IEA ECBCS Annex 36: Retrofitting in Educational Buildings – Energy Concept Adviser for Technical Retrofit Measures

SUBTASK A REPORT

State of the Art Overview: Questionnaire Evaluations

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Working Document

Contents

FOREWORD

In existing residential buildings, the energy consumption is mainly caused by heating energy consumption, that can efficiently be reduced by construction measures similar to those applied in new residential buildings. The energy saving potential of commercial buildings, however, is additionally determined and influenced by the energy required for lighting, cooling, controlling and often strongly by ventilation. Within the framework of the IEA Future Building Forum, the state of the art regarding the problems and obstacles occurring during the retrofitting (renovating) process of non-residential buildings was discussed at a workshop held in Stuttgart/Germany in April 1997. It became evident that this building sector is structured very differently and cannot be covered completely.

Analysis of the existing building stock showed that public-owned buildings usually have high energy consumption and, as they are constructed similarly in many countries, the experiences gained with retrofits of these types of buildings can easily be transferred to other countries. An especially large group among these buildings are educational buildings. The kindergartens, schools, training centers and universities of the IEA countries have similar typology and have high energy consumption often need to be retrofitted. Nevertheless, energy saving measures are applied only rarely when these buildings are retrofitted. One important reason for this is often a lack of knowledge of the decision makers on the investments and efficiency of potential energy saving measures. Due to this lack of information, in many cases, decisions are made that take into account the energy saving aspects only insufficiently. There are no rules of thumb allowing for the easy and quick estimates of the required investments or the potential energy savings before having analyzed the building structure in detail.

Based on these R & D needs it was suggested to the IEA ECBCS Executive Committee to establish a new Annex to develop an energy concept adviser for economical retrofit measures. This adviser will be useful both during the design and the construction phase. On the one hand it can help the investor and the owner select the most efficient measures in terms of energy and cost saving, and, on the other hand, to prevent them from exaggerated expectations. The adviser should be applicable during the entire retrofitting phase to ensure that both the calculated energy saving and the economical success will be achieved after retrofitting. Moreover, by applying exemplary retrofit measures to educational buildings the aspect of energy saving can be integrated into the learning and teaching process. In addition, the results gained in the exemplary retrofit projects can easily be transferred to other building types, such as office buildings, meeting halls, etc., due to their similar building structures.

The main objective of this Annex is to promote energy-efficient concepts for the retrofit process of educational buildings. Through selected case studies the Annex will demonstrate the viability of energy-efficient retrofit concepts under various climate conditions, emphasizing system performance with regard to energy saving, economic efficiency and user acceptance.
Within the proposed structure of Annex 36 the subtask A was separated in order to provide the required information on the state of the art knowledge in the field of retrofitting in participating countries. The questionnaire action had been performed. The following subjects were taken into consideration:
Decision makers motivation (performed by Lorenz V.Schoff from USA): - the questionnaire was based on four questions regarding the importance of different point character factors in making the decision wether and how to renovate/retrofit educational buildings;
Energy consumption (performed by Heike Kluttig from Germany): the questionnaire is dealing with the energy consumption of existing educational buildings for heating, domestic hot water and electrical power. The questions

on the energy demand were divided into educational buildings as a whole, universities, schools and nurseries;

National requirements + recommendations (performed Kirsten Engelund Thomsen from Denmark and Richard Daniels from UK): - the questionnaire is focused on the collecting of existing data on educational buildings operating parameters (temperature, ventilation rates, daylighting and artificial lighting factors, etc.), national guidelines and requirements and their comparison for participating countries;

Economic calculation (performed by Tomasz Mróz from Poland): - the questionnaire is combining the data on the economical performance of retrofitting projects. The questions are divided into three major groups dealing with: (i) basic economic data, (ii) investment cost factors and (iii) operation cost factors;

(Short-Term-)Measurements (performed by Jan de Boer from Germany): - the questionnaire prepared for the collection of existing information joined with the utilization of short term measurements and other audit procedures in verification of the energy savings caused by retrofitting process;

Calculation tools (performed by Pekka Tuomaala/Timo Kauppinen from Finland): - the questionnaire designed for the collection of the data considering the usage of different software in the prediction of energy behavior of educational buildings before and after retrofitting in participating countries;

The final results of the questionnaire action are presented in the following chapters.

Tomasz Mroz

Annex 36 Subtask A Leader

Hans Erhorn

Operating Agent Annex 36

January 2003

Chapter 1

Evaluation of Questionnaire on Decision Makers Motivations

by

Lorenz V. Schoff, PE

Table of Contents

1. SUMMARY

Eleven responses were received to the Questionnaire, five international responses and six from the United States of America. The six from the US included a School Director of Finance, a School Board member, two Superintendents of Schools, a Deputy Superintendent of Schools and a School Facility Manager. The five international responses were from our members.

An analysis of the responses was accomplished and the results are attached for each of the Questions. An analysis was made on all responses and the two categories, International and United States of America. The following results were made for each of the questions:

Question A – What importance do you place on each of the following factors in making a decision whether to renovate/retrofit an existing facility or to construction of a new facility?

All three groupings place factor 4*, Cost – New vs. Retrofit*, as top priority; All three groupings place factor 9, *Consolidation*, as the lowest priority. The US group places *Condition of existing facility* as priority two along with All responses, but the International group places *Economics* as priority two.

Question B -- What importance do you place on the factors listed below, when considering a project to renovate/retrofit an existing or constructing a new educational facility?

The highest priority given by All and International respondents was *Building Operating Costs* with the US respondents rating roofing the highest. The lowest priority given by All and the International respondents was to *Changes in Instructional Model* with the US responses rating *Orientation* the lowest. *Building Utilization* was rated second by All and the US Respondents and rated third by *International* respondents.

Question C -- What importance do you place on the factors listed below, when giving design instructions to the professionals for a project to renovate/retrofit an existing or constructing a new educational facility?

This question resulted in responses all over the field. There is no agreement to the top priority with all three groupings having a different number one: All with *Ventilation Systems*; International with *Building Costs* and the US with Roofing. All agree that *Use of Photovoltaics* is the lowest priority.

Question D -- What importance do you place on the cost related factors in making a decision on whether or not to use energy efficient systems or materials in the design to retrofit or construct a new educational facility?

The factor of *Initial Cost* had the highest priority by all three groups with all having an average over 9. *Operating Cost* were priority two for International respondents while US respondents gave *Operating Cost* a priority of four.

Attached are the results of the questionnaire for each question. Each question has the initial results and priority listings based on average rating for All, International and US respondents (See Attachments A – 1 to A – 4 thru D – 1 to D – 4). Attachment E – 1 is a copy of the questionnaire.

Lorenz V. Schoff, PE
United States of America

2. ATTACHMENT A-1 TO A-4

2.1. Attachment A-1. ALL RESPONSES TO QUESTIONNAIRE ON IMPORTANCE OF FACTORS

QUESTION A **What importance do you place on each of the following factors in making a decision where to renovate/retrofit an existing facility or to construction of a new facility?**

FACTOR/RESP.	USA FINANCE DIRECTOR	FIN ENG	USA SUPT	USA SB CHAIR	USA FACILITY MGT	USA SUPT	USA DEP SUPT
1. Community Factors	10	7	5	5	8	7	5
2. Historical Factors	2	8	5	10	5	7	5
3. Location	7	9	9	5	8	5	5
4. Cost -- New vs Retro	5	10	9	10	7	9	10
5. Condition Existing Fac	6	7	9	10	10	5	9
6. Avail. Of Utilities	5	8	5	7	7	5	2
7. Adaptability	3	8	7	7	8	5	8
8. Adapt. To Ed Model	5	9	8	7	8	9	8
9. Consolidation	0			7	6	2	3
10. Class Size	7	9		5	7	2	5
11. Economics	5	10	5	10	8	2	7
12. Adapt of Ed Model De	3	9	9	7	7	8	8
13. Current Operating $$	3	9	10	10	8	5	5
14. Environmental Issues	3	9	8	10	6	5	3
15. Hazardous Materials	3	8	10	10	5	5	1
16. Adapt. For Tech.	5	7	7	8	7	5	6

FACTOR/RESP.	POL UNV	DEN ENG	FRAN ENG	GER UNI	SUM	AVE
1. Community Factors	5	7	6	10	75	6,8
2. Historical Factors	7	1	6	2	58	5,3
3. Location	2	7	7	5	69	6,3
4. Cost -- New vs Retro	10	10	8	10	98	8,9
5. Condition Existing Fac	7	7	8	10	88	8,0
6. Avail. Of Utilities		3	8	8	58	5,3
7. Adaptability	7	3	4	5	65	5,9
8. Adapt. To Ed Model	7	2	4	1	68	6,2
9. Consolidation				4	22	2,0
10. Class Size	5	2	9	3	54	4,9
11. Economics	8	10	9	8	82	7,5
12. Adapt of Ed Model De	5	2	3	5	66	6,0
13. Current Operating $$	7	3	9	5	74	6,7
14. Environmental Issues	5	2	5	3	59	5,4
15. Hazardous Materials	5	10	5	5	67	6,1
16. Adapt. For Tech.	5	3	8	5	66	6,0

2.2. Attachment A-2. ALL RESPONSES TO QUESTIONNAIRE ON IMPORTANCE OF FACTORS

QUESTION A **What importance do you place on each of the following factors in making a decision whether to renovate/retrofit an existing facility or to construction of a new facility?**

FACTOR/RESP.	POL	DEN	FRAN	GER	SUM	AVE
	UNV	ENG	ENG	UNI		
4. Cost -- New vs Retro	10	10	8	10	98	8,9
5. Condition Existing Fac	7	7	8	10	88	8,0
11. Economics	8	10	9	8	82	7,5
1. Community Factors	5	7	6	10	75	6,8
13. Current Operating $$	7	3	9	5	74	6,7
3. Location	2	7	7	5	69	6,3
8. Adapt. To Ed Model	7	2	4	1	68	6,2
15. Hazardous Materials	5	10	5	5	67	6,1
12. Adapt of Ed Model De	5	2	3	5	66	6,0
16. Adapt. For Tech.	5	3	8	5	66	6,0
7. Adaptability	7	3	4	5	65	5,9
14. Environmental Issues	5	2	5	3	59	5,4
2. Historical Factors	7	1	6	2	58	5,3
6. Avail. Of Utilities		3	8	8	58	5,3
10. Class Size	5	2	9	3	54	4,9
9. Consolidation				4	22	2,0

FACTOR/RESP.	POL	DEN	FRAN	GER	SUM	AVE
	UNV	ENG	ENG	UNI		
4. Cost -- New vs Retro	10	10	8	10	98	8,9
5. Condition Existing Fac	7	7	8	10	88	8,0
11. Economics	8	10	9	8	82	7,5
1. Community Factors	5	7	6	10	75	6,8
13. Current Operating $$	7	3	9	5	74	6,7
3. Location	2	7	7	5	69	6,3
8. Adapt. To Ed Model	7	2	4	1	68	6,2
15. Hazardous Materials	5	10	5	5	67	6,1
12. Adapt of Ed Model De	5	2	3	5	66	6,0
16. Adapt. For Tech.	5	3	8	5	66	6,0
7. Adaptability	7	3	4	5	65	5,9
14. Environmental Issues	5	2	5	3	59	5,4
2. Historical Factors	7	1	6	2	58	5,3
6. Avail. Of Utilities		3	8	8	58	5,3
10. Class Size	5	2	9	3	54	4,9
9. Consolidation				4	22	2,0

2.3. Attachment A-3. UNITED STATES OF AMERICA RESPONSES TO IMPORTANCE OF FACTORS

QUESTION A **What importance do you place on each of the following factors in making a decision whether to renovate/retrofit an existing facility or to construction of a new facility?**

FACTOR/RESP.	USA	USA	USA	USA	USA	USA	SUM	AVE
	FINANCE	SUPT	SB	FACILITY	SUPT	DEP		
	DIRECTOR		CHAIR	MGT		SUPT		
4. Cost -- New vs Retro	5	9	10	7	9	10	50	8,3
5. Condition Existing Fac	6	9	10	10	5	9	49	8,2
8. Adapt. To Ed Model	5	8	7	8	9	8	45	7,5
12. Adapt of Ed Model De	3	9	7	7	8	8	42	7,0
13. Current Operating $$	3	10	10	8	5	5	41	6,8
1. Community Factors	10	5	5	8	7	5	40	6,7
3. Location	7	9	5	8	5	5	39	6,5
7. Adaptability	3	7	7	8	5	8	38	6,3
16. Adapt. For Tech.	5	7	8	7	5	6	38	6,3
11. Economics	5	5	10	8	2	7	37	6,2
14. Environmental Issues	3	8	10	6	5	3	35	5,8
2. Historical Factors	2	5	10	5	7	5	34	5,7
15. Hazardous Materials	3	10	10	5	5	1	34	5,7
6. Avail. Of Utilities	5	5	7	7	5	2	31	5,2
10. Class Size	7		5	7	2	5	26	4,3
9. Consolidation	0		7	6	2	3	18	3,0

2.4. Attachment A-4. INTERNATIONAL RESPONSES TO QUESTIONNAIRE ON IMPORTANCE OF FACTORS

QUESTION A **What importance do you place on each of the following factors in making a decision whether to renovate/retrofit an existing facility or to construction of a new facility?**

FACTOR/RESP.	FIN	POL	DEN	FRAN	GER	SUM	AVE
	ENG	UNV	ENG	ENG	UNI		
4. Cost -- New vs Retro	10	10	10	8	10	48	9,6
11. Economics	10	8	10	9	8	45	9,0
5. Condition Existing Fac	7	7	7	8	10	39	7,8
1. Community Factors	7	5	7	6	10	35	7,0
13. Current Operating $$	9	7	3	9	5	33	6,6
15. Hazardous Materials	8	5	10	5	5	33	6,6
3. Location	9	2	7	7	5	30	6,0
10. Class Size	9	5	2	9	3	28	5,6
16. Adapt. For Tech.	7	5	3	8	5	28	5,6
6. Avail. Of Utilities	8		3	8	8	27	5,4
7. Adaptability	8	7	3	4	5	27	5,4
2. Historical Factors	8	7	1	6	2	24	4,8
12. Adapt of Ed Model De	9	5	2	3	5	24	4,8
14. Environmental Issues	9	5	2	5	3	24	4,8
8. Adapt. To Ed Model	9	7	2	4	1	23	4,6
9. Consolidation					4	4	0,8

3. Attachment B-1 to B-4

3.1. Attachment B-1. ALL RESPONSES TO QUESTIONNAIRE

QUESTION **B** **What importance do you place on the factors listed below, when considering a project to renovate/retrofit an existing or constructing a new educational facility?**

FACTOR/RESP.	USA FINANCE DIRECTOR	FIN ENG	USA SUPT	USA SB CHAIR	USA FACILITY MGT	USA SUPT	USA DEP SUPT
1. Availability Technology	8	8	10	2	7	9	7
2. Square feet/Student	7	10	9	7	5	5	5
3. Indoor Air Quality	6	10	8	8	5	5	8
4. Natural Light	5	7	5	8	5	3	4
5. Changes of Ed Model	5	7		8	8	5	7
6. Building Utiitzation	8	8	7	10	7	5	7
7. Energy Efficiency	5	9	8	7	8	3	8
8. Use of Renewable Mtl	2	8	9	5	5	3	2
9. Susstainability/Design	2	9	9	5	8	3	6
10. Lighting Levels	5	9	6	9	7	6	7
11. Heat/Cool Sys. Used	6	9	5	7	8	8	5
12. Flooring	6	9	5	2	7	5	6
13. Roofing	8	9	9	2	9	9	9
14. Light Fixtures	5	8	5	1	7	7	5
15. Building Orientation	2	9	4	5	8	2	3
16. Site Characteristics	4	9	5	8	8	5	4
17. Environmental Issues	4	8	7	7	7	2	4
18. Building Operating $$	2	9	9	10	8	5	7

FACTOR/RESP.	POL UNI	DEN ENG	FRAN ENG	GER UNI	SUM	AVE
1. Availability Technology	7	2	8	10	78	7,1
2. Square feet/Student	7	10	8	6	79	7,2
3. Indoor Air Quality	5	8	6	5	74	6,7
4. Natural Light	5	7	7	5	61	5,5
5. Changes of Ed Model		5		2	47	4,3
6. Building Utiitzation	7	10	7	8	84	7,6
7. Energy Efficiency	10	8	5	8	79	7,2
8. Use of Renewable Mtl	5	5	3	2	49	4,5
9. Susstainability/Design	5	7	3	5	62	5,6
10. Lighting Levels	5	9	7	2	72	6,5
11. Heat/Cool Sys. Used	7	9	6	5	75	6,8
12. Flooring	7	9	4	2	62	5,6
13. Roofing	7	6	4	2	74	6,7
14. Light Fixtures	7	5	4	2	56	5,1
15. Building Orientation	7	6	5	2	53	4,8
16. Site Characteristics	7	2	7	4	63	5,7
17. Environmental Issues	5	7	4	3	58	5,3
18. Building Operating $$	10	8	9	8	85	7,7

3.2. Attachment B-2. ALL RESPONSES TO QUESTIONNAIRE ON IMPORTANCE OF FACTORS

QUESTION **B** **What importance do you place on the factors listed below, when considering a project to renovate/retrofit an existing or constructing a new educational facility?**

FACTOR/RESP.	USA	FIN	USA	USA	USA	USA	USA
	FINANCE	ENG	SUPT	SB	FACILITY	SUPT	DEP
	DIRECTOR			CHAIR	MGT		SUPT
18. Building Operating $$	2	9	9	10	8	5	7
6. Building Utilization	8	8	7	10	7	5	7
2. Square feet/Student	7	10	9	7	5	5	5
7. Energy Efficiency	5	9	8	7	8	3	8
1. Availability Technology	8	8	10	2	7	9	7
11. Heat/Cool Sys. Used	6	9	5	7	8	8	5
3. Indoor Air Quality	6	10	8	8	5	5	8
13. Roofing	8	9	9	2	9	9	9
10. Lighting Levels	5	9	6	9	7	6	7
16. Site Characteristics	4	9	5	8	8	5	4
9. Sustainability/Design	2	9	9	5	8	3	6
12. Flooring	6	9	5	2	7	5	6
4. Natural Light	5	7	5	8	5	3	4
17. Environmental Issues	4	8	7	7	7	2	4
14. Light Fixtures	5	8	5	1	7	7	5
15. Building Orientation	2	9	4	5	8	2	3
8. Use of Renewable Mtl	2	8	9	5	5	3	2
5. Changes of Ed Model	5	7		8	8	5	7

FACTOR/RESP.	POL	DEN	FRAN	GER	SUM	AVE
	UNI	ENG	ENG	UNI		
18. Building Operating $$	10	8	9	8	85	7,7
6. Building Utilization	7	10	7	8	84	7,6
2. Square feet/Student	7	10	8	6	79	7,2
7. Energy Efficiency	10	8	5	8	79	7,2
1. Availability Technology	7	2	8	10	78	7,1
11. Heat/Cool Sys. Used	7	9	6	5	75	6,8
3. Indoor Air Quality	5	8	6	5	74	6,7
13. Roofing	7	6	4	2	74	6,7
10. Lighting Levels	5	9	7	2	72	6,5
16. Site Characteristics	7	2	7	4	63	5,7
9. Sustainability/Design	5	7	3	5	62	5,6
12. Flooring	7	9	4	2	62	5,6
4. Natural Light	5	7	7	5	61	5,5
17. Environmental Issues	5	7	4	3	58	5,3
14. Light Fixtures	7	5	4	2	56	5,1
15. Building Orientation	7	6	5	2	53	4,8
8. Use of Renewable Mtl	5	5	3	2	49	4,5
5. Changes of Ed Model		5		2	47	4,3

3.3. Attachment B-3. UNITED STATES OF AMERICA RESPONSES TO IMPORTANCE OF FACTORS

QUESTION **B** **What importance do you place on the factors listed below, when considering a project to renovate/retrofit an existing or constructing a new educational facility?**

FACTOR/RESP.	USA	USA	USA	USA	USA	USA	SUM	AVE
	FINANCE	SUPT	SB	FACILITY	SUPT	DEP		
	DIRECTOR		CHAIR	MGT		SUPT		
13. Roofing	8	9	2	9	9	9	46	7,7
6. Building Utilization	8	7	10	7	5	7	44	7,3
1. Availability Technology	8	10	2	7	9	7	43	7,2
18. Building Operating $$	2	9	10	8	5	7	41	6,8
3. Indoor Air Quality	6	8	8	5	5	8	40	6,7
10. Lighting Levels	5	6	9	7	6	7	40	6,7
7. Energy Efficiency	5	8	7	8	3	8	39	6,5
11. Heat/Cool Sys. Used	6	5	7	8	8	5	39	6,5
2. Square feet/Student	7	9	7	5	5	5	38	6,3
16. Site Characteristics	4	5	8	8	5	4	34	5,7
5. Changes of Ed Model	5		8	8	5	7	33	5,5
9. Sustainability/Design	2	9	5	8	3	6	33	5,5
12. Flooring	6	5	2	7	5	6	31	5,2
17. Environmental Issues	4	7	7	7	2	4	31	5,2
4. Natural Light	5	5	8	5	3	4	30	5,0
14. Light Fixtures	5	5	1	7	7	5	30	5,0
8. Use of Renewable Mtl	2	9	5	5	3	2	26	4,3
15. Building Orientation	2	4	5	8	2	3	24	4,0

3.4. Attachment B-4. INTERNATIONAL RESPONSES TO QUESTIONNAIRE ON IMPORTANCE OF FACTORS

QUESTION **B** **What importance do you place on the factors listed below, when considering a project to renovate/retrofit an existing or constructing a new educational facility?**

FACTOR/RESP.	FIN	POL	DEN	FRAN	GER	SUM	AVE
	ENG	UNI	ENG	ENG	UNI		
18. Building Operating $$	9	10	8	9	8	44	8,8
2. Square feet/Student	10	7	10	8	6	41	8,2
6. Building Utilization	8	7	10	7	8	40	8,0
7. Energy Efficiency	9	10	8	5	8	40	8,0
11. Heat/Cool Sys. Used	9	7	9	6	5	36	7,2
1. Availability Technology	8	7	2	8	10	35	7,0
3. Indoor Air Quality	10	5	8	6	5	34	6,8
10. Lighting Levels	9	5	9	7	2	32	6,4
4. Natural Light	7	5	7	7	5	31	6,2
12. Flooring	9	7	9	4	2	31	6,2
9. Sustainability/Design	9	5	7	3	5	29	5,8
15. Building Orientation	9	7	6	5	2	29	5,8
16. Site Characteristics	9	7	2	7	4	29	5,8
13. Roofing	9	7	6	4	2	28	5,6
17. Environmental Issues	8	5	7	4	3	27	5,4
14. Light Fixtures	8	7	5	4	2	26	5,2
8. Use of Renewable Mtl	8	5	5	3	2	23	4,6
5. Changes of Ed Model	7		5		2	14	2,8

4. ATTACHMENT C-1 TO C-4

4.1. Attachment C-1. ALL RESPONSES TO QUESTIONNAIRE

QUESTION **C** **What importance do you place on the factors listed below, when giving design instructions to the design professionals for a project to renovate/retrofit an existing or constructing new?**

FACTOR/RESP.	USA FINANCE DIRECTOR	FIN ENG	USA SUPT	USA SB CHAIR	USA FACILITY MGT	USA SUPT	USA DEP SUPT
1. Technology	8	8	9	5	7	9	7
2. Use of Day Lighting	4	8	9	5	6	9	4
3. Use of Recycled Mat'l	2	9	5	2	6	2	2
4. Use of Photovoltaics		8	5	2	5	2	3
5. Building Utilization	8	9	5	10	8	5	8
6. Energy Efficiency	5	10	7	7	8	5	9
7. Use of Renewable	2	9	8	3	6	2	2
8. Sustainability of Design	2	10	5	5	8	5	6
9. Lighting Systems	5	8	5	5	8	6	7
10. Heating/Cooling Syst.	6	9	9	8	9	9	9
11. Ventilation Systems	6	10	10	7	8	9	9
12. Exterior Energy Sav.	3	9	5	5	9	9	6
13. Flooring	6	9	2	5	7	9	6
14. Roofing	8	10	9	8	9	9	8
15. Landscaping	2	9		5	6	3	2
16. Building Orientation	4	9	1	10	6	3	2
17. Environmental Issues	4	9	4	5	7	3	2
18. Buiding Costs	3	10	8	10	8	5	7
19. Water Saving Systems	2	9	5	10	7	5	5
20. Energy Equipment	4	10	4	7	8	5	6

FACTOR/RESP.	POL UNI	DEN ENG	FRAN ENG	GER UNI	SUM	AVE
1. Technology	7		5	10	75	6,8
2. Use of Day Lighting	5	8	7	8	73	6,6
3. Use of Recycled Mat'l	2	8	6	3	47	4,3
4. Use of Photovoltaics	1	1	3	2	32	2,9
5. Building Utilization	10	7	7	5	82	7,5
6. Energy Efficiency	10	8	8	10	87	7,9
7. Use of Renewable	5	7	4	5	53	4,8
8. Sustainability of Design	5	8	4	8	66	6,0
9. Lighting Systems	7	8	8	8	75	6,8
10. Heating/Cooling Syst.	7	6	7	8	87	7,9
11. Ventilation Systems	7	8	9	8	91	8,3
12. Exterior Energy Sav.	7	7	5	8	73	6,6
13. Flooring	7	8	4	2	65	5,9
14. Roofing	7	6	4	2	80	7,3
15. Landscaping	7	5	5	5	49	4,5
16. Building Orientation	7	7	6	6	61	5,5
17. Environmental Issues	5	9	3	8	59	5,4
18. Buiding Costs	10	10	9	10	90	8,2
19. Water Saving Systems	7	6	8	8	72	6,5
20. Energy Equipment	7	8	7	8	74	6,7

4.2. Attachment C-2. ALL RESPONSES TO QUESTIONNAIRE ON IMPORTANCE OF FACTORS

QUESTION **C** **What importance do you place on the factors listed below, when giving design instructions to the design professionals for a project to renovate/retrofit an existing or constructing new?**

FACTOR/RESP.	USA FINANCE DIRECTOR	FIN ENG	USA SUPT	USA SB CHAIR	USA FACILITY MGT	USA SUPT	USA DEP SUPT
11. Ventilation Systems	6	10	10	7	8	9	9
18. Building Costs	3	10	8	10	8	5	7
6. Energy Efficiency	5	10	7	7	8	5	9
10. Heating/Cooling Syst.	6	9	9	8	9	9	9
5. Building Utilization	8	9	5	10	8	5	8
14. Roofing	8	10	9	8	9	9	8
1. Technology	8	8	9	5	7	9	7
9. Lighting Systems	5	8	5	5	8	6	7
20. Energy Equipment	4	10	4	7	8	5	6
2. Use of Day Lighting	4	8	9	5	6	9	4
12. Exterior Energy Sav.	3	9	5	5	9	9	6
19. Water Saving Systems	2	9	5	10	7	5	5
8. Sustainability of Design	2	10	5	5	8	5	6
13. Flooring	6	9	2	5	7	9	6
16. Building Orientation	4	9	1	10	6	3	2
17. Environmental Issues	4	9	4	5	7	3	2
7. Use of Renewable	2	9	8	3	6	2	2
15. Landscaping	2	9		5	6	3	2
3. Use of Recycled Mat'l	2	9	5	2	6	2	2
4. Use of Photovoltaics		8	5	2	5	2	3

FACTOR/RESP.	POL UNI	DEN ENG	FRAN ENG	GER UNI	SUM	AVE
11. Ventilation Systems	7	8	9	8	91	8,3
18. Building Costs	10	10	9	10	90	8,2
6. Energy Efficiency	10	8	8	10	87	7,9
10. Heating/Cooling Syst.	7	6	7	8	87	7,9
5. Building Utilization	10	7	7	5	82	7,5
14. Roofing	7	6	4	2	80	7,3
1. Technology	7		5	10	75	6,8
9. Lighting Systems	7	8	8	8	75	6,8
20. Energy Equipment	7	8	7	8	74	6,7
2. Use of Day Lighting	5	8	7	8	73	6,6
12. Exterior Energy Sav.	7	7	5	8	73	6,6
19. Water Saving Systems	7	6	8	8	72	6,5
8. Sustainability of Design	5	8	4	8	66	6,0
13. Flooring	7	8	4	2	65	5,9
16. Building Orientation	7	7	6	6	61	5,5
17. Environmental Issues	5	9	3	8	59	5,4
7. Use of Renewable	5	7	4	5	53	4,8
15. Landscaping	7	5	5	5	49	4,5
3. Use of Recycled Mat'l	2	8	6	3	47	4,3
4. Use of Photovoltaics	1	1	3	2	32	2,9

4.3. Attachment C-3. UNITED STATES OF AMERICA RESPONSES TO IMPORTANCE OF FACTORS

QUESTION **C** **What importance do you place on the factors listed below, when giving design instructions to the design professionals for a project to renovate/retrofit an existing or constructing new?**

FACTOR/RESP.	USA	USA	USA	USA	USA	USA	SUM	AVE
	FINANCE	SUPT	SB	FACILITY	SUPT	DEP		
	DIRECTOR		CHAIR	MGT		SUPT		
14. Roofing	8	9	8	9	9	8	51	8,5
10. Heating/Cooling Syst.	6	9	8	9	9	9	50	8,3
11. Ventilation Systems	6	10	7	8	9	9	49	8,2
1. Technology	8	9	5	7	9	7	45	7,5
5. Building Utilization	8	5	10	8	5	8	44	7,3
6. Energy Efficiency	5	7	7	8	5	9	41	6,8
18. Building Costs	3	8	10	8	5	7	41	6,8
2. Use of Day Lighting	4	9	5	6	9	4	37	6,2
12. Exterior Energy Sav.	3	5	5	9	9	6	37	6,2
9. Lighting Systems	5	5	5	8	6	7	36	6,0
13. Flooring	6	2	5	7	9	6	35	5,8
19. Water Saving Systems	2	5	10	7	5	5	34	5,7
20. Energy Equipment	4	4	7	8	5	6	34	5,7
8. Sustainability of Design	2	5	5	8	5	6	31	5,2
16. Building Orientation	4	1	10	6	3	2	26	4,3
17. Environmental Issues	4	4	5	7	3	2	25	4,2
7. Use of Renewable	2	8	3	6	2	2	23	3,8
3. Use of Recycled Mat'l	2	5	2	6	2	2	19	3,2
15. Landscaping	2		5	6	3	2	18	3,0
4. Use of Photovoltaics		5	2	5	2	3	17	2,8

4.4. Attachment C-4. INTERNATIONAL RESPONSES TO QUESTIONNAIRE ON IMPORTANCE OF FACTORS

QUESTION **C** **What importance do you place on the factors listed below, when giving design instructions to the design professionals for a project to renovate/retrofit an existing or constructing new?**

FACTOR/RESP.	FIN	POL	DEN	FRAN	GER	SUM	AVE
	ENG	UNI	ENG	ENG	UNI		
18. Building Costs	10	10	10	9	10	49	9,8
6. Energy Efficiency	10	10	8	8	10	46	9,2
11. Ventilation Systems	10	7	8	9	8	42	8,4
20. Energy Equipment	10	7	8	7	8	40	8,0
9. Lighting Systems	8	7	8	8	8	39	7,8
5. Building Utilization	9	10	7	7	5	38	7,6
19. Water Saving Systems	9	7	6	8	8	38	7,6
10. Heating/Cooling Syst.	9	7	6	7	8	37	7,4
2. Use of Day Lighting	8	5	8	7	8	36	7,2
12. Exterior Energy Sav.	9	7	7	5	8	36	7,2
8. Sustainability of Design	10	5	8	4	8	35	7,0
16. Building Orientation	9	7	7	6	6	35	7,0
17. Environmental Issues	9	5	9	3	8	34	6,8
15. Landscaping	9	7	5	5	5	31	6,2
1. Technology	8	7		5	10	30	6,0
7. Use of Renewable	9	5	7	4	5	30	6,0
13. Flooring	9	7	8	4	2	30	6,0
14. Roofing	10	7	6	4	2	29	5,8
3. Use of Recycled Mat'l	9	2	8	6	3	28	5,6
4. Use of Photovoltaics	8	1	1	3	2	15	3,0

5. ATTACHMENT D-1 TO D-4

5.1. Attachment D-1. ALL RESPONSES TO QUESTIONNAIRE

QUESTION **D** **What importance do you place on the cost related factors in making a decision on whether or not to use energy efficient systems or matierals in design to retrofit or construct new?**

FACTOR/RESP.	USA	FIN	USA	USA	USA	USA	USA
	FINANCE	ENG	SUPT	SB	FACILITY	SUPT	DEP
	DIRECTOR			CHAIR	MGT		SUPT
1. Life Cycle Cost	3	10	10	7	9	5	8
2. Initial Cost	10	10	10	10	8	9	10
3. Maintenance Cost	3	10	8	7	7	8	7
4. Operating Cost	5	10	7	7	8	5	5

FACTOR/RESP.	POL	DEN	FRAN	GER	SUM	AVE
	UNI	ENG	ENG	UNI		
1. Life Cycle Cost	5	5	6	10	78	7,1
2. Initial Cost	10	9	9	8	103	9,4
3. Maintenance Cost	5	8	7	6	76	6,9
4. Operating Cost	7	9	8	8	79	7,2

5.2. Attachment D-2. ALL RESPONSES TO QUESTIONNAIRE ON IMPORTANCE OF FACTORS

QUESTION **D** **What importance do you place on the cost related factors in making a decision on whether or not to use energy efficient systems or matierals in design to retrofit or construct new?**

FACTOR/RESP.	USA	FIN	USA	USA	USA	USA	USA
	FINANCE	ENG	SUPT	SB	FACILITY	SUPT	DEP
	DIRECTOR			CHAIR	MGT		SUPT
2. Initial Cost	10	10	10	10	8	9	10
4. Operating Cost	5	10	7	7	8	5	5
1. Life Cycle Cost	3	10	10	7	9	5	8
3. Maintenance Cost	3	10	8	7	7	8	7

FACTOR/RESP.	POL	DEN	FRAN	GER	SUM	AVE
	UNI	ENG	ENG	UNI		
2. Initial Cost	10	9	9	8	103	9,4
4. Operating Cost	7	9	8	8	79	7,2
1. Life Cycle Cost	5	5	6	10	78	7,1
3. Maintenance Cost	5	8	7	6	76	6,9

5.3. Attachment D-3. UNITED STATES OF AMERICA RESPONSES TO IMPORTANCE OF FACTORS

QUESTION **D** **What importance do you place on the cost related factors in making a decision on whether or not to use energy efficient systems or matierals in design to retrofit or construct new?**

FACTOR/RESP.	USA	USA	USA	USA	USA	USA	SUM	AVE
	FINANCE	SUPT	SB	FACILITY	SUPT	DEP		
	DIRECTOR		CHAIR	MGT		SUPT		
2. Initial Cost	10	10	10	8	9	10	57	9,5
1. Life Cycle Cost	3	10	7	9	5	8	42	7,0
3. Maintenance Cost	3	8	7	7	8	7	40	6,7
4. Operating Cost	5	7	7	8	5	5	37	6,2

5.4. Attachment D-4. INTERNATIONAL RESPONSES TO QUESTIONNAIRE ON IMPORTANCE OF FACTORS

QUESTION **D** **What importance do you place on the cost related factors in making a decision on whether or not to use energy efficient systems or matierals in design to retrofit or construct new?**

FACTOR/RESP.	FIN	POL	DEN	FRAN	GER	SUM	AVE
	ENG	UNI	ENG	ENG	UNI		
2. Initial Cost	10	10	9	9	8	46	9,2
4. Operating Cost	10	7	9	8	8	42	8,4
1. Life Cycle Cost	10	5	5	6	10	36	7,2
3. Maintenance Cost	10	5	8	7	6	36	7,2

Chapter 2

Evaluation of Questionnaire on the Energy Consumption of Educational Buildings

by

Heike Kluttig
Fraunhofer Institute of Building Physics, Germany

Table of Contents

1. Summary

The questionnaire is dealing with the energy consumption of existing educational buildings for heating, domestic hot water and electrical power. To compare the values of different countries information on the specific climate was needed. All ten participating countries (Denmark, Finland, France, Germany, Greece, Italy, Norway, Poland, the United Kingdom and the USA) respectively their nominated experts gave input to the questionnaire. Yet some values could not be given until now because of missing information in the countries. The questions on the energy demand were devided into educational buildings as a whole, universities, schools and nursery schools.

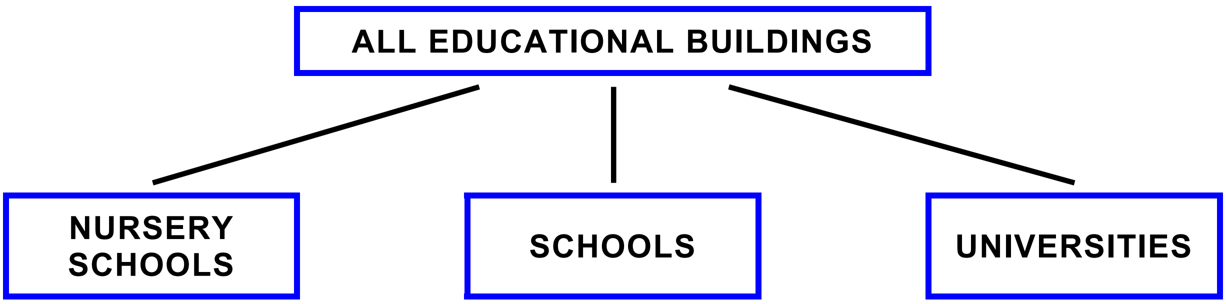

Figure 1: Classification of educational buildings in the questionnaire on the energy consumption.

2. Weather Conditions

The average outside temperature during the heating period of the replying countries differs from 1 to 13 °C with Norway as the coldest and Greece as the warmest country. During the summer the average outside temperature varies from 14 to 24 °C. The average horizontal radiation during the heating period is beween 40 kWh/m²mth. and 75 kWh/m²mth. with France having the highest radiation and the UK the lowest. In the summer time the average radiation is between 120 and 200 kWh/m²mth.

Data		Unit	Country									
			DK	SF	F	D	GR	I	N	PL	UK	USA
Mean tempe-rature	heating period	°C	3	1,7	6	6,2	13	8,3	0,8	4	6,5	
	non-heating period	°C	14,3	16	17	17,4	24	20,1	14,9	17	15,3	
Mean horizontal radiation	heating period	kWh / m²mth.	45		75	68	74	71	38	46	40	
	non-heating period	kWh / m²mth.	140		197	169	172	165	150	135	120	
Heating degree days	value	Kd	2800		2600	3500	1200	1900		4000	1856	4128
	range	Kd	2700-3000		1500-3000	3300-4000	800-2000	568-5165		3650-4580	1512-2110	506-8601
	internal temperature	°C	17		18	20	18	20	17	20	?	18,3
	maximum outside tem-perature for heating days	°C	spring: 10 autumn: 12		<18	15 new: 12/10	?	<12	spring: 10 autumn: 12	12	15,5	18,3
	speciality	-	correc-tion		-	-	-	3 cons. days			1.9.-30.4.	-
Cooling degree days	value	Kd	not used		not used	2660 Kh/a	not used	not used	not used	not used	not used	1410
	range	Kd				-						227-3870
	internal temperature	°C				18/16/14						18,3
	speciality	-				for offices						-

<u>**Tabel 1:**</u> Weather data of the participating countries.

At the meeting in Sophia-Antipolis the participants agreed to give information on heating and cooling degree days. Yet the input showed that the heating degree days are calculated differently concerning the inside temperature and the length of the heating period in most of the countries. Cooling degree days are used in the US and Germany (for offices) only. Due to that this information is not comparable.

3. Heating Energy Consumption

The average heating energy consumption including the space heating and the domestic hot water of all the educational buildings goes from 66 in Greece to 240 kWh/m²a in Poland. The average heating energy consumption of nursery schools differs from 20 to 320 kWh/m²a. Schools have an average heating energy consumption between 45 and 220 kWh/m²a with a mean value of 148 kWh/m²a. Some countries have less data on the heating energy consumption of universities. Six countries gave values between 100 kWh/m²a and 280 kWh/m²a. The range of the energy consumption is very broad for all types and in all countries.

Data			Unit	Country									
				DK	SF	F	D	GR	I	N	PL	UK	USA
Heating Energy Consump-tion (Building + DHW)	all edu-cational buildings	average	kWh/m^2mth	160	125	148	217	66	164	207	240		160
		range	kWh/m^2mth	60-185			85-461	0-110	105-223	86-450	70-435		
	nursery schools	average	kWh/m^2mth	185	177	215	201	20	208	193	330		160
		range	kWh/m^2mth	90-275	66-354		120-322	0-40	146-271		175-435		
	schools	average	kWh/m^2mth	130	131	118	211	45	143	194	220	145	148
		range	kWh/m^2mth	70-220	54-288		88-374	0-60	85-200	86-388	70-406	58-498	
	univer-sities	average	kWh/m^2mth	130		173	227	100		278			200
		range	kWh/m^2mth	60-200			85-461	30-150		110-450			

Tabel 2: Average value and range of the heating energy consumption of all building types in all participating countries.

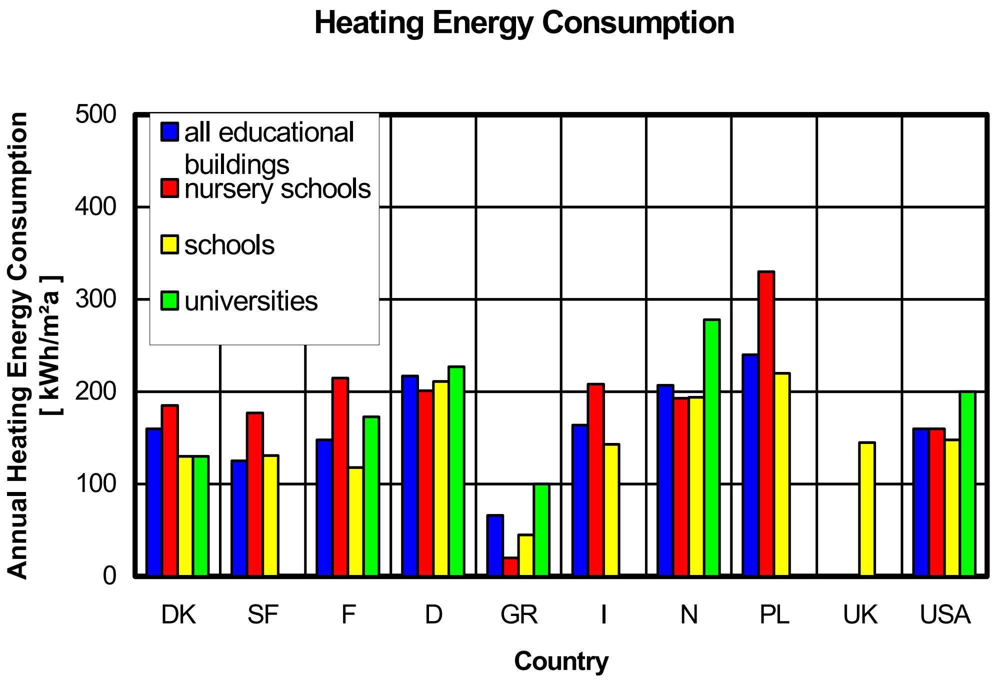

Figure 2: Average heating energy consumption for all building types and countries.

4. Electrical Power Consumption

The electrical power needed for lighting, equipment and HVAC systems for all educational buildings differs from 10 in Italy to 90 kWh/m²a in the US and 176 kWh/m²a in Norway. Please note that in Norway most of the buildings are heated by electricity (water power), so the electrical consumption also includes the heating consumption. In nursery schools electrical power from 13 to 90 kWh/m²a is needed. In most countries schools have an electrical power consumption of about 20 to 30 kWh/m²a with the exception of Italy, where just 9 kWh/m²a is needed, Greece with 15 kWh/m²a, the US with 70 kWh/m²a and Norway. The electrical power consumption of universities differs from 40 to 130 kWh/m²a. The range of the electrical power consumption of universities is not as broad as those of the heating energy consumption. Exception to this rule is the electrical power consumption of German universities. The explanation for that is that the German values for universities don't represent universities as a whole but certain buildings including for example external research labaratories for animals and plants.

Data			Unit	Country									
				DK	SF	F	D	GR	I	N	PL	UK	USA
Electrical Power Consumption	all educational buildings	average	$\frac{kWh}{m^2mth.}$	45	29	26	57	36	10	176	25		90
		range	$\frac{kWh}{m^2mth.}$	15-90			2-273	10-55	10-11	73-382	2-50		
	nursery schools	average	$\frac{kWh}{m^2mth.}$	50	72	21	22	15	13	170	30		90
		range	$\frac{kWh}{m^2mth.}$	35-90	3-90		6-46	10-20	12-13		8-50		
	schools	average	$\frac{kWh}{m^2mth.}$	30	27	25	20	30	9	172	24	30	76
		range	$\frac{kWh}{m^2mth.}$	15-45	12-63		6-46	15-35	9-10	76-344	2-35	15-105	
	universities	average	$\frac{kWh}{m^2mth.}$	40		54	82	45		198			134
		range	$\frac{kWh}{m^2mth.}$	20-45			2-271	30-55		78-320			

Tabel 3: Average value and range of the electrical power consumption of all building types in all participating countries.

Electrical Power Consumption

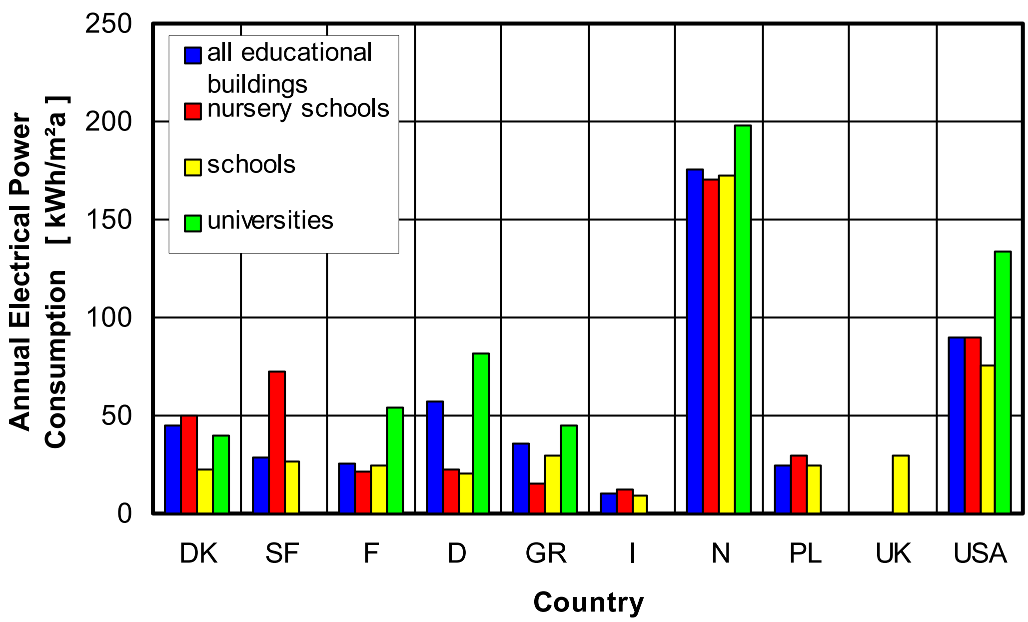

Figure 3: Average electrical power consumption for all building types and countries.

5. HVAC-Systems

The ratio of the mechanically ventilated and airconditioned educational buildings in their country was estimated by the experts. In some countries (Finland, USA) up to 50 % of the educational buildings are mechanically ventilated. In Germany, Greece, France and the UK only 10 to 18 % were estimated, Italy has less than 1 % mechanically ventilated buildings. The ratio of air-conditioned buildings is between 1 % in Italy and 50 % in Finland and the USA.

Data	Unit	Country									
		DK	SF	F	D	GR	I	N	PL	UK	USA
Ratio of mechanically venti-lated educational buildings	%	40	50	17	10	10	1			17,5	50
Ratio of air-conditioned educational buildings	%	0	50	2	3	2	1			5	50

Tabel 4: Average value and range of the heating energy consumption of all building types in all participating countries.

6. Result

The climatic influence on the energy consumption concerning both heating and electricity (incl. cooling) is rather significant. In some countries the use of mechanical ventilating or cooling systems is wide-spread. This leads to significantly higher electrical power consumptions. Yet the broad range of heating energy consumption values in each country shows the common need to retrofit. Since some countries have also further intentions when retrofitting an educational building besides reducing the energy demand e.g. improving the indoor air quality, the targets for the retrofit in this Annex should be variable by country and special existing problems.

Chapter 3

Review of National Requirements and Design Guidelines for Energy and Environmental Issues in the Refurbishment of Educational Buildings

by

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Architects & Building Branch, United Kingdom,

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Table of Contents

Information was received from the following organisations:

Austria	Dipl.Ing. Wibke Tritthart	Interuniversitaeres Forschungszentrum fuer Technik, Arbeit und Kultur Inter-University Research Center for Technology, Work and Culture
France	Dominique Caccavelli Véronique Richalet	Centre Scientifique et Technique du Batiment (CSTB) ENTPE/LASH
UK	Richard Daniels	Department for Education & Employment (DfEE)
Germany	Heike Kluttig	Fraunhofer Institute of Building Physics
Denmark	Kirsten Engelund Thomsen and Ove Mørck	Danish Building research Institute/ Cenergia
Finland	Timo Kauppinen	VTT Building Technology
Italy	Umberto Di Matteo And Eliana Pescatore	ENEA
Poland	Tomasz Mroz	Poznan University of Technology
United States of America	Lorenz (Larry)V. Schoff	US Dept of Energy, Oak Ridge National Labs, Rebuild America

A series of questions and tables asked for the basic information from participating countries. This summary of the questions and answers of participating countries includes tables on the main parameters. These tables are included as spreadsheets in an excel workbook which is available for further development as a basis for design parameters. Requirements are shown in bold type whereas guidelines are in normal type (country representatives are asked to check this classification and send alterations to Richard Daniels).
A CEN technical note has been published PD CR 1752:1999 entitled Ventilation for buildings - Design criteria for the indoor environment. This gives parameters for a category A, B or C building depending on the percentage of people dissatisfied. Taking Category C as being appropriate for a refurbished building these parameters have been included in the spreadsheets for information.

1. Regulations for Construction of Educational Buildings

Austria: Guidelines of the Austrian Institute of Standards are generally followed not only for educational buildings. There are guidelines referring to insulation, thermal mass and overheating in summer (ÖNORM B 8110/1 and B 8110/3). The Austrian Institute for the Construction of Schools and Sports Facilities recommends in its guidelines (draft version 1998) a heating energy demand of less than 25 $kWh/m^3/y$ for new buildings. Schools should be daylit and ventilated naturally by windows. There should be no mechanical cooling because of the energy costs.

UK: The School Premises Regulations 1999 give the minimum standards which apply to both new and existing buildings. All new educational buildings must comply with the national Building Regulations which are enforced by local authority building control officers. The Building Regulations quote some DSES Building Bulletins as compliance documents, eg. BB87 and BB93.

France: The Code for Civil Construction covers new buildings, extensions to buildings, conversion of and other alternatives to buildings and any changes in the use of buildings that are significant in relation to the building regulations. Educational buildings must comply with the general code of Building and Housing, the Code of work and the Security Regulation against fire and panic risks for public buildings. Although the general code for Building and Housing is applicable to new buildings together with extension of existing buildings, it is often referred to in the case of an old building retrofitting. Note that the thermal regulation that will be applicable on the 1st June 2001 is now valid for other buildings than housing with same level of requirements as it used to be for housing in the previous regulation.

Germany: For all new buildings an application has to be made to the authorities. Within this application is a "Wärmeschutznachweis" =the proof that your building has an energy demand below a certain level calculated following the Wärmeschutzverordnung. You have to meet a lot of other regulations =DINs. Some of them are listed below.

Denmark: Educational buildings must comply with the Building Regulation (BR 95) of the Danish Building and Housing Agency. BR 95 covers construction of new buildings, extensions to buildings, conversion of and other alternatives to buildings and any changes in the use of buildings that are significant in relation to the provision of the building regulations, together with demolition of buildings.

Finland: New buildings - National Building Code of Finland. There are some special requirements for schools (indoor climate, ventilation, resistance to the passage of sound, fire class and fire load).

Italy: The Building Energy Regulation for new buildings covers construction of new buildings, extensions to buildings, conversion of and other alternatives to buildings and any changes in the use of buildings that are significant in relation to the provision of the Building Regulations. If the building authorities have to give a permission to renovate, before starting the works, the Building Regulations demands have to be fulfilled. All educational buildings in Italy - nursery, elementary and high school, apart from university buildings - are regulated by the D.M. 18/12/1975. It contains prescriptions about the localisation of the area, dimensions of the building (using different indexes), collocation of schools in already existing buildings and, not the least, the technical standards for the building. Concerning interventions of retrofitting, we have to apply to the Law. 10/91, which refers to all kinds of buildings.

Poland: All new buildings, including school buildings have to match Building Regulations (Polish National Act No 10/95 & 132/97). Additionally primary schools have to be constructed according to Primary School Design Guidelines issued by the National Department of Education: IW1/TG/3832/2111-3/83: Primary School Buildings Regulations;
DE-3/2121-3/90: Primary School Buildings Regulations - Modifications.

United States of America: In the United States each state and in some instances locality can establish its own building code and standards. There is a minimum code established but it is always exceeded in construction and renovation. Most building officials and most new codes require that when an existing facility is renovated that it be brought up to current standards. That is true of the Americans with Disabilities Act (ADA) which requires that all buildings when modified be brought up to current standards for the disabled. The Federal government has several standards in the area of Indoor Air Quality in schools that impact renovations. These include Removal of Asbestos, Control of lead in paints and radon controls. The enforcement and control of the standards normally occurs through the local building officials and some inspections by state officials. State or Federal officials do not get involved unless there is a complaint.

2. Standards applicable to refurbishment work

UK: Building Bulletin 87 gives the recommended standards for lighting, ventilation, hot and cold water supplies and energy (carbon dioxide) targets. School Buildings must comply with Building Regulations. Their status is not mandatory for existing buildings but DfEE expect designers to follow them as far as possible in refurbishment work. Other standards that apply are the Workplace (Health, Safety and Welfare) Regulations 1992, and the Workplace(Fire Precautions) Regulations, 1997. The minimum standards given in the School Premises Regulations apply to all schools.

France: No standard is applicable for the thermal requirements but for acoustics, lighting, and security of people inside public buildings.

Germany: Wärmeschutzverordnung=Regulation of heating protection. A separate table shows which u-values you have to meet when you are retrofitting parts of the external surfaces Heizanlagenverordnung: Regulation of heating systems. Your heating system has to meet a decreasing level of emission. Otherwise you have to exchange the system.
DIN 4108 Mindestwärmeschutz=lowest level of thermal insulation (u-values) for not getting moisture problems

Denmark: DS 418: *Dansk Ingeniørforening´s Rules for the Calculation of Heat loss from Buildings*. The rules provide a simple and practical method for assessing heat losses, suitable for the design of requisite heating plant.
DS 700: *Artificial lighting in workrooms*.

Finland: It is recommended to apply the National Building Code of Finland in renovations, but it is not compulsory. Old buildings have to be healthy and suitable for purpose.

Italy: There are not particular rules, only law 10/91 provides to give a financial contribute only if there's an increase of thermal resistance of walls equal to $R=a\Delta t$, where a is the coefficient:

attic	a= 0.1
Roof & arcade	a=0.04
Insulated wall	a=0.04
Internal insulated wall	a=0.04

and ΔT is the temperature difference.

Poland: Basically there are no special standards for school refurbishment. Again retrofitted schools have to match Building Regulations and Polish Code No PN-91/B-02020 (Thermal Protection of Buildings).

3. GUIDELINES SPECIFIC TO SCHOOLS AND OTHER BUILDING TYPES AND GUIDELINES FOR ALL BUILDING TYPES

UK: Schools are included in the scope of normal building control arrangements, i.e., in compliance with the National Building Regulations issued by the Department for Transport, Local Government and the Regions.

France: There are separate guidelines for schools. Specific guidance is concerned with acoustics in educational buildings and some specific guidelines have been published concerned with lighting, or security in educational buildings.

Germany: The guidelines apply to all building types. In some regulations there are specific requirements, for example, for daylight-coefficients or ventilation levels. Others present values you have to use for internal gains, etc.

Denmark: In BR 95 schools are specifically mentioned. Furthermore in *Guidance concerning the indoor climate in schools,* (1972 guidance), in Danish.

Finland: Some special requirements for schools (indoor climate, ventilation, resistance to the passage of sound, fire class and fire load).

Italy: Specific guidelines concerning educational buildings are:
- the D.M. 18/12/1975
- the Law n. 23 of 11/01/1996;

the second nominate is still expecting the emanation of the new technical requirements.

General guidelines concerning:

- the passive requisites for buildings, D.P.C.M. 05/12/1997
- regulation of interventions on buildings with the aim of consumption reduction, D.P.R. 26/08/1993 (putting into effect the L. 10/01/1991) and , D.P.R. 21/12/1999

Poland: There are specific regulations for primary schools (issued by the National Department of Education) concerning the design guidelines.

4. Guidance from Local Authorities or municipalities, Government Departments

UK: DfES, Architects and Building Branch and BRECSU at the Building Research Establishment. Some Local Authorities produce standard design briefs, eg, for primary and secondary schools.

France: Agency for the promotion of energy saving, CSTB, Association of HVAC engineers.
Apart the above mentioned text, the Rhone Alpes region produced a document covering the general technical design guidelines and the sustainability in educational buildings. This document is nowaday distributed to any designer concerned with building a new high school or refurbishing an old one.

Germany: Yes. For example, the town of Stuttgart has made an "Energieerlaß"=energy decree in which new buildings, paid for by the town have to need 25 % less energy than the energy level of the Wärmeschutzverordnung. This decree is not specially made for educational buildings, but for all public buildings in Stuttgart.
For universities (paid for by the federal countries) there is no special design guidance but the Wärmeschutzverordnung.

Denmark: Only BR-standards

Finland: The Ministry of the Environment, The Ministry of Social Affairs and Health, The Ministry of Education

Italy: The only one is the Public Works Government Department which promulgated a technical standard (D.M. 18/12/1975)
There are also technical norms as follows:
Heating, cooling and ventilation : UNI 10344 - UNI 10345 - UNI 10346 - UNI 10347 - UNI 10348 - UNI 10349 - UNI 10351 - UNI 10355 - UNI 10376 - UNI 10379 - UNI 10389 – UNI 7357 - UNI 10399.

Poland: Yes, Government Education Department via Local Authorities.

5. Guidance from Local Authorities or municipalities, Government Departments concerning refurbishment

UK: Some publications focus on refurbishment, eg, DfEE Building Bulletin 73, *A guide to energy efficient refurbishment* and BRECSU guide 233, Energy efficient refurbishment of schools.

France: Same documents as above, referred to as guidelines in the case of refurbishment works.

Germany: Nothing special. When doing any retrofit you have to fullfill the "Wärmeschutzverordnung", that means for existing buildings your buildings have to have u-values lower than some values listed.
Refurbishments can be started by different causes: 1. Change of use; 2. Toxic substances;
3. Inspection of buildings; 4. Complaints by the user.

Denmark: No.

Finland: The Ministry of Social Affairs and Health, The Ministry of Education.

Italy: As for new buildings above.

Poland: No. Only General Standards (Polish Code No PN-91/B-02020)

6. Guidance for nurseries and crèches

UK: General architectural guidelines are currently being produced in line with the expansion in the provision for under 5 year olds.

France: Same as above.

Germany: No
Denmark: Standards for new buildings in general.
Finland:

Italy: Always in the D.M. 18/12/1975, point 3.1.1, there are described the spaces for nursery schools referring to pedagogical and didactical aspects. In Italy the nursery school is structured in sections (min. 3 - max. 9) and each section is composed by three different spaces for different activities. Besides the sections, there are the kitchen, the mensa and a room for the teachers.
The technical parameters are the same as for the other school-types.

Poland: No.

7. Guidelines for universities and colleges of further education i.e. post school

UK: very little available

France: Same as above.

Germany: No

Denmark: Standards for new buildings in general

Finland:

Italy: There are not specific guidelines.
Standards for new buildings are compulsory.

Poland: No, they have to match general standards (Building Regulation).

Can you briefly quote your guidelines for the following(or quote references):

8. Guidelines for acoustic performance

See Table 1 for review of all national acoustic parameters.

Austria:
The Austrian Institute for the Construction of Schools and Sports Facilities guidelines(draft 1998) referring to and in addition to ÖNORM B 8115 of the Austrian Institute of Standards):

UK: Building Bulletin 93 for schools;
British Standard 8233: 1987: *Code of Practice for sound insulation and noise reduction for buildings, Section 3, Part 9, Educational Buildings* for other educational buildings.

France: *RA 88*: Recommandations du Ministère de l'Education Nationales – Cahier des prescriptions techniques (1978, 1987) (Replaced in 2002).
Minimum sound insulation for facade 47 dB(A) for exposed zone and 35 dB(A) for lower exposed ones (Decree of January 1995 the 9th)

For partition walls:
44 dB(A) between ordinary classrooms
52 dB(A) if resting room, music room, meeting room …
56 dB(A) if noisy technic room
Reverberation time (500-2000 Hz)
0.4 s < Tr < 0.8 s for ordinary rooms

0.6 s < Tr < 1.2 s for nursery and library, music room and large enclosure > 250 m^3
(Guidance of January 1995 the 9th gives the above sound insulation values measured in situ that is, D expressed in dB(A). In the coming months $D_{nT,w}$ values will be used.)

Germany: Regulations for schools and other educational buildings are contained within:
DIN EN 12354 Bauakustik - Berechnung der akustischen Eigenschaften von Gebäuden aus den Bauteileigenschaften=Acoustic for buildings - Calculation of acoustical qualities of buildings by the quality of components
DIN 4109: Schallschutz im Hochbau=Sound insulation/protection in buildings; requirements and verifications (1989).
DIN 1946, P. 2: DIN 1946, Part 2: Ventilation and air conditioning; Technical health requirements (VDI ventilation rules), 1983.
Impact sound pressure level for technical installations
classrooms/lecture halls: 35 - 40 dB(A)
Bundeslärmschutzverordnung=Regulation of noise protection
Limit of traffic noise reduction:
Schools: >=57 dB
housing: >=59 dB

Denmark: BR 95: Building Regulations. Danish Building and Housing Agency.

Finland: National Building Code of Finland C1.

Italy: DM 18/12/1975– "Norme tecniche aggiornate relative all'edilizia scolastica, ivi compresi gli indici minimi di funzionalità didattica, edilizia ed urbanistica".
Legge 26 ottobre 1995 n. 447 - "Legge quadro sull'inquinamnerto acustico"
D.P.C.M. 5 dicembre 1997 – "Determinazione dei requisiti acustici passivi degli edifici".
Figures from D.M. 18/12/75, pto. 5.1.2:
Acoustics and resistance to the passage of sound
Sound level Differences:
Vertical inside walls ≥ 40 dB
External windows ≥ 25 dB
External air points (passive vents) ≥ 20 dB
External doors ≥ 35 dB
Sound between adjacent rooms ≥ 40 dB
Sound between overhanging rooms ≥ 42 dB
Normalised Impact sound transmission (trampling sound) ≤ 68 dB
Maximum background noise levels:
Intermittent working services ≤ 50 dB
Continuous working services≤ 40 dB

Poland: National Department of Education School Design Guidelines. IW1/TG/3832/2111-3/83: Primary School Buildings Regulations; “The rooms being the source of sound disturbances should be acoustically insulated" DE-3/2121-3/90: Primary School Buildings Regulations - Modifications. Internal sources: service installations < 35 dB

USA: Draft code in existence in support of Americans with Disabilities Act recommendations for classrooms to be published in the next year quote:
Background noise level of NR 30-35 which is roughly equivalent to an $L_{Aeq,1hr}$ level of 35 - 40 dB(A).
Reverberation time 0.4 to 0.6 seconds
Signal to noise ratio of +15 dB.
Local Building code may have requirements.

European: CEN CR 1752:1999: The standard gives a table of permissible A-weighted sound pressure levels generated and/or transmitted by the ventilation or air conditioning systems: The category C ratings taken from the table are reproduced in table 1.

9. Guidelines for Lighting Levels

See table 2 for review of all national lighting and daylighting parameters.

Austria:
Installed illuminance levels are recommended for various types of space and for exterior lighting (see Table 2). The uniformity of the illuminance is specified as:
Uniform distribution of illuminance: $E_{minimum}$ to $E_{average} \leq 1:1.5$
Maximum ratio of luminances of adjoining areas 5:1, of two areas within the field of view 100:1, reflective index of the ceiling at least 70%, of the floor 20%, of furniture and partition walls 30%.
There are further recommendations referring to the colour and to the lighting for VDU (visual display) work spaces in accordance to the ÖNORM-guideline O 1040.

UK: Information from BB87 and Building Bulletin 90: *Lighting design in schools*, included in table 2.

France:
- Minimum lighting levels
  400 lux on desks
  400 lux on blackboards
  But Working code gives higher figures of 500 lux on desks and 625 lux on blackboards+ some other comfort criteria.
- Lighting of general teaching areas:
  Minimal DLF > 1.5%
  Or window area > 25% of biggest facade area (Decree N°83.722)
  Norm NF C 71-121 of UTE
  Norm S 40-001 AFNOR

Recommendations for lighting of educational buildings (AFE)

- Specialist task lighting at a higher level:

Same document specifies lighting levels for blackboards
Norm NF X 35-103 Principles of visual amenity applicable to lighting of working rooms
Norm ISO 9241 for working on computers(+ some other ones)
See table 2 for illuminance levels.

Germany: DIN 5034 Tageslicht in Innenräumen=Daylight in interior rooms DIN 5035 Beleuchtung mit künstlichem Licht=illumination with artificial light DIN 5035, Part 4: Artificial lighting of interiors; special recomendations for lighting of educational interiors, regulations for the rated illuminance of educational buildings 1983.
LBO: Landesbauordnung: Regional Building Code. The window area must be at least 10% of the floor area of the room; in some of the federal states (Bundesländer) even 15 %

Denmark: Lighting installations shall be designed and constructed on the basis of the DS 700 series: Artificial lighting of workrooms and a guide, Good and energy efficient school lighting, in Danish.

Finland:

Italy: The reference is D.M. 18/12/1975, point 5.2.

Lighting of general teaching areas
Artificial lighting: 200 lux (D.M. 18/12/1975, point 5.2.2.)

Specialist task lighting at a higher level
Artificial lighting: 300 lux at the black-board and wall poster as well as in rooms applied to drawing, sewing and embroidery (D.M. 18/12/1975, point 5.2.2.)

Poland: Polish Code: PN-84/E-02033 gives artificial lighting illuminance levels. See table 2.

USA: Varies with type of construction space. Recommend levels in IESNA hand book 1981 Table 2, but local codes can require more.

10. GUIDELINES FOR USE OF DAYLIGHT

Austria: The guidelines of the Austrian Institute for Construction of Schools and Sports Facilities recommend to have a window to floor area ratio of at least 10%. If there is direct sunlight in a class room glare reduction should be taken care of.

UK: BB87 and DfEE, Building Bulletin 90, Lighting design in schools, 1998.

France: Use of daylight
Decree n°83-722 of 2 August 1983 attached to the general Code of Work implies that daylighting should be available when authorized with a recommended daylight factor of minimum 1.5% on desks
Regulations regarding windows and window sizes are due to fire safety. However, it is recommended to have a window area equal to at least 15% of the floor area in rooms with daylight.

Germany: DIN 5034

Denmark: BR 95. Lighting installations shall be zoned with the possibilities of use according to quantity of daylight and activities.
Regulations regarding window and window sizes are due to fire safety. It is though recommended to have a window area equal to at least 10% of the floor area (7% in case of skylights) in rooms with daylight. SBI 182: The Indoor Climate Guide (In Danish). Ove Valbjorn et al.(ed). SBI Direction 182, 1995.

Finland:

Italy: The D.M. 18/12/1975 at point 5.2.5. indicates η mean daylight factors as follows:

- 0,03 for teaching areas
- 0,02 for refectories, gyms
- 0,01 for offices, distribution space, general services

Poland: National Department of Education School Design Guidelines.
IW1/TG/3832/2111-3/83: Primary School Buildings Regulations;
DE-3/2121-3/90: Primary School Buildings Regulations - Modifications.
(Dept. of National Education), gives ratios of window to floor area for:

- classrooms - 1:4 to 1:5,
- service area - 1:6 to 1:8,
- communication - 1:8 to 1:12;

11. Guidelines for Indoor Climate and Indoor Air Quality

Following factors have been included: room temperatures (including type of temperature specified eg, air temp, dry resultant, etc); ventilation; carbon dioxide levels, radon levels, humidity.
See tables for review of all temperature (table 3) and ventilation (table 4) and indoor air quality (table 5) parameters.

Austria:
Indoor climate:
Requirements for air temperature in Winter were formulated in a decision of the Austrian government in the 1980s.

Ventilation:
The fresh air rate in class rooms for under 10-year-old pupils is 15 m^3/h; and for older pupils, 20 m^3/h, during the school hours. This should be achieved with natural ventilation. If mechanical ventilation is inevitable, the air flow velocity should not exceed 0.1 m/s in winter and 0.25 m/s in summer (according to the guideline ÖNORM H 6000/3).
Water/Humidity: Guidelines of the Austrian Institute of Standards refer to the diffusion of vapour through walls to avoid condensation problems (ÖNORM B 8110/2). The Austrian Institute for the Construction of Schools and Sports Facilities recommends to keep the humidity above 30% at 20° and below 55% in the long range (draft 1998).
Carbon dioxide: No limit or guideline for the carbon dioxide level. In a current working group of the Ministry for Education and Science, dealing with Indoor Air Quality, a requirement of 1000ppm or 1500ppm is being discussed. But it is not sure whether this will be a recommendation or a requirement and what the consequences will be when this limit is exceeded. As in other countries, in Austria the CO_2 levels in classrooms are often very high(often over 2500ppm and even higher). The working group will present a result in 1 or 2 years time.

UK:

School Premises Regulations: The heating system shall be capable of maintaining in the areas set out in column (1) of the Table below the air temperature set out opposite thereto, in column (2) of that Table, at a height of 0.5m above floor level when the external air temperature is -1°C:

Area	**Temperature**
Areas where there is the normal level of physical activity associated with teaching, private study or examinations.	18°C
Areas where there is a lower than normal level of physical activity because of sickness or physical disability including sick rooms and isolation rooms but not other sleeping accommodation.	21°C
Areas where there is a higher than normal level of physical activity (for example arising out of physical education) and washrooms, sleeping accommodation and circulation spaces.	15°C

(1) All occupied areas in a school building shall have controllable ventilation at a minimum rate of 3 liters of fresh air per second for each of the maximum number of persons the area will accommodate.

(2) All teaching accommodation, medical examination or treatment rooms, sick rooms, isolation rooms, sleeping and living accommodation shall also be capable of being ventilated at a minimum rate of 8 liters of fresh air per second for each of the usual number of people in those areas when such areas are occupied.

(3) All washrooms shall also be capable of being ventilated at a rate of at least six air changes an hour.

(4) Adequate measures shall be taken to prevent condensation in, and remove noxious fumes from, every kitchen and other room in which there may be steam or fumes.

The Health and Safety Executive guidance given in the Advisory Code of Practice to the Workplace (Health, Safety and Welfare) Regulations 1992 states "The fresh air supply rate should not normally fall below 5 to 8 litres per second, per occupant. Factors to be considered include the floor area per person, the processes and equipment involved, and whether the work is strenuous".

Recommended Constructional Standards as given in Building Bulletin 87 *Guidelines for Environmental Design in Schools*:

During the summer, when the heating system is not in operation, the recommended design temperature for all spaces should be 23ºC with a swing of not more than +/-- 4ºC. It is undesirable for peak air temperatures to exceed 28ºC during normal working hours but a higher temperature on 10 days during the summer term is considered a reasonable predictive risk.
Spaces where noxious fumes or dust are generated may need additional ventilation. Laboratories may require the use of fume cupboards, which should be designed in accordance with DfEE Building Bulletin 88. Design technology areas may require local exhaust ventilation.
All washrooms in which at least 6 air changes per hour cannot be achieved on average by natural means should be mechanically ventilated and the air expelled from the building.

France:

Temperature: Winter T = 19°C. This is the minimum set point value for the heating system but usually requirements for thermal comfort are those of the ISO 7730 norm (-0.5 < PMV < 0.5)
Summer T ≤ Tref where Tref is calculated depending on glazings area, noise exposition, and inertia. (Th-E calc. Rules)
Specific guidelines from the Ministry of Education on room air temperature depending on the use of the room are 19°C for classrooms and 16°C for corridors, workshops and gymnasiums.
SBI 182 uses dry resultant temperatures to specify temperatures and asymmetric radiation. See table 3.

Ventilation:
SBI 182: Air velocity 0.05-0.15 m/s
RS: Réglement sanitaire départemental type gives mechanical ventilation rates:

Nursery	> 10 m^3/h per m^2 floor area
Primary school	> 10 m^3/h per m^2 floor area
Secondary school	> 12 m^3/h per m^2 floor area

Ventilation and fresh air requirements – Department of Health Regulation
- 15 m^3/h for younger pupils
- 18 m^3/h for older students / offices
- 25 m^3/h for specific rooms

Humidity/condensation: No guidelines or rules

Carbon dioxide levels: 1000 ppm is the threshold value used to calculate the ventilation air flow but no standard to limit CO_2 level.

Other contaminants: Asbestos should be eliminated according to text n°96-60 of 19/7/96, and decrees n°96-97 , n°96-668 and n°96-1133. In existing buildings the concentration shall not exceed 5 fibers/litre.

Germany:
DIN 4701 Regeln für die Berechnung des Wärmebedarfs von Gebäuden=Rules for the calculation of the heating energy demand of buildings; VDI 2067 Berechnung der Kosten von Wärmeversorgungsanlagen. Kühlanlagen=Calculation of the costs of heating systems. Cooling systems;
DIN 4108 Wärmeschutz im Hochbau=Thermal insulation in building constructions
Arbeitsstättenverordnung; Regulation of workshop places.

Temperatures:
winter:
indoor air temperature:20 - 23°C
relative humidity: 40 - 60%
air velocity: <=0,15 m/s
summer:
indoor air temperature: <26°C caused by internal gains, with solar radiation a higher temperature is allowed.

Recknagel/Sprenger: Taschenbuch für Heizung + Klimatechnik. Guidelines for heating and air-conditioning engineering. ISBN 3-486-262214-9.
vertical temperature difference: < 2 K/m
maximum temperature of hot ceiling: 35°C
maximum temperature of floor heating system: 29°C
asymmetric to cold services: <= 3 K

Ventilation: DIN EN 832 Wärmetechnisches Verhalten von Gebäuden. Berechnung des Heizenergiebedarfs=Thermal performance of buildings. Calculation of energy use for heating. Residential Buildings
n_{Lmin}=0.5 h^{-1}

DIN 4108-Part 6 Wärmeschutz im Hochbau. Berechnung des Jahresheizwärmebedarfs von Gebäuden=Thermal insulation in building constructions. Calculation of the yearly heating energy demand of buildings
$n_{LStandard}$=0.8 h^{-1}
mechanical ventilation: 0.4-0.56 h^{-1}

DIN 1946- Part 2 Raumlufttechnik. Gesundheitstechnik (VDI-Lüftungsregeln)=Ventilation systems. Health technology (VDI-Ventilation-Rules) - Recommendations:

20 - 60 m^3/hPerson
4 - 20 $m^3/(m^2h)$
classrooms/lecture halls: 20 m^3/hPerson
15 $m^3/(m^2h)$
Carbon dioxide level not to exceed 0.15 percent of the volume (1500ppm), 0.1 percent (1000ppm) is recommended.

Humidity/condensation: DIN 4108, P. 3
By using the u-values of DIN 4108, P. 2 (s. energy) you avoid moisture with normal room temperatures and relative humidity.
In special cases you have to calculate the necessary u-value
For calculating the amount of moisture you have to use:
During the dew period:
outdoors: -10 °C, 80 % rel. humidity
indoors: 20 °C, 50 % rel. humidity
During the evaporation period:
outdoors: 12 °C, 70 % rel. humidity
indoors: 12 °C, 70 % rel. humidity

Denmark:
The Indoor Climate Guide (In Danish). Ove Valbjørn et al. (ed). SBI Direction 182, BR 95 and 1972 Guidance.

Mechanical ventilation (BR 95): For ventilation systems with a constant air output, the annual electricity consumption for air transport must not exceed 2500 J/m^3 of fresh air.
If special building measures are used, eg, larger room volumes per person and provision of several possibilities for airing rooms, including possibilities for cross-ventilation, the requirement of mechanical ventilation may be waived provided a healthy indoor climate can be maintained.
No guidelines or rules for humidity.

Norway:
The following guidelines are taken from an article[2] about the Recommended guidelines for indoor air quality updated recently and published by the National Institute of Public Health:

Tobacco smoke:
Norwegian government has determined by law which rooms should be smoke free and where smoking is permitted. In this context two practical guidelines have been established:
For areas that are supposed to be smoke free: Nicotine concentration not exceeding 1.0 micrgrammes/cubic meter,
For areas where smoking is permitted: Nicotine concentration not exceeding 10 micrograms/cubic meter;

Dampness: excessive or prolonged dampness should not occur;

Mould: Visible mould damage or odour of mould should not occur;

Suggested guideline for house dust mites: 1 microgram DerI allergen/gram dust (50 mites/gram dust);

Radon: At radon concentrations between 200 and 400 Bq/m^3 simple measures should be undertaken. At concentrations above 400Bq/m^3 , measures should be taken even if the costs will be high. Radon concentrations in future buildings should not exceed 200 Bq/m^3

Formaldehyde: suggested guideline 100 micrograms/cubic metre (30 minutes sampling time);

Asbestos: The risk for lung cancer from exposure to asbestos indicates that free asbestos fibres should not be found in indoor environments. A practical guideline is Free asbestos fibres should not be found in indoor air at concentrations above 0.001 fibres/ml air;

Man made mineral fibers: Free MMMF should not be found in indoor air at concentrations above 0.01 fibres/ml air;

Suspended particles: ($PM_{2.5}$) suggested guideline 20 micrograms/cubic metre, (24 hours sampling time);

Carbon dioxide: (CO_2) suggested guideline based on its quality as an indicator for poor indoor air quality 1800microgrammes/m^3 (1500ppm) (maximum value).
"The scientific basis for the CO2-criterion of 1000ppm is on studies of acceptability of air quality for persons entering the room - that is perceptions of non-adapted persons. There is not sufficient or conclusive evidence for effects on health or productivity when controlled for temperature, humidity and other pollutants. Such studies are needed."[3]

Carbon monoxide (CO) suggested guidelines:
10 micrograms/ cubic metre (8hrs sampling time)
25 micrograms/ cubic metre (1hr sampling time)

Nitrogen dioxide (NO_2):
suggested guideline 100 microgrammes/m^3 (1hr sampling time);

Finland:
National Building Code of Finland, D2: Air temperature and effective temperature plus draft characteristic used to determine maximum air velocity from a graph. Maximum velocity increases with space temperature, eg, classrooms < 0.15m/s. See Figure 1 in Building Code D2.
Humidity/condensation: No regulations (guideline: winter 25-45%, summer 30-60%). Carbon dioxide levels: The levels are 1500 ppm and 0800 ppm if CO2-controlled system.

The classification of indoor air is in progress (3 different levels)

Italy:
Temperature/relative humidity: The article n. 4 of D.P.R. 412/93 imposes a restriction on indoor air temperature.
Maximum indoor temperature (for every room) 20 ± 2 °C
Relative humidity (for every room) 45-55% (D.M. 18/12/75 pto. 5.3.11.)

Ventilation and fresh air requirements: The DM 18/12/1975– ”Norme tecniche aggiornate relative all’edilizia scolastica, ivi compresi gli indici minimi di funzionalità didattica, edilizia ed urbanistica”, at point 5.3.12, imposes a minimum ventilation rates.

Indoor Air Quality: There are no Government rules. It’s possible to apply the standard “UNI 10339” that give the procedure to obtain the ventilation rate.

Carbon dioxide levels: No rules.

Other contaminants: No rules.

Poland:

Temperatures: Polish Code, PN-82/02402 gives summer and winter temperatures.
DE-3/2121-3/90 (Dept. of National Education), specifies natural ventilation to be provided for all classrooms and mechanical ventilation provided for:

- chemical labs (exhaust system);
- sport centre (showers, cloak rooms); and
- dining areas.

Ventilation: Polish Code PN-83/B-03430: min. 20 m^3/h person.
Humidity/condensation: No guidelines or rules.

USA and Canada:

Ventilation/IAQ: The minimum standard is to comply with ASHRAE Standard 62-1989. ASHRAE Standard 62-1989 is the current standard (minimum standard) used in the US when dealing with Ventilation for IAQ. This standards sets minimum levels of ventilation (outside air input) per student or occupant. Like any standard that has varied rates or requirements the standard has to be appropriately and correctly applied. There have been instances where the standards have been taken literally and significant energy has been wasted due to oversizing of equipment.
Current requirements:
A classroom has a minimum requirement of 15 cfm or 8 liters/sec per student;
A laboratory -- 20cfm/p or 10 L/s/p;
Auditoriums --15cfm/p or 8 L/s/p; the minimum is 15 cfm or 8 L/s.
It should be noted that in restrooms the requirement is 20cfm or 10L/s continuous.

Carbon Dioxide: levels should be less than 1000 ppm.
Note: ASHRAE Standard 62-1999 has proposed an addendum to reduce minimum classroom ventilation rates for schools from the current 8L/s to 3 L/s per person. There is considerable opposition to this from IAQ experts. It is being proposed by the industry in the interests of energy reduction particularly in extreme climates(eg, Florida or Alaska) where it is a very serious problem to condition large volumes of air. Hence Mr. Larry Schoff's comments about not taking standards too literally.

Radon Levels: in schools should be less than 4pci/L.

Canada:
Reference 1 gives the following information for Canada: Currently there are no regulated standards for IAQ, but certain guidelines have been issued for pollutant exposures and ventilation rates by several government and professional organisations, some of which are shown in Table 1. The only widely accepted national standards addressing the issue are ANSI (American National Standards Institute) and ASHRAE (American Society of Heating, Refrigerating and Air-conditioning Engineers) Standard 62-1999, "Ventilation for Acceptable Indoor Air Quality."
The ANSI/ASHRAE standard establishes minimum outdoor air requirements for ventilation. These requirements are stated in cubic feet per minute (cfm) of outdoor air per person occupying the space, which is called ventilation rates (see Table 2)

Table 1: Guidelines for IAQ pollutants

Pollutant	Concentration	Remarks
Asbestos	0.2 fibers/cm^3	OSHA Standard set in July 1986
Carbon Dioxide (CO2)	800ppm 1000ppm 5000ppm	Ontario Hydro Standard - Workday Average ASHRAE Standard Ministry of Labor Standard (TWAEV)
Carbon Monoxide	5ppm 9ppm 35ppm	Ontario Hydro Standard - Workday Average ASHRAE- Average over 8 hours Ministry of Labor Standard (TWAEV)
Formaldehyde	0.4ppm 1ppm	ASHRAE Standard Ministry of Labor Standard (TWAEV)
Nitrogen Dioxide	3ppm 0.05ppm	Ministry of Labor Standard (TWAEV) Annual national ambient air quality standard (USA)
Ozone	0.1ppm 0.08ppm	Ontario Hydro and Ministry of Labor Standards - Peak Concentration WHO - Criteria Document
Particulates	120mg/m^3 150mg/m^3 260mg/m^3	Ontario Hydro Standard - one hour average National Ambient Air Quality standard - 24 hours average mean (USA) ASHRAE - 24 hours average mean
Radon	4pCi/L 20pCi/L	ASHRAE Standard Health & Welfare Canada

Volatile Organic Compounds (VOC)	1 to 5 mg/m^3	US Environmental Protection Agency guidelines
Microbial Fungi:	<50 CFU/m^3 <150 CFU/m^3 <500 CFU/m^3	2 spices or 3 spices or Agriculture Canada Standard
Others Temperature Relative Humidity	Winter 20-24^{O}C Summer 22-26^{O}C 30-70%	ASHRAE Standard ASHRAE Standard

Table 2: Key Ventilation Rates and Occupancy Levels

The occupancy levels below are those in the ANSI/ASHRAE which correlates these ventilation rates with the maximum occupancy in the net occupiable space, which is likely to be different from fire and safety occupancies required by local codes. The occupancy of schools also varies greatly.

Area	Density of occupation People/1000ft^3	Outdoor Air cfm/person
General Classrooms	35	15
Science Laboratories	25	20
Wood/Metal Shop	20	20
Reception Area	30	15
Office space	6	20

USA

Recommendations to avoid indoor air quality problems[4]:

- provide adequate outdoor air ventilation on a continuous basis (15cfm per student equivalent to 7.08 litres per second per student);
- control the space relative humidity between 30 and 60%; and
- provide effective particulate filtration of the outdoor air supplied via HVAC systems.

Total suspended particulates	<120microgrammes/cubic metre	National outdoor air guideline

Radon: Radon levels in schools should be less than 4pci/litre.
Humidity/condensation: Incorporated in the Local building codes and design of HVAC systems

Japan:

Carbon dioxide levels: Minimum standard of 1500ppm, 1000ppm for acceptable Indoor Air Quality.

New Zealand:
Reference gives the following information:
New Zealand building code requirements[6] for naturally ventilated buildings can be satisfied when openable window area exceeds 5% of the floor area. While this option has remained constant over many years, the airtightness of buildings has increased, occupant management of windows is likely to have changed and design fresh air delivery rates for mechanically ventilated buildings have changed. The standard for mechanically ventilated buildings, NZS 4303 “Ventilation for acceptable indoor air quality”[7] currently calls for 8l/s per person for classrooms with an assumed occupancy of 50 people per 100m^2 floor area.

Total Fungi	<400 cfu/m^3	Biodet Laboratory New Zealand, in-house database, private communication[5]
Total Bacteria	<100 cfu/m^3	Biodet Laboratory New Zealand, in-house database, private communication[5]
Formaldehyde	<0.1ppm	NZS 4303 *Ventilation for acceptable indoor air quality*[7]
Total Volatile Organic Compounds	0.5 mg/m^3	Australian National Health and Medical Research Council, Interim level of concern for volatile organic compounds in air[8]
Carbon dioxide in mechanically ventilated buildings	<1000 ppm	NZS 4303 *Ventilation for acceptable indoor air quality*[7]

European Technical Advice Note: CEN CR 1752:1999:

Operative temperature**:** **(**approximately equal to air temperature in spaces with moderate heating or cooling loads)**:**

Summer: Kindergarten category C: 23.5^{0}C+/- 2.5 ,
Classroom category C: 24.5^{0}C+/- 2.5
Winter: Kindergarten category C: 20^{0}C+/- 3.5 ,
Classroom category C: 22^{0}C+/- 3.

Radiant asymmetry: “Radiant asymmetry may cause discomfort. People are most sensitive to radiant asymmetry caused by warm ceilings or cool walls(windows). Radiant asymmetry is rarely a problem in ventilated/air conditioned spaces, except at high illumination levels and at large window areas.”
Radiant asymmetry for a category C building:

Warm ceiling	<7^{0}C	Cool wall	<13^{0}C
Cool ceiling	<18^{0}C	Warm wall	<35^{0}C

Maximum mean air velocity:
Summer: Kindergarten category C: 0.24m/s,
Classroom category C: 0.25m/s.
Winter: Kindergarten category C: 0.19m/s,
Classroom category C: 0.21m/s.

Ventilation rate:
Kindergarten category C: 2.8 l/s x m^2 ,
Classroom category C: 2.4 l/s x m^2

References and International researchers in the field of ventilation and IAQ in schools:

1. *Indoor air quality solutions for school buildings*, Proceedings of 8th International Conference Indoor Air, 1999, Rishi Kumar, P.Eng. Global Educational & Consulting Services, Mississauga, Ontario, Canada

2. *Revised guidelines for indoor air quality in Norway*, Proceedings of 8th International Conference Indoor Air, 1999, R.Becher[1], J K Hongslo[1],J V Bakke[2], J F Kvendbo[3], T Sanner[4], P E Schwarze[1] and E Dybing[1]

[1] National Institute of Public Health, Department of Environmental Medicine
[2] Directorate of Labour Inspection
[3] Trondheim municipality
[4] The Norwegian Radium Hospital, Department of Environmental and Occupational Medicine.

3. State-of-the-art report on requirements and recommendations for indoor climate in schools. A report to the Norwegian asthma and allergy association and the Norwegian Teachers Association, J V Bakke, The Labour Inspection, Norway, Proceedings of 8th International Conference Indoor Air, 1999.

4. *Causes of Indoor Air Quality Problems in Schools, Summary of scientific research*, 1998, Prepared by the Energy Division, Oak Ridge National Laboratory for the US Department of Energy.

5. Indicators of natural ventilation effectiveness in twelve New Zealand schools, MR Bassett[1] and P Gibson[2], Proceedings of 8th International Conference Indoor Air, 1999

[1] Building Research Association of New Zealand
[2] Paragon Health and Safety Ltd New Zealand

6. Building Industry Authority of New Zealand. 1998. *New Zealand Building Code, Approved Document G4, Ventilation.* Wellington.

7. New Zealand Standard NZS 4303:1990 *Ventilation for Acceptable Indoor Air Quality*. Standards New Zealand, Wellington.

8. Australian National Health and Medical Research Council NHMR. 1993. *Interim level of concern for volatile organic compounds in air,* Journal of Occupational Health and Safety - Australia and New Zealand, 9(3).

12. Guidelines for air tightness

UK:
Building Regulations require test results for new buildings, showing an air permeability not greater than 10 cubic metres per hour per square metre of external surface area ($m^3/h/m^2$) at an applied pressure of 50 pascals.

France:
< 0.2 Vol.h over the heating period
New thermal regulation for new buildings implies that permeability does not exceed 1.2 m3/h par m² of facade under differential pressure of 4 Pa
Not yet applicable (1st June 2001) but probably not.

Germany:
DIN EN ISO 9972 Wärmeschutz Bestimmung der Luftdichtheit von Gebäuden. Differenzdruck-Verfahren=Thermal Insulation. Determination of airtightness. Fan pressurisation method DIN EN 832: Very rarely measured during construction. Measured by the blower-door-method.

Denmark: No standard.

Finland: No requirements.

Italy:
The UNI 7979 norm defines 3 type of window tightness:

WINDOW TIGHTNESS (UNI-EN 42)

Class	Lost at 100 Pa (m^3/hm^2)
A1	≤ 50
A2	≤ 20
A3	≤ 07

Measurement during construction:
The DM 18/12/1975– "Norme tecniche aggiornate relative all'edilizia scolastica, ivi compresi gli indici minimi di funzionalità didattica, edilizia ed urbanistica", at point 5.3.5, imposes a working progress controls. These controls are : a) conformity control, b) air tightness control.

13. Thermal transmission (Maximum U-values)

See table 6 for review of all national u-values.

Austria:
In Austria there are minimum requirements concerning the U-value of various parts of a (new) building. These requirements have to be fulfilled also during major renovation of buildings. In this case there has to be an approval by the local department of building inspection.

UK:
New educational buildings must comply with Building Regulations (BR) Part L which gives maximum U-values for new buildings and retrofitting existing buildings. Required to improve the U-values as close as possible to the standard for new buildings.

France:
RT 88: Arrêté du 6 mai 1988 – Energy saving regulation in educational buildings.
Guidance of 30th November 2000 for new buildings - Calculation rules ThC:
$U \leq Uref+30\%$, where U is the overall heat loss coefficient of the building and Uref is calculated depending on the area of various envelope components.

Minimal req. on U values:

<u>Roofs</u>	<u>Walls</u>
0.47 W/m²K	0.47 W/m²K
0.30 W/m²K if attic	
<u>Glazing</u>	<u>Floor</u>
2.9 W/m²K	0.36 W/m²K if outside
	0.43 W/m²K if crawlspace

A new thermal regulation will be applicable after the 1st June 2001;

Germany:
German regulations (Wärmeschutzverordnung) do not have maximum u-values for new buildings but maximum heating energy demand.
For existing buildings: DIN 4108 PT 2: Mindestwärmeschutz=lowest level of insulation.
New Buildings: Wärmeschutzverordnung, (WSVO 95); maximum level of heating energy demand for buildings dependent on the ratio of exterior surface to volume: Between 54 and 100 kWh/m²a.
Renovated Buildings / retrofits: **Wärmeschutzverordnung, (WSVO 95);** maximum u-value for exterior surfaces.

Denmark: See BR 95. There are three ways to fulfil the BR:
a) use of mentioned U-values and limited window area;
b) maximum permissible heat loss (change of U-values and areas); or
c) maximum thermal energy required for ventilation and heating.
The building must be made of such materials, construction and in such a way regarding thermal insulation that acceptable health conditions are ensured.

The u-values may be changed and areas of windows etc, increased provided this does not result in higher heat losses than the following requirements: the total energy required for space heating and ventilation per m^2 heated floor area must not exceed 250 MJ/m^2.

Finland: National Building Code of Finland C3.

Italy: The building must be made of such materials, constructions and in such a way that regarding thermal insulation acceptable health conditions are ensured. (D.M. 18/12/75, pto. 5.3.7.)
The law D.M.I.C.A. 2 april 1998 allows the material manufacturer to certificate their own materials if these have thermal proprieties that may reduce energy consumption.
D.M.I.C.A. 2 april 1998 also gives U-values for external walls, ceiling or roof constructions to open spaces. See Table 6 of the Appendix.
D.M. 18/12/75, pto. 5.3.8. gives U-values for windows
D.M. 18/12/75, pto. 5.3.9. gives a composite U-value for a Wall with window's area ≥ 50% of U ≥ 1.16 W/m^2K (independent of mass of the wall)
D.M. 30.7.86 allows the U-values to be changed and areas of windows, etc, increased provided this does not result in higher heat losses than the following requirements: the total loss power required for space heating and ventilation per m^3 heated volume per Δt must not exceed the following values (see table 1).

Table. 1 Maximum values of Cd in W/m^3K required by DM 30.7.86
S= is the total loss surfaces
V= is the heated volume.
S/V small means a typology as like a tower while an high value means a typology as like a house.

S/V	**Climatic zone**									
	A	**B**		**C**		**D**		**E**		**F**
	degrees day	degrees day		degrees day		degrees day		degrees day		degrees day
	to 600	601	900	901	1400	1401	2100	2101	3000	over 3000
≤ 0.2	0.49	0.49	0.46	0.46	0.42	0.42	0.34	0.34	0.30	0.30
≤ 0.9	1.16	1.16	1.08	1.08	0.95	0.95	0.78	0.78	0.73	0.73

There are two controls:

a) use a U-value for roofs, walls, windows, floors in accordance with the parameters quoted in Table 6; These values arise from an old conception of energy saving; in fact the law is dated 1975. Many old schools are built from very thick blocks of rock of very high thermal conduction. Now it's very difficult to use this kind of "big brick" and many energy designers must respect only the Law 10/91 that imposes a limit on the combined thermal heat loss due to heat transmission through the building fabric & the ventilation heat loss.
b) maximum permissible value of total power required for space heating and ventilation per m^3 heated volume per Δt (Cd limit). D.M. 30/07/1986.

Poland:
National Act N° 132/97 (Dept. of Internal Affairs and Administration).

14. ENERGY PERFORMANCE TARGETS

See table 7 for review of all national energy targets

Do you have energy consumption targets/benchmarks?

Austria:
The Austrian Institute for the Construction of Schools and Sports Facilities recommends in its guidelines (draft version 1998) a heating energy demand of less than 25 kWh/m^3/y for new buildings.

UK:
Yes for schools, see BRECSU Energy Consumption Guide 73, *Saving energy in schools, a guide for headteachers, governors, premises managers and school energy managers* and BB87 target graphs. Other BRECSU publications refer to higher education.

France:
Yes for new buildings, the primary energy consumption should not exceed a reference value. Regulation for new buildings(Decree n°2000-1153): C ≤ Cref
Where C is the conventional consumption of the building and Cref its target value.

Germany:
Wärmeschutzverordnung: maximum heating energy demand depending on the surface/volume-ratio: between 54 kWh/m²a and 100 kWh/m²a.
VDI 3807 Energieverbrauchskennwerte für Gebäude. Heizenergie- und Stromverbrauchskennwerte =Characteristic values of the energy consumption of buildings. Characteristic values of the heating and electricity consumption. Here are presented values in which you can range your buildings.

Denmark:
BR 95 - maximum thermal energy required for ventilation and heating. The total energy required for space heating and ventilation per m^2 heated floor area must not exceed 250 MJ/m^2.

Finland: No.

Italy: D.M. 30/07/1986: maximum permissible value of total power required for space heating and ventilation per m^3 heated volume per Δt (Cd limit).
UNI 10344, UNI 10379: this standards give the procedure to calculate the maximum value of total energy required.

Poland:
Yes: Annual energy consumption cannot exceed:

E_0= 29 kWh m^{-3} a^{-1}; A/V 0.20

E_0= 26.6 + 12 × (A/V) kWh m^{-3} a^{-1};
0.20<A/V< 0.90

E_0= 37.4 kWh m^{-3} a^{-1}; A/V 0.90

USA:
US Dept. of Energy has a Model Energy Code that has been adopted by states but is not a requirement. ASHRAE 90.1 is a design guideline.

15. Energy performance calculations

UK: Steady state spreadsheet calculations

France: Steady state spreadsheet calculations;
The primary energy consumption is calculated according to the new thermal regulation ThC 2000 (as kWh primary energy use for heating, domestic hot water and electricity for lighting and circulators) and should not exceed a target value, using the same calculation but with reference characteristics for the building (U value, ventilation, Space Heating and Domestic Hot Water systems)

Germany: Wärmeschutzverordnung: A balance is made of transmission losses, ventilation losses, internal and solar gains. The remainder is the heating energy demand of the building.

Denmark: Simplified method of calculation based on monthly mean values for meteorological data, etc. Heat gains from solar radiation, people and the buildings heat-accumulating properties, etc, may be taken into account in the calculation.

Finland: There is a calculation method in the National Building Code of Finland, D5.

Italy: UNI 10379 minimum value of η_g.

Poland: Steady state calculations based on degree-days

16. Use of degree-day based calculations

UK: Yes; 20 year average figures or figures calculated from average monthly dry bulb temperatures.

France: Yes, figures calculated from average decade (10 days) dry bulb temperature. No. Coefficient C results of a monthly balance of heat losses and gains.

Germany: Yes. For the Wärmeschutzverordnung 3500 Kd (average value for Germany)
DIN 4108-6 and VDI 2067: different for each area.

Denmark: No.

Finland: Yes.

Italy: Yes

Poland: Yes.

17. UNITS USED FOR NATIONAL BENCHMARKS

UK: Kwh/$m^2$for fossil fuel and electricity, £/pupil for fossil fuel and electricity and KgCO_2/m^2

France: Coefficient C is expressed into KWh of primary energy (sometimes converted into kWh p.e /m^2). The conversion coefficients for kWh into kWh primary energy is 1 for gas, oil and solid fuels and 2.58 for electricity.

Germany: kWh/m^2a, kWh/m^3.a.

Denmark: MJ/m^2 per year for fossil fuel, kWh/m^2 for electricity and kgCO_2/m^2.

Finland: Kwh/m^3.a.

Italy: No

Poland: Energy benchmark in kWh/m^3.year, Electricity consumption measured in kWh/m^2.year.

18. MONITORING OF ENERGY USE OF EXISTING BUILDINGS

Is energy use of existing buildings monitored?

UK: Yes, usually local education authorities provide this service to schools. Sometimes private contract energy management companies do this and occasionally the schools themselves do it as part of a whole school approach to energy saving.

France: No. Through energy bills, energy use can be derived but there is not a systematic monitoring of energy use (except when a BEMS).

Germany: Rarely. Sometimes in sponsored projects by the government by institutes/universities.
More often by administrations but not so detailed.

Denmark: Large buildings where the total floor area is 1500 m^2 or more should be energy-rated. An approved energy consultant conducts the energy-rating and draws up, or updates the energy plan annually.

Finland: Voluntarily, in part.

Italy: No, it isn't

Poland: No (very seldom).

19. Measures used to reduce electricity consumption

UK: Encourage purchase of energy efficient equipment, eg, computers, see BRECSU publication Good Practice Guide 118 Managing energy use, minimising running costs of office equipment and related air-conditioning.

France: Encourage purchase of energy efficient equipment (eg, compact fluorescent bulbs, computers). Switching off the lights and appliances, but automatic control very little used at present.

Germany: no mechanical ventilation; no cooling; daylight dependent artificial lighting control.

Denmark: Varies from place to place.

Finland:

Italy: Actually it's going on through optimisation of electric contracts.

Poland:

20. Use of separate electricity consumption targets/benchmarks

Do you have separate electricity consumption targets/benchmarks?

UK: Yes; see BRECSU Energy Consumption Guide 73.

France: No.

Germany: Yes. VDI 3087 Energieverbrauchskennwerte für Gebäude. Heizenergie- und Stromverbrauchskennwerte=Characteristic values of the energy consumption of buldings. Characteristic values of the heating and electrical consumption. Here are presented values in which you can range you building.

Denmark: No.

Finland: No.

Italy: Actually we do not have national electricity consumption targets/benchmarks

Poland: No.

21. Management of electrical maximum demand

Do you manage electrical maximum demand?

UK: Yes, and considerable savings on bills result as the electricity companies charge for higher maximum demands.

France: If an electric heating, sometimes. Else no. Depends on the electricity tariffs. Most of the time the French electricity state supplier (EdF) charges for exceeding demands.

Germany: No

Denmark: Don't know

Finland:

Italy: No

Poland: No (very seldom in new office buildings)

22. Minimum standard areas for schools and other educational buildings accommodation or guidelines on floor areas

Austria: The following elements determine the area of classrooms (guidelines of the Austrian Institute for the Construction of Schools and Sports Facilities):

Desks	65×50 cm (6-10 year-olds),
	75×60 cm (10-19 year-olds).

Side distance of desks	55 cm (to other desks or furniture with low height), 65 cm to walls, etc, 100 cm to side blackboard.
Distance of desks (one behind the other)	70 - 80 cm (6-10 year-olds), 80 - 85 cm (10-19 year-olds).

There are also recommendations referring to the angle of view to the blackboard.

UK: DfEE Building Bulletin 82, *Area guidelines for schools*.

France: General teaching areas must have a surface of 1.5 m^2 per person, when effective mechanical ventilation is established. For kindergartens, exists a guide from Ministry of Solidarity (1993) that specifies a mean area between 5.5 m^2 and 8 m^2.
For classrooms ?

Germany: Arbeitsstättenrichtlinie=Rules for workshop places: a working room has to be at least as big as 8 m^2. For each worker (doing work in a sitting position) you need 12 m^3 of air.

Denmark: BR 95 give some minimum volumes for workroom, classrooms and kindergartens. Furthermore minimum areas for canteens are given the same place.
Normal classrooms and similar must have a volume of 6m^3 per person, when effective mechanical ventilation is established (BR 95).

Finland:

Italy: Yes, the reference is D.M. 18/12/1975, point 1.1. outlining the characteristics of a building site destined to be an educational building. Furthermore in point 2. are expressed the general characteristics and the minimum standards of the site area. (see as well tab.2 in the issue)

Poland: National Department of Education School Design Guidelines.

European standard: CEN CR 1752:1999: Classroom or kindergarten: 0.5 persons/m^2.

23. ARRANGEMENT OF BUILDINGS

Italy: D.M. 18/12/1975, point 1.0.2., 3.0.3., 3.0.8: The design concept should create an "homogeneous architectural organism, and not be a simple addition of space". The elevation is limited in relation to the type of school and the edge of the pupils and varies between one and three floors. Exceptions are made in big urban areas were we can find up to four storey buildings. Not allowed are teaching areas facing open or covered court-yards, because of the lighting.

Poland: IW1/TG/3832/2111-3/83 (Dept. of National Education), IW1/TG/3832/2111-3/83: Primary School Buildings Regulations;
Depends on the type of school (number of sections, school location - town/village),
generally: size of the classroom is 60 m^2 per 24 pupils; with min height 3.3 m.

USA: Local building codes will stipulate along with the national fire code the arrangement and spacing of buildings dependent on their use.

24. Area and cost guidelines for new build and refurbishments

UK: Yes, DfEE Area guidelines for schools and Information on Costs and Performance Data.

France: No

Germany: Costs: we have tables and computer programmes for architects with which you can calculate the costs of new build and refurbishment.
EPIQR; Energiediagnose=Energy diagnosis: A programme which can calculate the energy savings and the costs for retrofit.

Denmark: See above. Cost guidelines are individual for the communities.

Finland: To obtain a contribution from the Ministry of Education to build or renovate schools, the costs of building or renovations are limited(FMK/m^2).

Italy: No

Poland: No.

25. Water consumption targets/benchmarks

UK: Only unofficial ones, eg, DfEE 4m^3/pupil.year. Consultant, Price Waterhouse's report *Reducing the costs of water in schools* recommends 2.8m^3/pupil.year . New benchmarks being developed by Office of Government Commerce, see website www.watermark.gov.uk

France: No.

Germany: No, in the VDI 2067 there are values we use for calculating the heating output.

Denmark: No guidelines or rules.

Finland: No.

Italy: No.
Poland: Only standards for water consumption.

26. STORAGE OF COLD WATER ON SITE

UK: Usually; but some new schools have been built with no storage; it depends on the requirements of the local water company

France: No.

Germany: No.

Denmark: No.

Finland: No.

Italy: In a few cases. It is not compulsory.

Poland: No.

If so what for:

UK: 24 hour storage to cover one set of toilets in the main building only and the kitchen supply.

27. GUIDELINES ON PREVENTION OF LEGIONELLOSIS

Austria: Hot water temperature should not exceed 40°C, but there should be installed an electronic circuit that ensures a high temperature (70°C) in the tank to kill legionella bacteria.

UK: Yes, see BB87.

France: Yes (most of the times, spot overheating of water storage at temperature 70°C-75°C.

Germany: Yes. DVGW 551 Trinkwassererwärmungs- und Leitungsanlagen. Technische Maßnahmen zur Verminderung des Legionellenwachstums=Systems for heating up the domestic hot water and pipe systems. Technical measures to decrease the growth of legionellosis. Once a day you have to heat your domestic hot water in the storage up to 60°C.

Denmark: EUR 14988 EN: “Indoor air quality & its impact on man”. Report No. 12: Biological Particles in Indoor Environment.

Finland: Hot water T>55°C, National Building Code of Finland, D1.

Italy: There are not rules or norms but it is usual to use appliances that increase the boiler temperature until 50°C for a prefixed time.

Poland: No, standards under construction.

28. MAXIMUM TEMPERATURES OF DOMESTIC HOT WATER SUPPLIES

Austria: Hot water temperature should not exceed 40°C, but there should be installed an electronic circuit that ensures a high temperature (70°C) in the tank to kill legionella bacteria.

UK: To baths, showers and all nursery and primary school supplies, a maximum of 43^{0}C

France: Yes. 45-55°C
The temperature of the domestic hot water must be lower than 60 °C (at the tap).

Germany: No.

Denmark: BR 95.

Finland: T<65^{o}C, National Building Code of Finland, D1.

Italy: Yes, the art. 5 point 7 of DPR 412/93 imposes in 48°C +5°C the maximum temperature of hot water boiler.

Poland: Yes, 55 ^{o}C.

29. MAXIMUM SURFACE TEMPERATURES FOR RADIATORS AND HOT PIPES IN ACCESSIBLE POSITIONS

UK: In a special school, nursery school or teaching accommodation used by a nursery class in a school the surface temperature of any radiator, including exposed pipework which is accessible shall not exceed 43^{0}C (School Premises Regulations 1996).

France: Yes for kindergartens Tsurface < 60°C
For classrooms it is recommended too that the water temperature is lower than 70°C.

Germany: No.

Denmark: DS452: "Dansk Ingeniørforenings Code of Practice for thermal insulation of technical systems for heating, ventilation and water supply etc. and industrial processing systems". The requirements and guidelines include planning, design, execution and supervision.

Finland: < 70 °C

Italy: No

Poland:

30. Method for the environmental assessment of buildings

UK: Yes, DfEE Building Bulletin 83, *Schools' Environmental Assessment Method (SEAM)* which can be used to assess existing buildings as well as new designs. Also the *School toolkit* software produced by the Building Research Establishment Environmental Assessment (BREEAM) Office and issued free to all schools by the British Broadcasting Company (BBC) to enable them to carry out effective environmental management.

France: Some specialised consultants have developed their own method and tool, but there is no standard.

Germany: Not yet. We have drafts which are trying to set the borders for calculation.

Denmark: SBI Report 275: *Database and inventory tool for building components and buildings´ environmental parameters* describes a tool developed at SBI for use in connection with environmental assessment of buildings. The tool includes a database created with Microsoft access and an inventory tool which is an integrated part of the database.

Finland: No

Italy: No

Poland: Nothing that is mandatory.

USA: Environmental Protection Agency has requirements concerning Asbestos, Lead and Radon in schools along with the ASHRAE design standards.

31. Personal safety (health and safety)

Austria: There are no specific requirements for schools, but there are guidelines of the Austrian Institute for Construction of Schools and Sports Facilities e.g. for the entrance section, design of exterior facilities (no sharp-edged benches, etc.), furniture materials, floor-coverings, the storage of chemical substances, etc.

UK: Much legislation issued following the Health and Safety at Work Act 1974. Some specific guidance for schools issued by the Health and Safety Executive. Some by DfEE.

France: Security rules for public buildings.

Germany: DIN 58125: Schulbau: Bautechnische Anforderungen zur Verhütung von Unfällen. Construction of educational buildings: constructional requirements in order to prevent accidents. Regulations for walls, floor coverings, glazings, pillars, stairways, protection against sudden falls, etc.

Italy: Law n. 626 in date 19/9/1994: Every school must have a safety plan in which there are described the risks assessment.
D.M. n.382 in date 29/9/1998: The headmaster must indicate the person responsible for safety.
The safety responsible must inform teachers and students about the risks and the safety procedures.

Poland: No guidelines or rules

USA: Building Officials and Code Administrators' (BOCA) Code and Americans with Disabilities Act requirements which are normally included in Local Building Codes.

32. Fire safety

Austria: In addition to the normal requirements in buildings (buildings laws of the nine provinces) there are guidelines of the Austrian Institute for Construction of Schools and Sports Facilities concerning the escape routes and the time necessary to leave the building.

UK: Building Regulations Approved Code of Practice Part B: *Fire Safety* plus some additional clauses for schools published in DfEE Constructional Standards. Fire Safety management in accordance with the Fire Precautions (Workplace) Regulations, 1997.

France: Resistance duration to fire of partitions > 2 hours (Security rules for public buildings)

Germany: LBO: Landesbauordnung: Regional Building Code. Each common room must have two different escape routes.
Schools belong to buildings with a special use. That means that the important structural units in floors higher than the basement must have a fire rating F90-A0.

Finland: Fire load <600MJ/m^2. National Building Code of Finland E1.:
Italy: D.M. 26 august 1992 recommends:

That the construction materials must have the following fire resistances:
For buildings which have a fire height ≤ 24 m:
- Carrying structure ≥ R 60
- Internal/external wall ≥ R 60

For buildings which have a fire height > 24 m:
- Carrying structure ≥ R 90
- Internal/external wall ≥ R 90

And gives the following dimensional constraints:
- Minimum Width stairs: 1,20 m
- Maximum number of students in a classroom : 26 students/classroom
- A school must have minimum 2 way out.
- The way out width must be a multiple of 0.60 m (at least 1,20)
- The way out length must not exceed 60 m.
- The classroom must have a way out door for every 50 those present students;
  the width door is 1,20 m

And that the fire alarm system must be installed to give power to:
- Safety lighting
- Alarm system

The safety electric system must maintain the electricity for a period of more than 30 min.
A fire alarm system must be installed.
A number of fire extinguisher must be installed

Poland: National Act N° 132/97 (Dept. of Internal Affairs and Administration)
A classroom section shall constitute a separate fire division, the floor area of which may not exceed 1000 m² in buildings with more than one storey and 2000 m² in one-storey buildings.

USA: National Fire Code and local building codes. State Fire Marshals may have jurisdiction in reviewing design documents.

	Austria	France	England	Denmark	Sweden
Resistance to the passage of sound: Internal sources: eg, service installations	< 35 dB		< 25 - 50 dB	< 35 dB	<35 - 38 dB
Internal sources: water					
Maximum background noise level from adjacent areas, ventilation and traffic noise			(LAeq,30 mins)		
General teaching, offices, staff rooms			40 dB		
Music rooms			25 to 30 dB		
Indoor sports & swimming pools			50 dB		
Craft workshops			45 dB		

	Austria	France	England	Denmark	Sweden
External noise level (by traffic etc.):	< 55 dB(A)				
Maximum noise level in work rooms	< 85 dB				
Reverberation time	(500 Hz)	(250 - 2000 Hz)	(500-2000 Hz)	(125 - 2kHz)	
			Unoccupied		
General		0.4 – 0.8 s (ordinary rooms)	0.5 - 1.5s	0.6 - 2.0s	0.6 - 0.9s
Classrooms			0.5 - 0.8s		
classrooms (with pupils)	0.7 - 0.9 s				
Gymnasium/PE	1.2 - 2.2 s		1.0 - 1.5s		
Nursery		0.6 – 1.2 s (nursery, library, music room and large enclosure > 250m^3)			
Reverberation time in corridors, etc.	< 1.5 s				
Airborne sound insulation level			D_w [1]		
Between classrooms	> 50 dB				
Between classroom, horizontal		>38 dB	>40(50) dB	48 dB	44 dB
Partition walls(exc. doors) between:					
classrooms		>44 dB(A)			
resting room, music room, meeting room		>52 dB(A)			
noisy technic room		>56 dB(A)			
Between classroom, vertical	> 48 dB	>31 dB		51 dB	44 dB
Between classroom for carpentry		>50 dB	>56(62) dB	60 dB	
Between classroom for music/singing		>50 dB	>56(62) dB	60 dB	
Between gym room and classroom	> 60 dB				
Walls to staircases					
Doors	> 40 dB	>26 dB		37 dB	44 dB
Facades: noisy zone		>47 dB(A)			
quieter zone		>35 dB(A)			
Intermittent working services					
Continuous working services					
Impact sound pressure			$L'_{nT,w}$ (dB)		
Floors in classrooms		< 74 dB	<62	< 63 dB	
Floors in classrooms for music/singing		< 74 dB	<62	53 dB	

	Germany	Poland	Italy	Finland	CEN
Resistance to the passage of sound: Internal sources: eg, service installations	<35 - 40 dB	< 35 dB		LA,eq,T< 33 dB, LA,max< 38dB	Permitted A-weighted sound pressure levels generated
Internal sources: water	< 35 dB				and/or transmitted by the ventilation
Maximum background					or air conditioning systems.
noise level from adjacent					Nursery schools & day nurseries 45 dB(A)
areas, ventilation and traffic noise					Libraries 35 dB(A)
General teaching, offices, staff rooms				35 dB	Commercial computer rooms small 50 dB(A)
Music rooms					Restuarants and cafeterias 50 dB(A)
Indoor sports & swimming pools					Kitchens 60 dB(A)
Craft workshops				40 dB	
External noise level (by traffic etc.):					Schools: Classrooms 40 dB(A) Corridors 50 dB(A)
Maximum noise level in work rooms					Gymnasiums 45 dB(A)
					Teachers' rooms 40 dB(A) Sport:
Reverberation time					Covered sports stadia 50 dB(A)
					Swimming baths 50dB(A) General:
General					Toilets 50 dB(A)
Classrooms classrooms (with pupils)				0.6-0.9s	Locker rooms 50 dB(A)
Gymnasium/PE				1.5-2.9s	
Nursery				0.6s	
Reverberation time in corridors, etc.					
Airborne sound insulation level					
Between classrooms					
Between classroom, horizontal	47 dB				
	Germany	Poland	Italy	Finland	CEN
Partition walls(exc. doors) between: classrooms					
resting room, music room, meeting room				Rw >44 dB	
noisy technic room					
Between classroom, vertical	55 dB				

	Germany	Poland	Italy	Finland	CEN
Between classroom for carpentry					
Between classroom for music/singing					
Between gym room and classroom					
Walls to staircases	52 dB				
Doors	32 dB		External ≥35 δB		
Facades: noisy zone quieter zone					
Intermittent working services			≥50 δB		
Continuous working services			≥40 δB		
Impact sound pressure					
Floors in classrooms			<68 dB		
Floors in classrooms for music/singing					

Table 1: Acoustic parameters

[1] **Values in brackets are higher values needed for teaching the hearing impaired.**

(lux) levels	Austria	England (Maintained illuminance)	Germany	France	Italy	Poland	Denmark
Classroom	300 lx	**300 lux**	**300**	400	**200**	**300**	
On desks				500			
General teaching areas		**300 lux**					**200**
Specialist task lighting		**500 lux**		600			
Special classrooms used for physics,			**500**				
Reading rooms					**200**		
drawing and experiments							
Blackboards	500 lx	500 lux	**400**	400	**300**	**300**	**500**
Lecture halls with windows			**500**				
Lecture halls without windows			**750**				
Computer labs						**500**	
Drawing, handicraft, electronic	500 lx				**300**		
data processing							
Cooking	300 lx						
Meeting rooms, hygienic services, dressing rooms					**100**		
Sports halls					**100**	**200**	
Corridors, sanitary rooms, halls	200 lx				**100**		
Stairs and corridors		80 - 120 lux			**100**		
Entrance halls, lobbies, waiting rooms		175 - 250 lux					
Workrooms, laboratories	decided in each case				**200**		
Exterior lights	5 lx						
Window size	>= 15% of floor	**>20% of internal area**	**>10-15% of floor**	> 15% of floor		**window/**	**> 10% of floor area**

	Austria	England	Germany	France	Italy	Poland	Denmark
	area in rooms with daylight	**of exterior wall**	**area**	area		**floor area**	
				> 25% of biggest façade area		**classrooms 1:4-1:5**	**(>7% for skylights)**
CIBSE Limiting glare index		**19**					
Initial circuit luminous efficacy		**65 lumens/circuit watt**					
(Uniformity of distribution						**service area 1:6 - 1:8**	
of illuminance)	In classrooms	In teaching spaces					
E(minimum) to E(average)	< or = 1:1.5	0.8 for electric lighting				**communication 1:8 - 1:12**	
Uniformity ratio for daylight		0.3 - 0.4 for sidelit rooms 0.7 for toplit spaces eg, atria					
Maximum ratio of luminances							
of adjoining areas ,	5:1						
of two areas within the field of view	100:1						
reflective index							
of the ceiling ,	at least 70%	at least 70%					
of the floor ,	20%						
of furniture and partition walls .	30%						
walls		at least 60%					

Table 2: Lighting parameters

Temperatures	France Dry resultant	England Air	Denmark	Germany	Poland
Wintertime	Minimum set point of heating system = 19°C				
Nursery	20°C				**25°C**
Classrooms		**18**			**20°C**
Primary School	18°C				
Corridor/circulation	16°C	**15**			**16°C**
Showers		**15**			**25°C**
General	20 - 24°C		20 - 24°C	**20-23°C**	
Summertime	23 - 26°C	>28°C on less than 10 days	23 - 2?°C	**<26°C higher temp allowed with solar radiation**	**22-26°C**
Nursery					
Classrooms					
Asymmetric radiation to cold surfaces	<10 °C		<10 °C		
Asymmetric radiation to cool wall					
Asymmetric radiation to cool ceiling					
Asymmetric to cold services				<=3 K	
Asymmetric radiation to warm wall					
Asymmetric radiation to hot ceiling	< 3 °C		< 5 °C		
Max temp of hot ceiling				35°C	
Vertical temperature difference	<5 °C		<3 °C	<2 °C	
Surface temperature of floor	<28 °C		19 - 26 °C	<29 °C	
Temperature rise during the day			<4 °C		
Temperature rise gradient			<2 °C		

Temperatures	Italy	Finland	CEN cat C building	 cat B building	 cat A building
Wintertime	Max indoor temp for all rooms =20±2°C				
Nursery			20+/-3.5°C	20+/-2.5°C	20+/-1°C
Classrooms		**21°C**	22+/-3°C	22+/-2°C	22+/-1°C
Primary School					
Corridor/circulation					
Showers					
General					
Summertime					
Nursery			23.5+/-2.5°C	23.5+/-2°C	23.5+/-1°C
Classrooms			24.5+/-2.5°C	24.5+/-1.5°C	24.5+/-0.5°C
Asymmetric radiation to cold surfaces					
Asymmetric radiation to cool wall			<13 °C	<10 °C	<10 °C
Asymmetric radiation to cool ceiling			<18 °C	<14 °C	<14 °C
Asymmetric to cold services					
Asymmetric radiation to warm wall			<35 °C	<23 °C	<23 °C
Asymmetric radiation to hot ceiling			<5 °C	<5 °C	<5 °C
Max temp of hot ceiling					
Vertical temperature difference			<4 °C(0.1-1.1m)	<3 °C(0.1-1.1m)	<2 °C(0.1-1.1m)
Surface temperature of floor			17-31°C	19-29°C	19-29°C
Temperature rise during the day					
Temperature rise gradient					

Table 3: Temperature parameters

	Austria	France	England	Denmark	Germany	Poland	Italy	Finland	USA and Canada (ASHRAE)
Ventilation rates		15m3/h for younger pupils 18m3/h for older students/offices 25m3/h for specific rooms	>5 l/s/person [1] during occupancy 9l/s/p recommended for UK in HSE (GN EH22) to control odours Natural ventilation **3 l/s/person of background ventilation** [2] **8 l/s/person capability for rapid ventilation** [2], eg, by opening windows		**5.6 to 16.7l/s.p or 1.1 to 5.6l/s.m^2** 0.5ach^{-1} minimum			**6 to 8 l/s/p or 3 l/s.m^2**	follow ASHRAE Standard 62-1999 Standard sets minimum levels of ventilation (outside air input) per occupant. NB. There is a current proposal to reduce the minimum ventilation rate in Standard 62-1999 for classrooms from 8l/s/p to 3l/s/p
Nursery		**2.8l/s.m^2**		**3.1 - 5l/s/p or 0.4l/s.m^2**			**2.5 ach^{-1}**		
Primary School	4.2l/s/p	**2.8l/s.m^2**					**2.5 ach^{-1}**		
Secondary School	5.5l/s/p	**3.3l/s.m^2**					**3.5 ach^{-1}**		
High School							**5.0 ach^{-1}**		
Classrooms				**5l/s/p or 0.4l/s.m^2**	**5.6l/s.p or 4.2 l/s.m^2**	**5.6l/s.p**	25 m^3/h student		**8l/s/p or 15 cfm/p**
Passages, offices							**1.5 ach^{-1}**		
Hygienic services, gym, refectory							**2.5 ach^{-1}**		
Laboratory							25 m^3/h student		**10l/s/p or 20cfm**
Teacher's room							20 m^3/h student	**12 l/s/p or 2 l/s.m^2**	
Hall gym use									
Hall auditorium use								**8 l/s/p or 6 l/s.m^2**	**8l/s/p or 15cfm/p**
Lecture room				**5l/s/p or 0.4l/s.m^2**	**5.6l/s.p or 4.2 l/s.m^2**	**5.6l/s.p**		**8 l/s/p or 6 l/s.m^2**	
Lunch room								**6 l/s/p or 5 l/s.m^2**	
Lobby /hallway/ exhibition area								**4 l/s/p or 1 l/s.m^2**	
Washrooms			**6 ach^{-1}**						**Restrooms 10l/s/p or 20cfm/p continuous**
Toilet							**4-8 ach^{-1}**		
Air velocity	<0.1m/s winter <0.25m/s summer	0.05 to 0.15m/s		0.05 - 0.15m/s	<=0.15m/s			**See graphs** [3]	
Relative humidity	30 - 55%				40 - 60%		45-55%	25 - 45% winter 30 - 60% summer	30-70%(ASHRAE)
Mechanical ventilation			UK >5 l/s/person or >(10l/s/p if smoking allowed) (BS 5720:1979 Code of Practice)	**5l/s/p or 0.4l/s.m^2**		**5.6l/s.p**		**6 l/s/p or 3l/s.m2**	

	Austria	**France**	**England** for Mechanical ventilation and air conditioning)	**Denmark**	**Germany**	**Poland**	**Italy**	**Finland**	**USA and Canada (ASHRAE)**
Air tightness		<0.2 Vol/hr							
Electricity consumption when heated				**< 2500 J/m³ of fresh air**					

Table 4: Ventilation parameters - Values in bold type are regulations, values in normal type are recommendations

(1) Approved Code of Practice and guidance in support of the Workplace (Health, Safety and Welfare) Regulations 1992.
(2) School Premises Regulations 1999.
(3) National Building Coce of Finland, D2: Air temperature and effective temperature plus draft characteristic used to determine maximum air velocity from a graph (Figure 1 in Building Code D). Max velocity increases with space temperature. For classrooms velocity < 0.15 m/s.

	Austria	**Denmark**	**Norway**	**Germany**	**USA and Canada (ASHRAE)**
CO_2 (ppm)	No limit or guideline but 1000 or 1500 under discussion	1000 with upper limit of 2000	<1500ppm (1)	<1500 but preferably <1000	<1000 ASHRAE Standard
CO (ppm)					9 ppm ASHRAE ave. over 8 hrs
Ozone					
VOCs					1 - 5 mg/m³ US EPA guidelines
Nicotine			<1 microgm/m³ (smoking areas) <10 microgms/m³ (Non-smoking areas)		
Dust mites			1 microgm Derl allergen/gm dust (50 mites/gm dust) (1)		
Total Fungi					
Total Bacteria					
Nitrogen dioxide					0.05ppm Annual national ambient air quality standard (USA)
Radon levels			200-400Bq/m³ simple measures >400Bq/m³ inc. all high cost measures Future buildings<200Bq/m³		4pCi/litre
Formaldehyde			100microgms/m³ (30 min sampling)		0.4ppm
Asbestos			<0.001 fibers/ml of air (2)		
Man made fibers			<0.01 fibers/ml of air		
Suspended particles			$PM_{2.5}$<20 microgms/m³ (24 hr. sampling) (1)		Total susp. particles<120 microgms/m³ (US National outdoor air guidelines)
Relative humidity	30 - 55%			40 - 60%	30-70%(ASHRAE)

(1) suggested guideline
(2) practical guideline

Table 5a: Indoor Air Quality parameters

	Canada	**New Zealand**	**Japan**	**Finland**
CO_2 (ppm)	800ppm[1] (Workday average) 5000ppm [2] (TWAEV)	1000ppm [1]	**1500** but 1000 for acceptable IAQ	1500 and 800 if CO_2 controlled system
CO (ppm)	5ppm [1] (Workday average) 35ppm [2] (TWAEV)			
Ozone	0.1ppm [1&2] - peak level 0.08 WHO - criteria document			
VOCs		0.5mg/m^3 [2]		
Nicotine				
Dust mites				
Total Fungi		<400cfu/m^3 [3]		
Total Bacteria		<100 cfu/m^3 [3]		
Nitrogen dioxide	3ppm [2] (TWAEV)			
Radon levels	20pCi/litre[3]			
Formaldehyde	1ppm [2] (TWAEV)	0.1ppm [1]		
Asbestos	<0.002 fibers/m^3 [4]			
Man made fibers				
Suspended particles				
Relative humidity				25-45% winter 30-60% summer

Canada:
[1] Ontario Hydro Standard
[2] Ministry of labor Standards
[3] Health & Welfare Canada
[4] (OSHA standard 1986)

New Zealand:
[1] mechanical ventilation standard
[2] Australian interim level of concern
[3] unofficial guideline

Table 5b: Indoor Air Quality parameters

	Austria Requirements regulated by building code of each of nine provinces of Austria	UK[1] Requirements for new buildings,[values to be introduced in February 2002]	France	Germany
Roofs	Ceiling and roof against exterior or Ceiling against unheated roof or unheated space 0.2	0.3 [0.25](schools) or 0.45 [0.25](other educational buildings) for flat roofs 0.25 for roofs with a loft space [0.16] pitched roof with insulation between joists [0.20] pitched roof with insulation between rafters [0.25] retrofit of accessible lofts	0.47 0.30 if attic	All existing buildings ceilings to unused attics 0.90 cellar ceilings 0.81 ceilings over external air 0.51 ceilings under external air 0.79 ceilings between apartments 1.45 Renovated buildings 0.30 cellar ceilings 0.50
External walls	0.5 Walls against ground 0.5	0.4[0.35] (schools) 0.45 [0.35] (other educational buildings)	0.47	All existing buildings 1.32 Renovated buildings 0.50
Partition walls	next to unheated space 0.7		0.47 next to unheated space or heated to temperature below current room	All existing buildings adjacent stairways or other appartments 1.96

Glazing Area weighted average of windows, roof windows and doors Rooflights Vehicle access and similar large doors	Windows 1.90 Doors 1.70	2.8(schools) 3.3(other educational buildings) [2.2] glazing in metal frames [2.0] glazing in wood or PVC frames [2.2] [0.7]	2.9	Renovated buildings 1.8 (glazing+ frame)
Floor		0.4(schools) 0.45(other educational buildings) [0.25] all floors and ground floors	Ground floor 0.36 (perimeter) Basement floors 0.43	All existing buildings 0.81 Renovated buildings 0.50

	Denmark	**Finland**	**Italy**[2]	**Poland**
Roofs	0.15 for Ceiling & roof constructions 0.20 for flat roofs and sloping walls against roof	0.22	Ceiling or roof constructions and floors to open spaces: 500Kg/m^3 = 0.70 1000Kg/m^3 = 0.94 1500Kg/m^3 $\geq$1.16	t_i>16^0C 0.50 t_i<16^0C and floors over basements 0.60
External walls	(<100kg/m3) 0.2 (>100kg/m3 and basement walls against ground) 0.3	0.28	100Kg/m^3 = 0.50 250Kg/m^3 = 0.71 500Kg/m^3 = 0.94 $\geq$1000Kg/m^3 = 1.27 Gym & workroom situated in a remote block: 100Kg/m^3 = 0.35 250Kg/m^3 = 0.50 500Kg/m^3 = 0.70 1000Kg/m^3 = 0.94 $\geq$1500Kg/m^3 = 1.16 Walls with window area$\geq$ 50% (independent of mass) $\geq$ 1.16	t_i>16^0C 0.45 without windows 0.55 with windows 0.70 t_i<16^0C 3.00
Partition walls	0.40 next to unheated space or heated to 8^0C or more below current room			0.30
Glazing Area weighted average of windows, roof windows and doors Rooflights Vehicle access and similar large doors	1.80 (Windows and external doors)	2.1 (windows) 0.7 (doors)	Horizontal and vertical windows: Coastal bands and islands U=6.40 North Italy and over 500m U= 4.07	2.30 (windows) 2.60 (doors)
Floor	0.20 Ground floors and basement floors	0.22 (against outside air or unheated room) 0.36 (against ground)		0.60

Table 6: Thermal transmittance, U-values

[1]UK: Trade off is permitted between building elements and also the heating system thermal efficiency

[2]Italy: The U-values may be changed and areas of windows, etc, increased provided this does not result in higher heat losses than required by D.M.30.7.86 which gives values for the maximum total loss power required for space heating and ventilation per m^3 heated volume per Δt, depending on the Climatic zone and the Surface to volume ratio of the building.

England				Austria	Germany	France	Denmark
Building Research Establishment benchmarks for existing buildings:	£/pupil	kWh/m^2	KgCO$_2$/m^2	kWh/m^3.year <25			
	Fuel prices:	£0.01/kWh fossil fuels					
Primary		£0.07/kWh electricity					
Fossil fuels							
Good practice(top 25% of schools)	7.98	126					
Typical(average)	11.18	173					
Electricity							**MJ/m^2.year**
Good practice(top 25% of schools)	8.7	20					**250**
Typical(average)	11.69	28			kWh/m^2.year		**kWh/m^2.year**
Fossil fuels + Electricity					54-100		**69**
Good practice(top 25% of schools)	16.68	146	35.9		(depending on surface-volume ratio)		
Typical(average)	22.87	201					
Secondary							
Fossil fuels							
Good practice(top 25% of schools)	11.07	136					
Typical(average)	15.26	174					
Electricity							
Good practice(top 25% of schools)	15.53	24					
Typical(average)	19.56	30					
Fossil fuels + Electricity							
Good practice(top 25% of schools)	26.6	160	40				
Typical(average)	34.82	204					
DfEE KgCO$_2$/m^2 target bands depending on gross floor area of buildings:		KgCO2/m2					
Primary							
Good low energy design		17-23					
Maximum permissible for new buildings		41-48					
Maximum target for existing buildings		57-66					
Secondary							
Good low energy design		17-22					
Maximum permissible for new buildings		44-49					
Maximum target for existing buildings		62-68					

Table 7a: Energy consumption targets – parameters

England				**Poland**	**USA**
Building Research Establishment benchmarks for existing buildings:	£/pupil	kWh/m^2	$KgCO_2/m^2$	kWh/m^3.year	
				29 (for A/V<=0.2)	
	Fuel prices:	£0.01/kWh fossil fuels		26.6+12(A/V) (for 0.2<A/V<0.9)	
Primary		£0.07/kWh electricity		37.4 (for A/V>=0.9)	
Fossil fuels					
Good practice(top 25% of schools)	7.98	126		Minimum ceiling height = 3.3	
Typical(average)	11.18	173			
Electricity				Estimated average ceiling height = 3.5	
Good practice(top 25% of schools)	8.7	20			
Typical(average)	11.69	28		kWh/m^2.year	
Fossil fuels + Electricity				96 - 131	
Good practice(top 25% of schools)	16.68	146	35.9	(calculated from minimum & average	
Typical(average)	22.87	201		ceiling heights)	
Secondary					
Fossil fuels					
Good practice(top 25% of schools)	11.07	136			
Typical(average)	15.26	174			
Electricity					
Good practice(top 25% of schools)	15.53	24			
Typical(average)	19.56	30			
Fossil fuels + Electricity					
Good practice(top 25% of schools)	26.6	160	40		
Typical(average)	34.82	204			
DfEE $KgCO_2/m^2$ target bands depending on gross floor area of buildings:		KgCO2/m2			
Primary					
Good low energy design		17-23			
Maximum permissible for new buildings		41-48			
Maximum target for existing buildings		57-66			
Secondary					
Good low energy design		17-22			
Maximum permissible for new buildings		44-49			
Maximum target for existing buildings		62-68			

Table 7b: Energy consumption targets – parameters

Chapter 4

Evaluation of Questionnaire on Economic Calculation Procedures

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Table of Contents

1. INTRODUCTION

The questionnaire action dealing with the economical performance of retrofitting projects has been conducted. In order to compare the data from participating countries (Denmark, Finland, France, Germany, Italy, Norway, Poland, the United Kingdom and the USA) three groups of factors have been identified as the most important categories that might influence the decision makers choice of the specific retrofitting alternative. They are listed below:

- BASIC ECONOMICAL INFORMATION (methods of economical analysis, existing incentives of retrofitting, rate of return, rate of inflation, rate of depletion),
- INVESTMENT COST FACTORS (average cost of: thermal insulation, windows, technical equipment),
- OPERATING COST FACTORS (average cost of primary energy: natural gas, liquid gas, oil, electricity, district heating).

2. BASIC ECONOMICAL INFORMATION

The overview of economical efficiency calculation methods being in use in participating countries is given in the table 1. Majority of the responding countries utilize cash flow methods based on net present value (NPV) or internal rate of return (IRR), the first one being the most popular method. Among others the life cycle cost (LCC) method seems to be used relatively often.

Table 1. The methods of economical efficiency calculation

	Austria	Denmark	Finland	France	Germany	UK	USA	Poland
NPV	no	yes	yes	yes	yes	yes	no	yes
IRR	no	no	no	yes	yes	sometimes	yes	yes
OTHER	Life Cycle Cost - ONORM 7140	Simple Payback	Target Price Method	Simple payback time: Inv/y. savings	Additional Costs to Benefit Ratio		Life Cycle Costing	Life Cycle Costing

Considering the execution of retrofitting process one has to take into consideration the acceptable payback time of retrofitting of different building parts and installations. The table 2 summarizes the results of questionnaire action joined with the data mentioned above.

The acceptable payback time of building components is approximately:

- For building cover – 14 years, and is varying from 10 years for Austria and UK to 20 years for Germany and Poland,
- For technical equipment (HVAC systems) – 13 years, and is varying from 5 years for Austria and France to 20 years for Finland,
- For lighting and appliances – 10 years, and is varying from 3 years for France to 20 years for Finland.

Table 2. The acceptable payback time of building components retrofitting

	Austria	Denmark	Finland	France	Germany	UK	USA	Poland
Building Cover	**10**	**15**	**15**	**15**	**20**	**10**	**7**	**20**
HVAC Systems	**5**	**15**	**20**	**5**	**15**	**15**	**12**	**15**
Lighting and Appliances	**5**	**15**	**20**	**3**	**5**	**15**	**7**	**10**

The final results of economical efficiency calculation are strongly dependent on the existing incentives e.g.: loan preferences, tax reduction. The overview of the incentives of retrofitting process in different participating countries is given in the table 3.

The most common way of retrofitting process support in participating countries is the loan preference. In the case of France and Poland there is additional possibility to achieve the tax reduction.

Table 3. Existing incentives of retrofitting

	Austria	Denmark	Finland	France	Germany	UK	USA	Poland
Loan Preferences		yes	yes	no	yes	yes - interest free loans for energy efficiency measures	no	yes, possibility of application to Bank of Env. Protection
Tax Reduction		no	no	VAT reduction 20,6 to 5,5%	no		no	yes
Other		no	no		Comm. paid retrofit promotion		Financing of loan interest by Utilities	

3. INVESTMENT COST

The economical efficiency calculation of the specific retrofitting alternative based on the one of the methods listed in the table 1 requires the knowledge of the total investment cost of the process. The comparison of the average investment cost of basic building components including building cover and the technical equipment is given:

- For building cover in the table 4,
- For heating systems in the table 5,
- For ventilation systems in the table 6.

The average cost of retrofitting of building cover is approximately (table 4):

- For thermal insulation based on the 15 cm of mineral wool – 60 Euro m^{-2}, and is varying from 1 Euro m^{-2} years for USA to 160 Euro m^{-2} for Denmark,
- For windows 2,1 W m^{-2} K^{-1} – 246 Euro m^{-2}, and is varying from 140 Euro m^{-2} for Poland to 350 Euro m^{-2} for UK,
- For windows 1,6 W m^{-2} K^{-1} – 282 Euro m^{-2}, and is varying from 175 Euro m^{-2} for Poland to 450 Euro m^{-2} for UK,
- For windows 1,1 W m^{-2} K^{-1} – 355 Euro m^{-2}, and is varying from 225 Euro m^{-2} for Poland to 640 Euro m^{-2} for UK.

The average cost of retrofitting of heating system of building is (table 5):

- For heating system based on the natural gas fired boiler – 110 Euro kW^{-1}, and is varying from 50 Euro kW^{-1} for USA to 234 Euro kW^{-1} for Denmark,
- For heating system based on the liquid gas fired boiler – 99 Euro kW^{-1}, and is varying from 50 Euro kW^{-1} for USA to 150 Euro kW^{-1} for Germany,
- For heating system based on the oil fired boiler – 131 Euro kW^{-1}, and is varying from 70 Euro kW^{-1} for UK and USA to 292 Euro kW^{-1} for Denmark,

- For heating system based on the district heating – 77 Euro kW^{-1}, and is varying from 30 Euro kW^{-1} for France to 222 Euro kW^{-1} for Denmark.

Table 4. The investment cost factors – building cover [Euro m^{-2}]

	Austria	Denmark	Finland	France	Germany	UK	USA	Poland
Thermal Insulation - 15 cm mineral wool	20	160	140	25	95	7	1	25
Windows - U-value 2,1 W/m2K	280	260	280	280		350	175	140
Windows - U-value 1,6 W/m2K		260	280	330	260	450	220	175
Windows - U-value 1,1 W/m2K	360	260	400	no data	340	640	265	225

Table 5. The investment cost factors – heating system [Euro kW^{-1}]

	Austria	Denmark	Finland	France	Germany	UK	USA	Poland
Natural Gas Fired Boiler	90	234		100	125	70	50	100
Liquid Gas Fired Boiler		n/a			150	70	50	125
Oil Fired Boiler	100	292		135	125	70	70	125
District Heating	60	222		30	65	70	30	65

Table 6. The investment cost factors – ventilation system [Euro $(m^3h^{-1})^{-1}$]

	Austria	Denmark	Finland	France	Germany	UK	USA	Poland
Exhaust System	2,5	0,4		1,0	5,0	3,6	0,3	3,0
Inlet-Exhaust System - no heat recovery		7,4		1,8	25,0	3,6	0,4	6,5
Inlet-Exhaust System - with heat recovery	3,0	9,4		1,9	35,0	3,6	0,4	9,0

The average cost of retrofitting of building ventilation system is approximately (table 6):

- For exhaust systems – 2,3 Euro $(m^3h^{-1})^{-1}$, and is varying from 0,3 Euro $(m^3h^{-1})^{-1}$ for USA to 5,0 Euro $(m^3h^{-1})^{-1}$ for Germany,
- For inlet-exhaust systems without heat recovery – 7,4 Euro $(m^3h^{-1})^{-1}$, and is varying from 0,4 Euro $(m^3h^{-1})^{-1}$ for USA to 15,0 Euro $(m^3h^{-1})^{-1}$ for Germany,
- For inlet-exhaust systems with heat recovery – 8,9 Euro $(m^3h^{-1})^{-1}$, and is varying from 0,4 Euro $(m^3h^{-1})^{-1}$ for USA to 35,0 Euro $(m^3h^{-1})^{-1}$ for Germany.

4. OPERATING COSTS

The main goal of retrofitting process is to reduce the primary energy consumption of building, what finally allows for the improvement of the ecological and economical factors of building operation. The economical efficiency of retrofitting process is determined by two quantities:

- the cost of primary energy on the market,
- the possible amount of energy saved as the result of retrofitting process.

It can be derived as the cash flow value of the specific retrofitting process “i” using the equations:

$$CF_i = \sum_{j-1}^{n} \Delta E_{i,j} \cdot P_{i,j} \quad (1)$$

where:

$\Delta E_{i,j}$ - the "j" primary energy savings caused by the retrofitting process "i", kWh a^{-1},
$P_{i,j}$ - the price of the "j" primary energy unit in the calculation year "i", Euro kWh^{-1};

The primary energy savings are derived from the annual energy consumption balance before and after retrofitting process :

$$\Delta E_{i,j} = E_{0,j} - E_{i,j} \quad (2)$$

where:

$E_{i,j}$ - annual "j" primary energy consumption after retrofitting, kWh a^{-1},
$E_{0,j}$ - annual "j" primary energy consumption before retrofitting, kWh a^{-1},

The questionnaire action allowed for the comparison of the costs of different primary energy at the energy markets of participating countries. The questionnaire results are listed in the table 7.

Table 7. The primary energy cost in participating countries [kWh $unit^{-1}$]

	Austria	Denmark	Finland	France	Germany	UK	USA	Poland
Natural Gas Hu=10 kWh/m3	0,320	0,060		0,030	0,200	0,019	0,100	0,200
Liquid gas				0,060	0,360	0,067	0,570	0,600
Oil Hu= 11,6 kWh/kg	0,300	0,060		0,030	0,360	0,018	0,220	0,300
Electricity	0,130	0,170	0,830	0,110	0,070	0,113	0,080	0,080
District Heating	0,037	0,050	0,033	0,028	0,060			0,040

According to the table 7 there are significant difference in primary energy prices in participating countries. The average price of natural gas is approximately 0,133 Euro Nm^{-3} varying from 0,02 Euro Nm^{-3} for UK to 0,32 Euro Nm^{-3} for Austria. In the case of liquid gas (propane) the average price exceeds 0,33 Euro dm^{-3}, and it ranges from around 0,06 Euro dm^{-3} for France and UK to around 0,600 Euro dm^{-3} for USA and Poland. The significant difference in liquid gas price can be observed for those two groups of countries. The price of oil is comparable in Austria, Germany, USA and Poland where it reaches the highest values (over 0,22 Euro kg^{-1}). The lowest price that type of fuel is observed in Denmark, France and UK where it is kept between 0,02 up to 0,06 Euro kg^{-1}.

The cost of the electricity unit is fairly stable in majority of the responding countries ranging between 0,070 to 0,170 Euro kWh^{-1} with the exception of Finland where it exceeds 0,80 Euro kWh^{-1}, probably due to the environmental taxation. The average price of district heating energy is 0,041 Euro kWh^{-1}, and is relatively uniform in participating countries reaching the highest value of 0,060 Euro kWh^{-1} in Germany and the lowest – 0,028 Euro kWh^{-1} in France.

5. Conclusions

The economical efficiency of retrofitting process for educational buildings is one of the most important factors influencing the decision makers - school managers, local authority members, in choosing the specific alternative. In order to achieve the comparable results of economical efficiency calculations the common method has to be employed.

Considering the experience of different countries the net present value (NPV) calculation seems to be the most adequate method for creation the economic criterion of the quality of retrofitting process.

Comparing different retrofitting projects one has to be aware of the influence of national economic factors on the final result of NPV calculations.

The national economic factors: rate of discount, primary energy cost, investment cost coefficients, ... may significantly vary from country to country, so the same retrofitting project may have significantly different rate of profit in different countries.

Chapter 5

Evaluation of Questionnaire on Short-Term Energy Monitoring Procedures

by

Jan de Boer

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Table of Contents

1. Introduction

Within the framework of IEA ECBCS ANNEX 36 retrofitt concepts and measures for educational buildings shall be developed and shall be applied in demonstration projects. The retrofit methods shall be promoted to decision makers and designers helping to effectively manage the retrofit process. To measure the impact of the retrofit measures monitoring activities are indispensable (?). For a rather broad application of these procedures monitoring should be short in time and rather cheap at a potentially high information content.

This document lines out the general motivation for monitoring, gives a brief comparison of short-term energy monitoring compared to longterm monitoring and provides a brief overview on existing short-term methods. In a second step, in order to identify potential development needs, a questionnaire handed out to investigate monitoring activities within the countries interested in the participation in Annex 36 is evaluated.

2. Motivation for Monitoring

There are several reasons for energy monitoring. Following the developement and implementation of new energy concepts, monitoring procedures are often applied to validate these concepts under realistic conditions. Monitoring can be used to identify problems and malfunctions concerning the building envelope and within HVAC – systems. It can be used to analyse the user-behaviour and its impact on the buildings energetic behaviour. Under specific constraints, measurements are used for the validation of simulation tools (i.e. identification and clearification of differences between measurements & predictions). Measurements are part of control systems and are applied for peak-load management. In the scope of IEA ECBCS ANNEX 36 the *Before & After* analysis in retrofitting projects is the main field of interest.

3. Short-Term vs. Long-Term Monitoring

Detailled monitoring campaigns normally last two years or longer. They require a high number of sensors. The price paid for the possible detailled parameter and system analysis and accurate information on user behaviour are high installation, maintenance and evaluation costs. Projects with this high level in detail can often only be performed by nationally funded institutes. Mainly the cost and linked to this the time needed are the obstacles of not making energy monitoring for practioners as common as for instance blower door tests.

4. Short-term Energy Monitoring Activities

Due to the above mentioned aspects diverse approaches were undertaken to overcome these obstacles trying to confine the time for monitoring to a week or only a couple of days, while still being able to obtain substantial information on the energetic building characteristics. These methods normally do not require more than a portable data aquisition system (i.e. a notebook) and something up to 25 sensors. Figure 1 gives a small overview of selected methods. Some of them only deliver static builiding characteristics, others are able to go much more into detail by estimating and identifying the different energy flows using dynamic building models, which then can be directly taken for prediction (for instance for the whole heating period). As the level of accuracy, also the testing protocols are diverse. The most simple ones rely only on energy bill readings, other methods imprint special thermal conditions on the buildings. Using electric heaters the thermal zone of interest is for instance put into a *constant heat stage*. From this period the steady state heat loss coefficient can be deduced. To obtain information on the dynamic building characteristics so called *cool down test* can be used. The furnace and all internal heat inputs are set to zero after a constant heat phase, such that the thermal effects of the building mass are allocated. Solar gain behaviour is estimated at daytime intervals. Figure 2 illustrates an exemplary test protocol. Attempts are being made to monitor online, on-site, and non-intrusive.

The thermal building model can be obtained using a variety of methods, like the use of equivalent thermal networks depicted in figure 3, time series approaches shown in figure 4 or frequency domain analysis for the calibration of an audit model.

The overall accuracy of the methods described can be considered good. Compared to simulations the obtained models –depending on the methodology choosen - are often closer to reality since they are directly developped from reality, i.e. the existing building.

5. QUESTIONNAIRE ON MONITORING ACTIVITIES IN THE PARTICIPATING COUNTRIES

Based on the presentation of different short-term energy monitoring procedures - used among others for the validation of retrofit measures (before/after analysis) - at the first preparation phase workshop in Berlin, October 1999, a questionnaire was distributed to investigate monitoring activities within the countries participating in preparation phase of Annex 36. A copy of the questionnaire is attached to this document.

Completed questionnaires were received from 6 countries (Denmark, Finland, France, Germany, Italy, and USA). Due to only very few monitored buildings, Poland had difficulties completing it. Because of the big number of diverse activities throughout the United States, from governmental, over state, down to local community level answering some of the questions was not found meaningful by the US. Also for Italy it was difficult to get a representative overview on some of the questions asked. From the remaining set of completed questions some general tendencies could be identified.

In general, building monitoring and concept validation is predominant in new rather than retrofitted buildings. The average ratio new vs. old is 62.5 % to 37.5 %. In the US and Finland the ratio was judged to be about 50% : 50%, whereas in Denmark, Germany and France 75%-90% of monitoring concentrated on new rather than retrofitted. Only Italy showed the inverse tendency with a ratio of 30 % new to 70 % old buildings.

The quantities (consumptions) monitored most often are the heating energy consumption, electricity and lighting. Thermal comfort is the aspect monitored the least. Blower door, tracer gas, and especially thermography tests are quite common. Besides institutes private companies offer these tests as service.

Detailled level energy monitoring is mainly performed by institutes whereas the bigger number of „low level“ monitoring (evaluation of utility bills, etc.) is performed by utilities and private companies. Institutes are most often contracted directly from the government for validation monitoring. Communities are obviously working closely together on energy surveillance with (their) utilities. The least monitoring contracting is initiated by private investors.

Looking at what should be identified with short-term energy monitoring procedures, the item named most often was the estimation of the heating energy demand (all five countries), followed by the identification of static building characteristics and dynamic building parameters like the effective building mass.

Since in none of the countries which have completed the questionnaire validation measures are mandatory after construction or retrofit, the important points in enabling more frequent application of these procedures are the time needed for application and directly connected the expenses necessary. The estimates for the acceptable maximum number of days for application ranged for private companies conducting the monitoring from 1 to 5 days, for institutes 2 to 5 days (France and Italy specified, that also longer periods, no number of days provided, would be acceptable). The maximum costs ranged from around 2000 US$ to costs of up to 5000 US$ for private companies being contracted and up to 10 000 US$ if institutes are contracted (France and Italy also specified no limit here).

6. Conclusion and relevance to the planned work of ANNEX 36

The evaluation of the completed questionnaires showed, that in the participating countries no short-term energy monitoring tests unlike blower door tests, thermography etc. are well established.

There is an accordance between the output which existing short-term energy monitoring procedures can provide (estimates of the annual heating energy demand, estimates of building design parameters like steady state heat loss coefficient, effective building mass, ...) and what was demanded in the completed questionnaires as the output to be obtained from these types of performance / validation tests. In addition existing methods can be applied in the cost and time frame specified to be acceptable for a broader application.

For the scope of Annex 36 this cost effective monitoring approach could mean a valuable approach to get at limited expenses a good insight in the effectiveness of retrofit projects. Due to the limited effort the methods can be promoted to decicion makers and designers as a chaep mean to guarantee for the employed retrofit measures. An implementation into a design or concept advice software is favourable. Suited methods should be selected and evtl. further developed or improved. The methodology can be integrated as a user-friendly stand-alone software package and can also be integrated into the concept adviser software as part of a building assessement procedure for design (retrofit) process validation. The algorithms, methods, test set-up, test protocol, evaluation and application examples will be documented. Last but not least the retrofitt measure in the case study buildings shall be validated. The integration of monitored data into database is an option.

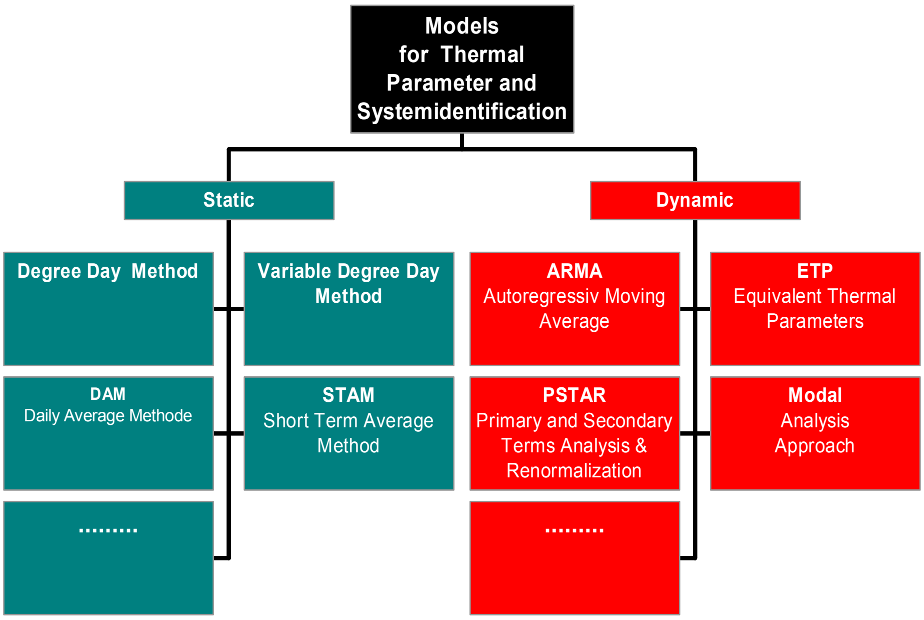

Figure 1: Selection of a number of different methods used for energy prediction of dwellings and non-residential buildings on short-term bases.

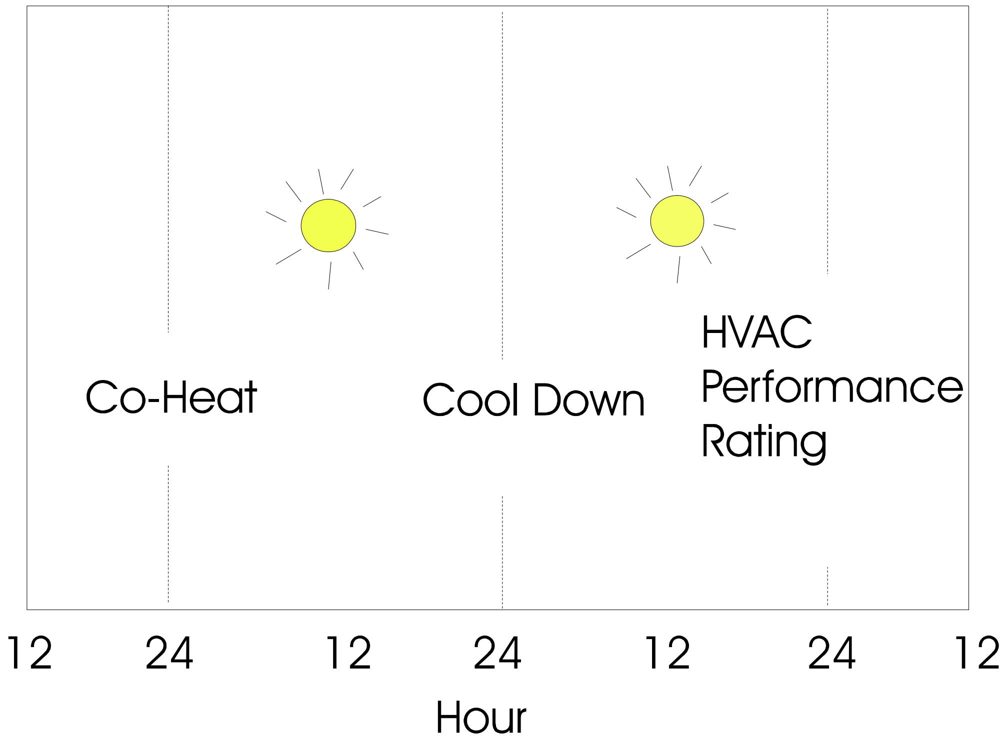

Figure 2: Example of an intrusive test protocol used for the estimation of steady state as well as dynamic building characteristics in a three day monitoring period.

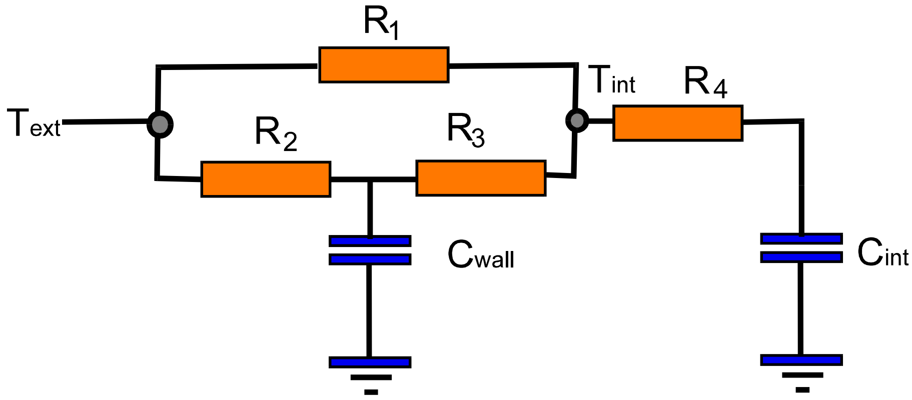

Figure 3: Example of a simple thermal network. R_1 can be understood as the thermal resistance of a window. R_2 and R_3 together with C_{wall} as are roughly representing the behaviour of a wall.The branch R_4 and C_{int} describes the thermal coupling with internal masses.

$$\sum_{k=0}^{N_{int}} a_{int}(k)\, T_{int}(n-k) - \sum_{k=0}^{N_{ext}} a_{ext}(k)\, T_{ext}(n-k) - \sum_{k=0}^{N_{aux}} a_{aux}(k)\, Q_{aux}(n-k) - \sum_{k=0}^{N_{sol}} a_{sol}(k)\, Q_{sol}(n-k) = 0$$

Figure 4: Time series model used for parameter estimation with the ARMA (Auto Regressive Moving Average) method (T_{int}[n]: internal temperature; T_{ext}[n]: internal temperature; Q_{aux}[n]: internal heat gains, including furnace; Q_{sol}[n]: solar heat gains).

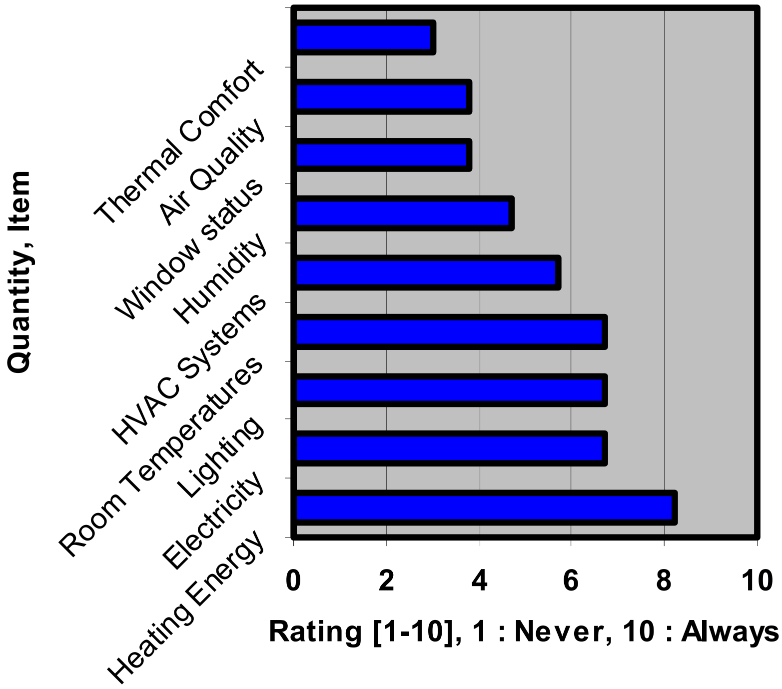

Figure 5: Type of physical quantities normally recorded in monitoring activities as specified in the evaluated questionaires.

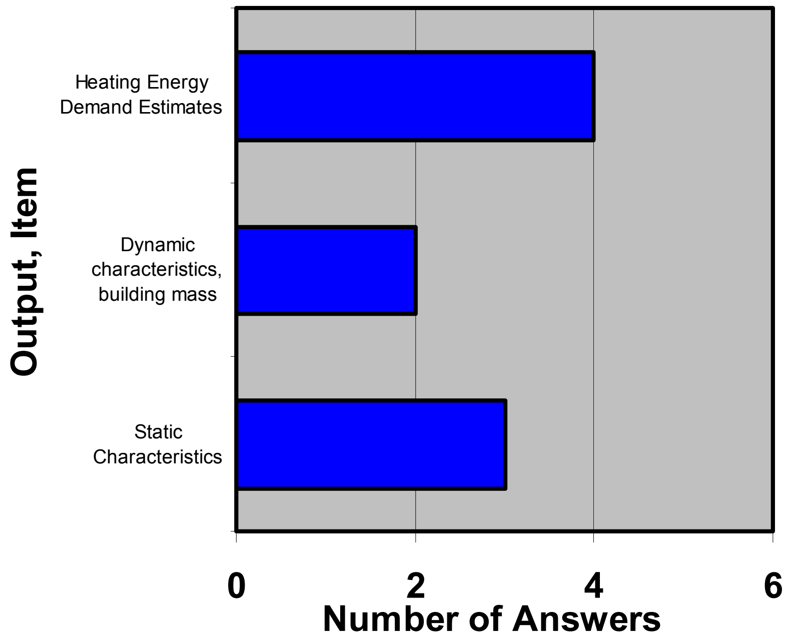

Figure 6: Specification of the minimum output monitoring procedures should deliver as specified in the evaluated questionnaires.

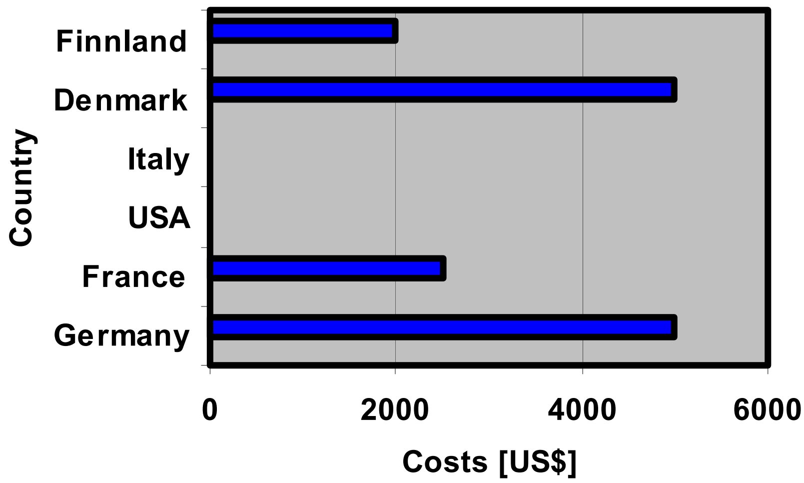

Figure 7: Maximum costs to put such programs on a broader basis (for private companies) as specified by the different countries.

Chapter 6

Evaluation of Questionnaire on Calculation Tools

by

Pekka Tuomaala, Timo Kaupinnen
VTT, Finland

Table of Contents

1. BACKGROUND

One action item decided in the Berlin Experts' Meeting (October 1998) was to conduct a questionnaire of calculation tool utilization in participating countries. The aim of this questionnaire was to clarify the state-of-art in this field.

2. METHODS

A two page questionnaire (together with a coverage page) was prepared (Appendix 6A). This questionnaire was distributed to all participating countries, and the completed questionnaires were returned to VTT Building Technology. All graphs and results presented in the next chapter are based on this questionnaire.

3. RESULTS

The final answers were received from nine organisations in eight participating countries (Germany, Sweden, USA, France, Germany, UK, Finland, Denmark, and Italy).

Question #1: According to the questionnaire, different calculation tools are most commonly utilized in Sweden, UK, and Finland. This might be due to a little longer traditions and a positive attitude towards these tools in these countries.

Question #2: Lists of the most important and commonly used calculation tools varied a lot in different organizations and participating countries. Traditional TRNSYS, DOE-2, and ESP-r are used in many countries, but the number of other - both old and new - tools is outstanding.

Question #3: Most of the participating organizations have or are involved in development of calculation tools. Therefore, all participants are most likely very well aware about realistic applications of calculation methods as research tools.

Question #4: Figure 1 shows frequences of utilizing calculation tools among different professions in different participating countries. Based on this questionnaire, it seems that there are not very suitable calculation tools available especially for architects.

Question #5: Attitudes among clients seems to be quite positive towards calculation tools. However, the attitude depends in some extend on clients themselves.

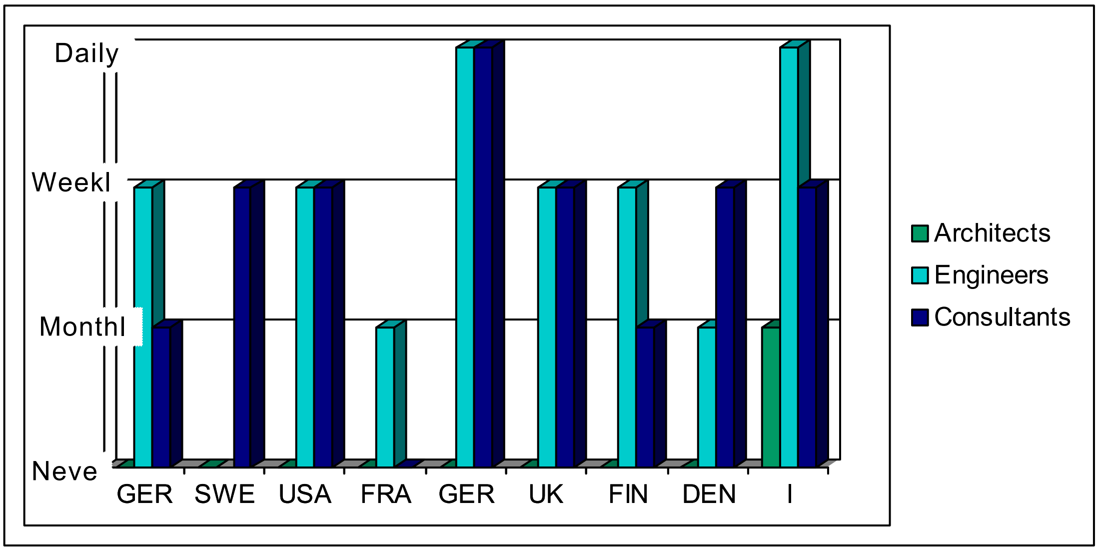

Figure 1: Frequences of utilizing calculation tools among different professions in different participating countries.

Questions #6, #7, and #8:

Figure 2 shows existence of public certification system, noticable development projects, and administration of calculation tools in different participating countries. Some kind of certification systems exist in Germany and UK. In all participating countries there are development projects going on, and there exist administration of calculation tools in Germany, UK, Denmark and Italy.

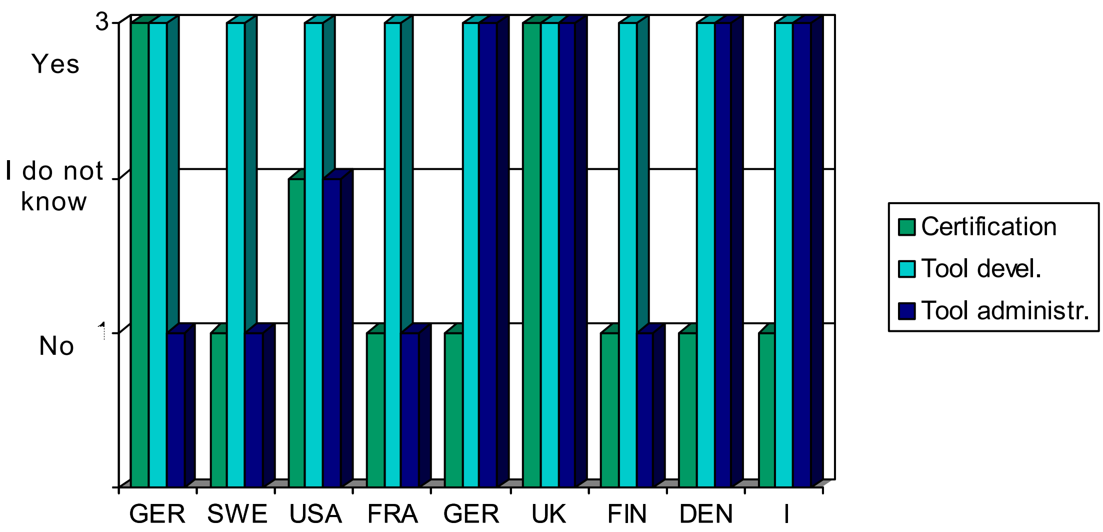

Figure 2: Existance of public certification system, noticable development projects, and administration of calculation tools in different participating countries.

4. CONCLUSOINS

The answers to the calculation tools questionnaire received from different participating countries indicate importance of calculation methods as valuable tools in building research work. There are several parallel development projects going on, and a great number of different simulation tools are used. Therefore, the results of this questionnaire back up need of better international coordination.

APPENDIX 6A

Planned IEA ECBCS Annex 36: Retrofitting in Educational Buildings - Energy Concept Adviser for Technical Retrofit Measures

Calculation Tool Questionnaire

January 13, 1999
Pekka.Tuomaala@vtt.fi

Greetings from Finland ! The participants agreed in the meeting in Berlin (October 12-13, 1998) to start the work of the Annex preparation phase by selecting and reviewing existing information on different topics to prepare a state of the art report as basis for the research phase in the Annex.

This questionnaire will collect information of calculation tools. On the next two pages you can find several questions dealing with utilization and popularity of building calculation tools. Please answer the questions according to your own knowledge and experiencies about your own country.

With kind regards,

Pekka.Tuomaala@vtt.fi

PS. Please send completed questionnaire before the end of January 1999 to:

Pekka Tuomaala
VTT Building Technology
P.O.Box 1804
FIN-02044 VTT
Finland

or fax it to:

INT + 358 - 9 - 455 2408

Questionnaire:

Your name: ____

Organization and country : _____________________________

Fax number: ____________________ E-mail address: ___________

1. In general, how commonly calculation tool are being utilized in your country compared with other countries?

- ☐ Less than in other countries
- ☐ About the same compared with other countries
- ☐ More than in other countries
- ☐ I do not know

2. Please list the five most important and commonly used calculation tools being used in your country:

	Name of the tool	Estimated Number of users
1.	_________________________	_____________
2.	_________________________	_____________
3.	_________________________	_____________
4.	_________________________	_____________
5.	_________________________	_____________

3. Have you been involved in developing calculation tools ? If yes, please list which tool(s).

- ☐ No
- ☐ Yes ____________________________________

____

____

4. How often calculation tools are typically used among different end-user groups ?

Architects	Engineers	Consultants
☐ Never in practise	☐ Never in practise	☐ Never in practise
☐ Monthly	☐ Monthly	☐ Monthly
☐ Weekly	☐ Weekly	☐ Weekly
☐ Every Day	☐ Every Day	☐ Every Day

5. What is typical attitude of clients towards calculation results ?
   - ☐ Clearly positive
   - ☐ Neutral
   - ☐ Clearly negative
   - ☐ Depends on a client
   - ☐ I dont know

6. Is there any certification system of calculation tools in your country ? If yes, please list which one(s).
   - ☐ No
   - ☐ I do not know
   - ☐ Yes ____

     ____

7. Are there any notable calculation tool development projects going on in your country ? If yes, please list which one(s).
   - ☐ No
   - ☐ I do not know
   - ☐ Yes ____

     ____

8. Are there any organizations taking repsonsibility of calculation tools in your country ? If yes, please list which one(s).
   - ☐ No
   - ☐ I do not know
   - ☐ Yes ____

     ____

Please send completed questionnaire to:

Pekka Tuomaala
VTT Building Technology
P.O. Box 1804
FIN-02044 VTT
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or fax it to:
INT + 358 - 9 - 455 2408

Thank you very much for your highly valuable answers !

Appendix A:

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