Hungary-Croatia
IPA Cross-border Co-operation Programme

Where rivers connect

Air tightness investigation of rooms from the point of view of energy and comfort

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The project is co-financed by the European Union through the Hungary-Croatia IPA Cross-border Co-operation Programme

Scientific targets

- **The main scientific target is to gather information on the air tightness and air change rate of the buildings and houses of various construction types, use and age in Hungary and in Croatia**
- **The collected data are being used to estimate the energy and thermal comfort as well air quality consequence of the typical air change rates, ventilation air flow and velocity within the rooms**

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Scientific targets

- **Another scientific target is to find correlation between air-change rate at 50 Pa pressure difference and that of during normal conditions**
- **50 Pa pressure compared to the ambient is high enough to eliminate the effect of the ambient conditions apart from strong wind**
- **Air change rate at 50 Pa pressure measured by Blower Door is suitable for classification purposes but it is much higher than during normal conditions**
- **Results of tracer gas tests provide an opportunity to find correlation between 50 Pa test and normal air change**

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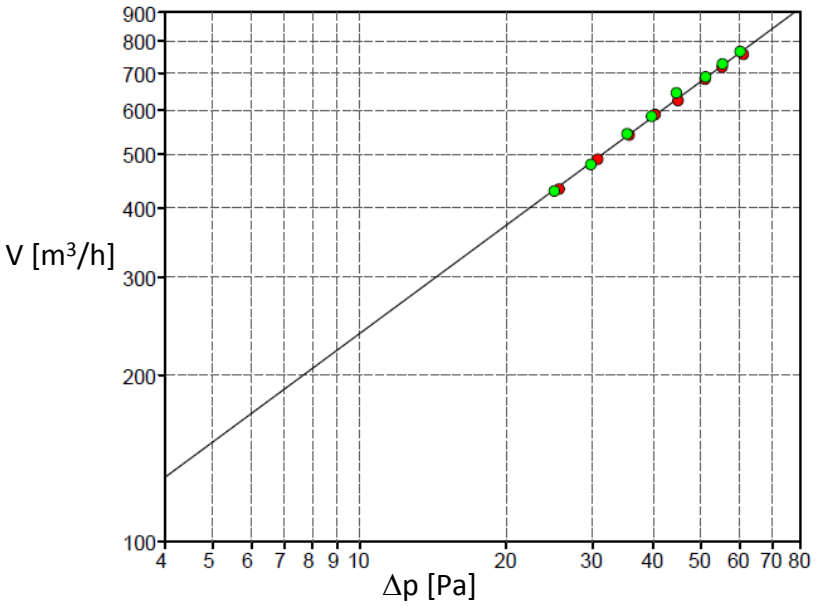
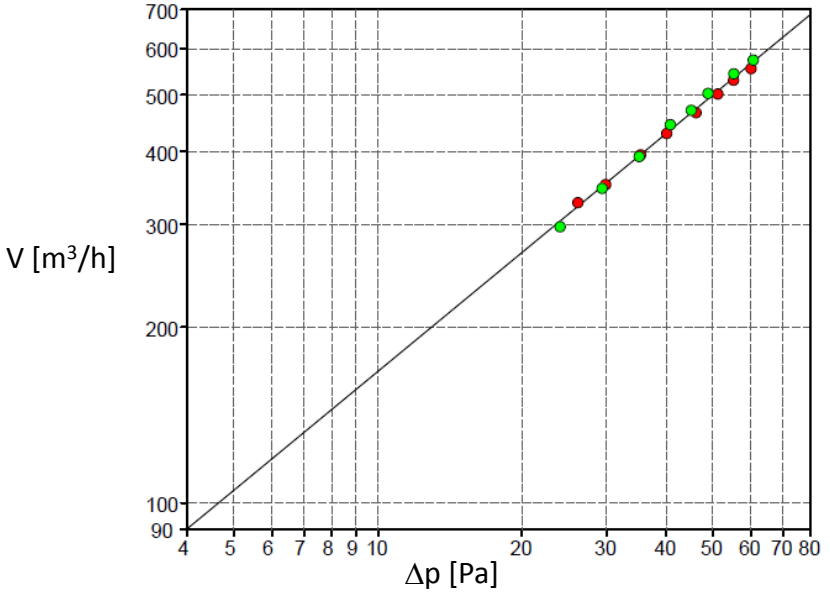
Air tightness vs natural ventilation

„A" type test: ACH (vents are not sealed)



Average:								
Δp_n [Pa]	60	55	50	45	40	35	30	25
Δp [Pa]	60.6	55.3	51.0	44.7	39.9	35.4	30.2	25.3
V [m³/h]	760.8	722.3	685.5	634.5	587.0	542.4	484.1	430.7

„B" type test: air tightness (sealed vents)



Average:								
Δp_n [Pa]	60	55	50	45	40	35	30	25
Δp [Pa]	60.0	54.8	49.6	45.2	40.0	34.8	29.2	24.6
V [m³/h]	564.2	536.7	502.5	468.4	437.0	393.4	348.5	312.1

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Difficulties to measure spontaneous Air-Change Rate

- **Any measurement should not affect the actual measured phenomena and should be repeatable delivering the same result**
- **In case of measuring natural ventilation the obvious requirements specified above cannot be fulfilled**
- **Natural ventilation is highly dependent of the temperature difference and the wind speed**
- **As a results there are as many Air-Change Rates as many ambient conditions**

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Concentration Decay test method to measure spontaneous ACH

- **A small quantity of tracer gas is released and thoroughly mixed into the room air**
- **The source of gas is then removed and the decay in the concentration of tracer-gas in the room is measured over a period of time**
- **The selected gas is Sulphur Hexafluoride (SF_6) that five times heavier than air**
- **To ensure that the tracer gas concentration is the same at all points in a room mixing fans are run throughout the measurement period**

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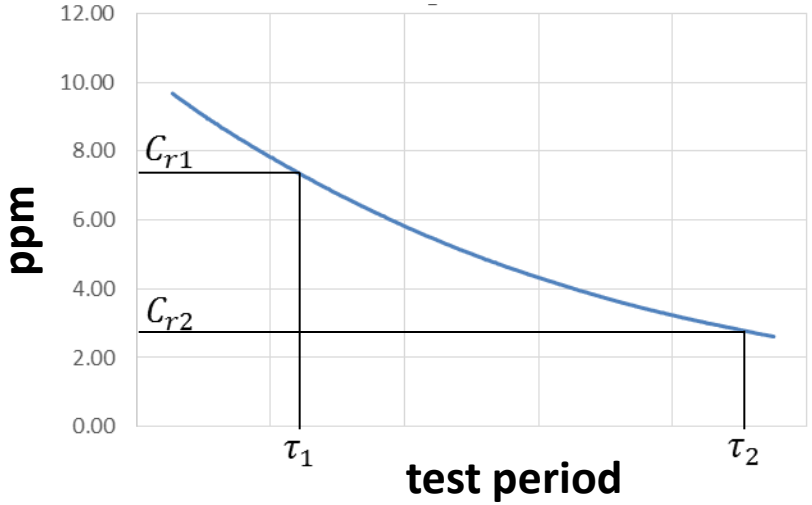
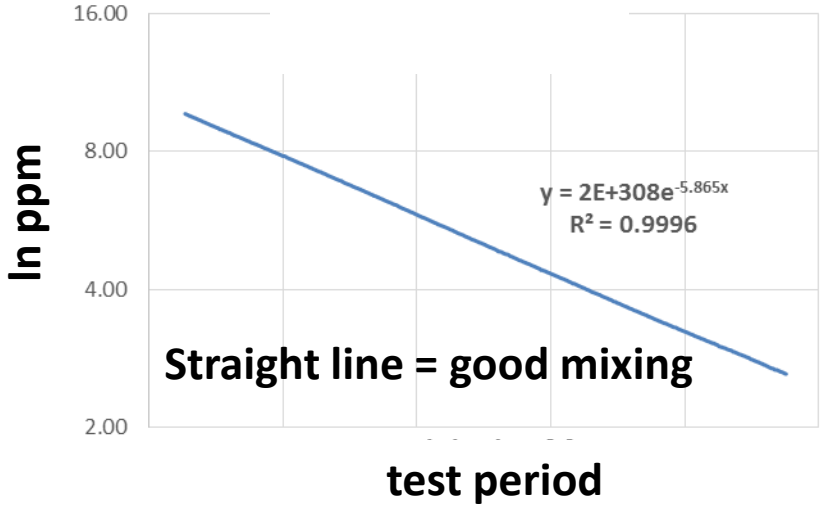
Tracer gas test

Concentration decay against linear scale



Concentration decay against natural logarithmic scale



$$ACH = \frac{\ln C_{r1} - \ln C_{r2}}{\Delta\tau} \left[\frac{1}{h}\right]$$

Where

C_{r2} - concentration at the end of test period

C_{r1} - concentration at the beginning of test period

$\Delta\tau$ – length of the test period

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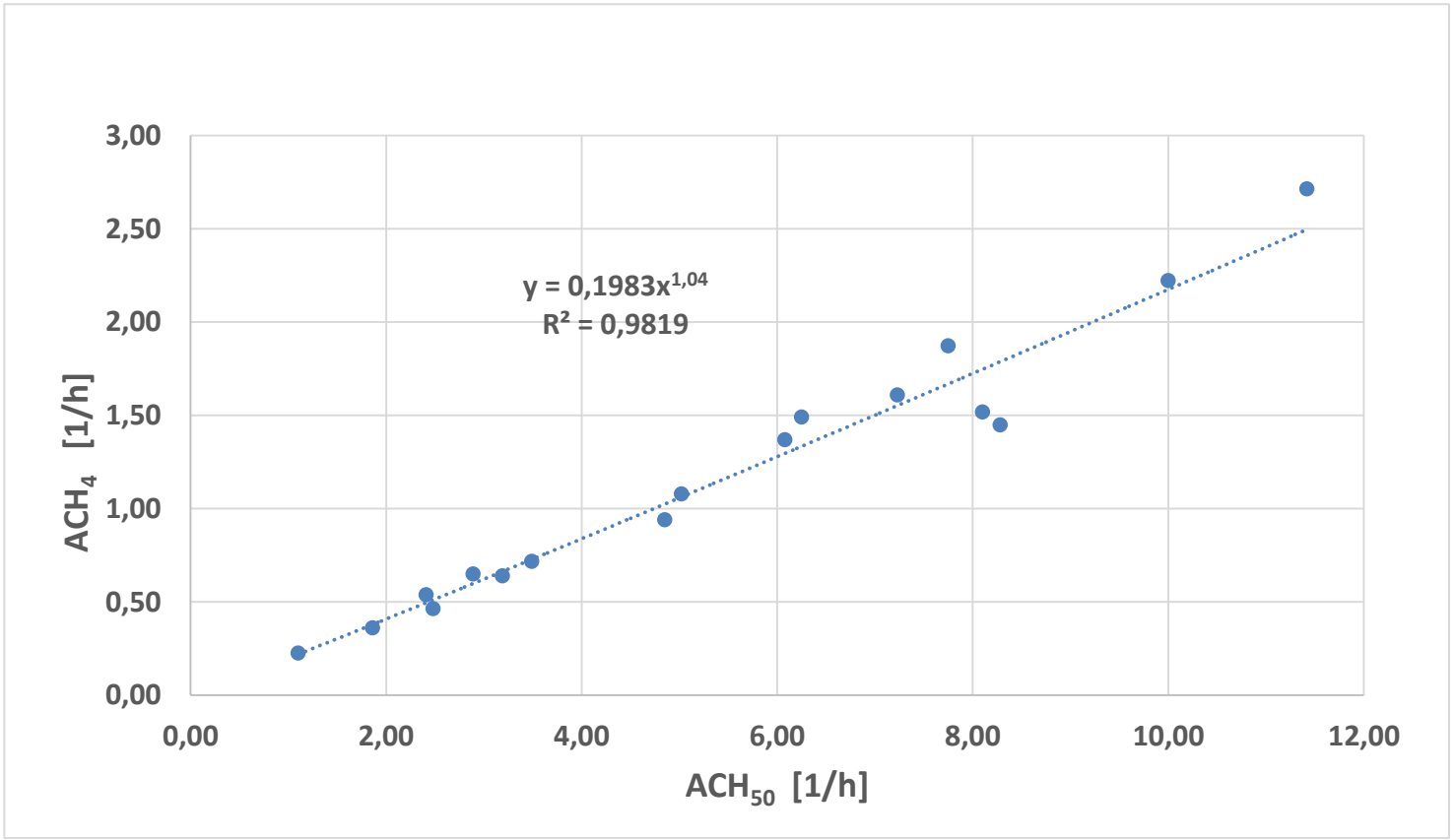
Correlation between ACH_{50} and ACH_4



Blower Door test results are verified by tracer gas tests

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Results of blower door „A" type tests (not sealed vents) in Hungary

Homes as a whole	Construc-tion	Refur-bishment	Loss V_{50} (A)	ACH_{50} (A)	ACH_4 (A)	Loss V_4 (A)
Type of the house and construction			m^3/h	[1/h]	[1/h]	m^3/h
Traditional brick detached house	1900	2012	876	7,75	1,87	211
Apartment in a concrete block	1979 (1)	-	1393	11,42	2,71	331
Traditional brick detached house	1979 (2)	2010	2502	7,23	1,61	556
Traditional brick apartment	1984	-	1368	6,08	1,37	308
Traditional brick semidetached house	1985	2008	1111	4,85	0,94	215
Traditional brick detached house	1989	-	4850	10,00	2,22	1078
Traditional brick apartment	2002	-	251	2,41	0,54	56
Traditional brick detached house	2003	-	2083	5,02	1,08	448
Traditional brick detached house	2004	-	861	2,48	0,46	161
Traditional brick detached house	2006	-	819	6,25	1,49	195
Lightweight	2008	Open fire	2001	8,10	1,52	375
Traditional brick detached house	2010	-	760	2,89	0,65	171
Lightweight	2011 (1)	-	695	3,19	0,64	139
Adobe detached house	2011 (2)	Open fire	2550	8,28	1,45	446
Traditional brick detached house	2011 (3)	-	675	1,86	0,36	131

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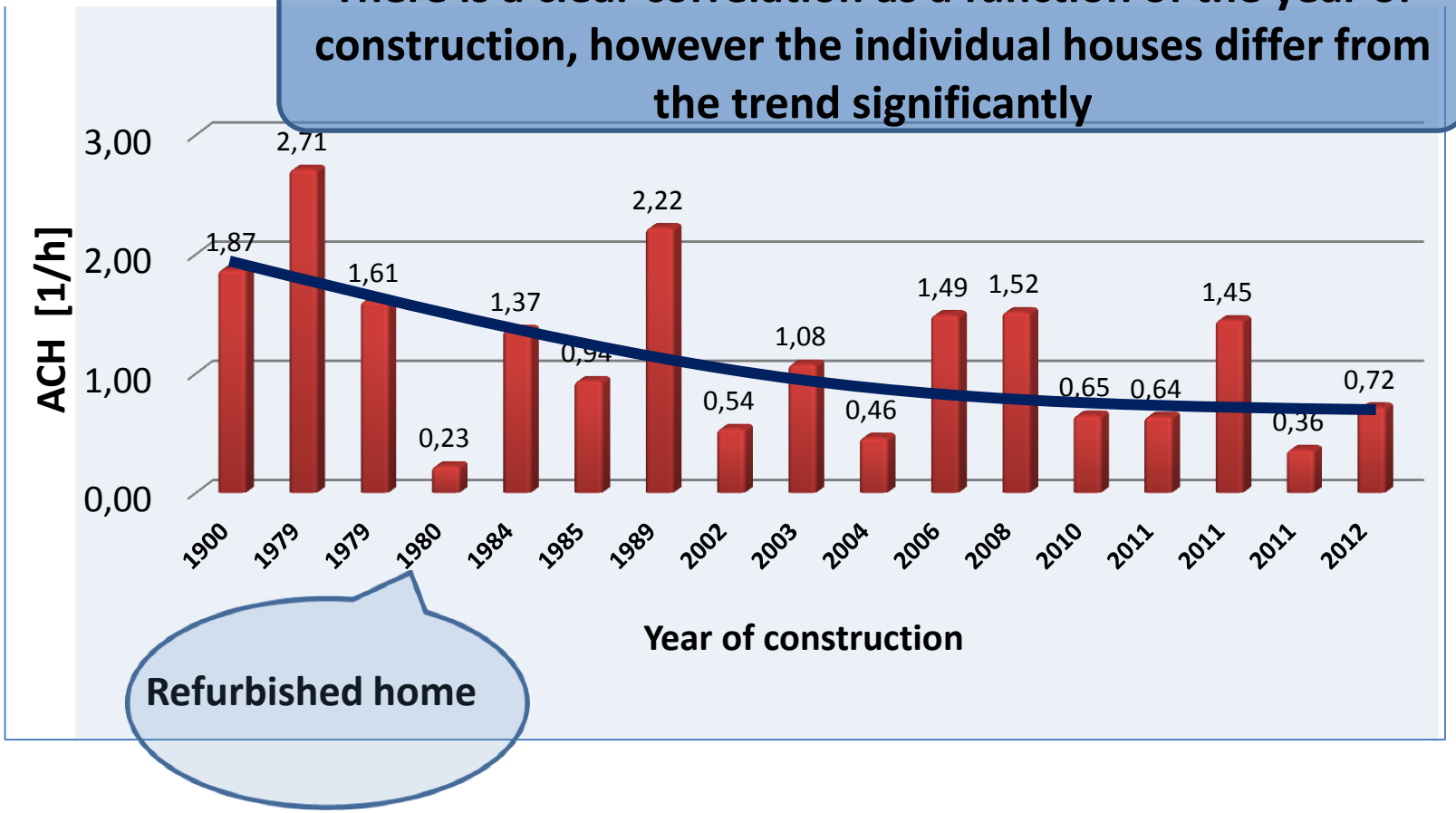
Blower Door ACH tests results in Hungary (vents not sealed)

There is a clear correlation as a function of the year of construction, however the individual houses differ from the trend significantly



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Results of blower door „B" type permeability tests (sealed vents) in Hungary

Homes as a whole	Construc-tion	Refur-bishment	Loss V_{50} (B)	ACH_{50} (B)	ACH_4 (B)	Loss V_4 (B)
Type of the house and construction			m^3/h	[1/h]	[1/h]	m^3/h
Apartment in a concrete block	1979	-	1233	10,11	2,41	294
Traditional brick apartment	1984	-	1195	5,31	1,11	249
Traditional brick apartment	2002	-	151	1,45	0,27	28
Traditional brick detached house	2004	-	833	2,40	0,46	159
Traditional brick detached house	2006	-	688	5,25	1,26	165
Lightweight	2008	-	1709	6,92	1,52	376
Lightweight	2011	-	600	2,75	0,50	108
Traditional brick detached house	2011	-	501	1,38	0,25	90

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BLOWER DOOR TEST RESULTS IN CROATIA (1)

CONSTR. PERIOD	NO.	CITY/VIL-LAGE	ADDRESS	YEAR OF CON-STRUCTION	YEAR OF RECON-STRUCTION	AIR LEAKAGE RESULTS, n50	AIR LEAK-AGE MEAN VALUE, n50
PRIOR TO 1945.	1.1	Osijek	K. F. Šepera 8	1912	2007	7.35	9.69
	1.2	Osijek	Radićeva 29	1912	2009	8.53	
	1.3	Osijek	Josipa Bosendorfera 1	1920	-	16.21	
	1.4	Osijek	Reljkovićeva 19	1925	2006	3.94	
	1.5	Osijek	Alojzija Stepinca 4	1925	-	3.16	
1945. - 1965.	2.1	Osijek	Vukovarska 167, kuća	1958	1981.201	2.51	8.43
	2.2	Osijek	Vukovarska 167, stan	1958	1981	18.39	
	2.3	Osijek	Drinska 11, prizemlje	1958	2001	0.99	
	2.4	Osijek	Vijenac A. Cesarca 19d	1961	2007	2.12	
	2.5	Osijek	Vijenac A. Cesarca 1c	1961	-	8.77	
	2.6	Osijek	Sutlanska 27	1962	1994	3.22	
	2.7	Petrijevci	Hrvatske Republike 89	1962	-	10.12	
	2.8	Petrijevci	Hrvatske republike 87A	1962	1993	9.77	
	2.9	Osijek	Prolaz Matice Hrvatske 1, neren.	1964	-	6.39	
	2.10	Osijek	Prolaz Matice Hrvatske 1, ren.	1964	2004	1.13	
	2.11	Osijek	Sutlanska 23, prizemlje	1965	1975	6.01	
1966.- 1975.	3.1	Osijek	Lovranska 8	1967	2010	2.20	10.87
	3.2	Osijek	Lovranska 7	1967	-	9.26	
	3.3	Osijek	I. Zajca 40	1968	2008	6.49	
	3.4	Osijek	Bosutska 7	1970	2010	2.35	
	3.5	Osijek	Pulska 3, prizemlje	1971	2010	1.71	
	3.6	Osijek	Pulska 3, 1 kat	1971	2005	1.69	
	3.7	Osijek	Čevapovićeva 35c	1971	-	7.35	
	3.8	Osijek	K. F. Šepera 8A	1973	2013	2.32	
	3.9	Sarvaš	Kolodvorska 34	1974	1998	2.86	
	3.10	Osijek	Vijenac Murse 4	1974	-	19.64	
	3.11	Osijek	Drinska 11, 1 kat	1975	2003	0.76	
	3.12	Osijek	Sjenjak 1	1975	-	7.23	
	3.13	Sarvaš	Kolodvorska 27	1975	1998	2.18	

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BLOWER DOOR TEST RESULTS IN CROATIA (2)

CONSTR. PERIOD	NO.	CITY/VIL-LAGE	ADDRESS	YEAR OF CON-STRUCTION	YEAR OF RECON-STRUCTION	AIR LEAKAGE RESULTS, n50	AIR LEAK-AGE MEAN VALUE, n50
1976. - 1985.	4.1	Ernestinovo	Vladimira Nazora 102	1976	2010	10.95	5.26
	4.2	Osijek	Sjenjak 131, 6 kat, Krstić	1977	2007	0.94	
	4.3	Osijek	Sjenjak 131, 6 kat, Komlenić	1977	2006	3.14	
	4.4	Osijek	Sjenjak 131, 2 kat	1977	-	5.73	
	4.5	Osijek	Sutlanska 23, 1 kat	1978	2003	5.77	
	4.6	Osijek	Sjenjak 37	1980	2002	2.13	
	4.7	Osijek	Vijenac Petrove Gore 17	1980	-	3.63	
	4.8	Osijek	Vijenac P. Gore 16	1980	2009	2.07	
	4.9	Osijek	Belišćanska 41, kuća	1982	2012	2.63	
	4.10	Osijek	Belišćanska 41, potkrovlje	1982	2012	14.91	
	4.11	Osijek	Biokovska 13, kuća	1985	1994	2.56	
	4.12	Osijek	Biokovska 13, stan	1985	1994	7.21	
	4.13	Osijek	Gornjodravska obala 93	1985	-	6.41	
1986.- 1995.	5.1	Osijek	Sjenjak 95	1986	2011	2.34	3.00
	5.2	Osijek	Sjenjak 51	1986	2008	1.07	
	5.3	Osijek	Trpanjska 10	1986	2004	1.20	
	5.4	Osijek	Laslovačka 22, prizemlje	1989	2007	2.64	
	5.5	Osijek	Laslovačka 22, 1 kat	1989	2007	5.02	
	5.6	Sarvaš	I. Mažuranića 34	1990	2009	1.45	
	5.7	Sarvaš	I. Mažuranića 36	1990	-	2.37	
	5.8	Osijek	Cara Hadrijana 13	1995	-	3.63	
1996. - 2005.	6.1	Osijek	Bračka 138	1996	2007	2.96	2.32
	6.2	Tenja	Vjekoslava Hengla 68	1999	-	3.69	
	6.3	Sarvaš	I. Mažuranića 17	2000	-	1.81	
	6.4	Tenja	Luke Botića 19	2005	-	1.45	
FROM 2006. TO THIS DAY	7.1	Sarvaš	Lovre Matačića 8	2008	-	2.82	2.99
	7.2	Osijek	Mlinska 128	2011	-	0.86	
	7.3	Osijek	Koranska 2a	2011	-	3.40	
	7.4	Osijek	Kišpatićeva 71a	2013	-	4.88	

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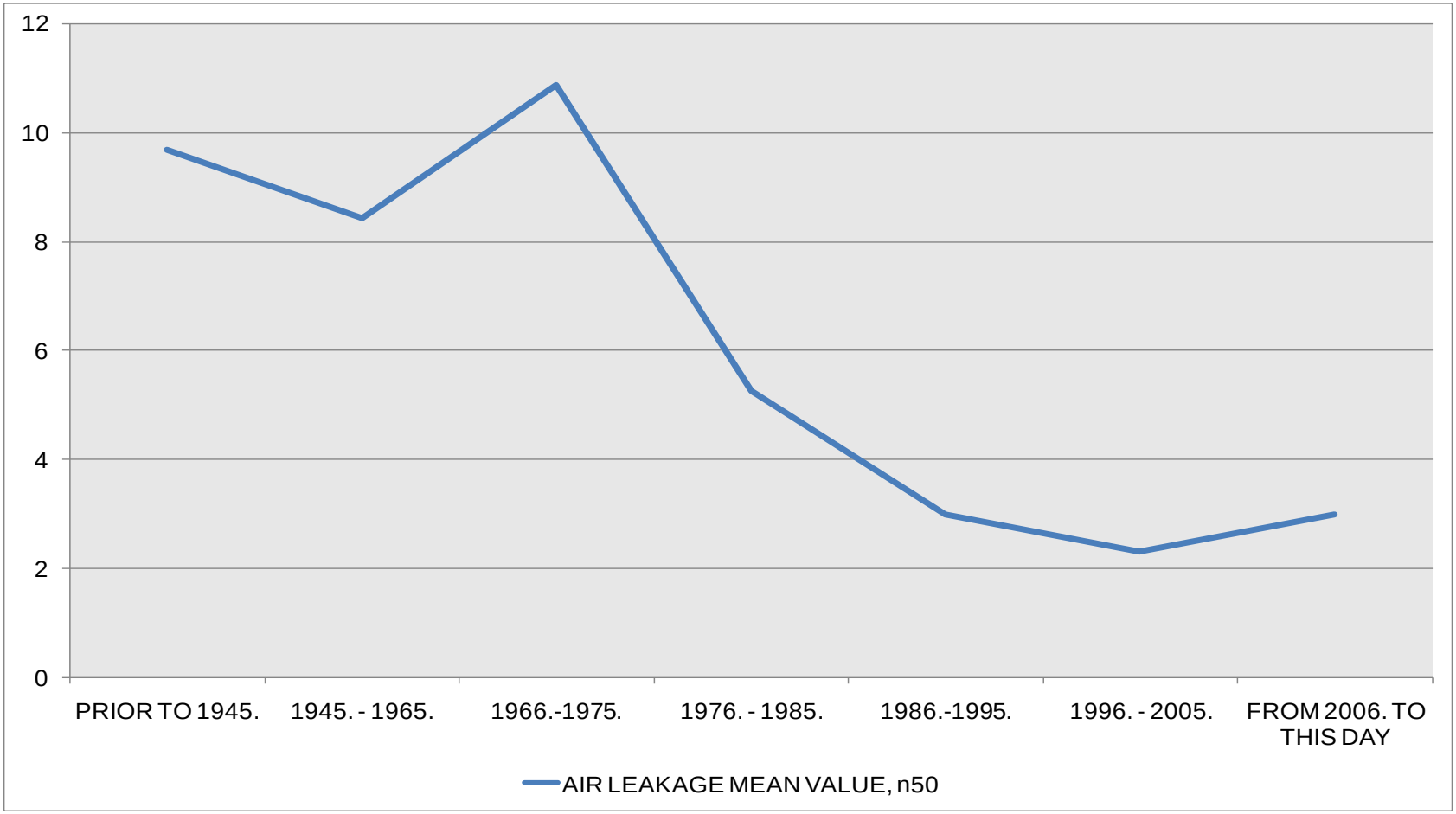
BLOWER DOOR TEST RESULTS IN CROATIA



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Conclusion

- **Field tests were carried out in Hungary and in Croatia to test houses against air tightness, natural air change rate and comfort**
- **Correlation found between Blower Door test and tracer gas test. From a series of Blower Door test equation natural ACH can be expressed**
- **Co-operation between the research team of Osijek and Pécs Universities established**

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Air Tightness Investigation of Buildings from the Point of View of Energy and Comfort

Thank you for your kind attention

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