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A) Project data

General overview	
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General overview	
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B) Project overview

1 Kurzfassung

Motivation und Projektziele

Österreichs Transformation zu einer klimaneutralen Gesellschaft steht vor der Herausforderung, Klimaziele ohne soziale Beeinträchtigungen zu erreichen BALANCE analysierte aktuelle und zukünftige Überschneidungen zwischen Klima- und Sozialpolitik im Wohnsektor. Wohnen trägt einerseits signifikant zu den österreichischen Treibhausgasemissionen bei, und spielt andererseits eine kritische Rolle in der Reduktion von sozialer Ungleichheit.

Methode

BALANCE verfolgte ein empirisches inter- und transdisziplinäres Methodendesign: Berührungspunkte zwischen Klima- und Sozialpolitik im Wohnsektor sowie vulnerable Personengruppen und Gebäudesegmente wurden mittels Sekundäranalysen der SILC 2016 Daten, einer Dokumentenanalyse von Gesetzen und Strategien, sowie Interviews mit 16 SchlüsselakteurInnen identifiziert. Standardisierte Befragungen in Wiener Gemeindewohnungen (n=415) und BezieherInnen von Unterstützungsleistungen in Graz (n=1.062) untersuchten Energieverbrauchsverhalten und Einstellungen zu Gebäudesanierung. Die Befragungsdaten wurden mittels Latent Class Analyse hinsichtlich versteckter Energiearmut und mittels Strukturgleichungsmodellen zur Akzeptanz von Verteilungsprinzipien und Umsetzungsformen von Gebäudesanierung analysiert. Ein ökonometrisches EASI Demand System Model basierend auf der Österreichischen Konsumerhebung 2004-2014 (n=22.096 Haushalte) schätzte die Anfälligkeit gegenüber Preisschocks in heterogenen Haushaltsgruppen. Ein Discrete Choice Experiment (n=76) untersuchte Präferenzen in der Kostenteilung bei Gebäudesanierung. Stakeholder wurden durch Interviews und vier Workshops eingebunden, um Politikempfehlungen zu diskutieren und zu überarbeiten.

Zentrale Erkenntnisse

Die aktuelle Klima- und Sozialpolitik fokussieren auf ihre jeweiligen Interessen innerhalb der Bundes-/Länderzuständigkeiten und berücksichtigen kaum wechselseitige Einflüsse. Im klimapolitischen Ziel der Gebäudesanierung und des Austausches von Ölheizungen sind soziale Aspekte unterrepräsentiert. Soziale Ziele sind meist zu vage als dass sie in Klimastrategien einfließen könnten. Aktuelle Politikinstrumente beachten nur oberflächlich sozio-ökonomische Rahmenbedingungen, Strukturen am Wohnungsmarkt und Wohnqualität.

Energiearmut und allgemeine Armut hängen beide mit Benachteiligungen zusammen, die durch schlechte Wohnqualität verursacht werden. Aus dem Zusammenspiel von sozioökonomischen Merkmalen und Wohnstrukturen ergeben sich drei kritische Segmente: (1) MieterInnen in städtischen Mehrparteienhäusern mit fossiler Heizung; (2) privater MieterInnen, unter denen hohe Heizkosten und schlechte Wohnbedingungen vorherrschen; und (3) hoch energieineffiziente Gebäude der Bauperiode 1945-1980. Energiesparen zur Vermeidung hoher Heizkosten (zB weniger warm heizen als notwendig) ist ein Auslöser für versteckte Energiearmut in einkommensschwachen Haushalten, die in energieineffizienten Wohnungen leben. Es besteht ein beträchtlicher blinder Fleck an Haushalten, welche diese Bewältigungsstrategien einsetzen, aber nicht als einkommens- oder energiearm eingestuft werden und daher nicht in Armutsstatistiken oder Anspruchskriterien für Unterstützungsleistungen berücksichtigt werden.

Bei der Verteilung der Investitionskosten für Gebäudesanierung werden das Verursacherprinzip und die Refinanzierung über die Energierechnung bevorzugt. Gleich hohe Beiträge für alle BewohnerInnen, eine Staffelung nach Zahlungsfähigkeit oder die Zahlung zusätzlicher Raten werden nur in Gebäuden mit hohem Renovierungsbedarf akzeptiert. Eine sparsame Einstellung, Vertrauen in den Vermieter und ein unsicheres Mietverhältnis führen zur einer höheren Akzeptanz einer Staffelung nach Zahlungsfähigkeit. Das Haupthindernis für die Bereitschaft von Mietern, in eine Sanierung ihrer Wohnung zu investieren, sind die Investitionskosten, insbesondere bei Haushalten mit sehr geringem Einkommen. Die Investitionsrendite wird über einen kurzen Zeithorizont betrachtet, ausgenommen bei unbefristeten Mietverträgen. Im Choice Experiment werden größere CO2-Einsparungen bevorzugt, mit einer Zahlungsbereitschaft von 6,47 Euro pro 1% eingespartem CO2.

Haushalte mit niedrigem Einkommen sind von einer CO2-Steuer überproportional stärker betroffen (compensation variation 2,0%) als wohlhabende Haushalte (1,1%). Verschiedene Haushaltssegmente sind über unterschiedliche Wirkungskanäle von einer CO2-Steuer betroffen, etwa je nach genutztem Energieträger. Ein Transfersystem, das weitere Haushaltsmerkmale neben Haushaltsgröße und Einkommen berücksichtigt, kann die negativen Nebeneffekte eines CO2-Steuerszenarios besser abschwächen, als die gegenwärtig diskutierten Varianten einer pauschalen oder einkommensgestaffelten Rückvergütung.

Schlussfolgerungen

Wie im BALANCE Policy Brief dargestellt, sind mögliche Designs integrierter politischer Maßnahmen: a) Kostenteilungsprinzipien für sozial gerechte Sanierungen einzuführen, b) Heterogenität der Haushalte in den Umverteilungsmechanismen der Einnahmen einer CO2 Steuer zu berücksichtigen und c) gezielte Unterstützung für vulnerable Haushalte, um soziale Härten zu vermeiden. Allgemeinere Empfehlungen umfassen 1) die Einführung von Multi-Stakeholder-Plattformen für politischen Dialog und interministerielle Zusammenarbeit, um die Integration von Klima- und Sozialpolitik zu verankern; 2) die gemeinsame Umsetzung der drei oben vorgestellten integrierten Politikmaßnahmen; und 3) die Ausrichtung der gesetzlichen Rahmenbedingungen im Wohnsektor auf eine Integration von Klima- und Sozialpolitik.

2 Executive Summary

Project rationale and objectives

Austria's low carbon transformation needs to reach climate targets without negatively impacting the social agenda. BALANCE analysed current and future intersections between climate and social policy measures in the domain of housing. Housing, on the one hand, contributes significantly to Austria's carbon emissions and, on the other hand, is pivotal for reducing social inequality.

Methods

BALANCE applied an empirical inter- and transdisciplinary framework: Critical intersections between climate and social housing policy as well as vulnerable population groups and building segments were identified by means of secondary analysis of SILC 2016 data, document analysis of legal documents and semi-structured interviews with 16 key actors. Standardised surveys among residents in social housing in Vienna (n=415) and social welfare beneficiaries in Graz (n=1062) analysed energy consumption behaviours and attitudes regarding building renovation. Survey data were analysed by means of latent class analysis to determine hidden energy poverty, and by means of structural equation modelling to determine preferences for distributional principles and procedural options in building renovation. An econometric EASI demand system based on the pooled 2004-2014 waves (n=22,096 households) of the Austrian Household Budget Survey estimated susceptibility to price shocks in heterogeneous household segments. A discrete choice experiment (n=76) determined preferences of renters in retrofitting cost allocation. Stakeholders were involved via interviews with key actors and a series of four workshops addressing different audiences in order to discuss and revise policy implications.

Main Findings

Current climate and social policy are narrowed to their own interests within their federal or provincial jurisdictions and hardly consider their reciprocal consequences. The climate policy approach towards building retrofitting and phasing out oil heating neglects social aspects. In return, social policy targets are in general too vaguely defined as to be incorporated in climate strategies. Current policy instruments only superficially incorporate socio-economic conditions, existing housing market structures and housing conditions.

Energy poverty and general poverty both relate to disadvantages caused by poor housing quality. Three crucial segments emerge at the interplay of socio-economic characteristics and housing structures: (1) tenants in urban multistory houses with non-renewable heating; (2) the private rental segment, which implies high heating costs and bad housing conditions; and (3) highly energy inefficient buildings constructed between 1945 and 1980. Energy coping behaviours emerge as a source of hidden energy poverty among low-income households living in non-renovated, energy inefficient housing. We confirm a substantial blind spot of households who engage in energy coping but are not classified as income poor or energy poor, and therefore are not recognized in poverty statistics or eligibility criteria of welfare and housing policies.

The distributional principles of polluter-pays and energy bill neutrality are preferred for allocating renovation costs. Equal-pay, ability-to-pay, and paying extra instalments to finance the renovation are only accepted for buildings in high need of renovation. A frugal mindset, trust in the landlord and renter concerns make low-income renters endorse ability-to-pay to avoid being displaced to lower-grade dwellings on a discriminating housing market. The main obstacle to renters' willingness to invest in their non-owned dwellings is the initial investment cost, in particular among lowest-income households. They consider a short time horizon for return on investment; this is mitigated for renters with permanent contracts. In the experimental scenario, participants have a preference for larger CO2 savings, with a Willingness to Pay (WTP) of 6.47 Euros per 1% of CO2 saved.

Low income households (compensation variation 2.0%) are disproportionally more affected by a CO2 tax than affluent households (1.1%). Different household segments are affected by the CO2 tax via different impact channels, such as the energy source they are using. A transfer scheme considering household attributes beyond household size and income has a higher ability to mitigate the negative side effects of a CO2 tax scenario, compared to a flat or income based transfer as discussed in the current political debate.

Conclusions

As highlighted in the BALANCE policy brief, possible designs of integrated policy measures are: a) cost sharing principles for socially fair renovations, b) the redistributive design of carbon taxes recognising household heterogeneity and c) specific support for vulnerable households to avoid social hardship. As more general recommendations, 1) the introduction of multi-stakeholder platforms seem suitable for policy dialogue and inter-ministerial collaboration to mainstream the integration of climate and social policy; 2) joint implementation of the three integrated policy measures presented above is recommended; and 3) the adaption of legislative frameworks affecting housing should be geared towards the integration of climate and social policies.

3 Motivation and objectives

Austria has set out on an ambitious pathway towards low carbon transformation. For this historical endeavour to be successful, policy fields need no longer be conceived as isolated silos, but should be harmonised and balanced in order to leverage synergies and to cushion detrimental side-effects. BALANCE took up this call and designed low carbon policy mixes that reconcile the climate and social policy arenas in the domain of housing. Housing, on the one hand, contributes significantly to Austria's carbon emissions and, on the other hand, is pivotal for reducing social inequality. Up to now, Austrian climate and social policy have been largely disconnected. Apart from the debate on energy poverty, the apparent interrelations have not yet been systematically investigated – in particular how both policy arenas target and affect overlapping population segments.

BALANCE applied an empirical inter- and transdisciplinary framework to understand climate and social policy as interlinked and mutually reinforcing fields. First, the project analysed impacts of currently implemented climate and social policies in the housing domain on both climate and social targets. Building on these insights, BALANCE designed future low carbon policy mixes that integrate measures from both policy spheres in order to align climate with social targets. The derived policy mixes were validated by multiple methods and disseminated to relevant stakeholders.

Figure 1: Contrasting the climate and social policy sphere.

4 Content and results

Note: This report features selected core findings from the scientific publications produced during the project (see Section 9); for more detailed information and comprehensive results, please refer to the respective publications and to the project website https://balance.joanneum.at/.

4.1 Targets and instruments of climate and social housing policy in Austria

In Austrian climate and social policy, the historically grown multi-level institutional context hinders the integrated design of targets and strategies that support both policy spheres. Current climate and social policy are narrowed to their own interests within their federal or provincial jurisdictions and hardly consider their reciprocal consequences. The climate policy approach towards building retrofitting and phasing out oil heating neglects social aspects. In return, social policy targets are in general too vaguely defined as to be incorporated in climate strategies. Minimum building standards are not harmonized, e.g. adequate housing conditions do not include energy efficiency standards. The interviewed key actors verify potential synergies between both policy spheres, such as thermal retrofits triggering improved housing conditions at low additional costs, or energy awareness fostering the empowerment of low-income households. Yet, the main contradiction lies between retrofitting buildings while keeping housing affordable. This raises questions of redistributing financial means and calls for accurate and effective policy instruments.

Current policy instruments only superficially incorporate socio-economic conditions, existing housing market structures and housing conditions. Renters as the predominant living situation of the energy poor are poorly addressed. Especially energy poor households on the private rental market experience high vulnerability, because Tenancy Law keeps them from demanding a retrofit from their landlord, and because they may witness more pressing problems due to multiple deprivations. Rental Law rather enables private landlords to renovate dwellings at increased social costs. The particularly inefficient segment of buildings constructed in 1945-1980 is not addressed explicitly by building renovation subsidies. Additionally, Tenancy Law neither regulates rents nor provides renter protection after retrofits in this segment. Disadvantaged households are not reached by retrofitting subsidies, because they cannot raise financing for upfront investments and often lack investment security due to time-limited tenancy contracts. The limited-profit and communal segments do offer rent regulated and comparatively affordable housing, but they are not able to supply residential space for all low-income households, as they also have to be open for mid-income households to prevent spatial concentration of poverty. Personalized support may ease the symptoms of energy poverty, but its case-by-case approach seems too costly to be up-scaled to the entire Austrian territory.

Three climate policy targets affect renters in existing buildings (BMNT and BMVIT 2018):

1. The annual rate of retrofitting existing private buildings with improved insulation shall be increased to 2% in the 2020-2030 period. Since introduced two decades ago, the retrofitting target has been pursued with subsidy programs, complemented by awareness-raising activities, e.g. training construction companies in promoting and installing efficient building technologies. There is yet no binding regulation forcing homeowners to renovate.
2. Energy awareness of citizens shall be improved. This entails empowering households to manage their own energy consumption, increasing consumer demand for energy efficient products and services, and enabling active participation of citizens on the electricity market (e.g. via self-consumption/feed-in of decentrally produced energy). Besides broad-brush public information campaigns, energy topics shall be incorporated in school curricula and target group-specific energy consulting shall be offered; these target groups are not specified, though.
3. Starting from 2025, oil-powered heating boilers aged 25 years or older shall be exchanged for heating systems using renewable energy; thus, by 2050, the entire stock of oil heating systems will be substituted. This exchange of heating systems shall be done in a socially compatible manner avoiding social hardship, "although there is no agreement on how to specify social hardship" (Interview No. 1). Similar to the retrofitting target, the portfolio of policy instruments encompasses voluntary subsidy schemes and awareness-raising among homeowners and heating engineers, but does not involve obligatory regulations or increased taxation of heating fuel.

Austrian social policy focuses on decreasing poverty and social exclusion as a cross-sectional issue. It touches a multitude of policy fields: retirement, labor market and unemployment, social insurance and health, care-taking and family but also minimum income schemes and poverty prevention; it targets disadvantaged population segments such as elderly people living alone, gender differences and single parents (BMASK 2018a, Bundeskanzleramt 2018).

1. The impact of social policy is mainly measured in the number of persons at risk of poverty, as put forward in the EU poverty reduction goals, which foresee a reduction of 235.000 people at risk of poverty until 2020. Housing is understood as a basic human need and human right and (social) housing policies are listed as important measures to combat poverty and exclusion.
2. Legal regulations at different levels create communal, limited-profit, and rent-regulated housing segments that should ensure affordable housing (Matznetter 2002; Mundt 2018). The main instruments at the federal level are rent-regulation for selected building segments within the Tenancy Law and the Limited-Profit Housing Act. Building-centered housing subsidies and

communal housing are the main instruments at the province level. The latter have a clear social focus since access criteria are usually tied to income levels. Also located at the province level are person-centered instruments such as general housing benefit payments, housing benefits as part of the minimum income scheme, and winter fuel payments.

3. Ensuring adequate housing conditions for renters is uncontested among Austrian policy makers, but there is considerable ambiguity and lacking preciseness in the definition of criteria for mold, humidity, leaking roofs or other building shortcomings. In regions with limited access to communal housing, overcrowding, i.e. a high share of household members per floor area, may also constitute inadequate conditions.

Although governance practice is firmly restricted to the actors' functions and jurisdictions within their policy silos, the interviewed key actors acknowledge cross-sphere impacts and trade-offs. Table 1 and Table 2 summarize reciprocal impacts that may arise when pursuing the respective climate or social policy targets. The climate targets of building insulation and changing heating systems play together well with the social target of adequate housing conditions; for example, thermal retrofitting of buildings in overall bad condition offers, at the same time, the opportunity to renovate derelict installations at low additional costs. Convergence arises also from raising energy awareness: Enabling households to actively manage their energy demand resonates well with the social claim to empower the disadvantaged.

Critical divergence, however, lies between refurbishing existing buildings versus decreasing poverty and providing affordable housing. Insulating building envelopes or changing heating systems may increase rents as landlords argue with improved housing quality to justify passing (part of) upfront investment costs on to their renters. Low-income residents are, in consequence, overtaxed in their financial capabilities and forced "to relocate to cheaper, low-quality housing they can still afford" (Interview No. 5).

Table 1: Impacts of climate targets on social targets.

	Decrease poverty and social exclusion	Affordable housing	Adequate housing conditions
Increase rate of retrofitting existing buildings	- Investment costs lead to increased rents - Poor residents are pushed to remaining cheap low-quality housing + Heating costs decrease, but may rise later from rebound effect + Operating costs for shared building areas decrease	- Higher costs for communities and cooperatives to provide affordable housing - Investment costs lead to increased rents + Operating costs for shared building areas decrease	+ Reduction of humidity, draft, mold + Improvement of indoor air quality reduces the risk of respiratory diseases + Increased quality of life
Build energy awareness	+ Energy literacy leads to savings in heating costs	+ Energy literacy leads to savings in heating costs	+ Venting behavior improves indoor air quality + Floor area and size of household appliances are better aligned with household needs
Phase out oil heating systems in a socially compatible manner	- Implemented last in cheap, non-premium property - Investment costs lead to increased rents - Poor residents are pushed to cheap low-quality housing + Regulations specifically targeted at low-income households allow them to catch up	+ Pursued in communal and limited-profit housing - Obligatory investments in existing buildings limit available budgets for providing new housing	+ Substituting in-flat stoves improves indoor air quality

+ = Positive, concerted, reinforcing impact. - = Negative, contradictory, hindering effect.

Table 2: Impacts of social targets on climate targets.

	Increase rate of retrofitting existing buildings	Build energy awareness	Phase out oil heating systems in a socially compatible manner
Decrease poverty and social exclusion	+ More disposable income makes it easier to cover upfront investment costs + More disposable income enables small investments and partial renovations + More disposable income increases residents' demand for high-quality housing + Renters with indefinite tenancy contracts are more willing to carry part of investments with long amortization periods - High social diversity in multistory buildings blocks investment decisions requiring unanimous votes	+ Reduction of multiple deprivation enables households to look into energy saving	+ More disposable income makes it easier to cover phase-out investment costs + Renters with indefinite tenancy contracts are more willing to carry part of investments with long amortization periods - High social diversity in multistory buildings blocks investment decisions requiring unanimous votes
Affordable housing	- Landlords have low profit margin for financing investments - Investments are postponed unless heavily subsidized or obligatory	+ Reduction of multiple deprivation enables households to look into energy saving	- Landlords have low profit margin for financing investments - Investments are postponed unless heavily subsidized or obligatory
Adequate housing conditions	+ Renovation activities may include energy efficiency improvements at low additional costs	+ Raises knowledge on efficient technologies and use	+ Improvements of indoor air quality may include non-fossil heating system at low additional costs

+ = Positive, concerted, reinforcing impact. - = Negative, contradictory, hindering effect.

4.2 Identification and characterization of energy poor households

Energy poverty and general poverty both relate to disadvantages caused by poor housing quality, thereby highlighting critical segments in buildings and residents relevant for climate and social policy efforts. This intersection with housing quality remains valid regardless of the particular definition of energy poverty or general poverty.

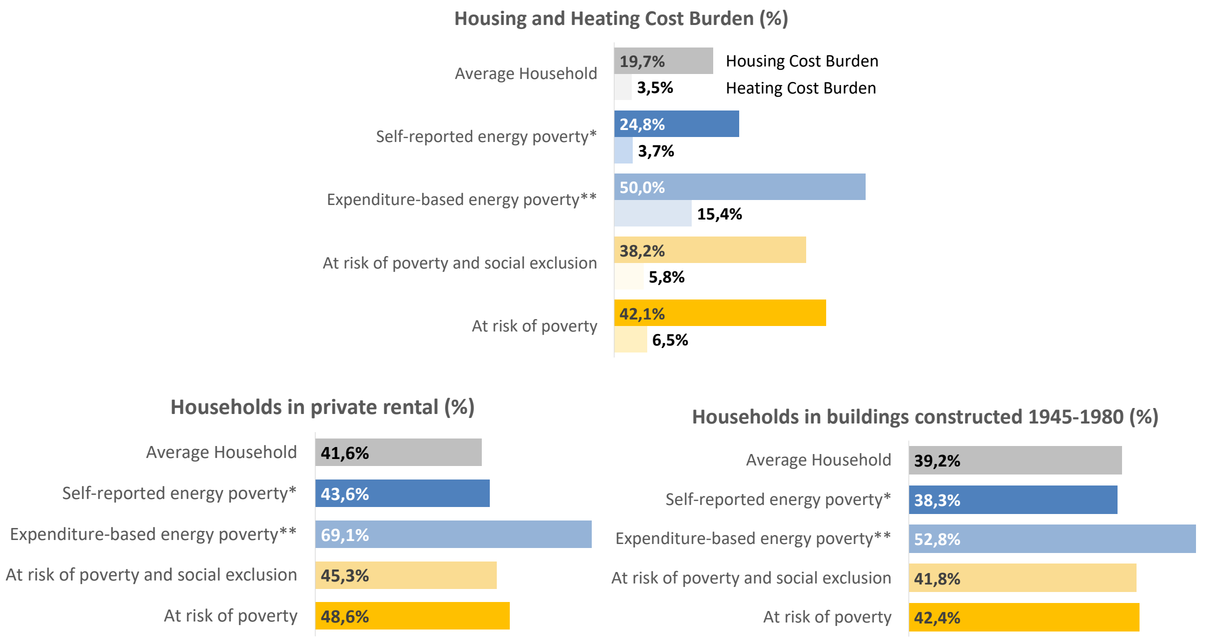
First and foremost, energy poor as well as households at risk of poverty have disproportionally high housing and heating costs. Depending on the considered definition, disadvantaged households spend a third or more of their income for housing, which brings them close to material deprivation if they cannot afford basic goods and services from their remaining income or have to cut back room temperatures. More than half of low-income and poor households live as tenants in multistory apartment houses. The almost equally high share among self-reported energy poor households suggests that bad housing conditions are very much linked to the multistory rental segment. In contrast, energy poor households defined by disproportionately high heating expenditures predominantly live in owned, detached houses with comparatively larger floor areas.

Renters on the private rental market are more exposed to structural disadvantages. High heating costs coincide with renting on the private rental housing market. In comparison to all energy poor households in renting, 69% of households in private rental witness disproportionately high heating expenditures. Also energy poor households who face problems with housing conditions and payment arrears tend to live more often in private rental (43.6%) than in other rental segments. According to key actors, two factors contribute to higher heating costs in private rental: private rental often uses gas as the main heating fuel, whereas limited-profit and communal housing commonly use district heating, which is more efficient and less polluting, but not necessarily cheaper. Unlike private rental, limited-profit and communal housing depend on subsidies that enforce stricter efficiency standards. Moreover, limited-profit and communal housing charge lower rents which enables leeways for other costs, such as higher expenses for heating. As a consequence, vulnerable groups on the private rental market need to be addressed by comprehensive policy measures, since the classic energy poverty nexus of bad housing conditions, low income and high heating costs applies in this segment.

A further disadvantage unfolds along the construction period from 1945 to 1980. Compared to other building segments, these buildings have the highest average heating demand of ca. 220 kWh/m²/a and the highest annual heating costs (Lang 2007; Umweltbundesamt 2018), and often feature insufficient housing conditions. Therefore, it comes with no surprise that energy poor as well as generally poor households more often live in buildings of this construction period than higher or mid-income groups. As buildings from this construction period constitute 47.6% of all Austrian buildings, thermal retrofitting schemes should prioritize this building segment in order to reduce carbon emissions.

At the interplay of socio-economic characteristics and housing structures, this analysis points to three crucial segments for both policy arenas to be tackled: (1) tenants in urban multistory houses with non-renewable heating; (2) the private rental segment, which implies high heating costs and bad housing conditions; and (3) highly energy inefficient buildings constructed between 1945 and 1980.

Figure 2: Intersections between housing characteristics and energy poverty.



Energy poverty has been largely studied from an economical angle focusing on the triad of above-average energy costs, low income and bad housing conditions (Boardman, 1991; Fabbri, 2015; Hills, 2012; Rademaekers et al., 2016). Using energy expenditures as a proxy can lead to a blind spot as households may underconsume to keep their energy bill manageable, i.e. by cutting down on everyday heating and by self-restricting their households needs. Coping by underconsumption may blur the lines between being classified as energy poor or not (Legendre and Ricci, 2015). For instance, accepting colder room temperatures in order to save costs may make a household pass just below the eligibility threshold for receiving winter fuel payments even though this household does not achieve an adequate level of warmth.

Energy coping behaviours emerge as a source of hidden energy poverty among low-income households living in non-renovated, energy inefficient housing. Latent class analysis (LCA) finds two distinct groups of households in Vienna and Graz: on the one hand, households showing unobtrusive energy consumption behaviour; on the other hand, households engaging in energy coping, in other words, underconsuming heating below comfortable indoor temperatures to avoid exceeding energy costs.

A substantial share of households who are captured by current poverty classifications apply energy coping behaviours (quadrant a. in Table 3). Despite their active effort of thrifty behaviours and sufficiency strategies, coping does not remedy these households' situation to lift them out of poverty. Table 3 draws attention to a significant blind spot in current poverty classifications: Across various poverty definitions, of those not considered income poor or energy poor, 30-40% do engage in energy coping behaviours (quadrant c.). These households self-restrain their energy consumption below their comfort level to avoid excessive energy costs. Households who are income or energy poor and do not cope (quadrant b.) could potentially benefit from energy counselling or nudges to lower energy consumption; however, energy saving interventions should not conflict with the household's energy needs or vulnerabilities.

Table 3: Intersection of energy coping, income poverty and energy poverty.

	Coping	**Non-coping**
Income/ energy poor	a.) Correctly identified (recognized by policy) Disadvantaged households who are captured by current poverty definitions. These households employ energy coping to remedy their situation, but coping does not suffice to lift them out of poverty. ca. 50-60% (Vienna) and ca. 30% (Graz) of all households classified as income/energy poor	b.) Energy needs not curtailed (potential target group) Disadvantaged households who are captured by current energy poverty definitions and who might benefit from counselling how to decrease energy consumption, dependent on their specific energy needs and vulnerabilities. ca. 30-50% (Vienna) and ca. 55-70% (Graz) of all households classified as income/energy poor
Not income/ energy poor	c.) Blind spot (lack of recognition) Coping households who are overlooked in current poverty definitions. Coping may keep some of these households barely over the poverty threshold. ca. 30-40% (Vienna, Graz) of all households classified as not income/energy poor	d.) Correctly identified (no aid needed) Households who do not have any problem with heating expenses and with maintaining comfortable indoor temperatures.

We confirm a substantial blind spot of households who cope but are not classified as income poor or energy poor, and therefore are not recognized in poverty statistics or eligibility criteria of welfare and housing policies. This detected blind spot applies across a range of common income poverty and energy poverty definitions. Replicating both groups of non-coping and coping households in two separate samples reflecting different housing contexts in the cities of Vienna and Graz speaks for the reliability of our results. Energy coping blurs the lines of current poverty classifications. Thus, we propose to consider coping behaviour as a fourth characteristic of energy poverty complementary to the established triad of above-average energy costs, low income and bad housing conditions in order to avoid recognition injustice.

4.3 Distributional principles and procedural options for building renovation

Making renovation work for low-income renters is a matter of sharing the costs and implementing the renovation process in a fair manner. Distributional and procedural aspects are core elements in the energy justice debate (Walker & Day 2012, Jenkins et al. 2016). Distributional justice refers to the source of inequity, i.e. the allocation of direct and indirect costs and benefits. Procedural justice refers to strategies for remediating inequity, foremost impartial, inclusive and unbiased decision-making. Procedural aspects include disclosing critical information, providing access to legal and technical basics, or treating those affected with respect.

Approaching a just distribution may follow three distributional principles (Brooks & Davoudi 2014): equal-pay, meaning that each party pays the same amount; polluter-pays, each party pays according to their consumption; or ability-to-pay, each party pays according to their capabilities and needs. Generally, households prefer polluter-pays over the other distributional principles (Groh & Ziegler 2018). Unless the renovation costs are fully borne by the state or the building owner, however, renters need to repay a share of the renovation costs over time. Repayment can be done by withholding cost savings from the energy bill, so that tenants pay the same amount as they did before the renovation (termed 'energy bill neutrality' in the present study), or by increasing rent over a given period (termed 'green lease' in the present study; Astmarsson et al. 2013, Brown et al. 2019).

Low-income households prefer the distributional principles of polluter-pays and energy bill neutrality for allocating renovation costs. Equal-pay, ability-to-pay, and paying extra instalments to finance the renovation are only accepted for buildings in high need of renovation. Presumably, polluter-pays is preferred because households are familiar with this principle as the current rule for allocating heating costs in apartment buildings. Psychological and relational capabilities play into these preferences: households holding pro-environmental attitudes favour polluter-pays to prevent free-riders. A frugal mindset, trust in the landlord and renter concerns make low-income renters endorse ability-to-pay to avoid being displaced to lower-grade dwellings on a discriminating housing market.

Table 4: Endorsement of distributional principles for sharing renovation costs.

Distributional principle	Mean	SD
Equal-pay All residents pay the same amount, regardless of income, energy consumption or situation.	2.23	1.35
Polluter-pays Each resident pays as much as he consumes in energy for heating.	3.94	1.23
Ability-to-pay-income Each resident pays as much as he can afford, depending on income.	3.46	1.35
Ability-to-pay-situation Each resident pays as much as he can manage, depending on his living situation. For example, residents with many children, those chronically ill or those with special needs pay less.	3.49	1.31
Energy bill neutrality Each resident keeps paying the same costs for heating as before the renovation. Repayment goes slowly.	3.56	1.26
Green lease Each resident pays a bit more for heating than before the renovation. Repayment goes faster.	2.79	1.28

Data: Graz household survey. Items translated from German; five-step response scale from 1=very bad to 5=very good to the question 'How do you find these options for sharing renovation costs?'

Procedural options may be implemented throughout the renovation process:

- In the *planning phase*, by providing information at renter assemblies, online, or in personal meetings with the architect; by conducting independent pre-renovation audits; by visiting demo buildings which have been successfully retrofitted; or by giving residents a saying in the renovation decision. Early participation of residents is paramount, whereas post-decision consultation may trigger protest.
- During the *construction phase*, in particular if residents stay in their homes during renovation works, by adhering to a prearranged schedule; by integrating the renovation with other building modifications; by maintaining privacy and quality of living despite the disruption by noise, dust and presence of craftspeople; or by allowing the opening of windows and use of balconies during the fitting of wall insulation.
- In the *post-retrofit repayment phase*, by detailing the tariff structure of energy bills; by enabling occupants to monitor their energy consumption; or by offering support for new energy-saving domestic practices. Regarding renovation payback and renter security, by guaranteeing minimum energy savings after the renovation; by suspending rent increases or termination of rental contracts until the renovation investment has been repaid; or by

restricting renovation efforts to short-term leases where each unit is renovated after its rental contract has expired (Castellazzi et al. 2017).

Conducting stepwise partial renovation instead of all-at-once deep renovation may stretch the cost burden over a longer period and may allow readjustment of planning to emerging needs, concerns or technological advancements (Femenias et al. 2018).

Low-income households show generally high interest in procedural options and in having a say in how renovation would be implemented in their home. Among this general call for being included in renovation decisions, information on costs and construction details stand out as most important. Households are less interested in site visits to already renovated buildings and in stepwise partial renovation over a longer period, which runs counter to the recommendation by Femenias et al. (2018) for extending refurbishments over time and therefore making them more adaptable to changing needs. Options for participation in decision-making tend to be rated as less important than the other procedural options. Possibly, households not only see the benefit, but also the potential drawback of inclusive decision-making, if a few objecting residents block a consensus vote and stall renovation.

4.4 Cost allocation of building renovation between tenants and landlords

There is currently little empirical evidence on the preferences of renters regarding retrofits and their costs and benefits. Using a discrete choice experiment (DCE), we shed light on the preferences of renters for different hypothetical retrofitting options. Table 5 shows the coefficients of our preferred specification, with standard errors in brackets and stars signifying statistical significance at the 1%, 5%, and 10% levels, respectively. These estimations are conducted purely based on the results from the Discrete Choice Experiment; the results from the estimations in conjunction with the demographic characteristics of the participants are discussed below. The first estimations contain only the alternative-specific variables monetary savings, renter cost, owner cost, and CO2 savings.

Table 5: Estimation Results

Variable	Model 1 Coefficient Estimate	Model 2 Coefficient Estimate
Intercept	-0.205** (0.096)	
Monetary Savings	0.001* (0.001)	0.001* (0.001)
Renter Cost	-0.001*** (0.0001)	-0.001*** (0.0001)
Owner Cost	-0.0001** (0.0001)	-0.0001** (0.0001)
CO_2 Savings	0.005* (0.002)	0.005** (0.002)

All of the estimates are statistically significant at least at the 10% level, with most of them also being significant at the 5% level. The coefficient estimates have the expected signs. Higher savings both in terms of energy cost and CO2 increase the likelihood of choosing a certain option, while the two investment cost variables have negative signs. As expected, the effect size of renter cost is larger than that of owner cost. While households have a preference for a lower investment cost for their landlord, their own investment costs are a much stronger factor in the decision for or against a certain choice card. For the owner cost variable, different interpretations would be possible. From a purely economic point of view, the cost for the owner should not matter for the participants' decision, which would require the coefficient estimates to be not statistically significant. However, other factors may be involved here: renters may have a preference for lower owner cost as a form of altruism, potentially due to having a personal relationship with their landlord. The opposite effect is also feasible: Renters may be willing to invest more if their landlord also invests due to a preference for sharing the investment cost in a way that they would perceive as fair. Either way, the small negative coefficient we find shows that renters have a slight preference for a lower investment cost of owners.

The intercept, which captures the alternative specific component, may appear inherently meaningless in an unlabeled experiment such as ours. However, we include it to account for a potential left-right bias, i.e. the possibility that participants have a preference for choosing the first option they see, which is the left option when reading from left to right (Chyung et al. 2018). We find that the intercept coefficient is statistically significant, which indicates the presence of left-side bias. However, the effect appears to be small, as the other coefficient estimates are virtually identical between the two specifications. For the remainder of this section, we continue with the results from Model 1.

Unlike in a regular OLS regression, the coefficient estimates depicted in Table 5 cannot be directly interpreted as percentages due to the non-linear relationship between choice probability and representative utility. However, the marginal effects can be derived, reported in Table 6.

Table 6: Marginal Effects, Model 1

Variable	Marginal Effect, in %
Monetary Savings	0.0238
Renter Cost	-0.0173
Owner Cost	-0.0029
CO2 Savings	0.1120

These marginal effects denote the change in selection probability if the accompanying attribute is increased by one unit, i.e. one Euro for the investment cost and monetary savings variables and one percent for the CO_2 savings. For example, a retrofit that is 100 Euros less expensive for the renter would, ceteris paribus, have a 1.73% higher chance of being selected. While the relationship between coefficient estimates and marginal effects is not linear, larger coefficients are still correlated with larger marginal effects, as Table 6 shows.

Based on the coefficients depicted in Table 6, we can calculate the Willingness to Pay (WTP) for the attributes used in the experiment. We can obtain the ratio for which the utility of households is unchanged by dividing one coefficient estimate by another. This ratio signifies the amount of one attribute (e.g. investment cost in Euros) that consumers are willing to give up in order to increase or decrease another attribute by one unit (e.g. CO2 savings in %). In principle, this relationship can be calculated between any two attributes.

Usually, however, a variable that is expressed in monetary terms is used as the denominator, such as renter cost in this case. Table 7 shows the mean WTP for the different attributes in Euros, obtained by dividing the coefficient estimates for the different variables by the renter cost coefficient.

Table 7: Willingess to Pay, Model 1

Variable	**WTP, in Euros**
Monetary Savings	1.38
Renter Cost	1.00
Owner Cost	-0.17
CO_2 Savings	6.47

As Table 7 shows, households are willing to pay 1.38 Euros in additional investment costs today to save 1 Euro in energy costs every year. Additionally, they are willing to invest 6.47 Euros in order to save one additional percent of CO2 in their home. The WTP to lower the investment cost for the homeowner by 1 Euro is 0.17 Euros. The WTP for the variable Renter Cost is, by definition, 1 Euro.

Based on these WTP values, we can calculate the implicit Internal Rate of Return (IRR) of the retrofitting investment. The IRR is defined as the discount rate at which someone is indifferent between investing and not investing. The IRR can be computed by using the formula

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+IRR)^t} - C_0$$

with NPV as the Net Present Value and C_t as the net cash flow in time period t. Setting NPV to 0 and solving numerically yields the IRR.

Table 8: Internal Rate of Return, Model 1

Timeframe, in years	1	2	3	4	5
IRR, in %	-27.42	28.90	51.86	62.06	67.00

The IRR depends on the assumed time horizon of the investment, which may vary between individuals. Table 8 shows the implied yearly IRR for different investment horizons. The values show that for an investment period of 2 or more years, the rate of return that participants implicitly expect grows excessively large. There could be three explanations for this, namely: 1) households have a very short time horizon when considering this investment; The WTP values imply an expected payback period of 16.5 months. This may be appropriate if renters expect to move out within the foreseeable future. 2) households strongly discount future savings, i.e. they have high discount rates. 3) households have low access to financial resources and thus would not be able to invest any substantial amount of money in the first place, which results in foregoing potential future savings in order to reduce the invested amount today.

Combining the data obtained in the DCE with the demographic data from the first survey, yields additional insights into renters' preferences. To this end, we first match the two datasets of the discrete choice experiment and the Graz survey. This reduces the sample size from 495 choice situations of 76 individuals to 422 choice situations of 65 participants. In an unlabeled experiment, individual characteristics can only be meaningfully included if they are interacted with product attributes.

The willingness to make an investment may be heavily influenced by the financial situation of a household. In particular, higher income households can be expected to be more willing, and able, to invest into retrofits. To test this hypothesis, we divide the investment cost and monetary savings by the yearly household income in the following estimations. This means that a value of 0.1 in renter costs divided by yearly income would represent investment costs of 10% of the yearly household income.

In this estimation, the values for the monetary savings and renter cost variables are not directly comparable between models due to the different units. For example, while renter costs range from 500 to 2000 Euros, renter costs divided by disposable income ranges from 0.02 to 0.42. Still, we find that the choice probabilities are sensitive to the income situation of households, with lower income participants putting a stronger emphasis on avoiding high investment costs.

As discussed previously, the implicit internal rate of return may depend heavily on the expected time horizon of the investment, which in turn is influenced by the expected future duration of occupancy by the tenant. We therefore additionally include the contract situation in our estimations. Here, we find that those with a permanent contract are more willing to invest long-term, which is what could be expected. The IRR values are lower for those with a permanent contract, which implies that these households are using a longer time horizon when planning (hypothetical) retrofit investments.

4.5 Distributional effects of carbon pricing when considering household heterogeneity

The Austrian government aims to become climate-neutral by 2040 (Österreich Bundeskanzleramt 2020). A core lever in meeting this ambitious target is the restructuring of the current tax system, based on ecological components. Although carbon taxes have several advantages, they are among the least used climate policy instruments (Carattini et al. 2018; Barrage 2020). One reason is the regressive nature of carbon and energy taxes. Pertinent studies emphasize the necessity of compensation measures when carbon taxes are introduced, but mainly focus on lump sum transfers and ignore household heterogeneity (Kirchner et al. 2019, Reanos and Wölfling 2018). In order to shed light on the role of household heterogeneity and how it steers a household's vulnerability, we investigated the distributional effects of carbon and energy taxation in Austria at a high level of resolution. In addition, we tested different transfer schemes, which consider these vulnerabilities.

The estimation results of the applied demand system for the household characteristics revealed that heterogeneity matters and that the impacts of energy price increases depend on housing attributes, socio-economic as well as socio-demographic characteristics which vary, and are even diametral, across energy goods. While a larger household size has a positive impact on the expenditures for electricity, the primary heating source has a clear impact on the heating budget share. Car owning increases the budget share on motor fuels and living in an urban area has a negative impact on expenditures for motor fuels and heating. Thus, in order to take a closer look on this issue, we derive household types capturing multiple characteristics and attributes, which steer vulnerability towards changing energy prices (as identified above).

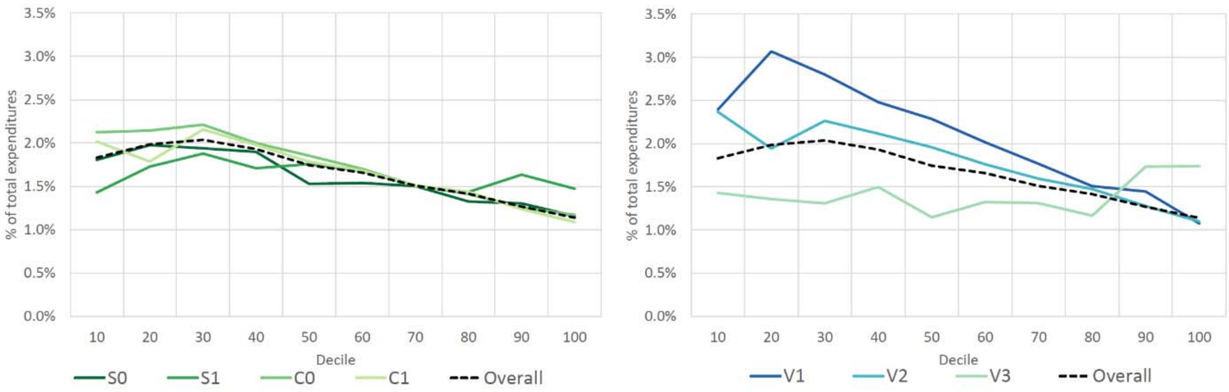
This illustrative selection of three distinct household types represent different levels of vulnerability and allows a higher level of resolution of distributional impacts. While two of the examples of household types "house-owning couple without children living in rural areas" (from here on Elderly couple rural, V1) and "family living in a rural area and car-owning" (Family rural, V2) show high vulnerability regarding energy price increases, the household type "single household in urban areas" (Urban single, V3) is among the less affected groups. These groups were compared with typical household composition groups: Single without Children (S0), Single with Children (S1), Couple without children (C0) and Couples with children (C1).

Studying a 20% price increase for each energy good separately revealed a complex picture of impacts. While electricity and heating show a regressive behaviour, motor fuels follow an inverse u-shape. Including household compositions and attributes underscores the diversity of effects and varying vulnerabilities a carbon-based taxation scheme would have. While elderly couples in lower income deciles are severely affected by an increase in the price of heating, a young family needs more compensation to cope with a price increase of electricity or motor fuels.

Additionally, our results revealed differences in urban and rural regions; however depending on the energy goods these effects feature opposite directions.

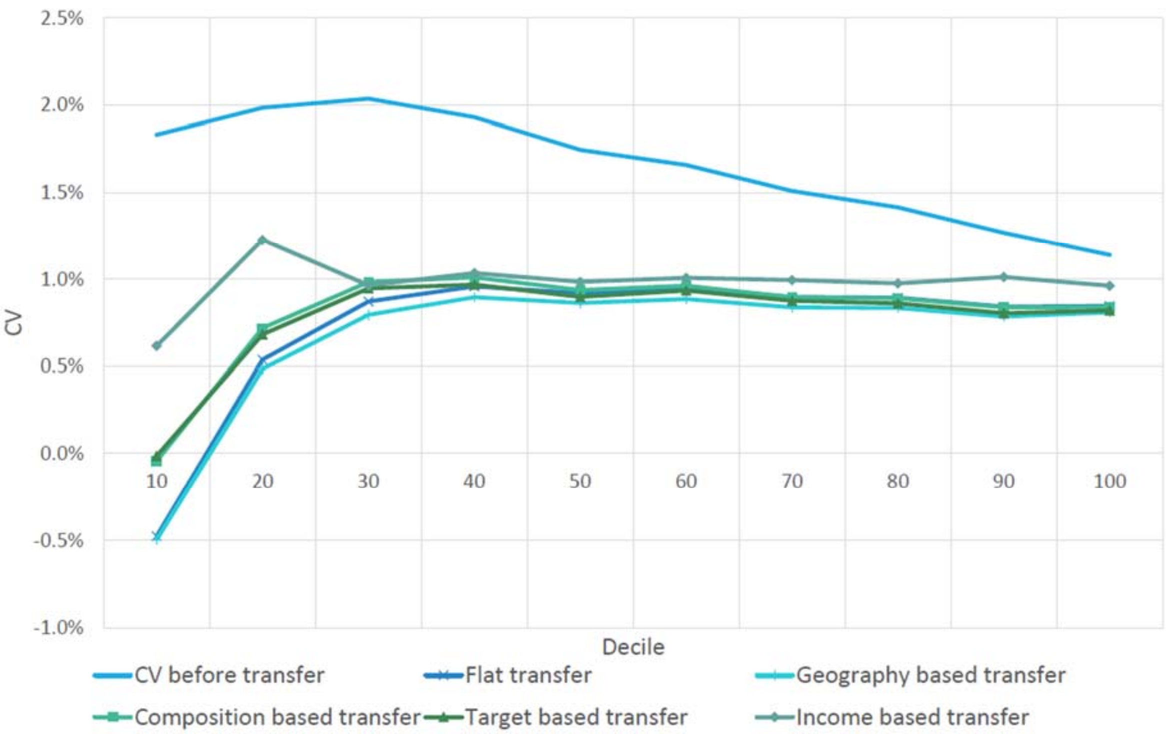
Next, we simulate a carbon tax scenario where prices of all energy goods increase according to their carbon content. The modelling of this scenario aligns itself to Berry (2018) and affects all carbon based energy sources (gas, oil, coal, motor fuel and electricity). The carbon tax rate is modelled on top of current energy prices and follows Kirchner et al. (2019) who assume a EUR 120 /tCO2 for Austria. On the one hand this tax rate is politically feasible, similar to the tax rate in Sweden (Carl and Fedor 2016) and on the other hand, it allows a comparison of results with Kirchner et al. (2019) who apply a more aggregated macro-economic perspective. The carbon tax is equivalent to price increases of between 12% and 69%. Figure 3 illustrates distributional effects of the carbon tax for both household groupings by means of the compensation variation (CV). It measures the necessary compensation a household needs to attain the initial utility level after a price change. As expected, the CO2 tax showed that low income households (2.0%) are disproportionally more affected than affluent households (1.1%). Turning to the composite-based groupings revealed a similar pattern between the groups across income, except for singles households with children. The latter are under-proportionally affected in the lower income deciles, while the extremely affluent are over-proportionally affected. A similar pattern was observed by ”Urban single” (V3) of the vulnerability-based grouping. The ”Elderly couple rural” (V1) is the most harmed, in particular in the lowest income quartile. The nature of the regressiveness of the ”Elderly couple rural” mirrors their behaviour in the stylised example of a 20% increase in the fossil-based heating price (of course, on a much higher magnitude). The analysis by means of different, heterogeneous groups underscored that households are affected by the CO2 tax via different channels. For instance, the impacts for house owning elderly couples are rooted in the price increase in heating, while for single households price increases in electricity are the dominant factor (which are relatively small). Additionally, rural households are more strongly affected in price increases of motor fuel and heating.

Figure 3 Carbon tax simulation: Effects [CV in %] of a CO2 dependent price increase across income deciles for the composite and vulnerability-based household types



Based on the identified characteristics and attributes steering a household’s vulnerability we tested five different transfer schemes in order to mitigate negative side effects and enhance equality: (i) flat cash transfer, where every household receives the same amount of governmental transfer, (ii) geography based, where the amount differs between urban and rural areas, (iii) composition based, where the amount is based on the number of persons living in the household, (iv) target based, where the amount differs based on the actual impact, that is to say further defined groups and (v) an income-based transfer that divides households into income quintiles.

Figure 4 Effect [CV in%] of different transfer schemes across income deciles



When analysing welfare effects of these transfer schemes the consideration of household attributes and socio-demographics has a higher ability to mitigate the negative side effects of a CO_2 tax scenario. Turning to equality and fairness revealed a similar picture. In comparison to the CO_2 tax scenario without compensation, all transfer schemes enhanced equality, and thus the Gini coefficient was reduced (see Table 9). Additionally, the Suits index, which measures the distribution of the tax burden across the income deciles underscores that all transfer schemes except the income based, cushion the regressive nature of the CO_2 tax scenario; some even changed it to a progressive tax scheme. This is particularly pronounced in the case of the geography based transfer. The Suits index also highlighted that the composition based and the target based are positive as well as close to zero and hence indicate a proportional distribution of the tax burden.

Table 9: Equality indices of transfer schemes

	Gini-Index	**Δ Gini-Index**	**Suits-Index**	**% of revenues**
Carbon tax scenario	0.3136		-0.1743	
Flat cash transfer	0.3099	0.0037	0.0990	68.77%
Geography based transfer	0.3098	0.0038	0.5980	71.90%
Composition based transfer	0.3102	0.0034	0.0112	64.01%
Target based transfer	0.3102	0.0034	0.0172	65.30%
Income based transfer	0.3104	0.0032	-0.0177	51.91%

The analysis of carbon pricing in combination with compensation measures revealed two important findings. First, households react differently to a price change depending on the energy source they are using. This implies that the analyzed energy goods (motor fuels, electricity and heating) cause different vulnerabilities for households. While more affluent households are hit harder by a price increase for motor fuels, lower income households are stronger affected when the price of heating increases. Second, transfer schemes focusing on household attributes that go beyond household size and income and consider the specific household vulnerabilities, show the strongest effects in terms of equality, proportionality of the tax burden and welfare. Consequently, a transfer schemes that is efficient and socially fair has to go beyond household size and income.

5 Conclusions and recommendations

Integrating climate and social policy

Enduring structural change that alleviates energy poverty is more likely by policy instruments that marry the social policy practice of reducing burdens of vulnerable groups trough redistribution with the climate policy practice of introducing mandatory standards for energy-intensive services. As the most vulnerable households in Austria are renters, the tenant/landlord dilemma is the main hindrance for achieving substantial carbon reductions in a socially acceptable manner. Resolving this dilemma implies critical tradeoffs between climate and social policy targets: Market uptake could be accelerated by weakening rent caps, easing billing regulations for heating costs, or opening maintenance reserve funds for non-repair purposes. However, this would undermine the social rationale of these regulations and may displace low-income renters to substandard housing. Potential compromise lies in curbing the monthly back payments of tenants for structural improvements by extending the duration for refinancing, as it is currently done in the Austrian limited-profit housing segment. Yet, this only works with open-ended tenancy contracts; if the time limit of the tenancy contract is shorter than the payback period of the investment, additional rules are needed to balance the contributions and benefits of individual tenants. Buildings inhabited by households with weaker financial capacity could receive correspondingly higher subsidies. Such an integrated policy dedicated to ultimately renovating the entire building stock would also benefit hard-to-reach households that cannot be identified by social eligibility criteria or even by social workers.

The multi-level governance structure in Austria, as most probably also in other European countries, still favors monolithic areas of responsibility over vertical, horizontal or even diagonal policy integration. At the federal and provincial level, poverty reduction programs should coordinate with climate change initiatives to target energy poor households. Multi-stakeholder platforms seem suitable for policy dialogue and inter-ministerial collaboration to mainstream the integration of climate and social policy in strategies, programs and budgeting. Referring to recognition justice of vulnerable groups, grass-root initiatives and multi-stakeholder platforms including welfare organizations, NGOs, energy utilities and others may offer help, advice, possibilities for policy dialogue and targeted support across policy spheres as they have context-sensitive knowledge on the difficulties faced by vulnerable households and hear their voice. As energy poverty is a cross-cutting issue, touching upon different policy fields, tackling energy poverty needs to be done on concert with other problems vulnerable households have to deal with in their every-day lives.

Recognizing the many facets of energy poverty

BALANCE does not intend to make the prolonged debate on energy poverty definitions and generic indicators even more complicated. However, observing only partial overlap between energy poverty and energy coping suggests that the binary logic of being energy poor or not used in prevalent comparative European indicators might be too simplistic. Instead, common expenditure-based and income-based indicators should be complemented by measures of how occupants actively deal with their deprived situation in order to capture the full spectrum and variability of experienced energy poverty. We suggest to include occupant behaviour as the fourth driver of energy poverty in addition to the traditional triad of above-average energy costs, low income and bad housing conditions. Thus, painting the full picture of energy poverty calls for a perspective that includes multiple top-down technical and economic as well as bottom-up every day-practices on deprivation in the access to energy services. Focusing on energy coping as an outcome of lived experiences and personal livelihoods suggests a shift from formalized indicators to local expertise in identifying and approaching those in need. Social workers or non-profit charity organizations may be familiar with the difficulties of vulnerable households; energy suppliers may draw on customer information on payment difficulties and the amount of energy used.

Yet, when addressing hidden energy poverty as underconsumption, the elephant-in-the-room question remains: What constitutes a normal comfort level, and how much does it have to be undercut to qualify as deprivation? "Normal" heating behaviour may vary between warmer and colder climatic zones, between regions with different efficiency standards and availability of central heating in the housing stock, even between individual residents with different thermal sensitivity and subjective temperature tolerance. A certain degree of conscientious heating is desirable for climate-friendly energy saving, even among low-income households. Thresholds for "normal" indoor temperatures may be set at uniform values such as 18 to 21°C, or at temperatures achievable within a specific building's technical specifications at reasonable costs. Self-reported energy coping cannot substitute for a political debate on the objective comfort level every citizen is entitled to.

Sharing renovation costs and implementing in a fair manner

From the households' perspective, distributional and procedural justice in building renovation seem not as closely connected as the energy justice literature suggests. Thus, when implementing renovation projects, distributional and procedural issues could be tackled successively instead of simultaneously, which may stretch the planning and negotiation workload over a longer period and could flatten peak demand for professional manpower in deliberative processes.

The results on material, psychological and relational drivers indicate entry points for promoting specific distributional principles and procedural options. The need for renovation influences most principles and options and therefore may act as trigger and opener for commencing a debate with residents. An urgent need for renovation may even bring the less-preferred principles of equal-pay, ability-to-pay and green lease to the negotiation table. Some low-income renters hold pro-environmental attitudes even though it could be alleged that this group has more pressing personal issues than caring for the environment. Activating these attitudes by pointing out the environmental benefits of building renovation could increase support for polluter-pays. Trust in the landlord increases support for ability-to-pay and green lease; thus, when aiming to adopt these principles, advice can be given to either start trust-building activities before announcing the renovation plans, or to prioritise those buildings where tenants and landlords already trust each other. By contrast, income does not seem a particularly precise attribute for targeting specific groups: in regard to preferences for distributional principles, income plays a marginal role; in regard to procedural options, income appears to be a proxy for social standing.

From the Discrete Choice Experiment, we find the following conclusions: 1) The main obstacle to renters' willingness to invest in their non-owned dwellings is the initial investment cost; 2) either the return on investment that renters desire is prohibitively large, or the time horizon they consider is short, i.e. less than 2 years. This is mitigated for renters with permanent contracts. 3) In this hypothetical scenario, participants have a preference for larger CO_2 savings, with a Willingness to Pay (WTP) of 6.47 Euros per 1% of CO_2 saved. The main mechanisms to promote stronger inclusion of renters in retrofitting would therefore be to: 1) lower investment costs for low-income households, e.g. through investment subsidies; 2) promote long term or permanent rental contracts so that renters have a longer time horizon for investments; and 3) advertise the potential for CO_2 savings through retrofitting.

Acknowledging household heterogeneity in the design of carbon taxes

Carbon taxes without supporting measures clearly show regressive behavior, but when heterogeneity and socio-demographics are considered, the severity of effects differs strongly and so does the impact channel: (i) welfare loss is higher in rural regions than in urban areas, (ii) age of the household members matters, with elderly households more harmed than younger ones rooted in the heating system used and age of the building and (iii) couples with children are disproportionally more harmed, mainly due to the increase in motor fuel.

Transfer schemes aim to mitigate the negative side effects of the carbon-oriented tax regime. As the most simple transfer scheme, a flat cash transfer is already applied in Switzerland as the so-termed "Ökobonus" and sits high on the political agenda in Austria. Generally, we find that every transfer scheme is able to enhance equality and cushioning negative welfare effects. Transfer schemes focusing on household size, or on particular groups who are vulnerable to price increases, show the strongest effects in terms of equality, proportionality of the tax burden and welfare. Income based transfer decreases inequality and the regressive effects of carbon pricing, but the most vulnerable groups stay undercompensated while others are overcompensated, hence fostering inequality in society. Consequently, in order to yield a socially fair energy or carbon tax regime, it is essential to take household heterogeneity into account.

Specific household types are not extremely vulnerable towards carbon pricing because of low income but as a result of characteristics like heating systems, dwelling conditions or the region they live in. Financial support schemes have the ability to mitigate negative side-effects of a carbon tax in the short term but to achieve the transformation to a carbon neutral society, other incentives and measures, such as regulatory policies, are indispensable in the long-term. Vulnerable households need financial support in the introduction phase because they are not able to free themselves from their fossil fuel dependency; at least not in the short term. This raises the issue of widespread building retrofitting for higher energy efficiency and lower heating costs. Budgeting the retrofitting of the entire building stock towards higher energy efficiency remains an open and highly controversial question in the Austrian policy debate. Some key actors propose taxes on capital, inheritances or real estate transactions to gain public revenues that may be redistributed as retrofitting subsidies; these taxes tend to affect the more affluent and would barely impair or even advance social equality targets. Extensive investments in retrofitting may stimulate green growth and may enhance low-wage employment opportunities, which poses a win-win solution for climate and social policy targets. In contrast, raising fuel taxes or green electricity surcharges bears the risk of hitting poorer households harder, as they require energy as a basic necessity and expend a large share of their income for energy costs.

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C) Project details

7 Methods and concepts

7.1 Targets and instruments of climate and social housing policy in Austria

A concurrent triangulation design (Creswell 2009) was utilized to detect critical intersections between climate and social housing policy and to connect policy targets and instruments with vulnerable population groups and building segments.

Documents of the national legislative architecture were analysed. Quantitative (legally binding) and qualitative (non-legally binding) Austrian climate and social policy targets were identified that explicitly address the housing sector or specific population groups and building segments. The selected documents comprise main national laws, regulations, strategies, party programs, coalition agreements, and major programs from national administrations as well as policy documents from non-governmental organizations. Synergies and conflicts between policy targets were mapped in a matrix following Wackerbauer et al. (2011).

Qualitative interviews with key actors (Meuser and Nagel 2009) explored policy integration between the social and climate policy sphere. The interviews were conducted face-to-face in Vienna and Graz between November and December 2018 and lasted about an hour each. Interviewees were purposefully selected based on their expertise in climate or social policy following a process of theoretical and snowball sampling. In all, 16 key actors affiliated with federal and regional authorities, NGOs, academia and energy utility companies were interviewed (see Table 10). The interviews uncovered informal aspects and reconstructed governance practice regarding gaps, barriers or overlaps between both policy spheres. Interview audio-records were transcribed and analysed by applying thematic coding.

These two analytical steps consecutively informed each other; the data were analysed separately but then specific findings were compared, cross-validated and synthesized to answer questions that one method alone could not address.

Table 10: List of interviewees.

Policy sphere	Home institution of the interview partners
Climate policy	Federal Ministry for Sustainability and Tourism, Section IV/4 Energy efficiency and buildings, and Section IV/1 Climate policy coordination E-Control, the Austrian energy market regulator Executive Office for the Coordination of Climate Protection Measures, City of Vienna Wien Energie, a communal energy utility company Environmental protection office, City of Graz Caritas Verbund-Stromhilfefonds MA 22 Environmental protection and spatial development, City of Vienna
Social policy	Federal Ministry for Labour, Social Affairs, Health and Consumer Protection, Section V European, international and social issues MA50 Housing research, City of Vienna Chamber of Labour Vienna Social welfare office, City of Graz Chamber of Labour Styria Professor, University of Vienna, Expert in Housing Wiener Wohnen (Social Housing Vienna)

7.2 Identification and characterization of energy poor households

Secondary data analysis quantified and differentiated energy poverty in Austria on the household level. A national sample of the 2016 European Union Statistics on Income and Living Conditions (EU-SILC) survey provided information on income inequality, poverty and energy poverty which was cross-referenced against housing market structures (such as legal status, construction period, housing segments) and housing conditions (such as housing/heating costs, heating system). The national microdata comprised 6,000 households, provided by courtesy of Statistics Austria.

Household surveys in Vienna and Graz collected information on energy consumption, energy poverty indicators, coping behaviours, policy acceptance, and other topics (see Table 11).

In order to identify subgroups engaging in energy coping and underconsumption, the parametric model-based clustering technique of latent class analysis (LCA) was employed (Collins and Lanza, 2010). LCA is particularly useful in capturing complex constructs when multiple behaviours are measured. It is commonly used in an explorative manner to identify unobserved heterogeneous subpopulations based on a set of observed survey items. It allocates individuals into mutually exclusive and exhaustive subgroups, each subgroup comprising households similar to members of the same subgroup and dissimilar to households in other subgroups. LCA is a person-centred technique that assumes that the population consists of different types of classes and identifies attributes the households in the same class have in common (compared to e.g. variable-centred regression analysis which focuses on associations between attributes).

Table 11: Survey methods overview.

	Vienna	**Graz**
Population	Residents in retrofitted and non-retrofitted municipal housing	Beneficiaries in the SozialCard program of the welfare office of Graz
Sampling procedure	Random sample of non-retrofitted and retrofitted buildings stratified by district	Distribution to all current beneficiaries
Data collection period	June-October 2019	July-September 2020
Distribution of questionnaires	Handed over personally at the doorstep, dropped in the mailbox, plus online option	Direct personally addressed mailing
Gross sample	N=6,500	N=9,815
Response rate	6.4%	10.9%
Net sample for analysis	n=415	n=1,062

7.3 Distributional principles and procedural options for building renovation

Mean comparisons showed how strongly low-income households agree with the various distributional principles and procedural options, using the Graz survey data (see Table 11). In further in-depth analyses (omitted from the present report, but available in detail in the BALANCE Working Paper 4), intercorrelations showed how principles and options may preclude or complement each other. The same set of material (need for renovation, income poverty, energy poverty), psychological (personal norms, frugality) and relational (trust in the landlord, renter concerns) capabilities was applied to explain the endorsement of distributional principles and procedural options in order to compare differing motivations.

Structural equation modelling was applied to analyse causal relationships between latent factors (Byrne 2010). The drivers need for renovation, personal norms, frugality, trust in the landlord and renter concerns entered the analysis as latent factors. The drivers income poverty (income, make ends meet) and energy poverty (housing expenditures, keep home warm) entered the models as single items, pursuant to the use of single indicators in energy poverty research (Karpinska & Smiech 2020). Endorsement of each distributional principle and procedural option was analysed in a separate model. Jointly entering all drivers as explanatory factors allowed the unique, stand-alone influence of each driver to be shown while controlling for the influences of all other drivers.

7.4 Cost allocation of building renovation between tenants and landlords

The Discrete Choice Experiment (DCE) was conducted between November 2020 and January 2021. Two reminders were sent in December of 2020 and January of 2021, respectively. All participants of the previous survey conducted in Graz (see Section 7.2) who had indicated that they would be interested in participating in a follow-up survey were invited to take part in the experiment. Participation was incentivised via the chance to win an online gift card. In each choice situation, participants were given two options for potential retrofits and were asked to choose the option that they liked the most. At the start of the survey, participants received an explanation that their choice was hypothetical and that no actual renovation would be made based on their choices.

The different options were characterized by four attributes with different levels. Figure 5 shows an example of a choice card used in the experiment (in German).

Figure 5: Choice Card Example

As a compromise between high retention and achieving a larger sample size, each respondent was asked to complete 7 choice cards with different attribute levels. The attribute levels were chosen based on previous literature to present realistic options to the participants. Figure 6 shows the attributes and levels. The cost savings attribute was generated dynamically based on the current energy costs of the participants, with values of 5%, 10%, 15%, and 20% of the current monthly costs, respectively.

Figure 6: Attribute levels used in the DCE

Eigenschaft	Erklärung	mögliche Werte
Einsparungen an Energiekosten pro Monat	Durch die Maßnahme wird Ihr Energieverbrauch gesenkt. Dies führt jedes Jahr zu Kosteneinsparungen für Sie. Die Ersparnis ist abhängig von Ihren jetzigen Energiekosten.	abhängig von Ihren jetzigen Energiekosten
Einmalige Kosten der Maßnahme für Sie	Diesen Betrag bezahlen Sie einmalig für die Umsetzung der Effizienzmaßnahme.	500 € 1.000 € 1.500 € 2.000 €
Kosten der Maßnahme für Ihre Vermieterin bzw. Ihren Vermieter	Diesen Betrag bezahlt Ihre Vermieterin bzw. Ihr Vermieter einmalig.	1.000 € 2.000 € 3.000 € 4.000 €
Senkung der CO2-Emissionen	Durch eine höhere Energieeffizienz werden die CO2-Emissionen vermindert, zum Beispiel durch den Einbau einer neuen Heizung.	25 % 50 % 75 % 95 %

The choice sets were generated using a balanced overlap design via the Sawtooth Lighthouse Studio Software, which was also used to host the experiment. The sample size is 76 participants for a total of 495 choice situations, out of a potential pool of 271 participants. This includes all participants who answered at least one choice situation, with 68 respondents answering all 7 of their choice cards.

To analyse the DCE, we are using a discrete choice framework, based on the random utility model (Train 2009, McFadden 1974). We work in characteristic space, which assumes that the utility of a choice or product is derived from its attributes and attribute levels. The utility of individual *n* for alternative *i* in choice situation t can be described as

$$U_{nit} = V_{nit} + \epsilon_{nit}$$

where V_{nit} denotes the deterministic component and ϵ_{nit} is the unobserved stochastic component, which is assumed to be independently and identically distributed (I.I.d.) following a Gumbel distribution. In each choice situation t, households choose the option which has the highest utility, which means that

$$U_{nit} > U_{njt}\ (\forall i \neq j)$$

Following McFadden (1974), the probability that individual *n* chooses alternative *i* can be written as

$$P_{ni} = Prob(V_{ni} + \epsilon_{ni} > V_{nj} + \epsilon_{nj} \forall i \neq j)$$
$$= Prob(\epsilon_{nj} < \epsilon_{ni} + V_{ni} - V_{nj} \forall j \neq i)$$

This type of distribution leads to a S-shaped relationship between the representative utility V_{nit} and the choice probability P_{ni} (Train 2009).

7.5 Distributional effects of carbon pricing when considering household heterogeneity

The economic assessment quantified the effects of a carbon tax and several compensating measures. Methodologically, the Exact Affine Stone Index (EASI) demand system was employed, enabling us to include socio-economics and socio-demographics of households. The model focuses on heterogeneous preferences in household consumption and how consumption is affected by different price shocks. It is an advancement of the almost ideal (Deaton and Muellbauer 1980) and quadratic almost ideal (Banks et al. 1997) demand system and, as with its predecessors, the expenditure shares are linear in parameters given real expenditures. In contrast to other demand systems the EASI demand system can have any rank and the Engel curves can have any shape over real expenditures (Lewbel and Pendakur (2009)).

In a typical demand system analysis, a cost function is specified and after using Shepard's Lemma the Hicksian demands are obtained. As a next step, one would obtain the Marshallian demand by solving indirect utility and substituting this into the Hicksian demand function. For the EASI demand system a cost function is constructed that contains a simple expression for the indirect utility (u) called implicit utility function (y). After replacing indirect utility u by the implicit utility function, the so-termed implicit Marshallian demand function is obtained. The parametric EASI cost function for empirical work has the following form:

$$C(p,u,z,\epsilon) = u + p'\left[\sum_{r=0}^{R} b_r u^r + Cz + Dzu\right] + \frac{1}{2}\sum_{l=0}^{L} z_l p' A_l p + \frac{1}{2} p' Bpu + p'\epsilon.$$

The cost function depends on the log prices p, the indirect utility u, some household characteristics z and on ϵ which equals random utility parameters and represents unobserved preference heterogeneity. In addition, b,A,B,C and D are parameters to be estimated. By using Shepard's lemma the Hicksian budget shares can be obtained which are represented by:

$$w = \sum_{r=0}^{R} b_r u^r + Cz + Dzu + \sum_{l=0}^{L} z_l A_l p + Bpu + \epsilon$$

As a last step the indirect utility function u has to be replaced by the implicit utility function y which is defined as:

$$y = \frac{x - p'w + \sum_{l=0}^{L} z_l p' A p/2}{1 - p'Bp/2}$$

It can be seen that y only depends on the observable variable x, which is the log real expenditure, the log prices p, the household characteristics z and the log Stones index p'w. Finally, after replacing the indirect utility function the budget shares take the following form:

$$w = \sum_{r=0}^{R} b_r y^r + Cz + Dzy + \sum_{l=0}^{L} z_l A_l p + Bpy + \epsilon$$

In addition, y is a function dependent on variables that arise on the left hand side of the equation and so the demand system becomes non-linear. Therefore, the system can be estimated by using non-linear GMM or iterative linear three stage least square (3SLS). The latter option is used for this analysis.

By doing so, we showed how household characteristics influence a household's vulnerability towards carbon pricing and how these impacts differ across the examined energy goods. For the analysis three waves (2004/2005, 2009/2010 and 2014/2015) of the Austrian Households Budget Survey (HBS) as well as price indices data from Statistics Austria were used. HBS is a nationally representative survey and comprises detailed expenditure data as well as socio-demographic information of around 7,000 households per wave. Our estimation was based on a pooled cross-section data set of 22,096 households, which was matched with monthly consumer price indices at a state level. For the simulation, we divided the household expenditures in eight goods (motor fuels, electricity, heating, living, food and beverages, durables, non-durables and other goods).

The evaluation is based on three measures. The compensating variation (measures the amount of compensation a household needs to attain the initial utility level after a price change), Gini-index (measure of statistical dispersion intended to represent the income inequality) and Suit-index (measures the distribution of the tax burden across the income deciles), in order to cover a broad spectrum of inequality and welfare.

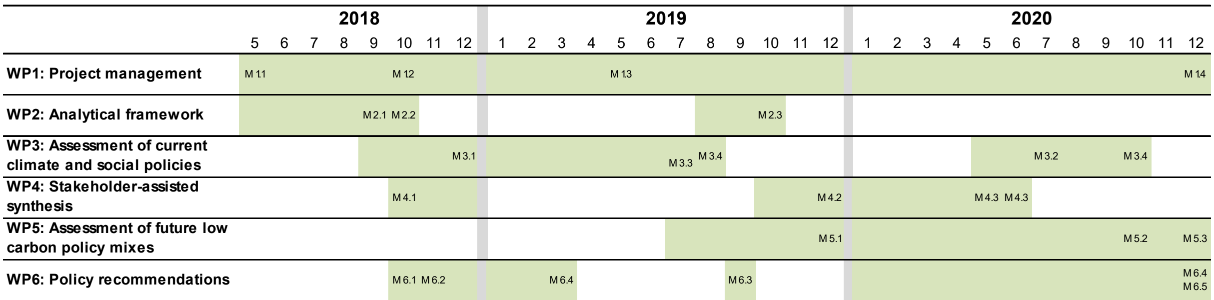
7.6 Stakeholder involvement

Stakeholder involvement and discussion proceeded in two steps: first, interviews with 16 key actors to map intersections between climate and social policy (see section 7.1). Second, four workshops directed at national and international stakeholders to discuss and revise policy implications, each workshop involving 10-15 stakeholder participants from different audiences:

- SSPCR 2019, session on "Solutions for decarbonising housing in specific target groups of residents and buildings" (predominantly housing researchers)
- Degrowth 2020, workshop on "Behaviour change and system change in the housing sector" (predominantly NGOs and activists)
- REScoop working group on building renovation, webinar on "Procedural justice in retrofitting low-income housing" (predominantly cooperatives and community projects)
- Joint stakeholder workshop with the ACRP sister project Decarb_Inclusive "Leistbares und nachhaltiges Wohnen" (predominantly public administration and interest groups)

8 Work and time schedule

The project BALANCE started in May 2018 and ended in December 2020 (project duration 32 months). It comprised of six interlocking work packages, each structured by tasks and methodological steps.



MILESTONES

WP1
M1.1: Kick-off meeting
M1.2: Project team meetings
M1.3: Interim report to Climate & Energy Fund
M1.4: Final report to Climate & Energy Fund

WP2
M2.1: Matrices of climate and social targets and indicators
M2.2: Climate and social governance landscape
M2.3: International climate and social case studies

WP3
M3.1: Data repository established
M3.2: Survey of beneficiaries of winter fuel payments completed
M3.3: Survey of tenants in social housing completed
M3.4: Ex-post policy assessment completed

WP4
M4.1: List of stakeholders completed
M4.2: First integrative stakeholder workshop held
M4.3: Second integrative stakeholder workshop held

WP5
M5.1: Calibration of EASI model completed
M5.2: Quantification of distributional + welfare effects
M5.3: Choice experiment completed

WP6
M6.1: Dissemination plan developed
M6.2: Project website set up
M6.3: Revision and re-alignment of dissemination plan
M6.4: Scientific publications submitted
M6.5: Policy briefs published

9 Publications and dissemination activities

All publications are linked and available at https://balance.joanneum.at/.

Scientific publications	
Authors, title	*Available at*
Seebauer, S., Friesenecker, M., Eisfeld, K. (2019). Integrating climate and social housing policies to alleviate energy poverty: An analysis of targets and instruments in Austria.	*Energy Sources, Part B: Economics, Planning, and Policy*, 14(7-9), 304-326.
Eisner, A., Kulmer, V., Kortschak, D. (2021). Distributional effects of carbon pricing when considering household heterogeneity: An EASI application for Austria.	*Energy Policy*, 156, 112478. doi:10.1016/j.enpol.2021.112478
Eisfeld, K., Seebauer, S. (under review). The austerity pitfall. Self-restriction in energy use as a blind spot in energy poverty classifications.	under review BALANCE Working Paper 3
Seebauer, S. (2021). How to make building renovation work for low-income renters: Preferences for distributional principles and procedural options in Austria.	*Energy Research & Social Science*, 82, 102270. doi:10.1016/j.erss.2021.102270.
Schmitz, H., Madlener, R. (2021). Preferences for retrofit investments among low income renters	submission in preparation BALANCE Working Paper 5
Scientific conferences	
Authors, title	*Presented at*
Oral presentations	
Madlener R. (2019). Zunehmende Ungleichheiten bei Einkommen und Energiekonsum in der Energiewende.	11th Internationale Energiewirtschaftstagung IEWT, 13-15 February 2019, Vienna (AT).
Madlener R. (2019). Energy Prosumage, Energy Poverty, and Energy Justice.	16th International Association for Energy Economics European Conference, 25-28 August 2019, Ljubljana (SLO).
Friesenecker, M. (2019). Coordinating climate and social housing policies to alleviate energy poverty: An analysis of targets and instruments in Austria.	Engager (COST) workshop on socio-ecological justice, 13-17 March 2019, Erfurt (DE).
Kazepov, Y., Friesenecker, M., Eisfeld, K. (2019). Équilibrer le climat et les politiques de logement social: concevoir un ensemble de politiques intégrées pour l'Autriche.	Colloque Innovation et territoires face aux inégalité, 22-25 May 2019, Rimouski (CAN).
Eisfeld, K. (2019). Balancing climate and social housing policy to alleviate energy poverty.	European Network for Housing Research: Housing for the

	next European Social Model, 27-30 August 2019, Athens.
Eisfeld, K., Kranzl, L., Seebauer, S., Müller, A., Leubolt, B. (2019). Solutions for decarbonising housing in specific target groups of residents and buildings.	3rd Conference SSPCR Smart and Sustainable Planning for Cities and Regions, 9-13 December 2019, Bozen.
Eisfeld, K. (2019). Just retrofitting!?! The interrelation of energy justice and retrofit in social housing.	3rd Conference SSPCR Smart and Sustainable Planning for Cities and Regions, 9-13 December 2019, Bozen.
Friesenecker, M. (2020). Recent trends in Vienna's social housing approach: Fostering environmentally 'just' modes of living?	ResearchLab New Social Housing, 7-8 September 2020, online.
Kulmer V. (2021). CO2-Besteuerung: Energie als Drehpunkt der Klimapolitik.	11. Klimaforum Steiermark, 1 March 2021, online.
Eisner, A. (2021). The impacts of carbon taxation on household energy consumption, welfare and inequality in Austria.	21st Austrian Climate Day, 12-13 April 2021, online.
Eisner, A., Kulmer, V., Kortschak, D. (2021). Distributional effects of carbon pricing when considering household heterogeneity: An EASI application for Austria.	International Energy Workshop (IEW), 14-17 June 2021, Freiburg.
Eisner, A., Kulmer, V., Kortschak, D. (2021). Impacts of energy and carbon taxation on household energy consumption, welfare and inequality in Austria.	International Conference on Economic Modeling and Data Science (EcoMod2021), 7-9 July 2021, Milano.
Schmitz, H., Madlener, R. (2021). Preferences for Energy Retrofit Investments among Low Income Renters.	12. Internationale Energiewirtschaftstagung an der TU Wien (IEWT), 8-10 September 2021, Vienna/online.
Poster presentations	
Seebauer, S., Eisner, A., Friesenecker, M., Eisfeld, K., Kazepov, Y. (2019). Balancing climate and social housing policies in the transformation to a low carbon society: Designing integrated policy mixes for Austria.	20th Austrian Climate Day, 25-26 April 2019, Vienna. Proceedings pp. 96-97.
Materials for non-academic audiences	
Friesenecker, M., Eisfeld, K., Kazepov, Y., Seebauer, S., Eisner, S., Kulmer, V., Kortschak, D., Schmitz, H. (2021): Wie kann der Gebäudesektor sozial-fair dekarbonisiert werden?	BALANCE Policy Brief
Seebauer, S., Sessig, E. (2020): Energiearmut und Wohnsituation von Haushalten mit geringem Einkommen in Graz.	BALANCE Factsheet
Stakeholder involvement and outreach	

Seebauer, S. (2019). Balancing climate and social housing policies.	Presentation at Joanneum Research Zukunftskonferenz, 13 March 2019, Graz
Seebauer, S. (2020). Procedural justice in retrofitting low-income housing	Presentation at REScoop European federation of citizen energy cooperatives, 29 May 2020, online
Eisfeld, K., Friesenecker, M., Kulmer, V., Mocca, E., Seebauer, S. (2020). Behaviour change and system change in the housing sector	Workshop at Degrowth Vienna – Strategies for Social-Ecological Transformation, 31 May 2020, online
Schipfer, F., Seebauer, S., Kranzl, L., Leubolt, B., Eisfeld, K., Kulmer, V., Smet, K. (2020). Workshop Leistbares und nachhaltiges Wohnen	Joint stakeholder workshop of the ACRP projects Decarb_Inclusive and BALANCE, 10 June 2020, online
Kulmer V. (2020). Soziale Auswirkungen ökologischer Steuermaßnahmen	Radio interview at FM4 Klimatalks, 18 September 2020.

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