Supported by:

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Innosuisse – Swiss Innovation Agency
Swiss Federal Office of Energy

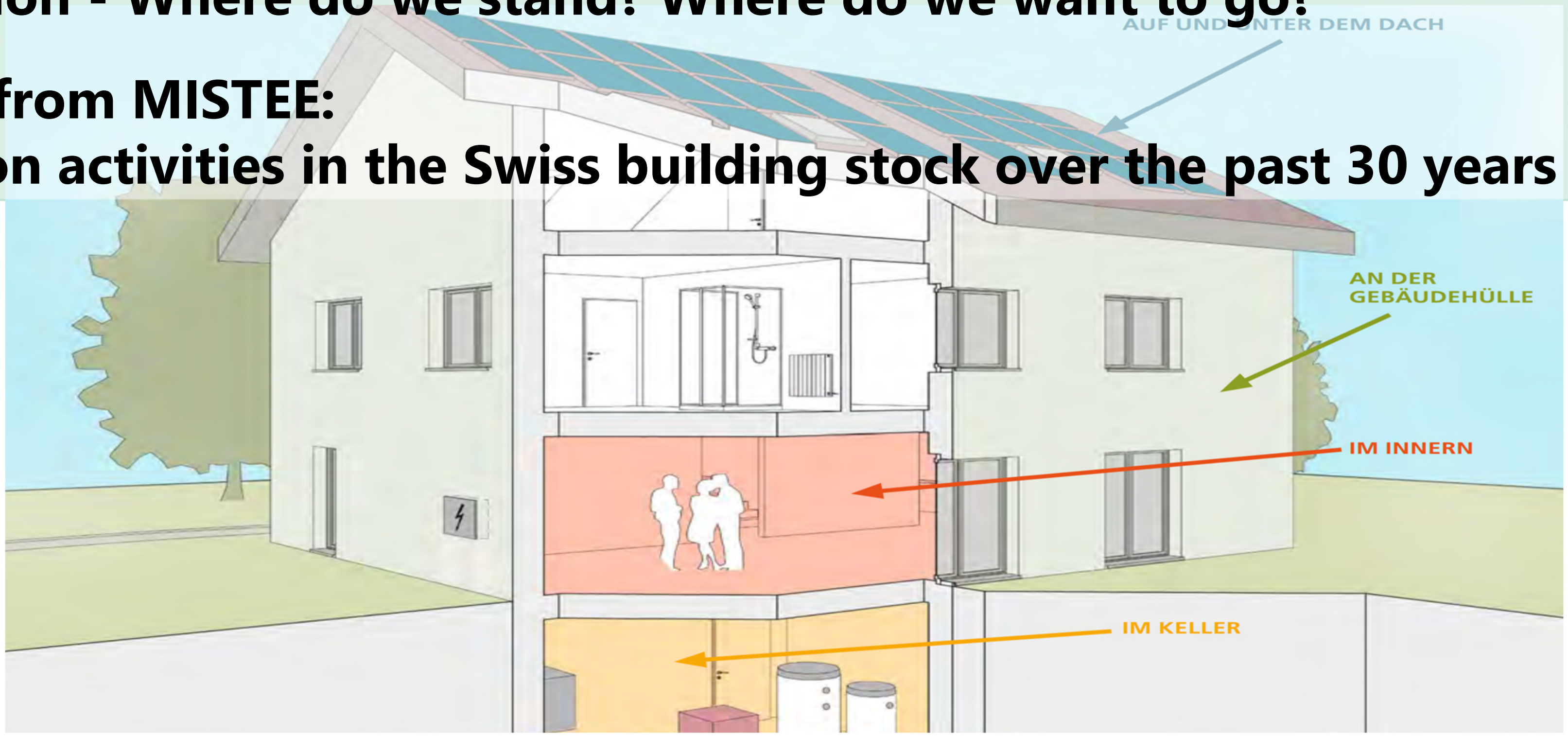
SCCER CREST
Swiss Competence Centers for Energy Research
Competence Center for Research in Energy, Society and Transition

UNIVERSITÉ DE NEUCHÂTEL

Energy Efficient Buildings: Accelerating the transition
1st February 2024 from 13:15 to 17:15 in Bern at Welle 7

Introduction - Where do we stand? Where do we want to go?

Evidence from MISTEE:
Renovation activities in the Swiss building stock over the past 30 years



Source: SwissEnergy (brochure Energy-efficient refurbishment guide for building owners)

Energy retrofit: where do we stand - and why?

1. How high was and is the maintenance and energy retrofit rate?
   Identify possible drivers that affect the probability of building envelope renovations:
   - Location
   - Building and owner-specific factors
   - energy policy measures (e.g. $CO2$ levy, subsidies).

2. Determine the heating system components and show the influence of various drivers

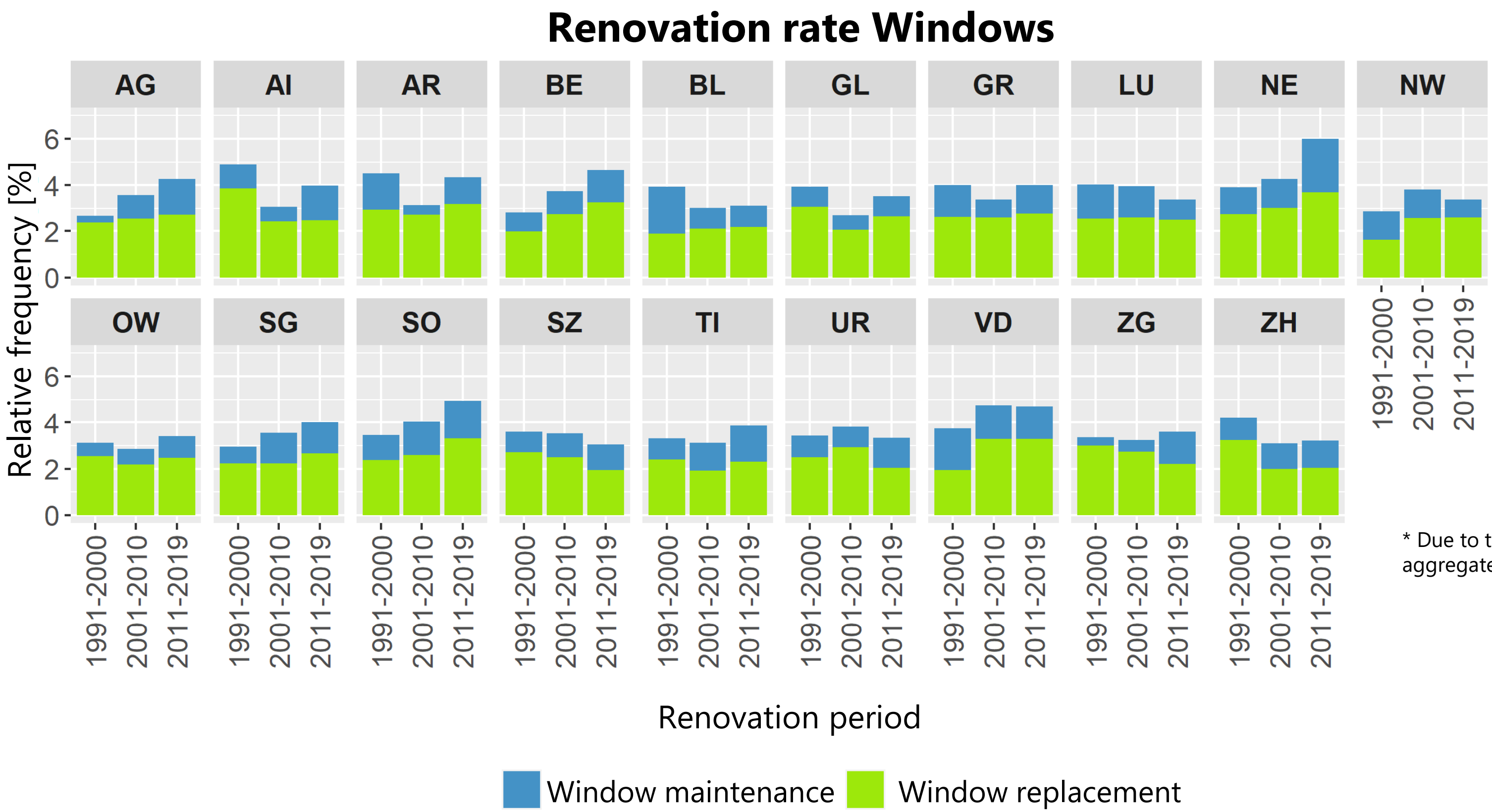
SCCER CREST

unine UNIVERSITÉ DE NEUCHÂTEL

TEP

Replacement rates (%/year) of windows
Descriptive statistics

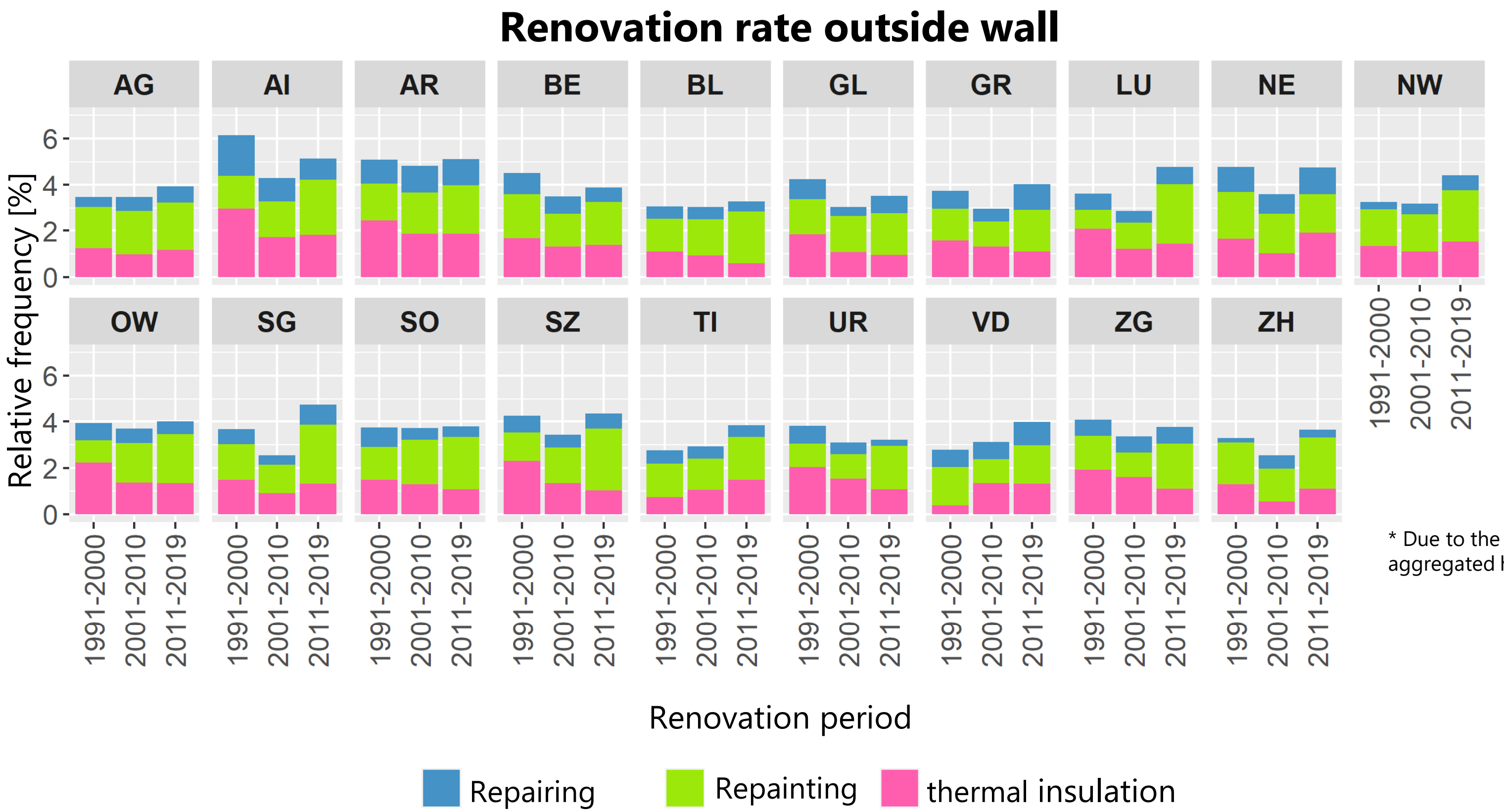
Research questions:
Which differences are random?
Which are statistically significant?
What are the relevant determinants



* Due to the number of cases, the renovation periods are aggregated here to 10-year periods

Renovation rates (%/year) using the exterior wall
Descriptive statistics

Research questions:
Which differences are random?
Which are statistically significant?
What are the relevant determinants



* Due to the number of cases, the renovation periods are aggregated here to 10-year periods

SCCER CREST

unine UNIVERSITÉ DE NEUCHÂTEL

TEP

Energy renewal: where do we stand and why?

1. How high was and is the maintenance and energy renewal rate?
   Identification of possible influencing factors that affect the probability of building envelope renovations:
   - Location
   - Building attributes
   - Owner-specific attributes (e.g. socio-economic)
   - Energy policy measures (e.g. CO_2 levy, subsidies).

2. Determine the heating system components and show the influence of various drivers

Objective and approach

Objective: To analyse the past renovation activities of building owners over the last 30 years.

Data collection

- Survey in 19 cantons (in cooperation with the cantons' CO2 reporting)
- Renovation and refurbishment work carried out in the last 30 years
- Heating system and last change

Analysis

- Descriptive evaluation of past renovation activities on the building envelope (derivation of average renovation rates) and the heating system shares
- Econometric evaluations of renovation behavior and heating system selection in order to distinguish statistically significant from non-significant effects
- Descriptive evaluations of motivations and obstacles

2. Heating system

Determining factors for heating systems

- **Relative risk ratio**
  Reading aid: The probability of using wood heating systems compared to oil heating systems (reference) is around twice as high in rural communities as in urban communities.
- Building sector:
  - Wood and HP compared to oil heating significantly lower in MFHs than in EFHs.
  - HP lower, FW higher (in each case compared to oil) in the NWG Construction period:
- Building period:
  - 1946-1980: increase in oil heating systems
  - 1981-2000: Increase in HP, decrease in wood
  - From 2001: increase in all heating systems compared to oil and old buildings

Variable	Andere		Fernwärme		Gas		Holz		WP	
Intercept	0.180	***	0.093	***	0.045	***	0.243	***	0.644	**
Ländliche Gemeinde	1.400	*	1.120		0.582	***	2.082	***	1.024	
Periurbane Gemeinde	0.831		1.168		0.814	*	1.052		1.023	
Gasversorgt	0.925		1.319	**	30.160	***	0.794	*	0.979	
MFH	0.453	***	1.007		0.996		0.645	***	0.707	***
NWG	0.766	.	1.671	***	1.177		1.000		0.533	***
BAUP_1946_1980	0.821	.	0.690	***	0.501	***	0.378	***	0.846	*
BAUP_1981_2000	1.105		0.961		1.164	.	0.428	***	2.020	***
BAUP_ab2001	1.967	***	4.420	***	2.688	***	2.466	***	18.091	***

Signif. Codes: *** $p < 0.0001$, ** $p < 0.001$, * $p < 0.05$, . $p < 0.1$Base categories: "Urban municipality", "Not supplied with gas", "EFH", "BAUP_bis_1945"

- The proportion of gas is significantly higher in gas-supplied municipalities,
- Also the proportion of district heating is higher (1.3 times)
- Conversely, the proportion of wood is lower (factor 0.8)

Determining factors for heating systems

- The probability ratio of heat pumps and oil heating systems is approx. 50% lower in the case of STWEGs and even approx. 65% lower in the case of private communities than in the case of private individuals.
- Negative significant effects can also be observed for wood heating systems in the case of STWEG, insurance companies, pension funds and other companies (always in comparison to private individuals).
- Compared to oil heating, district heating is used significantly more by the public sector and STWEG than by private individuals.
- 20-25% higher WK for gas or HP compared to oil for tertiary education qualifications
- Less HP compared to oil in the cantons of BE, BL, GL, GR, NE, SZ, VD, ZG compared to the base canton of AG
- Most cantons with significantly more wood than canton AG

Variable	Andere		Fernwärme		Gas		Holz		WP	
Eigentum_Weitere/k.A.	0.733		1.758		0.950		0.454	*	0.682	
Eigentum_Private Gemeinschaft	1.092		1.158		1.024		0.749		0.343	***
Eigentum_Versich./PK/Firma	0.800		1.594		1.028		0.471	*	0.739	
Eigentum_Genossenschaft	0.864		2.020		1.280		0.695		0.748	
Eigentum_Öffentliche Hand	1.264		6.266	***	1.367		1.469		1.333	
Eigentum_STWEG	0.816		1.689	*	1.179		0.396	***	0.497	***
Ausbildung_k.A./indifferent	1.097		1.533		1.172		0.928		0.738	
Ausbildung_Tertiärstufe	0.942		1.214		1.200	*	0.861	.	1.258	**
AI	0.756		0.262	**	0.486	***	3.195	***	1.014	
AR	0.596		1.627	*	1.845	**	2.577	***	0.741	
BE	1.281		0.709	.	0.701	*	2.448	***	0.599	**
BL	0.955		1.422	.	1.651	***	2.336	***	0.549	***
GL	1.312		0.557	*	0.589	**	2.375	***	0.696	*
GR	1.868	**	0.236	***	0.317	**	1.865	**	0.564	***
LU	1.760	*	1.031		1.086		2.068	**	1.434	*
NE	1.260		0.795		1.216		1.939	**	0.192	***
NW	2.477	***	1.102		0.762		2.090	**	0.881	
OW	1.346		1.937	**	0.334		1.984	**	1.282	
SG	1.356		0.690	*	1.399	**	1.570	*	1.000	
SO	0.993		0.609	.	1.266		1.575	.	0.760	
SZ	1.576	.	1.144		0.467	***	2.900	***	0.668	*
TI	3.046	***	0.105	***	0.689	*	0.904		0.927	
UR	2.177	***	1.162		0.000		1.732	*	1.087	
VD	2.254	***	0.539	**	1.452	*	1.441		0.413	***
ZG	1.666	.	1.086		0.650	*	2.538	***	0.638	*
ZH	0.990		0.857		1.003		2.007	**	0.905	

Signif. Codes: *** $p < 0.0001$, ** $p < 0.001$, * $p < 0.05$, . $p < 0.1$Base categories: "Property_private individual", "Education_non-tertiary level", "AG"

Determining factors for energy-related renovation of the building envelope

Econometric Results (1/4):
Cantons, components, periods

- Some few cantons have significantly different renewal rates
- Compared to windows, significantly lower renovation rates for: Exterior walls, pitched roofs and basement ceilings
- Reduced renovation rates in the 1990s, increased from 2006 (base category: 2001-2005)

	Koeffizient		OR
Intercept	-1.226	***	0.294
AI	0.334	***	1.397
AR	0.317	***	1.373
BL	-0.118	*	0.888
LU	0.230	***	1.258
Kellerdecke	-1.636	***	0.195
Aussenwand	-1.002	***	0.367
Steildach	-0.889	***	0.411
Erneuerung_1991_1995	-0.226	***	0.798
Erneuerung_1996_2000	-0.041		0.960
Erneuerung_2006_2010	0.266	***	1.305
Erneuerung_2011_2015	0.425	***	1.530
Erneuerung_2016_2019	0.424	***	1.528

Signif. Codes: *** p < 0.0001, ** p < 0.001, * p < 0.05, . p < 0.1Base categories: "Rest", "Window", "Renewal_2001_2005"

OR: Odds Ratio: Ratio with which the renovation rate is influenced (compared to the base category)

SCCER CREST

unine UNIVERSITÉ DE NEUCHÂTEL

TEP

Econometric Results (2/4):
Building und Heizsysteme

- Lower rates for buildings built after 1981
  (only 0.26 or 0.05 times as often as buildings built "before 1946")
- Slightly higher renovation rates for apartment buildings
  (a good 6% more frequent)
- Lower rates for buildings heated by CH, gas and HP
  (20%, 18% and 15% less respectively)

Intercept	Koeffizient	OR
BAUP_1946_1980	-0.021	0.980
BAUP_1981_2000	-1.338 ***	0.262
BAUP_ab2001	-2.954 ***	0.052
MFH	0.061 *	1.063
NWG	-0.039	0.961
HS_Andere	-0.096 *	0.909
HS_Fernwärme	-0.215 ***	0.806
HS_Gas	-0.194 ***	0.824
HS_Holz	0.003	1.003
HS_Wärmepumpe	-0.166 ***	0.847
HS_k.A.	-0.120	0.887

Signif. Codes: *** $p < 0.0001$, ** $p < 0.001$, * $p < 0.05$, . $p < 0.1$
Basic Categories: «BAUP_vor_1945», «EFH», «HS_Heizöl»

Econometric Results (3/4):
Owners and municipalities

- Owner types, compared to private individuals:
  - Significantly lower rates for STWEG and other private communities
  - Lowest rates for public and other buildings
- Renewal rates around 20% lower for older people
- Increased renewal rates at tertiary level (around +14%)
- No stat. sign. Influence of community types

Intercept	Koeffizient	OR
Eigentum_Weitere/k.A.	-0.747 ***	0.474
Eigentum_Private Gemeinschaft	-0.254 ***	0.775
Eigentum_Versich./PK/Firma	-0.446 ***	0.640
Eigentum_Genossenschaft	-0.246 .	0.782
Eigentum_Öffentliche Hand	-0.762 ***	0.467
Eigentümer_STWEG	-0.226 ***	0.798
Alter_>=60	-0.200 ***	0.819
Alter_k.A./indifferent	-0.133	0.875
Ausbildung_k.A./indifferent	0.242 *	1.274
Ausbildung_Tertiärstufe	0.130 ***	1.138
LändlicheGemeinde	0.035	1.035
PeriurbaneGemeinde	0.042	1.043

Signif. Codes: *** p < 0.0001, ** p < 0.001, * p < 0.05, . p < 0.1
Base categories: "Ownership_private individual", "Age_<60", "Education_non-tertiary level", "Urban municipality"

Econometric Results (4/4):
Policies

	Model variant 2		Model variant 3		Model variant 4	
Intercept	Koeffizient	OR	Koeffizient	OR	Koeffizient	OR
Green	0.146	1.157	0.262 **	1.299	0.271 **	1.311
Fördersatz	0.011 ***	1.011				
Energiepreis_Fossil	0.044 ***	1.045				
CO2-Abgabe			0.005 ***	1.005		
CO2-Abgabe:Schwellenwert30					0.004 ***	1.004

Signif. Codes: *** p < 0.0001, ** p < 0.001, * p < 0.05, . p < 0.1

- Model specifications 2-4: without renewal periods as explanatory variable (otherwise the same as model 1)
- Cantonal "Green" voter share has a positive significant influence
  (model variants 3 and 4, each with around 30% higher rates)
- Increased renewal rates with rising subsidy rates and energy prices for fossil heating systems (Model variant 2)
- Increased chances of renewal with rising CO2 tax
  (Model variant 3 without and model variant 4 with threshold value)

SCCER CREST

UNIVERSITÉ DE NEUCHÂTEL

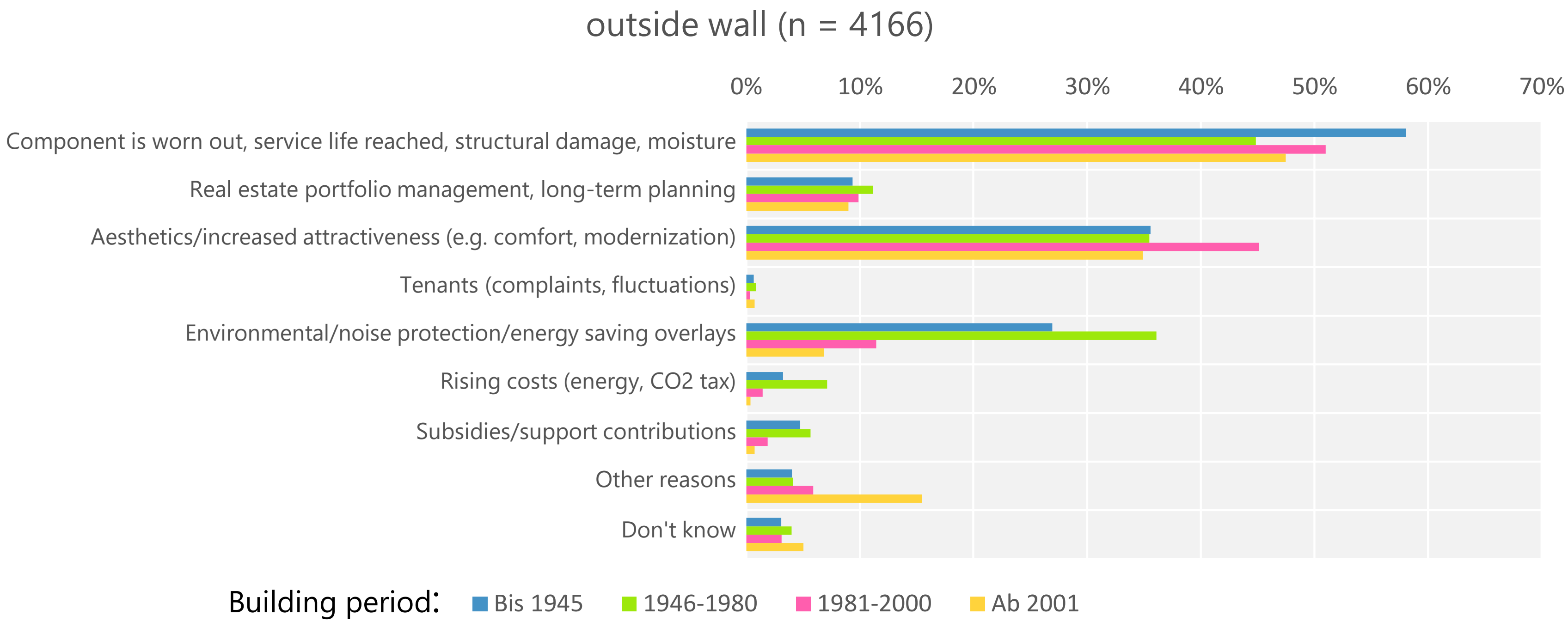
TEP

Conclusions retrofit rates

- Retrofit rates (RR) have increased steadily since the 1990s, especially from 2006 onwards
- Building technology
  - RR differ greatly between the building components
  - RR increased for old buildings (up to and including 1980) and residential buildings
  - RR lower for grid-bound energy sources and heat pumps => trade-off of motivations
- Socio-economic:
  - RR increased for private individuals in relation to companies/public buildings or communities
  - RR increases for well-educated people (proxy for income?)
  - Age problem (of owners)
- Policy:
  - Few cantons differ (taking all other effects into account)
  - Higher renovation rates with increased subsidy rates and increased CO_2 tax
  - Subsidies and subsidies will continue to be an important incentive in the future (in addition to tax deductions, which are on the "wish list")

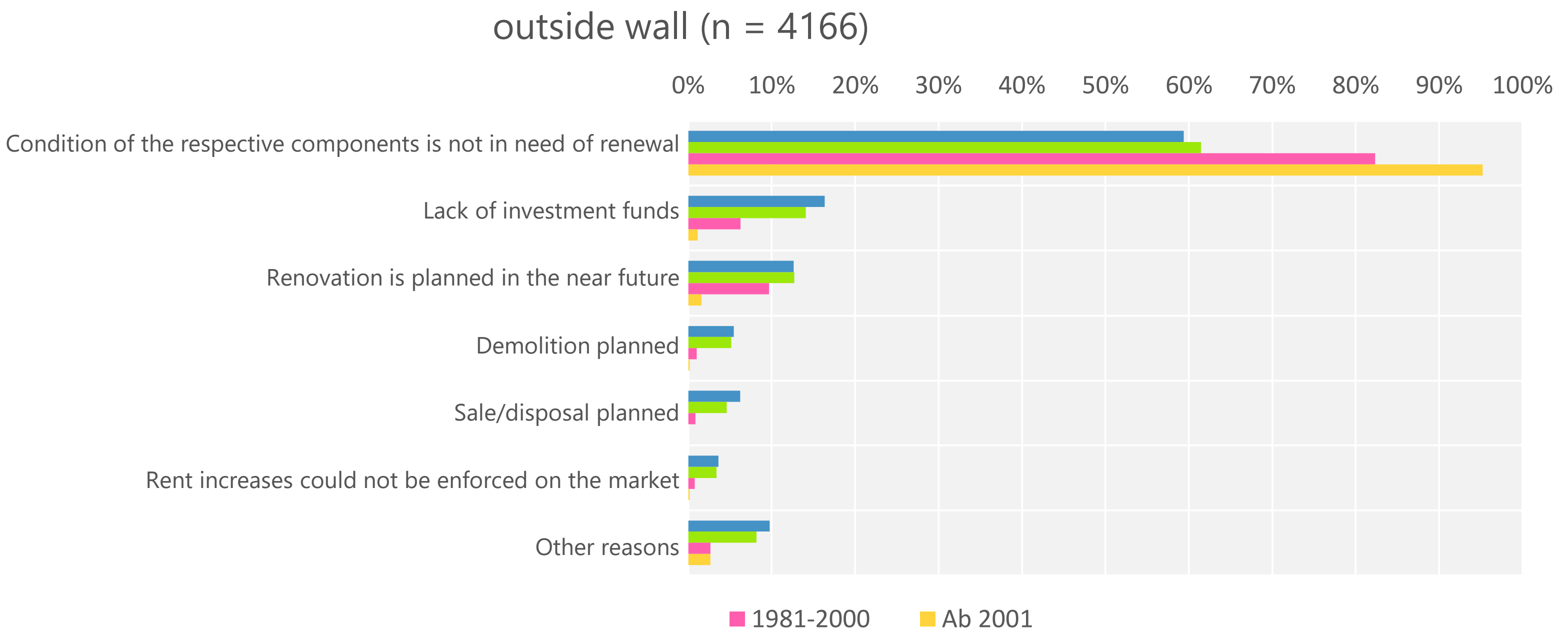
What do the building owners say?

Motivations for renovations: Facade



Technical (e.g. worn building component) and aesthetic as well as environmental/energy-specific reasons are in the foreground (the latter mainly for older buildings)

Obstacles to renovations: Facade

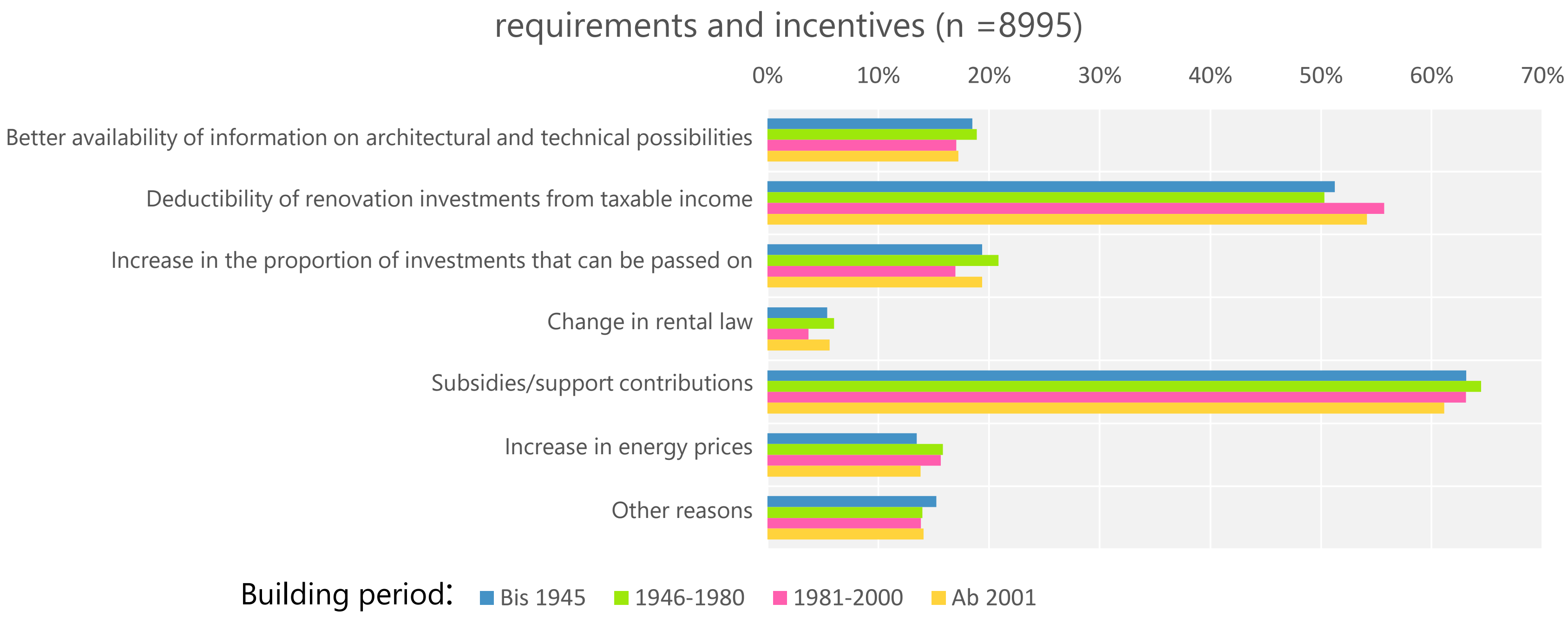


- Condition of the respective components not in need of renewal as the main obstacle
- Financial aspects only play a subordinate role

SCCER CREST

UNIVERSITÉ DE NEUCHÂTEL

Incentives to be created for renovations



- Conditions and incentives to be created to make renovation activities more attractive
- Financial aspects are important for future renovations

Thank you
for your attention.

Stichprobe

- Mehr als 10’000 Datensätze zu Einfamilienhäusern (EFH), Mehrfamilienhäusern (MFH) und Nichtwohngebäuden
- Verteilung über alle Bauperioden

	EFH	MFH	NWG
Bis 1945	1034 (24%)	1287 (32%)	867 (34%)
1946-1980	1387 (33%)	1322 (33%)	787 (31%)
1981-2000	1148 (27%)	719 (18%)	442 (17%)
Ab 2001	698 (16%)	650 (16%)	464 (18%)
Total	4267 (100%)	3978 (100%)	2560 (100%)