventilation opening: R_a = 0 dB(A)	0	-	-	-	-	0	-	-	-	-	-	-	-	-	-
	Soundproofed ventilation opening: R_a = 10 dB(A)	++	++	++	++	++	+	+	+	+	0	+	0	0	0	-
	Soundproofed ventilation opening: R_a = 15 dB(A)	++	++	++	++	++	+	+	+	+	0	+	+	+	0	0
Mechanical supply and exhaust		++	++	++	++	++	+	+	+	+	+	+	+	+	+	+

Ventilation system		$G_{a,c}$ = 35 dB(A)														
		Percentage of inferior soundproofing constructions in the facade exposed to traffic noise [%]														
		0					< 50					≥ 50				
		A net [cm²]					A net [cm²]					A net [cm²]				
		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
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)	++	++	-	-	-	0	-	-	-	-	-	-	-	-	-
	Soundproofed ventilation opening: R_a = 15 dB(A)	++	++	++	++	++	0	0	0	-	-	0	-	-	-	-
Mechanical supply and exhaust		++	++	++	++	++	0	0	0	0	0	0	0	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 m^2

Ventilation system		$G_{a,c}$ = 20 dB(A)														
		Percentage of inferior soundproofing constructions in the facade exposed to traffic noise [%]														
		0					< 50					> 50				
		A net [cm^2]					A net [cm^2]					A net [cm^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
Natural supply	Ventilation opening without soundproofing: R_a = -5 dB(A)	++	++	++	++	o	++	++	+	+	o	++	++	++	0	o
	Soundproofed ventilation opening: R_a = 0 dB(A)	++	++	++	++	++	++	++	++	++	+	++	++	++	++	++
	Soundproofed ventilation opening: R_a = 10 dB(A)	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++
	Soundproofed ventilation opening: R_a = 15 dB(A)	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++
Mechanical supply and exhaust		++	++	++	++	++	++	++	++	++	++	++	++	++	++	++

Ventilation system		$G_{a,c}$ = 25 dB(A)														
		Percentage of inferior soundproofing constructions in the facade exposed to traffic noise [%]														
		0					< 50					> 50				
		A net [cm^2]					A net [cm^2]					A net [cm^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
Natural supply	Ventilation opening without soundproofing: R_a = -5 dB(A)	++	++	o	o	o	++	o	o	o	o	++	0	o	o	o
	Soundproofed ventilation opening: R_a = 0 dB(A)	++	++	++	++	o	++	++	+	0	o	++	++	+	0	o
	Soundproofed ventilation opening: R_a = 10 dB(A)	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++
	Soundproofed ventilation opening: R_a = 15 dB(A)	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++
Mechanical supply and exhaust		++	++	++	++	++	++	++	++	++	++	++	++	++	++	++

Ventilation system		$G_{a,c}$ = 30 dB(A)														
		Percentage of inferior soundproofing constructions in the facade exposed to traffic noise [%]														
		0					< 50					> 50				
		A net [cm^2]					A net [cm^2]					A net [cm^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
Natural supply	Ventilation opening without soundproofing: R_a = -5 dB(A)	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
	Soundproofed ventilation opening: R_a = 0 dB(A)	++	++	o	o	o	+	o	o	o	o	0	o	o	o	o
	Soundproofed ventilation opening: R_a = 10 dB(A)	++	++	++	++	++	+	+	+	+	+	+	+	+	0	o
	Soundproofed ventilation opening: R_a = 15 dB(A)	++	++	++	++	++	+	+	+	+	+	+	+	+	+	0
Mechanical supply and exhaust		++	++	++	++	++	+	+	+	+	+	+	+	+	+	+

Ventilation system		$G_{a,c}$ = 35 dB(A)														
		Percentage of inferior soundproofing constructions in the facade exposed to traffic noise [%]														
		0					< 50					> 50				
		A net [cm^2]					A net [cm^2]					A net [cm^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
Natural supply	Ventilation opening without soundproofing: R_a = -5 dB(A)	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
	Soundproofed ventilation opening: R_a = 0 dB(A)	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
	Soundproofed ventilation opening: R_a = 10 dB(A)	++	++	o	o	o	0	0	o	o	o	o	o	o	o	o
	Soundproofed ventilation opening: R_a = 15 dB(A)	++	++	++	++	++	0	0	0	0	o	0	0	o	o	o
Mechanical 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 ⇒	< 5 meter			≥ 5 meter		
Number of branches ⇒	0	1	2	0	1	2
No silencer	--	--	--	--	--	--
Silencer 1000 mm	-	0	0	0	0	0
Silencer 1000 mm and cross-talk absorber 500 mm	0	+	+	0	+	++

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

L_w = 65 dB(A)

Duct length ⇒	< 5 meter			≥ 5 meter		
Number of branches ⇒	0	1	2	0	1	2
No silencer	--	--	-	--	-	-
Silencer 1000 mm	+	++	++	+	+	++
Silencer 1000 mm and cross-talk absorber 500 mm	++	++	++	++	++	++

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

L_w = 60 dB(A)

Duct length ⇒	Not applicable		
Number of branches ⇒	0	1	2
No silencer	--	--	--
Silencer 1000 mm	0	0	+
Silencer 1000 mm and cross-talk absorber 500 mm	+	++	++

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

Duct length ⇒	Not applicable		
Number of branches ⇒	0	1	2
No silencer	-	-	0
Silencer 1000 mm	++	++	++
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*

Table 11: Building aspects. Ductwork and flow influence

System	**Inner Elements**		**Envelope**	
Window Airing	Wall	**0**	Wall	**0**
	Slab	**0**		
	Corridor	**0**	Window	✋✋✋
	Doors	✋✋	Roof	**0**
Passive Stack	Wall	✋	Wall	✋
	Slab	✋		
	Corridor	**0**	Window	✋
	Doors	✋✋	Roof	✋✋✋
Mechanical exhaust only	Wall	✋	Wall	✋
	Slab	✋		
	Corridor	**0**	Window	✋
	Doors	✋	Roof	✋
Mechanical supply and exhaust	Wall	✋✋	Wall	✋
	Slab	✋✋		
	Corridor	✋	Window	**0**
	Doors	✋	Roof	✋

Table 12: Building aspects, architectural, building service

System	**Architectural**						**Building services**		
	Spatial		Replacement		Building		Elect-ricity	Plumb-ing	Control system
	Opera-tion	Mainten-ance	Same system	Other system	Lay out	External appearance			
Window Airing, NWA	0	0	0	✋✋✋	0	0	0	0	0
Passive Stack, PSV	0	✋	✋✋	✋✋	✋✋✋	✋✋	✋	✋✋✋	0
Mechanical exhaust only, MEO	✋	✋	✋	✋	✋	✋	✋	✋	✋
Mechanical supply and exhaust, MSE	✋✋	✋✋	✋	✋	✋✋	✋	✋	✋✋	✋

Table 13: Buildingaspects, at building site and usage

Systems	Construction – at site				Building in use		Others	
	Con-struction	Bldg services	Decora-tion	Commis-sioning	Mainte-nance	Fire	Building Age	Furnish-ing
Window airing	0	0	0	✋	0	0	✋✋	✋✋
Stack	✋✋	✋	✋	✋✋	✋	✋	✋✋✋	✋
Mechanical exhaust	✋	✋	✋	✋	✋	✋	✋	✋
Mechanical supply and exhaust	✋✋	✋✋	✋✋	✋	✋	✋	✋	✋

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 cm^2*
- *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

Indoor air quality

		nat. wind. airing								p. stack				mechanical exhaust												balanced					
	airing ->	no				yes				no																					
	supply ->	0		410		0		410		0		400		0						100											
	flow rate ->													15		30		45		15		30		45		15		30		45	
	add fan ->	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
dwelling	n 50																														
D4a	1	--	--	o	+	--	--	o	+	--	-	+	++	-	-	+	-	+	o	o	o	+	+	+	++	o	o	+	++	+	++
	2.5	-	-	o	++	-	-	o	++	-	o	+	++	o	-	+	o	+	+	o	o	+	+	+	++	+	+	+	++	+	++
top	5	-	o	o	++	-	o	o	++	+	+	+	++	o	+	+	+	+	++	+	++	+	++	+	++	+	++	+	++	+	++
D4a	1	--	--	o	+	--	--	o	+	-	-	+	++	-	-	+	-	+	o	o	o	+	+	+	+	o	o	+	++	+	++
	2.5	-	-	o	+	-	-	o	+	o	o	+	++	o	-	+	o	+	+	o	o	+	+	+	++	o	+	+	++	+	++
ground	5	-	o	o	++	-	o	o	++	+	+	+	++	o	+	+	+	+	++	+	+	+	++	+	++	+	++	+	++	+	++
D4c	1	--	--	o	o	--	--	o	o	--	--	+	++	-	-	o	-	+	-	o	-	+	o	+	+	o	o	+	++	+	++
	2.5	--	-	o	+	--	-	o	+	-	-	+	++	-	-	o	o	+	o	o	o	+	+	+	+	o	o	+	++	++	++
	5	-	-	+	+	-	-	+	+	o	o	+	++	o	o	+	+	+	+	o	o	+	+	+	++	+	+	+	++	++	++
	10 case a	o	+	+	++	o	+	+	++	+	++	++	++	+	+	+	+	+	++	+	+	+	++	+	++	+	++	+	++	++	++
	10 case b	-	-	+	++	-	-	+	++	o	o	++	++	o	o	o	o	o	o	o	o	+	+	+	+	+	+	+	++	++	++

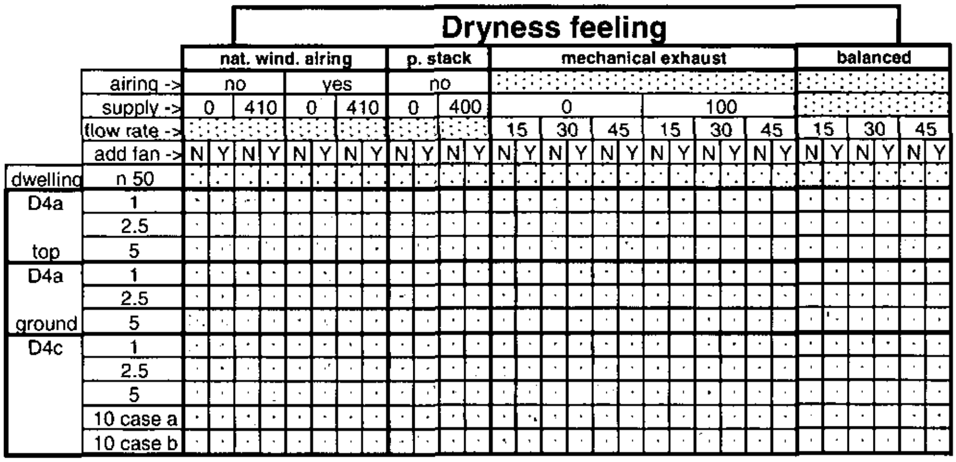
Condensation

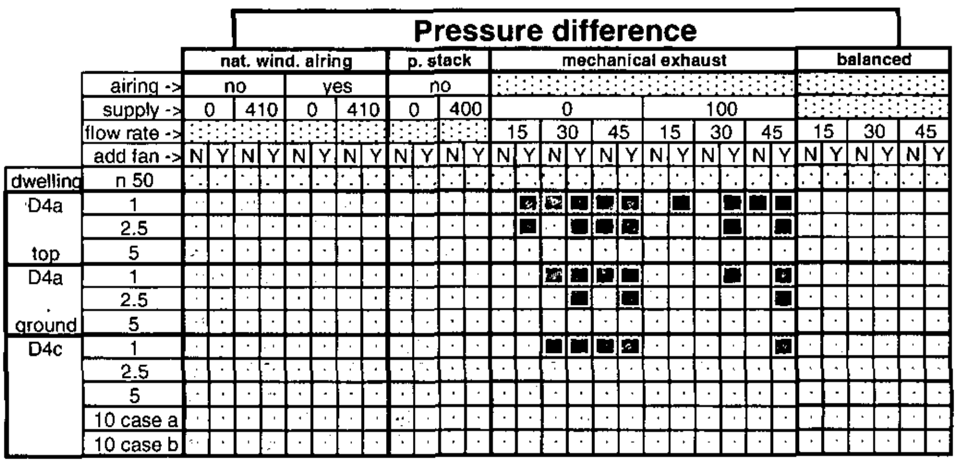
		nat. wind. airing								p. stack				mechanical exhaust												balanced					
	airing ->	no				yes				no																					
	supply ->	0		410		0		410		0		400		0						100											
	flow rate ->													15		30		45		15		30		45		15		30		45	
	add fan ->	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
dwelling	n 50																														
D4a	1	--	-	--	++	--	-	--	++	-	-	o	++	-	+	o	++	+	++	-	++	o	++	+	++	-	++	o	++	+	++
	2.5	--	+	--	++	--	+	--	++	-	++	o	++	-	++	o	++	+	++	-	++	o	++	+	++	-	++	o	++	+	++
top	5	--	++	-	++	--	++	-	++	-	++	o	++	-	++	o	++	+	++	-	++	o	++	+	++	-	++	o	++	+	++
D4a	1	--	-	--	++	--	-	--	++	-	-	o	++	-	+	o	++	+	++	-	++	o	++	+	++	-	++	o	++	+	++
	2.5	--	+	--	++	--	+	--	++	-	++	o	++	-	++	o	++	+	++	-	++	o	++	+	++	-	++	o	++	+	++
ground	5	--	++	--	++	--	++	--	++	o	++	+	++	-	++	o	++	+	++	-	++	o	++	+	++	-	++	o	++	+	++
D4c	1	--	--	-	++	--	--	-	++	-	-	+	++	-	o	o	++	+	++	-	++	o	++	+	++	-	++	o	++	+	++
	2.5	--	+	-	++	--	++	-	++	o	++	+	++	-	++	o	++	+	++	-	++	o	++	+	++	o	++	+	++	++	++
	5	--	++	o	++	--	++	o	++	+	++	+	++	o	++	o	++	+	++	o	++	+	++	++	++	o	++	+	++	++	++
	10 case a	-	++	o	++	-	++	o	++	+	++	++	++	o	++	+	++	++	++	o	++	+	++	++	++	+	++	++	++	++	++
	10 case b	--	++	-	++	--	++	-	++	+	++	++	++	o	++	+	++	++	++	o	++	+	++	++	++	o	++	+	++	++	++

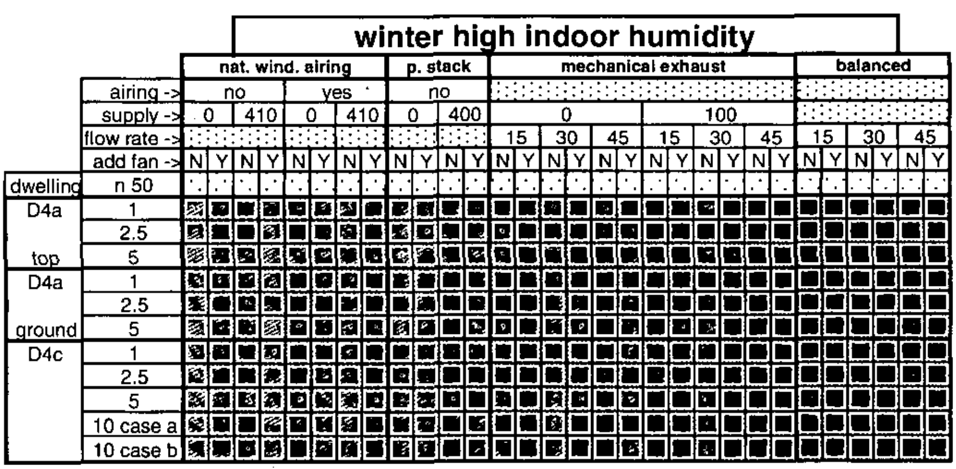
Heat needs

		nat. wind. airing								p. stack				mechanical exhaust												balanced					
	airing ->	no				yes				no																					
	supply ->	0		410		0		410		0		400		0						100											
	flow rate ->													15		30		45		15		30		45		15		30		45	
	add fan ->	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
dwelling	n 50																														
D4a	1	++	++	+	o	++	++	+	o	++	+	o	-	++	++	+	o	-	-	++	+	+	o	-	-	++	++	++	++	++	+
	2.5	++	++	+	o	++	++	o	o	+	o	-	--	++	+	+	o	-	-	++	+	+	o	-	-	++	++	++	+	+	+
top	5	++	+	o	-	++	+	-	-	o	o	--	--	+	+	o	o	-	-	+	o	o	-	-	--	++	+	+	o	+	o
D4a	1	++	++	+	+	++	++	+	o	++	+	-	--	++	++	+	o	-	-	++	+	+	o	-	-	++	++	++	++	++	+
	2.5	++	++	+	o	++	++	o	o	+	o	--	--	++	+	+	o	-	-	++	+	+	o	-	-	++	++	++	+	+	+
ground	5	++	+	o	-	++	+	-	-	-	-	--	--	+	+	o	o	-	-	+	o	o	-	-	--	++	+	+	o	+	o
D4c	1	++	++	+	+	++	++	+	o	++	+	-	-	++	++	+	o	o	-	++	+	+	o	o	-	++	++	++	++	++	+
	2.5	++	++	+	o	++	++	+	o	+	o	-	--	++	+	+	o	o	-	++	+	+	o	o	-	++	++	++	+	+	+
	5	++	++	o	o	++	+	o	-	o	o	--	--	++	+	+	o	o	-	+	o	o	o	-	-	++	+	+	+	+	o
	10 case a	+	o	-	--	o	o	--	--	-	--	--	--	o	-	-	-	-	--	o	-	-	--	--	--	o	o	o	-	-	-
	10 case b	+	+	-	-	+	o	-	--	-	--	--	--	+	o	o	-	-	--	o	o	-	-	-	--	+	o	o	o	o	-

climate : NICE







climate : LONDON

Indoor air quality

		nat. wind. airing								p. stack				mechanical exhaust												balanced					
	airing ->	no				yes				no																					
	supply ->	0		410		0		410		0		400		0						100											
	flow rate ->													15		30		45		15		30		45		15		30		45	
	add fan ->	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
dwelling	n 50																														
D4a	1	--	--	-	-	--	--	-	-	--	--	-	-	-	--	o	-	+	o	-	-	o	o	+	+	-	-	o	+	+	++
	2.5	--	--	-	-	--	--	-	-	--	--	-	o	-	--	o	-	+	o	-	-	o	o	+	+	-	o	o	+	+	++
top	5	--	-	-	o	--	-	-	o	-	-	o	o	-	-	o	o	+	+	-	-	o	o	+	+	o	o	o	+	+	++
D4a	1	--	--	-	-	--	--	-	-	--	--	o	o	-	--	o	-	+	o	-	-	o	o	+	+	-	-	o	+	+	++
	2.5	--	--	-	-	--	--	-	-	-	-	o	+	-	--	o	-	+	o	-	-	o	o	+	+	-	o	o	+	+	++
ground	5	--	-	-	o	--	-	-	o	o	o	+	+	-	-	o	o	+	+	-	-	o	o	+	+	o	o	o	+	+	++
D4c	1	--	--	-	o	--	--	-	o	--	--	o	o	--	--	o	-	+	-	-	--	o	-	+	o	-	-	o	+	+	++
	2.5	--	--	-	o	--	--	-	o	--	--	o	+	--	--	o	-	+	o	-	-	o	-	+	o	-	-	o	+	+	++
	5	--	--	o	o	--	-	o	o	-	-	o	+	--	-	-	-	+	o	-	-	-	-	+	o	o	o	o	+	+	++
	10 case a	o	o	o	+	o	o	o	+	o	o	+	++	o	o	-	-	-	-	o	+	o	o	o	o	o	+	o	++	+	++
	10 case b	-	-	o	o	-	-	o	o	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	o	o	+	+	+	++

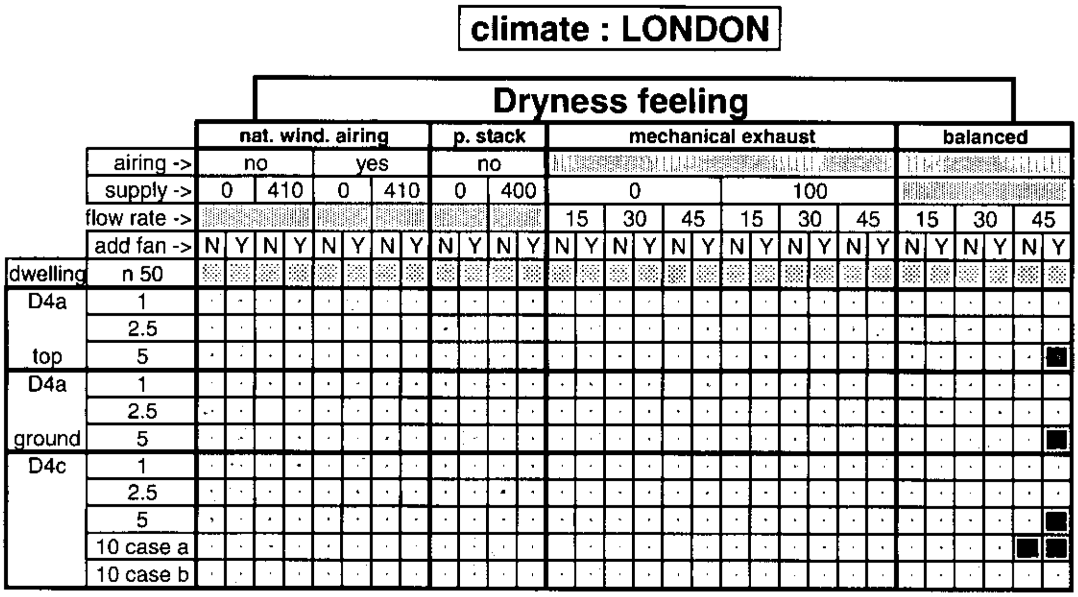
Condensation

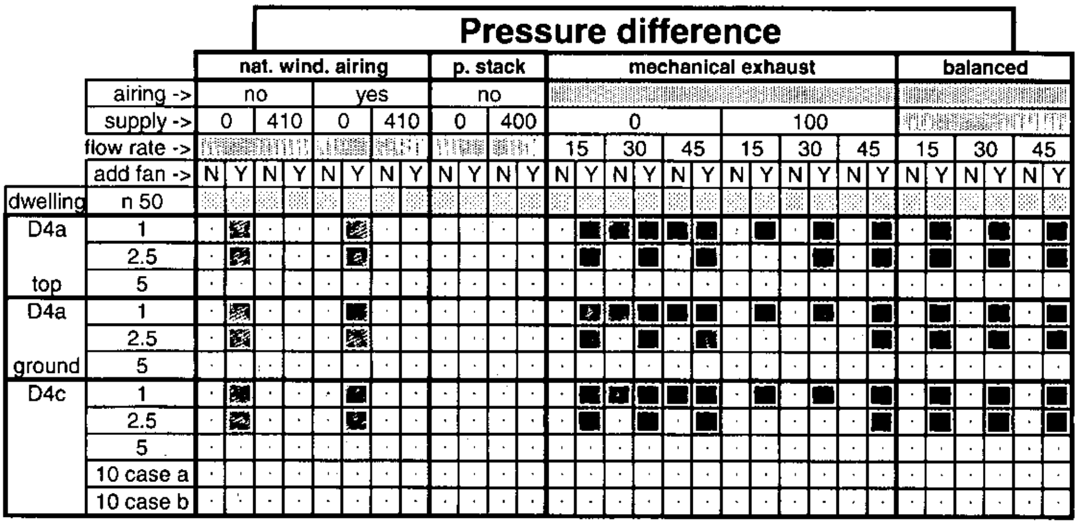
		nat. wind. airing								p. stack				mechanical exhaust												balanced					
	airing ->	no				yes				no																					
	supply ->	0		410		0		410		0		400		0						100											
	flow rate ->													15		30		45		15		30		45		15		30		45	
	add fan ->	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
dwelling	n 50																														
D4a	1	--	--	--	-	--	--	--	-	--	--	-	++	--	-	-	++	o	++	--	+	-	++	o	++	--	++	-	++	o	++
	2.5	--	--	--	o	--	--	--	o	--	-	-	++	--	+	-	++	o	++	--	++	-	++	o	++	--	++	-	++	o	++
top	5	--	-	--	+	--	-	--	+	-	++	-	++	--	+	-	++	o	++	--	++	-	++	o	++	--	++	-	++	o	++
D4a	1	--	--	--	-	--	--	--	-	--	--	-	++	--	-	-	++	o	++	--	+	-	++	o	++	--	++	-	++	o	++
	2.5	--	--	--	o	--	--	--	o	-	+	o	++	--	+	-	++	o	++	--	+	-	++	o	++	--	++	-	++	o	++
ground	5	--	-	--	+	--	-	--	+	-	++	o	++	--	+	-	++	o	++	--	++	-	++	o	++	--	++	-	++	o	++
D4c	1	--	--	--	++	--	--	--	++	--	--	o	++	-	-	o	++	+	++	-	o	o	++	+	++	-	++	o	++	+	++
	2.5	--	--	--	++	--	-	--	++	--	--	o	++	-	-	o	++	+	++	-	o	o	++	+	++	-	++	o	++	+	++
	5	--	o	--	++	--	+	--	++	o	+	o	++	-	o	o	++	+	++	-	++	o	++	+	++	-	++	o	++	+	++
	10 case a	-	++	-	++	-	++	-	++	+	++	+	++	-	++	o	++	+	++	-	++	o	++	+	++	o	++	+	++	++	++
	10 case b	--	o	-	++	--	o	-	++	o	+	+	++	-	+	-	o	+	+	-	++	o	++	+	++	-	++	o	++	+	++

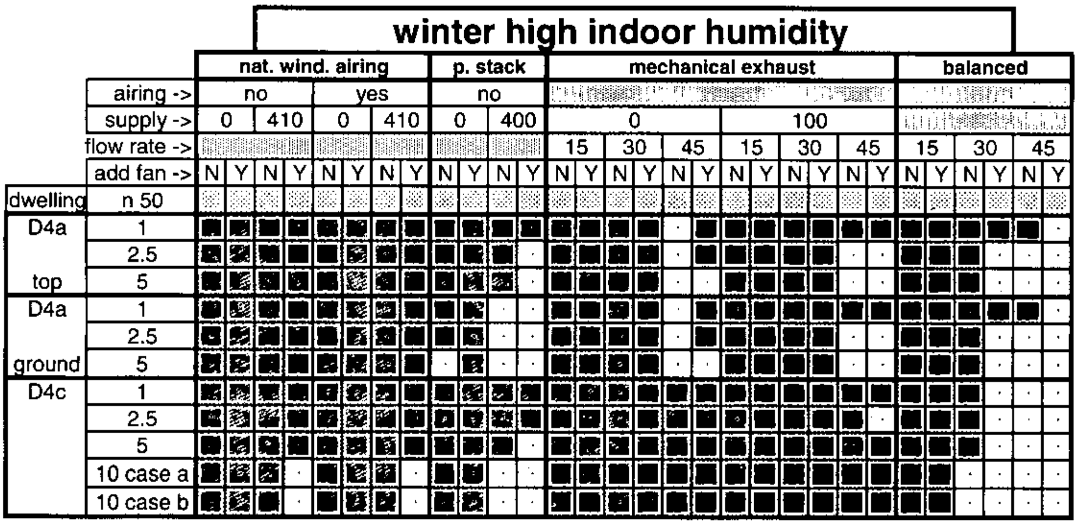
Heat needs

		nat. wind. airing								p. stack				mechanical exhaust												balanced					
	airing ->	no				yes				no																					
	supply ->	0		410		0		410		0		400		0						100											
	flow rate ->													15		30		45		15		30		45		15		30		45	
	add fan ->	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
dwelling	n 50																														
D4a	1	++	++	++	++	++	++	++	+	++	++	+	o	++	++	+	o	-	-	++	++	+	o	-	-	++	++	++	++	++	+
	2.5	++	++	++	++	++	++	++	+	++	+	+	o	++	++	+	o	-	-	++	+	+	o	-	-	++	++	++	++	++	+
top	5	++	++	++	+	++	++	+	+	+	+	o	o	++	+	+	o	-	-	++	+	+	o	-	-	++	++	++	+	+	+
D4a	1	++	++	++	++	++	++	++	+	++	+	-	-	++	++	+	o	-	-	++	++	+	o	-	-	++	++	++	++	++	+
	2.5	++	++	++	++	++	++	++	+	+	o	-	--	++	++	+	o	-	-	++	+	+	o	-	-	++	++	++	++	++	+
ground	5	++	++	++	+	++	++	+	+	o	-	--	--	++	+	+	o	-	-	++	+	+	o	-	-	++	++	++	+	+	+
D4c	1	++	++	++	+	++	++	+	+	++	+	o	o	++	++	+	o	o	-	++	++	+	o	o	-	++	++	++	++	++	+
	2.5	++	++	++	+	++	++	+	o	++	+	o	o	++	++	+	o	o	-	++	+	+	o	o	-	++	++	++	+	++	+
	5	++	++	+	+	++	+	+	o	+	+	o	-	++	+	+	o	o	-	++	+	+	o	o	-	++	++	++	+	+	+
	10 case a	+	+	o	-	+	o	-	-	o	-	--	--	+	o	o	-	-	--	o	o	o	-	-	--	+	o	o	o	o	-
	10 case b	++	+	o	-	+	o	-	-	o	-	--	--	+	o	o	-	-	-	+	o	o	-	-	--	+	+	+	o	o	o

Table 15: Indoor Air Quality for Ventilation Systems in London







climate : OTTAWA

Indoor air quality

		nat. wind. airing								p. stack				mechanical exhaust												balanced					
	airing ->	no				yes				no																					
	supply ->	0		410		0		410		0		400		0						100											
	flow rate ->													15		30		45		15		30		45		15		30		45	
	add fan ->	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
dwelling	n 50																														
D4a	1	--	--	-	o	--	--	-	o	--	--	o	o	-	--	o	-	+	o	-	-	o	o	+	+	-	-	o	+	+	++
	2.5	--	-	-	o	--	-	-	o	-	-	o	+	-	-	o	-	+	o	-	-	o	o	+	+	o	o	o	+	+	++
top	5	-	-	-	+	-	-	-	+	o	o	o	++	o	o	o	o	+	+	o	o	o	+	+	+	o	+	o	++	+	++
D4a	1	--	--	-	o	--	--	-	o	--	--	o	+	-	--	o	-	+	o	-	-	o	o	+	+	-	-	o	+	+	++
	2.5	--	-	-	o	--	-	-	o	-	-	+	++	-	-	o	-	+	o	-	-	o	o	+	+	o	o	o	+	+	++
ground	5	-	-	-	+	-	-	-	+	+	+	+	++	o	o	o	o	+	+	o	o	o	+	+	+	o	+	o	++	+	++
D4c	1	--	--	o	o	--	--	o	o	--	--	+	+	-	--	o	--	+	-	-	-	o	-	+	o	-	-	o	+	+	++
	2.5	--	--	o	+	--	--	o	+	-	-	+	++	-	-	o	-	+	o	-	-	o	-	+	o	o	o	o	+	+	++
	5	-	-	o	+	-	-	o	+	-	-	+	++	-	-	o	-	+	o	o	o	o	o	+	o	o	o	+	++	+	++
	10 case a	o	+	+	++	o	+	+	++	+	+	+	++	o	+	+	+	+	+	+	++	+	++	+	+	+	++	+	++	+	++
	10 case b	-	-	+	+	-	-	+	+	-	-	+	++	-	-	-	-	-	-	o	o	o	o	o	o	o	o	+	++	+	++

Condensation

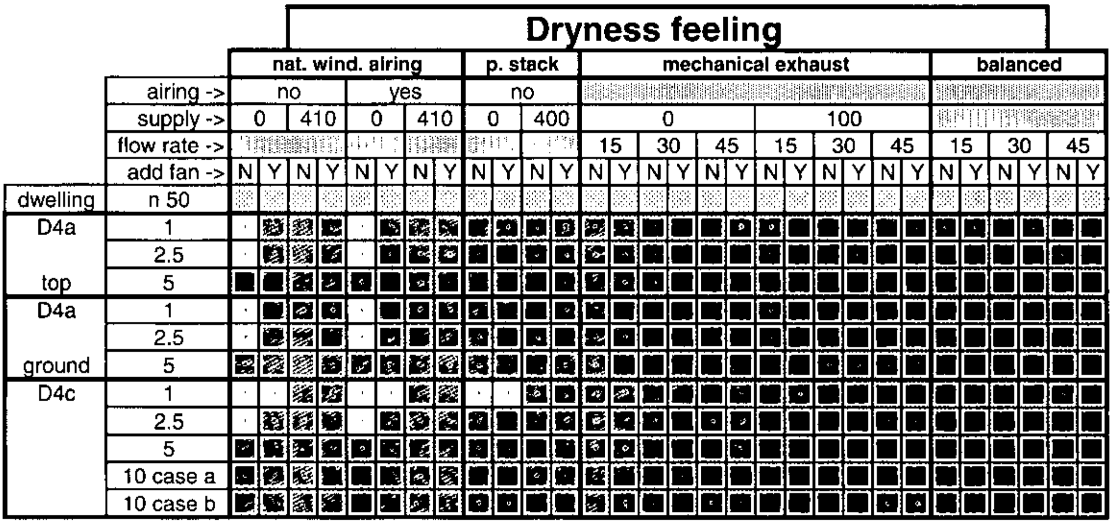
		nat. wind. airing								p. stack				mechanical exhaust												balanced					
	airing ->	no				yes				no																					
	supply ->	0		410		0		410		0		400		0						100											
	flow rate ->													15		30		45		15		30		45		15		30		45	
	add fan ->	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
dwelling	n 50																														
D4a	1	--	--	--	++	--	--	--	++	--	--	o	++	-	-	o	++	+	++	-	++	o	++	+	++	-	++	o	++	+	++
	2.5	--	o	--	++	--	o	--	++	-	+	o	++	-	++	o	++	+	++	-	++	o	++	+	++	-	++	o	++	+	++
top	5	--	+	--	++	--	++	--	++	o	++	o	++	-	++	o	++	+	++	-	++	o	++	+	++	-	++	o	++	+	++
D4a	1	--	--	--	++	--	--	--	++	-	-	+	++	-	-	o	++	+	++	-	++	o	++	+	++	-	++	o	++	+	++
	2.5	--	-	--	++	--	o	--	++	o	++	+	++	-	+	o	++	+	++	-	++	o	++	+	++	-	++	o	++	+	++
ground	5	--	+	--	++	--	+	--	++	o	++	+	++	-	++	o	++	+	++	-	++	o	++	+	++	-	++	o	++	+	++
D4c	1	--	--	-	++	--	--	-	++	--	--	++	++	-	-	o	++	++	++	-	o	o	++	++	++	-	++	o	++	++	++
	2.5	--	-	-	++	--	o	-	++	o	o	++	++	-	o	o	++	++	++	-	++	o	++	++	++	o	++	+	++	++	++
	5	-	+	o	++	-	++	o	++	++	++	++	++	o	+	+	++	++	++	o	++	+	++	++	++	o	++	+	++	++	++
	10 case a	o	++	+	++	o	++	+	++	++	++	++	++	+	++	++	++	++	++	+	++	++	++	++	++	+	++	++	++	++	++
	10 case b	-	++	o	++	-	++	o	++	++	++	++	++	o	++	+	++	++	++	o	++	+	++	++	++	o	++	+	++	++	++

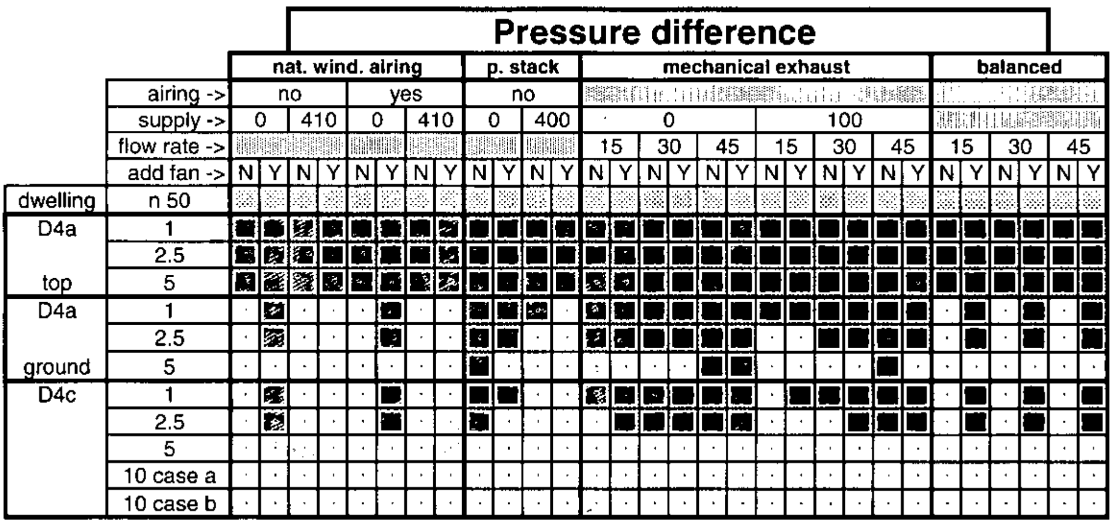
Heat needs

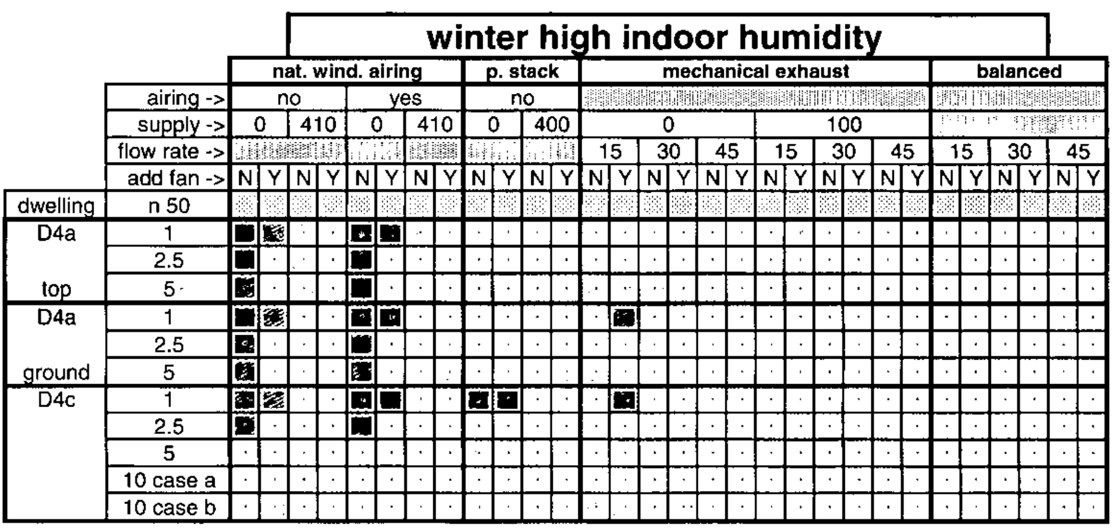
		nat. wind. airing								p. stack				mechanical exhaust												balanced					
	airing ->	no				yes				no																					
	supply ->	0		410		0		410		0		400		0						100											
	flow rate ->													15		30		45		15		30		45		15		30		45	
	add fan ->	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
dwelling	n 50																														
D4a	1	++	++	+	o	++	++	+	o	++	+	-	--	++	+	+	o	-	-	++	+	+	o	-	-	++	++	++	+	++	+
	2.5	++	++	+	o	++	++	+	o	+	o	-	--	++	+	+	o	-	-	++	+	+	o	-	-	++	+	++	+	+	o
top	5	++	+	o	-	++	+	o	-	o	-	--	--	+	o	o	o	-	--	+	o	o	-	-	--	++	+	+	o	o	o
D4a	1	++	++	+	o	++	++	+	o	+	-	--	--	++	+	+	o	-	-	++	+	+	o	-	-	++	++	++	+	++	+
	2.5	++	++	+	o	++	++	+	o	o	--	--	--	++	+	+	o	-	-	++	+	+	o	-	-	++	+	++	+	+	o
ground	5	++	+	o	-	++	+	o	-	--	--	--	--	+	+	o	o	-	-	+	o	o	-	-	--	++	+	+	o	+	o
D4c	1	++	++	+	o	++	++	+	o	+	o	-	--	++	++	+	o	o	-	++	+	+	o	o	-	++	++	++	+	++	+
	2.5	++	++	o	o	++	++	o	-	+	o	--	--	++	+	+	o	o	-	+	+	+	o	-	-	++	+	++	+	+	o
	5	++	+	o	-	++	+	-	-	-	-	--	--	+	o	o	-	-	-	+	o	o	-	-	--	+	+	+	o	o	o
	10 case a	-	-	--	--	-	--	--	--	--	--	--	--	-	--	--	--	--	--	--	--	--	--	--	--	-	--	--	--	--	--
	10 case b	o	-	--	--	o	-	--	--	--	--	--	--	o	-	-	--	--	--	-	--	--	--	--	--	o	-	-	--	-	--

Table 16: Indoor Air Quality for Ventilation Systems in Ottawa

climate : OTTAWA







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.

Table 17: Reliability flow rate stability. Climate ***Nice***

System	Airing	Inlet	Exhaust	Extra	8.2.1.1 Dwelling					
		area	fan flow	fan	Apartment				House	
		(cm^2)	rate		D4a top		D4a ground		D4c	
			(l/s)		n50 (ach)		n50 (ach)		n50 (ach)	
					1	5	1	5	2.5	10
NWA	No	0		N	- -	-	- -	-	- -	- -
				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	++	++	++	++	++	++
				Y	++	++	++	++	++	++
			45	N	++	++	++	++	++	++
				Y	++	++	++	++	++	++

*Table 18: Reliability flow rate stability. Climate **London***

System	Airing	Inlet	Exhaust	Extra	8.2.1.2 Dwelling					
		area	fan flow	fan	Apartment				House	
		(cm^2)	rate		D4a top		D4a ground		D4c	
			(l/s)		n50 (ach)		n50 (ach)		n50 (ach)	
					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	++	++	++	++	++	++
				Y	++	++	++	++	++	++

Table 19: Reliability flow rate stability. Climate: ***Ottawa***

System	Airing	Inlet	Exhaust	Extra	8.2.1.3 Dwelling					
		area	fan flow	fan	Apartment				House	
		(cm²)	rate		D4a top		D4a ground		D4c	
			(l/s)		n50 (ach)		n50 (ach)		n50 (ach)	
					1	5	1	5	2.5	10
NWA	No	0		N	-	0	-	0	-	0
				Y	-	0	-	0	-	0
		410		N	0	+	0	+	0	0
				Y	0	+	0	+	0	0
	Yes	0		N	0	0	0	0	0	0
				Y	0	0	0	0	0	0
		410		N	+	+	+	+	0	+
				Y	+	+	+	+	0	+
PSV	No	100		N	0	0	0	0	-	0
				Y	0	0	0	0	-	0
		400		N	+	+	0	0	0	0
				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
				Y	+	++	+	+	0	0
MSE			15	N	0	+	0	+	0	+
				Y	0	+	0	+	0	+
			30	N	++	++	++	++	++	++
				Y	++	++	++	++	++	++
			45	N	++	++	++	++	++	++
				Y	++	++	++	++	++	++

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 quality of system	Maintenance level		
	High	Medium	Low
Poor system	++	++	-
Average system	++	++	+
Best practice	++	++	++

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

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

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.

Single family houses

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

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

Central supply and exhaust ventilation			
Technical quality of system	Maintenance level		
	High	Medium	Low
Poor system	+	--	--
Average system	++	0	-
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.

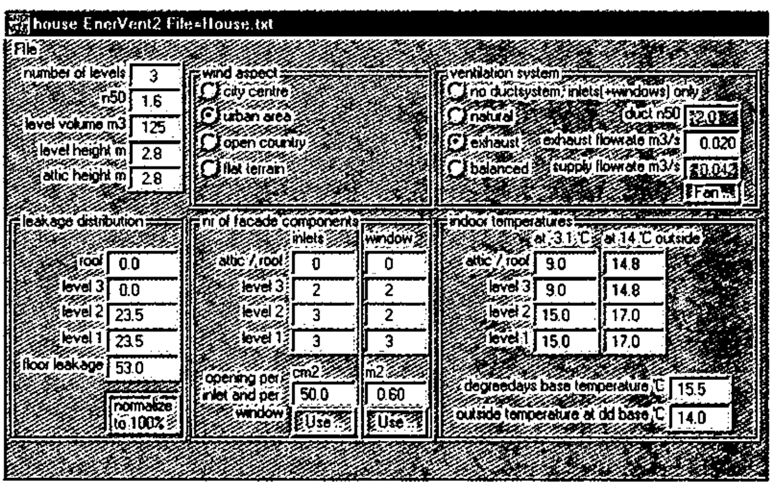
The energy tool can be applied to the four generic ventilation systems previously described for almost all types of dwelling in any location, due to the flexibility of the input data. More detailed information on the tool can be found in the background report [1].

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:

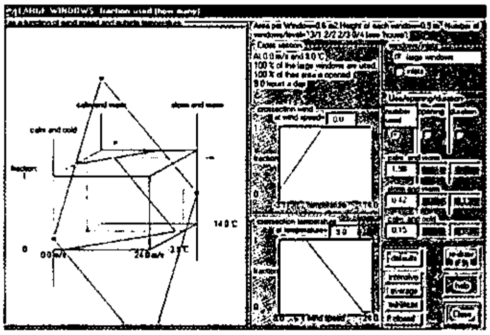
Ventilation Flow Rates

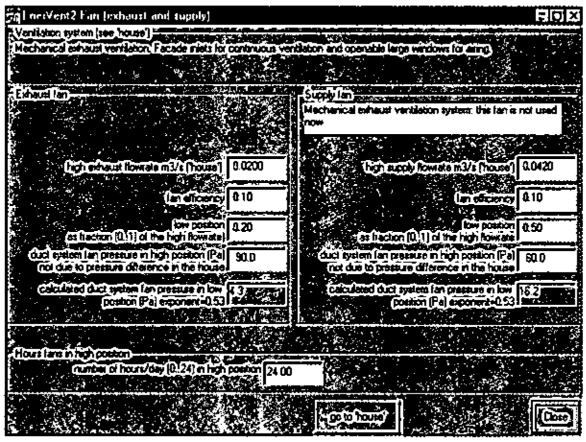


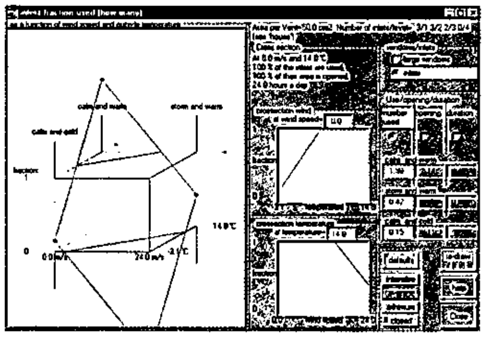
Ventilation rates for mechanical systems are relatively simple to provide and these can be input using the "house" input sheet.

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 "windows". 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.



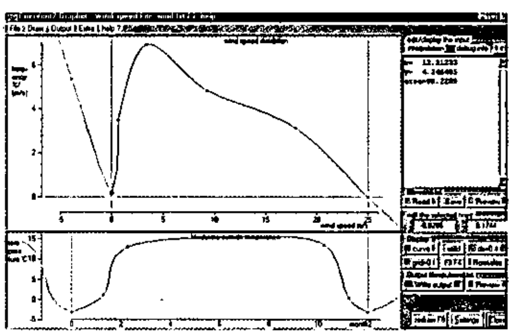




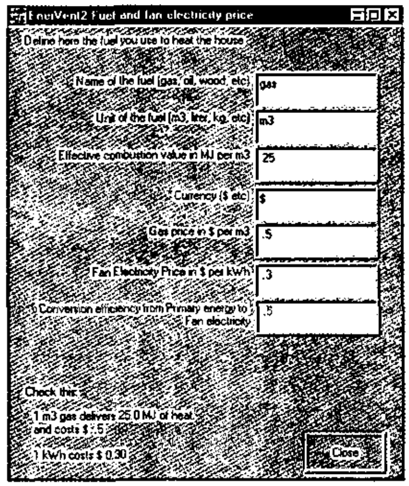
Infiltration

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.

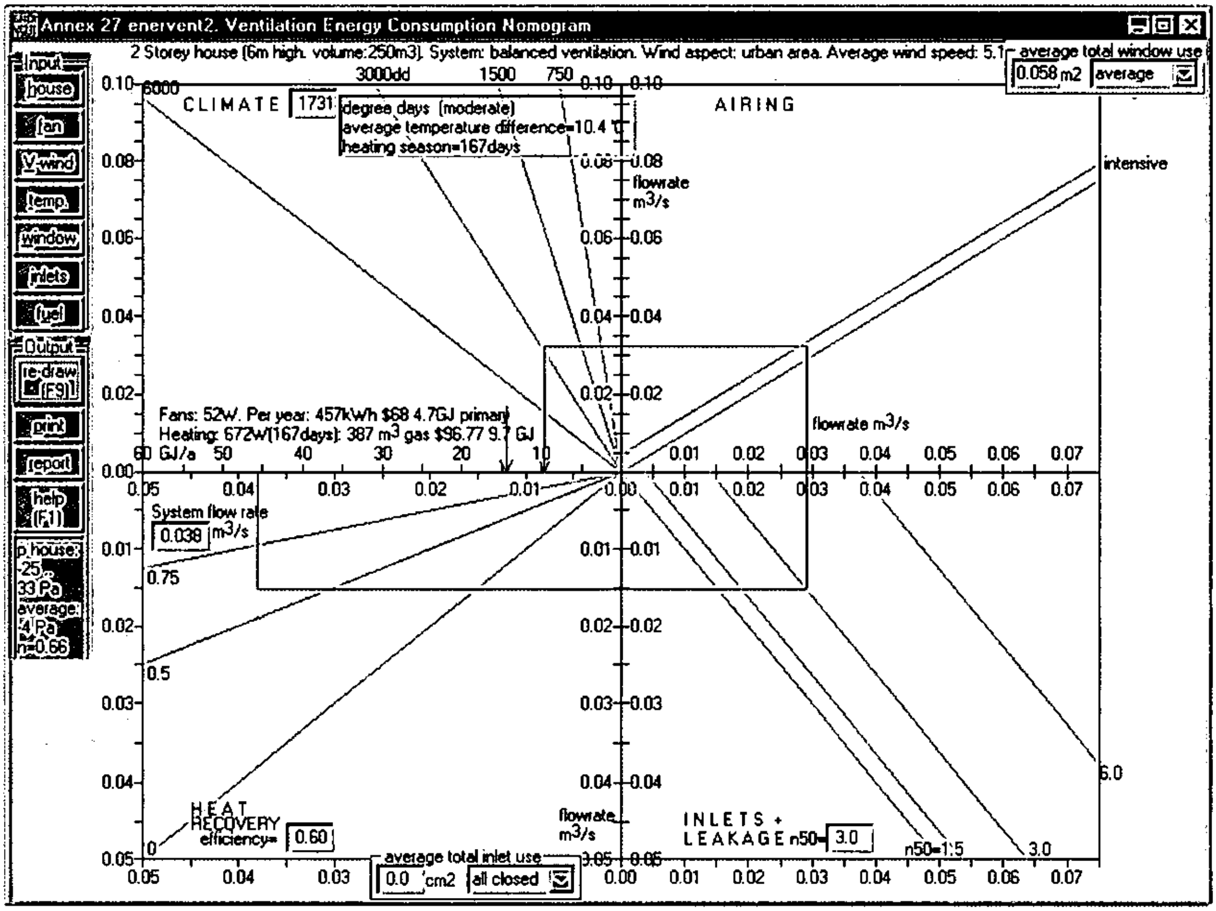


Figure 2: Example of Energy Nomogram

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: 438m^3). 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 m^3/s
Air leakage value, n50 =1.6 Air Changes per Hour at 50 Pa giving:
0.1944 m^3/s at 50 Pa; 0.0615 m^3/s at 10 Pa; 0.0320 m^3/s at 4 Pa; 0.0119 m^3/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

======C a l c u l a t i o n======

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 m^3/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 m^3/s
The ventilation inlets that have an average area of 141.6 cm^2 result in an extra ventilation flow rate of 0.018 m^3/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 m^3 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 house
Type 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 house
Type 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**
		Installation	
Unit	• Easily accessible Mounted on construction with special sound proofing provisions	• 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
Commissioning and adjustment	• Adjustment and commissioning in every dwelling • Completion reports of commissioning required	• Adjustment in limited number of test dwellings • Completion report of test dwellings required	• No measurements and/or completion reports required
Grilles, devices	• Cleaning possibilities without disorder the adjustment (marking or securing) (???) • Self regulating inlets (pressure and temperature)	• Cleaning possibilities with limited chance of disorder the adjustment • Good quality grilles (controllable, airtight when closed)	• No cleaning possibilities or cleaning possibilities with chance of disorder • No special requirements
		Building	
Air tightness	• n50 = 3.. 5	• n50 = 5...6	• No requirements
Initial costs	• 1200	• 900	• 800

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:**	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 installation		
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 instructions	Disordering system
Building			
Ventilating, airing	Conscious use of provisions	Alternating use of provisions	Incidental, very alternating 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 system:	Mechanical extract, natural supply (MEO)

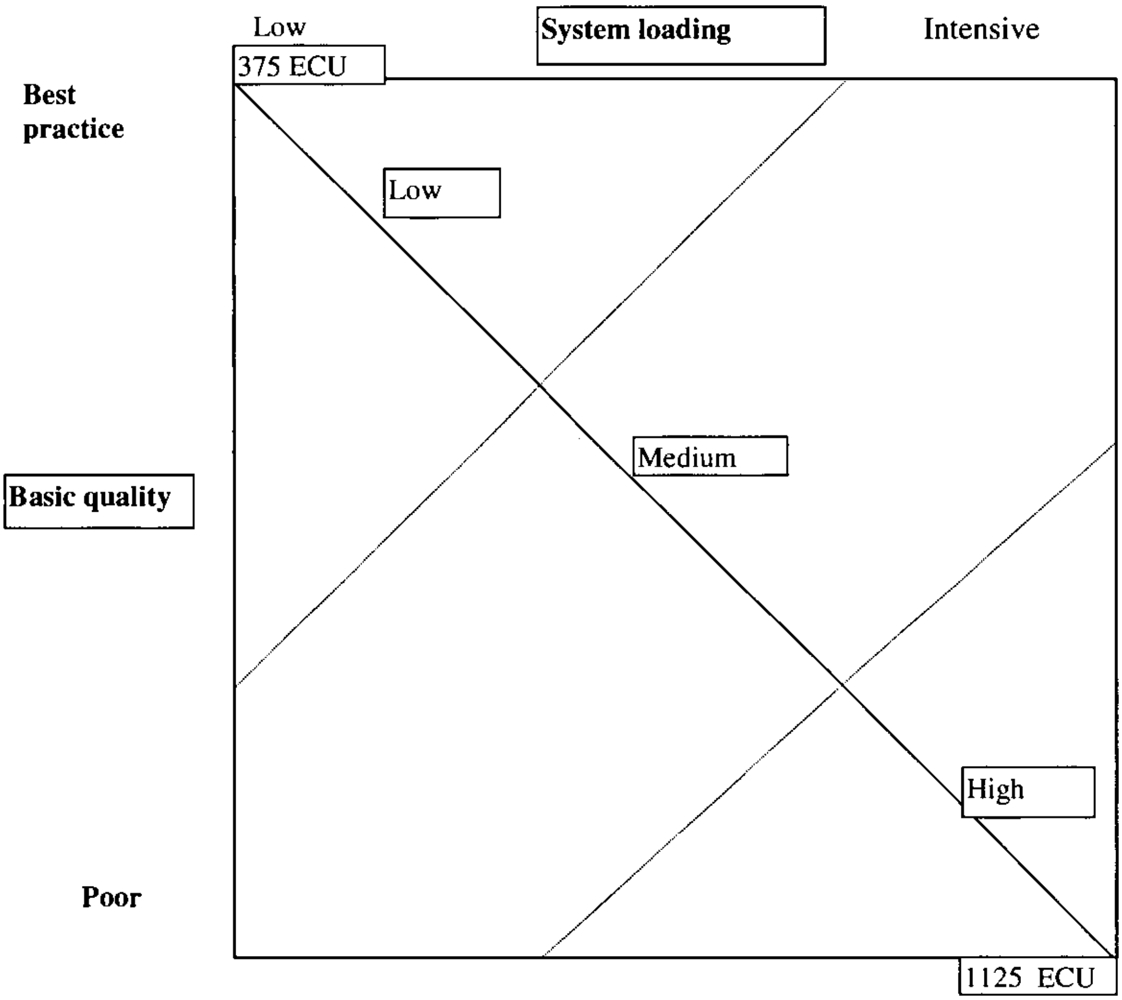
STEP 4: After estimating the most suitable maintenance class the expected maintenance costs can be estimated by Table 21D and the planned maintenance activities by Table 21E

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

Activities	**Maintenance class. Cycle**		
	Low	**Medium**	**High**



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
Building			
• 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**	**Alternative**			
		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	1 1	**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 cm²/inlet NWA & PSV 20 cm²/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 bathroom	Kitchen fan No bathroom fan	No	Yes (As given)		
Window airing	Average	No (windows closed)	Yes **(As given)**		
Technical quality of ventilation system	Average	Poor	**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:

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