

2<sup>nd</sup> AIEE Energy Symposium  
Current and Future Challenges to Energy Security

# **Contracting the Gap: Empirical evidence on the role of energy performance contracting to promote investment in energy efficiency**

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# Presentation overview

- Short introduction and overview of project
- Hypotheses
- Methodology
- Data
- Results
- Conclusions and policy implications

# Short introduction

- Research project funded by the Swiss Federal Office for Energy
- 3 stages project
  - Evaluation of the current state of energy performance contracting in Switzerland (literature review)
  - Empirical study on EPC demand side (presented here)
  - Empirical study on supply side of EPC

# What is EPC

- Is a form of alternative financing for capital improvement which allows funding energy upgrades from cost reductions
- Under an EPC arrangement, an external organisation (Energy Service Company - ESCO) implements a project to deliver energy efficiency, or a renewable energy project
- The ESCO uses the stream of income from the cost savings or the renewable energy produced to repay the costs of the project (including the costs of the investment)
- The ESCO will not receive its repayment unless the project delivers energy savings as expected

# Short introduction

## overview of the project

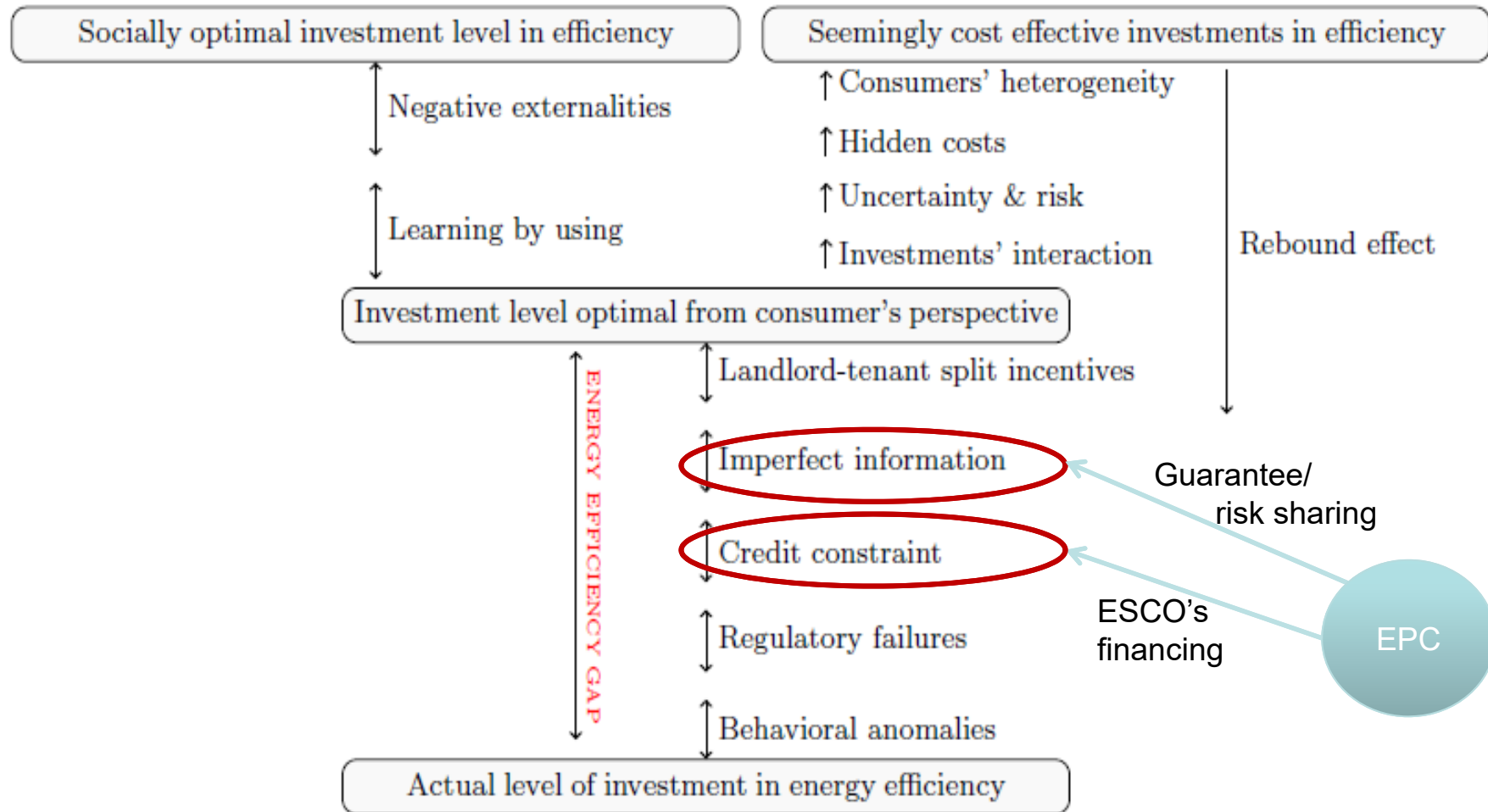
- Energy performance contracting counts amongst the set of market based instruments available in order to reach the objectives defined by the Swiss energy strategy 2050
- Empirically assessing to which extent, and through which channels, EPC can promote investments in energy efficiency is of primary interest for policy-makers
- If the energy efficiency gap exists, it is of particular concern for policymakers to focus primarily on the most binding constraints
- This study, in addition to informing about EPC adoption, also provides information on the determinants hampering investments in energy efficiency
- The main channels through which EPC can induce investment, such as risk sharing, access to capital, technical expertise and enduring performance have been often highlighted in the literature. However, quantitative evidence in support of these conjectures is scarce

# Short introduction

## overview of the project

- While providing useful insights, the current state of the EPC literature lacks empirical evidence on the decision mechanisms through which EPC can induce investments, and on their underlying trade-offs and heterogeneity
- This study attempts to reduce the research gap using a discrete choice experiment targeted to managers of large energy-consuming buildings in Switzerland
- This empirical strategy permits to explore the diversity of channels through which EPC can foster energy efficiency investments

# EPC and the energy efficiency gap



source: S. Klinke, based on the concepts in Gillingham and Palmer (2013).

# Market demand for EPC and its future potentials

- Aim: provide empirical evidence on the decision mechanisms through which EPC can induce investments in energy efficiency
- Determine the most binding constraints to investments in energy efficiency
- Account for the underlying trade-offs and heterogeneity in preference and decision process
- Survey and choice experiment analysis of 297 potential EPC clients



# Hypotheses

- H1: EPC induces energy efficiency investments through financing only in cases where **credit constraints** are important
- H2: EPC induces energy efficiency investment through performance guarantee which results in **risk sharing**
- H3: Having tenants decreases the likelihood of energy efficiency investment, with or without EPC
- H4: The payment to the ESCO has a negative impact, while the effect of contract's duration is ambiguous and depends on type of clients
  - H4b: Private entities have a negative valuation of the contract's duration
- H5: Unawareness to EPC results in an “unexplained” reluctance towards EPC solutions

# Methodology

- Online survey amongst potential EPC clients
  - Including choice experiment on EPC options
- Survey design
  - Target group
  - Survey structure and choice experiment
  - Data collection
  - Econometric framework

# Survey design

## Target group

- The sample includes buildings with private ownership as well as public buildings
- Sample size is about 2200 buildings throughout Switzerland
  - Large enterprises with own building portfolio or high energy demand (services sector)
  - Private small and medium-sized companies (SMEs) with own building portfolio or high energy demand (hotels, restaurants, shopping center)
  - Public sector owning building infrastructure such as hospitals, schools, office buildings, swimming halls, etc.

# Data collection

2203 Potential users / target groups / building types for EPC with potentially high energy demand

- Schools (244)
- Public offices (1008)
- Sport facilities (32)
- Hospitals (91)
- Hotels (496)
- Office buildings (233)
- Shopping centres (87)
- Others (12)

# Data collection

- Web-based survey, participant specific (unique code)
- Pre-test addressed 125 participants to determine priors (31 started, 15 finished survey)
- Invitation via mail and e-mail
  - Two reminder e-mails
  - 69 additional phone contacts
- Main survey response rate
  - 533 started the survey
  - 297 completed the survey

# Survey structure and choice experiment

- Part 1: Introductory questions on the building and the respondent
- Part 2: Current situation of the building
- Part 3: Information on EPC
- Part 4: Choice experiment
- Part 5: Decision process
- Part 6: Socio-economic statistics of respondents
- Part 7: Contact and end

# Survey structure and choice experiment

Dans la situation où une révision est nécessaire pour le bâtiment, quelle option envisageriez-vous?

*Vous pouvez déplacer votre souris sur les éléments traitillés pour obtenir plus d'information.  
(Situation 1 sur 4)*

	Investissement sans contrat	Simple révision
Mesure	Automation du bâtiment	peinture façade et fenêtres
Coût total de réalisation	120CHF/m <sup>2</sup> surface chauffée [SS1 Script]	80CHF/m <sup>2</sup> surface chauffée [SS1 Script]
Economie d'énergie	moyenne de 5% (peut varier de 4% à 6%)	Pas d'économies d'énergie
	<input type="radio"/>	<input type="radio"/>

Maintenant, un prestataire vous propose un contrat. Quelle option envisageriez-vous?

	Contrat de Performance énergétique	Investissement sans contrat	Simple révision
Mesure	Isolation enveloppe + automation du bâtiment	Automation du bâtiment	peinture façade et fenêtres
Coût total de réalisation	200CHF/m <sup>2</sup> surface chauffée dont le prestataire finance 60% et vous 40% [SS1 Script]	120CHF/m <sup>2</sup> surface chauffée [SS1 Script]	80CHF/m <sup>2</sup> surface chauffée [SS1 Script]
Economie d'énergie	39% d'économie garantie (mais peut atteindre 48%)	moyenne de 5% (peut varier de 4% à 6%)	Pas d'économies d'énergie
Termes du contrat	21.55CHF/m <sup>2</sup> surface chauffée par an durant 10 ans [SS1 Script]		
	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

# Econometric framework

$$\begin{aligned}V_{it,ee} &= \beta_{0,ee} + \beta_1 cost_{it,ee} + \beta_2 sav_{it,ee} + \beta_3 risk_{it,ee} + \beta'_4 meas_{it,ee} \\V_{it,epc} &= \beta_{0,cpe} + \beta_1 cost_{it,epc} + \beta_2 sav_{it,epc} + \beta_3 risk_{it,epc} + \beta'_4 meas_{it,epc} \\&\quad + \beta_5 fin_{it,epc} + \beta_6 guar_{it,epc} + \beta_7 pay_{it,epc} + \beta_8 dur_{it,epc} \\V_{it,ovh} &= \beta_1 cost_{it,ovh}\end{aligned}$$

- Conditional logit
- Heterogeneity in decision process and preferences:
  - Conditional logit with stated weights
  - Latent class model with attribute non-attendance (ANA)
- Individual characteristics:
  - EPC responsive, familiarity with EPC, public vs. private, etc.
- Reluctance towards EPC?
  - Alternative-specific estimates of attributes

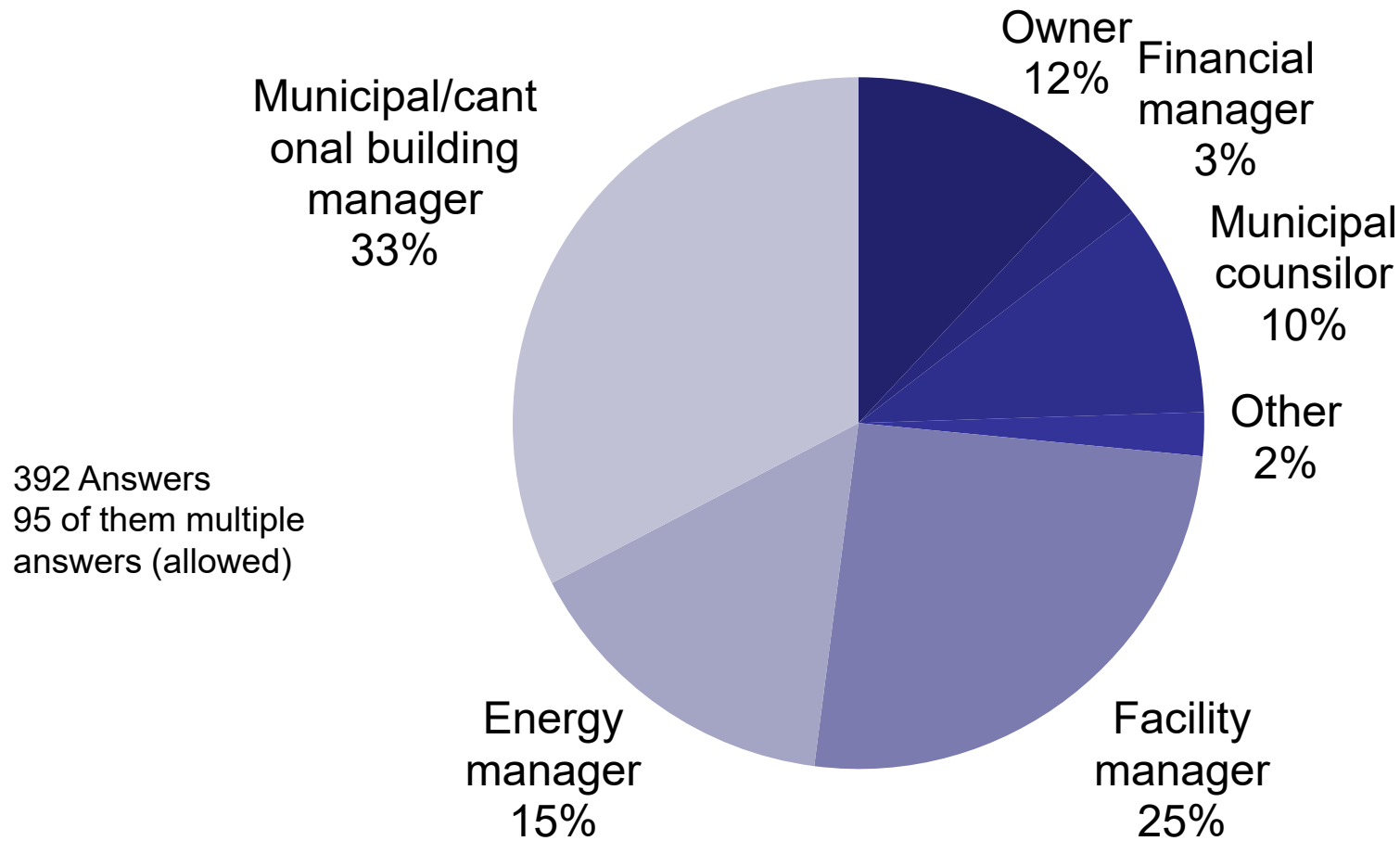


# Data: Descriptive statistics of the respondents and their building

- Structure of the response group

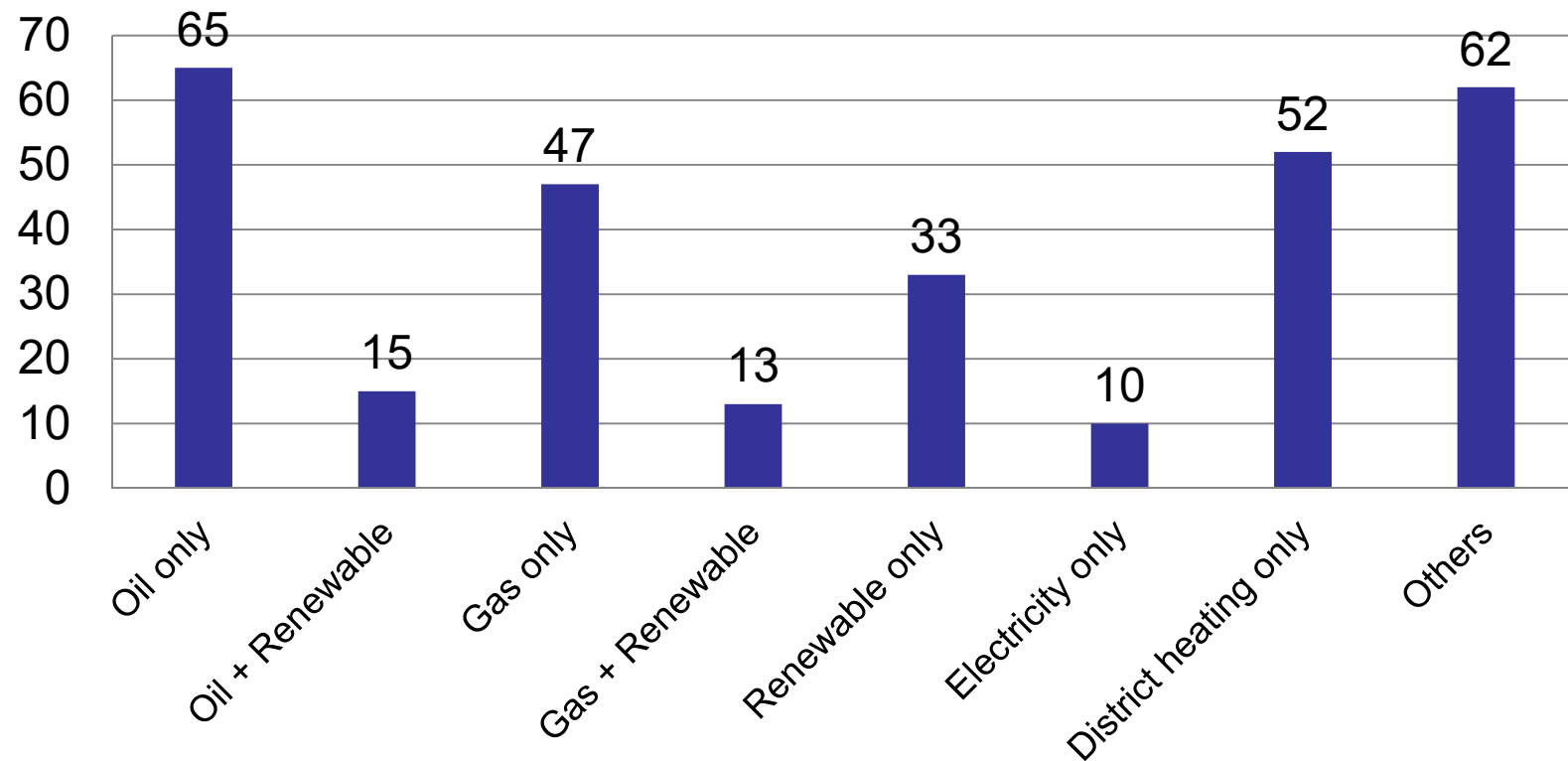
	Publicly-owned building (% with public ownership)	Privately-owned building	Total
Education facility	142 ()	4 ()	146 ()
Offices	10 ()	13 ()	23 ()
Hotel	1 ()	19 ()	20 ()
Hospital	10 ()	4 ()	14 ()
Public administration	58 ()	0 ()	58 ()
Shopping center	3 ()	4 ()	7 ()
Sport facility	9 ()	0 ()	9 ()
Residential	10 ()	2 ()	12 ()
Other	6 ()	2 ()	8 ()
<b>Total</b>	<b>241 ()</b>	<b>52 ()</b>	<b>297 ()</b>

# Data: respondents' function



# Data: heating systems

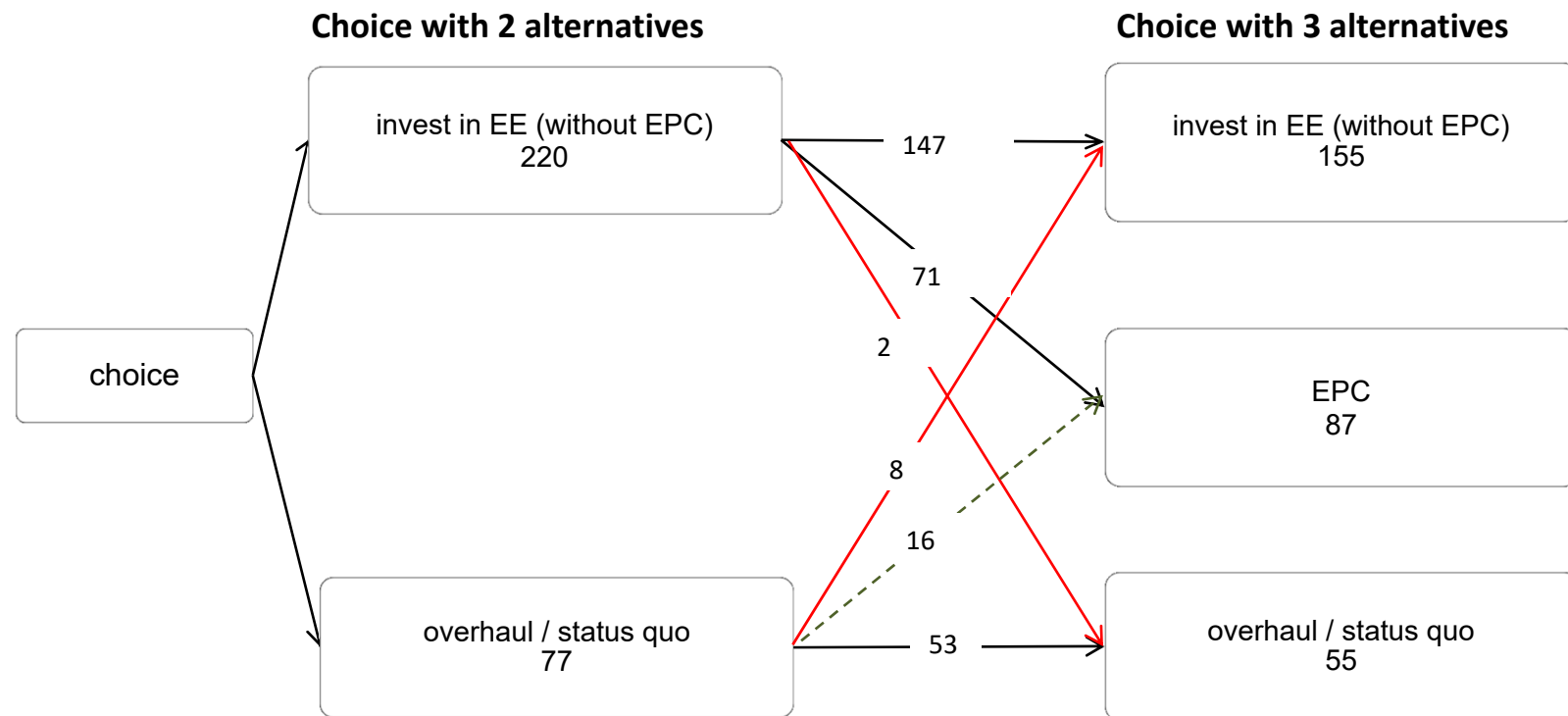
- Currently installed heating systems (297)



# Results

- Familiarity with EPC concept
- Investment decision
- Stated barriers to investment in energy efficiency actions
- Stated barriers to EPC
- Estimation results: Does EPC induce investment in energy efficiency and through which mechanisms?
- Robustness checks and further research

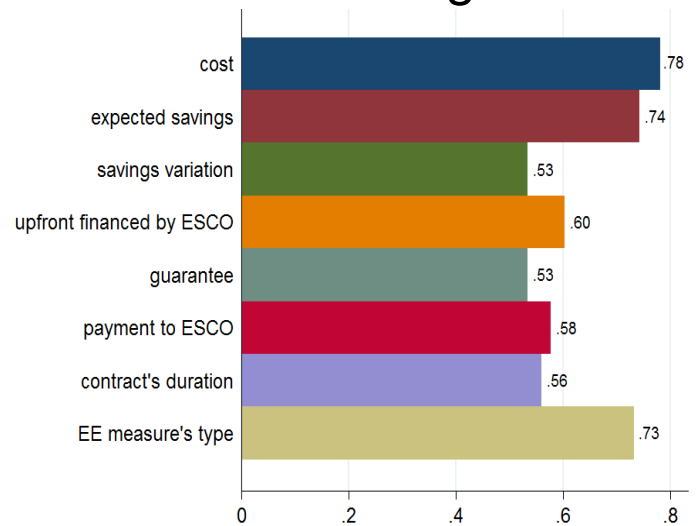
# Results: investment decision



Nb of respondents: average across 4 choice tasks

# Results: heterogeneity in decision process

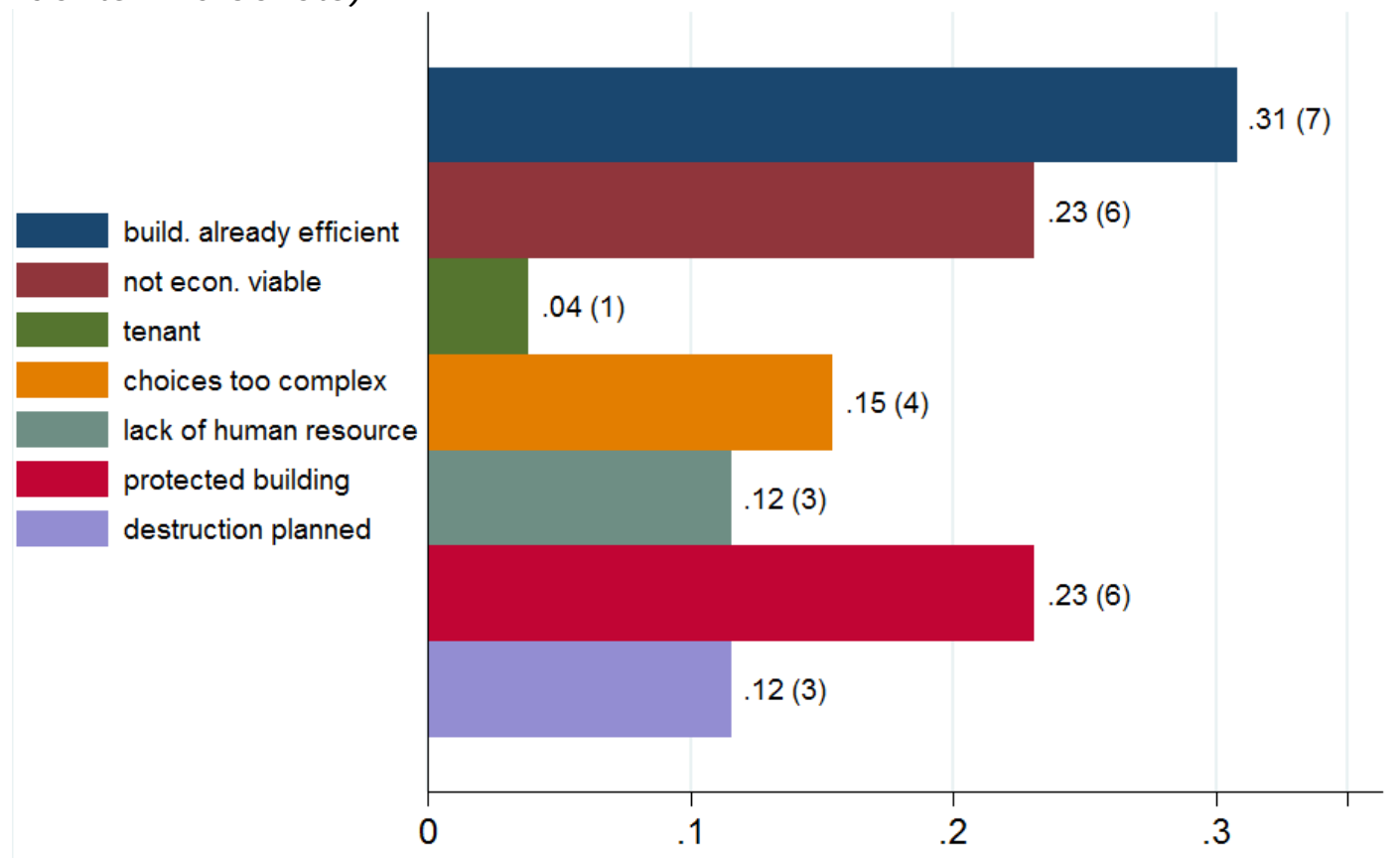
- Simplification of decision process and/or attribute non-attendance is supported by:
  1. Persistence of choices across choice tasks for 138 persons (70% of the sample)
  2. Median time spent on each choice task decreases drastically across the four choice tasks.
  3. Stated weights:



Combination of important attributes	nb resp.	share
no attribute is more important than another	23	0.08
cost-sav.-meas.	19	0.06
cost-sav.-meas.-risk	16	0.05
cost-sav.	13	0.04
cost-sav.-meas.-fin. by ESCO	12	0.04
cost	9	0.03
cost-sav.-meas.-guar. / sav.-meas.	7 (2x)	0.02 (0.05)

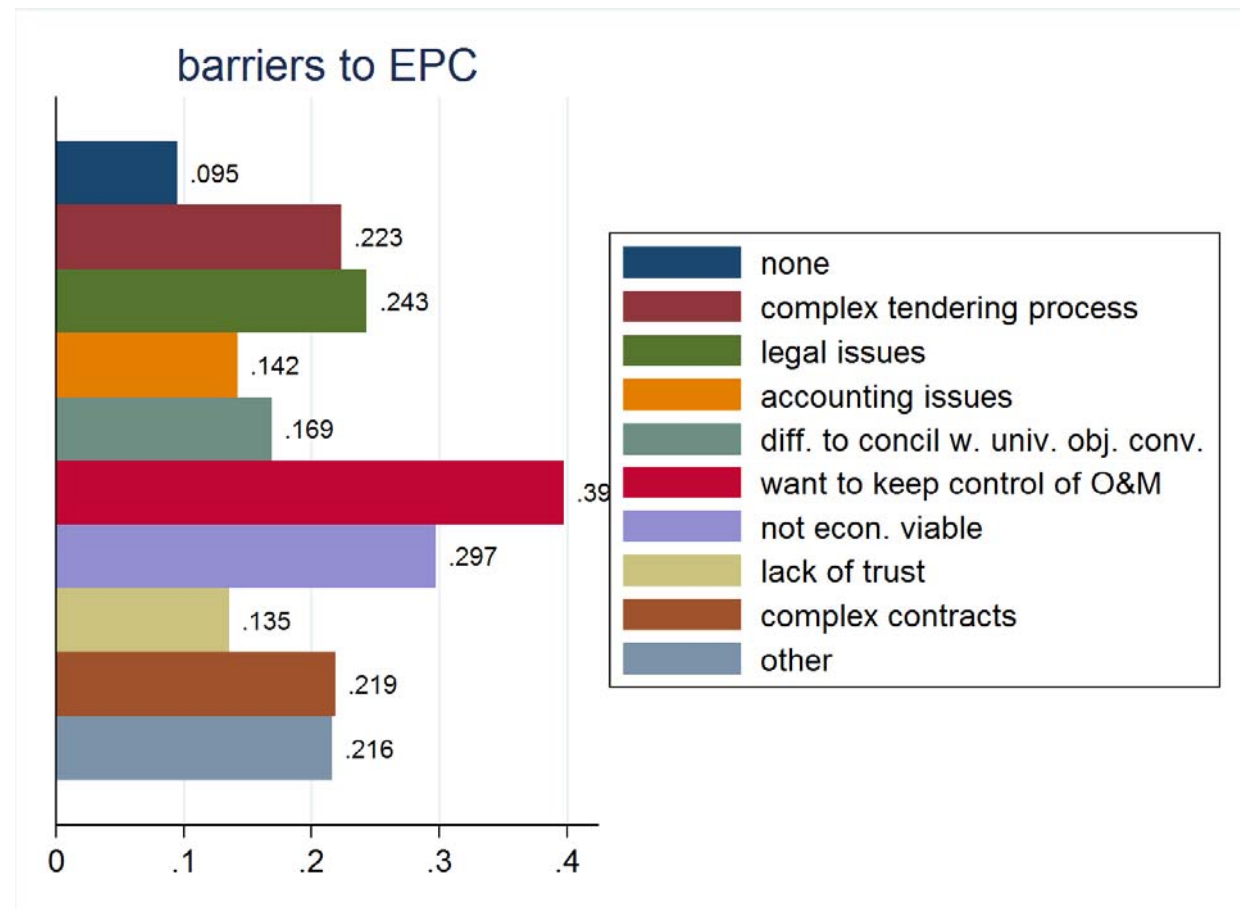
# Results: barriers to energy efficiency investments

- Notes: Percent of 26 respondents which always opt for **overhaul/status quo** (nb. of respondents in brackets)



# Results: barriers to EPC

- Notes: Percent of 149 respondents who never chose EPC (50% of the sample)





## Results: intrinsic reluctance towards EPC

- 147 respondents (~50% of the sample) never opt for EPC
- Non-attendance to EPC contractual attributes
- Alternative-specific estimates: upfront cost is valued more negatively under EPC than under EE investment without contract

# Results: individual and building characteristics

	Willingness to adopt EE	Willingness to adopt EPC
Familiarity with EPC	+	+
Employed energy manager	+	
Respondent = energy manager	+	+
Respondent = owner	-	-
Respondent = Politician (executive)		-
Nb years' experience in that function		-

No impact:

- Private building, rented building, electricity/energy yearly costs, heated surface
- Age, gender, language, role in the decision process
- Random information on non-monetary benefits of EE or cost guarantee of EPC
- Budget or contract's duration thresholds

# Conclusions and policy implications

- The econometric analysis showed first that ESCO's financing is positively affecting investment only for a minority of respondents. These are mostly public entities, presumably with debt ceilings. This result implies that for the majority of our sample, **limited access to credit at reasonable costs is not a determinant of underinvestment in energy efficiency**
- When the client cannot observe nor verify the performance or the adequacy of a technology and the risk related to energy efficiency investments, seems to be relevant for a majority of respondents. This conclusion stems from the fact that the ESCO's guarantee has a persistent and significant positive impact on the willingness to invest. **Risk sharing is an important driving factor for energy efficiency investments**
  - This result provides importance policy guidance. While EPC may not be suitable for small energy consumers due to the entailed transaction costs, alternative instruments may be found to provide other forms of performance guarantee to reach all market segments.

# Conclusions and policy implications

- This study failed to capture any impact of landlord tenant split incentives as a barrier to energy efficiency investments. This should however be tested further using a sample with a larger share of private rented buildings.
  - We found no divergence in the decision-making or in the valuation of contractual attributes between private and public entities. The energy costs and the size of the building did not have a significant impact either
- We showed that if the respondent is an energy manager, the willingness to adopt EPC and energy efficiency increases.
  - The director of cantonal or municipal buildings conversely considered less energy efficiency and EPC. This reluctance towards EPC increases with the respondent's years of experience in her function.
- The results show important heterogeneity in the decision-making processes when it comes to energy efficiency and energy performance contracting.
  - Some respondents simplified their decision process using attribute non-attendance. This study provides insights about the behavioral complexity underlying decision processes with energy efficiency investment.

# Conclusions and policy implications

- Performance guarantee facilitates investments:
  - Rational for policy support for EPC?
  - Adapt performance guarantee for smaller energy consumers?  
-> Khoury and Holmuller (2016), Performance gap in building retrofit
- Only a minority values ESCO's financing:
  - Need to clarify how EPC can be accounted off-balance sheet
  - Prepare for economic cycle where credit constraints are effective
- Importance of heterogeneity in decision process and preferences
  - Necessity for ESCOs to detect each customer's needs and propose tailor-made solutions
  - Support use cases for selected target groups
- Reluctance and misperceptions towards EPC:
  - Provide reliable, independent information

## Further research

- Willingness to pay/willingness to invest while accounting for heterogeneity, common-metric attribute aggregation
- Test further issue with rented buildings using a more targeted sample
- No need for ESCO financing for a majority: due to current economic Swiss context or more structural?
- Smaller energy consumers (e.g. SMEs)
- Focus more on behavioral anomalies

# Thank you for your attention

- Questions?

# Results

dependent variable: choice (=1 if choose alternative <i>j</i> )	Conditional logit full attendance	Conditional logit stated weights
upfront cost (CHF/m <sup>2</sup> heated surface)	-0.004*** (0.001)	-0.003** (0.001)
expected savings (% kWh saved)	0.011*** (0.003)	0.023*** (0.004)
savings variation (exp. sav. ±%)	0.007 (0.008)	-0.001 (0.012)
upfront cost share ESCO (CHF/m <sup>2</sup> heated surface)	-0.001 (0.002)	0.002 (0.002)
savings guarantee (dummy)	0.401** (0.160)	0.918*** (0.214)
payment to ESCO (CHF/m <sup>2</sup> heated surface per year)	-0.001 (0.011)	-0.018* (0.011)
contract's duration (years)	-0.017 (0.015)	-0.038** (0.015)
measure envelope (dummy)	0.860* (0.441)	0.680*** (0.274)
measures group technic (dummy)	0.409** (0.186)	0.087 (0.199)
measures group biogas/green elec mix (dummy)	0.025 (0.394)	0.167 (0.311)
measures group heating (dummy)	-0.071 (0.392)	-0.073 (0.310)
alternative specific constant <i>ee alt.</i> (dummy)	0.409 (0.415)	0.638*** (0.221)
alternative specific constant <i>epc</i> alt. (dummy)	-0.243 (0.520)	-0.045 (0.251)
observations	5940	5580
individuals	297	279
loglikelihood	-1839.407	-1640.606
AIC	3704.8	3307.2
BIC	3791.8	3393.4



dependent variable: choice (=1 if choose alternative <i>j</i> )	Latent class model with inferred attribute non-attendance (6classes)				
	(1)	(2)	(3)	(4)	(5)
upfront cost	-0.016*** (0.005)	-0.006* (0.003)	-0.006 (0.006)	0	-0.111*** (0.025)
expected savings	0.018* (0.011)	0.034*** (0.006)	0.031** (0.012)	0.017** (0.007)	0
savings variation	-0.030 (0.032)	0	0	0	0
upfront ESCO	0.019 (0.012)	0	0	0	0
savings guarantee	-0.167 (0.634)	0.660** (0.319)	0	0	0
payment to ESCO	-0.147** (0.057)	0	0	0	0
contract's duration	-0.345*** (0.105)	0	0	0	0
meas. envelope	7.135*** (1.127)	0.280 (1.067)	-2.474*** (0.902)	-0.688 (0.796)	0
meas. technic	2.175*** (0.635)	0.282 (0.391)	1.874** (0.834)	-0.566 (0.356)	0
meas. mix	2.800*** (0.654)	-0.819 (0.944)	-1.303* (0.757)	-1.291* (0.715)	0
meas. heating	1.095** (0.950)	-0.312 (0.975)	0.104 (0.851)	-2.098** (0.822)	0
ASC <i>ee</i> alt.	0	3.753*** (1.093)	0	0.691 (0.772)	0
ASC <i>epc</i> alt.	0	3.978*** (1.138)	0	0.896 (0.823)	0
<b>Class probability as a function of stated weights group</b>					
constant	1.046*** (0.297)	0.777** (0.313)	-0.716 (0.521)	0.652** (0.326)	0
Familiar with <i>epc</i> (dummy)	0.625 (0.450)	0.808* (0.463)	0.938 (0.671)	-0.359 (0.589)	0
average posterior class probabilities	0.363	0.309	0.075	0.159	0.094
observations	5940				
individuals	297				
loglikelihood	-1214.374				
AIC	2512.7				
BIC	2755.2				

Individual characteristics:  
EPC responsive individuals

dependent variable: choice (= 1 if choose alternative $j$ )	Conditional logit
upfront cost (CHF/m <sup>2</sup> heated surface)	-0.003** (0.002)
<b>upfront cost x EPC responsive indiv. (CHF/m<sup>2</sup> heated surface)</b>	<b>-0.008*** (0.002)</b>
expected savings (% kWh saved)	0.009*** (0.003)
risk: savings variation (difference from exp.sav)	0.011 (0.008)
upfront cost share ESCO (CHF/m <sup>2</sup> heated surface)	-0.001 (0.002)
<b>upfront cost share ESCO x EPC responsive indiv. (CHF/m<sup>2</sup> heated surface)</b>	<b>0.009*** (0.003)</b>
savings guarantee (dummy)	0.235 (0.175)
<b>savings guarantee x EPC responsive indiv. (dummy)</b>	<b>1.390*** (0.286)</b>
payment to ESCO (CHF/m <sup>2</sup> heated surface per year)	0.001 (0.013)
contract's duration (years)	-0.022 (0.016)
measure envelope (dummy)	0.965** (0.444)
measures group technic (dummy)	0.405** (0.187)
measures group biogas/green elec mix (dummy)	0.142 (0.396)
measures group heating (dummy)	0.027 (0.398)
alternative specific constant <i>ee</i> alt. (dummy)	0.337 (0.415)
alternative specific constant <i>epc</i> alt. (dummy)	-0.283 (0.525)
observations	5940
individuals	297
loglikelihood	-1787.218
AIC	3606.4
BIC	3713.5