Stadt Zürich

ENERGIEFORSCHUNG
STADT ZÜRICH
EIN ewz-BEITRAG
ZUR 2000-WATT-
GESELLSCHAFT

Themenbereich Haushalte

Datenanalyse der «Swiss Household Energy Demand Survey» für die Stadt Zürich

Forschungsprojekt FP-1.22
Schlussbericht, September 2020

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Energieforschung Stadt Zürich
Ein ewz-Beitrag zur 2000-Watt-Gesellschaft

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Für den Inhalt sind alleine die Autorinnen und Autoren verantwortlich. Der vollständige Bericht kann unter www.energieforschung-zuerich.ch bezogen werden.

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Energieforschung Stadt Zürich

Ein ewz-Beitrag zur 2000-Watt-Gesellschaft

Energieforschung Stadt Zürich ist ein auf zehn Jahre angelegtes Programm und leistet einen Beitrag zur 2000-Watt-Gesellschaft. Dabei konzentriert sich Energieforschung Stadt Zürich auf Themenbereiche an der Nahtstelle von sozialwissenschaftlicher Forschung und der Anwendung von neuen oder bestehenden Effizienztechnologien, welche im städtischen Kontext besonders interessant sind.

Im Auftrag von ewz betreiben private Forschungs- und Beratungsunternehmen sowie Institute von Universität und ETH Zürich anwendungsorientierte Forschung für mehr Energieeffizienz und erneuerbare Energien. Die Forschungsergebnisse und -erkenntnisse sind grundsätzlich öffentlich verfügbar und stehen allen interessierten Kreisen zur Verfügung, damit Energieforschung Stadt Zürich eine möglichst grosse Wirkung entfaltet – auch ausserhalb der Stadt Zürich. Geforscht wird zurzeit in zwei Themenbereichen.

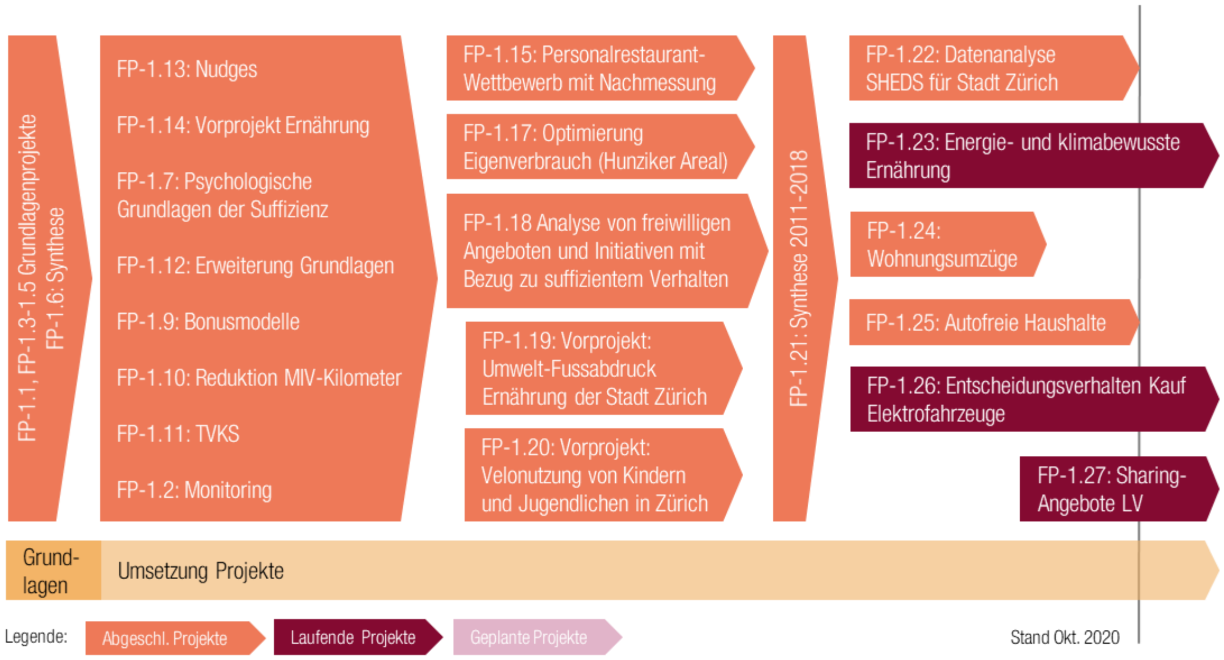
Themenbereich Haushalte

Der Themenbereich Haushalte setzt bei den Einwohnerinnen und Einwohnern der Stadt Zürich an, die zuhause, am Arbeitsplatz und unterwegs Energie konsumieren und als Entscheidungsträgerinnen und Entscheidungsträger in vielerlei Hinsicht eine zentrale Rolle bei der Umsetzung der 2000-Watt-Gesellschaft einnehmen. Dabei werden insbesondere sozialwissenschaftliche Aspekte untersucht, die einen bewussten Umgang mit Energie fördern oder verhindern. In Feldversuchen mit Stadtzürcher Haushalten wird untersucht, welche Hemmnisse in der Stadt Zürich im Alltag relevant sind und welche Massnahmen zu deren Überwindung dienen.

Themenbereich Gebäude

Der Themenbereich Gebäude setzt bei der Gebäudeinfrastruktur an, welche zurzeit für rund 70 Prozent des Endenergieverbrauchs der Stadt Zürich verantwortlich ist. In wissenschaftlich konzipierten und begleiteten Umsetzungsprojekten sollen zusammen mit den Eigentümerinnen und Eigentümern sowie weiteren Entscheidungsträgerinnen und Entscheidungsträgern Sanierungsstrategien für Gebäude entwickelt und umgesetzt werden, um damit massgebend zur Sanierung und Erneuerung der Gebäudesubstanz in der Stadt Zürich beizutragen. Im Vordergrund stehen die Steigerung der Energieeffizienz im Wärmebereich und die Minimierung des Elektrizitätsbedarfs.

Übersicht und Einordnung der Forschungsprojekte (FP) im Themenbereich Haushalte



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List of abbreviations

ATET: Average Treatment Effect on the Treated

DM: Decision Making

ECB: Energy Consumption Behaviour

EFZ: Energieforschung Stadt Zürich

IOS: Individual Opportunity Space

KZH: Zurich Canton (Kanton Zürich), excluding the cities of Zurich and Winterthur

LPM: Linear Probability Model

M2: Two major Swiss cities other than Zurich (Geneva and Basel)

M8: Eight major Swiss cities other than Zurich (Geneva, Lausanne, Bern, Basel, Luzern, Winterthur, Biel, St. Gallen)

OLS: Ordinary Least Squares

PSM: Propensity Score Matching

RCH: Rest of Switzerland, i.e. entire country excluding Zurich city (SZH), Zurich Canton (KZH) and 8 major Swiss cities (M8)

SCCER CREST: Competence Centre for Research in Energy, Society, and Transition

SFSO: Swiss Federal Statistical Office

SFOE: Swiss Federal Office of Energy

SOS: Social Opportunity Space

SHEDS: Swiss Household Energy Demand Survey

STATPOP: Population and Households Statistics

SZH: Zurich City (Stadt Zürich)

ZHSO: Zürich Statistical Office

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Zusammenfassung

Der vorliegende Bericht präsentiert die Ergebnisse einer vergleichenden Analyse der Schweizerischen Energieverbrauchserhebung für Haushalte (SHEDS) auf Mikroebene aus der Perspektive der Stadt Zürich. SHEDS ist eine Online-Umfrage, die von Forschenden von SCCER CREST konzipiert und durchgeführt wurde. Bei der Stichprobe handelt es sich um einen Paneldatensatz, der aus vier Wellen des SHEDS von 2016 bis 2019 extrahiert wurde, darunter rund 1'200 Beobachtungen in der Stadt Zürich und insgesamt rund 20'000 Beobachtungen in der Deutsch- und Westschweiz. Die SHEDS-Stichproben sind in Bezug auf Alter und Geschlecht der Befragten sowie auf die Region und die Miet-/Eigentumssituation der Haushalte repräsentativ für die Schweizer Bevölkerung. Alle Informationen in SHEDS basieren auf Selbstauskünften desjenigen Haupthaushaltsmitglieds, das über Energiefragen entscheidet.

Obwohl die Studie in erster Linie darauf abzielt, politische Empfehlungen für die Stadt Zürich zu formu-lieren, zeigt sie viele allgemeinere Zusammenhänge auf, die auf die Struktur der Energienachfrage in der Schweizer Bevölkerung insgesamt zutreffen könnten. Die Studie besteht aus zwei Phasen. Phase I um-fasst eine explorative Analyse, um zentrale Muster an Unterschieden zwischen den Haushalten der Stadt Zürich und denjenigen in anderen Teilen der Schweiz zu identifizieren. Ziel von Phase I ist es, eine brei-te Palette von Variablen zu analysieren, die die Nachfrage der Haushalte in den drei Hauptenergiefel-dern (Elektrizität, Mobilität und Heizung) sowie eine Auswahl damit zusammenhängender psychologi-scher Faktoren wie Absichten und Normen charakterisieren.

Um die Stärken und Schwächen der Stadt Zürich in dieser Hinsicht aufzuzeigen, betrachten wir vier sich gegenseitig ausschliessende Vergleichsgruppen:

1. Haushalte in der Stadt Zürich (SZH).
2. Haushalte im Kanton Zürich (KZH), ohne SZH und Winterthur.
3. Haushalte in den 8 Schweizer Grossstädten ohne SZH (M8), nämlich Genf, Lausanne, Bern, Basel, Luzern, Winterthur, Biel/Bienne und St. Gallen. In einigen Analysen werden nur die Daten von 2 Grossstädten betrachtet: Basel und Genf (M2). Letzteres wird speziell ausgewiesen.
4. Haushalte aus der übrigen Schweiz (RCH), d.h. alle ohne die oben genannten Gruppen 1-3.

Beigefügt sind grafische Darstellungen der Unterschiede zwischen den Vergleichsgruppen auf der Basis von Gruppenmittelwerten sowie Messungen von statistischer Signifikanz, die hauptsächlich auf generi-schen OLS-Regressionsmodellen basieren, welche die jährlichen nationalen Variationen berücksichtigen.

In Phase II wurden die für die Energiepolitik der Stadt Zürich identifizierten besonders interessanten Unterschiede beim Stromverbrauch, bei den Investitionen in die Energieeffizienz beim Strom, bei der Umsetzung von Energiespartipps vertieft analysiert.

Phase I

Die Ergebnisse der explorativen Analyse (Phase I) sind in einem Zwischenbericht (auf Anfrage bei den Autoren/innen erhältlich) ausführlich dargestellt. Ausgehend von den Ergebnissen der Phase I konzentriert sich die Studie auf eine Auswahl von Variablen, die statistisch signifikante Unterschiede zwischen den oben genannten Gruppen aufweisen und als politikrelevante Variablen für SZH betrachtet werden. Der vorliegende Bericht konzentriert sich zwar auf Phase II, gibt jedoch auch einen Überblick über die wichtigsten explorativen Ergebnisse von Phase I (vgl. Kapitel 2 im Schlussbericht).

Die wichtigsten Ergebnisse der explorativen Analyse lassen sich wie folgt zusammenfassen:

Es besteht eine signifikante Kluft zwischen den suburbanen und ländlichen Gebieten einerseits und den Grossstädten andererseits. Dieses Stadt-Land-Gefälle zeigt, dass die Grossstädte im Durchschnitt in allen Bereichen (Elektrizität, Heizung und Mobilität) durch einen geringeren Energiebedarf gekennzeichnet sind. Die grundlegenden Faktoren, die den Energieverbrauch beeinflussen, unterscheiden sich jedoch von Region zu Region. Im Allgemeinen erleichtern die Nähe zu Arbeit und Dienstleistungen in den Städten sowie ein dichtes

Infrastrukturnetz unterschiedliche Verhaltensweisen, die den Energieverbrauch begrenzen. So sind z.B. in Großstädten die Haushalte im Allgemeinen kleiner und leben in kleineren Wohnungen bzw. Häusernen. Die Stadtbewohner haben zwar ein höheres Durchschnittseinkommen, besitzen aber seltener ein Eigenheim oder ein privates Auto. Wenn sie ein Privatfahrzeug besitzen, ist das Alter ihres Autos im Durchschnitt höher als das der Haushalte in den Vorstädten und auf dem Land. All diese Unterschiede sind sowohl zwischen SZH und KZH als auch zwischen SZH und RCH signifikant.

Etwa jeder dritte Haushalt in SZH ist sich nicht bewusst, dass sein Strommix vollständig erneuerbar ist, was auf eine mangelhafte «Energiekompetenz» zurückzuführen sein könnte, aber auch als Hinweis darauf gewertet werden kann, dass die Energieversorgungsunternehmen die Präsentation ihrer Produkte optimieren könnten. Was die Geräte im Haushalt betrifft, so ist die Zahl der Elektrogeräte in SZH im Durchschnitt zwar geringer, die Wahrscheinlichkeit, dass sie energieeffizient sind, ist jedoch deutlich geringer.

Die Ergebnisse für psychologische Determinanten sind vielfältig. Am auffälligsten ist, dass sich die Menschen zwar persönlich verpflichtet fühlen, sich umweltfreundlich zu verhalten, dass sie aber (in der gesamten Stichprobe) nur geringe Absichten bekunden, ihr Energieverbrauchsverhalten zu ändern. SZH-Haushalte äußern im Vergleich zu den Haushalten in M8 und RCH noch weniger die Absicht, ihr Energieverbrauchsverhalten zu ändern (abgesehen von ihrem CO2-Fußabdruck). Wir beobachten auch, dass die Umsetzung von Energiespartipps (von lokalen Versorgungsunternehmen und dem Bundesamt für Energie (BFE)) in allen Haushalten relativ gering ist. Wahrscheinlich besteht ein Potenzial zur Verbesserung des Vertrauens in die Energieberatung durch lokale und nationale Behörden und somit der Umsetzung von Energiespartipps, das für SZH weiter untersucht werden kann.

Die signifikanten Unterschiede zwischen SZH und den anderen oben beschriebenen Gruppen rechtfertigen eine tiefergehende und detailliertere Analyse. Wir betonen, dass die gesamte Stichprobe des SHEDS zwar repräsentativ für die Schweizer Bevölkerung ist, dass es aber wahrscheinlich bei deskriptiven Vergleichen auf der Basis von Unterstichproben, insbesondere in der SZH-Gruppe, an Repräsentativität mangelt, was zu Problemen bei der Vergleichbarkeit führt. Bei nicht repräsentativen und unähnlichen Stichproben könnten die geschätzten Unterschiede zwischen den Gruppen tatsächlich verzerrt sein. Daher bilden unsere vorläufigen Ergebnisse die Grundlage für eine ausführliche ökonometrische Analyse (in Phase II), die darauf abzielt, das Problem der Repräsentativität durch geeignete Regressionsmodelle und/oder Propensity Score Matching (PSM) zu lösen, und mit deren Hilfe aussagekräftige politische Schlussfolgerungen gezogen werden können.

Phase II

Basierend auf den Ergebnissen von Phase I und nach Gesprächen mit Energieforschung Stadt Zürich (EFZ) konzentrieren wir uns in vertiefenden Analysen (Phase II) auf die folgenden drei Bereiche, die für EFZ von grösstem politischem Interesse sind:

1. Verstehen der identifizierten Stadt-Land-Gefälle zwischen SZH und KZH, um Politikbereiche und Bevölkerungsgruppen zu identifizieren, die für eine Reduktion des Stromverbrauchs in Frage kommen. Darüber hinaus zeigt der grosse Mangel an Wissen über den Stromverbrauch der Haushalte, dass trotz der Tatsache, dass der in SZH gelieferte Strom vollständig erneuerbar ist, diese Information für viele Haushalte nicht hervorstechend ist. Unsere Forschung soll daher herausfinden, ob dies auf bestimmte Gruppen beschränkt oder weit verbreitet ist und ob dieses Wissen Auswirkungen auf das Verhalten hat.
2. Angesichts des relativ schlechten Abschneidens von SZH bei Effizienzinvestitionen in Elektrogeräte ist es wichtig, die Ursachen dieser Unterschiede zu untersuchen und Bereiche und/oder Bevölkerungssegmente für wirksame politische Maßnahmen zu identifizieren.
3. Die Umsetzung von Energiespartipps zur Verringerung des Energieverbrauchs ist gering (10%-40%), und variiert beträchtlich zwischen den Informationsquellen. Weitere Forschung sollte untersuchen, welche Faktoren mit einer erfolgreichen Umsetzung von Energiespartipps zusammenhängen und welche Gruppen besser auf Informationen durch welche Institution reagieren könnten.

Um diese Fragen zu untersuchen, konzentrieren wir uns auf die folgenden abhängigen Variablen:

1. Jährlicher Stromverbrauch der Haushalte (kWh) und Stromrechnung (CHF), beide ausgedrückt in Logarithmen;
2. Investitionen der Haushalte in effiziente Elektrogeräte (Fernseher, Kühlschrank, Geschirrspüler und Waschmaschinen), erfasst durch den Anteil der Geräte mit A+++ oder A++ Label;
3. Umsetzung von Energiespartipps, insbesondere von BFE und lokalen Versorgungsunternehmen, ausgedrückt in binären Variablen (1: Ja, 0: Nein);
4. Kenntnis der Stromquellen, wobei nur Standorte berücksichtigt werden, an denen die Stromversorgung zu 100% aus erneuerbaren Energien besteht, nämlich in SZH im Vergleich zu M2, ausgedrückt in binären Variablen (1: Befragter berichtet korrekt, 0: Nicht korrekt berichtet).

Aufgrund der Ergebnisse von Phase I konzentrieren wir uns auf statistisch signifikante Unterschiede, die hauptsächlich zwischen SZH und KZH beobachtet wurden. Der Vollständigkeit halber und in Anbetracht der Tatsache, dass systematische Unterschiede innerhalb bestimmter Bevölkerungssegmente durch die in Phase I berichteten explorativen Analysen nicht festgestellt werden konnten, dehnen wir unsere Vergleichsgruppen jedoch auf die beiden anderen Gruppen, nämlich M8 und RCH, aus.

Auf Grundlage einer interdisziplinären Studie des Energieverbrauchsverhaltens von Haushalten (Burger et al., 2015), angepasst an den Strombereich und die verfügbaren Daten, definieren wir die folgende Hierarchie der Determinanten:

1. Sozio-demographische Merkmale und strukturelle Faktoren sind jene Aspekte, die sich zumindest kurzfristig der Kontrolle der Haushalte entziehen. Dazu gehören Variablen wie Einkommen, Haushaltstyp und -grösse, Wohneigentum (Mieter/Eigentümer/innen) und -typ (Ein-/Mehrfamilienhäuser), Bildung, Geschlecht und Alter sowie die Wohnsituation (städtisch/vorstädtisch/ländlich), die Bevölkerungsdichte und die Heiztechnik;
2. Technische Faktoren im Zusammenhang mit Art, Menge und Effizienz von Elektrogeräten. Diese Faktoren unterliegen der Kontrolle der Haushalte und können sich in relativ kurzer Zeit ändern;
3. Verhaltensfaktoren im Zusammenhang mit der Nutzung von Energiegeräten, die von Lebensstil, Routinen und Gewohnheiten sowie von psychologischen Faktoren und Umwelteinstellungen bestimmt werden;
4. Latente oder residuale Faktoren umfassen die übrigen Unterschiede, die nicht durch eine der oben genannten Kategorien erklärt werden können.

Auf der Mikroebene könnten die Unterschiede zwischen Haushalten aus SZH und einer anderen Region auf einen oder mehrere der oben genannten Faktoren zurückzuführen sein. Die erste Kategorie an Faktoren (soziodemographisch und strukturell) sollte nicht als politikrelevante Effekte betrachtet werden, die sich leicht durch kurzfristige politische Interventionen beheben lassen. Für die Forschung interessant sind daher besonders die Kategorien 2 bis 4, die von der Politik in einem angemessenen Zeithorizont adressiert werden können. Insbesondere, handelt es sich sowohl bei technischen als auch bei verhaltensbezogenen Faktoren um Entscheidungen der Haushalte, die durch angemessene politische Maßnahmen, einschließlich anreizbasierter Instrumente und Anstöße («nudges»), beeinflusst werden können.

Auf der Grundlage der oben skizzierten Hierarchie der Determinanten verwenden wir die folgenden Modelle, um den relativen Effekt jeder Kategorie zu ermitteln:

1. Modell 0: Generisches Modell, das nur Gruppen-Dummies und Jahres-Dummies enthält (ähnlich wie in Phase I);
2. Modell 1: Modell 0 plus soziodemographische Merkmale und strukturelle Determinanten;
3. Modell 2: Modell 1 plus technische Determinanten;
4. Modell 3: Vollständiges Modell, d.h. Modell 2 plus Verhaltensfaktoren.

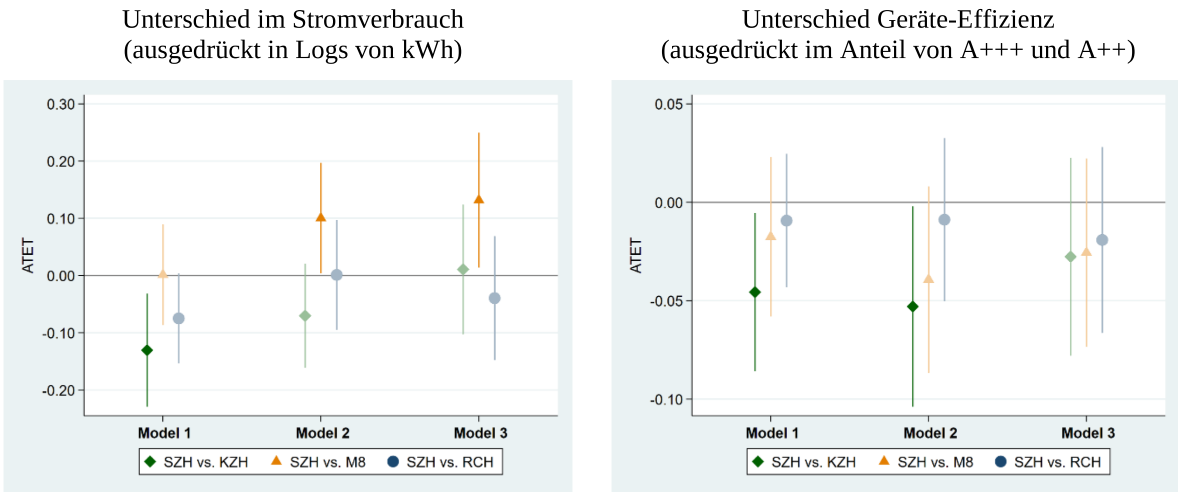
Die angewandte ökonometrische Methodik basiert auf Regressionen von Paneldaten mit Zufallseffekten sowie auf Propensity Score Matching (PSM). Wir wenden beide Ansätze auf die Modelle 1 bis 3 an und verwenden die Regressionskoeffizienten, um Beziehungen und zugrundeliegende Assoziationen zu identifizieren. Bei der Schlussfolgerung stützen uns hauptsächlich auf das vollständige Modell (Modell 3).

Mit den PSM-Modellen können wir direkt die Unterschiede zwischen Haushalten in SZH ("Treatment"-Gruppe) und anderen Gruppen ("Kontrollgruppen»), insbesondere KZH und M8, schätzen. Vergleiche der Effekte der Haushalte in SZH, d.h. der durchschnittlichen Behandlungseffekte auf die Behandelten (Average Treatment Effects on the Treated (ATET)), zwischen den drei Modellen ermöglichen, das relative Gewicht jeder Kategorie von Determinanten bei der Definition der Unterschiede zwischen den Haushalten in SZH und ansonsten vergleichbaren Haushalten in anderen Regionen zu ermitteln.

Der PSM-Ansatz wird auch angewandt, um Unterschiede innerhalb spezifischer Bevölkerungssegmente (Unterstichproben) auf der Grundlage relevanter Variablen (wie Einkommen, Haushaltstyp/Größe und Wohnungstyp/Eigentum) zu untersuchen. Aufgrund der signifikanten Unterschiede werden Bevölkerungssegmente identifiziert, auf die politische Interventionen ausgerichtet werden können. Dies ist ein wichtiger Teil der Analyse, da einige der insgesamt unbedeutenden Effekte für bestimmte Bevölkerungssegmente dennoch signifikant sind.

Ein Vergleich der mit Modell 0 und Modell 1 erzielten Ergebnisse legt nahe, dass ein Großteil der Unterschiede zwischen SZH und anderen Gruppen bei der Stromnachfrage auf strukturelle und soziodemographische Unterschiede zurückzuführen ist. So verringert sich beispielsweise die scheinbar große Verbrauchslücke zwischen SZH und KZH von Modell 0 (42% weniger Verbrauch und 35% weniger Ausgaben in SZH) in Modell 1 erheblich (etwa 12% beim Verbrauch und nur 6% bei den Ausgaben). Eine ähnliche Schlussfolgerung kann für die Messung der Geräteeffizienz sowie für das Wissen über den Energiemix gezogen werden. Während Modell 0 eine deutlich niedrigere Effizienz in SZH im Vergleich zu KZH (Differenz von etwa 4%) und ein besseres Wissen über den Energiemix in SZH im Vergleich zu M2 (Differenz von etwa 11%) anzeigt, verschwinden beide Unterschiede, wenn soziodemographische und strukturelle Faktoren einbezogen werden. Diese Ergebnisse zeigen, wie wichtig potenzielle Verzerrungen einer aggregierten Analyse sind, ohne dass vergleichbare Haushalte in Bezug auf soziodemographische und strukturelle Variablen übereinstimmen.

Unsere wichtigsten Ergebnisse aus dem PSM werden in Abbildung 1 veranschaulicht. Die vier Abbildungen zeigen die durchschnittlichen Unterschiede zwischen den Haushalten von SZH und vergleichbaren Haushalten in den Kontrollgruppen.



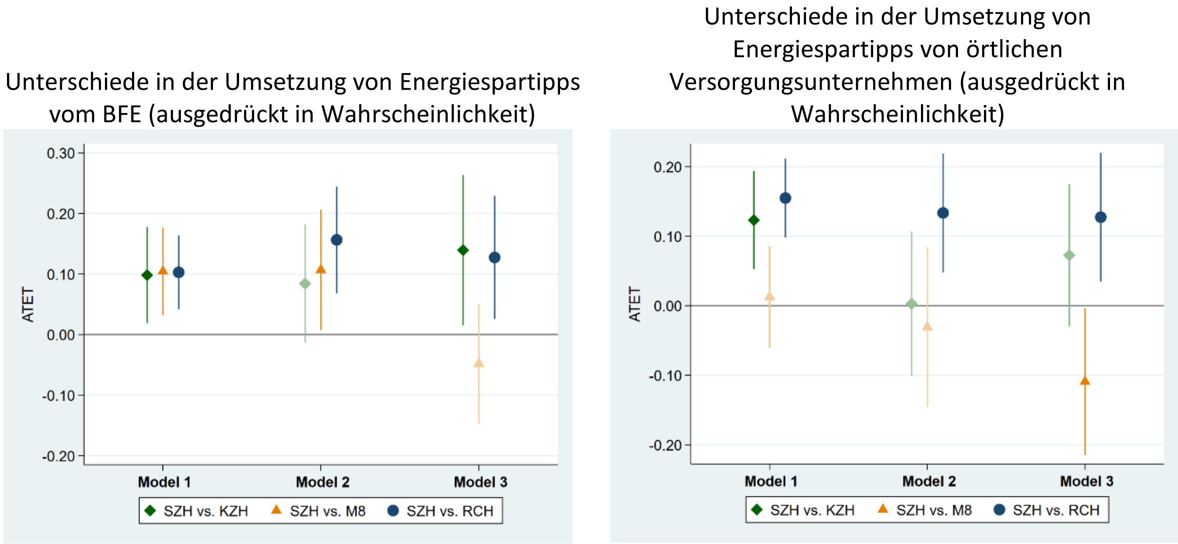


Abbildung 1: Hinweis: Vertikale Lienen repräsentieren 90% Konfidenzintervalle. Statistisch signifikante Unterschiede (p<0,1) werden in dunklen Farben dargestellt, nicht-signifikante Behandlungseffekte in hellen. ATET Effekt unter Null (< 0) weist auf einen niedrigeren Verbrauch, Effizienz oder Umsetzung von Energiespartipps für SZH-Haushalte zur jeweiligen Verbrauchsgruppe (siehe Legende) hin. Ein ATET Effekt über Null (> 0) weist auf einen höheren Verbrauch, Effizienz oder Umsetzung von Energiespartipps für SZH-Haushalte im Vergleich zur jeweiligen Vergleichsgruppe hin.

Diese Ergebnisse lassen mehrere Muster erkennen, die auf die folgenden Schlussfolgerungen hindeuten:

- Der im Modell 1 beobachtete signifikante Unterschied im Stromverbrauch zwischen SZH und KZH verschwindet in den Modellen 2 und 3, was darauf hindeutet, dass die Ursachen der Unterschiede hauptsächlich technischer Natur sind (weniger Geräte, aber nicht unbedingt effizientere in SZH).
- Signifikante Unterschiede in der Effizienz bleiben in Modell 2 mehr oder weniger gleich, verschwinden aber in Modell 3, was darauf hindeutet, dass eine geringere Effizienz nicht mit weniger Geräten verbunden ist.
- Signifikante Unterschiede in der Beratungsaufnahme (BFE und Versorgungsunternehmen) bleiben mit einigen kleinen Ausnahmen unabhängig vom Modell (1, 2 oder 3) mehr oder weniger gleich. Daher können diese Unterschiede insgesamt mit unbeobachteten Faktoren wie z.B. politischen und kulturellen Variablen in Verbindung gebracht werden.

Berücksichtigt man nur soziodemographische Merkmale und technische Faktoren (Modell 1), so hat SZH im Durchschnitt etwa:

- 10% bis 13% weniger Verbrauch im Vergleich zur KZH;
- 5% geringeren Anteil effizienter Geräte im Vergleich zu KZH;
- 10% bis 15% höhere Wahrscheinlichkeit der Umsetzung von Energiespartipps vom BFE und Versorgungsunternehmen.

Die Analyse der zeitlichen Veränderungen zeigt, dass die Effizienzunterschiede (SZH versus KZH) relativ stabil bleiben. Die Verbrauchsunterschiede zwischen SZH und KZH scheinen jedoch im Laufe der Zeit zuzunehmen, wobei SZH eine Verbesserung (d.h. einen relativen Rückgang) aufweist. Diese Ergebnisse sind in Abbildung 2 dargestellt.

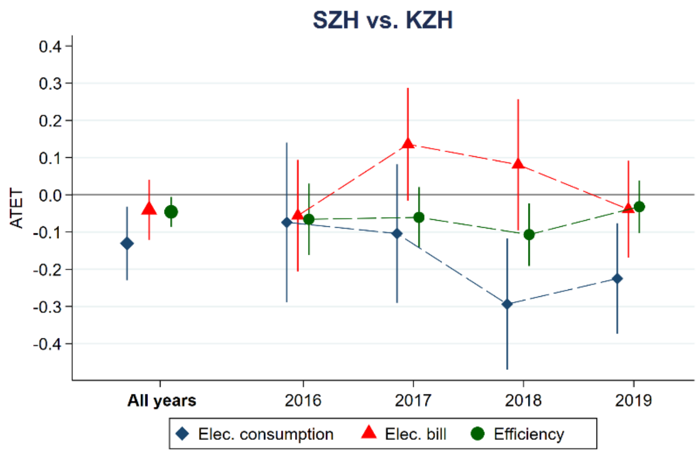


Abbildung 2: Zeitliche Entwicklung der Unterschiede. Hinweis: Vertikale Lienen repräsentieren 90% Konfidenzintervalle.

Insgesamt zeigen diese Ergebnisse eine relativ gute Leistung der SZH-Haushalte, was darauf hindeutet, dass die bestehenden politischen Maßnahmen wahrscheinlich erfolgreich sind und beibehalten werden sollten. Während positive Trends durch die Fortführung der bestehenden Politik durchgesetzt werden, zeigen die Ergebnisse auch, dass eine stärkere Konzentration auf die Förderung effizienterer Geräte hilfreich wäre.

Die PSM-Analyse liefert zwei wichtige Ergebnisse für Verbesserungspotentiale der Politikmassnahmen:

- Die durchschnittliche Umsetzung von Energiespartipps variiert zwar je nach Quelle (12% bei den lokalen Behörden, 32% bei den lokalen Versorgungsunternehmen und 42% beim BFE), zeigt aber insgesamt eine geringe Umsetzung, denen durch politische Maßnahmen begegnet werden könnte. Nichtsdestotrotz ist die Umsetzung von Energiespartipps bei den Einwohnern in SZH höher als in RCH, KZH und bis zu einem gewissen Grad in M8.
- Die Daten deuten auf eine relativ schlechte Kenntnis des eigenen Strommixes, da ein Drittel der Haushalte in SZH fälschlicherweise angibt, nicht erneuerbaren Strom zu verbrauchen. Dennoch ist die Kenntnis des Strommixes in SZH etwas (aber nicht signifikant) besser als in vergleichbaren Haushalten in M2.

Um die zugrundeliegenden Effekte und Zusammenhänge zu analysieren, wurden verschiedene Zufallseffekt-Regressionsanalysen durchgeführt. Eine Auswahl dieser Ergebnisse ist Tabelle 1 zusammengefasst.

Tabelle 1. Zugrundeliegende Effekte und Beziehungen auf der Grundlage von Panel-Regressionsmodellen.

Faktoren	Höhe Stromverbrauch kWh	Anteil an effizienten Elektrogeräten	Umsetzung von Energiespartipps vom BFE	Umsetzung von Energiespartips von Versorgungs-unternehmen
Einpersonenhaushalte Männer vs. Frauen	+	–	– / NS	NS
Mieter vs. Eigentümer	–	–	–	–
Haus vs. Wohnung	+	NS	NS	NS
Kenntnis zum eigenen Strommix (eigene Angabe)	NS	+	+	+
Energiekompetenz	NS	–	+	+
Effiziente Elektrogeräte	NS		NS	NS
Anzahl Elektrogeräte	+ meistens	+ / NS	– meistens	– meistens
Persönliche Normen	NS	NS	+	+
Vertrauen (in das BFE)	NA	NA	+	–
Vertrauen (in Versorgungs-unternehmen)	NA	NA	NS	+

+: positive Wirkung; -: negativer Effekt; NS: statistisch nicht signifikant bei p<0,1; NA: Nicht im endgültigen Modell enthalten, weil er in den vorläufigen Modellen nicht signifikant war. Lesebeispiel erste Zeile in der Tabelle: Haushalte mit männlichen Alleinstehenden haben einen höheren Stromverbrauch (positiver Effekt) und weniger effiziente Geräte (negativer Effekt) als Haushalte mit weiblichen Alleinstehenden. Alleinstehende Männer (negativer Effekt) setzen weniger oft Energieberatungsratschläge des BFE um als weibliche Alleinstehenden bei denen kein signifianker Unterschied zu Mehrpersonenhaushalten zu finden war (NS=nicht signikant). Bei männlichen und weiblichen Alleinstehenden gab es keinen Unterschied bei der Umsetzung von Energiespartipps durch lokale Versorgungsunternehmen (nicht signifikant, NS) im Vergleich zu Mehrpersonenhaushalten.

Die wichtigsten Ergebnisse bezüglich des Stromverbrauchs sind:

- Der Stromverbrauch weist starke Skaleneffekte auf: Jedes zusätzliche Haushaltsmitglied hat nur etwa 12% mehr an Verbrauch. Pro Person verbrauchen kleinere Haushalte unverhältnismäßig mehr als Paare und größere Familien.
- Unter den Einpersonenhaushalten verbrauchen alleinstehende Männer mehr (ca. 10%) und weisen eine relativ geringe Effizienz auf (ca. 5% weniger effiziente Geräte) im Vergleich zu Frauen.
- Mieter/innen verbrauchen weniger als Eigentümer/innen (ca. 20%) und weisen geringere Effizienzinvestitionen auf (ca. 5% weniger effiziente Geräte).
- Hausbewohner/innen verbrauchen mehr als Haushalte, die in Wohnungen leben (im Durchschnitt etwa 30% bis 40%).
- Die Anzahl der Elektrogeräte hat einen positiven (d.h. Steigerung) Effekt auf den Stromverbrauch.
- Es gibt keine signifikanten Belege dafür, dass die Geräteeffizienz den Stromverbrauch senkt.
- Der Verbrauch eines Strommixes mit mehr als 50% erneuerbaren Energieträgern (eigene Angabe) scheint keine Auswirkungen auf den Gesamtstromverbrauch zu haben (d.h. es scheint keinen verhaltensbedingten Rebound-Effekt zu geben). Es besteht jedoch ein positiver Zusammenhang mit der Geräteeffizienz, so dass es keinen indirekten Rebound-Effekt gibt.

In Bezug auf die Inanspruchnahme von Beratungen lassen sich aus den Panel-Regressionen und den beobachteten Differenzmustern die folgenden Ergebnisse ableiten:

- Persönliche Normen und Vertrauen haben einen signifikanten Einfluss auf die Umsetzung von Energiespartipps. Auch wenn diese Variablen keinen direkten Einfluss auf Konsum/Effizienz haben, könnten sie dennoch durch ihren indirekten Effekt auf die Umsetzung von Energiespartipps eine wichtige Rolle spielen.
- Die Umsetzung von Energiespartipps ist bei Mieter/innen geringer, daher könnten sie bei Interventionen speziell angesprochen werden.

- Wir schlagen maßgeschneiderte Beratungen vor (Zielsetzung, bestimmte Gruppe und/oder bestimmtes Konsumverhalten), z.B. Beratungen zu Effizienzinvestitionen, die sich an die Mieter/innen richten, könnte maximale Effizienz erreichen.
- Eine bessere Umsetzung von Energiespartipps kann durch die Verbesserung des Vertrauens in den Beziehungen zu den Kunden und durch auf persönliche Normen ausgerichtete Werbekampagnen erreicht werden.

In Bezug auf das Wissen über den Strommix und die Auswirkungen der Energiekompetenz können wir die folgenden Schlussfolgerungen ziehen:

- Geringe Kenntnis des Energiemixes (etwas besser in SZH mit 66% gegenüber 57% in M2).
- Das Wissen über den Energiemix zeigt einen starken Zusammenhang mit einem in SHEDS gemessenen allgemeinen Energiekompetenz-Score, d.h. allgemeine Energiekompetenz ist niedriger, wenn das Wissen über den Energiemix auch niedriger ist und andersrum.
- Wichtige Faktoren mit signifikanten positiven Auswirkungen auf das Wissen sind persönliche Normen, Alter (>65); wohingegen Familien mit Kindern eher weniger gutes Wissen aufweisen.
- Die Energiekompetenz wirkt sich leicht (negativ) auf die Effizienz aus, d.h. je mehr Menschen über energiebezogene Themen wissen, desto geringer ist die Wahrscheinlichkeit, dass sie effiziente Geräte besitzen. Es gibt jedoch keinen direkten Einfluss der Energiekompetenz auf den Stromverbrauch. Ein Teil der negativen Auswirkungen auf die Effizienz könnte durch die Besorgnis der Verbraucher über die bei der Herstellung von Geräten verbrauchte (graue) Energie erklärt werden.
- Die Bewertung der Energiekompetenz hat einen wesentlichen Einfluss auf die Umsetzung von Energiespartipps (vom BFE und Versorgungsunternehmen). Die Verbesserung der Energiekompetenz durch Informationskampagnen könnte daher ein Mittel zur Verbesserung der Beziehung zwischen Energieversorgungsunternehmen und ihren Verbrauchern sein.

Unsere politische Schlussfolgerung zu den angestrebten Auswirkungen der Energiekompetenz und der Umsetzung von Energiespartipps beruht auf der Prämisse, dass sich gezielte Beratung und Energiespar-tips durch eine Verringerung des Energieverbrauchs auswirken. Obwohl diese Prämisse im Allgemeinen durch die Differenzen zwischen den untersuchten Regionen begünstigt wird, liefern unsere Regressi-onsergebnisse keine soliden Belege für einen statistisch signifikanten Einfluss auf den Energieverbrauch. Dies könnte darauf zurückzuführen sein, dass unsere Daten keine ausreichenden Informationen über die spezifischen Ratschläge und Informationskampagnen liefern, die während des Untersuchungszeitraums durchgeführt wurden.

Die Aufschlüsselung der Unterschiede zwischen den Haushalten in SZH im Vergleich zu den entspre-chenden Haushalten in den beiden Kontrollgruppen (KZH und M8) liefert wichtige Erkenntnisse. Die durchschnittlichen Unterschiede auf Grundlage des PSM (Modell 1) einer Auswahl von Bevölkerungs-segmenten sind in Tabelle 2 und Tabelle 3 aufgeführt. Diese Ergebnisse können verwendet werden, um zu verstehen, welche Bevölkerungssegmente mit welchem spezifischen Verhalten adressiert werden können und ob diese Segmente auf die Beratung durch das BFE und die Versorgungsunternehmen ansprechen könnten. Die Ergebnisse zeigen zwar eine starke Heterogenität der Unterschiede zwischen den verschiedenen Bevölkerungssegmenten, weisen aber dennoch auf mehrere "tiefhängende Früchte" hin, d.h. auf Segmente, die bei politischen Interventionen gezielt und prioritär adressiert werden könn-ten.

Interessanterweise zeichnen sich Einpersonenhaushalte in SZH im Vergleich zu den Haushalten in KZH durch höheren Konsum aus, aber diese Haushalte reagieren auch relativ gut auf die Energiespartipps von Versorgungsunternehmen.

Wir können zudem zwei Verhaltensmuster in SZH im Vergleich zu den entsprechenden Haushalten in KZH identifizieren:

1. Relativ geringe Geräteeffizienz, aber relativ empfänglich für die Ratschläge des Versorgungsunternehmens:
   - Männer
   - Haushalte mit niedrigem Einkommen
2. Relativ geringe Geräteeffizienz und nicht besonders beratungsempfänglich:
   - Große Haushalte (mehr als 2 Mitglieder)
   - Mieter/innen

Für einkommensschwache Haushalte könnten finanzielle Anreize für Investitionen in Betracht gezogen werden, z.B. Zuschüsse für den Kauf effizienterer Geräte. Ebenso könnten für die beiden Gruppen, die für Beratung weniger empfänglich sind (d.h. große Haushalte und Mieter/innen) auch Maßnahmen wie finanzielle Anreize zur Effizienzsteigerung (z.B. Geräteeffizienz) in Betracht gezogen werden. Bei großen Haushalten kann die geringere Beratungsaufnahme mit der Anwesenheit von Kindern in Verbindung gebracht werden. Tatsächlich stellen wir fest, dass Haushalte ohne Kinder eine bessere Aufnahmebereitschaft für die Beratung durch die Versorgungsunternehmen und das BFE zeigen.

Insgesamt können wir die folgenden Gruppen identifizieren, die prioritär angesprochen werden könnten (Gruppe mit relativ guten Beratungsaufnahmen, weshalb Informationen oder Anstösse (nudges) wirksam sein könnten). Die Beratungen sollten jedoch auf diese Zielgruppen zugeschnitten sein:

- Zur Verbesserung der Effizienz:
  - Gruppe mit niedrigem Einkommen
  - Eigentümer/innen
- Zur Verbrauchsreduzierung:
  - Einpersonenhaushalte

Abschliessend weisen unsere Ergebnisse auf die folgenden politischen Schlussfolgerungen hin:

- Insgesamt beobachten wir in SZH eine relativ gute Performance, was zwei Hauptstrategien nahelegt: Beibehaltung einer erfolgreichen Politik und Entwicklung maßgeschneiderter Beratung für bestimmte Bevölkerungsgruppen (z.B. Mieter/innen) für bestimmte Verhaltensweisen.
- Informationskampagnen und andere Mittel zur Verbesserung der Energiekompetenz tragen zur Vertrauensbildung bei und könnten für eine höhere Inanspruchnahme der Beratung sorgen. Einige frühere empirische Ergebnisse deuten jedoch darauf hin, dass eine reine Informationsvermittlung wahrscheinlich nicht wirksam sein wird. Die Informationskampagnen müssen auf bestimmte Verhaltensweisen abzielen und andere Faktoren wie persönliche und soziale Normen bezüglich des Energiesparens ansprechen. Beispielsweise können Schulkampagnen zur Förderung von Wissen und sozialen Normen empfohlen werden.
- Werbekampagnen sollten wichtige Faktoren wie Vertrauen in die beratende Institution, höhere Energiekompetenz sowie Unterschiede zwischen Bevölkerungsgruppen berücksichtigen. Insbesondere fallen die Verhaltensunterschiede zwischen Eigentümer/innen und Mieter/innen, Hausbewohner/innen und Wohnungshaushalten sowie zwischen männlichen und weiblichen Single-Haushalten auf.

Tabelle 2: Performance der Haushalte in SZH im Vergleich zu KZH

	Höhe Stromverbrauch kWh	**Anteil an effizienten Elektrogeräten**	**Höhe Stromverbrauch Rechnung**	**Umsetzung von Energiespartipps vom BFE**	**Umsetzung von Energiespartipps von Versorgungs-unternehmen**
Insgesamt	*-0.13*	*-0.05*	*ns-*	*+0.10*	*+0.12*
< CHF 9 K	ns+	-0.11	ns+	+0.15	+0.10
≥ CHF 9 K	-0.22	ns-	-0.14	ns+	+0.12
Alter < 65	ns-	-0.07	ns-	ns+	+0.09
Alter ≥ 65	-0.16	-0.11	ns+	na	na
Frauen	-0.24	ns-	ns-	+0.13	+0.15
Männer	-0.19	-0.06	ns-	ns+	+0.12
HH=1	+0.20	ns-	ns+	+0.12	+0.20
HH=2	-0.25	ns-	ns+	ns+	+0.14
HH > 2	-0.22	-0.09	ns-	ns+	ns-
Mieter/innen	ns-	-0.06	ns-	+0.09	ns+
Eigentümer/innen	ns-	-0.09	ns+	ns+	+0.32

Blau: Die SHZ zeigt eine deutlich bessere Leistung; Rot: Die SZH weist eine deutlich geringere Leistung auf; ns+: Nicht signifikant (p=.1) mit positivem Vorzeichen; ns-: Nicht-signifikant (p=.1) mit negativem Vorzeichen; ns-: Nicht signifikant (p=.1) mit negativem Vorzeichen; na: Nicht verfügbar aufgrund des Versagens des Matching-Modells.

Tabelle 3. Performance der Haushalte in SZH im Vergleich zu M8

	Höhe Stromver-brauch kWh	**Anteil an effizienten Elektro-geräten**	**Höhe Stromver-brauch Rechnung**	**Umsetzung von Energiespar-tipps vom BFE**	**Umsetzung von Energiespar-tipps von Versorgungs-unternehmen**	**100% erneuerbare Energieträger Strommix wissen***
Insgesamt	*ns+*	*ns-*	*-0.08*	*+0.10*	*ns+*	*ns+*
< CHF 9 K	ns+	ns-	ns+	+0.12	ns+	ns+
≥ CHF 9 K	ns+	ns+	-0.13	ns+	ns+	ns+
Alter < 65	+0.10	ns-	ns-	+0.15	ns+	ns-
Alter ≥ 65	-0.17	-0.11	-0.15	na	na	+0.40
Frauen	ns-	-0.06	ns-	ns+	ns+	ns+
Männer	ns-	ns+	-0.22	ns+	ns-	ns+
HH=1	ns-	-0.09	ns-	+0.12	ns-	ns+
HH=2	ns+	ns-	-0.17	+0.13	ns+	+0.20
HH > 2	ns+	ns+	-0.20	+0.15	ns+	ns-
Mieter/innen	ns+	ns-	ns-	+0.12	ns-	+0.10
Eigentümer/innen	ns+	-0.09	ns-	ns+	+0.22	ns+

Blau: Die SHZ zeigt eine deutlich bessere Leistung; Rot: Die SZH weist eine deutlich geringere Leistung auf; ns+: Nicht signifikant (p=.1) mit positivem Vorzeichen; ns-: Nicht-signifikant (p=.1) mit negativem Vorzeichen; ns-: Nicht signifikant (p=.1) mit negativem Vorzeichen; na: Nicht verfügbar aufgrund des Versagens des Matching-Modells.

Executive Summary

This report presents the findings of a comparative micro-level analysis of the Swiss Household Energy Demand Survey (SHEDS) from Zurich City's perspective. SHEDS is an online survey designed and implemented by researchers from SCCER CREST. The sample is a panel data set extracted from four waves of the SHEDS from 2016 to 2019, including around 1'200 observations in Zurich City and in total about 20'000 observations across the German and French-speaking parts of Switzerland. SHEDS samples are representative of the Swiss population with respect to respondents' age and gender, and households' region and tenancy/ownership situation. All the information in SHEDS is based on self-reported data, by the main household member making decisions about energy related matters.

While primarily aiming at formulating policy recommendations for Zurich City, the study identifies many general relationships that could apply to the energy demand structure in the Swiss population at large. The study consists of two phases. In phase I, we use an exploratory analysis in order to identify important patterns of differences between households residing in Zurich City and those in other parts of Switzerland. Phase I's objective is to analyse a wide scope of variables characterizing household demand in three main energy fields (electricity, mobility and heating) as well as a selection of related psychological factors such as intentions and norms.

To demonstrate Zurich City's strengths and weaknesses in this regard, we consider four mutually exclusive comparison groups:

1) Households in Zürich City (**SZH**).
2) Households in Zürich Canton (**KZH**), excluding SZH and Winterthur.
3) Households in the 8 major Swiss cities other than SZH (**M8**) namely, Geneva, Lausanne, Bern, Basel, Luzern, Winterthur, Biel/Bienne, and St. Gallen. In some analyses, we only consider data from 2 major cities other than SZH (**M2**), namely Geneva and Basel. This is indicated in the specific analyses.
4) Households from the rest of Switzerland (**RCH**), i.e. all excluding groups 1-3 above.

We provide graphical demonstrations of the differences among the comparison groups based on group means, as well as measures of statistical significance that are mainly based on generic OLS regression models accounting for yearly national variations.

Phase I

The results of phase I are detailed in an intermediary report (available upon request from the authors). Drawing upon the findings in phase I, the study focuses on a selection of variables that show statistically significant differences between the groups named above and are considered as policy-relevant variables for SZH. This report, while focusing on phase II, provides a review of the main exploratory findings of phase I (*cf.* chapter 2).

The main results of the exploratory analyses (phase I) can be summarized as follows:

- There is a significant divide between suburban and rural areas on one hand and the major cities on the other. This urban-rural gap suggests that, on average, major cities are characterized by lower energy demand across all domains (electricity, heating and mobility). However, fundamental factors that influence energy consumption differ across regions. Generally speaking, the proximity to work and services in cities, as well as a dense infrastructure network, facilitate different behaviours that limit energy consumption. For instance, in major cities, households are generally smaller and live in smaller dwellings. While having a higher average income, the city-dwellers are less likely to own their home or a private car. If they own a private car, their car's age is on average higher than households living in suburban and rural areas. All these differences are significant between SZH and KZH as well as between SZH and RCH.
- About one in three households in SZH is unaware that its electricity mix is entirely renewable, which could be due to poor energy literacy but can also be considered as an indication that energy utilities could improve in presenting their products. In terms of household appliances, while the number of appliances and devices in SZH is lower on average, they are significantly less likely to be energy efficient.
- Findings for psychological determinants are diverse. Most striking is that even though people feel personally obliged to behave environmentally friendly, they express low intentions to change their energy consumption behaviours across the sample. SZH households express even less intention to change energy

consumption behaviour compared to households in M8 and RCH (apart from their carbon footprint). We also observe that uptake of energy consumption advice from authorities such as local utilities and Swiss federal office of energy (SFOE) is relatively low and limited to a minority of households. There is probably a potential for improving trust levels in energy advice from local and national authorities, which is worth investigating for SZH.

The significant differences between SZH and the other groups described above justify a deeper and more detailed analysis. Indeed, we emphasize that while the entire sample of SHEDS is representative of the Swiss population, it is likely that descriptive comparisons based on subsamples, especially the SZH group, lack representativeness, thus causing comparability issues. With non-representative and dissimilar samples, estimated differences between groups could indeed be biased. Therefore, our preliminary findings provide the basis for an elaborate econometric analysis (in phase II), which is designed to overcome the representativeness issue through adequate regression models and/or Propensity Score Matching (PSM) and can be used to draw meaningful policy conclusions.

Phase II

Based on the results of phase I and after discussions with Energieforschung Stadt Zürich (EFZ), we focus on the following three areas, which are of most policy interest to EFZ:

I. Assessment and decomposition of the identified urban-rural divide between SZH and KZH, in order to identify policy areas and population segments that could be targeted for reductions in electricity consumption. In addition, the important lack of knowledge regarding electricity consumed by households shows that, despite the fact that the electricity delivered in SZH is fully renewable, this information is not salient to many households. Our research should therefore identify if this is limited to specific groups or is widespread, and whether this knowledge has any effect on behaviour.

II. Considering the relatively poor performance of SZH regarding efficiency investments in electrical appliances, it is important to study the sources of these differences and to identify areas and/or population segments for effective policy measures.

III. The uptake of energy advice to reduce energy consumption is low (10%-40%) and uptake of advice varies considerably between information providers. Further research should explore what factors are related to a successful uptake of energy advice and which groups might respond better to advice from which institution.

In order to investigate these questions, we focus on the following dependent variables:

i. Annual household electricity consumption (kWh) and expenditures (CHF), both expressed in logarithms;

ii. Household investment in efficient electrical appliances (TV, fridge, dishwasher and washing machines), captured through the share of appliances with A+++ or A++ labels;

iii. Uptake of energy advice, especially from SFOE and local utilities, expressed in binary variables (1: Yes, 0: No);

iv. Knowledge of electricity sources, considering only locations where the electricity supply is 100% renewable namely, SZH vs. M2, expressed in binary variables (1: respondent reports correctly, 0: Not reported correctly).

The results of phase I guide us to focus on statistically significant differences, mainly observed between SZH and KZH. However, for completeness, and considering that systematic differences within specific population segments could not be detected through exploratory analyses reported in phase I, we extend our comparison groups to the other two groups, namely, M8 and RCH.

Drawing upon an interdisciplinary review of household energy consumption behaviour (Burger et al., 2015), adapted to the electricity domain and the available data, we define the following hierarchy of determinants:

1. **Socio-demographic characteristics and structural factors** are those aspects which are beyond households' control, at least in the short-term. This includes variables such as income, household type and size, dwelling ownership (tenant/owner) and type (single/multiple family housing), education, gender

and age, as well as dwelling situation (urban/suburban/rural), population density, and the heating technology;

2. **Technical factors** related to type, quantity, and efficiency of electric appliances. These factors are under household control and can change in a relatively short time frame;
3. **Behavioural factors** related to the usage of energy equipment that is driven by lifestyle, routines and habits as well as psychological factors and environmental attitudes;
4. **Latent or residual factors** include the residual differences that cannot be accounted for by any of the above categories.

At the micro-level, differences between a household from SZH and a household from another region could be due to one or several factors listed above. The first category (socio-demographic and structural) should not be considered as policy-relevant effects that can be easily addressed by short-term policy interventions. In this research, we are therefore interested in categories 2 to 4, which can be addressed by policy in a reasonable time horizon. In particular, both technical and behavioural factors are household choices that can be influenced by adequate policies, including incentive-based instruments and nudges.

Based on the hierarchy of determinants outlined above, we use the following models in order to identify the relative effect of each category:

- Model 0: Generic model including only group dummies and year dummies (similar to phase I);
- Model 1: Model 0 plus socio-demographic characteristics and structural determinants;
- Model 2: Model 1 plus technical determinants;
- Model 3: Full model, i.e., Model 2 plus behavioural factors.

The adopted econometric methodology is based on random-effects panel data regressions as well as on Propensity Score Matching (PSM). We apply both approaches to Models 1 to 3. We use the regression coefficients to identify relationships and underlying associations. We rely mainly on the full model (Model 3) for inference.

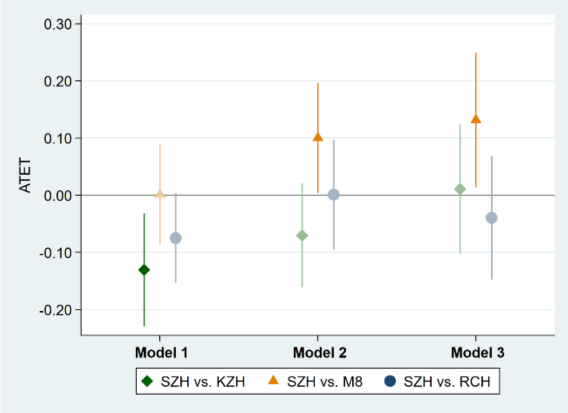
The PSM models allow us to directly estimate the differences between households in SZH ('treatment' group) with other groups ('control' groups), in particular KZH and M8. Comparisons of SZH's effects, namely the Average Treatment Effects on the Treated (ATET), across the three models allow us to identify the relative weight of each category of determinants in defining the differences between SZH's households and otherwise comparable households in other regions.

The PSM approach is also applied to investigate differences within specific population segments (subsamples) based on relevant variables (such as income, household type/size and dwelling type/ownership). The significant differences are used to identify population segments that can be targeted in policy interventions. This is an important part of the analysis because some of the effects that are overall insignificant are nonetheless significant for specific population segments.

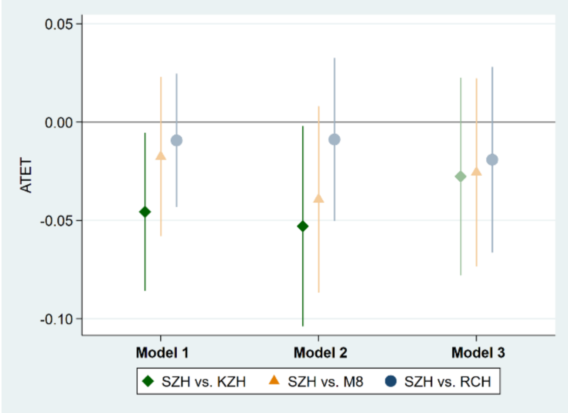
A comparison of results obtained with Model 0 and Model 1 suggests that a major part of differences between SZH and other groups in electricity demand is related to structural and socio-demographic differences. For instance, the apparently wide consumption gap between SZH and KZH in Model 0 (42% less consumption and 35% less expenditure in SZH) diminishes considerably in Model 1 (about 12% in consumption and only 6% in expenditure). A similar conclusion applies to the measure of appliance efficiency as well as the knowledge of energy mix. While Model 0 indicates a significantly lower efficiency in SZH compared to KZH (difference of about 4%) and a better knowledge of energy mix compared to M2 (difference of about 11%), both differences vanish when socio-demographics and structural factors are included. These findings show the importance of potential biases of an aggregate analysis without matching comparable households in terms of socio-demographics and structural variables.

Our main findings from PSM applied to the entire sample can be illustrated in the following graphs that plot average differences between SZH households and comparable households in control groups.

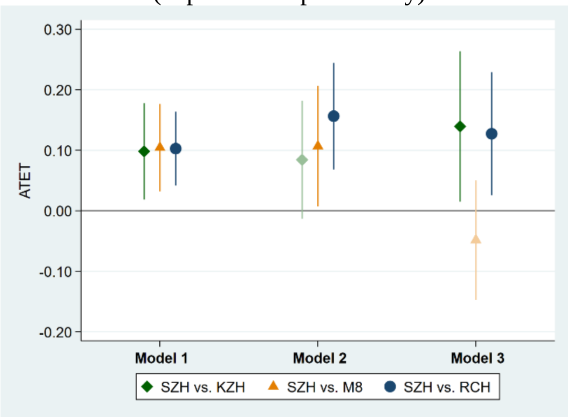
Difference in Electricity Consumption
(expressed in logs of kWh)



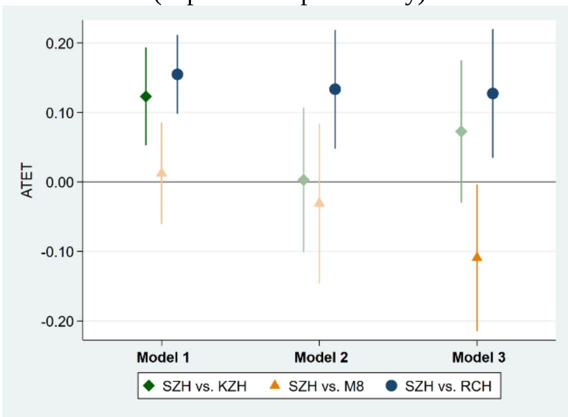
Difference Appliance Efficiency
(expressed in the share of A+++ and A++)



Difference in Advice Uptake from SFOE
(expressed in probability)



Difference in Advice Uptake from Local Utility
(expressed in probability)



Note: Whiskers represent 90% confidence intervals. Statistically significant differences ($p<0.1$) are displayed in dark colours, non-significant treatment effects in light. ATET < 0 (> 0) indicates a lower (higher) level of consumption, efficiency or advice uptake for SZH households compared to the respective comparison group.

These results reveal several patterns pointing to the following conclusions:

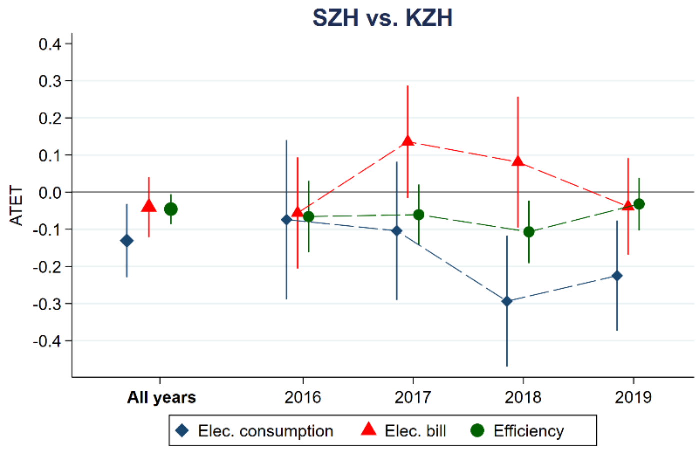
- The significant difference in electricity consumption observed in Model 1 between SZH and KZH disappear in Models 2 and 3, suggesting that the sources of differences are mainly technical (fewer appliances, although not necessarily more efficient ones in SZH).
- Significant differences in efficiency remain more or less the same in Model 2, but disappear in Model 3, suggesting that lower efficiency is not associated with fewer appliances.
- Significant differences in advice uptake (SFOE and utilities) remain more or less the same regardless of the Model (1, 2 or 3) with some small exceptions. Therefore, overall, these differences can be associated with unobserved factors such as, for instance, policy and cultural variables.

Accounting only for socio-demographic characteristics and technical factors (Model 1), SZH has on average about:

- 10% to 13% less consumption compared to KZH;
- 5% less in the share of efficient appliances compared to KZH;
- 10% to 15% higher likelihood of advice uptake from SFOE and utilities.

The analysis of temporal changes suggests that efficiency differences (SZH versus KZH) remain more or less stable. However, consumption differences between SZH and KZH seem to increase over time, with SZH showing improvement (i.e., a relative decrease). These results are illustrated in the following figure:

Temporal development of differences



Note: Whiskers represent 90% confidence intervals.

Overall, these findings indicate a relatively good performance for SZH households, suggesting that ongoing policies are probably successful and should be retained. While enforcing positive trends by continuation of ongoing policies, the results call for a better focus on the promotion of more efficient appliances.

The PSM analysis also provides two important findings that stand out for policy consideration seeking improvements:

- While average levels of energy advice uptake vary by source, (12% from local authorities, 32% for local utilities and 42% for SFOE), they show an overall low uptake that could be addressed by policy interventions. Nevertheless, advice uptake in SZH inhabitants is higher than in RCH, KZH and to some extent M8.
- The data point to a relatively poor knowledge of the electricity mix consumed at home, with one third of the households in SZH incorrectly stating that they consume non-renewable electricity. Nevertheless, knowledge of the electricity mix is slightly (but not significantly) better in SZH than in comparable households in M2.

A variety of random-effects regression analyses have been conducted to identify the underlying effects and relationships. A selection of these results is summarized in the following table:

Underlying effects and relationships based on panel regression models.

Determinants	**Electricity consumption** kWh	**Percentage of efficient appliances**	**Uptake of energy advice from the SFOE**	**Uptake of energy advice from utilities**
Single-person household (men vs. Women)	+	–	– / NS	NS
Tentant (vs. owner)	–	–	–	–
House vs. apartment	+	NS	NS	NS
Knowledge of own energy mix (self declaration)	NS	+	+	+
Energy literacy	NS	–	+	+
Appliance efficiency	NS		NS	NS
Number of appliances	+ mostly	+ / NS	– mostly	– mostly
Personal norms	NS	NS	+	+
Trust (in SFOE)	NA	NA	+	–
Trust (in utility)	NA	NA	NS	+

+: positive effect; −: Negative effect; NS: statistically not significant at $p<0.1$; NA: Not included in the final model because it was not significant in preliminary models. Reading example first row in the table: households with single male occupants are more likely to have a higher electricity consumption (positive effect) and less efficient devices (negative effect) than single female households. Single men (negative effect) are also less likely to take up energy advice from the SFOE than women (non-significant, NS), who don't show any significant difference to multi-person households. Finally there is no significant difference in energy advice uptake from local utilities (non-significant, NS) for single men/women compared to multi-person households.

The main results regarding electricity consumption can be listed as follows:

- Electricity consumption shows strong economies of scale: each additional household member only adds about 12% more consumption. Per person, smaller households consume disproportionately more than couples and larger families.
- Among single-member households, single men consume more (about 10%) and show relatively low efficiency (about 5% fewer efficient appliances).
- Tenants consume less than owners (about 20%) and have lower efficiency investment (about 5% fewer efficient appliances).
- House dwellers consume more than households living in apartments (on average about 30% to 40%).
- Number of appliances has a positive (i.e., increasing) effect on electricity consumption.
- There is no significant evidence showing that appliance efficiency decreases electricity consumption.
- Consuming an electricity mix with more than 50% renewable seems to have no effect on the overall electricity consumption (i.e., there appears to be no behavioural rebound effect). It has nevertheless a positive relationship with appliance efficiency, hence indicating no indirect rebound effect.

In regard to advice uptake, the following results can be drawn from the panel regressions and the observed patterns of differences:

- Personal norms and trust have a significant impact on advice uptake. Even though these variables have no direct effect on consumption/efficiency, they could nevertheless play an important role through their indirect effect on advice uptake.
- Advice uptake is lower among tenants, who could be a specific target group.
- We suggest to tailor advice (goal setting, particular group and/or particular consumption behaviour), e.g. on efficiency investments directed to tenants, could reach maximal efficiency.
- Better advice uptake can be achieved by improving trust in relationships with customers and promotion campaigns targeting personal norms.

Regarding knowledge of electricity mix, and the impact of energy literacy, we can point out the following conclusions:

- Poor knowledge of energy mix (slightly better in SZH with 66% vs. 57% in M2).
- Knowledge of energy mix shows a strong relation with a general energy literacy score measured in SHEDS, i.e. general energy literacy is lower when knowledge about the energy mix is lower and vice versa.
- Important factors with significant positive effects on knowledge are personal norms, age (>65), and absence of children.
- Energy literacy has a slightly (negative) impact on efficiency, i.e. the more people know about energy-related issues the lower their probability of owning efficient appliances. However, there is no direct effect of energy literacy on electricity consumption. Part of the negative effect on efficiency could be explained by the consumer's concern about embodied (grey) energy used in the production of appliances.
- The energy literacy score has a significant impact on advice uptake (from SFOE and utilities). Improving energy literacy via (general) information campaigns could hence serve as a mean to improve the relationship between energy utilities and their consumers.

Our policy conclusion on the desirable impacts of energy literacy and advice uptake is based on the premise that targeted advice and good information will have an effect in reducing energy consumption. While this premise is generally favoured by the patterns of differences between the studied regions, our regression results do not provide any solid evidence of a statistically significant impact on energy consumption. This could be explained by the fact that our data that do not provide sufficient information about the specific advices and information campaigns conducted during the study period.

The breakdown of the differences between households in SZH compared to their matched counterparts living in the two control groups (KZH and M8) provides important insights. These average differences based on the PSM (Model 1) in a selection of population segments are provided in the following tables. These results can be used to identify what population segments to target for which specific behaviour and to understand if these segments are responsive to advice from the SFOE and utilities. While showing a strong heterogeneity in differences across various population segments, the results point to several "low-hanging fruits", that is, segments that could be targeted and prioritized in policy interventions.

Interestingly, single-member households in SZH stand out as a distinctive segment with higher consumption compared to KZH households. These households show relatively high consumption, but they are relatively responsive to the utility's advices.

We can also identify two patterns of behaviour in SZH compared to matched households in KZH:

1. Relatively low appliance efficiency, but relatively responsive to advice:
    - Men
    - Low-income households
2. Relatively low appliance efficiency, but not particularly receptive to advice:
    - Large households (more than 2 members)
    - Tenants

For low-income households, financial incentives for investments could be considered, e.g. grants for buying more efficient appliances. Moreover, targeting the two groups that are less receptive to advice (i.e., large households and tenants), other measures such as financial incentives for efficiency improvement (e.g., appliance efficiency) could also be applicable. For large households, the lower advice uptake could be associated with the presence of children. In fact, we find that households without children show better receptiveness to advice from utilities and the SFOE.

Overall, we can identify the following groups which could be targeted with priority (relatively good uptake of advice and, hence, information or nudges could be effective). However, advice should be tailored to these target-groups:

- For efficiency improvement:
    - Low-income group
    - Owners
- For consumption reduction:
    - Single-member households

Finally, our findings point to the following policy conclusions:

- Overall, we observe a relatively good performance in SZH, thus suggesting two main strategies: keep successful policies and develop tailored advice for specific population segments (e.g. tenants) for specific behaviours.
- Information campaigns and other means to improve energy literacy help to build up trust and could ensure better advice uptake. However, some previous empirical findings suggest that mere information is unlikely to be effective. The information campaigns need to target specific behaviours and address other factors such as personal and social norms in favour of energy saving. For instance, school campaigns can be recommended for the promotion of knowledge as well as social norms.
- Promotion campaigns should consider important factors such as trust in the advice-giving institution, higher energy literacy as well as differences between population groups. In particular, the behavioural differences stand out between owners and tenants, house-dwellers and households living in flat, and single male vs. single female households.

SZH's performance compared to KZH

	Consumption kWh	Percentage of efficient appliances Efficiency	Electricity Bill	Uptake of energy advice from the SFOE	Uptake of energy advice from utilities
Overall	*-0.13*	*-0.05*	*ns-*	*+0.10*	*+0.12*
< CHF 9 K	ns+	-0.11	ns+	+0.15	+0.10
≥ CHF 9 K	-0.22	ns-	-0.14	ns+	+0.12
age < 65	ns-	-0.07	ns-	ns+	+0.09
age ≥ 65	-0.16	-0.11	ns+	na	na
Women	-0.24	ns-	ns-	+0.13	+0.15
Men	-0.19	-0.06	ns-	ns+	+0.12
HH=1	+0.20	ns-	ns+	+0.12	+0.20
HH=2	-0.25	ns-	ns+	ns+	+0.14
HH > 2	-0.22	-0.09	ns-	ns+	ns-
Tenant	ns-	-0.06	ns-	+0.09	ns+
Owner	ns-	-0.09	ns+	ns+	+0.32

Blue: Zurich City shows a significantly better performance; Red: Zurich City shows a significantly lower performance; ns+: Not significant (p=.1) with positive sign; ns-: Not significant (p=.1) with negative sign; na: Not available due to matching model's failure

SZH's performance compared to M8

	Consumption kWh	Percentage of efficient appliances	Electricity Bill	Uptake of energy advice from the SFOE	Uptake of energy advice from utilities	100% renewable energy knowledge*
Overall	*ns+*	*ns-*	*-0.08*	*+0.10*	*ns+*	*ns+*
< CHF 9 K	ns+	ns-	ns+	+0.12	ns+	ns+
≥ CHF 9 K	ns+	ns+	-0.13	ns+	ns+	ns+
age < 65	+0.10	ns-	ns-	+0.15	ns+	ns-
age ≥ 65	-0.17	-0.11	-0.15	na	na	+0.40
Women	ns-	-0.06	ns-	ns+	ns+	ns+
Men	ns-	ns+	-0.22	ns+	ns-	ns+
HH=1	ns-	-0.09	ns-	+0.12	ns-	ns+
HH=2	ns+	ns-	-0.17	+0.13	ns+	+0.20
HH > 2	ns+	ns+	-0.20	+0.15	ns+	ns-
Tenant	ns+	ns-	ns-	+0.12	ns-	+0.10
Owner	ns+	-0.09	ns-	ns+	+0.22	ns+

Blue: SZH shows a significantly better performance; Red: SZH shows a significantly lower performance; * Compared to M2; ns+: Not significant (p=.1) with positive sign, not significant (p=.1) with negative sign; na: Not available due to matching model's failure

Introduction

There are many reasons to expect systematic differences in energy demand between households in Zurich city and those living in other Swiss cantons/cities. The city of Zurich is a relatively rich area with many possibilities for investment but also many opportunities for implementation of policies aimed at reducing energy consumption. In addition, people living in Zurich city might be more aware of environmental issues, partly because of the pioneering role Zurich's institutions play in energy policy and related investments, and partly because of cultural differences and environmental attitudes that could be specific to this area.

Identifying these potential differences could be informative for policy makers. First, to the extent that these differences could be linked to various household characteristics, one could draw important policy lessons. Secondly, the analysis of systematic differences between a specific group of households residing in Zurich city with an otherwise comparable group living in another part of Switzerland, allows one to identify possibilities for further improvements. These include, in particular, relevant policy instruments as well as population segments ('low-hanging fruits') that could be readily targeted for inducing a specific behavioural change.

While a number of analyses point to differences between Swiss cantons and cities, the empirical evidence is not conclusive. In fact, in most cases, the focus of empirical research is on well-defined determinants rather than city/canton indicators that are usually included as incidental parameters.[1] However, the Swiss case with 26 different cantonal regimes, in particular Zurich that stands out in certain aspects, lends itself to an analysis focusing on local and regional specificities. To the best of our knowledge, the empirical literature has little guidance to offer for an adequate analysis detecting and investigating differences between Zurich city households and comparable households in other places. This shortcoming puts a special importance for any quantitative evidence of "Zurich city" effects, their relation with various determinants, and their distribution among population segments.

Do Zurich city's households differ from other Swiss cantons/cities with respect to energy consumption and its changes? How are these differences distributed in the electricity domain? What are the moderating effects, if any? Are differences limited to specific population segments in terms of income, household size, or usage intensity? To what extent are these differences related to structural/contextual differences? What are the driving forces resulting in these differences? Could Zurich city be a model for energy transition for the rest of Switzerland? Do historical changes in energy consumption support this premise? What are Zurich city's strengths and weaknesses regarding performance in energy transition?

Responses to these research questions could have a great significance in guiding Zurich city's future climate and energy policies. There are also potentially important lessons for policies at the national and cantonal levels. Addressing these questions raises, however, challenges in terms of data and methodology. Most available household data are either wanting in energy-related variables (e.g. SFSO data such as Household Budget Survey), or do not provide a reasonable sample size or representativeness allowing a direct utilization for a comparative analysis. Moreover, longitudinal household data are scarce.

This report is based on a selection of variables collected in the Swiss Household Energy Demand Survey (SHEDS), which provides an exceptional opportunity for a comparative analysis with reasonable power and representativeness. With four annual waves (2016-2019) and a total of 5'000 respondents per year, SHEDS contains a representative sample of the Swiss population (except Ticino) with regard to gender, age, dwelling ownership and linguistic region. It therefore provides a panel dataset that allows statistical inference in various population segments regarding energy demand and its longitudinal changes. In addition to socio-economic variables, SHEDS contains a wide range of psychological, behavioural and sociological characteristics.

On average, SHEDS includes about **about 300 households per year from Zurich city**. Over the four waves, the size of the Zurich city sample is thus about 1'200, hence giving a reasonably large sample for a robust econometric analysis. However, it is likely that the global representativeness of SHEDS sample is lost in Zurich city subsamples, so that sophisticated econometric methods have to be implemented to deliver unbiased estimates.

[1] For instance, canton dummies show almost invariably a statistically significant effect on various domains of energy consumption. See for instance Weber and Farsi (2014), Tilov et al. (2019) and Hediger et al. (2018).

It is also important to note that all the information in SHEDS is self-reported data, and hence is subject to the usual reporting errors. It is therefore crucial to apply caution in interpreting the differences between groups or across various years, based on mean values.

This study is conducted in two phases. In the first phase (**Phase I**), using an exploratory analysis of a wide range of energy-relevant variables we identified a selection of variables that could be used for further analysis. We used the conceptual framework proposed by Burger et al. (2015), to identify important variables that characterize a household's energy demand function. We also consider several variables representing longitudinal changes in energy demand.

The analysis in Phase I has been implemented by sample mean tests and OLS regression models. The latter have generic specifications controlling for year dummies and regional groups. We consider four mutually-exclusive groups of households based on the residence location namely, Zurich City, Zurich Canton (except Zurich city and Winterthur), eight major Swiss cities (Geneva, Lausanne, Bern, Basel, Luzern, Winterthur, Biel/Bienne, and St. Gallen), and the rest of Switzerland.

The results of the analyses conducted in phase I allow us to identify a number of statistically significant and potentially interesting differences. The objective of the project's second and final phase (**Phase II**) is to study a selection of these variables deemed to be relevant from a policy perspective for Zurich City. In particular, after an exchange with Energieforschung Stadt Zürich (EFZ), we selected seven dependent variables measuring electricity consumption and appliance efficiency as well as the propensity of uptake of energy advice from authorities and utilities.

The analyses in Phase II use the same sample and follow the same grouping as in Phase I that is, the four mutually exclusive groups mentioned above. However, in Phase II, we excluded observations from a few households whose residence could not be reliably identified.

The research conducted in phase II takes the following steps:

1. Considering four groups of households based on the location of their residence, we implement an econometric analysis to investigate heterogeneity and identify genuine differences between Zurich city and other regions. The model specification draws upon theory and focuses on four categories of explanatory variables: structural and socio-demographic characteristics that are beyond the households' "control", at least in the short term, technical factors resulting from households' decisions, and behavioural characteristics. These regression results are also used to identify relationships and significant determinants for each variable.
2. Differences between regions and relationships between dependent variables and each determinant at the population level are investigated using a series of panel data models. The objective is to determine which types of factors (structural/socio-demographic, technical, or behavioural) are responsible for differences across regions and which trigger factors could be utilized to develop interventions or formulate policies.
3. We then implement a matching analysis that accounts for differences in the composition of the population across regions. This allows to more precisely estimate the differences between Zurich city and other regions, by comparing comparable households.
4. The matching analysis is further refined and applied to subgroups defined by important characteristics, providing a heterogeneity analysis across population segments and over the years. This allows to more precisely pin down the groups of households responsible for the differences across regions.
5. Finally, with a policy synthesis based on based on the group-specific effects as well as the underlying mechanisms identified via regression models, we provide policy recommendations. A twofold objective is followed: First, the results will be used to identify a relative measure of success for recent or ongoing policy measures and across different population segments. Second, with a special focus on underlying mechanisms in each case, the sources of success and/or failure (the drivers and barriers) in achieving energy consumption reduction are identified.

While providing a brief summary of the Phase I's main findings, the present report focuses on the Phase II analyses. Phase I is the focus of an intermediary report (Farsi et al., 2019) which is available upon request from the authors.

The rest of this report is organized as follows. Section 1 presents a description of the survey (SHEDS), its design and its representativeness. Section 2 provides a brief summary of the exploratory analyses conducted in project phase I. Section 3 presents the adopted methods for the phase II analyses. Results are presented separately for electricity and psychological factors in Section 4. Section 5 includes a series of policy recommendations. Finally, Section 6 concludes the report with a summary of the policy conclusions.

1 Swiss Household Energy Demand Survey

1.1 Survey design

SHEDS is an online survey, designed and implemented by researchers from SCCER CREST. It is fielded in collaboration with the survey company Intervista, mandated to conduct the sampling; namely, contacting potential respondents and offering them an incentive (bonus points) for answering the survey. Respondents are invited until a sample size of 5,000 is reached. Only respondents who report being involved (at least partly) in their household's expenses qualify for the survey. The final sample is constructed to be representative of the Swiss population (excluding Ticino) according to the following pre-selected characteristics and quotas:

- Age: 18-34 = 30%, 35-54 = 40%, 55+ = 30%;
- Gender: male = 49%, female = 51%;
- Region: French-speaking = 25%, German-speaking = 75%;
- Living situation: tenants = 62.5%, owners = 37.5%.

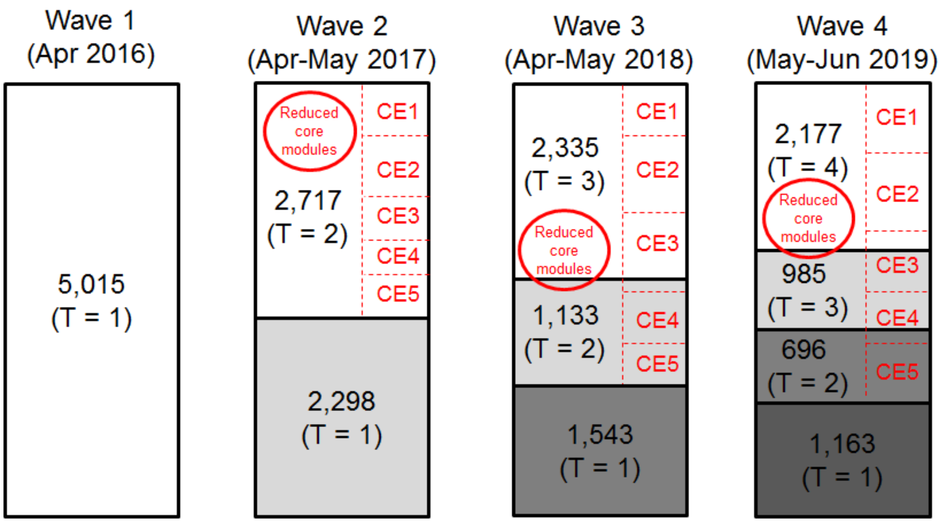
SHEDS is designed as a series of modules: core modules intended to collect longitudinal data, as well as additional modules dedicated to one-time experiments. The core modules represent a major part of the survey (more than two thirds of the survey). The questions therein are based on the multidisciplinary framework developed by the research group (Burger et al., 2015), and are drawn from the established and cutting-edge research literature of their respective fields. The core modules are dedicated to eliciting energy-related, psychological, social context, and socio-economic information. The energy-related modules collect information about equipment and usage in three energy domains: electricity, heating, and mobility.

Most of the core modules are repeated in every wave of SHEDS and for all respondents, in order to collect information from the same individuals and concerning identical topics over time (e.g., annual energy expenditures). Time-invariant characteristics, however, are naturally collected only once for each respondent, at the time of first entrance in SHEDS (e.g., gender). In addition, regarding elements which are unlikely to change on a yearly basis (e.g., cars or living situation), respondents are only asked to answer again if they experienced changes compared to what they stated in the previous wave. Finally, some of the core modules are rotated in further waves of the survey and are asked on a less frequent basis (every 2-3 years or during the first and last planned wave of the survey) since they do not need to be collected on a yearly basis due to their relatively stable nature (e.g., values). The duration of core modules is thus shorter for the returning respondents, freeing up valuable survey time which can be dedicated to additional modules.

Next to core modules, each wave (except the first) of SHEDS encompasses a series of additional modules in which various types of choice experiments are implemented. Only returning respondents are eligible for the additional modules, and each respondent is randomly allocated to only one of the choice experiments. Total survey duration is intended to be similar (25-30 minutes) for new and returning respondents.

Figure 1 provides an overview of the data that have been collected to date in the context of SHEDS. SHEDS started in 2016 with 5,015 respondents. In 2017, all of these respondents were re-contacted and more than half of these (2,717) returned and answered wave 2. In waves 3 and 4, more than 2,000 of wave 1 respondents are still in the sample. Every year, the panel is then filled with fresh respondents until the total number reaches 5,000. The return rate from one year to the next is always above 50%, which makes it possible to create a sample of a reasonable size for conducting longitudinal analyses.

Figure 1: SHEDS structure and number of observations.



1.2 Sample distribution and representativeness

To provide meaningful comparisons, the observations of SHEDS have been split in the following four mutually exclusive groups (see Figure 2):

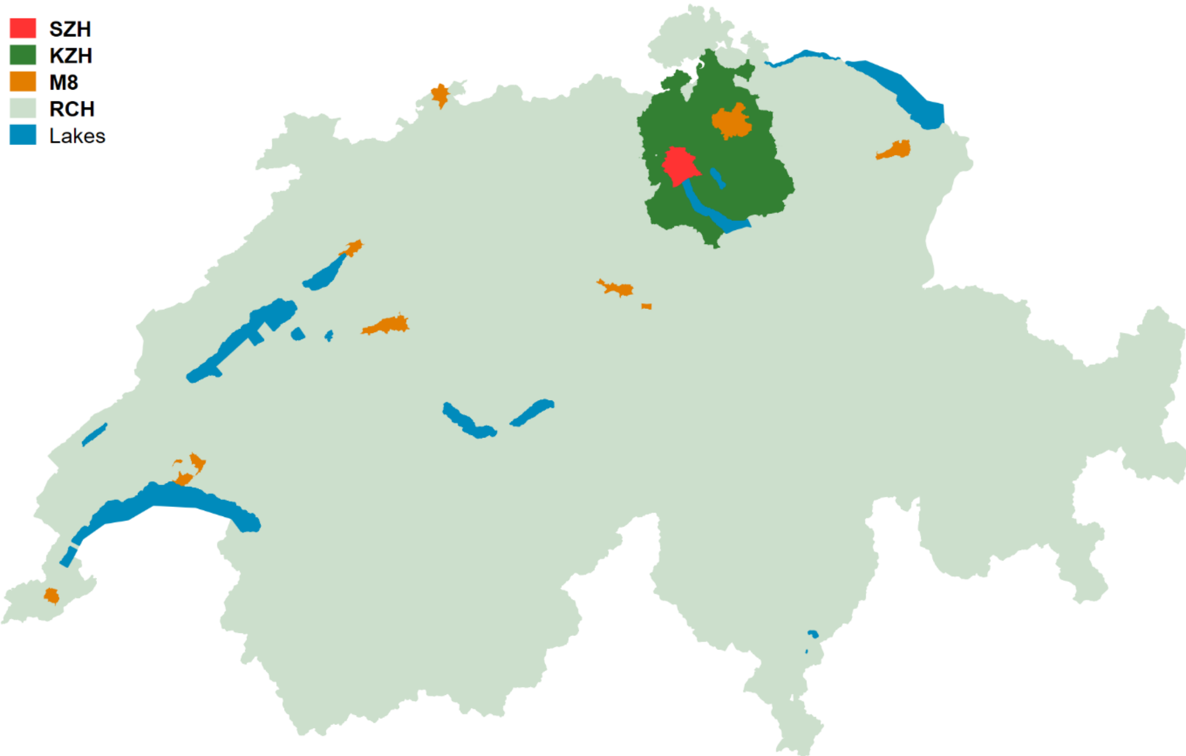
1. Households in Zürich city (**SZH**).
2. Households in Zürich canton (**KZH**), excluding SZH and Winterthur. (Winterthur is excluded from KZH because it belongs to the next group of major Swiss cities.)
3. Households in the 8 major Swiss cities other than SZH (**M8**): Geneva, Lausanne, Bern, Basel, Luzern, Winterthur, Biel/Bienne, and St. Gallen. In some analyses, we will only consider the data from 2 major cities other than SZH (**M2**): Geneva and Basel.
4. Households in the rest of Switzerland (**RCH**), i.e. all excluding groups 1-3.

The numbers of observations (see Table 1) are stable across the years, with around 300 observations for SZH, 600 for KZH, 800-900 for the 8 major cities (M8), and 3200-3300 for the rest of Switzerland (RCH). Such numbers constitute a reasonable sample size, even for the smallest group. For comparison, we computed proportions of households in each region using data from the survey STATPOP, which is conducted annually by SFSO (see Figure 3). We observe that the proportions in SHEDS and STATPOP are relatively close. Yet, it appears that SHEDS tends to slightly oversample major cities (SZH and the 8 other major cities) at the expense of the rest of Switzerland.

Table 1: Number of SHEDS respondents, by group and year.

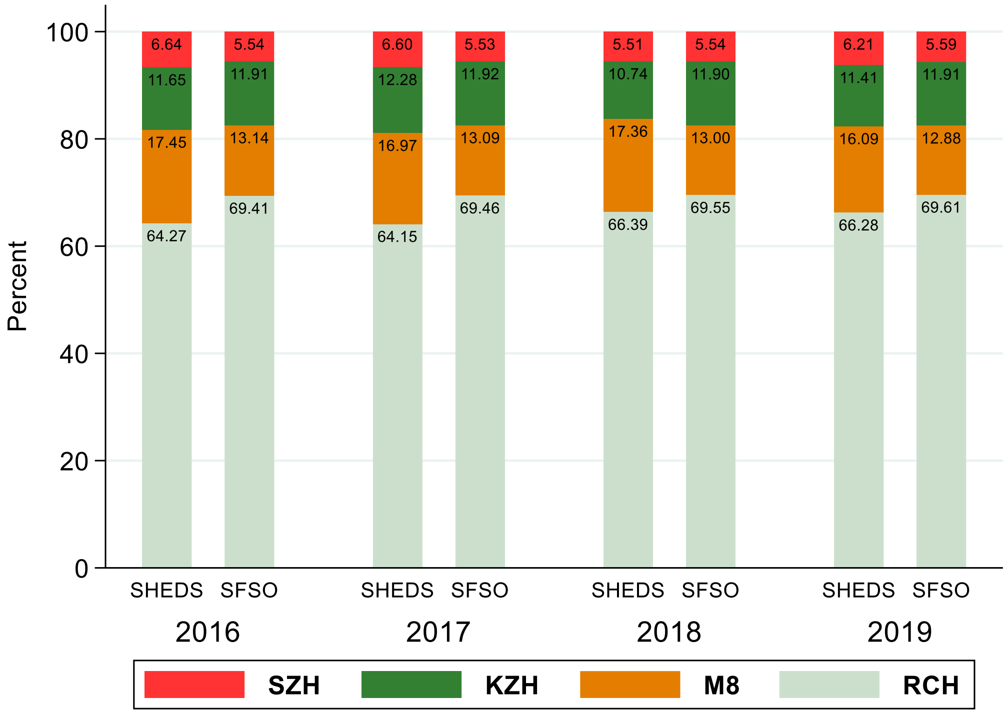
Year	SZH		KZH		M8		RCH		Total	
	N	(% row)	*N*	(% row)	*N*	(% row)	*N*	(% row)	*N*	(% row)
2016	333	(6.64)	584	(11.65)	875	(17.45)	3,223	(64.27)	5,015	(100.00)
2017	331	(6.60)	616	(12.28)	851	(16.97)	3,217	(64.15)	5,015	(100.00)
2018	276	(5.51)	538	(10.74)	870	(17.36)	3,327	(66.39)	5,011	(100.00)
2019	312	(6.21)	573	(11.41)	808	(16.09)	3,328	(66.28)	5,021	(100.00)
Total	1,252	(6.24)	2,311	(11.52)	3,404	(16.97)	13,095	(65.27)	20,062	(100.00)

Figure 2: Map of the four groups.



Source: swissBOUNDARIES3D 2018, Swiss Federal Office of Topography (swisstopo).

Figure 3: Distribution (%) of households in each group compared to Swiss population excluding Ticino (SFSO).



2 Exploratory Analysis (Phase I)

During phase I, an explorative analysis of SHEDS data revealed patterns of differences in energy demand and consumption behaviour between households living in Zurich city and their counterparts in other parts of Switzerland. The objective of phase 1 was to analyse a wide scope of variables characterizing household demand in three main energy fields (electricity, mobility and heating) as well as a selection of related psychological factors such as intentions and norms, based on the four mutually exclusive comparison groups mentioned in section 1.2. We provide the conclusions of the graphical demonstrations of the differences among the comparison groups based on group means, as well as measures of statistical significance that are mainly based on generic OLS regression models accounting for yearly national variations (the intermediary report is available on request from the authors).

We show that most differences in energy consumption patterns are between SZH and KZH, and major cities and the rest of the country. This largely demonstrates a significant divide between major cities and the rest of Switzerland i.e., suburban and rural areas. Our findings confirm the urban-rural gap suggesting that on average, major cities are characterized by lower energy demand across all domains, smaller dwellings, and lower ownership of individual housing and private cars (e.g. Figures 4 and 5).

Figure 4: Annual household electricity consumption

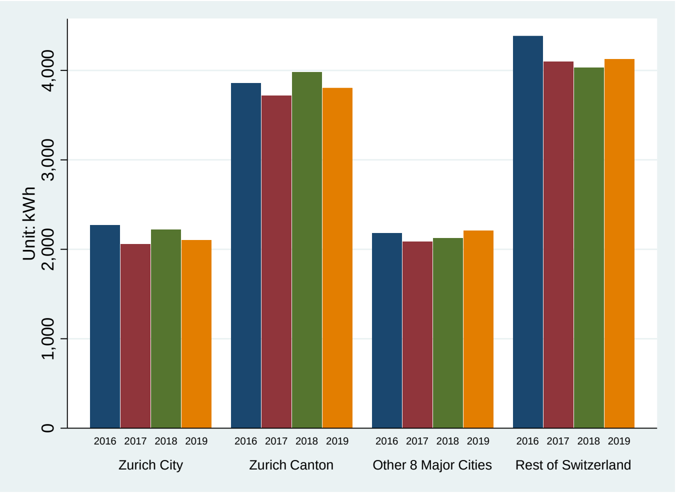


Figure 5: Number of cars per household

These differences are in fact significant between SZH and KZH as well as between SZH and the rest of Switzerland. However, fundamental factors that influence energy consumption differ across regions. For instance, in SZH and in the other cities, households are generally smaller (Figure 6), live in smaller dwellings (Figure 7), are less likely to own their home, and are richer on average. More broadly, the proximity to work and services in cities, as well as a dense infrastructure network, facilitates different energy behaviours.

Figure 6: Number of household members

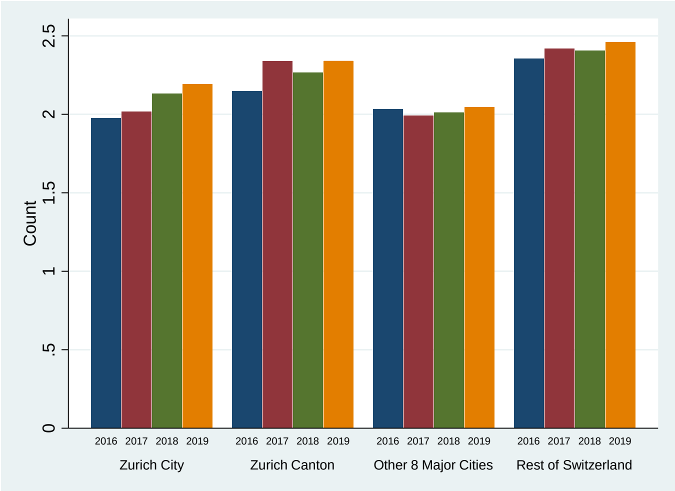
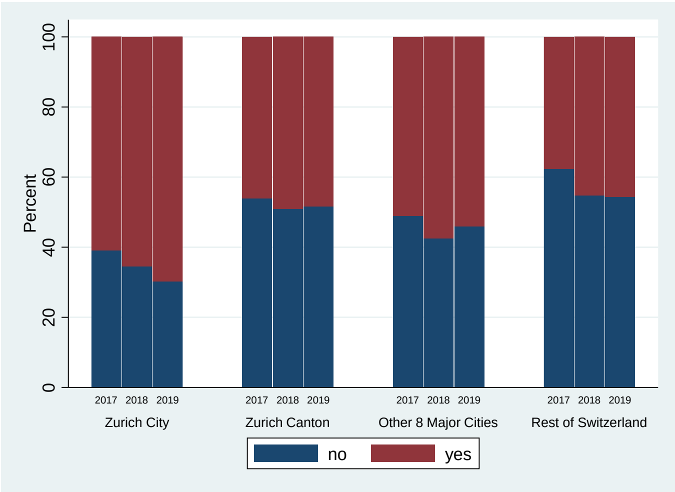


Figure 7: Living area (m^2) per household member

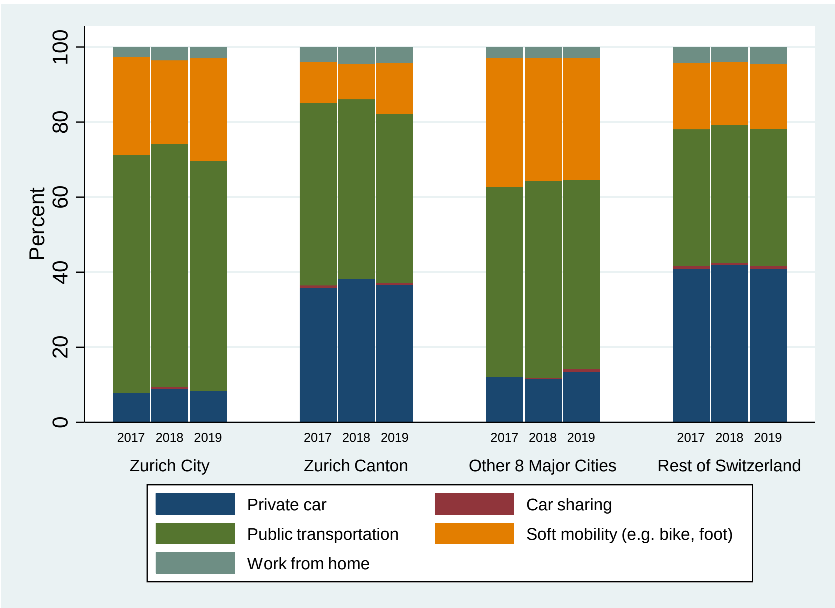
It is also interesting to note that our regressions indicate some differences between SZH and the other major cities. For instance, households in SZH spend on average less on electricity but consume more kWh per household and per household member. Findings show that about 30% of households in SHZ are unaware that their electricity mix is 100% renewable (including hydropower). The proportion of respondents who report more than 50% renewables is larger elsewhere (Figure 8), but part of this difference could be genuinely due to lower commitment to renewables in other regions. In terms of household appliances, while the number of appliances and devices in SZH is lower on average, they are significantly less likely to be highly energy efficient.

Figure 8: Electricity mix - more than 50% renewables



In terms of mobility, households in SZH drive significantly less than those in KZH and the rest of the country, but not differently compared to those in other major cities. Significantly fewer cars are owned per household in SZH and the other cities compared to the less urban groups. Moreover, SZH households are even less likely to own a car than households in the other cities (Figure 5). Cars owned in SZH and the other cities are on average significantly older than those in KZH and the rest of Switzerland. Households in SZH are less likely to use a car for commuting to work than those in all other groups. Instead, they are more likely to use public transport (Figure 9). Although more households use soft transport to commute in SZH than in KZH and the rest of the country, households in the other cities are still more likely to walk or cycle. As for the reasons people commute with different modes of transport, the speed of the journey appears highly important for all mode types. Access to public transport stops and routes, as well as good connections, is an important positive factor for those using public transport, and a lack of this access is a negative influence for those who choose to drive. Interestingly, the availability of parking places near work is an important factor for those choosing to drive, and a lack of this is important for those using soft mobility.

Figure 9: Usual transport mode for work commute



Regarding heating, a greater proportion of SZH households use district heating compared to all other groups. SZH and the other major cities have a lower proportion using heat pumps compared to KZH and the rest of the country. Households in SZH pay less for heating and hot water, on average, than all other regions. SZH and M8 households act similarly in their heating patterns, and these two groups are different from the less-urban groups. This again can be tracked down to the size difference between average city- versus agglomeration- or rural homes.

Findings for psychological determinants are diverse. Most striking is that even though people feel personally obliged to behave environmentally friendly, they express low intentions to change their energy consumption behaviours across the sample. SZH households express even less intention to change energy consumption behaviour compared to people in other major cities and the rest of Switzerland (apart from their carbon footprint). One reason for this could be that SZH inhabitants express less pressure from their network to act environmentally friendly compared to people in other major cities and the rest of Switzerland.

We also found that uptake of energy consumption advice is relatively low. Between 10% and 40% of SZH participants report previously taking up energy advice from local authorities (Figure 10) and the SFOE respectively (Figure 11). There is still room for improvement here and it is worth investigating why this is the case. One indicator could be that trust levels in energy advice from local and national authorities as well as local utilities, although not being very low, are also not very high (3-4 on a 5-point scale).

Figure 10: Energy advice uptake from local authorities

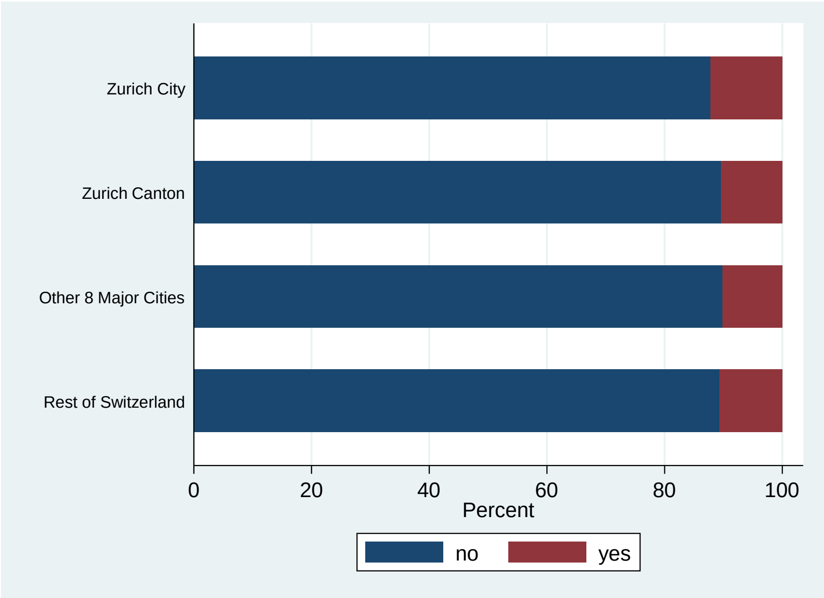
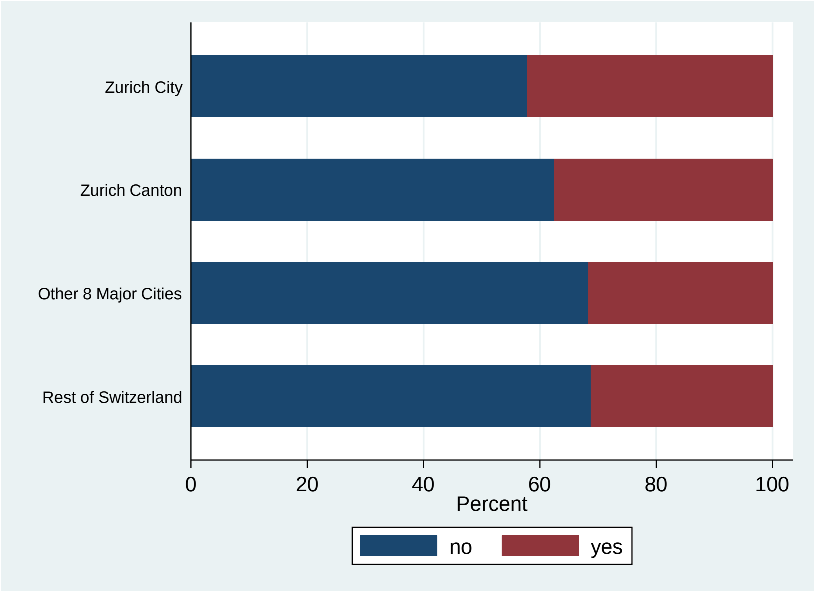


Figure 11: Energy advice uptake from the Swiss Federal Office of Energy



The interesting and significant findings described in phase I justify a deeper and more detailed analysis. Indeed, we emphasize that while the entire sample is representative of the Swiss population, it is likely that the descriptive comparisons based on subsamples as above, especially the SZH group, lack representativeness, thus causing comparability problems. With non-representative and dissimilar samples, estimated differences between groups could be biased. Therefore, our preliminary findings provide the basis for an elaborate econometric analysis, which will be able to overcome the representativeness issue through adequate regression models and/or Propensity Score Matching, and can be used to draw meaningful policy conclusions.

3 Methods

Based on the results of phase I and after discussions with Silvia Banfi Frost and Reto Dettli, from the Energieforschung Stadt Zürich (EFZ), we have honed in on the following three areas, which are of most interest to the EFZ:

IV. Assessment and decomposition of the identified urban-rural divide between Zurich City and Zurich Canton, in order to identify policy areas and population segments that could be targeted for reductions in electricity consumption.

   - We also observe a relatively important lack of knowledge regarding renewable electricity sources. The fact that electricity delivered in Zurich is fully renewable is not salient to many households. Further research should identify if this is limited to specific groups or is widespread, and whether this knowledge has any effect on behaviour.

V. Considering the relatively poor performance of SZH regarding efficiency investments in electrical appliances it is important to study the source of these differences and to identify areas and/or population segments for effective policy measures.

VI. Psychological drivers of energy consumption, in particular the uptake of energy advice to reduce energy consumption is low (10%-40%) and uptake of advice varies dramatically between information providers. Further research should explore what factors are related to a successful uptake of energy advice and which groups might respond better to advice from which institution.

In order to investigate these questions, we focus on the following dependent variables:

v. Household electricity consumption and expenditures;

vi. Household investment in efficient electrical appliances (TV, fridge, dishwasher and washing machines);

vii. Uptake of energy advice especially from SFOE and local utilities;

viii. Knowledge of electricity sources, considering in this case only locations where the electricity supplied is 100% renewable.

The results of Phase I guide us to focus mainly on statistically significant differences, observed mainly between Zurich city (SZH) versus Zurich canton (KZH). For the sake of completeness, and considering that systematic differences (specially within specific population segments) could not be detected by generic analyses reported in Phase I, we extend our comparison groups to the other two groups, namely, eight major Swiss cities (M8) and the rest of Switzerland (RCH).

The econometric methods implemented include a random effect panel data model (random effects at the household level) and a Propensity Score Matching (PSM) model. While the first analysis (panel model) represents an aggregate analysis of differences and relationship between dependent variables and each determinant at the population level, the second analysis (matching analysis) estimates differences after accounting for selection issues in the overall population. The PSM approach is consequently applied to subsamples from different years as well as various relevant population segments.

Last not least, we provide a policy synthesis summarizing the results from various econometric models emphasizing a discussion of policy recommendations. The synthesis is based on the group-specific effects estimated in the matching analyses as well as the underlying mechanisms identified in aggregate models. In our policy synthesis we follow a twofold objective: First, the results will be used to identify a relative measure of success for currently ongoing policies regarding the studied energy behaviour indicators across different population segments. Second, with a special focus on underlying mechanisms in each case, the sources of success and/or failure (the drivers and barriers) in achieving energy consumption reduction will be identified.

3.1 Model specification

In order to guide our modelling strategy, we draw upon an interdisciplinary review of household energy consumption behaviour (ECB) (Burger et al., 2015). Determinants of ECB come from a wide range of factors pertaining to both individual opportunity space (IOS) and social opportunity space (SOS), embedding the individual in a broad environment. SOS factors describe external societal circumstances such as available technology, economic factors, institutional norms/policies, geographical and climatic factors as well as cultural differences. IOS factors, on the other hand, are individual boundaries and opportunities, such as the social milieu and lifestyle, household/personal appliances and facilities, place of dwelling, household size, as well as socio-demographic factors, such as income, age, gender and knowledge.

Individuals also consider various internal decision-making factors interacting with IOS and SOS factors. Internal decision-making (DM) factors are, for example, control, norms, values and emotions, which influence deliberate choices (e.g., purchasing an energy-efficient washing machine) and habitual routines (e.g., washing clothes), and ultimately the energy consumption.

A number of the SOS factors are not available in SHEDS. In particular, any analysis of institutions, such as evaluation of existing policies, is beyond the scope of this study. Focusing on factors pertaining to the IOS and DM space, we therefore propose the following hierarchy of determinants:

5. **Socio-demographic factors** related to variables such as income, household type and size, dwelling ownership (tenant/owner) and type (single/multiple family housing), education, nationality, gender and age;
6. **Structural factors** related to location such as dwelling situation (urban/suburban/rural), population density, and access to public amenities;
7. **Technical factors** related to type, quantity, size and efficiency of energy equipment used for heating/cooling, washing/cooking, lighting, communication and entertainment;
8. **Behavioural factors** related to the usage of energy equipment that is driven by life-style, routines and habits as well as psychological factors and environmental attitudes;

9. **Latent or residual factors** include the residual differences that cannot be accounted for by the first four categories.

This general specification has been adapted to each dependent variable and the available data. In particular, we focus on the determinants of demand in the electricity domain. Households are obviously very different along these five dimensions across regions. For instance, incomes tend to be relatively high in Zurich city, so that average behaviours in Zurich city and other regions are expected to be different, although that does not necessarily imply that households with a similar income level in Zurich city and other regions behave differently. Different incomes may in fact be the reason for part of the differences. With non-comparable samples across regions, differences will be incorrectly estimated, which could yield to the formulation of misleading policy conclusions. In order to provide an adequate comparative inference, it is necessary to rely on comparable groups. To this end, we design a strategy borrowed from experimental economics and consider SZH as a "treatment group" which we will compare to other regions KZH, M8, and RCH, which we consider as "control groups".

At the micro-level, the difference between a household from SZH and a household from another region could be due to one or several factors listed above. The first two categories (socio-demographic and structural factors) should not be considered as policy-relevant effects that can be easily addressed by policy intervention. Factors in these two categories should be considered as characteristics that are not perfectly (at least in short-term) under households' control. It is not desirable let alone possible (at least in the short term) to change the socio-demographics and structural factors in a community. However, if socio-demographic or structural differences are discovered, these could be used to tailor interventions to certain groups. On average there might be socio-demographic and structural differences between SZH and other regions. However, overall, people with various demographics live in SZH as well as in other places in Switzerland. There are also neighbourhoods and towns in Switzerland with densities similar to that of Zurich city. Therefore, an adequate research design aiming at identifying Zurich city's effects needs to have a random representation of both SZH sample (treatment group) and other regions (control groups). In other words, the groups should be comparable in all that is not interesting for the analysis. To this end, households in the treatment group (SZH) will be "matched" and compared to their equivalent counterparts (households in control groups) using factors from categories 1 and 2.

In this research, we are therefore particularly interested in categories 3 to 5, which can be addressed by policy in a reasonable time horizon. Both technical and behavioural factors are household choices that can be influenced by adequate policies including incentive-based instruments and nudges. The last category (residual difference) can be attributed to all unobserved factors ranging from cultural differences to differences related to institutional and legal framework. Since, we do not have any cultural factor included in the data, the residual factors might be mainly due to cultural differences. However, the residual factors could also include factors related to institutional and legal framework, only to the extent that these factors do not affect the observed technical and behavioural determinants used in categories 3 and 4.

In a first stage, we thus need to abstract from socio-demographic and structural differences. Namely, we seek a comparability criterion that allows us to identify the differences unrelated to socio-demographics and location. For instance, Zurich city is probably comparable only to large cities. But there are many other variables that could be used for constructing an optimal comparability criterion (matching). Without proper matching, the estimated effects would be subject to a selection bias.

The generic model used in Phase I (dubbed as Model 0 here) includes only year dummies (four years from 2016 to 2019) and group dummies (four groups SZH, KZH, M8 and RCH). Socio-demographic and structural factors, technical factors, and behavioural factors are sequentially integrated in extended models, respectively labelled model 1, 2, and 3. These models can be summarized as follows:

- Model 0: Generic model including only group dummies and year dummies
- Model 1: Model 0 plus socio-demographic characteristics and structural determinants
- Model 2: Model 1 plus technical determinants
- Model 3: Full model, i.e., Model 2 plus behavioural factors

Table 2 lists the explanatory variables included in each model for each of the dependent variables. All models include Model 0 (dummies for years and groups) when applicable. Separate columns are used for the panel data and matching analyses (PSM). The details will be presented in the following subsection. Two qualifications are warranted at this stage: First, we have estimated many alternative models in our preliminary analyses. The final models presented below are the outcome of an iterative process aimed at building models that comply with theory while including as many variables as possible without losing statistical significance beyond a reasonable limit. In particular, in the panel models we exclude meaningful variables only if their effect is statistically insignificant *and* their magnitude is practically negligible. Second, as seen in the table, the PSM models slightly deviate from the panel models. The reason for these deviations resides in the existence of a trade-off between the matching quality and the precision of the estimation of the treatment effect. As our panel results illustrate, some independent variables (covariates) have little explanatory power over the dependent variable (outcome). Including them is therefore unlikely to bring about a reduction in the bias of the potential confounders (see, for instance, Garrido et al. 2014). On the other hand, while the inclusion of additional variables may bring only a minor improvement in matching efficiency, an excessive number of covariates may create multicollinearity and non-convergence, forcing us to exclude some observations from our sample. This problem, which is especially acute when population segments (subsamples) are analysed, can lead to a reduction in precision. Therefore, in each model we exclude potentially irrelevant covariates to focus on covariates that produce best overall matching results.

Table 2: Model specifications in panel and matching analysis.

	Consumption and Bill		**Appliance Efficiency**		**Advice Uptake**		**Knowledge of Elec. Mix**	
	Panel	PSM	Panel	PSM	Panel	PSM	Panel	PSM
Socio-demographic and structural determinants (Model 1)								
Income < CHF 3,000	●	●	●	●	●	●	●	●
Income CHF 3,000-4,499	●	●	●	●	●	●	●	●
Income CHF 4,500-5,999	●	●	●	●	●	●	●	●
Income CHF 6,000-8,999	●	●	●	●	●	●	●	●
Income CHF 9,000-12,000	●	●	●	●	●	●	●	●
Income >12 KCHF	●	●	●	●	●	●	●	●
University Degree	●	●	●	●	●	●	●	●
Number of HH members	●	●	●		●	●	●	
m2/HH member	●	●	●		●		●	
Tenant	●	●	●	●	●	●	●	●
Space heating: electricity	●	●	●		●		●	
Water heating: electricity	●	●	●		●		●	
Space heating: heat pump	●	●	●	●	●		●	
Living in a house	●	●	●		●	●	●	●
Checked bill info	●	●	●		●		●	
ln(Price of 1 kWh)	●				●		●	
Time-of-use tariff	●	●	●	●	●	●	●	●
Man in single person HH	●	●	●	●	●	●	●	●
Woman in single person HH	●	●	●	●	●	●	●	●
Technical determinants (Model 2)								
Number of fridges	●	●	●	●	●		●	
Number of freezers	●	●	●	●	●		●	
Number of TVs	●	●	●		●		●	
Number of computers	●	●	●		●		●	
Number of laptops	●	●	●		●		●	
Number of tablets	●	●	●		●		●	
% of A+++ or A++	●	●			●	●	●	●
>50% renewable elec. mix	●	●	●	●	●	●		
Behavioural determinants (Model 3)								
At least one e-bike	●	●	●	●	●	●	●	●
Electricity saving habits	●	●						
Intention to reduce elec.	●	●	●		●	●	●	●
Intention to reduce carbon	●	●	●		●	●	●	●
Perceived injunctive norms	●		●		●		●	●
Perceived descr. norms	●		●		●		●	●
Personal norms	●		●		●	●	●	●
Energy literacy score	●	●	●	●	●	●	●	●
Trust: SFOE	●	●			●	●		
Trust: local authorities	●	●			●	●		
Trust: local utility	●	●			●	●		
Advice: SFOE	●		●					
Advice: local authorities	●		●					
Advice: local utility	●	●	●					
Usage/week: dishwasher	●	●						
Usage/week: wash. machine	●							
Usage/week: dryer	●							
Usage/week: oven	●							
Switch off frequency (1)	●	●						
Switch off frequency (2)	●	●						
Electricity price future	●		●					

Note: All models include Model 0 (dummies for years and groups) when applicable. Columns "Panel" indicate covariates used in the panel data analyses (Stage 1 as described below). Columns "PSM" indicate covariates used in the matching analyses (Stages 2 and 3). For certain estimations on subsamples in Stage 3, we are not able to use the whole set of covariates due to collinearity problems or due to a lack of variation.

3.2 Econometric models

The econometric analyses are conducted in three stages. Each stage has specific objectives and builds logically on the preceding stage. In the first stage, a regression analysis (random effect panel data model) is used to identify the main determinants for each dependent variable. The objective is threefold. First, the differences between Zurich city and other groups are estimated with a large sample (but without properly accounting for selection issues). Second, the results are used to guide the choice of segmentation variables for the analysis of heterogeneity. Third, and most importantly, the results are used to test the effect of each one of the explanatory factors as estimated in the entire population. These relationships are important for guiding any meaningful policy implication based on matching analyses.

The panel analysis results can in addition be used to identify the importance of each category of variables (structural/socio-demographics, technical, behavioural). However, because of potential selection issues the results are only indicative and cannot be used for a decomposition of the "treatment" effects.

The second stage consists of a matching analysis using the Propensity Score Matching (PSM) approach. This stage represents the core of our analysis. In order to provide adequate comparative inference, it is required that the households in SZH (treatment group) are "matched" and compared with their comparable counterparts in other regions KZH, M8, RCH (control groups). We implement a Propensity Score Matching approach to identify the optimal matching households that can be compared with each household in Zurich city. The "Zurich city" effect is then estimated as the Average Treatment Effect on the Treated (ATET), i.e. the mean of the difference between observed outcomes for the households living in Zurich city and a counterfactual based on similar households in other regions.

The PSM approach has an important advantage in that any household in SZH will be matched with one or several comparable observations hence allowing an estimation of the Zurich effect at the household level. The matching algorithm searches the optimal comparison observation for each household based on a set of specified selection variables. For instance, a high-income household in Zurich city could be compared with a more or less similar household in a comparably large city. Hence, household characteristics such as income and education should be included in the selection variables.

We applied the matching algorithm to identify the closest matching household, as well as the three closest matches. The results are not sensitive to the number of matching households. Therefore, we decided to focus on a single matching (the closest) household approach. The results based on three closest matching households are reported in the Appendix but not discussed in the text. For selection variables, we primarily focus on socio-demographic characteristics and structural factors (Model 1). We then add sequentially the technical and behavioural factors (Models 2 and 3) in order to identify the effects of these factors (items 3, 4 and 5 defined above). The matching analysis is conducted separately for each dependent variable.

Model 1's results are used to estimate the average "Zurich city" effects (ATET) on all SZH households included in the sample. Comparing the effects among Models 1, 2 and 3 allows to decompose the effects between technical, behavioural and residual effects. The results can be directly compared to the effects derived from the panel data models (stage 1) to assess the extent of selection biases in each case.

Stage 3 is dedicated to the estimation of the distribution of heterogeneous treatment effects in a limited number of relevant household profiles (segments) based on segmentation variables. These segments (subsamples) are based on relevant variables (such as income, household type/size and dwelling type/ownership) that are identified in stage 1. The adopted model is a matching model based on socio-demographic and structural factors (PSM Model 1). In each segment, we focus on households who have a reasonably well-matched counterpart in the comparison group. That is, the poorly matched households will be deleted from the analysis. All effects will be tabulated and will be accompanied by their standard errors. The significant differences are used to identify population segments that can be targeted in policy interventions. This is an important part of the analysis because as we will see, some of the effects that are overall insignificant might nonetheless be significant for specific population segments.

The treatment effects may moreover change over the years. To investigate time variations, longitudinal data is necessary. We do have such data for electricity consumption, electricity expenses, and efficiency investment, but not for the other dependent variables (advice uptake and knowledge).[2] From a policy perspective, it is important

[2] In SHEDS, questions regarding advice uptake and knowledge are included only for new respondents, hence not repeated over time. Moreover, our complementary panel analyses show that for SZH households all these variables

to distinguish the persistent effects from those limited to a short period. The available panel data can be used to identify the "treatment" effects by year during the observation period (2016 to 2019). The effects can therefore be classified according to their persistence. While the transient effects might be related to specific events, the persistent effects can be interpreted as systematic effects that could be used for policy revision and improvement. Moreover, estimating the effects over time allows us to identify potential evolution of differences. While in some cases, the small sample size by year could reduce the statistical significance, the general trends can be readily identified for policy conclusions.

With models 2 and 3, the decomposition procedure cannot be implemented for separate population segments because of too small sample size. For the analysis of heterogeneity, we therefore focus on Model 1.

Overall, our econometric modelling strategy can be summarized as follows:

1. **Panel data analysis**: Estimation of random effects panel data Models 0, 1, 2, 3. This analysis aims at:
    a. Testing the significance and the direction of Zurich city (treatment) effects.
    b. Guiding the choice of segmentation variables in stage 3 below.
    c. Testing the relationship (impact) of each explanatory variable on the dependent variables.
    d. In addition, for variables with statistically significant average treatment effects we will use a complete model including technical and behavioural factors. The results will be used to guide the modelling strategy and to refine the specification of variables used in the following stages.

2. **Matching analysis (PSM)**: A propensity score matching approach is used to identify the closest matching household for each SZH households and to estimate the Zurich city effects (ATET) for Models 1, 2 and 3. This analysis aims at:
    a. Identifying the Zurich city effects averaged over all SZH households in the sample, for each dependent variable.
    b. Decomposing these effects into three components related respectively to technical, behavioural and residual factors.
    c. Assessing the extent of selection biases by comparing the results with the indicative findings from panel models.

3. **Analysis of heterogeneous treatment effects (PSM)**: A propensity score matching approach (based on Model 1) is applied to a selection of subsamples (population segments and yearly samples). This analysis aims at:
    a. Identifying policy-relevant population segments in which the treatment effects are meaningful and significant. These groups can be targeted by policy interventions.
    b. Identifying the changes over time in order to distinguish persistent effects from transient differences as well as potential temporal evolutions that could be used for policy conclusions.

4 Results

In this section, we provide the principal findings of our analyses, including relevant graphs and reference to regressions displayed in appendices. We structure this section by domains as follows. We investigate household

are more or less stable over the sample period. That no statistically significant trend is detected with the available data could be related to relatively small and decreasing sample sizes. For instance, for advice uptake, there are only about 120 SZH respondents in 2016, and only about 40 new ones in each of the following years.

electricity consumption in section 4.1, household electricity expenditures in section 4.2, and the efficiency of household electrical appliances in section 4.3. Results regarding the evolution over time of the first three dependent variables is presented in section 4.4. We then return to static analyses and show results on household knowledge of the energy mix in section 4.5, and the advice uptake by households in section 4.6.

4.1 Electricity consumption

Of the four regional groups analysed in this report, the residents of Zurich city (SZH) have the lowest electricity consumption. As shown in Table 20 in the Appendix, SZH households consume on average 2,200 kWh per year, which is about half as much as those in KZH (4,182 kWh/year) and in RCH (4,483 kWh/year). While this urban-rural gap is considerable, the gap between Zurich city and the other major cities in Switzerland (M8) is more limited, with electricity usage only 9% higher in M8 (2,432 kWh/year).

Panel regression models reported in Table 3 confirm these descriptive statistics. The generic model, Model 0, which only controls for variations over time and across regions, reveals that M8 consumption is not statistically different from that of SZH. Differences in electricity consumption with less urbanized groups, while substantial and statistically significant in Model 0, decrease considerably once accounting for socio-economic and structural determinants.

Models 1 to 3 in Table 3 provide some evidence on the sources of differences between groups. From more than 40% in Model 0, the difference between the annual electricity consumption of KZH and RCH compared to SZH falls to just 12-15% in Model 1. This decrease suggests that an important part of the difference is due to the fact that households in urban areas have very different socio-economic and structural characteristics from those in rural areas. Differences in electronic equipment also seem to be an important factor. Indeed, we find that the differences in annual electricity consumption further decreases when adding control variables for the technical determinants (Model 2), to become only 8% (10%) higher in KZH (RCH) than that of SZH. On the other hand, behavioural determinants do not appear to be an important factor, since the differences between groups remain virtually unchanged in Model 3.

The coefficients for the control variables also reveal interesting information. Consistently with our expectations, the size and composition of the household have a significant impact on consumption. An additional member in the household increases consumption by 7 to 10%, while single-male and single-female households consume respectively 16% to 22% and 29% to 35% less than the average multi-person household. The consumption of homeowners and households living in a house is also higher than that of tenants and households living in an apartment.

Table 4 reports the results of the estimation of the treatment effect using the PSM approach, which allows for a deeper consideration of inter-group differences in the control variables than our panel analysis. Although the results are generally consistent, the matching approach suggests that differences in electricity consumption may be less salient than suggested by the panel regressions. The upper part of the table shows the results for the comparison of SZH ("treatment" group) against KZH ("control" group). In this analysis, households in SZH are matched with similar households in KZH in terms of socio-economic characteristics (Model 1). The estimated "treatment effect" is -0.131, implying that households living in Zurich city consume on average 13% less electricity than equivalent households living in other municipalities in the canton. This is very close to the 12% difference obtained from the panel analysis.[3] As in the panel analysis, the treatment effect is no longer statistically significant and falls to about -7% for the model including technical determinants (Model 2).

[3] Note that there is a switch in reference category between the panel analysis and the matching analysis. In the panel analysis, SZH is the reference category, while in the matching analysis, SZH is sequentially compared against each other group, each being in turn considered as the reference category. As a consequence, the sign of the coefficients is to be interpreted in opposite ways in the two analyses. For instance, +0.12 in the panel analysis (first coefficient in Model 1 of Table 3) means that KZH households consume 12% more than SZH households, whereas -0.13 in the matching analysis (first coefficient in Model 1 of Table 4) means that SZH households

Interestingly and in contrast to the panel analysis, we find that the consumption of SZH does not differ significantly from that of other major cities (central part of Table 4) nor from that of the rest of Switzerland (lower part of Table 4) as soon as the socio-economic and technical determinants are accounted for (Model 1). When using M8 as the control group, the "treatment effect" tends to be positive in Models 2 and 3, which would indicate higher consumption in SZH. Note however that these results should be taken with caution due to their relatively low statistical significance (p>5%).

The ATETs in Table 4 are estimated for the population as a whole, hiding potential heterogeneity across different subsets of the population. In order to learn more about the distribution of the treatment effect, we divide the population into two or three segments on the basis of segmentation variables. We then estimate the treatment effect for each segment separately, i.e. focusing only on households who share a similar profile in the treatment and control groups. For the sake of brevity and because of sample size issues, the matching is done only on the basis of the covariates of model 1. The results are shown in Figure 12.

The left panel of Figure 12 compares the city and canton of Zurich. The decomposition of the overall treatment effect (-13%) shows that it is mainly driven by households with high incomes, large size, or with children. More specifically, we find that households with an income of CHF 9,000 or more consume 21.5% less in SZH than their counterparts in KZH. For households with more modest incomes, the difference is small and insignificant. A similar pattern is observed for households with and without children. Concerning the size of the household, we observe a strong heterogeneity: While households with three or more members consume 22% less in SZH than in KZH, the treatment effect is reversed and becomes positive for households with only one member (+20%).

The role of accommodation type and ownership is less clear. The electricity consumption of households living in apartments does not seem to diverge significantly between SZH and KZH, and there are not enough data to determine whether this would be the case for households living in a house. For both owners and tenants, our approach does not identify any significant difference between the city and the canton of Zurich.

Comparing SZH with M8 for each segment separately (right panel of Figure 12) does not reveal important differences in electricity consumption, except for the age of the respondent. Households with persons below 65 appear to consume more in SZH than in other cities, whereas the opposite is true for older households.

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consume 13% less than KZH households. Both coefficients therefore tell a similar story despite being of different signs.

Table 3: Random effect regressions for electricity consumption.

Dependent variable: logqty_ele_tot

	Model 0		Model 1		Model 2		Model 3	
KZH	0.423***	(0.055)	0.123**	(0.049)	0.082	(0.056)	0.084	(0.059)
M8	-0.013	(0.051)	-0.019	(0.047)	-0.074	(0.053)	-0.046	(0.056)
RCH	0.473***	(0.047)	0.145***	(0.043)	0.101**	(0.050)	0.097*	(0.054)
year=2017	-0.030**	(0.013)	-0.052***	(0.016)	-0.052***	(0.019)	-0.049**	(0.021)
year=2018	-0.040***	(0.014)	-0.062***	(0.017)	-0.036*	(0.019)	-0.032	(0.023)
year=2019	-0.049***	(0.014)	-0.083***	(0.016)	-0.065***	(0.018)	-0.064***	(0.021)
Income < CHF 3,000	-		-0.027	(0.052)	0.034	(0.059)	-0.006	(0.062)
Income CHF 3,000-4,499	-		-0.034	(0.039)	0.035	(0.042)	0.038	(0.045)
Income CHF 4,500-5,999	-		-0.043	(0.033)	-0.023	(0.035)	-0.012	(0.038)
Income CHF 6,000-8,999	-		-0.070***	(0.027)	-0.046	(0.029)	-0.036	(0.031)
Income CHF 9,000-12,000	-		-0.054**	(0.023)	-0.034	(0.025)	-0.035	(0.027)
University Degree	-		-0.046**	(0.020)	0.005	(0.021)	-0.012	(0.023)
Number of HH members	-		0.112***	(0.015)	0.091***	(0.012)	0.070***	(0.014)
m2/HH member	-		0.003***	(0.001)	0.002***	(0.001)	0.002***	(0.001)
Tenant	-		-0.238***	(0.029)	-0.180***	(0.031)	-0.196***	(0.033)
Space heating: electricity	-		0.263***	(0.055)	0.287***	(0.057)	0.287***	(0.061)
Water heating: electricity	-		0.208***	(0.025)	0.224***	(0.027)	0.218***	(0.029)
Space heating: heat pump	-		0.235***	(0.029)	0.242***	(0.031)	0.208***	(0.033)
Living in a house	-		0.392***	(0.031)	0.370***	(0.032)	0.390***	(0.035)
Checked bill info	-		0.009	(0.024)	0.009	(0.026)	0.007	(0.029)
ln(Price of 1 kWh)	-		0.006	(0.023)	-0.022	(0.026)	0.002	(0.028)
Time-of-use tariff	-		0.142***	(0.025)	0.136***	(0.027)	0.124***	(0.029)
Man in single person HH	-		-0.220***	(0.042)	-0.161***	(0.044)	-0.159***	(0.045)
Woman in single person HH	-		-0.353***	(0.037)	-0.301***	(0.041)	-0.292***	(0.046)
Number of fridges	-		-		0.080***	(0.025)	0.056**	(0.028)
Number of freezers	-		-		0.100***	(0.017)	0.091***	(0.018)
Number of TVs	-		-		0.074***	(0.014)	0.066***	(0.015)
Number of computers	-		-		0.065***	(0.012)	0.064***	(0.014)
Number of laptops	-		-		-0.012	(0.009)	-0.008	(0.010)
Number of tablets	-		-		0.025**	(0.011)	0.007	(0.012)
Share of A+++ or A++	-		-		0.016	(0.026)	0.018	(0.028)
>50% renewable elec. mix	-		-		-0.023	(0.018)	-0.018	(0.020)
At least one e-bike	-		-		-		0.040	(0.026)
Electricity saving habits	-		-		-		0.000	(0.010)
Intention to reduce elec.	-		-		-		0.013	(0.009)
Intention to reduce carbon	-		-		-		-0.009	(0.010)
Perceived injunctive norms	-		-		-		-0.008	(0.011)
Perceived descr. norms	-		-		-		-0.002	(0.010)
Personal norms	-		-		-		0.008	(0.010)
Energy literacy score	-		-		-		0.003	(0.013)
Trust: SFOE	-		-		-		-0.011	(0.019)
Trust: local authorities	-		-		-		-0.058**	(0.023)
Trust: local utility	-		-		-		0.039**	(0.019)
Advice: SFOE	-		-		-		0.007	(0.026)
Advice: local authorities	-		-		-		-0.046	(0.036)
Advice: local utility	-		-		-		0.067**	(0.028)
Usage/week: dishwasher	-		-		-		0.014***	(0.005)
Usage/week: wash. machine	-		-		-		0.004	(0.006)
Usage/week: dryer	-		-		-		0.015*	(0.008)
Usage/week: oven	-		-		-		0.016***	(0.005)
Switch off frequency (1)	-		-		-		-0.035*	(0.018)
Switch off frequency (2)	-		-		-		-0.039**	(0.016)
Electricity price future	-		-		-		0.022	(0.015)
Random effects	Yes		Yes		Yes		Yes	
N	7,881		5,878		4,506		3,747	
R^2	0.0733		0.4896		0.5167		0.5424	

Robust standard error in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

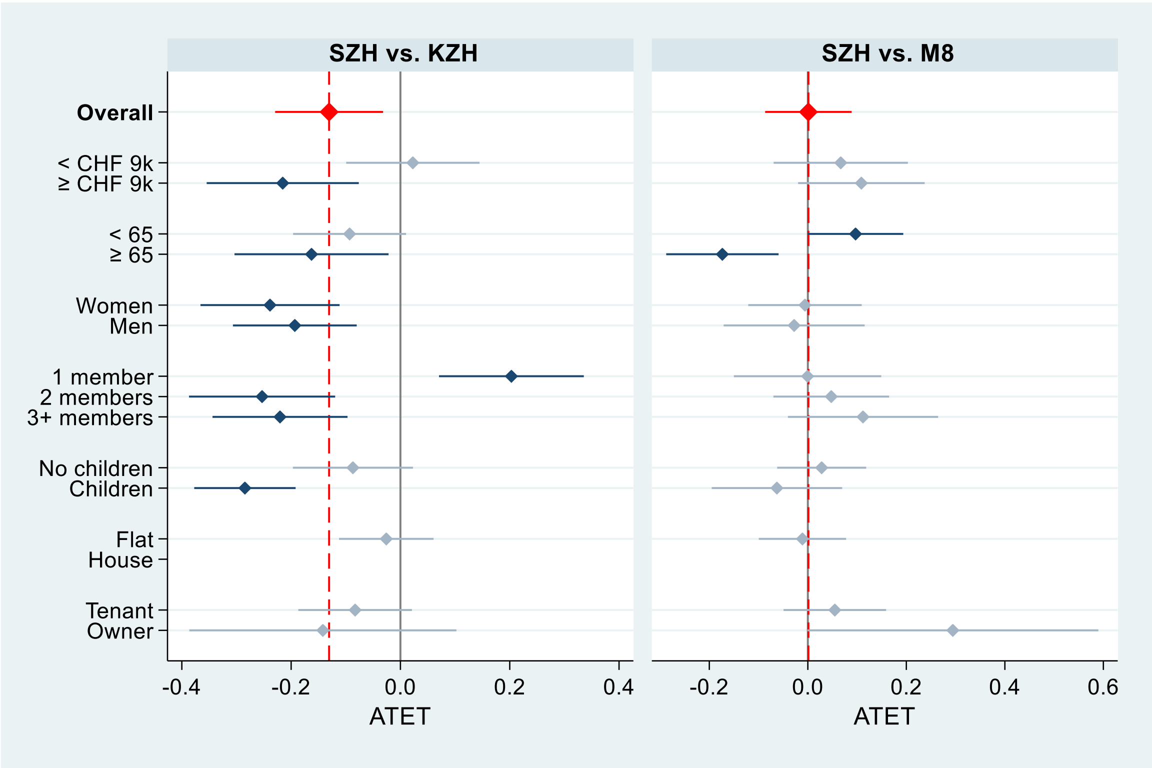
Table 4: ATET for electricity consumption.

Outcome variable: logqty_ele_tot

	Model 1	Model 2	Model 3
ATET			
SZH vs. KZH	-0.131**	-0.070	0.011
	(0.060)	(0.055)	(0.069)
N (Total sample size)	1,090	842	712
N (Treated obs.)	301	231	192
N (Matched controls)	194	133	95
ATET			
SZH vs. M8	0.001	0.100*	0.132*
	(0.053)	(0.059)	(0.072)
N (Total sample size)	1,122	857	734
N (Treated obs.)	301	231	192
N (Matched controls)	205	155	121
ATET			
SZH vs. RCH	-0.075	0.001	-0.040
	(0.048)	(0.058)	(0.066)
N (Total sample size)	4,268	3,269	2,767
N (Treated obs.)	301	231	192
N (Matched controls)	267	175	144

Robust Abadie-Imbens standard error in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1

Figure 12: ATET for electricity consumption, by population segment.



Note: This figure plots the average treatment effect on the treated (ATET) for different population segments. Whiskers represent 90% confidence intervals. Statistically significant differences (p<0.1) are displayed in dark colours, insignificant treatment effects in light. The complete estimation results are provided in Table 21 of the Appendix.

4.2 Electricity bill

We complete our analysis of electricity consumption by looking at household expenditures on electricity, measured in CHF per year. Provided that respondents have provided accurate amounts and that the price per kilowatt-hour is comparable between groups, we should obtain results similar to those based on quantity (section 4.1). Yet, the results show some discrepancies especially regarding differences between SZH and M8.

Table 5 reports the results of the panel analysis. As with the quantity of electricity consumed, we observe for the generic model that expenditures are lower in SZH than in the more rural groups (both KZH and RCH). While similar patterns of reduction appear in expenditure differences between SZH and KZH (compare results in Table 5 with those in Table 3), the differences are lower in magnitude and less significant, from 6% in Model 1 to 4% in Model 2. The lower magnitude of differences could be explained by the fact that KZH households benefit from slightly lower average prices (23.6 c/kWh) compared to SZH (25.2 c/kWh).

Surprisingly, however, household expenditures on electricity in SZH are also lower than in M8, although to a lesser extent than in KZH and RCH. Moreover, this difference between urban groups still exists in Models 1 and 2, while the coefficient for the dummy variable KZH becomes statistically significant. The estimates of the ATETs using the matching analysis, which are reported in Table 6, provide similar results. This difference between urban groups, which does not appear in our analyses of the quantity of electricity consumed, could be explained by a lower price per kilowatt-hour in SZH than in M8. The data available to us, however, invalidate this hypothesis and suggest instead that the expenditure data may be unreliable.

The estimated difference between SZH and M8 shows some discrepancy according to whether we look at expenditures or quantity. While results show little difference (insignificant and small coefficient) in quantity, they suggest a higher average expenditure for M8 (about 17% difference). However, when we focus on respondents who have checked their bills (about 61% of the sample), the average SZH-M8 gap falls to half the difference estimated with all respondents (to about 8%). This is in contrast with all other group coefficients that are more or less stable whether we focus on respondents who check their bill.

Higher average bill in SZH with more or less same average consumption, might suggest that SZH has a lower electricity price. Yet, price data publicly available from Elcom indicate the opposite. Namely, prices are on average higher in SZH (25.2 c/kWh on average) compared to M8 (21.5 c/kWh). Our investigations (details reported in Appendix) suggest indeed that the self-reported electricity prices available in SHEDS show a significant discrepancy as compared to Elcom prices. This might indicate that respondents do have difficulties in reporting exact prices out of their electricity bills. This might be due to the bill's complexity and the presence of multiple items composing the overall price of one kWh (electricity, distribution as well as various emoluments and taxes). Similar arguments could apply to annual expenditure data. In fact, respondents might have mistakenly used their intermediate bills that are generally estimates based on previous years. Given these issues, we focus on quantity data. As for consumption data, these sources of error are non-existent or less prevalent because the number of kWh consumed is reported solely in the final bill. This number is commonly based on a single reading or is estimated based on previous readings, hence a good approximation of the consumption quantities.

Random reporting errors exist in both reported variables (consumption and expenditure). However, we contend that the variation in taxes in different service areas could create artificial but systematic differences across different groups, thus biasing our estimated expenditure differences. These differences are likely to be relatively important in the M8 group that combines 8 different cities with as many utilities with different billing practices. On the other hand, given the relatively uniform manner of reporting total kWh across Switzerland, the reporting kWh errors should be mainly limited to random errors (noise) rather than systematic biases across different regions.

While recognizing the need for potentially more precise data from utilities, we point out that the main results regarding differences between SZH and KZH are more or less confirmed with bill data. Moreover, the general consistency of effects of various household characteristics between regressions with the two dependent variables (compare results in Table 5 with those in Table 3) suggests that the reporting errors do not create biases in estimated relationships. However, in our analysis the regional differences especially in the M8 group could bias the estimated SZH-M8 differences that could explain our somewhat inconsistent results. Given the observed discrepancy between quantity and expenditures for these differences, we do not present here the estimate of ATETs by population segments. For information purposes, the results of the heterogeneity analysis are nevertheless available upon request.

Table 5: Random effect regressions for electricity bill.

Dependent variable: logbil_ele_tot

	Model 0		Model 1		Model 2		Model 3	
KZH	0.354***	(0.040)	0.063	(0.044)	0.045	(0.049)	0.049	(0.053)
M8	0.167***	(0.037)	0.143***	(0.042)	0.121**	(0.047)	0.083	(0.052)
RCH	0.545***	(0.033)	0.220***	(0.038)	0.176***	(0.044)	0.146***	(0.048)
year=2017	-0.014	(0.013)	-0.017	(0.016)	-0.010	(0.019)	-0.007	(0.021)
year=2018	-0.090***	(0.013)	-0.091***	(0.016)	-0.072***	(0.018)	-0.065***	(0.022)
year=2019	-0.075***	(0.014)	-0.087***	(0.016)	-0.069***	(0.019)	-0.064***	(0.022)
Income < CHF 3,000	-		-0.126***	(0.044)	-0.061	(0.052)	-0.052	(0.057)
Income CHF 3,000-4,499	-		-0.038	(0.031)	0.002	(0.036)	0.017	(0.040)
Income CHF 4,500-5,999	-		-0.090***	(0.028)	-0.068**	(0.032)	-0.066*	(0.035)
Income CHF 6,000-8,999	-		-0.065***	(0.023)	-0.021	(0.025)	-0.017	(0.028)
Income CHF 9,000-12,000	-		-0.027	(0.021)	-0.006	(0.024)	0.004	(0.026)
University Degree	-		-0.068***	(0.017)	-0.029	(0.019)	-0.041*	(0.021)
Number of HH members	-		0.116***	(0.010)	0.085***	(0.011)	0.062***	(0.013)
m2/HH member	-		0.003***	(0.000)	0.002***	(0.000)	0.002***	(0.001)
Tenant	-		-0.218***	(0.023)	-0.162***	(0.025)	-0.139***	(0.027)
Space heating: electricity	-		0.159***	(0.038)	0.217***	(0.044)	0.216***	(0.047)
Water heating: electricity	-		0.191***	(0.020)	0.197***	(0.021)	0.189***	(0.024)
Space heating: heat pump	-		0.184***	(0.023)	0.204***	(0.025)	0.192***	(0.027)
Living in a house	-		0.314***	(0.022)	0.288***	(0.025)	0.303***	(0.027)
Checked bill info	-		-0.043***	(0.015)	-0.051***	(0.018)	-0.057***	(0.020)
ln(Price of 1 kWh)	-		0.029	(0.019)	0.039*	(0.023)	0.049*	(0.025)
Time-of-use tariff	-		0.061***	(0.021)	0.043*	(0.025)	0.033	(0.027)
Man in single person HH	-		-0.217***	(0.033)	-0.191***	(0.037)	-0.177***	(0.039)
Woman in single person HH	-		-0.310***	(0.031)	-0.245***	(0.035)	-0.241***	(0.039)
Number of fridges	-		-		0.059***	(0.021)	0.032	(0.023)
Number of freezers	-		-		0.085***	(0.014)	0.080***	(0.016)
Number of TVs	-		-		0.071***	(0.012)	0.063***	(0.013)
Number of computers	-		-		0.080***	(0.011)	0.075***	(0.012)
Number of laptops	-		-		-0.004	(0.009)	-0.011	(0.010)
Number of tablets	-		-		0.036***	(0.010)	0.033***	(0.011)
Share of A+++ or A++	-		-		0.018	(0.025)	0.029	(0.027)
>50% renewable elec. mix	-		-		-0.040**	(0.019)	-0.042**	(0.021)
At least one e-bike	-		-		-		0.043*	(0.024)
Electricity saving habits	-		-		-		-0.025***	(0.009)
Intention to reduce elec.	-		-		-		0.031***	(0.008)
Intention to reduce carbon	-		-		-		-0.013	(0.009)
Perceived injunctive norms	-		-		-		0.012	(0.011)
Perceived descr. norms	-		-		-		-0.010	(0.010)
Personal norms	-		-		-		-0.002	(0.010)
Energy literacy score	-		-		-		-0.010	(0.011)
Trust: SFOE	-		-		-		-0.005	(0.016)
Trust: local authorities	-		-		-		-0.011	(0.017)
Trust: local utility	-		-		-		0.012	(0.015)
Advice: SFOE	-		-		-		-0.026	(0.023)
Advice: local authorities	-		-		-		0.019	(0.032)
Advice: local utility	-		-		-		0.066***	(0.024)
Usage/week: dishwasher	-		-		-		0.010**	(0.005)
Usage/week: wash. machine	-		-		-		0.017***	(0.005)
Usage/week: dryer	-		-		-		0.011*	(0.006)
Usage/week: oven	-		-		-		0.002	(0.005)
Switch off frequency (1)	-		-		-		-0.042**	(0.017)
Switch off frequency (2)	-		-		-		-0.019	(0.016)
Electricity price future	-		-		-		0.022	(0.013)
Random effects	Yes		Yes		Yes		Yes	
N	14,763		9,866		7,300		6,050	
R^2	0.0555		0.3525		0.3734		0.3855	

Robust standard error in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1

Table 6: ATET for electricity bill.

Outcome variable: logbil_ele_tot

	Model 1	Model 2	Model 3
ATET			
SZH vs. KZH	-0.040	0.013	-0.031
	(0.049)	(0.054)	(0.082)
N (Total sample size)	1,801	1,356	1,135
N (Treated obs.)	535	392	319
N (Matched controls)	357	244	191
ATET			
SZH vs. M8	-0.081*	-0.139**	-0.092
	(0.044)	(0.055)	(0.061)
N (Total sample size)	1,976	1,454	1,244
N (Treated obs.)	535	392	319
N (Matched controls)	387	266	198
ATET			
SZH vs. RCH	-0.211***	-0.186***	-0.151***
	(0.042)	(0.055)	(0.052)
N (Total sample size)	7,159	5,274	4,460
N (Treated obs.)	535	392	319
N (Matched controls)	487	317	238

Robust Abadie-Imbens standard error in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

4.3 Efficiency of electrical appliances

As reported in Table 20 in the Appendix and illustrated in Figure 13, the share of electrical appliances with an A+++ or A++ efficiency label are relatively close across regions. KZH appears to have the largest share of highly efficient electrical appliances (67%), followed by RCH (64%), SZH (62%) and finally M8 (61%).

The 1st-stage analysis (random effect panel models 0, 1, 2, and 3) is summarized in Table 7. While Model 0 points to a statistically significant difference of 3.5 percentage points (a higher percentage of efficient appliances in SZH), the difference becomes insignificant when including socio-economic and structural covariates (Model 1). The point estimate of the difference remains however, around 3 to 4 percentage points. Regarding the other groups, M8 and RCH, the panel data regressions for all models do not indicate any significant differences in appliance efficiency. Hence, the panel analysis does not provide any information except that there is prevalent heterogeneity among households. A matching analysis is therefore required to draw any adequate conclusion about the genuine differences between comparable households across regions.

The results displayed in Table 7 nevertheless provide some additional interesting information on the determinants of the efficiency of electrical appliances. For instance, households heating their homes with a heat pump appear to have a higher share of efficient appliances. This share is also higher among households having (subscribed) to electricity tariffs varying according to the time of day (generally lower night tariffs as opposed to day-time prices). Noting the relatively high cost of renewable electricity and high consumption of heat pumps, we can expect higher electricity costs in these households. Therefore, these findings point to a self-selection pattern with cost-conscious households and intensive electricity users opting for greater efficiency. Finally subscribing to an energy mix composed of at least 50% renewable energy has an increasing effect on efficiency suggesting that cost-intensive consumers (due to higher price of renewable electricity) are more likely to opt for efficiency investments. More importantly, this latter finding shows that there is no evidence of a "behavioural rebound" effect inducing renewable users to go low on efficiency. Overall, we can therefore conclude that efficiency is a relevant policy instrument that can be effective in reducing consumption without any undesired effect on the number of equipment.

Moreover, higher efficiency could be associated with higher demand for renewables. Last not least, cost-saving incentives play an important role in households' decisions regarding efficiency investments.

Table 8 assesses the differences in appliance efficiency using the matching approach (2nd-stage analysis). Consistently with the panel analysis, we do not find any statistically significant treatment effects when comparing SZH with M8 or RCH. However, we find that households in the city of Zurich have a lower share of highly efficient appliances than their equivalent counterparts living in the other municipalities in the canton of Zurich. The difference amounts to 4-5 percentage points in models 1 and 2, but decreases and becomes insignificant in model 3. The fact that the difference between SZH and KZH disappears when the last block of determinants is considered in the matching process indicates that households behave differently in the two regions.

Interestingly, with the inclusion of technical determinants (e.g. number of appliances), the difference in appliance efficiency remains more or less the same (compare models 1 and 2 in Table 8) which is consistent with our panel data results (Table 7) showing no evidence of higher average efficiency for households with more appliances. With only one exception (freezers), the number of appliances shows no significant correlation on the aggregate measure of appliance efficiency. This finding implies that the greater aggregate efficiency in KZH is not associated with more appliances in that group, suggesting that appliance efficiency is a relevant policy variable for SZH and interventions aiming at raising efficiency could lead to no indirect rebound effect via increasing the number of appliances.

While overall "treatment effects" are either modest or non-existent, decomposing them by population segment allows to uncover significant differences for some specific household profiles. The results of this 3rd-stage analysis are provided in Figure 14. We observe, in particular, that the lower proportion of efficient appliances in SZH compared to KZH is mainly attributable to low-income households, with three or more members, and living in an apartment. Regarding the comparison of SZH and M8, we note that a statistically significant difference ($p<10\%$) exists once we focus on households of one person, owning their home, whose respondent is of retirement age or is a woman. For each of these segments, appliance efficiency is lower in the city of Zurich than in the other eight major cities of Switzerland.

While showing a strong heterogeneity in efficiency differences across various population segments, the findings illustrated in Figure 14 point to several "low-hanging fruits", that is, groups that can be targeted and prioritized in policy interventions. In particular, we can underscore two groups that could show a great potential for interventions. These groups are low-income families and house-owners.

Figure 13: Energy label of devices owned.

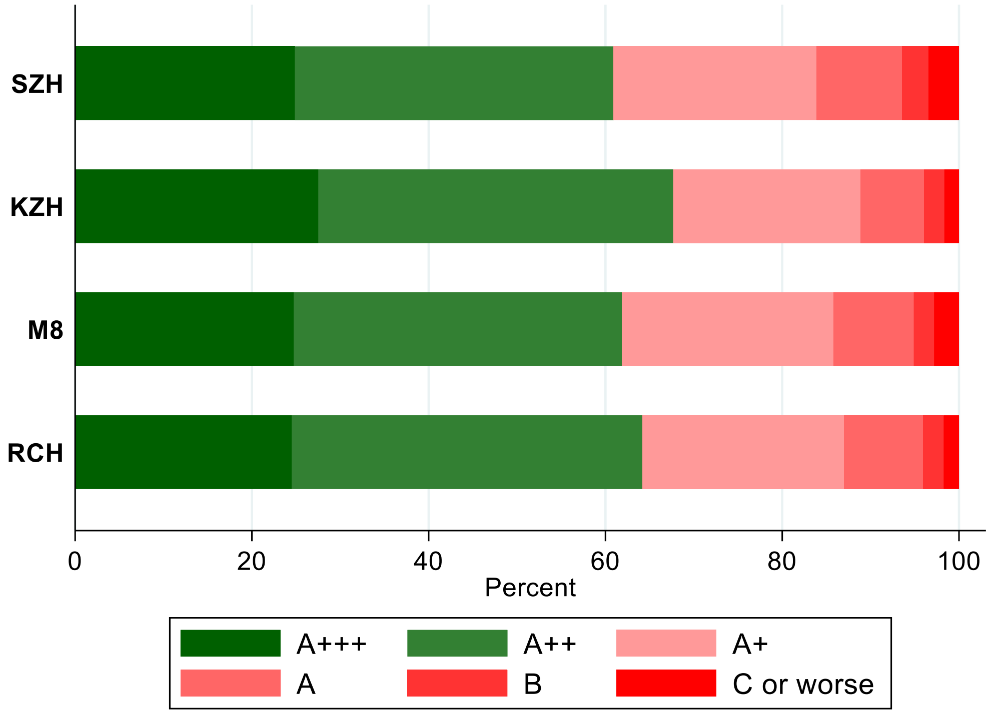


Table 7: Random effect regressions for appliances efficiency.

Dependent variable: elecEffi

	Model 0		Model 1		Model 2		Model 3	
KZH	0.035*	(0.020)	0.033	(0.027)	0.041	(0.027)	0.046	(0.028)
M8	-0.026	(0.019)	-0.002	(0.027)	0.010	(0.028)	0.012	(0.028)
RCH	0.003	(0.017)	-0.004	(0.024)	0.003	(0.025)	0.006	(0.026)
year=2017	-0.024***	(0.007)	-0.018*	(0.010)	-0.019*	(0.010)	-0.022**	(0.011)
year=2018	0.050***	(0.008)	0.057***	(0.010)	0.055***	(0.010)	0.047***	(0.011)
year=2019	0.023***	(0.008)	0.027***	(0.010)	0.027***	(0.010)	0.018	(0.011)
Income < CHF 3,000	-		-0.012	(0.026)	-0.021	(0.027)	-0.020	(0.027)
Income CHF 3,000-4,499	-		-0.023	(0.019)	-0.033	(0.020)	-0.038*	(0.021)
Income CHF 4,500-5,999	-		-0.028*	(0.016)	-0.033*	(0.017)	-0.034*	(0.017)
Income CHF 6,000-8,999	-		-0.005	(0.013)	-0.005	(0.014)	-0.005	(0.014)
Income CHF 9,000-12,000	-		-0.010	(0.012)	-0.012	(0.013)	-0.011	(0.013)
University Degree	-		-0.019*	(0.010)	-0.013	(0.010)	-0.008	(0.011)
Number of HH members	-		-0.000	(0.005)	-0.000	(0.006)	-0.002	(0.006)
m2/HH member	-		0.000**	(0.000)	0.000*	(0.000)	0.000	(0.000)
Tenant	-		-0.046***	(0.012)	-0.048***	(0.013)	-0.045***	(0.013)
Space heating: electricity	-		-0.004	(0.019)	-0.001	(0.020)	-0.006	(0.021)
Water heating: electricity	-		-0.014	(0.012)	-0.014	(0.012)	-0.014	(0.012)
Space heating: heat pump	-		0.021*	(0.012)	0.029**	(0.013)	0.029**	(0.013)
Living in a house	-		-0.003	(0.012)	-0.010	(0.013)	-0.005	(0.013)
Checked bill info	-		-0.004	(0.009)	-0.004	(0.009)	-0.005	(0.009)
Time-of-use tariff	-		0.026**	(0.012)	0.025*	(0.013)	0.022*	(0.013)
Man in single person HH	-		-0.048***	(0.018)	-0.047**	(0.019)	-0.041**	(0.019)
Woman in single person HH	-		-0.007	(0.018)	-0.006	(0.020)	-0.006	(0.020)
Number of fridges	-		-		0.013	(0.011)	0.016	(0.011)
Number of freezers	-		-		0.023***	(0.008)	0.022***	(0.008)
Number of TVs	-		-		-0.005	(0.007)	-0.007	(0.007)
Number of computers	-		-		0.003	(0.006)	0.003	(0.006)
Number of laptops	-		-		-0.008	(0.005)	-0.009*	(0.005)
Number of tablets	-		-		-0.003	(0.005)	-0.002	(0.005)
>50% renewable elec. mix	-		-		0.025**	(0.010)	0.025**	(0.010)
At least one e-bike	-		-		-		0.020*	(0.012)
Intention to reduce elec.	-		-		-		-0.008*	(0.004)
Intention to reduce carbon	-		-		-		0.008*	(0.005)
Perceived injunctive norms	-		-		-		0.006	(0.005)
Perceived descr. norms	-		-		-		0.003	(0.005)
Personal norms	-		-		-		0.008	(0.005)
Energy literacy score	-		-		-		-0.016***	(0.005)
Advice: SFOE	-		-		-		-0.002	(0.011)
Advice: local authorities	-		-		-		-0.002	(0.016)
Advice: local utility	-		-		-		-0.007	(0.012)
Electricity price future	-		-		-		0.002	(0.006)
Random effects	Yes		Yes		Yes		Yes	
N	14,799		9,066		8,207		7,964	
R^2	0.0062		0.0193		0.0250		0.0303	

Robust standard error in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1

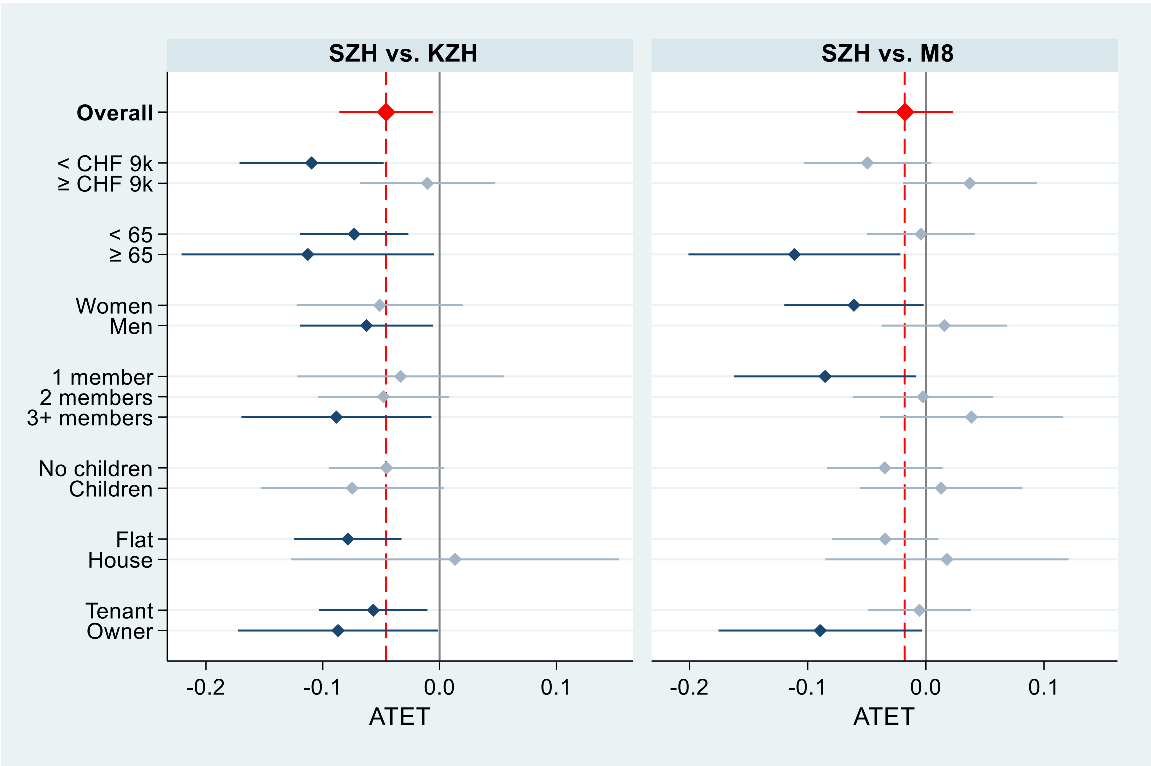
Table 8: ATET for appliances efficiency.

Outcome variable: elecEffi

	Model 1	Model 2	Model 3
ATET			
SZH vs. KZH	-0.046*	-0.053*	-0.028
	(0.024)	(0.031)	(0.031)
N (Total sample size)	1,686	1,578	1,578
N (Treated obs.)	478	456	456
N (Matched controls)	842	454	340
ATET			
SZH vs. M8	-0.018	-0.039	-0.026
	(0.025)	(0.029)	(0.029)
N (Total sample size)	1,872	1,726	1,726
N (Treated obs.)	478	456	456
N (Matched controls)	946	517	382
ATET			
SZH vs. RCH	-0.009	-0.009	-0.019
	(0.021)	(0.025)	(0.029)
N (Total sample size)	7,125	6,322	6,322
N (Treated obs.)	478	456	456
N (Matched controls)	4,012	1,527	665

Robust Abadie-Imbens standard error in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1

Figure 14: ATET for appliances efficiency, by population segment.



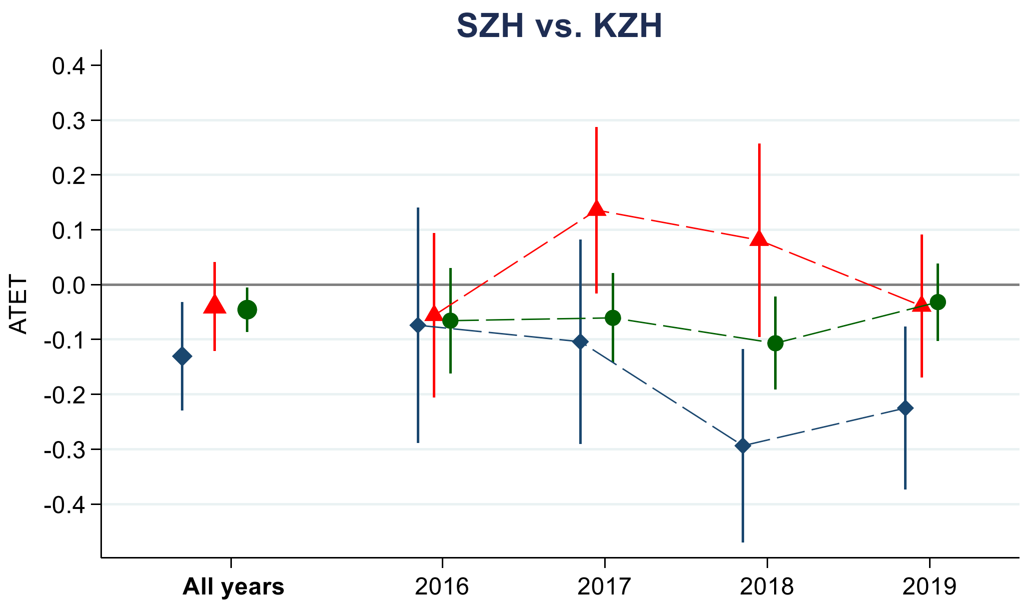
Note: This figure plots the average treatment effect on the treated (ATET) for different population segments. Whiskers represent 90% confidence intervals. Statistically significant differences (p<0.1) are displayed in dark colours, insignificant treatment effects in light. The complete estimation results are provided in Table 22 of the Appendix.

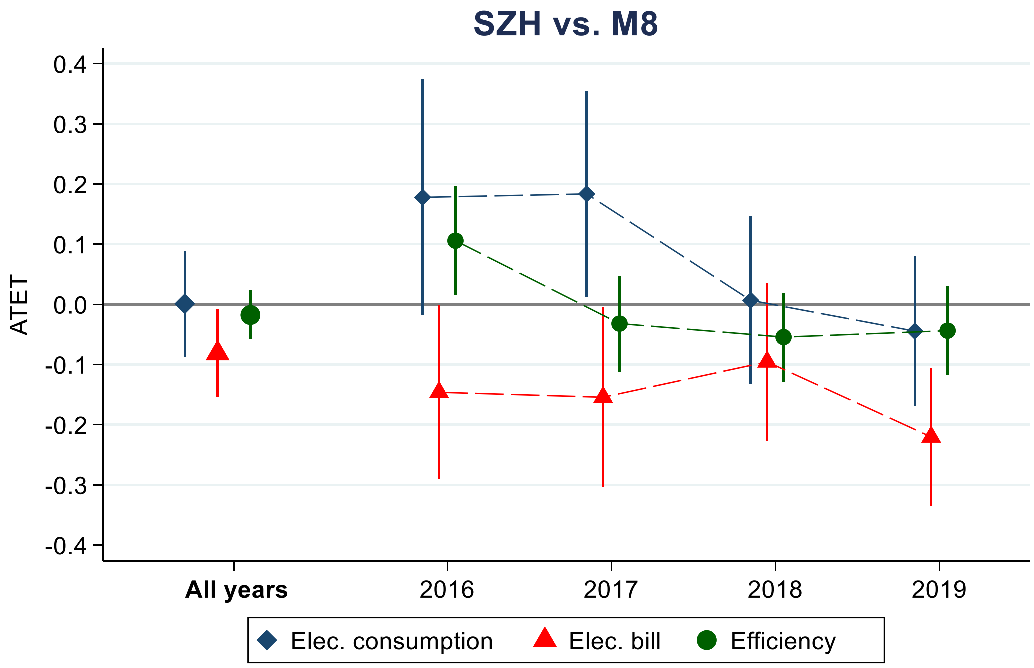
4.4 Evolution over time

SHEDS respondents are recontacted year after year. This makes it possible to collect the same information from the same persons multiple times, hence giving rise to a longitudinal dataset. This is in particular the case for electricity consumption, electricity expenditures, and appliances efficiency, which were already analysed in sections 4.1, 4.2, and 4.3. For these variables, we are thus able to conduct a longitudinal analysis, in which we estimate the evolution of the treatment effects over the years.

Figure 15 shows the results, with the overall results displayed on the left ("All years") and year-specific results on the right of the graphs. Even though no clear patterns emerge for electricity expenses or appliance efficiency, a very interesting trend appears for electricity consumption. While the overall estimate indicates that SZH households consume 13% less electricity than KZH households, the difference was much lower (and insignificant) in 2016-2017 and became large and significant since 2018. In the last two years of the observation period, the difference between SZH and RZH is larger than 20% and it almost reached 30% in 2018. A relative decline of SZH consumption is also observed in comparison with M8 consumption. Even though the overall difference is negligible between these two groups, a positive (and slightly significant) difference was observed in 2016-2017. In 2018, the difference disappeared and SZH households now appear to consume no more than M8 households (if not less).

Figure 15: ATET for electricity consumption, electricity expenditures and appliances efficiency, by year





Note: Whiskers represent 90% confidence intervals.

4.5 Knowledge of electricity mix

SHEDS respondents are asked to state whether the electricity they are consuming at home encompasses at least 50% of renewable energy. We rely on this information to investigate households' knowledge regarding their electricity mix. Specifically, we focus on households living in the cities of Zurich, Geneva, and Basel (M2), because all three cities obtain 100% renewable energy, hence all respondents should indeed indicate that their electricity mix is composed of renewable energy. If they fail to do so, we can safely interpret their answer as revealing a lack of knowledge regarding their electricity mix. It is important to note that we cannot extend this subsample to other municipalities or cantons whose major power source is renewable, because virtually in all these cases, even if a small part of the power is non-renewable, the consumers could opt for non-renewable electricity.

Results presented in Figure 16 and Table 9 reveal that SZH inhabitants are more knowledgeable about their energy supply being 100% renewable than inhabitants from Geneva and Basel (M2), with 66% of SZH inhabitants knowing this fact compared to 57% in M2. This difference is however only significant in model 1 (social demographic and structural factors) in the panel analysis.

Panel results further show that those who have space heating and those in the higher income classes are more likely to know that their energy mix is 100% renewable (reference category for income is the group above CHF 12,000). However, people with higher personal norms, i.e. personal convictions to behave environmentally friendly and higher energy literacy are more likely to know that their energy mix is 100% renewable.

In the matching analysis (Table 10), the difference between SZH and M2 inhabitants related to knowledge is only significant for model 2 (technical factors) compared to results of the panel analysis.

Heterogeneity analysis (Figure 17) further reveals that retired SZH inhabitants (> 65 years) and those households without children are more likely to know that their energy mix is 100% renewable than matched households in M2. Furthermore, SZH inhabitants living in a flat and SZH tenants are also more likely to know this fact about their electricity mix than similar households in M2.

Figure 16: Knowledge of 100% renewable electricity mix.

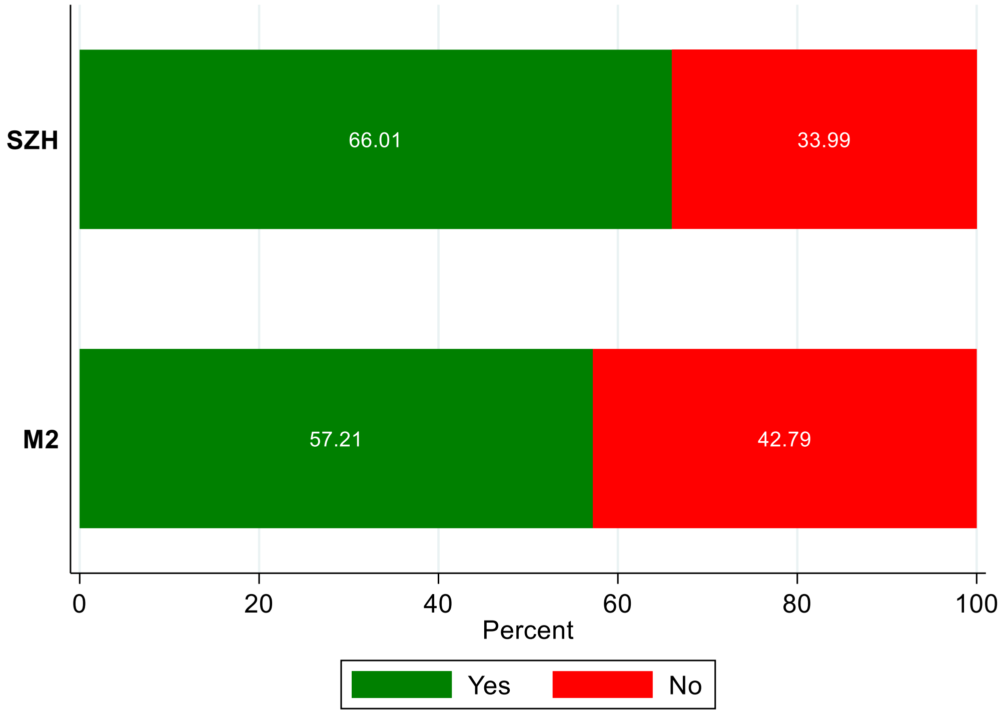


Table 9: Random effect regressions for knowledge of the electricity mix (0/1).

Dependent variable: elecRenMixKno

	Model 0		Model 1		Model 2		Model 3	
M2	-0.108***	(0.035)	-0.013	(0.049)	-0.035	(0.051)	-0.042	(0.050)
year=2017	0.000	(.)	0.000	(.)	0.000	(.)	0.000	(.)
year=2018	0.046*	(0.027)	0.032	(0.035)	0.024	(0.043)	0.015	(0.043)
year=2019	0.053**	(0.027)	0.045	(0.035)	0.052	(0.041)	0.034	(0.042)
Income < CHF 3,000	-		-0.121	(0.096)	-0.140	(0.123)	-0.066	(0.123)
Income CHF 3,000-4,499	-		-0.155*	(0.083)	-0.117	(0.092)	-0.124	(0.093)
Income CHF 4,500-5,999	-		-0.119*	(0.069)	-0.081	(0.072)	-0.077	(0.073)
Income CHF 6,000-8,999	-		-0.081	(0.056)	-0.066	(0.060)	-0.072	(0.059)
Income CHF 9,000-12,000	-		-0.099*	(0.053)	-0.141**	(0.061)	-0.129**	(0.059)
University Degree	-		-0.045	(0.044)	-0.001	(0.050)	-0.014	(0.049)
Number of HH members	-		-0.015	(0.032)	-0.019	(0.034)	-0.009	(0.029)
m2/HH member	-		-0.000	(0.001)	-0.000	(0.001)	-0.000	(0.001)
Tenant	-		0.020	(0.070)	0.054	(0.073)	0.087	(0.071)
Space heating: electricity	-		-0.203*	(0.107)	-0.237**	(0.105)	-0.214**	(0.106)
Water heating: electricity	-		0.079	(0.057)	0.094	(0.065)	0.071	(0.066)
Space heating: heat pump	-		0.079	(0.072)	0.036	(0.079)	0.041	(0.078)
Living in a house	-		-0.065	(0.066)	-0.093	(0.072)	-0.079	(0.072)
Checked bill info	-		0.053	(0.037)	0.079*	(0.044)	0.073*	(0.044)
ln(Price of 1 kWh)	-		0.046	(0.040)	0.042	(0.046)	0.037	(0.044)
Time-of-use tariff	-		-0.004	(0.061)	0.002	(0.068)	-0.034	(0.065)
Man in single person HH	-		-0.047	(0.091)	-0.026	(0.094)	-0.020	(0.090)
Woman in single person HH	-		-0.020	(0.081)	0.022	(0.090)	0.056	(0.085)
Number of fridges	-		-		-0.146**	(0.069)	-0.143**	(0.065)
Number of freezers	-		-		0.118***	(0.035)	0.123***	(0.034)
Number of TVs	-		-		-0.041	(0.038)	-0.031	(0.037)
Number of computers	-		-		0.026	(0.031)	0.038	(0.032)
Number of laptops	-		-		0.017	(0.023)	0.012	(0.023)
Number of tablets	-		-		0.033	(0.027)	0.038	(0.026)
Share of A+++ or A++	-		-		0.074	(0.056)	0.055	(0.056)
At least one e-bike	-		-		-		-0.094	(0.066)
Intention to reduce elec.	-		-		-		0.004	(0.020)
Intention to reduce carbon	-		-		-		0.014	(0.019)
Perceived injunctive norms	-		-		-		0.023	(0.025)
Perceived descr. norms	-		-		-		0.025	(0.024)
Personal norms	-		-		-		0.042*	(0.025)
Energy literacy score	-		-		-		0.063***	(0.022)
Random effects	Yes		Yes		Yes		Yes	
N	1,167		705		555		555	
R^2	0.0113		0.0471		0.0953		0.1501	

Robust standard error in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1
Note: These regressions are done only on Zurich city, Basel city and Geneva city (M2). The dummy variable "M2" therefore only includes Geneva city and Basel city (M2).

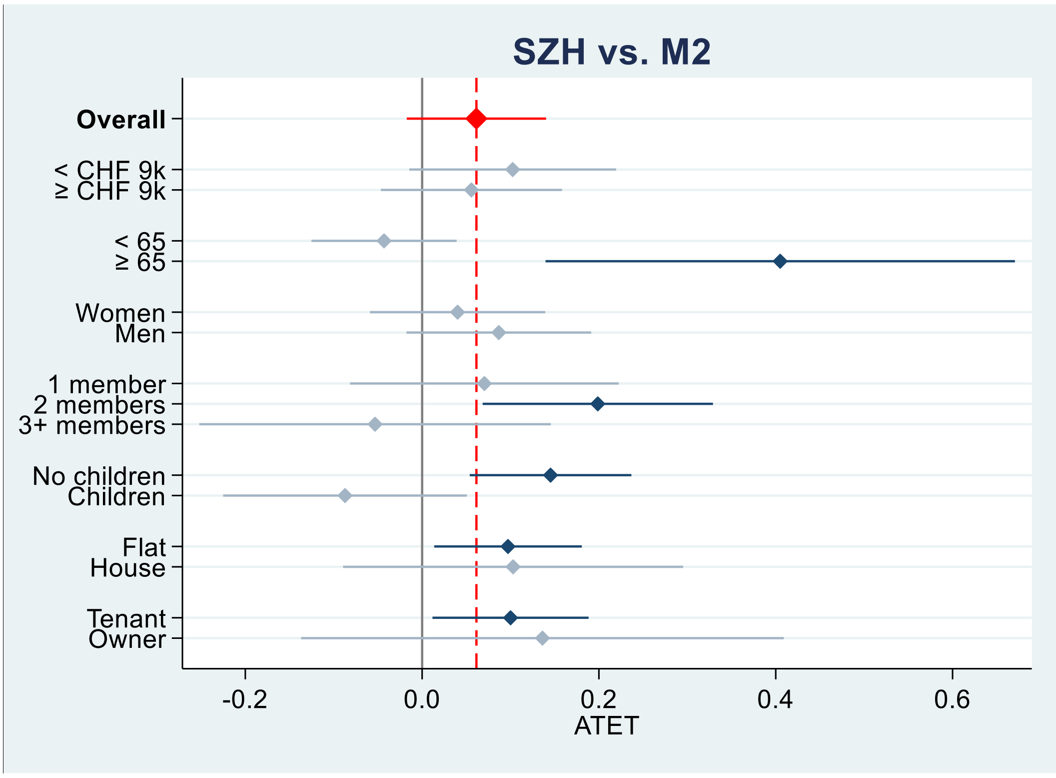
Table 10: ATET for knowledge of electricity mix.

Outcome variable: elecRenMixKno

	Model 1	Model 2	Model 3
ATET			
SZH vs. M2	0.061	0.088*	0.082
	(0.048)	(0.051)	(0.054)
N (Total sample size)	764	587	587
N (Treated obs.)	465	342	342
N (Matched controls)	234	141	135

Robust Abadie-Imbens standard error in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1

Figure 17: ATET for knowledge of electricity mix, by population segment.

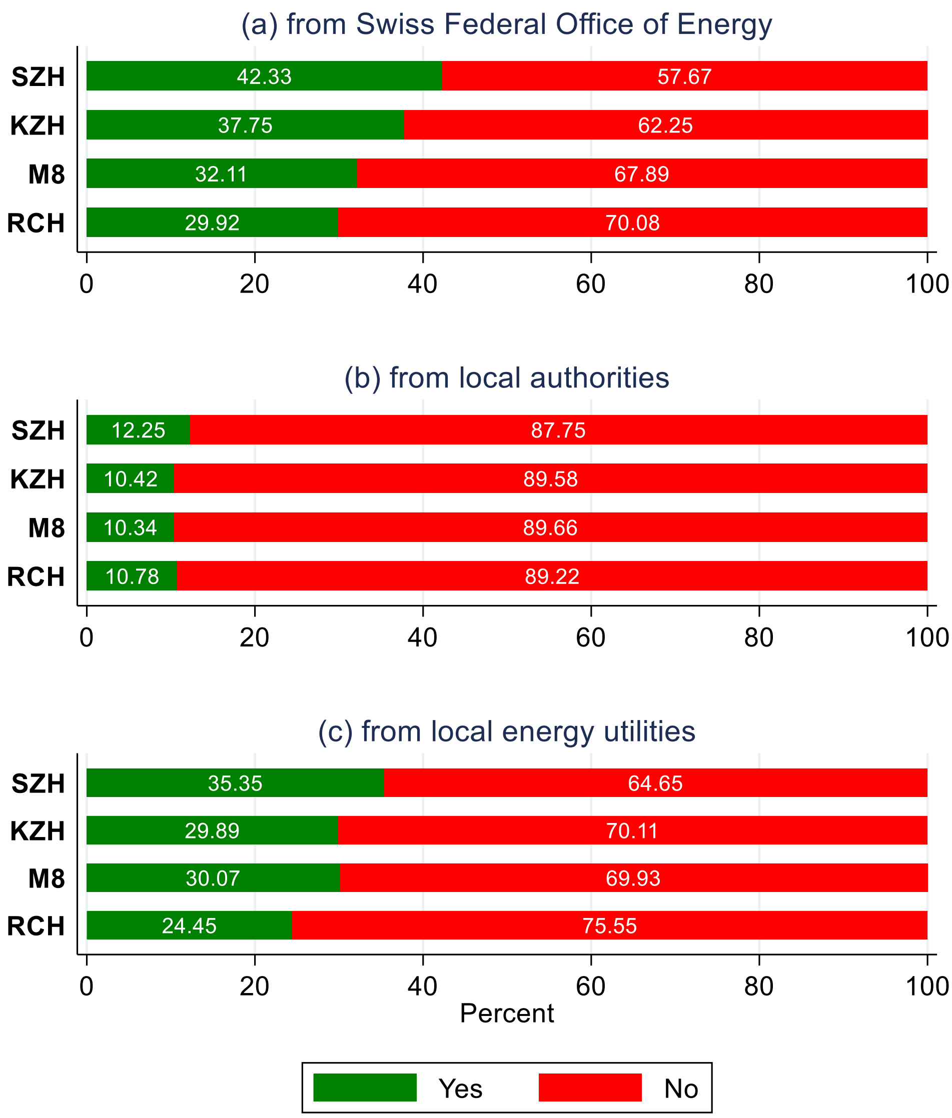


Note: This figure plots the average treatment effect on the treated (ATET) for different population segments. Whiskers represent 90% confidence intervals. Statistically significant differences ($p<0.1$) are displayed in dark colours, insignificant treatment effects in light. The complete estimation results are provided in Table 23 of the Appendix.

4.6 Energy advice uptake from different sources

We report energy advice uptake from three different sources: the Swiss Federal Office of Energy (SFOE), local utilities, and local authorities (Figure 18). Overall average levels of energy advice uptake vary by source, with the highest uptake levels from the SFOE (30%-42%), followed by uptake of energy advice from local utilities (24%-35%) and then local authorities (10%-12%). We look at advice uptake separately for each advice source.

Figure 18: Energy advice uptake in each group.



4.6.1 Energy advice uptake from the SFOE

For SZH inhabitants we find the following advice uptake figures: 12% from local authorities, 32% for local utilities and 42% for SFOE (Figure 18).

Panel data analysis (Table 11) shows that SZH inhabitants have the highest levels of energy advice uptake from the SFOE. We also find that uptake of energy advice from the SFOE tends to be higher when trust in the SFOE is higher. Furthermore, some factors of all types are significant in explaining higher uptake, thus socio-demographic/structural, technical and behavioural factors are all significant in explaining higher uptake. It is particularly interesting to observe that tenants are less likely to take up energy advice from the SFOE compared to owners. Also, uptake levels tend to be higher if energy literacy levels are higher.

Findings from the matching analysis (Table 12) show a similar pattern, albeit not all models yield significant results. Only comparing matched households, we find that SZH inhabitants take up more advice compared to those in RCH, across all three models. Compared to M8, similar differences can be seen for SZH inhabitants taking up more advice (this finding does not hold for model 3 that includes psychological factors). Finally, for the comparison of SZH against KZH, the treatment effect in model 2 (with technical factors) becomes non-significant while in models 1 and 3 we still find significant differences with SZH inhabitants taking up more advice than KZH inhabitants.

Heterogeneity analysis (Figure 19) shows that SZH tenants, those living in flats, those in lower household incomes (< CHF 9k per months) and households without children are more likely to take up advice from the SFOE than comparative groups living in KZH and M8. Additionally, SZH inhabitants below 65 years of age are more likely to take on energy advice compared to comparative households in M8.

Table 11: Linear regression for Energy advice uptake from the Swiss Federal Office of Energy (SFOE).

Dependent variable: soc7_3

	Model 0		Model 1		Model 2		Model 3	
KZH	-0.047*	(0.024)	-0.093**	(0.039)	-0.115**	(0.046)	-0.098**	(0.046)
M8	-0.102***	(0.022)	-0.093**	(0.037)	-0.087*	(0.045)	-0.074*	(0.045)
RCH	-0.123***	(0.020)	-0.152***	(0.034)	-0.160***	(0.041)	-0.141***	(0.041)
year=2017	-0.040***	(0.012)	-0.049**	(0.019)	-0.043*	(0.023)	-0.032	(0.022)
year=2018	-0.052***	(0.013)	-0.068***	(0.020)	-0.034	(0.025)	-0.050**	(0.025)
year=2019	-0.074***	(0.015)	-0.090***	(0.023)	-0.100***	(0.029)	-0.099***	(0.029)
Income < CHF 3,000	-		-0.044	(0.037)	-0.094*	(0.049)	-0.051	(0.047)
Income CHF 3,000-4,499	-		-0.028	(0.032)	-0.103***	(0.039)	-0.072*	(0.040)
Income CHF 4,500-5,999	-		0.013	(0.028)	-0.020	(0.035)	0.004	(0.035)
Income CHF 6,000-8,999	-		-0.028	(0.023)	-0.062**	(0.028)	-0.045	(0.028)
Income CHF 9,000-12,000	-		-0.012	(0.023)	-0.034	(0.028)	-0.021	(0.027)
University Degree	-		0.026*	(0.015)	0.020	(0.019)	0.005	(0.018)
Number of HH members	-		-0.006	(0.009)	-0.011	(0.011)	-0.008	(0.010)
m2/HH member	-		-0.000	(0.000)	-0.000	(0.000)	0.000	(0.000)
Tenant	-		-0.061***	(0.019)	-0.068***	(0.023)	-0.045**	(0.023)
Space heating: electricity	-		-0.042	(0.030)	-0.031	(0.037)	-0.016	(0.036)
Water heating: electricity	-		0.039**	(0.019)	0.023	(0.023)	0.027	(0.022)
Space heating: heat pump	-		0.016	(0.022)	0.036	(0.026)	0.025	(0.025)
Living in a house	-		0.011	(0.019)	0.037	(0.024)	0.035	(0.023)
Checked bill info	-		0.021	(0.015)	0.009	(0.019)	-0.020	(0.019)
ln(Price of 1 kWh)	-		-0.010	(0.021)	-0.001	(0.026)	-0.019	(0.025)
Time-of-use tariff	-		0.073***	(0.018)	0.069***	(0.022)	0.052**	(0.022)
Man in single person HH	-		-0.062**	(0.027)	-0.117***	(0.034)	-0.075**	(0.033)
Woman in single person HH	-		-0.057**	(0.026)	-0.066**	(0.034)	-0.066**	(0.033)
Number of fridges	-		-		-0.005	(0.021)	0.006	(0.020)
Number of freezers	-		-		-0.021	(0.015)	-0.024	(0.015)
Number of TVs	-		-		-0.036***	(0.012)	-0.024**	(0.011)
Number of computers	-		-		-0.010	(0.011)	0.000	(0.011)
Number of laptops	-		-		0.012	(0.010)	0.004	(0.009)
Number of tablets	-		-		-0.033***	(0.010)	-0.027***	(0.010)
Share of A+++ or A++	-		-		-0.022	(0.025)	-0.002	(0.025)
>50% renewable elec. mix	-		-		0.060***	(0.020)	0.006	(0.020)
At least one e-bike	-		-		-		0.079***	(0.024)
Intention to reduce elec.	-		-		-		-0.001	(0.009)
Intention to reduce carbon	-		-		-		0.001	(0.010)
Perceived injunctive norms	-		-		-		0.003	(0.010)
Perceived descr. norms	-		-		-		-0.016	(0.010)
Personal norms	-		-		-		0.049***	(0.010)
Energy literacy score	-		-		-		0.036***	(0.008)
Trust: SFOE	-		-		-		0.137***	(0.012)
Trust: local authorities	-		-		-		-0.025*	(0.014)
Trust: local utility	-		-		-		0.013	(0.012)
Random effects	No		No		No		No	
N	10,019		4,430		3,060		2,902	
R^2	0.0096		0.0298		0.0467		0.1520	

Robust standard error in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1

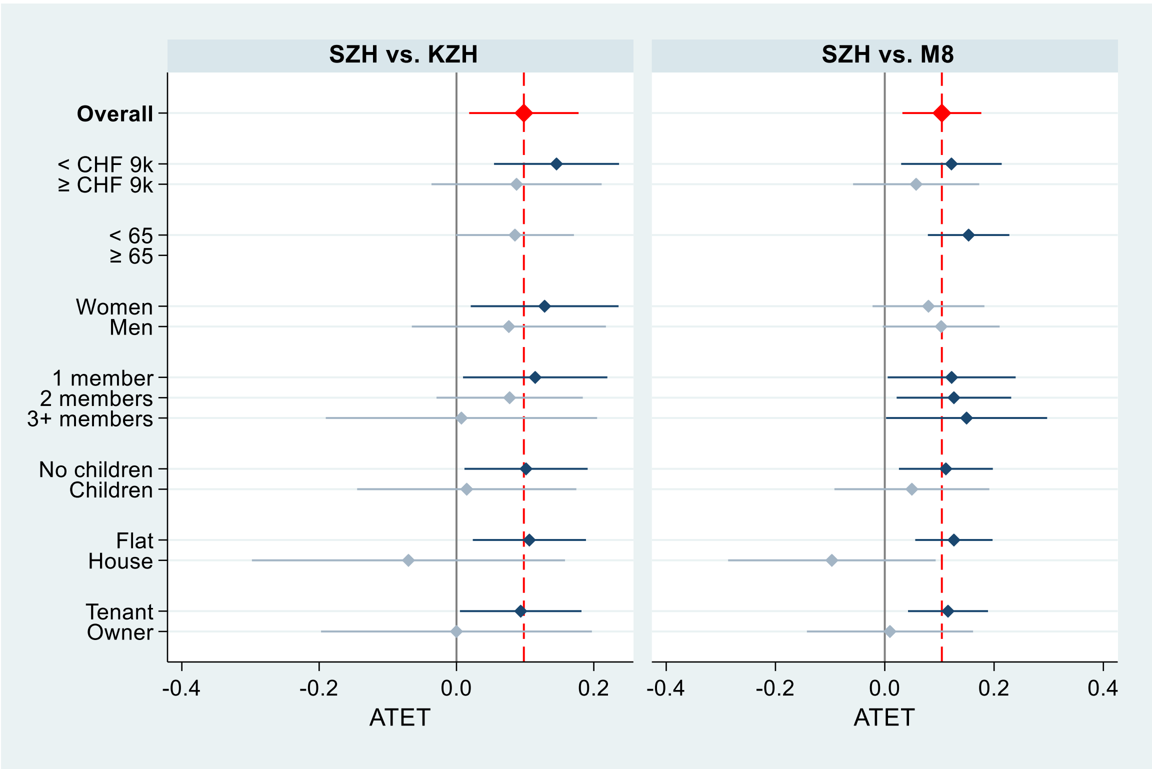
Table 12: ATET for Energy advice uptake from the Swiss Federal Office of Energy (SFOE).

Outcome variable: soc7_3

	Model 1	Model 2	Model 3
ATET			
SZH vs. KZH	0.098**	0.084	0.139*
	(0.048)	(0.059)	(0.076)
N (Total sample size)	872	593	553
N (Treated obs.)	270	178	165
N (Matched controls)	319	119	99
ATET			
SZH vs. M8	0.104**	0.107*	-0.048
	(0.044)	(0.061)	(0.060)
N (Total sample size)	1,033	663	629
N (Treated obs.)	270	178	165
N (Matched controls)	377	129	119
ATET			
SZH vs. RCH	0.103***	0.156***	0.127**
	(0.037)	(0.054)	(0.062)
N (Total sample size)	3,656	2,435	2,310
N (Treated obs.)	270	178	165
N (Matched controls)	1,072	180	134

Robust Abadie-Imbens standard error in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1

Figure 19: ATET for Energy advice uptake from the Swiss Federal Office of Energy (SFOE), by population segment.



Note: This figure plots the average treatment effect on the treated (ATET) for different population segments. Whiskers represent 90% confidence intervals. Statistically significant differences (p<0.1) are displayed in dark colours, insignificant treatment effects in light. The complete estimation results are provided in Table 24 of the Appendix.

4.6.2 Energy advice uptake from local utilities

About 35% of SZH inhabitants have previously taken up energy advice from local utilities. Panel data models (Table 13) show an urban-rural divide across most models with KZH and RCH taking up significantly less advice from local utilities than SZH inhabitants for most models. We also observe that higher levels of energy advice uptake are related to higher levels of trust in the local utilities, ownership (vs. tenants) and living in a house (rather than flat). As with SFOE uptake, uptake levels of advice from local utilities also tend to be higher if energy literacy levels are higher and if personal norms, hence personal convictions to behave environmentally-friendly, are higher.

Findings for the uptake of information from local utilities remain roughly the same for the matching analysis (Table 14). There is still an urban-rural divide and SZH inhabitants are more likely to take up advice from local utilities than RCH across all models. Compared to KZH, SZH inhabitants are also more likely to take up advice, however this finding only holds true with model 1 (social-demographic and structural factors). We find significant differences between SZH and M8 in model 3, when psychological factors are added to the other factors, but not in model 1, unlike in the panel analysis findings.

Heterogeneity analysis (Figure 20) shows that SZH homeowners are more likely to take up advice from local utilities than KZH and M8 owners. Furthermore, SZH households below 65 years of age, without children and those living in flats are also more likely to take up energy advice from local utilities than KZH households.

Table 13: Linear regressions for energy advice uptake from the local energy supply utilities.

Dependent variable: soc7_5

	Model 0		Model 1		Model 2		Model 3	
KZH	-0.056**	(0.023)	-0.102***	(0.038)	-0.093**	(0.046)	-0.069	(0.044)
M8	-0.052**	(0.022)	-0.056	(0.037)	-0.069	(0.045)	-0.041	(0.043)
RCH	-0.108***	(0.020)	-0.163***	(0.033)	-0.165***	(0.040)	-0.135***	(0.039)
year=2017	-0.049***	(0.011)	-0.071***	(0.018)	-0.067***	(0.022)	-0.060***	(0.022)
year=2018	-0.058***	(0.013)	-0.062***	(0.019)	-0.022	(0.024)	-0.042*	(0.024)
year=2019	-0.084***	(0.014)	-0.080***	(0.022)	-0.097***	(0.027)	-0.091***	(0.027)
Income < CHF 3,000	-		-0.052	(0.035)	-0.067	(0.047)	-0.060	(0.047)
Income CHF 3,000-4,499	-		-0.001	(0.031)	-0.025	(0.039)	-0.029	(0.039)
Income CHF 4,500-5,999	-		-0.025	(0.026)	-0.036	(0.033)	-0.023	(0.033)
Income CHF 6,000-8,999	-		0.022	(0.022)	0.006	(0.027)	0.016	(0.026)
Income CHF 9,000-12,000	-		-0.020	(0.022)	-0.038	(0.027)	-0.022	(0.026)
University Degree	-		-0.003	(0.015)	0.003	(0.018)	0.009	(0.018)
Number of HH members	-		-0.018**	(0.008)	-0.024**	(0.010)	-0.021**	(0.010)
m2/HH member	-		-0.000	(0.000)	-0.000*	(0.000)	-0.000	(0.000)
Tenant	-		-0.086***	(0.019)	-0.088***	(0.023)	-0.069***	(0.022)
Space heating: electricity	-		-0.050*	(0.028)	-0.032	(0.034)	-0.047	(0.033)
Water heating: electricity	-		-0.017	(0.018)	-0.016	(0.021)	-0.012	(0.021)
Space heating: heat pump	-		-0.021	(0.020)	-0.007	(0.024)	-0.035	(0.024)
Living in a house	-		0.011	(0.019)	0.027	(0.023)	0.045**	(0.023)
Checked bill info	-		0.062***	(0.015)	0.049***	(0.018)	0.020	(0.018)
ln(Price of 1 kWh)	-		-0.008	(0.020)	0.017	(0.025)	0.019	(0.024)
Time-of-use tariff	-		0.024	(0.017)	0.000	(0.022)	0.005	(0.022)
Man in single person HH	-		-0.007	(0.027)	-0.034	(0.033)	0.002	(0.033)
Woman in single person HH	-		0.003	(0.025)	-0.033	(0.032)	-0.042	(0.032)
Number of fridges	-		-		-0.016	(0.020)	-0.020	(0.019)
Number of freezers	-		-		0.009	(0.015)	0.009	(0.014)
Number of TVs	-		-		0.002	(0.011)	0.004	(0.011)
Number of computers	-		-		-0.008	(0.011)	0.003	(0.011)
Number of laptops	-		-		-0.017*	(0.009)	-0.012	(0.009)
Number of tablets	-		-		-0.014	(0.010)	-0.012	(0.010)
Share of A+++ or A++	-		-		-0.012	(0.025)	-0.010	(0.024)
>50% renewable elec. mix	-		-		0.116***	(0.020)	0.078***	(0.020)
At least one e-bike	-		-		-		-0.003	(0.024)
Intention to reduce elec.	-		-		-		0.012	(0.009)
Intention to reduce carbon	-		-		-		0.010	(0.009)
Perceived injunctive norms	-		-		-		0.015	(0.010)
Perceived descr. norms	-		-		-		0.009	(0.010)
Personal norms	-		-		-		0.016*	(0.010)
Energy literacy score	-		-		-		0.022***	(0.008)
Trust: SFOE	-		-		-		-0.029**	(0.012)
Trust: local authorities	-		-		-		-0.002	(0.013)
Trust: local utility	-		-		-		0.143***	(0.011)
Random effects	No		No		No		No	
N	10,018		4,430		3,060		2,902	
R^2	0.0108		0.0324		0.0478		0.1448	

Robust standard error in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

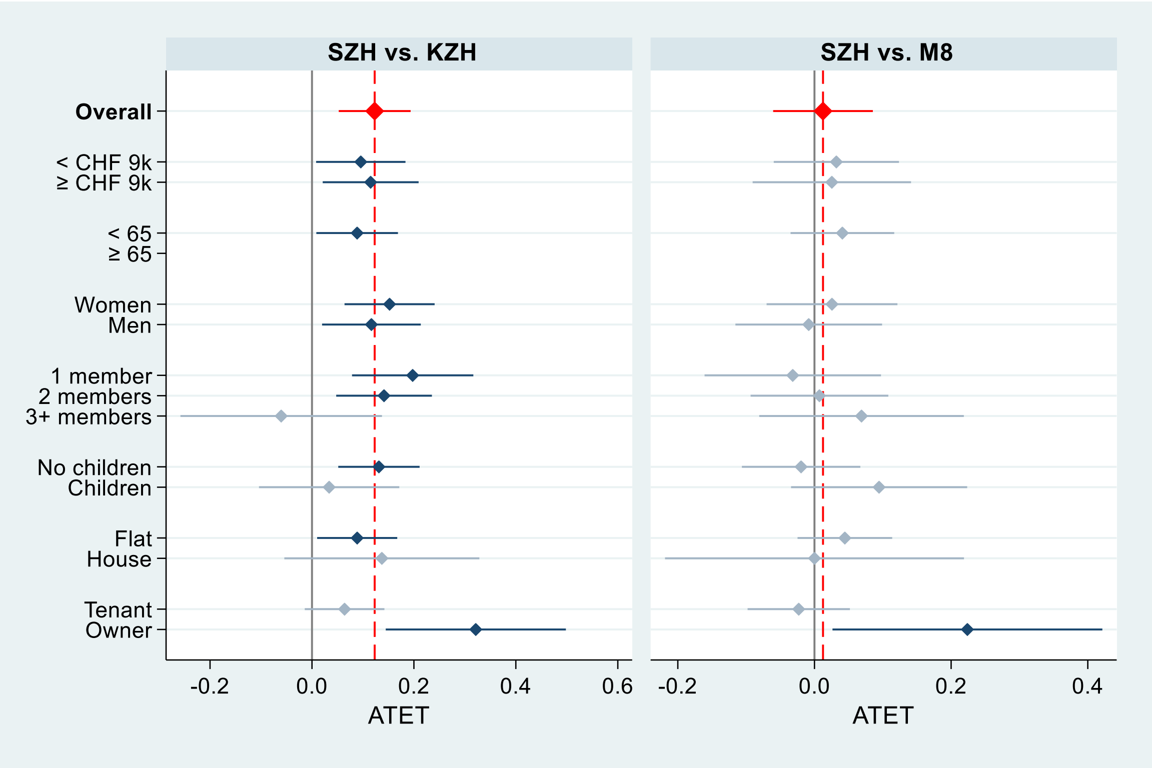
Table 14: ATET for energy advice uptake from the local energy supply utilities.

Outcome variable: soc7_5

	Model 1	Model 2	Model 3
ATET			
SZH vs. KZH	0.123***	0.003	0.073
	(0.043)	(0.063)	(0.062)
N (Total sample size)	872	593	553
N (Treated obs.)	270	178	165
N (Matched controls)	319	119	99
ATET			
SZH vs. M8	0.012	-0.031	-0.109*
	(0.044)	(0.070)	(0.064)
N (Total sample size)	1,033	663	629
N (Treated obs.)	270	178	165
N (Matched controls)	377	129	119
ATET			
SZH vs. RCH	0.155***	0.133**	0.127**
	(0.035)	(0.052)	(0.056)
N (Total sample size)	3,656	2,435	2,310
N (Treated obs.)	270	178	165
N (Matched controls)	1,072	180	134

Robust Abadie-Imbens standard error in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1

Figure 20: ATET for energy advice uptake from the local energy supply, by population segment.



Note: This figure plots the average treatment effect on the treated (ATET) for different population segments. Whiskers represent 90% confidence intervals. Statistically significant differences (p<0.1) are displayed in dark colours, insignificant treatment effects in light. The complete estimation results are provided in Table 25 of the Appendix.

4.6.3 Energy advice uptake from the local authorities

We do not identify any significant differences between the SZH and the other groups on the uptake of energy advice from local authorities (Figure 18), which shows the lowest levels of uptake of energy advice overall. Panel data analysis (Table 15) again shows that advice uptake is more likely if trust in local authorities is higher. Additionally, advice uptake is higher for owners (vs. tenants). We also find that woman living on their own are less likely to take up energy advice from local authorities than larger or single-male households. Finally, uptake levels of advice from local authorities tend to be higher for people with higher personal norms (personal convictions to behave environmentally-friendly).

Matching analysis (Table 16) yield results globally in line with that of the panel analysis, revealing almost no significant differences between the groups. We only find a slightly lower advice uptake for SHZ inhabitants compared to M8 inhabitants with model 2. Heterogeneity analyses (Figure 21) do not reveal any further differences.

Table 15: Linear regressions for energy advice uptake from the local authorities.

	Model 0		Model 1		Model 2		Model 3	
KZH	-0.019	(0.016)	-0.036	(0.026)	-0.021	(0.031)	-0.025	(0.032)
M8	-0.019	(0.015)	-0.011	(0.025)	0.025	(0.031)	0.014	(0.032)
RCH	-0.014	(0.013)	-0.019	(0.023)	0.002	(0.027)	-0.013	(0.029)
year=2017	-0.016^{**}	(0.008)	-0.020	(0.012)	-0.017	(0.015)	-0.012	(0.016)
year=2018	-0.012	(0.009)	-0.007	(0.013)	0.004	(0.017)	-0.003	(0.018)
year=2019	-0.015	(0.010)	-0.001	(0.016)	-0.001	(0.020)	-0.003	(0.021)
Income < CHF 3,000	-		0.028	(0.024)	-0.030	(0.030)	-0.033	(0.032)
Income CHF 3,000-4,499	-		0.025	(0.021)	-0.009	(0.026)	-0.019	(0.027)
Income CHF 4,500-5,999	-		0.042^{**}	(0.019)	0.007	(0.024)	0.010	(0.024)
Income CHF 6,000-8,999	-		0.032^{**}	(0.016)	0.015	(0.020)	0.016	(0.020)
Income CHF 9,000-12,000	-		-0.003	(0.015)	-0.016	(0.019)	-0.016	(0.019)
University Degree	-		0.008	(0.010)	-0.006	(0.013)	-0.004	(0.013)
Number of HH members	-		-0.009	(0.006)	-0.007	(0.008)	-0.012	(0.008)
m2/HH member	-		-0.000^{*}	(0.000)	-0.000	(0.000)	-0.000	(0.000)
Tenant	-		-0.072^{***}	(0.014)	-0.076^{***}	(0.016)	-0.069^{***}	(0.017)
Space heating: electricity	-		-0.013	(0.020)	0.006	(0.026)	-0.005	(0.026)
Water heating: electricity	-		-0.003	(0.013)	-0.002	(0.015)	0.006	(0.016)
Space heating: heat pump	-		-0.006	(0.014)	0.001	(0.017)	-0.005	(0.018)
Living in a house	-		-0.018	(0.014)	-0.008	(0.017)	-0.001	(0.017)
Checked bill info	-		0.022^{**}	(0.010)	0.017	(0.013)	0.009	(0.013)
ln(Price of 1 kWh)	-		0.001	(0.014)	0.015	(0.017)	0.018	(0.017)
Time-of-use tariff	-		0.021^{*}	(0.012)	0.009	(0.016)	0.013	(0.016)
Man in single person HH	-		-0.022	(0.019)	-0.036	(0.024)	-0.024	(0.024)
Woman in single person HH	-		-0.058^{***}	(0.017)	-0.080^{***}	(0.021)	-0.095^{***}	(0.022)
Number of fridges	-		-		0.008	(0.015)	0.007	(0.015)
Number of freezers	-		-		-0.005	(0.010)	-0.005	(0.011)
Number of TVs	-		-		-0.014^{*}	(0.008)	-0.010	(0.008)
Number of computers	-		-		0.000	(0.008)	0.003	(0.008)
Number of laptops	-		-		-0.007	(0.006)	-0.009	(0.007)
Number of tablets	-		-		-0.019^{***}	(0.007)	-0.015^{**}	(0.007)
Share of A+++ or A++	-		-		-0.006	(0.017)	-0.003	(0.018)
>50% renewable elec. mix	-		-		0.042^{***}	(0.014)	0.030^{**}	(0.015)
At least one e-bike	-		-		-		0.045^{**}	(0.019)
Intention to reduce elec.	-		-		-		0.008	(0.006)
Intention to reduce carbon	-		-		-		0.015^{**}	(0.007)
Perceived injunctive norms	-		-		-		0.001	(0.007)
Perceived descr. norms	-		-		-		-0.008	(0.007)
Personal norms	-		-		-		0.013^{*}	(0.007)
Energy literacy score	-		-		-		0.001	(0.006)
Trust: SFOE	-		-		-		-0.036^{***}	(0.008)
Trust: local authorities	-		-		-		0.088^{***}	(0.009)
Trust: local utility	-		-		-		-0.007	(0.008)
Random effects	No		No		No		No	
N	10,018		4,430		3,060		2,902	
R^2	0.0008		0.0153		0.0273		0.0751	

Robust standard error in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

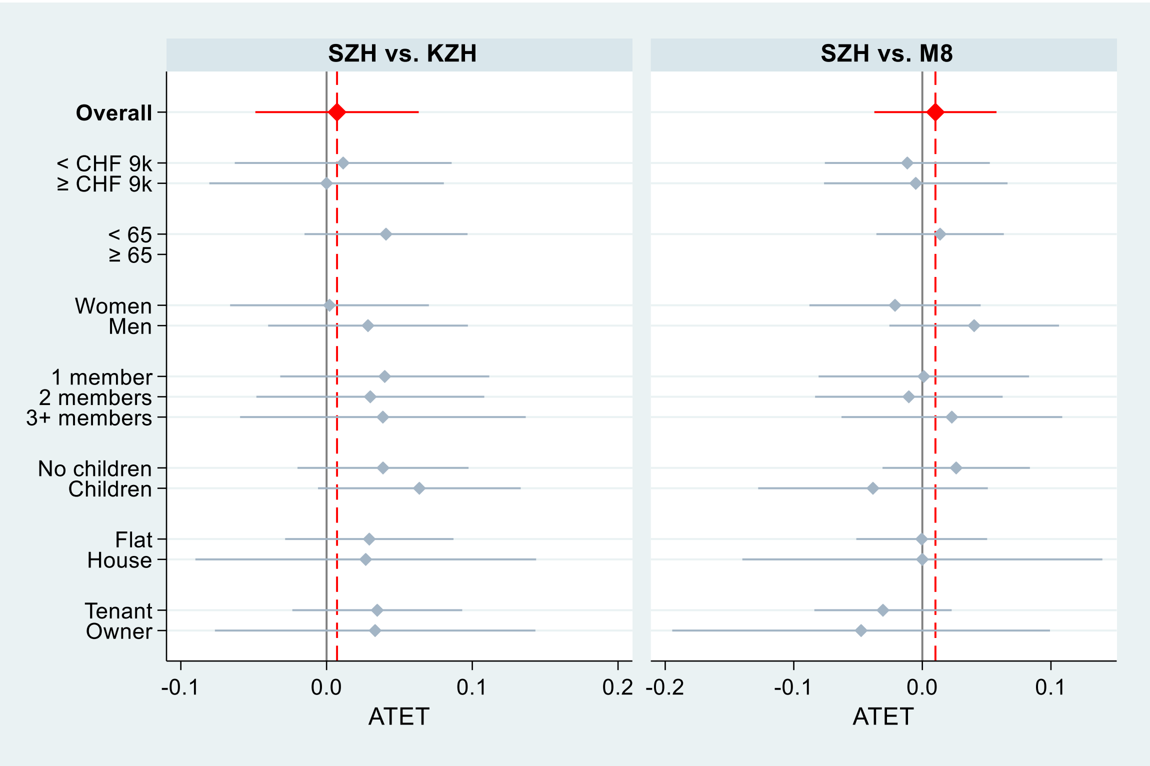
Table 16: ATET for energy advice uptake from the local authorities.

Outcome variable: soc7_4

	Model 1	Model 2	Model 3
ATET			
SZH vs. KZH	0.007	0.022	-0.073
	(0.034)	(0.039)	(0.058)
N (Total sample size)	872	593	553
N (Treated obs.)	270	178	165
N (Matched controls)	319	119	99
ATET			
SZH vs. M8	0.010	-0.081*	-0.030
	(0.029)	(0.048)	(0.045)
N (Total sample size)	1,033	663	629
N (Treated obs.)	270	178	165
N (Matched controls)	377	129	119
ATET			
SZH vs. RCH	0.028	-0.014	0.018
	(0.024)	(0.037)	(0.038)
N (Total sample size)	3,656	2,435	2,310
N (Treated obs.)	270	178	165
N (Matched controls)	1,072	180	134

Robust Abadie-Imbens standard error in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1

Figure 21: ATET for energy advice uptake from the local authorities, by population segment.



Note: This figure plots the average treatment effect on the treated (ATET) for different population segments. Whiskers represent 90% confidence intervals. Statistically significant differences (p<0.1) are displayed in dark colours, insignificant treatment effects in light. The complete estimation results are provided in Table 26 of the Appendix.

Overall results indicate that advice uptake is highest when it comes from the SFOE closely followed by the local utility and is related to higher trust levels. There is also a tenant-owner divide, with tenants being in general less likely to act on energy advice from any source (SFOE, energy utilities, or local authorities). There are some regional differences, with SZH households taking up generally more energy advice than other households. The differences are especially strong compared to KZH households and when the source of energy advice is the SFOE.

5 Discussion and policy recommendations

In this report we use data from SHEDS, which contains a sample of around 1'200 households in SZH and 22'000 across the entire country over 2016-2019. Specifically, we explore consumption patterns in the electricity domain, as well as advice uptake from authorities and utilities. To demonstrate SZH's strengths and weaknesses in this regard, we compare SZH to the remainder of the canton of Zürich (excluding Winterthur), the 8 largest Swiss cities after SZH (excluding Lugano that is outside geographical coverage of SHEDS), and the rest of Switzerland (excluding Ticino). We conduct a series of thorough econometric analyses based on panel data estimations and propensity score matching and present most of the findings graphically to make them as easy as possible to understand.

Before turning to presenting the policy discussion in three sections regarding consumption and efficiency, energy literacy and advice uptake, we provide a synthesis of results from the econometric analyses.

5.1 Synthesis of econometric results

A variety of random-effects regression analyses conducted has been used to identify the underlying effects and relationships. A selection of these results could be summarized in Table 17:

Table 17: Underlying effects and relationships based on panel regression models.

Determinants	Electricity consumption kWh	Percentage of efficient appliances	Uptake of energy advice from the SFOE	Uptake of energy advice from utilities
Single-person household (men vs. Women)	+	–	– / NS	NS
Tentant (vs. owner)	–	–	–	–
House vs. apartment	+	NS	NS	NS
Knowledge of own energy mix (self declaration)	NS	+	+	+
Energy literacy	NS	–	+	+
Appliance efficiency	NS		NS	NS
Number of appliances	+ mostly	+ / NS	– mostly	– mostly
Personal norms	NS	NS	+	+
Trust (in SFOE)	NA	NA	+	–
Trust (in utility)	NA	NA	NS	+

+: positive effect; –: Negative effect; NS: statistically not significant at p<0.1; NA: Not included in the final model because it was not significant in preliminary models. Reading example first row in the table: households with single male occupants are more likely to have a higher electricity consumption (positive effect) and less efficient devices (negative effect) than single female households. Single men (negative effect) are also less likely to take up energy advice from the SFOE than women (non-significant, NS), who don't show any significant difference to multi-person households. Finally there is no significant difference in energy advice uptake from local utilities (non-significant, NS) for single men/women compared to multi-person households.

5.2 Electricity consumption (kWh) and efficiency of appliances

In a first step we present the urban-rural divide in electricity consumption. Our "generic" panel data models indicate a lower consumption for SZH as well as M8 as compared to KZH and RCH, with a staggering average difference of 42% between SHZ and KZH. This result is robust to whether or not we focus on respondents who have checked their electricity bills. The differences however fade out and even become non-significant when we introduce further determinants, showing that the spread in electricity consumption across the two regions is due to heterogeneity in the households. In particular, our panel data analysis indicates that the gap falls from 42% to 12% as soon as we include socio-economic and structural variables (Model 1 in Table 3). The 12% difference remains significant, pointing to lower consumption in SZH compared to KZH across comparable households. The difference falls to about 8% (statistically insignificant with p>0.10) when we add technical variables, namely, number and efficiency of electric appliances (Model 2 in Table 3). A similar pattern applies to the differences between SZH and RCH, with about 14% difference in Model 1 falling to 10% in Model 2 (see Table 3).

Further, it is remarkable that the effect of appliance efficiency is statistically insignificant and limited in magnitude. If we use the point estimate of 0.018 as an indicator (Model 3 in Table 3Table 7), the results suggest that if all households replace their relatively inefficient appliances (currently about 40% of appliances on average) to A++ appliances, there will be only about 0.7% reduction in electricity consumption.

Now, adding behavioural variables in Model 3 produces little change in the coefficients, especially as far as the group differences are considered (compare Models 2 and 3 in Table 3). In particular, the KZH/SZH gap remains similar (about 8% on average consumption), still insignificant statistically, suggesting that on average, KZH households consume slightly more electricity even after controlling for their observed behavioural differences with SZH households. More or less similar pattern is observed in the difference between SZH and RCH, with the exception that in the latter case the difference remains significant but remains about 10%.

Observing the point estimates of group coefficients discussed above, one could conclude that only about a third of the SZH/KZH gap (about 4 percentage points) between comparable households is associated with appliances and their efficiency, leaving the remaining difference (about 8%) to other factors such as behavioural differences. However, this observation is not consistent with the fact that adding behavioural variables (including some usage indicators) does not reduce the difference. Moreover, the difference becomes statistically insignificant as soon as technical variables are included (Model 2). Noting these two observations, we can conclude that the behavioural factors have either little effect or that their effect is dominated by the observed heterogeneity among households. Therefore, our aggregate analysis (without matching comparable households across regions) can identify only one meaningful source of difference that is, technical variables (number and efficiency of electric appliances). In particular, while after controlling for socio-economic and structural variables, SZH on average consumes about 12% less than KZH, only a third of this can be associated with better efficiency and fewer appliances. Refining this result requires a better analysis of heterogeneity, in our case, a matching analysis.

Comparing the overall matched differences (Table 4) that the only discernible difference between comparable households in SZH and KZH is limited to differences in technical determinants (Model 1). Other differences observed in more complete models accounting for differences in appliances (Model 2) and behaviour (model 3) are not statistically significant, that is to say, they are either non-existent or most probably, suppressed by unobserved heterogeneity. While the findings for SZH-KZH differences show a clear decreasing pattern as we include additional determinants (from Model 1 to Model 3), the estimated differences with other groups are less conclusive. In the case of RCH, the differences remain statistically insignificant. However, the pattern of increasing differences in SZH-M8 comparisons (especially significant differences in Model 3) point to potentially important heterogeneity among population segments, which are illustrated in Figure 12.

The estimated differences between matched households between SZH and KZH in each population segment (left panel of Figure 12) point to several policy-relevant groups. First, single-member households show a peculiar result that opposes the overall trend. In fact, in this segment the SZH households show more electricity consumption (about 20%) than their counterparts in KZH. These households constitute therefore an important segment that could be addressed by appropriate policy measures. The SZH-M8 differences (right panel of Figure 12) show a clear divide based on age: while elderly households (respondent 65 years or older) show a lower consumption in SZH, the comparable non-elderly households (respondent younger than 65) consume less in M8. These results do not have clear policy implications except that the SZH elderly households are particularly on the low side of electricity consumption.

As for efficiency, the panel data analysis (Table 7) do not show conclusive differences except for strong heterogeneity. Nevertheless, these results point to a self-selection pattern with cost-conscious households and intensive electricity users opting for greater efficiency. This finding underscores the importance of cost-savings for promoting energy efficiency. There is however no indication of an important behavioural instrument that could be used for increasing efficiency.

The matching analysis on the other hand (Table 8) shows some conclusive patterns. First, there is no significant overall efficiency difference between comparable households in SZH with their comparable counterparts in M8 or RCH. More importantly the SZH-KZH difference (5% more efficiency in SZH) is invariant to whether technical variables are controlled for (Model 2), but vanishes to half its value with no statistical significance, when behavioural determinants are included (Model 3). This finding, combined with those from panel data analysis, suggest that there is no evidence of rebound effect (neither resulting from opting for renewable electricity mix, or through more appliances) to worry about. Higher efficiency could even be associated with higher demand for renewables. We can therefore conclude that promoting efficiency is a relevant and the cost-saving incentives and/or information could be used as an instrument for promoting energy efficiency among households.

The analysis of differences by population segments (summarized in Figure 14) indicates that the efficiency gap varies considerably across different groups. We can identify from one hand, low-income households, and from the other, the house-owners as low-hanging fruits for efficiency promotion.

Overall, considering the differences in electricity consumption and appliance efficiency and their evolution over the sample period (Figure 15), we can conclude that SZH is in a relatively good position compared to KZH. While its households show about 10% to 25% lower consumption compared to KZH households, their efficiency difference is limited to statistically significant but negligible amounts.

5.3 Knowledge and energy literacy

In general, our results show a relatively poor knowledge of the electricity mix, with slightly better results in SZH. We can see that SZH inhabitants are more knowledgeable (66%) about their energy supply being 100% renewable than inhabitants from Geneva and Basel (M2) (57%). Nevertheless, our results suggest that in the majority of cases, households know whether their electricity is renewable. However, observing about a third of households ignoring that about their power supply could be an alarming result for utilities' public communication. This knowledge of electricity mix is positively correlated with our energy literacy score regarding energy efficient consumption behaviour.

As shown in our panel analysis, higher personal norms, so a personal conviction to behave environmentally-friendly, is related to better knowledge of electricity mix. Therefore, personal norms could be used as an instrument to increase awareness. Energy literacy is related to advice uptake (from SFOE and utilities), thus is an important driver to be considered when designing energy advice interventions. Moreover, knowledge of more than 50% renewable electricity mix seems to cause no "rebound" effect, i.e. people tend to show higher efficiency and lower electricity consumption when knowing or believing that their electricity mainly is renewable.

In addition, as shown in our matching analysis comparing SZH with M2, that older (those over 65 years of age) and households without children (so possibly more time to inform themselves) are more knowledgeable about their energy supply. Particularly, results relating to households without children appear in line with results on energy advice uptake. Interestingly, SZH inhabitants living in a flat and SZH tenants are better informed about their electricity mix than similar households in M2. While the overall differences between tenants vs owners and flat vs house are not statistically significant, they point to a similar direction disfavouring house-owners. This latter group could represent a relevant target group for information campaigns, because in addition to relatively poor knowledge, they represent a relatively high electricity consumption.

Overall, we see a mixed picture when looking at the effects of energy knowledge on energy consumption. While showing a slightly negative effect of energy literacy on efficiency, our regressions do not show any evidence of significant correlation between energy literacy and electricity consumption. Thus, mere information will probably not be effective in reducing energy consumption. However, when drawing policy implications, a direct promotion of knowledge of power supply and energy literacy seems to be helpful as it increases advice uptake, which in turn is related to electricity consumption. Moreover, the negative effect of literacy on efficiency might be at least partly explained by the consumer's concern about embodied (grey) energy used in the production of appliances. Therefore, we expect information campaigns will be effective, providing that they target specific behaviour and that personal norms and other factors are addressed at the same time. This result is coherent with other research (e.g. Diekmann and Meyer, 2008; Farsi et al., 2020), which shows that information and knowledge may not have a direct impact on energy consumption but are likely to facilitate the discussion and adoption of policy measures to reduce environmental damage.

Specifically, since there appears to be an age or family-related gap regarding knowledge and energy literacy, one could think about involving schools (and possibly even kindergarten) when teaching about energy-saving behaviours and energy sources. One way to address personal norms would be if the (school) campaign communicates social norms, which can be seen as internalized personal norms.

5.4 Advice uptake

The results show that the overall average levels of energy advice uptake vary by source, with the highest uptake from the SFOE, closely followed by uptake of energy advice from local utilities and then local authorities. However, overall advice uptake is low with SZH inhabitants following advice (12% from local authorities, 32% for local utilities and 42% for SFOE), but still higher than in RCH, KZH and to some extent M8. Therefore, the data confirm the observed rural-urban divide favouring major cities.

We have seen that significant differences in advice uptake from the SFOE remain more or less the same regardless of Models (1, 2 or 3) in the panel analysis and matching analysis (model 2 – KZH, model 3 – M8, become non-significant). A similar picture can be seen for significant differences in advice uptake from utilities with KZH disappear with Model 2, but differences with M8 remain more or less the same regardless of Models (1, 2 or 3). Other factors that are not observed in SHEDS likely explain these significant differences in advice uptake. These could be related to policies or possible cultural aspects. In addition, there is no evidence of any temporal changes in these differences over the sample period (2016-2019), perhaps partly because of data limitations.

As mentioned above, advice uptake levels are low and are clearly linked to energy consumption, especially advice from local utilities. One of the most important factors appears to be trust in the advice-giving institution, i.e. uptake of energy advice from the SFOE, local utilities or local authorities tends to be higher when trust in the respective actor is higher. Moreover, higher energy literacy increases the probability of advice uptake. In addition, other socio-demographic/structural, technical and behavioural factors explain higher uptake, particularly tenants are less likely to take up energy advice compared to owners and those living in a flat compared to houses. This can be explained with higher motivations of (house)owners to take up advice for improving the energy efficiency of their own property. In addition, uptake levels of advice from local utilities, local authorities and SFOE correlate for people with higher personal norms, hence personal convictions to behave environmentally-friendly. We also find that women living on their own are less likely to take up energy advice from local authorities than larger or single male households.

These findings point to certain policy implications. Particularly, the tenant-(house)owner divide indicates that tenants are in general less likely to act on energy advice. Energy advice so far has mainly targeted insulation and renewable energy installations for (house)owners, so there seems to be a gap for more tailored advice for tenants. Specifically, advice could target investments in more efficient appliances or a more efficient usage behaviour. Moreover, trust and energy literacy are important mediating factors to increase advice uptake (see also knowledge). Interventions that address personal norms could also be a promising policy avenue. Overall, advice needs to be tailored to a certain group or behaviour, so that it will have some effect, as general advice seems to be less effective.

6 Summary of policy conclusions

Overall, we can identify the following groups which could be targeted with priority (relatively good uptake of advice and, hence, information or nudges could be effective). However, advice should be tailored to these target-groups:

- For efficiency improvement:
    - Low-income group
    - Owners
- For consumption reduction:
    - Single-member households

Finally, our findings point to the following policy conclusions:

- Overall, we observe a relatively good performance in Zurich City, thus suggesting two main strategies: keep successful policies and develop tailored advice for specific population segments (e.g. tenants) for specific behaviours.
- Information campaigns and other means to improve energy literacy help to build up trust and could ensure better advice uptake. However, some previous findings (e.g. Lang et al., 2020) suggest that mere information is unlikely to be effective. The information campaigns need to target specific behaviours and address other factors such as personal and social norms in favour of energy saving. For instance, school campaigns can be recommended for the promotion of knowledge as well as social norms.
- Promotion campaigns should consider important factors such as trust in the advice-giving institution, higher energy literacy as well as differences between population groups. In particular, the behavioural differences stand out between owners and tenants, house-dwellers and households living in flat, and single male vs. single female households.

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Appendix 1: Variables and summary statistics

Table 18: Variable names and descriptions

Variable name	Variable label	Description
Dependent/Outcome variables		
elec8_1	Elec. consumption (kWh/year)	Annual electricity consumption per household (kWh)
elec7_1	Electricity bill (CHF/year)	Annual electricity bill per household (CHF)
elecEffi	% of A+++ or A++ appliances	Share of electrical appliances with efficiency label A+++ or A++
soc7_3	Advice: SFOE	Consideration of the recommendations of the Swiss Federal Office of Energy (SFOE) regarding changes in energy consumption
soc7_4	Advice: local authorities	Consideration of the recommendations of the local authorities regarding changes in energy consumption
soc7_5	Advice: local utility	Consideration of the recommendations of the local energy supply utility regarding changes in energy consumption
elecRenMixKno	Knowledge of energy mix	Respondent knows correctly that energy mix in Zurich canton or Geneva city is 100% renewable (hydro included)
Socio-demographic and structural determinants (Model 1)		
seco5_1	Income < CHF 3,000	Household gross monthly income below CHF 3,000 (1=yes, 0=no)
seco5_2	Income CHF 3,000-4,499	Household gross monthly income CHF 3,000-4,499 (1=yes, 0=no)
seco5_3	Income CHF 4,500-5,999	Household gross monthly income CHF 4,500-5,999 (1=yes, 0=no)
seco5_4	Income CHF 6,000-8,999	Household gross monthly income CHF 6,000-8,999 (1=yes, 0=no)
seco5_5	Income CHF 9,000-12,000	Household gross monthly income CHF 9,000-12,000 (1=yes, 0=no)
seco5_6	Income > CHF 12,000	Household gross monthly income over CHF 12,000 (1=yes, 0=no)
UnivDegr	University Degree	Respondent has university education (1=yes, 0=no)
hh	Number of HH members	Number of household members
area_hh	m2/HH member	Accommodation living area per household member (m2)
accom1TenCoo	Tenant	Accommodation ownership: Tenant or Living in a cooperative (1=yes, 0=no)
SpaHeaEle	Space heating: electricity	Electricity is the primary source for space heating (1=yes, 0=no)
WatHeaEle	Water heating: electricity	Electricity is the primary source for water heating (1=yes, 0=no)
SpaHeaPum	Space heating: heat pump	Heat pump is the primary source for space heating (1=yes, 0=no)
accom2House	Living in a house	Accommodation type: House (1=yes, 0=no)
elec7_2Bill	Checked bill info	Information about electricity cost comes from bill (1=yes, 0=no)
price	Price of 1 kWh	Price of 1 kWh, in cents
elec15	Time-of-use tariff	Electricity price variation according to the period of the day/night (1=yes, 0=no)
man1	Man in single person HH	Man in a single person household (1=yes, 0=no)
woman1	Woman in single person HH	Woman in a single person household (1=yes, 0=no)
Technical determinants (Model 2)		
elec2_1	Number of fridges	Number of fridges owned
elec2_2	Number of freezers	Number of freezers (separated from fridge) owned
elec2_12	Number of TVs	Number of TVs owned
elec2_16	Number of computers	Number of computers owned
elec2_17	Number of laptops	Number of laptops owned
elec2_18	Number of tablets	Number of tablets owned
elecIndEffi	Share of A+++ or A++	Share of main electricity appliances goods with efficiency label A++ and A+++ (TV plus white goods: Fridge, freezer, oven/stove, dish washer, washing machine, dryer)
Behavioural determinants (Model 3)		
elec10b_2	>50% renewable elec. mix	Electricity mix contains a significant share (over 50%) of renewable energy
mob2_4x	At least one e-bike	Households owns at least one e-bike (1=yes, 0=no)
socAv4a_4a_b_c_d	Electricity saving habits	Average of electricity saving habits
psyInd8_1	Intention to reduce elec.	Intention to reduce electricity consumption
psyInd8_4	Intention to reduce carbon	Intention to reduce carbon footprint
psy5ax	Perceived injunctive norms	Perceived injunctive norms of network
psy5a_2	Perceived descr. norms	Perceived descriptive norms of network

psy5a_4	Personal norms	Personal norms
EnergyLiteracy	Energy literacy score	Energy literacy (score ranging from 0 to 5, with higher score meaning higher energy literacy)
socInd6_3	Trust: SFOE	Trust in information provided by the Swiss Federal Office of Energy (SFOE)
socInd6_4	Trust: local authorities	Trust in information provided by the local authorities
socInd6_5	Trust: local utility	Trust in information provided by the local energy supply utility
socInd7_3	Advice: SFOE	Consideration of the recommendations of the Swiss Federal Office of Energy (SFOE) regarding changes in energy consumption
socInd7_4	Advice: local authorities	Consideration of the recommendations of the local authorities regarding changes in energy consumption
socInd7_5	Advice: local utility	Consideration of the recommendations of the local energy supply utility regarding changes in energy consumption
elec4_4	Usage/week: dishwasher	Number of uses per week for dishwasher
elec4_9	Usage/week: wash. machine	Number of uses per week for washing machine
elec4_10	Usage/week: dryer	Number of uses per week for dryer
elec4_28	Usage/week: oven	Number of uses per week for oven
elecReAv13_5_12_16_17	Switch off frequency (1)	Average frequency of switch off for coffee machine, TV and computer (1=often, 2=occasionally, 3=almost never, 4=never)
elecReAv13_13_15_19	Switch off frequency (2)	Average frequency of switch off for TV box, internet router and smartphone (1=often, 2=occasionally, 3=almost never, 4=never)
enlit6_2	Electricity price future	Belief about electricity price variation in the future (1=significant decrease, 2=decrease, 3=no decrease or increase, 4=increase, 5=significant increase)

Table 19: Summary statistics

Variable	Mean	S.D.	Min.	Max.	*N*
Dependent/Outcome variables					
Elec. consumption (kWh/year)	4,007.715	3,811.41	500.00	25,000.00	7,881
Electricity bill (CHF/year)	770.264	642.30	25.00	4,000.00	14,763
% of A+++ or A++ appliances	0.634	0.38	0.00	1.00	14,799
Advice: SFOE	0.320	0.47	0.00	1.00	10,019
Advice: local authorities	0.108	0.31	0.00	1.00	10,018
Advice: local utility	0.267	0.44	0.00	1.00	10,018
Knowledge of electricity mix*	0.626	0.48	0.00	1.00	1,167
Socio-demographic and structural determinants (Model 1)					
Income < CHF 3,000	0.063	0.24	0.00	1.00	17,974
Income CHF 3,000-4,499	0.097	0.30	0.00	1.00	17,974
Income CHF 4,500-5,999	0.156	0.36	0.00	1.00	17,974
Income CHF 6,000-8,999	0.289	0.45	0.00	1.00	17,974
Income CHF 9,000-12,000	0.228	0.42	0.00	1.00	17,974
Income > CHF 12,000	0.168	0.37	0.00	1.00	17,974
University Degree	0.450	0.50	0.00	1.00	20,055
Number of HH members	2.295	1.46	1.00	80.00	20,062
m2/HH member	59.455	36.12	8.33	555.00	19,862
Tenant	0.640	0.48	0.00	1.00	20,062
Space heating: electricity	0.069	0.25	0.00	1.00	20,062
Water heating: electricity	0.214	0.41	0.00	1.00	20,062
Space heating: heat pump	0.140	0.35	0.00	1.00	20,062
Living in a house	0.339	0.47	0.00	1.00	20,062
Checked bill info	0.613	0.49	0.00	1.00	16,997
Price of 1 kWh	20.227	6.30	5.52	34.93	20,062
Time-of-use tariff	0.802	0.40	0.00	1.00	13,636
Man in single person HH	0.112	0.32	0.00	1.00	20,062
Woman in single person HH	0.166	0.37	0.00	1.00	20,062
Technical determinants (Model 2)					
Number of fridges	1.107	0.40	0.00	5.00	18,620
Number of freezers	0.678	0.63	0.00	5.00	19,113
Number of TVs	1.174	0.77	0.00	5.00	20,062
Number of computers	0.631	0.76	0.00	5.00	20,062
Number of laptops	1.331	0.98	0.00	5.00	20,062
Number of tablets	0.901	0.89	0.00	5.00	20,062
Share of A+++ or A++	0.615	0.35	0.00	1.00	14,799
Behavioural determinants (Model 3)					
>50% renewable elec. mix	0.273	0.45	0.00	1.00	15,145
At least one e-bike	0.147	0.35	0.00	1.00	20,062
Electricity saving habits	3.408	1.22	1.00	5.00	16,663
Intention to reduce elec.	2.924	1.10	1.00	5.00	18,594
Intention to reduce carbon	2.951	1.09	1.00	5.00	18,594
Perceived injunctive norms	3.184	1.01	1.00	5.00	20,062
Perceived descr. norms	3.204	0.95	1.00	5.00	20,062
Personal norms	3.912	0.99	1.00	5.00	20,062
Energy literacy score	3.512	1.25	0.00	5.00	20,062
Trust: SFOE	3.766	1.02	1.00	5.00	19,214
Trust: local authorities	3.475	1.01	1.00	5.00	18,698
Trust: local utility	3.512	1.04	1.00	5.00	19,187
Advice: SFOE	0.331	0.47	0.00	1.00	20,062
Advice: local authorities	0.109	0.31	0.00	1.00	20,061
Advice: local utility	0.282	0.45	0.00	1.00	20,061
Usage/week: dishwasher	2.935	2.60	0.00	36.00	20,062
Usage/week: wash. machine	2.262	2.29	0.00	33.00	20,062
Usage/week: dryer	1.092	1.78	0.00	31.00	20,062
Usage/week: oven	2.163	1.96	0.00	35.00	20,062
Switch off frequency (1)	2.452	0.59	1.00	3.00	19,968
Switch off frequency (2)	1.627	0.67	1.00	3.00	19,930
Electricity price future	3.854	0.84	1.00	5.00	18,671

* Knowledge of electricity mix in M8 group is observed only for Basel and Geneva (i.e. M2).

Table 20: Sample means, by group

	SZH		KZH		M8		RCH	
Variable	Mean	*N*	Mean	*N*	Mean	*N*	Mean	*N*
Dependent/Outcome variables								
Elec. consumption (kWh/year)	2,219.909	[452]	4,180.663	[988]	2,431.524	[1,182]	4,483.142	[5,259]
Electricity bill (CHF/year)	477.330	[922]	707.264	[1,764]	565.709	[2,393]	860.178	[9,684]
% of A+++ or A++ appliances	0.621	[798]	0.669	[1,741]	0.611	[2,304]	0.635	[9,956]
Advice: SFOE	0.423	[645]	0.378	[1,094]	0.321	[1,769]	0.299	[6,511]
Advice: local authorities	0.122	[645]	0.104	[1,094]	0.103	[1,769]	0.108	[6,510]
Advice: local utility	0.353	[645]	0.299	[1,094]	0.301	[1,769]	0.245	[6,510]
Knowledge of electricity mix*	0.660	[709]	-	-	0.572	[458]	-	-
Socio-demographic and structural determinants (Model 1)								
Income < CHF 3,000	0.046	[1,095]	0.038	[2,067]	0.092	[3,067]	0.061	[11,745]
Income CHF 3,000-4,499	0.086	[1,095]	0.082	[2,067]	0.110	[3,067]	0.097	[11,745]
Income CHF 4,500-5,999	0.166	[1,095]	0.137	[2,067]	0.162	[3,067]	0.157	[11,745]
Income CHF 6,000-8,999	0.250	[1,095]	0.296	[2,067]	0.271	[3,067]	0.296	[11,745]
Income CHF 9,000-12,000	0.232	[1,095]	0.242	[2,067]	0.202	[3,067]	0.232	[11,745]
Income > CHF 12,000	0.220	[1,095]	0.205	[2,067]	0.164	[3,067]	0.157	[11,745]
University Degree	0.566	[1,252]	0.422	[2,309]	0.548	[3,404]	0.418	[13,090]
Number of HH members	2.089	[1,252]	2.243	[2,311]	2.019	[3,404]	2.396	[13,095]
m2/HH member	49.333	[1,246]	63.430	[2,291]	51.707	[3,378]	61.747	[12,947]
Tenant	0.907	[1,252]	0.628	[2,311]	0.851	[3,404]	0.561	[13,095]
Space heating: electricity	0.070	[1,252]	0.055	[2,311]	0.068	[3,404]	0.072	[13,095]
Water heating: electricity	0.141	[1,252]	0.206	[2,311]	0.167	[3,404]	0.235	[13,095]
Space heating: heat pump	0.071	[1,252]	0.195	[2,311]	0.057	[3,404]	0.158	[13,095]
Living in a house	0.119	[1,252]	0.315	[2,311]	0.163	[3,404]	0.409	[13,095]
Checked bill info	0.582	[1,051]	0.661	[2,005]	0.611	[2,787]	0.607	[11,154]
Price of 1 kWh	23.740	[1,252]	16.252	[2,311]	21.388	[3,404]	20.290	[13,095]
Time-of-use tariff	0.911	[753]	0.927	[1,705]	0.710	[2,017]	0.790	[9,161]
Man in single person HH	0.133	[1,252]	0.109	[2,311]	0.152	[3,404]	0.100	[13,095]
Woman in single person HH	0.193	[1,252]	0.166	[2,311]	0.222	[3,404]	0.149	[13,095]
Technical determinants (Model 2)								
Number of fridges	1.022	[1,137]	1.108	[2,161]	1.033	[3,126]	1.134	[12,196]
Number of freezers	0.500	[1,204]	0.691	[2,206]	0.437	[3,266]	0.756	[12,437]
Number of TVs	0.882	[1,252]	1.218	[2,311]	0.948	[3,404]	1.253	[13,095]
Number of computers	0.458	[1,252]	0.694	[2,311]	0.491	[3,404]	0.673	[13,095]
Number of laptops	1.322	[1,252]	1.317	[2,311]	1.313	[3,404]	1.339	[13,095]
Number of tablets	0.807	[1,252]	0.929	[2,311]	0.785	[3,404]	0.935	[13,095]
Share of A+++ or A++	0.599	[798]	0.646	[1,741]	0.595	[2,304]	0.615	[9,956]
Behavioural determinants (Model 3)								
>50% renewable elec. mix	0.473	[978]	0.295	[1,850]	0.339	[2,475]	0.232	[9,842]
At least one e-bike	0.069	[1,252]	0.144	[2,311]	0.087	[3,404]	0.170	[13,095]
Electricity saving habits	3.297	[1,025]	3.379	[1,953]	3.398	[2,766]	3.426	[10,919]
Intention to reduce elec.	2.780	[1,135]	2.828	[2,158]	2.943	[3,121]	2.950	[12,180]
Intention to reduce carbon	2.916	[1,135]	2.884	[2,158]	3.043	[3,121]	2.943	[12,180]
Perceived injunctive norms	3.079	[1,252]	3.113	[2,311]	3.202	[3,404]	3.202	[13,095]
Perceived descr. norms	3.161	[1,252]	3.158	[2,311]	3.194	[3,404]	3.219	[13,095]
Personal norms	3.998	[1,252]	3.950	[2,311]	3.916	[3,404]	3.896	[13,095]
Energy literacy score	3.592	[1,252]	3.594	[2,311]	3.515	[3,404]	3.488	[13,095]
Trust: SFOE	3.934	[1,220]	3.732	[2,232]	3.834	[3,273]	3.738	[12,489]
Trust: local authorities	3.582	[1,130]	3.426	[2,145]	3.538	[3,173]	3.458	[12,250]
Trust: local utility	3.790	[1,213]	3.606	[2,227]	3.556	[3,256]	3.457	[12,491]
Advice: SFOE	0.422	[1,252]	0.384	[2,311]	0.323	[3,404]	0.315	[13,095]
Advice: local authorities	0.117	[1,252]	0.106	[2,311]	0.107	[3,404]	0.109	[13,094]
Advice: local utility	0.357	[1,252]	0.309	[2,311]	0.319	[3,404]	0.260	[13,094]
Usage/week: dishwasher	2.543	[1,252]	3.044	[2,311]	2.310	[3,404]	3.116	[13,095]
Usage/week: wash. machine	1.575	[1,252]	2.480	[2,311]	1.625	[3,404]	2.454	[13,095]
Usage/week: dryer	0.712	[1,252]	1.257	[2,311]	0.664	[3,404]	1.211	[13,095]
Usage/week: oven	1.807	[1,252]	2.141	[2,311]	1.878	[3,404]	2.276	[13,095]
Switch off frequency (1)	2.446	[1,236]	2.414	[2,303]	2.472	[3,371]	2.454	[13,058]
Switch off frequency (2)	1.605	[1,248]	1.599	[2,291]	1.630	[3,376]	1.633	[13,015]
Electricity price future	3.864	[1,191]	3.828	[2,175]	3.812	[3,150]	3.868	[12,155]

* Knowledge of electricity mix in M8 group is observed only for Basel and Geneva (i.e. M2).

Appendix 2: Treatment effects by population segments

Table 21: ATET for electricity consumption, by population segment.

Outcome variable: logqty_ele_tot

	Household income		Age of respondent		Gender of respondent	
	< CHF 9k	≥ CHF 9k	< 65	≥ 65	Women	Men
ATET						
SZH vs. KZH	0.023	-0.215**	-0.093	-0.163*	-0.239***	-0.193***
	(0.074)	(0.085)	(0.063)	(0.086)	(0.077)	(0.069)
N (Total sample size)	563	527	799	291	423	667
N (Treated obs.)	153	148	233	68	129	172
N (Matched controls)	102	91	148	46	69	124
ATET						
SZH vs. M8	0.067	0.109	0.097*	-0.174**	-0.006	-0.028
	(0.083)	(0.078)	(0.059)	(0.069)	(0.070)	(0.087)
N (Total sample size)	618	504	874	248	462	660
N (Treated obs.)	153	148	233	68	129	172
N (Matched controls)	105	96	158	43	88	105

	Household size			Household type	
	1 member	2 members	3+ members	No children	Children
ATET					
SZH vs. KZH	0.203**	-0.253***	-0.220***	-0.087	-0.285***
	(0.081)	(0.081)	(0.075)	(0.067)	(0.056)
N (Total sample size)	293	500	297	724	366
N (Treated obs.)	89	131	81	202	99
N (Matched controls)	65	78	53	137	55
ATET					
SZH vs. M8	-0.001	0.048	0.112	0.028	-0.063
	(0.091)	(0.071)	(0.093)	(0.055)	(0.081)
N (Total sample size)	366	463	293	784	338
N (Treated obs.)	89	131	81	202	99
N (Matched controls)	55	92	52	132	67

	Accommodation type		Accomm. ownership	
	Flat	House	Tenant	Owner
ATET				
SZH vs. KZH	-0.026	-	-0.083	-0.142
	(0.053)		(0.063)	(0.149)
N (Total sample size)	749	341	652	438
N (Treated obs.)	265		255	46
N (Matched controls)	185		161	35
ATET				
SZH vs. M8	-0.011	-	0.055	0.294
	(0.054)		(0.063)	(0.180)
N (Total sample size)	913	209	869	253
N (Treated obs.)	265		255	46
N (Matched controls)	183		163	33

Robust Abadie-Imbens standard error in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1

Table 22: ATET for appliances efficiency, by population segment.

Outcome variable: elecEffi

	Household income		**Age of respondent**		**Gender of respondent**	
	< CHF 9k	≥ CHF 9k	< 65	≥ 65	Women	Men
ATET						
SZH vs. KZH	-0.110***	-0.010	-0.073***	-0.113*	-0.051	-0.063*
	(0.038)	(0.035)	(0.028)	(0.066)	(0.043)	(0.035)
N (Total sample size)	910	776	1,327	359	748	938
N (Treated obs.)	253	225	389	89	234	244
N (Matched controls)	436	396	634	93	296	416
ATET						
SZH vs. M8	-0.049	0.037	-0.004	-0.111**	-0.061*	0.016
	(0.033)	(0.034)	(0.028)	(0.055)	(0.036)	(0.032)
N (Total sample size)	1,088	784	1,531	341	858	1,014
N (Treated obs.)	253	225	389	89	234	244
N (Matched controls)	538	407	713	92	391	456

	Household size				**Household type**	
	1 member	2 members	3+ members		No children	Children
ATET						
SZH vs. KZH	-0.033	-0.048	-0.088*		-0.045	-0.075
	(0.054)	(0.034)	(0.049)		(0.030)	(0.048)
N (Total sample size)	441	770	475		1,091	595
N (Treated obs.)	147	213	118		324	154
N (Matched controls)	180	343	197		472	261
ATET						
SZH vs. M8	-0.085*	-0.002	0.039		-0.035	0.013
	(0.047)	(0.036)	(0.047)		(0.030)	(0.042)
N (Total sample size)	631	783	458		1,284	588
N (Treated obs.)	147	213	118		324	154
N (Matched controls)	242	387	192		540	260

	Accommodation type				**Accomm. ownership**	
	Flat	House			Tenant	Owner
ATET						
SZH vs. KZH	-0.078***	0.013			-0.057**	-0.087*
	(0.028)	(0.085)			(0.028)	(0.052)
N (Total sample size)	1,176	510			1,061	625
N (Treated obs.)	416	62			402	76
N (Matched controls)	573	143			558	274
ATET						
SZH vs. M8	-0.034	0.018			-0.005	-0.089*
	(0.027)	(0.063)			(0.027)	(0.052)
N (Total sample size)	1,513	359			1,479	393
N (Treated obs.)	416	62			402	76
N (Matched controls)	737	127			763	187

Robust Abadie-Imbens standard error in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 23: ATET for Knowledge of electricity mix, by population segment.

Outcome variable: elecRenMixKno

	Household income		**Age of respondent**		**Gender of respondent**	
	< CHF 9k	≥ CHF 9k	< 65	≥ 65	Women	Men
ATET						
SZH vs. M2	0.102	0.056	-0.043	0.405**	0.040	0.087
	(0.071)	(0.062)	(0.050)	(0.161)	(0.060)	(0.064)
N (Total sample size)	395	369	638	126	349	415
N (Treated obs.)	223	242	386	79	221	244
N (Matched controls)	112	118	186	27	103	110

	Household size				**Household type**	
	1 member	2 members	3+ members		No children	Children
ATET						
SZH vs. M2	0.070	0.199**	-0.053	-	0.145***	-0.087
	(0.092)	(0.079)	(0.121)		(0.056)	(0.084)
N (Total sample size)	250	323	191		526	238
N (Treated obs.)	136	210	119		313	152
N (Matched controls)	63	91	51		140	70

	Accommodation type				**Accomm. ownership**	
	Flat	House			Tenant	Owner
ATET						
SZH vs. M2	0.097*	0.103	-	-	0.100*	0.136
	(0.051)	(0.117)			(0.054)	(0.166)
N (Total sample size)	651	113			662	102
N (Treated obs.)	397	68			405	60
N (Matched controls)	192	35			199	29

Robust Abadie-Imbens standard error in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1

Table 24: ATET for Energy advice uptake from the SFOE, by population segment.

Outcome variable: soc7_3

	Household income		**Age of respondent**		**Gender of respondent**	
	< CHF 9k	≥ CHF 9k	< 65	≥ 65	Women	Men
ATET						
SZH vs. KZH	0.146***	0.088	0.085	-	0.128**	0.076
	(0.055)	(0.075)	(0.052)		(0.065)	(0.086)
N (Total sample size)	480	392	740	132	403	469
N (Treated obs.)	150	120	241		133	137
N (Matched controls)	178	128	244		137	127
ATET						
SZH vs. M8	0.122**	0.057	0.153***	-	0.080	0.103
	(0.056)	(0.070)	(0.045)		(0.062)	(0.065)
N (Total sample size)	627	406	901	132	509	524
N (Treated obs.)	150	120	241		133	137
N (Matched controls)	245	146	308		180	153

	Household size				**Household type**	
	1 member	2 members	3+ members		No children	Children
ATET						
SZH vs. KZH	0.115*	0.077	0.007		0.101*	0.015
	(0.064)	(0.065)	(0.120)		(0.055)	(0.097)
N (Total sample size)	249	381	242		571	301
N (Treated obs.)	82	119	69		181	89
N (Matched controls)	103	152	51		230	70
ATET						
SZH vs. M8	0.122*	0.127**	0.150*		0.112**	0.050
	(0.071)	(0.064)	(0.090)		(0.052)	(0.086)
N (Total sample size)	345	428	260		702	331
N (Treated obs.)	82	119	69		181	89
N (Matched controls)	123	191	73		279	81

	Accommodation type				**Accomm. ownership**	
	Flat	House			Tenant	Owner
ATET						
SZH vs. KZH	0.106**	-0.070			0.094*	0.000
	(0.050)	(0.139)			(0.054)	(0.120)
N (Total sample size)	647	225			595	277
N (Treated obs.)	239	31			235	35
N (Matched controls)	265	35			250	52
ATET						
SZH vs. M8	0.127***	-0.097			0.116***	0.010
	(0.043)	(0.115)			(0.044)	(0.092)
N (Total sample size)	879	154			874	159
N (Treated obs.)	239	31			235	35
N (Matched controls)	362	28			355	30

Robust Abadie-Imbens standard error in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 25: ATET for Energy advice uptake from the local energy supply utilities, by population segment.

Outcome variable: soc7_5

	Household income		**Age of respondent**		**Gender of respondent**	
	< CHF 9k	≥ CHF 9k	< 65	≥ 65	Women	Men
ATET						
SZH vs. KZH	0.096*	0.115**	0.089*	-	0.152***	0.117**
	(0.053)	(0.057)	(0.049)		(0.054)	(0.059)
N (Total sample size)	480	392	740	132	403	469
N (Treated obs.)	150	120	241		133	137
N (Matched controls)	178	128	244		137	127
ATET						
SZH vs. M8	0.032	0.025	0.041	-	0.026	-0.008
	(0.056)	(0.070)	(0.046)		(0.058)	(0.065)
N (Total sample size)	627	406	901	132	509	524
N (Treated obs.)	150	120	241		133	137
N (Matched controls)	245	146	308		180	153

	Household size				**Household type**	
	1 member	2 members	3+ members		No children	Children
ATET						
SZH vs. KZH	0.198***	0.141**	-0.060		0.131***	0.034
	(0.072)	(0.057)	(0.120)		(0.049)	(0.084)
N (Total sample size)	249	381	242		571	301
N (Treated obs.)	82	119	69		181	89
N (Matched controls)	103	152	51		230	70
ATET						
SZH vs. M8	-0.032	0.007	0.069		-0.020	0.095
	(0.078)	(0.061)	(0.091)		(0.053)	(0.078)
N (Total sample size)	345	428	260		702	331
N (Treated obs.)	82	119	69		181	89
N (Matched controls)	123	191	73		279	81

	Accommodation type				**Accomm. ownership**	
	Flat	House			Tenant	Owner
ATET						
SZH vs. KZH	0.089*	0.137			0.064	0.321***
	(0.048)	(0.116)			(0.048)	(0.107)
N (Total sample size)	647	225			595	277
N (Treated obs.)	239	31			235	35
N (Matched controls)	265	35			250	52
ATET						
SZH vs. M8	0.044	0.000			-0.023	0.224*
	(0.042)	(0.133)			(0.046)	(0.120)
N (Total sample size)	879	154			874	159
N (Treated obs.)	239	31			235	35
N (Matched controls)	362	28			355	30

Robust Abadie-Imbens standard error in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 26: ATET for Energy advice uptake from the local authorities, by population segment.

Outcome variable: soc7_4

	Household income		**Age of respondent**		**Gender of respondent**	
	< CHF 9k	≥ CHF 9k	< 65	≥ 65	Women	Men
ATET						
SZH vs. KZH	0.011	0.000	0.041	-	0.002	0.028
	(0.045)	(0.049)	(0.034)		(0.041)	(0.042)
N (Total sample size)	480	392	740	132	403	469
N (Treated obs.)	150	120	241		133	137
N (Matched controls)	178	128	244		137	127
ATET						
SZH vs. M8	-0.012	-0.005	0.014	-	-0.021	0.040
	(0.039)	(0.043)	(0.030)		(0.040)	(0.040)
N (Total sample size)	627	406	901	132	509	524
N (Treated obs.)	150	120	241		133	137
N (Matched controls)	245	146	308		180	153

	Household size			**Household type**	
	1 member	2 members	3+ members	No children	Children
ATET					
SZH vs. KZH	0.040	0.030	0.039	0.039	0.064
	(0.044)	(0.048)	(0.060)	(0.036)	(0.042)
N (Total sample size)	249	381	242	571	301
N (Treated obs.)	82	119	69	181	89
N (Matched controls)	103	152	51	230	70
ATET					
SZH vs. M8	0.001	-0.010	0.023	0.026	-0.038
	(0.050)	(0.044)	(0.052)	(0.035)	(0.054)
N (Total sample size)	345	428	260	702	331
N (Treated obs.)	82	119	69	181	89
N (Matched controls)	123	191	73	279	81

	Accommodation type		**Accomm. ownership**	
	Flat	House	Tenant	Owner
ATET				
SZH vs. KZH	0.029	0.027	0.035	0.033
	(0.035)	(0.071)	(0.035)	(0.067)
N (Total sample size)	647	225	595	277
N (Treated obs.)	239	31	235	35
N (Matched controls)	265	35	250	52
ATET				
SZH vs. M8	-0.000	0.000	-0.031	-0.048
	(0.031)	(0.085)	(0.032)	(0.089)
N (Total sample size)	879	154	874	159
N (Treated obs.)	239	31	235	35
N (Matched controls)	362	28	355	30

Robust Abadie-Imbens standard error in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1