Publizierbarer Endbericht

Gilt für Studien aus der Programmlinie Forschung

A) Projektdaten

Allgemeines zum Projekt	
Kurztitel:	Decarb_inclusive
Langtitel:	Transitioning buildings to full reliance on renewable energy and assuring inclusive and affordable housing
Zitiervorschlag:	Kranzl L., Müller A., Schipfer F., Smet K., Grabner D., Litschauer K., Leubolt B., Kautnek T., Hafner-Auinger M. 2020. Transitioning buildings to full reliance on renewable energy and assuring inclusive and affordable housing. The Decarb_Inclusive project, supported by the ACRP program. 2018-2020. www.eeg.tuwien.ac.at/decarb_inclusive
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KoordinatorIn/ ProjekteinreicherIn:	TU Wien, Institute for Energy Systems and Electric Drives, Energy Economics Group
Kontaktperson Name:	Lukas Kranzl
Kontaktperson Adresse:	Gußhausstraße 25/370-3, 1040 Wien
Kontaktperson Telefon:	0043 1 58801 370351
Kontaktperson E-Mail:	kranzl@eeg.tuwien.ac.at
Projekt- und KooperationspartnerIn (inkl. Bundesland):	WU Vienna, Institute for Institutional and Heterodox Economics (Wien) Klimabündnis Österreich Katholische Sozialakademie
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B) Project overview

1. Kurzfassung

Das Ziel des Projekts ist die Entwicklung und Analyse von Transitionspfaden hin zu einer vollständigen Dekarbonisierung des österreichischen Wohngebäudesektors durch effektive Politikinterventionen unter Berücksichtigung von Inklusion und Leistbarkeit.

Für eine Dekarbonisierungsstrategie, die sowohl leistbaren Wohnraum und soziale Inklusion garantiert, zeigt das Projektergebnis, dass ein holistischer Ansatz notwendig ist. Zudem befürworten die Ergebnisse eine allgemeine Verpflichtung zur Dekarbonisierung, die mit einer strikteren Regulierung des Mietbereichs einhergeht. Nur so kann energieeffizienter und CO_2-neutraler Wohnraum sich relativ schnell als Standard etablieren und der ganzen Bevölkerung zur Verfügung gestellt werden.

Das Projekt integriert unterschiedliche wissenschaftliche Disziplinen und Ansätze: (1) techno-ökonomische Bottom-up Modellierung des Gebäudebestands und dessen Energiebedarf sowie energiesystemische Analysen, (2) kritische politische Ökonomie und (3) Politikwissenschaft werden mit (4) transdisziplinären Methoden verschränkt.

Die Ergebnisse dieses inter- und transdisziplinären Projekts richten sich vor allem an politische EntscheidungsträgerInnen auf kommunaler, regionaler und nationaler Ebene. Indem technische Aspekte der Transition im Wohngebäudesektor im Zusammenhang mit deren sozialem Kontext diskutiert werden, werden Entscheidungsträger darin unterstützt, effektive Dekarbonisierungsstrategien zu entwickeln, die auch die Aspekte der Leistbarkeit und Inklusion berücksichtigen.

Um jedoch nicht nur zur bestehenden theoretischen wissenschaftlichen Debatte beizutragen, sondern auch zu zeigen, wie die Theorie in der empirischen, inter- und transdisziplinären Forschung zur Anwendung kommen kann, wurden aktiv Stakeholdern in den Forschungsprozess eingebunden. Das Klimabündnis Österreich und die Klimabündnisgemeinden spielten in dem Prozess eine wesentliche Rolle.

Bei einer österreichweiten Ausschreibung wurden dafür gemeinschaftliche Bauprojekte gesucht, die leistbares Wohnen, Klimaschutz und sozialen Zusammenhalt fördern. Aus über 30 Einreichungen wurden im eigens dafür ausgeschriebenen „NaWo Award" vier Gewinnerprojekte prämiert. Ihre Erfahrungen und Wissen flossen über Fokus Gruppen und Interviews ein. Die Wohnprojekte KliNaWo in Feldkirch, Sonnengarten Limberg in Zell am See, Bikes and Rails in Wien und das Haus of Commons in Innsbruck repräsentieren eine gute Balance zwischen Ökologie, Leistbarkeit und sozialer Inklusion. Details zu den

innovativen Praxisbeispielen finden Sie unter https://www.klimabuendnis.at/aktuelles/na-wo-award-preistraeger.

Um die Treffsicherheit von Politikinterventionen zu garantieren, hat das Projekt den institutionellen Kontext der Bereitstellung von Wohnraum analysiert. So konnten fünf sozio-ökonomische Wohnstrukturen identifiziert werden: Eigentum-Nutzer von Ein- und Zweifamilienhäuser, Eigentum-Nutzer von Wohnungen, private Miete, gemeinnützige Miete, und Gemeindewohnungen. Trotz dieser deutlichen Klassifizierung sollte die gegenseitige Wechselwirkung zwischen diesen Strukturen nicht vernachlässigt werden.

Die Möglichkeiten und Implikationen einer vollständigen Dekarbonisierung wurden sowohl für Österreich sowie für Gemeindetypen berechnet, die jenen der „NaWo Award" Gewinner entsprechen. Die Ergebnisse wurden dafür erstmals auch auf unterschiedliche Kombinationen aus Gebäude- und Bewohnertypen heruntergebrochen. Strukturen zur Bereitstellung von Wohnraum wurden identifiziert und analysiert, um die speziellen Anforderungen, Rahmenbedingungen und Möglichkeiten einer leistbaren und inklusiven Dekarbonisierung greifbar zu machen und zu modellieren. Die Unterscheidung zwischen Ein- und Mehrfamiliengebäuden erscheint vor allem im österreichischen Kontext genauso wichtig, wie die Unterscheidung zwischen privat vermietetem Wohnraum, gefördertem Wohnen und von Eigentümern genutzten Wohnraum.

Um zusätzlich Raum für Inklusion zu schaffen, können auch anhand der „NaWo Award" Gewinner Beispiele sozialer Innovation aufgezeigt werden. Zentrales Merkmal war die Verbesserung sozialer Beziehungen: Enge Zusammenarbeit von Akteuren, die zuvor nicht koordiniert oder sogar argwöhnisch miteinander umgingen, war besonders wichtig. Ein ebenso wichtiger Aspekt sozial-ökologischer Innovation ist die gemeinschaftliche Nutzung von Räumen: Ein gemeinschaftliches Gästeapartment erspart Gästezimmer und kostengünstiger Zugang zu urbanem Wohnraum für Jugendliche wird durch Co-Housing mit älteren Menschen und Kompensation für Hilfeleistungen ermöglicht.

Eine vollständige Dekarbonisierung des österreichischen Gebäudesektors erfordert neben einer konsequenten Sanierungsstrategie, um in etwa eine Halbierung des Energiebedarfs zu erreichen, einen breiten gebäude- und siedlungsspezifischen Mix integrierter erneuerbarer Wärmeversorgungssysteme. Dieser Umstieg wird basierend auf den Projektergebnissen als möglich und leistbar bewertet.

Kostentreiber im Wohnbau sind nicht Dekarbonisierungsmaßnahmen, sondern Dynamiken des Immobilienmarkts wie z.B. eine erhöhte Nachfrage nach Wohnimmobilien als Ferienwohnungen oder Investition(‚Betongold'). Es zeigt sich, dass vor allem ein Sanierungsgebot, insbesondere im Mietensektor dazu beiträgt, den Druck einer zukünftigen CO_2-Besteuerung auf einkommensschwache Haushalte zu verringern und so gleichzeitig den Zielsetzungen von Leistbarkeit, Inklusion und Dekarbonisierung gerecht wird.

2. Executive Summary

The aim of the project is to develop and analyse transition pathways towards complete decarbonisation of the Austrian residential building sector through effective policy interventions that take into account inclusion and affordability.

The results of this interdisciplinary and transdisciplinary project are primarily aimed at political decision-makers at local, regional and national level. By discussing technical aspects of transition in the residential building sector in the context of its social context, decision-makers will be supported in developing effective decarbonisation strategies that fully consider important issues of inclusion and affordability.

For a decarbonisation strategy that guarantees both affordable housing and social inclusion, the project outcome shows that a holistic approach is necessary. The results advocate a general commitment to decarbonisation, accompanied by stricter regulation of the rental sector. Only in this way can energy-efficient and CO_2-neutral housing establish itself as a standard and be made available to the broader population.

The project integrates different scientific disciplines and approaches: (1) techno-economic bottom-up modelling of the building stock and its energy demand as well as energy system analyses, (2) critical political economy and (3) political science are intertwined with (4) transdisciplinary methods. However, in order to not only contribute to the existing theoretical scientific debate but also to show how the theory can be applied in empirical, interdisciplinary and transdisciplinary research, the research process actively engaged stakeholders and practitioners, whose insights offered valuable contributions to project outcomes.

The Austrian Climate Alliance and the Climate Alliance communities played an essential role in this process. In an Austria-wide call for best practice examples, we sought to identify joint building projects that promoted affordable housing, climate protection and social cohesion. From more than 30 submissions, four winning projects were awarded the "NaWo Award", which was specifically created for this purpose: the housing projects *KliNaWo* in Feldkirch, *Sonnengarten Limberg* in Zell am See, *Bikes and Rails* in Vienna and the *Haus of Commons* in Innsbruck represented a good balance between ecology, affordability and social inclusion. The knowledge and experience garnered through these projects were incorporated through interviews and focus groups. Further details of the innovative, practical examples can be found at https://www.klimabuendnis.at/aktuelles/na-wo-award-preistraeger.

In order to ensure the effectiveness of policy interventions, the project analysed the institutional context of housing provision. Five socio-economic housing structures were identified: owner-occupiers of (semi-)detached houses, owner-occupiers of flats, private rentals, non-profit rentals, and municipal social housing. Despite this clear classification, the variance within the structures and the mutual interaction between them remains an important consideration.

The possibilities and implications of full decarbonisation were calculated both for Austria as a whole and for community types corresponding to those of the "NaWo Award" winners. For the first time, the results were also broken down into different combinations of building and resident types. Structures for the provision of housing were identified and analysed in order to make tangible and to model the special requirements, framework conditions and possibilities for affordable and inclusive decarbonisation. In this case, the distinction between single-family and multi-family buildings was revealed to be as important, especially in the Austrian context, as the distinction between privately rented housing, subsidised housing and owner-occupied homes.

In order to create additional space for inclusion, examples of social innovation are illustrated by the "NaWo Award" winners. A central feature of these examples was the improvement of social relations: close cooperation between actors who had previously been uncoordinated or even suspicious of each other was particularly important. An equally important aspect of social-ecological innovation was the communal use of space, such as the inclusion of a communal guest flat in a building – a solution which then limits the requirement and demand for guest rooms in individual units. Inexpensive access to urban living space for young people can also be made possible through co-housing with older people with compensation for assistance.

Cost drivers are also of critical importance in helping to understand the choices that influence behaviour in the housing sector. The project found that it is not decarbonisation measures that are driving costs in the housing construction sector, but rather the dynamics of the real estate market, especially with regard to increased demand for residential property as holiday homes or investment property ('concrete gold').

It is shown, above all, that a mandatory refurbishment requirement, especially in the rental sector, helps to reduce the pressure of future CO_2 taxation on low-income households, thus simultaneously meeting the objectives of affordability, inclusion and decarbonisation. Complete decarbonisation of the Austrian building sector, however, requires not only a consistent renovation strategy in order to roughly halve the energy demand, but also a broad mix of integrated renewable heat supply systems specific to buildings and settlements. Based on the project results, this changeover is deemed both possible and affordable.

3. Background and ambition

The Sustainable Development Goals (SDGs) aim at promoting social, economic, and ecological sustainability. The New Urban Agenda, based on the 11th SDG, acknowledges access to housing as a basic right to be provided to all citizens (UN, 2016a). At the same time, it underlines the importance of reducing air pollution and, therefore, commits authorities in cities and municipalities to increasing the share of renewable energy in line with the 7th SDG on affordable and clean energy. Considering the role of buildings in Austria's gross energy consumption — close to 30% (Statistik Austria, 2018a) — efficiency, sufficiency and consistency measures, including comprehensive retrofitting campaigns, energy-efficient (re-)construction and a shift to renewable heating systems are crucial. Only with this combination of measures will Austria be able to meet the goals of the Paris Agreement (and the 13th SDG). It also addresses the reduction of inequality which, according to the 10th SDG, includes the promotion of "appropriate legislation, policies and action in this regard" (UN, 2016b). It adds the additional dimension of "transitioning buildings research", demonstrating a move towards inclusive and affordable housing.

It is impossible to underestimate the importance of housing for our society. Housing represents a central juncture in society; an arena where multiple factors — legal, political, economic, social, technological, geological, geographical and psychological — come together. This is also acknowledged by the New Urban Agenda of the UN (UN, 2016a), which states that access to housing is a basic right of all citizens and fundamental to enjoying an adequate standard of living. It also connects access to housing to issues of social inclusion, e.g., access to food, culture, public services such as health, education and public space, and transport. The topic of housing accessibility is closely linked to the cost of housing. Data provided by the Austrian Federal Bank (OeNB, 2018) shows that between 2000 and 2017 the overall price of residential property increased by 87% without indicating a price dip in the wake of the financial and economic crisis of 2009. In addition, rental costs increased by 43.5% between 2005 and 2017 (Statistik Austria, 2018b). Simultaneously, the gross median wage income increased by 32.7% from 2000 to 2017 and by 23.37% from 2005 to 2017 (Statistik Austria, 2019). From a macroeconomic perspective, it is clear that housing has become more expensive.

The New Urban Agenda also stresses the sustainability of human settlements, and the need to "minimize their environmental impact" (UN, 2016a). This, in conjunction with the Paris Climate Agreement, requires national governments to implement ambitious decarbonisation strategies (Rogelj et al., 2016). Within this context, the housing sector is said to play a key role, since, from a technological standpoint, it offers large potential for reductions in energy use and carbon emissions (Herring, 2009). Due to the longevity of housing units, it is clear that this decarbonisation has to be implemented within the existing stock. Unfortunately, despite a decade of political rhetoric on the issue of decarbonisation

measures in Austria, current refurbishment rates will not suffice to reach full decarbonisation within the next 30 years. While there is clear potential in the decarbonisation of residential buildings, this occurs in a social context of increasing housing costs to the detriment of social inclusion.

The Austrian commitment to climate goals is complemented by a government programme that aims to achieve climate neutrality by latest 2040 with net-neutral electricity generation by 2030. Refurbishment rates are to reach a 3% yearly quota, and the utilization of heating oil, coal and natural gas are to be phased-out by 2035. Full decarbonisation of the heating market is to be planned as part of a broader heating strategy (ÖVP and Die Grünen, 2020).

On an EU level, several directives have been enacted to achieve decarbonisation goals by increasing the energy performance of the building sector. The most relevant directive — next to the renewable energy directives and the energy efficiency directive — is the energy performance of buildings directive EPBD (2018/844/EU). The EPBD obliges Member States to decarbonise their building stock by 2050, with realistic intermediate targets. It was already established in previous legislation that all new buildings would have to achieve a "nearly zero-energy buildings" standard by the end of 2020, although the definition of this remained somewhat vague and was left to the responsibility of each individual Member State.

Key project objectives

A key objective of this current project was to develop and analyse pathways towards full decarbonisation in Austria, which, through effective policy interventions, would assure a housing sector that was both inclusive and affordable. Given the complexity of the subject matter, the project opted for a transdisciplinary approach combining technical and social sciences with the active involvement of residential real estate practitioners.

More specifically, the project objective can be broken down into five key aspects:

(1) **Housing**: The project focused on renovation and new construction of residential buildings. We focused on the energy system boundary applied in building codes by taking into account the whole energy performance of the building, and all energy end-uses which are directly linked to the building, such as hot water preparation and cooling. Household electric appliances such as those used for telecommunication, computing, entertainment and cooking are not included.

(2) **Full decarbonisation**: The target of full reliance on renewable energy is unambiguous. However, certain challenges are present when it comes to decarbonisation at the interface of the building and the energy supply network. Focusing on buildings, we analysed these interfaces on the basis of existing decarbonisation scenarios over a timeframe of 30 years from 2020 to 2050.

(3) **Affordability:** This primarily refers to monetary factors such as the ratio between household income and housing expenditure. The project focused on the

economic structures of housing provision and the driving factors, including the various social actors involved. Inclusion also considers non-monetary locational factors. As energy-efficient thermal renovation often leads to increasing house prices, the dangers of gentrification, as well as social polarisation and fragmentation, had to be considered. Socially and environmentally sustainable solutions need to be innovative if they are to solve the trade-off between decarbonisation of housing and social inclusion.

(4) **Policy interventions**: The Austrian multi-level governance framework for housing was analysed, and the relevant political frameworks at European, national, regional and local levels were identified. This enabled us to work with four best practice models of Climate Alliance municipalities, analysing the potential for — and limits of — social innovation in sustainable housing and its institutional underpinnings.

(5**) Transdisciplinary research**: Effective policy interventions have to consider practical realities of regional and municipal policymakers and other relevant stakeholders such as residential property developers and civil society organisations. These groups were not only the target of dissemination efforts but were actively involved in the research process, particularly across the four selected best practice municipalities.

4. Project content and results

The main activities of the ACRP Decarb-Inclusive project are illustrated in the work package structure in Figure 1.

WP2 provided the required framework conditions and constraints for the transition pathways analysed in WP3, WP4, and WP5. These three work packages (WP3-WP5) were the analytical backbone of the project. In close interaction, the techno-economic decarbonisation pathways were delivered (WP3), the structure of housing provision and implications for affordable solutions were analysed (WP4) and multi-level governance of social innovation and social inclusion were addressed (WP5). While all these WPs received inputs from WP2, they partly also built on each other. WP3, for example, provided cost data on building renovation to WP4 where they were used to assess affordability. Furthermore, WP6 guaranteed a broad science-society interface, in particular in the context of Climate Alliance municipalities. WP1 and WP7 were dedicated to project management and dissemination, respectively.

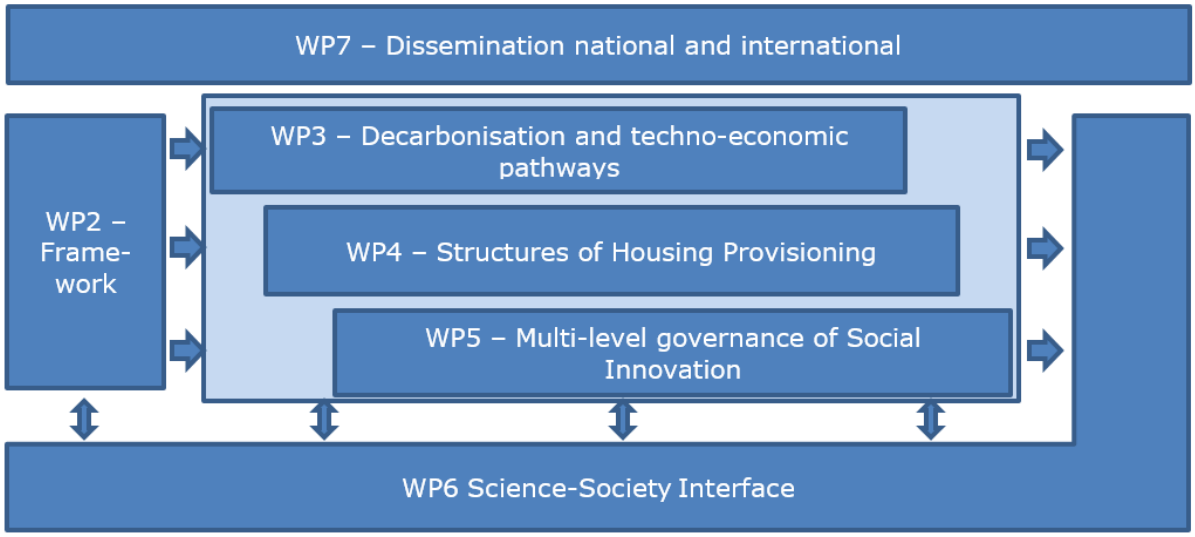

Figure 1: Structure of work packages and methodological steps of the ACRP Decarb-Inclusive project.

4.1. Framework, targets and constraints in housing transition

In June 2019, we published a comprehensive report on the interdisciplinary framework on the project website. The working paper D2 of the ACRP Decarb Inclusive project (Kranzl et al., 2019) addresses (1) policy targets and their possible implications on transition pathways of the building stock, (2) the specific demographic and socio-economic context in Austria and (3) physical constraints regarding renewable energy potentials and energy efficiency.

Relevant policies are discussed in detail in the report and based on five levels, summarized in Table 1. Next to the relevant climate and energy policies at the time of writing of this first Decarb-inclusive working paper, policy targets regarding

social inclusion and affordability were also addressed. This included examining public spending on housing, international comparisons of ownership status, as well as data on housing affordability and severe housing deprivation. In additional sections, housing-related policy targets and provisions, including the development of the housing subsidies (Wohnbauförderung), the non-profit housing law (Wohnungsgemeinnützigkeitsgesetz) and tenancy law (Mietrechtsgesetz) were addressed.

Table 1: Policy focus of the framework – work package published in 2019.

Municipal level (Gemeinden)	Regional level (Bundesländer)	Austria - national	European Union (EU)	Beyond EU
Climate Alliance programs	Regional climate and energy programs, protection plans and strategies	National Energy- and Climate plan	Energy performance of builings directive	Sustainable development goals (SDGs)
e5 program	Energy autonomy plans	Climate and Energy Strategy – Mission 2030	Renewable energy directive	Paris Agreement
Climate and energy modell regions	Housing-, energy- and environment subsidies	Renovation offensive	Energy efficiency directive	
	Housing Promotion (Wohnbauförderung)	Energy taxes		
	Limited-Profit Housing Law (Wohnungs-gemeinnützigkeitsgesetz)	Tenancy Law (Mietrechtsgesetz)		

Regarding the demographic and socio-economic context, we outlined the impact of declining birth rates and improved life expectancy on Austria's changing demography, showing the highest growth rates in the 55+ age category. The number of households has tended to grow at a much faster pace than the population as a whole, with a general trend towards more, smaller households, with single parents, unmarried cohabitating couples and single-person households.

Developments in the construction industry were also relevant to this study. The Austrian welfare state is characterised as conservative-corporatist, with little focus on direct cash transfers to low-income households to pay for market-provided housing. Austria instead has a strong tradition of subsidies for the construction industry to support the building of new social housing units. Our analysis drew on key data, including persons employed, turnover index and deflated production, as well as analysis of construction prices and costs in relation to GDP.

Living conditions of households based on the weighted mean total disposable yearly household income for Austria and for different federal states are discussed and their tenure status analysed. This information is set against housing prices using residential property price indices and rental costs. A detailed analysis of the Austrian domestic property ownership structure based on 2011 census data and the current micro-census provides an overview of how the available data were used to address issues including urbanisation and investment decisions for renovation measurements.

In the final section of the working paper, we addressed the projections for renewable energy as well as the potential and the limitations of achieving energy efficiency in the housing sector. We identified a current usage for bioenergy applications in a magnitude of about 245 PJ (about $2*10^7$ t) and found that, based on various feedstock types, we can project a rise to 307 PJ-421 PJ by 2030. Lowest energy densities are discussed in the form of ambient heat, and we illustrated coefficients of performances of ground-source and air-source heat pumps, finding that, by 2050, approximately 41 PJ of heat is expected to be supplied by heat pumps (31% of the total gross floor area), which will have to be powered by renewable electricity. For the greening of the gas grid, we outlined projections for biomethane and renewable hydrogen. Several studies report projections for space heating in the range of 4 PJ-52 PJ. This would be based on biomethane from biogenic residuals and be subject to strict constraints regarding gas-grid connection and the utilisation of biogas in other sectors with fewer options to phase out fossil fuels.

4.2. Science-Society Interface: The "NaWo Award"

The objective was to engage in transdisciplinary research by actively engaging stakeholders and decision-makers in Austrian housing policy. Active involvement began with a nationwide call to find four best practice examples for socially and environmentally sustainable housing in Austria. The process (further details below, in Section 6.5) led to the selection of four best practice examples, with whom we initiated a process of transdisciplinary research:

Table 2: The „NaWo Award“ winners of the ACRP Decarb-inclusive project

KliNaWo (Feldkirch, Vorarlberg)
An ambitious research project by different stakeholders set the stage to construct a three-story multiple-family building with 18 dwellings and spacious communal areas. It was renovated as part of a non-profit housing project (a cooperation between the Chamber of Labour, an environmental agency and a prominent limited-profit building company) with the aim to improve energy efficiency and increase its renewable energy shares. Based on more realistic assumptions concerning the longevity of buildings, they noted that ecologically sustainable buildings are also cost-effective.
Bikes and Rails (Vienna)
Next to the new central railway station, a timber-framed passive house was erected. The building was optimised for bike accessibility and ecological architecture. The 18 dwellings and common space, as well as a shared flat for refugees, are part of the habiTAT-renting houses syndicate which aims at ensuring self-governed and affordable space and prevents the resale and commercial exploitation of the property.
Sonnengarten in Limberg (Zell am See, Salzburg)
Since 2017 a total of 79 subsidised rentable dwellings, one guest apartment and 61 subsidised owner-occupied and 38 exclusively owner-occupied flats have been built. The complex includes local food provisions, childcare facilities, multiple functioning spaces, common gardens and other amenities. Centralised pellet heating and a local heating network, as well as PV-installations, cover the energy demand of the community.
Haus of Commons in Innsbruck (Tirol)
A fully renovated building from the early 20th century in Pradl, Innsbruck consumes heat and electricity based on 100% renewable sources using centralised heat pumps and solar thermal storage. Appliances, games, books and sports devices are shared between the different households, and a common garden supplies them with recreational space.

The focus groups primarily served to engage in a dialogue with the stakeholders responsible for the best practice projects. The project team presented the outline of the project and preliminary results concerning possibilities for decarbonising the municipalities where the projects are situated. In return, the stakeholders presented the most important details concerning their experiences and engaged in lively dialogue among themselves and with the researchers on how they tackled the main challenges and shared their specific practical insights.

4.3. Structures of housing provisioning (SHP)

A comprehensive report on the Structures of Housing Provision (SHP) was published and broadly disseminated in October 2020 (Smet et al., 2020).

Far from being an ordinary consumption good, housing fulfils a key role in social and economic processes and is embedded in broader institutional arrangements (Aalbers and Christophers, 2014). SHP helped us to address this complexity, dealing on the one hand with the implementation of decarbonisation measures and, on the other hand, with its effects on households. To structure this complexity, we focus not only on the main agents but also on the three functions

of an SHP: production, distribution and consumption. This approach acknowledges that, although SHPs are social constructs based on cooperation, they also imply potential conflict. This is especially relevant with respect to the measures of decarbonisation since they are likely to have broader repercussions and may spur resistance by vested interests.

A Structure of Housing Provision (SHP) is a specific constellation of social relations between social agents that produce, exchange, distribute and use a built environment (Ball, 2003, 1986, 1985; Ball and Harloe, 1992). SHPs are not defined by tenure type (although tenure type is a relevant factor) but are rather located in a specific historical context and are subject to change. Different SHPs coexist and are subject to interdependencies. In fact, an SHP is always in flux, changing to some moderate extent in response to a variety of factors.

Ball's initial approach has also been subject to critique. Responding to this, Ball seemed rather anxious to present the core framework of the SHP approach as a neutral tool which can be and needs to be employed flexibly in conjunction with various current theories on housing and the built environment (Ball, 1998; Ball and Harloe, 1992). Nevertheless, despite this supposed flexibility and lack of theory, there are several key assumptions inherently present within the SHP framework:

i. In housing-related issues, the spheres of production, exchange and consumption are inherently linked;
ii. Housing provision is a physical as well as a social process;
iii. Housing provision is continually subject to change.

Considering these three points, Ball's SHP approach seems to complement original institutional economics, not least since the latter has a "strong impetus to specific and historically located approaches to analysis" (Hodgson, 1998) p.168.

It should be clear by now that the main functions of an SHP are the production, distribution and consumption of housing. These functions are provided by networks of agents, each of which fulfil different tasks. At the same time, an SHP is embedded in a wider societal context and subject to regulations. Table 3 provides an overview of an SHP.

Table 3: Structure of Housing Provision framework

<table>
<tr><td rowspan="6">REGULATION</td><td rowspan="6">Agents: (supra-)national, regional and local government bodies</td><td>PRODUCTION</td></tr>
<tr><td>Agents: developers, landlords, construction industry, building materials producers, professional service providers</td></tr>
<tr><td>DISTRIBUTION</td></tr>
<tr><td>Agents: landlords, real estate agents, social housing providers, investors</td></tr>
<tr><td>CONSUMPTION</td></tr>
<tr><td>Agents: owner-occupier or rental households, special interest groups</td></tr>
</table>

By means of this framework, we identified key agents within the provision of housing, which we subsequently contacted to conduct semi-structured expert interviews. Interviews were structured according to three main themes, although each interview was based on its own unique dossier. First, the role of the respective agent within housing networks was addressed. Secondly, the feasibility of decarbonisation measures was assessed. Thirdly, recent price developments were contextualised, and price effects of decarbonising were evaluated.

Based on the information provided, we identified five distinct SHPs in Austria. Moreover, this allowed a nuanced discussion of contemporary decarbonisation rates of the Austrian housing stock.

The identified SHPs are (cf. Table 4): (1) owner-occupied (semi-)detached housing, (2) owner-occupied flats, (3) private rental housing, (4) limited-profit rental housing, and (5) municipal housing. These SHPs cover around 90% of Austrian households. Around 50% of the households are homeowners (40% living in houses, 10% living in flats). Almost 40% of households rent their housing unit (16% private market, 15% LPHAs and 7% municipalities). The physical structures can be classified simply according to (semi-)detached houses and multi-family buildings. We are aware that this classification covers important differences in age and location, both of which are relevant for the feasibility of decarbonisation measures. However, this more technical aspect is covered by WP3. Through different forms of distribution processes, households are divided into one of the five identified SHP. It should be noted that households within these SHP also display different characteristics. As a case in point, Table 4 includes median income levels and levels of poverty incidence. A detailed analysis shows that these differences are significant, except between the private rental housing SHP and the limited-profit rental housing SHP. Furthermore, income poverty is an issue in all SHPs.

To conclude, we draw attention to the regulatory context. The key regulatory elements driving these social and physical processes are Housing Promotion, the Limited-Profit Act, Tenancy Law and the Residential Property Act.

Table 4: Five Austrian SHP

Housing Promotion (*Wohnbauförderung*) Limited-Profit Housing Act (*Wohnungsgemeinnützigkeitsgesetz*) Tenancy Law (*Mietrechtsgesetz*) Residential Property Act (*Wohnungseigentumsgesetz*)	Private Households	Private Organisations	LPHAs	Public Authorities
	Production (incl. Refurbishment)			
	One/Two-Family Houses		Multi-Family Buildings	
	Distribution			
	Owner-Occupied(semi-)detached Housing	Owner-Occupied Flats	Private Rental Housing	Limited-Profit Rental Housing	Municipal Housing
	51 804,09 (9,86%)	43 086,03 (16,57%)	34 691,35 (32,10%)	34 154,72 (24,53%)	27 870,19 (39,61%)
	Consumption			

With respect to the implementation of decarbonisation measures, it is clear that the main pivotal agents are either developers (new buildings) or owners (refurbishments). The production and refurbishment of housing units are initiated by four agents. The overall role of public authorities is, however, negligible, since it is mainly concentrated in Vienna. Whereas building codes and housing promotion schemes can be used to encourage further decarbonisation of new buildings, the decarbonisation of existing housing stock is more challenging. This is due to the different features of both households and owners.

In owner-occupied (semi-)detached housing, SHP ownership coincides with the households living in the housing unit. Decarbonisation within this SHP depends, among other things, on the age of the household members and their financial means. Within the other SHP, there is a discrepancy between those who own the property and the households using the property. This situation can be further complicated by multiple-owner structures of buildings.

The central aspect with respect to decarbonisation is the conflicting interests of owners and households. In the rental SHP, use-value (i.e., living comfort) considerations do not directly influence investment decisions of owners or developers (neither with respect to construction nor refurbishment). This being said, it is clear that use-value indirectly influences the competitiveness of housing units as it is linked to consumers' willingness to pay. For LPHAs and Municipal Housing, investments in construction and refurbishments are supported by common welfare goals as per the respective SHPs' *raison-d'être*. In addition, other considerations such as ecological impacts or political motives can also play a role in Owner-Occupied (semi-)detached Housing. Within this SHP, the owner can make independent investment decisions with direct impacts which they themselves experience. This is in contrast to households in Owner-Occupier Flats, who have only a limited impact on the building, or to owners in the Private Rental Housing SHP, who may be more concerned with profitability.

Regulation can both incentivise or impede investments. The Limited-Profit Housing Act clearly stipulates that LPHAs have to reinvest a significant share of their (limited) profits in housing. As a result, LPHAs have the financial means and willingness to invest. For Private Rental Housing, however, Tenancy Law can create barriers. Landlords have only limited possibilities to recuperate investment costs through increases in rent levels. Although they can resort to a legal procedure (§18 MRG), the criteria that need to be met are extremely high and the process extremely laborious. This is especially true for housing units fully subject to Tenancy Law.

The affordability debate centres around the relationship between household income and wealth along the identified SHP and recent price developments of residential real estate. This debate is set against the backdrop of the political economy of Austria and developments in the labour market, which are relevant for wage incomes, and the financialization of residential real estate, which stems from changing investment trends.

With respect to housing prices, it should be noted that in the last decade, households increasingly faced issues of housing affordability. Increases both in prices of residential real estate and rental costs outpaced increases in wage income during the same period. Moreover, the distribution of incomes and wages between households is rather uneven. Rental households display on average lower incomes and limited equity. Owner-occupier households enjoy medium to high incomes, with the vast majority of their equity tied up in residential real estate property. High wealth households are also those who can utilise their equity to generate further income, for example, through rental properties. In general, there is a low level of ownership concentration within real estate. Nonetheless, with respect to private organisations, the role of the Austrian state through the parastatal *Bundesimmobiliengesellschaft* and the remarkably high number of private foundations (*Stiftungen*) should not be neglected.

A major reason for recent price increases is the ongoing process of residential real estate financialization. Since the 2009 financial and economic crisis, affluent households and institutional investors have started treating residential real estate increasingly as a financial asset. The inflow of such investments prompted a shift within the private development sector, with private developers catering for this specific investment-motivated demand for housing units. This led to increased land prices, increased prices for construction materials and work, as well as increases in consumer prices.

Given these developments in Austria, we argue that residential real estate owners should take greater responsibility with respect to decarbonisation and be held accountable for the CO_2 emissions resulting from their housing units. In order to guarantee affordability and social inclusion, the costs of such measures should be borne by owners themselves and not passed on to consumers, many of whom already face increasing housing costs. Considering the current low rate of decarbonisation, the most effective route would likely be legal obligation. This

being said, tailored subsidies should be made available for poorer owner-occupier households.

4.4. Techno-economic bottom-up modelling of buildings' decarbonisation pathways

The objective of this part of the project was to develop techno-economic transition pathways of the residential building stock in Austria and in the selected municipalities of "NaWo Award" winners (cf. section 4.2). The transition pathways are consistent with the target of full reliance on renewable energy. The objective was to deliver the required details of these transition pathways in order to deal with questions of how to assure decarbonised, inclusive and affordable housing at the same time. Moreover, the objective was to extend the existing building stock model (cf. section 6.3) by social differentiation to better address the aspect of affordability for different income groups.

During the discussion process with stakeholders and representatives of "NaWo Award" winners, it was revealed that a comparison of different policy pathways was of particular interest, in particular considering the relevance of regulatory instruments such as renovation obligation and their impact on vulnerable groups.

As a first step, we integrated the relevant agents and structures of housing provision in the model Invert/EE-Lab. Table 5 specifies the interest rate and the option for allocating investments to the user for these agent types. We are aware that the return on investment and the debt capital interest rate do not necessarily reflect the concept of Weighted Average Cost of Capital (WACC), which would not allow for the inclusion of interest rates, however, based on the discussions in Müller et al. (2019), we concluded that the resulting total interest rates properly reflect time and risk preferences, especially when we consider non-institutional investors.

Table 6 specifies agents regarding their share of the building stock in different regions in Austria. These data were implemented accordingly in the model Invert/EE-Lab.

Table 5: Specification of agents in the model Invert/EE-Lab according to total interest rate and the option to allocate the investment to the user.

	Owner-occupied					Rental housing			
	(Semi-)detached housing			Flats		Private			Limited profit and municipal housing
	Other	Low income	Elderly	Other	Low Income	other	Low-income tenant	Before 1945	
Return on investment	5%	6%	6%	7%	7.7%	6%	6%	6%	1%
Debt ratio	50%	100%	50%	75%	75%	50%	50%	50%	50%
Dept capital interest rate	1%	2%	2%	1%	1%	1%	1%	1%	1%
Total interest rate	**5.0%**	**8.0%**	**7.0%**	**7.3%**	**8%**	**6.5%**	**6.5%**	**6.5%**	**1.5%**
Option to allocate investment to the user	**100%**	**100%**	**100%**	**100%**	**100%**	**50%**	**20%**	**10%**	**35%**

Table 6: Specification of agents regarding their share of the building stock in different regions in Austria.

	Owner-occupied housing					Rental housing			Limited profit and municipal housing
	(Semi-)detached			Flats		Private			
	Other	Low income	Elderly	Other	Low income	Other	Low income	Pre-1945	
SFH_non_Vie	61%	9%	18%			11%			
SFH_Vie	55%	8%	16%			21%			
MFH_BU				9%	3%	34%	11%		43%
MFH_CA				13%	4%	34%	11%		37%
MFH_LA				17%	6%	31%	10%		36%
MFH_UA				13%	4%	33%	11%		39%
MFH_SA				23%	8%	35%	12%		23%
MFH_ST				19%	6%	35%	12%		28%
MFH_TY				25%	8%	35%	12%		20%
MFH_VO				24%	8%	34%	11%		23%
MFH_Vie				10%	3%	31%	10%		45%
MFH_pre1945				10%	3%	21%		21%	45%
SFH_new	58%	8%	17%			16%			
MFH_new				17%	6%	34%	11%		33%

SFH – Single-family houses, MFH – multifamily houses, Vie – Vienna, non_Vie – all other regions in Austria except Vienna; BU – region of Burgenland; CA – the region of Carinthia, LA - the region of lower Austria; UA – the region of Upper Austria; SA – the region of Salzburg, ST – region of Styria; Tthe Y – the region of Tyrol; Vthe O – region of Vorarlberg; new – buildings constructed according to the model results between the base year and 2050. (Eurostat, 2018; Statistik Austria, 2013)

Scenario design: comparing policy settings for achieving decarbonisation

The starting point of the decarbonisation scenario was the pathway developed and described in (Kranzl et al., 2018). This scenario showed how full decarbonisation of the sector can be achieved. Starting from this model run, we developed the following derived scenarios:

Scenario A - no renovation obligation: In this scenario, we removed the renovation obligation as a policy instrument in the Invert/EE-Lab model run. Thus, we assume that policies do not impose any binding regulatory obligation on building owners to carry out a thermal building retrofitting.

Scenario B - no renovation obligation and no renewable heat obligation: In addition to the changes assumed in Scenario A, we also removed the renewable heat obligation as a policy instrument in the Invert/EE-Lab model run.

Scenario C - no renovation obligation, no renewable heat obligation and no phase-out of fossil heating system in new installations: In addition to the conditions set out in scenario B, we removed the assumption of a complete phase-out of fossil heating systems in new installations. Thus, we assume that policies do not impose any binding regulatory obligation on building owners to carry out a thermal building retrofitting or to install renewable heating systems.

Table 7 Scenario design and related policy assumptions. "X" marks the presence of a policy instrument in each of the scenarios.

	Base-Scenario "Decarbonisation"	Scenario A	Scenario B	Scenario C
CO2-tax	X	X	X	X
Renovation obligation	X			
Renewable heat obligation	X	X		
Phase-out fossil heating system installations	X	X	X	

By comparing the results of these scenarios, we identify and discuss the impact of obligation schemes on achieving decarbonisation targets and on different structures of housing provisions and agents.

Selected scenario results for the base case scenario

Under the chosen policy settings and conditions, the base-scenario leads to a reduction of the final energy demand for space heating and hot water by about 50% by 2050 (Figure 2). While – in this scenario – oil and coal are completely phased out by 2040, gas heating systems remain in place until 2050; however, the corresponding final energy demand reduces to around one quarter. Achieving full decarbonisation would require meeting the remaining – strongly reduced – gas demand with renewable gas. According to recent analyses of the potential for

renewable gas, this should be feasible, even though it depends, of course, on the demand for renewable gas in other sectors as well.

The scenario shows the strongest growth for heat pumps (ambient heat and electricity demand for heat pumps). Due to the fact that the model indicates a strong decline in electricity direct heating systems, the growth in heat pumps does not lead to overall growth in electricity consumption for supplying space heating and hot water. In terms of conditioned floor area, the share of heat pumps is even higher due to the fact that heat pumps are mainly applied in buildings with lower specific energy need for space heating.

While the scenario was calculated for the whole Austrian residential building stock, dedicated model runs have been carried out for the municipalities of the "NaWo Award" winners: Innsbruck, Feldkirch, Wien, Zell am See (cf. section 4.2). However, we want to emphasize that the results are not only relevant to these municipalities but also for others in Austria with an equivalent structure of energy carriers and building stock. To provide an example, Figure 3 shows the development of the energy carriers on delivered energy (excluding on-site renewable energy generation, such as ambient and shallow geothermal heat and solar thermal energy). The reduction of delivered energy demand is similar in all cases (with the lowest reduction in Vienna due to the lowest share of individual heat pumps, delivering a relevant part of ambient heat and thus significantly reducing the demand of delivered energy). However, the energy carrier mix differs strongly. While the share of district heating as a potential for decarbonisation is highest in densely populated cities, this is most probably less relevant in municipalities such as Zell am See, where individual heat pumps and biomass would play a more relevant role, according to the model output.

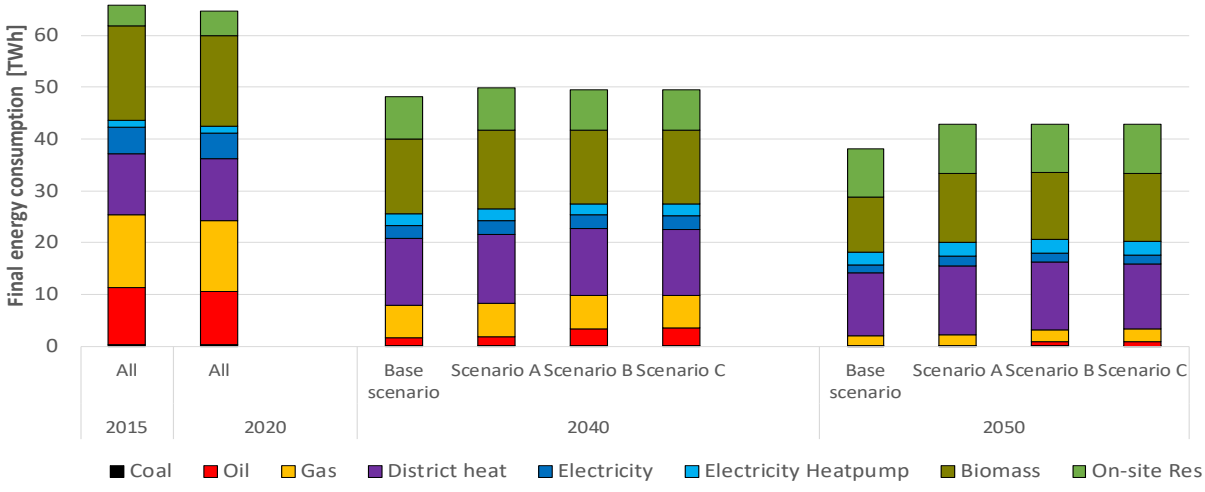

Figure 2 Scenarios of final energy consumption in the Austrian residential buildings for the four different policy cases.

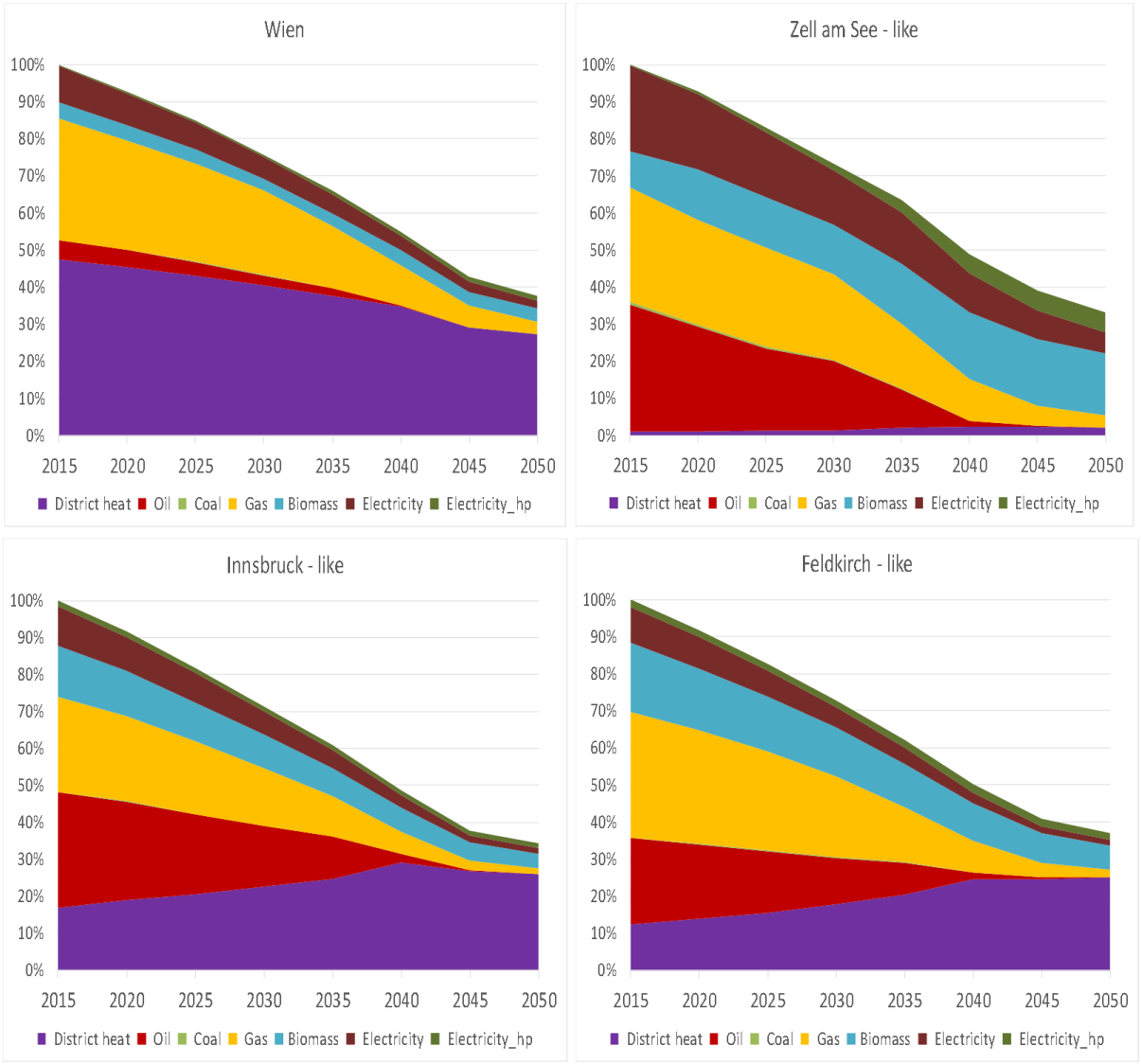

Figure 3 Scenarios of development of delivered energy (no on-site RES) by energy carriers in the base-case scenario for the cases "Innsbruck-like" (top left), "Feldkirch-like" (top right), Vienna (bottom-left) and "Zell-am-See-like" (bottom-right)

Selected scenario results for the base case scenario

The comparison of the four policy scenarios as described above shows that the renovation obligation has a strong impact, particularly in rented apartment buildings. This leads to a significantly lower renovation rate in scenarios A-C (about 1.3%) compared to the base-case decarbonisation scenario (with a renovation rate of more than 2%). While decarbonisation is also possible in scenarios A-C, a much greater emphasis is put on the supply through renewable heating systems (via district heating and a higher need for biomass and electricity).

The policies also have a significant impact on the different agents, as shown in Table 8 and Table 9. While energy needs are significantly reduced due to the renovation obligation in the whole building stock in the base scenario, in scenarios A-C, this is not the case for rental housing. This has a strong impact on low-income

households, who have to bear higher expenses for energy carriers, due to the assumed increased energy and CO_2 taxes.

Conclusions and related policy implications of these results are discussed in chapter 5 below.

			Reduced energy needs for space heating				Reduced energy costs			
			Base	A	B	C	Base	A	B	C
Owner-occupied housing	(Semi-)detached	other	53%	45%	45%	45%	26%	18%	16%	16%
		Low income	51%	41%	41%	41%	24%	14%	12%	12%
		elderly	52%	43%	43%	43%	25%	16%	14%	14%
	Flats	other	54%	41%	41%	42%	26%	17%	15%	15%
		Low income	53%	40%	40%	40%	24%	14%	12%	12%
Rental housing	Private	Other, SFH	43%	16%	16%	16%	14%	-13%	-15%	-15%
		Other, MFH	44%	15%	15%	15%	18%	-6%	-8%	-8%
		Low income, MFH	43%	14%	14%	14%	16%	-6%	-9%	-9%
		Before 1945, MFH	51%	16%	15%	15%	2%	-33%	-31%	-33%
	Limited profit and municipal housing		61%	59%	59%	59%	29%	29%	27%	27%

Table 8. Model results for different agents, structures of housing provision and policy settings for the year 2050 for the scenarios Base, A, B and C: Reduced energy needs for space heating, reduced energy costs

			Investment in building shell [€2019/m²]				Investment building shell and heating system [€2019/m²]			
			Base	A	B	C	Base	A	B	C
Owner-occupied housing	(Semi-) detached	other	126	111	110	111	212	197	194	194
		Low income	121	102	101	102	204	187	183	184
		elderly	124	106	105	106	209	192	189	190
	Flats	other	121	97	96	97	149	125	123	124
		Low income	119	93	92	93	142	117	115	116
Rental housing	Private	Other, SFH	110	62	61	61	194	148	143	144
		Other, MFH	111	56	55	55	139	86	83	83
		Low income, MFH	105	53	52	52	131	80	78	78
		Before 1945, MFH	141	70	68	68	163	93	92	91
	Limited profit and municipal housing		145	144	143	145	175	175	172	175

Table 9. Model results for different agents, structures of housing provision and policy settings for the year 2050 for the scenarios Base, A, B and C: Investment in building shell and heating system Euro per m²

4.5. Multi-level governance of Social Innovation in Housing

The objective of our research on multi-level governance of social innovation in housing was two-fold. First, it sought to generate information on the institutional prerequisites for Austrian housing policies and possibilities and limits for social innovation. Secondly, it sought to process information about international experiences of social and ecological innovation in housing. This concerns best practice examples and the conditions as well as institutional prerequisites for their success. We also analysed possible problems or obstacles to implementing innovations. Making use of the findings concerning structures of housing provision and techno-economic bottom-up modelling of buildings, we produced working papers on possibilities and limitations of implementing socially and environmentally innovative housing policies in Austria. Research tasks included (1) generation of the information on the institutional demands on Austrian housing policies as a prerequisite for (2) research on governance of social and environmental innovation in Austrian housing. The latter combined lessons learned from the case studies of the "NaWo Award" winners (cf. section 4.2) and from international experiences of social innovation in ecologically and socially inclusive housing.

The multi-level governance framework of Austrian housing

We started the research on multi-level governance of affordable and sustainable housing in Austria by highlighting the challenges of socially and environmentally sustainable housing. The discussion drew on two key aspects. The first aspect was that of the individual situation of housing for households, often seen as the most important factor in affordable housing. Costs of living for households include costs for rent or financing owner-occupied buildings and operating expenses such as electricity costs or other costs related to heating and cooling of the property. These other costs are often seen as vital to the question of socio-ecological improvement. The second aspect relates to the issue of social and environmental sustainability. We must acknowledge that housing units do not only accommodate people but are also part of the built environment. Processes such as "ghettoization" or "gentrification" reinforce the reproduction of inequalities. These processes are heavily influenced by market processes, as prices for land and housing are crucial determining factors for the accessibility of space for living. Therefore, social housing should consider not only affordability as an important factor but also social and territorial cohesion.

The issue of housing is subject to important multi-level governance dynamics. While the major influences in the Austrian context are on the municipal and regional levels, important influences stemming from the national policy framework and EU-regulations have to be considered. Different competencies dealing with the promotion of socially and environmentally sustainable housing lead to a rather fragmented policy context, particularly when it comes to regionalised housing policies and the integration of federal policies to reduce carbon emissions.

Based on an institutionalist approach to the analysis of social policies (Esping-Andersen, 1990, 1999), we described the Austrian housing regime and discussed the most important possibilities and limitations for policy intervention. The Austrian housing regime is described as conservative-corporatist, leading to a housing regime with rather sluggish reform processes. There is a tendency towards object-based (supply side) financing and a strong presence of limited profit companies in providing social housing. Austrian tenancy law is also somewhat fragmented. However, despite this fragmented nature, tenancy law in Austria is still more protective to tenants than in comparable legislation in other countries. Therefore, tendencies towards spatial segregation are less pronounced than in many other European countries. A further decisive factor for the relatively low level of segregation is the historical presence of social housing in more affluent neighbourhoods. Recent changes favour a stronger market-based approach and thereby endanger the historical heritage of social and spatial cohesion. This framework reinforces important findings when it comes to policy recommendations: if social housing were disproportionally targeted towards low-income households, there would be a danger of ghettoization in the long run and, therefore, the Austrian focus on providing social housing for both low and middle-income households should not be abandoned.

Social and environmental innovation in housing

First, social innovation was defined as finding new solutions to new or existing governance challenges, democratically involving the public sector, civil society and market agents. Ideally, this process leads to (1) the fulfilment of human needs, coupled with (2) empowerment of hitherto marginalised groups and (3) democratic improvement of governance relations (Moulaert et al., 2007; Moulaert and McCallum, 2019). Important governance challenges were identified by the findings of the work packages on the Structures of Housing Provision and techno-economic bottom-up modelling of buildings' decarbonisation pathways, as well as the findings concerning the multi-level governance framework of Austrian housing policies. These challenges demand socially innovative solutions by public, market and civil society agents. The most important such governance challenges were identified as:

- Globalisation, financialization and rising housing prices
- Flexibilization of legal framework and privatisation – exclusion, insider/outsider
- Migration, ageing population, family structure (growing floor space/capita)
- Lack of coordination between different governance actors and policy departments
- Refurbishment as a socio-environmental challenge: the "principal-agent dilemma"
- Mobility and transport, including the price of housing and land as a key driver of urban sprawl

A systematic analysis of socio-environmental innovation for Austrian housing policies resulted in the following theoretical framework (Figure 4):

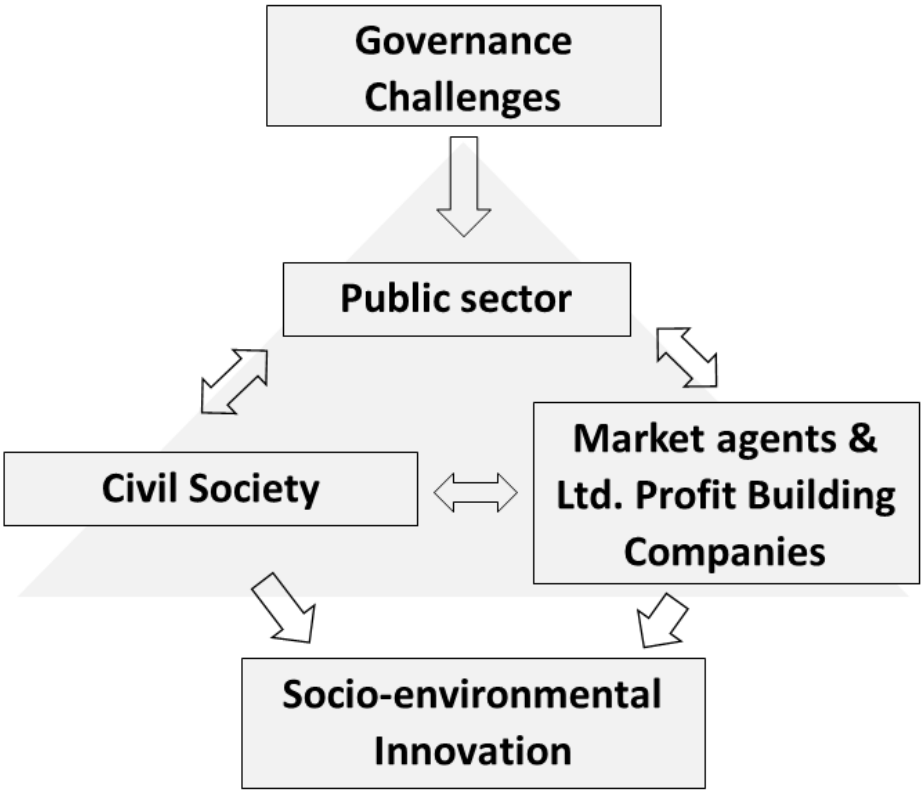

Figure 4: Socio-environmental innovation framework. Source: own elaboration, based on (De Weerdt and Garcia, 2016; Moulaert et al., 2007)

We used this framework to analyse the four best practice examples selected the "NaWo Award" call (cf. section 4.2). Our findings were complemented by literature research on international best practices of socio-environmental innovation in housing policies.

The most important forms of socio-environmental innovation combined affordable housing with social inclusion. Affordable social housing for poor people has been combined with owner-occupied housing for the middle classes in the same housing complex. In the case of "Sonnengarten" (see below), social cohesion was further promoted through the integration of an agency specialised in participation and social inclusion. This facilitated a better functioning of another important feature for socio-environmental innovation — that of shared space, such as community gardens, leisure facilities or community rooms. Shared space was a common feature in the analysed case studies and demonstrated how the environmental challenge of growing floor space per capita could be tackled without adversely affecting quality of life. Another important common feature was the improvement of social relations through more intensive cooperation between stakeholders.

Summing up our most important findings, using concrete examples from the analysis of case studies, we highlighted:

- **Improvement in social relations**. Better political coordination of different stakeholders contributed to building trust. In the case of "KliNaWo", this was explicitly pointed out by the stakeholders in the focus group, who stated that the most important improvement resulting from their project was the building of trust and positive working relationship between actors who had not previously cooperated. In the case of "Sonnengarten", an agency specialised in democratic planning was mandated with facilitating the improvement of social relations between the inhabitants of the apartment block.
- **Shared space:** The shared use of space was identified as a major improvement in facilitating the reduction of square metres of living space per person without adversely affecting quality of life. Important examples include a guest apartment in the housing complex of "Sonnengarten", shared working spaces in the "Haus of Commons" in Innsbruck, and an event room in the "Bikes & Rails" house which also serves as a common kitchen.
- **Inclusion of persons with special needs:** The "Bikes & Rails" project features an apartment for refugees.
- **Institutional frameworks preventing financial speculation.** To meet the challenge of rising prices as a result of financialization and real estate investments, innovative solutions have to be found. In the case of "KliNaWo", traditional forms of innovation proved to be effective, with limited profit housing companies — when used correctly — making an important contribution to social innovation. The "Bikes & Rails" project is structured and organised as an association and is connected with the habiTAT-renting housing syndicate, which prevents the resale of the property and secures collective ownership and affordable housing.
- **Possibilities for financing housing.** The "KliNaWo" project clearly pointed out that higher costs for better and more ecological building materials are easily offset by savings throughout the lifecycle of the buildings. Compared to factors linked to the real estate boom, such as the rise in prices for land and construction, the cost increases associated with ecological material are very moderate. The "Bikes & Rails" project also provides evidence of financial innovation. Participants in the project successfully set up a crowdfunding scheme, which profited from a form of bottom-linked social innovation in collaboration with the City of Vienna. The building group of "Bikes & Rails" participated in a call through which building space was provided at subsidised rates for projects that could demonstrate the social benefits of their housing project.
- **Participation of inhabitants in the planning of housing projects**. Participation can be fostered before future inhabitants move into a new apartment. In the case of "Sonnengarten Limberg", future inhabitants were engaged in a dialogue on how to reduce the number of cars per household and on different recreational areas in the apartment complex. This dialogue would help prevent future conflicts. A specialised agency is responsible for organising the introduction of shared gardens in the facilities of the housing complex and other shared facilities, such as a rehearsal room. In the case of

"Bikes & Rails", the construction of the building itself was planned by the future inhabitants. While this form of participation requires a considerable amount of time, it also contributed to the empowerment of the involved inhabitants of the building.

Further lessons from international examples pointed out additional possibilities for socio-environmental innovation, mostly linked to strengthening the shared use of housing:

- **Co-Housing of older people**, living in rather big apartments, **with young people** (e.g., students) facilitates affordable housing for youngsters, who can, in return, help their elderly flatmates with tasks (such as shopping) which are increasingly difficult for older people.
- Social projects (e.g., "Tausche Bildung für Wohnen") offering free **housing for students in return for helping disadvantaged young people** in deprived neighbourhoods with their studies.

5. Conclusions and recommendations

From the project's perspective, the production, distribution and consumption of housing are intertwined processes with a specific temporal, spatial and social context. This implies that housing should be considered accordingly as the outcome of specific social processes. Therefore, the decarbonisation of housing in Austria cannot be treated as separated from issues of housing affordability and social inclusion. The societal importance of housing is not only given by its capacity to cover the basic need for environmental and social protection, but also its ramifications on almost all aspects of our daily life, including health, education, employment, transport, leisure, consumption, and social networks. Any society that values some degree of social inclusion needs to develop housing policies to secure adequate quality housing. Whereas distribution processes per definition imply both inclusion and exclusion, our attention is not focused on the fact that landed property exists but on the distribution processes of landed property. Within this setup of private and public interests in housing, it is unsurprising that frictions emerge.

Within the Austrian context, these frictions are institutionally mediated along five broad Structures of Housing Provisions (SHPs): owner-occupied (semi-)detached housing, owner-occupied flats, private rental housing, limited-profit rental housing and municipal housing. While not negating the underlying dynamic processes, our research attests these structures a more or less stable character. This implies also that policy recommendations should consider the differences between these structures. Nonetheless, general guidelines can be formulated.

Holistic focus on sustainable energy, housing affordability and social inclusion

First, as we learned through this project, a holistic approach with an equivalent treatment of efficient, sustainable energy use, housing affordability, and social inclusion is indispensable. It does not suffice to pursue a policy that does not include these three perspectives from the beginning. A reformulation of existing policies, which is extended by the other themes, would fall short as a comprehensive solution. Instead, a coherent policy approach should aim at overcoming problems caused by the fragmentation of government agencies; the current multi-level governance framework separates social, housing and environmental policies to different ministries and levels of governance. The current Austrian government has pledged to establish new targets for the sustainable renewal of buildings. This program would benefit from efforts towards de-fragmentation of government agencies in dealing with the challenge of sustainable, socially inclusive and affordable housing. We advocate for a collective effort by the responsible political bodies, whether federal ministries or provincial administrations, which draws on respective expertise at hand and includes relevant civil society organisations.

Political focus on the use-value of housing units

Secondly, the political measures to implement sustainable, socially inclusive and affordable housing should maintain a clear focus on the use-value of housing units. Considering current climatological developments, the decarbonisation of our housing stock is imperative. The concrete transformation, however, can have different outcomes. From our perspective, it is important that sustainable housing can be established as a standard practice with the effect that non-sustainable housing can be perceived as sub-standard. This could potentially help to avoid a price mark-up for sustainable housing units whilst also alleviating the financial burden on low-income households, which could benefit from lower energy costs. This would also be accompanied by a responsibilisation of real estate owners, derived from the societal importance of housing and their private control over a collective good.

Long-term perspectives

Thirdly, any policy recommendation should keep account of the longevity of residential real estate and the framework of housing policies inherited from previous regimes. The decarbonisation of residential real estate will have a long-lasting effect on energy use, affordability and social inclusion. Such social inclusion is fostered by the Austrian housing regime, which has made social housing accessible for both middle and lower-income households. This has been guaranteed by a focus on object-based subsidies (financing new buildings) with rather generous criteria for accessibility. While the introduction of some new subject-based subsidies might be beneficial in helping those in need of support, the transformation to a subject-based subsidy system could easily lead to social polarisation and ghettoisation in the long run. This actually reinforces our call for the adoption of a coherent, interdisciplinary policy approach.

Perspectives on the five SHPs

With respect to the five identified Structures of Housing Provisions (SHPs), more concrete policy considerations can be formulated.

Both **owner-occupier households of (semi-)detached houses** and **flats** have a direct interest in decarbonisation measures as they are also their beneficiaries. Through a well-thought-out decarbonisation plan, they could benefit from lower energy costs and increased living standards. At the same time, they have the possibility to make an active contribution towards achieving Austria's climate goals. Additionally, these households have the highest incomes in Austria and are also owners of wealth. Therefore, a subsidy system to financially support this transformation should be kept minimal. On the one hand, it would be possible to introduce for (semi-) detached houses a preservation and refurbishment contribution (*Erhaltungs- und Verbesserungsbeitrag*), which would be saved by the household on a separate account. Owner-occupier households would subsequently build up the means to finance the decarbonisation of their property. As an incentive, these savings could be taxed at a lower rate. Moreover, they could

develop an overall decarbonisation plan, which can be executed in different phases. With respect to owner-occupiers of flats, it would be necessary to overhaul the voting procedure. Considering the heterogeneity of these households and the necessity to reach agreement, it could make sense to differentiate between owner-occupiers and mere owners, with preferential treatment of the former group as the former are directly impacted from this transformation. On the other hand, we have a non-negligible incidence of low-income households in both these SHPs. Whereas in the case of older households, it would be possible to initially abstain from the implementation of decarbonisation measures, the decarbonisation of these housing units would become obligatory for their descendants or beneficiaries. For the remaining low-income households, a flanking subsidy system could be put in place.

The **limited-profit rental housing units** currently display a relatively high degree of refurbishment activity. Therefore, a minor overhaul of the existing system could be fruitful. One possibility would be to increase minimum standards, which should then be met through refurbishments. Whereas the execution of decarbonisation measures would be relatively easy for **municipal housing**, the major challenge is to finance this transformation given current EU and domestic legislation on state aid. In addition, since these decarbonisation measures affect inhabitants, we advocate for social mediation with the aim of strengthening social inclusion.

Currently, the **private rental housing units** display the lowest level of refurbishment rates. This is, given the different interests of owners and users, not surprising. Taking into account the fact that households in this SHP have high rates of poverty and that owners are among the wealthiest deciles in Austria, the cost of decarbonisation of this housing stock should be borne by its owners. Moreover, since housing has become increasingly less affordable in the last decade, tougher regulations should be placed on landlords, prohibiting the passing on of investment costs to tenants.

All in all, however, we are sceptical that without a general renovation obligation, as mentioned also in the Austrian government programme from 2019 (ÖVP and Die Grünen, 2020) and the communication from the European Commission on the renovation wave (COM(2020) 662 final), an overall move to decarbonisation which ensures both affordability and inclusion can realistically be attained.

Decarbonisation pathways

The results show that a full decarbonisation of space heating and hot water demand (as the main end-use sectors of buildings' energy demand and related carbon emissions) is possible. However, achieving this target depends on a series of conditions in particular how to overcome barriers, which are described in the following.

Full reliance on renewable energy is only possible with a substantial reduction of energy demand. Building renovation has the potential to achieve this efficiency

improvement. However, policies need to be intensified and adjusted, in particular considering the different structures of housing provision as described above.

A crucial barrier for renewable space heating is the fact that a relevant part of the building stock is not yet equipped with central heating systems. The replacement of room heaters and systems for single apartments by a central heating system is an important condition and assumed to be achievable by correspondingly stringent policies.

The local conditions play a key role in the mix of technologies and energy carriers. In high-density urban settings, represented by the cases of Vienna, Innsbruck and Feldkirch, in our modelled transition pathway, district heating holds the majority of space heating and hot water demand. In other areas with lower densities, represented by Zell am See, and similar regions, a mix of heat pumps, biomass and solar energy is expected to cover the remaining energy demand. According to our model results, replacing gas will be the most significant challenge. Thus, regions with a high share of gas need to take actions as soon as possible. In our scenario, a small share of decentral gas systems is remaining in the supply mix of space heating, which could be covered by renewable gas. However, it needs to be considered that the supply of renewable gases and maintaining the gas grid with very low demand will become more and more costly.

The transition pathway developed assumes several stringent policy measures to be implemented, in particular regulatory schemes. Economic incentives alone – even high CO2-taxes – are not sufficient to provide an effective trigger in all structures of housing provision. In particular, in private rented apartments, the implementation of regulatory schemes (obligation for renovation and RES-H) is essential to ensure achieving the decarbonisation target and at the same time ensure affordability for tenants.

Social and environmental innovation

For social and environmental innovation, collective facilities have been identified as an important element for further promotion. Thereby, the environmental challenge of growing living space per person can be tackled sustainably, without losing or even by promoting more quality of life. Community gardening, shared rooms in apartment buildings for cooking and eating, guest apartments for short term stays (avoiding the need for a guest room in individual flats), or shared workrooms are among the many examples for collective facilities. For the initiation, it can be helpful to employ specialists to facilitate the organisation of collective use.

In addition, co-housing should be further promoted by housing policies. International examples point at possibilities to provide free or cheap living space for young people (e.g., students) in exchange for helping people with special needs or running social projects to support marginalised or disadvantaged youngsters. There may also be possibilities for young people to live together with elderly people in larger apartments and for lower rental costs in exchange for helping with tasks such as shopping. Another important possibility to promote social and

environmental innovation include policies aimed at providing land at reduced rates in exchange for housing projects with benefits for society, as has been successfully applied by the City of Vienna. For the financing of housing projects by civil society, crowdfunding or other means for pre-financing civil society projects in housing projects appears to be an interesting tool that could be promoted through dissemination campaigns.

How to enforce synergies with regard to multi-level governance and cohesive integration of regional housing policies with predominantly national social and environmental policies should be further investigated in follow-up projects.

Limitations of the Decarb_Inclusive project

The target of this project was not to deeply discuss techno-economic details of the transition process with respect to the complex mix, interaction and implications of technical measures. Many follow-up questions concerning these details, potentially also affecting affordability and inclusiveness of the transition process, remain open for further research, e.g. how the gradual retrofitting of the building stock and the transformation of district heating grids can and should be aligned; where could low-temperature heating grids be an economically viable solution; what is the role of (thermal) storage and load shifting; how life cycle carbon of the building stock can and should be factored in when designing related policies; how should the gradual decommissioning of gas grids be organised and incentivised; what is the impact of the demand for e-gases, biogas, renewable H2 and electricity for space heating and hot water on the generation of these energy carriers and resulting prices?

These considerations and questions were clearly out of the scope of the Decarb_Inclusive project, but we recommend considering them in future studies.

Also, it is essential to emphasize that the transition pathways developed for the local cases were not meant to serve as a basis for the detailed technical planning of the transition process. Instead, a more detailed analysis of the local energy system, related data and, in particular, the spatial conditions need to be considered in more detail for such a task. Our modelled scenario results are meant to provide a strategic direction of the pathways under specific typical regional settings, in particular how the heat densities and the current heat supply system frame the possible options for the transition process towards climate neutrality.

Outlook

We identified several topics which we consider as highly relevant to be further analysed in the context of Decarb_Inclusive. They are briefly listed below:

- The research showed that there is a continuing need for research on how to best balance policy targets and find synergetic solutions, in particular in a multi-level policy framework. In particular, we identified a need for further research on participatory policy processes, better understanding and replicating ways how to overcome hurdles by learning from good

practise examples, like the one identified for the Vorarlberg NaWo-Award Winner.

- In order to achieve full decarbonisation of building-related energy systems, in particular heating and cooling, **changes in property law and tenancy laws** and other legal context would be required. First, these required changes need to be better understood. Second, it also needs to be better understood how existing barriers for implementing these changes in the political reality could be overcome.
- CO2-taxes will probably be implemented in a gradually increasing way. Thus, there is a changing dynamic relation of the affordability of renovation measures and the social implication of renovation obligations in the context of this gradually increasing CO2-tax. This mutual dependency and relationship of these policy instruments is not yet fully analysed and could help to identify most beneficial policy pathways.
- The recent debate has shown that stepwise renovation is a reality in building refurbishment processes that needs to be better understood. Analysing the **impacts of stepwise renovation on the affordability of measures and the long-term dynamics of GHG-savings** would be an important task.
- Renewable energy communities are expected to have an increasing role in the transition to full reliance on renewable energy. Their role for RES-H/C is not yet fully explored and understood and should gain higher priority in future research activities, also in the context of affordability and social inclusiveness.
- The European Commission, in the "**Renovation wave**" (COM(2020)662) laid down a series of important concepts and measures on how to decarbonize the building stock in the coming decades. Some of these elements have a strong link to the measures analyzed and recommendations derived in this project. In particular, this is the case for mandatory standards for the energy performance of existing buildings. We expect that the renovation wave might have a strong impact on the future European and national policy framework. Thus, it will be very important to better **understand and analyse the implications of these provisions on the national policy context and the affordability and social inclusiveness of decarbonisation**.

C) Project details

6. Methodology

6.1. Overall approach and interdisciplinary linking of methods

The objective of the ACRP Decarb Inclusive project was to develop and analyse pathways towards full decarbonisation and assuring inclusive and affordable housing for the Austrian housing sector through effective policy interventions. Therefore, we decided to work together in a highly transdisciplinary team including techno-economic knowledge (Technische Universität Wien, Energy Economics Group), macro-economic competences (Wirtschaftsuniversität Wien), and socio-scientific expertise (Katholische Sozialakademie Österreich). The interdisciplinarity (i.e. involving various scientific disciplines) was complemented by intradisciplinary (i.e. involving stakeholders) approaches (Schinko et al., 2017). Therefore, the Climate Alliance, with close connections to the target groups and policymakers, in particular within Austrian municipalities, was added to the team. The required competencies for this intradisciplinary research and the coverage within the project consortium are summarized in Table 10.

Table 10: Required competencies and coverage per consortium partners

	TU Wien	WU	Climate Alliance	KSÖ
General experience and know-how in the housing sector	✓	✓	✓	✓
Techno-economic modelling of energy demand, efficiency measures, renewable energy systems and associated economics; experience in the development of decarbonisation pathways	✓			
Real estate economics, economics of housing in the context of affordability and social inclusion		✓		✓
Social science competences in the context of policy interventions		✓		✓
Close connection to the target group: policymakers, in particular in municipalities			✓	
Experience with transdisciplinary design of research projects	✓	✓	✓	✓
Experience in managing and cooperating efficiently in research projects	✓	✓	✓	✓

For an optimal linkage of the disciplines, we designed a work package and the first phase of the project to define a common language based on a number of internal discussion rounds and meetings. In parallel, we set up the framework, general outline and targets of the transition process of the building stock towards full reliance on renewable energy and at the same time assuring inclusive and affordable housing. We documented and discussed the policy targets, challenges, controversies and framework conditions with implications for transition pathways based on three dimensions: (1) policy targets and implications for the transition pathways, (2) demographic and socio-economic context and (3) physical constraints regarding renewable energy potential and energy efficiency.

The quantitative and qualitative framework, as well as the extensive almost bi-monthly discussion rounds, served as an important basis and common understanding within the group. A science-society interface (c.f. section 6.5) established the link to the stakeholders in four on-site focus group meetings with a diverse set of participants, two dedicated workshops with renowned experts and a final conference with well-known key-note speakers (c.f. section 8 for publication and dissemination activities). Furthermore, the diverse and extensive list of contacts engaged in the science-society interface grew and was continuously updated. These contacts were involved in the discussion of final results, as presented in this report, and provided systematic feedback on policy recommendation flyers and working papers.

6.2. Structures of housing provisioning

From the outset of this project, it was clear that the goals of work package four could only be achieved by means of a mixed-method approach, i.e., the collection, analysis and integration of quantitative and qualitative data. Whereas quantitative data provide facts and snapshots with respect to multiple relevant aspects of housing, qualitative data enable us to understand these facts and their interrelatedness within their socio-economic and temporal-spatial contexts.

To begin with, we developed our understanding of the institutional concept of Structures of Housing Provision (SHP). Based on an elaborate literature review of mainly Michael Ball's work, our institutional framework puts housing within its historical and social context. Moreover, it explicitly conceptualises the core, interrelated processes of production, distribution and consumption. The main agents of these processes are developers, landowners and property owners, landlords, households and regulatory bodies. Notwithstanding the SHP concept's structured approach to frame housing, it does not provide specific information about housing characteristics in Austria. Therefore, we were obliged to collect and to combine the necessary data in order to sketch a comprehensive picture.

As part of this second step, we gathered relevant specialist literature covering the production, distribution and consumption of housing. We tested and combined this general information with quantitative data on Austria's construction and real estate sectors as well as with specific literature on housing in Austria. The data indicated

that construction and real estate sectors do not play a defining role, while the Austrian state, in various forms and represented through various legal entities, is a relevant agent.

Following on from this, we conducted a literature review on different regulatory aspects of housing in Austria. This analysis identified the legal context of Housing Promotion, the Limited-Profit Housing Act, Tenancy Law and the Residential Property Act as elements with significant influence on Austria's SHP.

Our fourth step was the descriptive analysis of Austrian households by means of EU-SILC data (Eurostat, 2020). This analysis, which focused on household income, revealed significant differences between households depending on their spatial location (i.e., provincial level or degree of urbanisation) and SHP.

Whereas these literature reviews and data analyses helped to develop a clearer picture and better understanding of Austrian SHP, the information they provided was stiff insufficient. What was lacking was qualitative analysis that would shed light on the concrete social configuration of housing in Austria (i.e., SHP), on the feasibility of decarbonisation measures and subsequently on housing affordability. In order to obtain this information, we planned and conducted around 25 semi-structured qualitative interviews. The execution of these interviews was informed by the insights provided by Helfferich (2011); Meuser and Nagel (2009).

We faced initial sampling concerns owing to a lack of clarity on the type of information we would need and the potential sources of such information. With respect to the social configuration of SHP, we needed persons with specific knowledge of at least one SHP and its relation to other SHPs. This required familiarity with different agents involved in housing provision. Moreover, these persons should also have had experience with questions relating to sustainable housing or energy efficiency. In addition, we had a preference for interviewees with general knowledge of housing markets and the housing situation in their respective region. By means of our sample, we wanted to cover the core functions of SHP (i.e., production, distribution and consumption) and main agents. With respect to the latter, we faced the challenge that agents such as households, construction firms, commercial developers and real estate agents constitute diverse heterogeneous groups. Other agents, such as LPHAs, regulatory bodies and municipal housing (mainly in Vienna), are more centralised.

Considering our information requirements and the need to define our sample both as narrowly and as diversely as possible, we opted for semi-structured, expert interviews. Experts were defined in this case as persons who are both knowledgeable of and professionally active in the Austrian housing sector. As gatekeepers to our field of experts, we used contact persons from "NaWo Award"-dossiers, government officials and research institutes. Moreover, we applied the saturation principle, i.e., we opted to stop looking for new interview partners when we encountered the situation in which new interviews provided relatively little new information. This resulted in a total of sixteen one to one-and-a-half hour expert interviews, which were conducted in the first quarter of 2019. Table 11 provides a

descriptive list of our interviewees. It should be noted that none of the interviews took place at the research site, but at a location of our interviewees' choosing.

Table 11: List of conducted expert interviews

Date	Type of Agent	# Experts	Province[1]
23.01.2019	Private Landlord	1	Vienna
24.01.2019	Parastatal	2	Vienna
01.02.2019	Construction Company	1	Lower Austria
01.02.2019	Housing Collective	1	Vienna
05.02.2019	LPHA	1	Vienna
05.02.2019	Association of Owners	1	Vienna
06.02.2019	LPHA	1	Styria
12.02.2019	Research Institute	1	Salzburg
12.02.2019	City Government	1	Salzburg
20.02.2019	Research Institute	1	Vienna
21.02.2019	Regulatory Body	1	Lower Austria
21.02.2019	LPHA	1	Lower Austria
28.02.2019	Private Developer	1	Salzburg
28.02.2019	LPHA	1	Salzburg
13.03.2019	LPHA	2	Styria
25.03.2019	Construction Company	1	Lower Austria

In preparation for each expert interview, two members of our research team composed a semi-structured interview guide specifically for the respective expert(s) for an estimated interview time of one hour. Notwithstanding this customised approach, each interview guide still covered the three broad themes defined by our research question — SHP in Austria, decarbonisation measures, and the implications of decarbonisation on housing affordability. After transcribing the audio recorded interviews, we used the three main themes and subsections to code text paragraphs. In subsequent steps, we clustered and compared text fragments from all interviews according to these codes. This was followed by a conceptualisation of this information in line with our developed framework of SHP. We then generalised this information to identify the main five SHP in Austria (cf. section 4.3).

6.3. Techno-economic bottom-up modelling of building's decarbonisation pathways

In order to derive techno-economic bottom-up decarbonisation pathways of the Austrian residential building stock and to investigate the affordability and social inclusiveness of these pathways, we applied the existing building stock model

[1] This column indicates where the interview took place and does not necessarily indicate the action radius of the respective agent.

Invert/EE-Lab (invert.at, 2020; Müller, 2015a). According to the system boundary described in the research proposal of this project, we focus on the end-uses space heating and hot water in residential buildings. This is in line with the dominant relevance of these end-uses for achieving decarbonisation in the residential building sector.

By integrating the structures of housing provision in Austria (see section 6.2) and by distinguishing low-income households from other households in each of these structures of housing provisions, we described agents and integrated these results into the building stock model. By analysing the model results for different policy scenarios and different agent types, we derive the possible impact of selected policy settings on low-income households in different structures of housing provision.

Invert/EE-Lab builds on a strongly disaggregated bottom-up building stock, represented by building archetypes (Figure 5). Considering the lifetime distribution of building components and assuming certain investment rationales for different agents, we can derive scenarios of the building stock evolution in the coming years and decades.

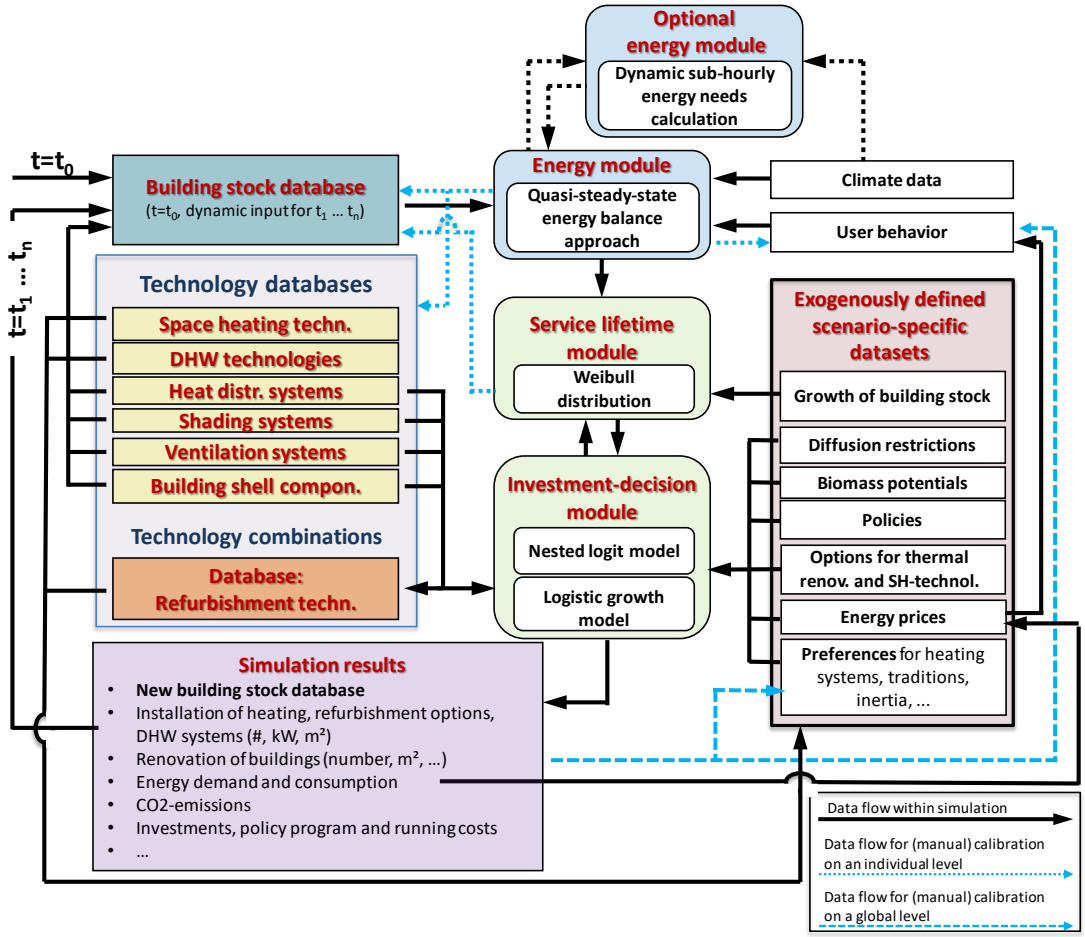

Figure 5. Structure of the model Invert/EE-Lab (Müller, 2015b), www.invert.at)

In Kranzl et al. (2018), the so-called "heat transition scenario" has been developed, showing a pathway of how the Austrian space heating and hot water demand could be supplied by 100% renewable energy. This scenario has been the starting point for the analyses in this project.

The decision making algorithm in the model Invert/EE-Lab is based on a multi-nominal nested-logit approach, as explained in detail in Müller (2015b), assuming bounded rationality and myopic economic optimization rationale of the agents taking the decisions regarding building renovation or the choice of heating systems. However, these agents are highly heterogeneous in their preferences, financial capabilities, interests and consideration of economic and non-economic aspects. This is achieved by assigning a certain mix of agents to the building classes used in the model Invert/EE-Lab. These investment agents differ in terms of their interest rate, the weight they put on economic criteria compared to non-economic criteria, the need to reinvest profits in energetic improvements and the ability to refinance the investment by savings of running costs–either since they occupy the building by themselves or the ability to increase the rent. The relative preferences for the different non-economic criteria such as environmental aspects, comfort and status quo bias are kept the same for all agents investing in the residential sector.

Within this project, the agent structure of the model was adapted by considering explicitly the different structures of housing provisions. In addition, low-income households and the elderly were considered in the definition of agents. On the other hand, in order to keep computation time within acceptable limits, it was necessary to reduce the number of agents in the model as far as possible. Finally, this led to the consideration of the following agents in Invert/EE-Lab:

- Owner-Occupied (semi-)detached Housing (low-income, elderly, other)
- Owner-Occupied Flats (low-income, other); (In owner-occupied apartment buildings it is assumed that the investment decisions are made by majority voting (interest rate at CDF (cumulated distribution function) = 80%, standard deviation = 50% of mean); also, since the property management organizes the process, limited access to capital is less of an issue. In contrast to (semi-)detached houses, we do not distinguish buildings occupied by elderly, since we presume that different age groups are present in apartment buildings; it is assumed that these buildings explicitly target lower-income households and, accordingly, feature multidimensionally lower building standards).
- Private Rental Housing (low-income tenants, built before 1945[2])
- Limited-Profit Rental Housing and municipal social housing

[2] Considering the peculiarities of the Austrian rental law with special provisions for buildings erected before 1945. Such restrictions partly exists for other cohorts as well. However due to lack of available data and data simplicity, we considered that for buildings constructed before the end of WW2 only.

This approach enabled us to identify the impact of the selected decarbonisation pathways and different policy settings on the groups described and the Structures of Housing Provision in terms of costs, energy savings and related investments for achieving the overall decarbonisation target in the building stock.

6.4. Multi-level governance of Social Innovation in Housing

Research on the multi-level governance of social innovation in housing methodologically combined literature research and case study research (further information on case study research is given in section 6.2) to generate information on social and environmental innovation in housing. Socio-environmental innovation is conceptualised as a creative response by private, market and government agents to current governance challenges. The final result of these efforts should be a better satisfaction of housing needs, along with empowerment and social inclusion and changes in governance relations.

The basic methodological approach towards understanding social and environmental innovations has been derived from the literature on social innovation. Based on a literature review, the general approach by Moulaert et al. (2007) and Moulaert and McCallum (2019) towards analysing social innovation and its application to housing by De Weerdt and Garcia (2016) have been adapted, using information generated in the project on Structures of Housing Provision, techno-economic bottom-up modelling and the analysis of the Austrian housing regime (for further information, cf. section 4.3). The following chart (Figure 6) illustrates the detailed approach. For a discussion of the results see section 4.5.

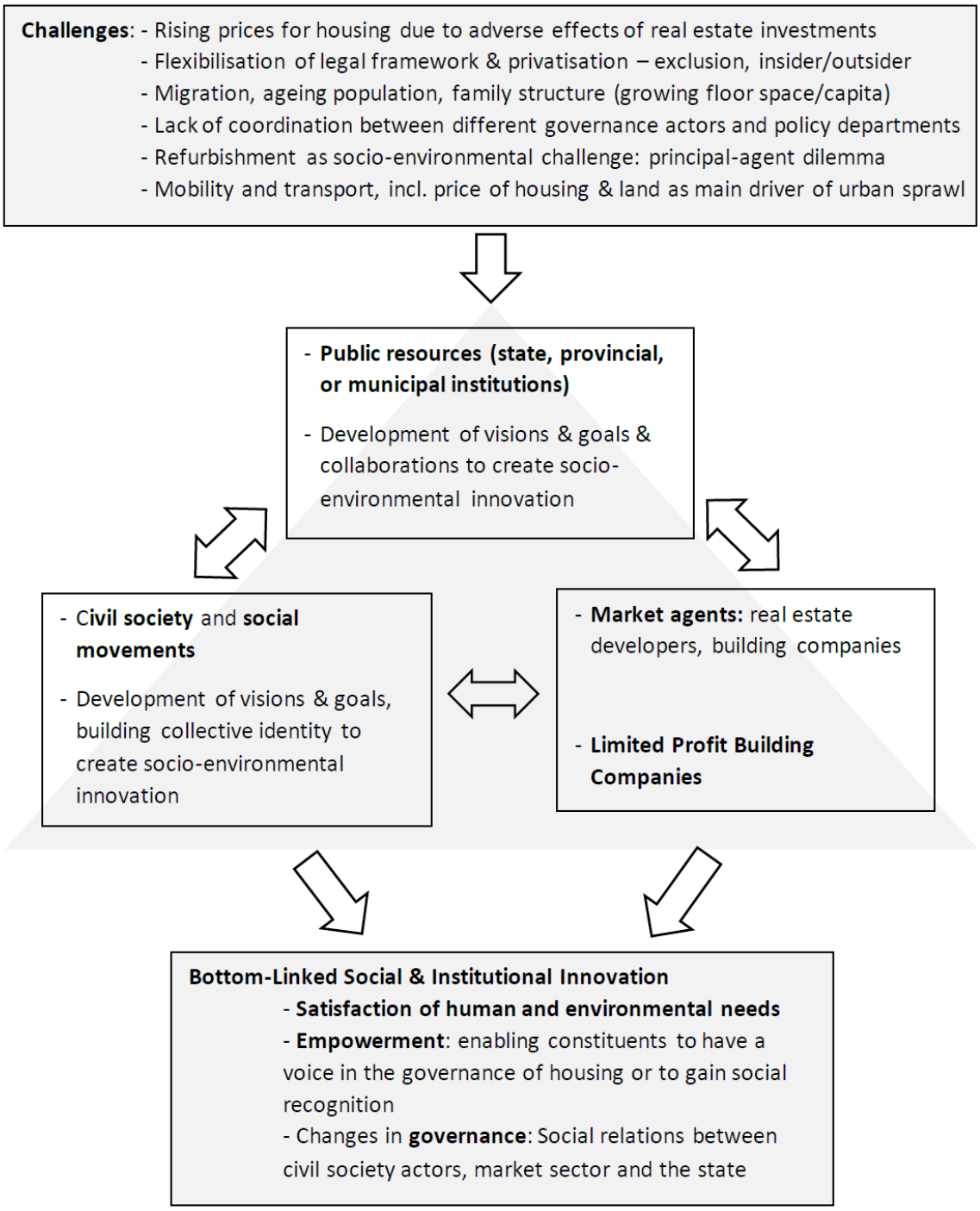

Figure 6: Socio-environmental innovation framework. Source: own elaboration, based on De Weerdt and Garcia (2016); Oosterlynck et al. (2019)

The approach by Moulaert et al. (2007) has already been successfully applied to comparable research on social innovation in housing policies (De Weerdt and Garcia, 2016; Oosterlynck et al., 2019) and could be adapted to the project's findings on the Austrian Structures of Housing Provision and the multi-level governance framework of housing. It was further refined by literature research on social and environmental innovation in international contexts in order to broaden the horizon for practical examples of social and environmental innovations. In-

depth information by the stakeholders (cf. section 6.5 below) could be used for a more nuanced understanding of the workings within the governance triangle of agents (public, market and civil society agents).

6.5. Science-Society Interface and Transdisciplinarity

First, the project team considered how to gain significant and project-relevant best practice examples out of a call for best practice projects. We concluded that some form of an award would increase the willingness of municipalities and other stakeholders to participate. Therefore, the so-called "NaWo Award" (*Nachhaltiges Wohnen*) was established. After the logo was designed and all the call criteria were defined, the call itself was published in June 2018. Eligibility criteria included the motivation and target of the project, project schedule, investment and project volume, reproducibility and ecological and social sustainability. The delayed project start (April instead of March) shifted the beginning of the call process into June. Over the course of the summer, the number of applicants remained below expectations. Therefore, the deadline had to be extended to October 22.

Based on the above-mentioned criteria, the project consortium had pre-selected eight projects by the beginning of November. An external jury agreed to carry out the final stage of the selection process with highly-esteemed experts — namely, Mag.[a] Elisabeth Matt (Austrian Energy Agency / Klimaaktiv), DI[in] Alexandra Bauer (die Umweltberatung) and Prof. em. Marina Fischer-Kowalski (Emeritus Univ.-Prof. for Social Ecology). By December 13, four best practice examples of socially and environmentally sustainable housing projects were selected (see section 4.2).

In December 2018, the participants in the call for the "NaWo Award" were informed of the results of the selection process. In coordination with the main agents responsible for the four best practice examples of the "NaWo Award", four focus groups were set up at the beginning of 2019. The focus groups were planned in the project proposal to take place during the first reporting period. However, in order to provide added value to the stakeholders, the focus groups were rescheduled to take place in June and September 2019.

The focus groups (c.f. Table 12) primarily served to facilitate dialogue with those responsible for the respective best practice projects. The project team presented the outline of the project and preliminary results concerning possibilities for decarbonising the municipalities where the projects are situated. In return, the stakeholders presented the most important details relating to their experiences and engaged in lively dialogues among themselves and with the researchers on how they tackled the main challenges, sharing their specific practical insights. The four focus groups occurred on the following dates with the following participants:

Table 12: The four focus groups meetings and their participants.

Focus group KliNaWo (Dornbirn/Vbg)	**17.06.2019**
Participants: Project consortium decarb inclusive, stakeholders and representatives of KliNaWo (Energieinstitut Vorarlberg – project developing and evaluation, Arbeiterkammer, VOGEWOSI – non-profit housing association of Vorarlberg, construction management)	
Focus Group Haus of Commons (Innsbruck/Tir)	**18.06.2019**
Participants: Project consortium decarb inclusive, stakeholders and representatives of Haus of Commons (Owner and his wife, other house residents, Energie Tirol, journalist, representative of economy for the common good)	
Focus Group Bikes and Rails (Klimabündnis Österreich office Wien/W)	**18.09.2019**
Participants: Project consortium decarb inclusive, stakeholders and representatives of Bikes and Rails (architect, chairwoman, project-developers, house resident, wohnbund consult, Famielenwohnbau)	
Focus Group Sonnengarten Limberg (Zell am See/Sbg)	**24.10.2019**
Participants: Project consortium decarb inclusive, stakeholders and representatives of Sonnengarten Limberg (Mayor and Deputy Mayor of the municipality, building administration, sociologist, SIR - Salzburger Institut für Raumordnung und Wohnen, Habitat Wohnbau GmbH – project developing and management, Bau und Service Hillebrand GmbH – construction management)	

7. Work and sheduling

Table 13: Overview of the final scheduling of the ACRP Decarb Inclusive project

Date	Milestone
04.2018	ACRP Decarb Inclusive Project Start
02.2019	"NaWo Award" winners and focus municipalities selected
03.2020	Prolongation of the project confirmed until 30.09.2020
04.2020	ACRP Decarb Inclusive Project Policy recommendations published
09.2020	Final conference including results presentation and official "NaWo Awards" ceremony
12.2020	Final reports submitted and results uploaded to the official Decarb Inclusive Homepage

8. Publications and dissemination activities

All publications have been made fully accessible on the project homepage and have been shared with the stakeholders and scientific peers.

Table 14: All publication and dissemination activities of the ACRP Decarb Inclusive project.

Date	Description	Link
04.2018	Homepage	https://eeg.tuwien.ac.at/research/projects/decarb-inclusive
06.2018	"NaWo Award" Call	https://www.klimabuendnis.at/aktuelles/na-wo-award
02.2019	"NaWo Award" Winner communication	https://www.klimabuendnis.at/aktuelles/na-wo-award-preistraeger
04.2019	Klimatag und ACRP Qualitätssicherung 2019 Poster Presentation	https://eeg.tuwien.ac.at/fileadmin/user_upload/projects/downloads/Decarb_Inclusive_Klimatag2019_v4.pdf?v=1560259510
06.2019	Working Paper D2. Interdisciplinary framework and constraints in housing transition	https://eeg.tuwien.ac.at/fileadmin/user_upload/projects/downloads/Decarb_Inclusive_D2.pdf?v=1560259445
09.2019	Presentation at TU Wien Blickpunkt Forschung	https://eeg.tuwien.ac.at/fileadmin/user_upload/projects/downloads/K1.3_Kranzl_Lukas_BlickpunktForschung.pdf?v=1607945076
09.2019	Presentation for the excursion of the economy- and cultural geography Leibniz/Uni Hannover	Without slides
10.2019	Paper Submission – Progress in Human Geography	Un-published

12.2019	Workshop at SSPCR 2019 "Smart and sustainable planning for cities and regions"	https://eeg.tuwien.ac.at/fileadmin/user_upload/projects/downloads/decarb_SSPCR_19-12-10_v2.pdf?v=1607944819
01.2020	Paper Submission Antipode	Un-published
02.2020	Presentation at EnInnov Conference Graz	https://eeg.tuwien.ac.at/fileadmin/user_upload/projects/downloads/EnInnov2020_Kranzl_Lukas_decarb_inclusive.pdf?v=1607944963
04.2020	Flyer policy recommendations	https://eeg.tuwien.ac.at/fileadmin/user_upload/projects/downloads/Decarb_Inclusive_Zusammenfassung.pdf?v=1592464462
06.2020	Online workshop jointly with the ACRP Balance Project	https://eeg.tuwien.ac.at/fileadmin/user_upload/projects/downloads/Workshop_20200610.pdf?v=1592464721
08.2020	Preparing book chapter in BEIGEWUM-book on ecological transformation	http://www.beigewum.at/ueber-uns/
09.2020	Final Conference @ TU Wien	https://eeg.tuwien.ac.at/fileadmin/user_upload/projects/downloads/Programm_Konferenz.pdf?v=1607944706
09.2020	ACRP Qualitätssicherung 2020 Posterpräsentation	https://eeg.tuwien.ac.at/fileadmin/user_upload/projects/downloads/Decarb_Inclusive_Klimatag2020_v2.pdf?v=1607944591
10.2020	Working Paper D4 – Structures of Housing Provision	https://eeg.tuwien.ac.at/fileadmin/user_upload/projects/downloads/decarb_report_WP4.pdf?v=1602843347
12.2020	Paper D3 – Decarbonisation pathways	Paper draft under submission process
12.2020	Working Paper D5.1 – Multi-level governance of affordable and sustainable housing	https://eeg.tuwien.ac.at/fileadmin/user_upload/projects/downloads/D5_1_Multi-Level_Governance_Housing.pdf?v=1608736691
12.2020	Working Paper D5.2 – Social and environmental innovation in housing	https://eeg.tuwien.ac.at/fileadmin/user_upload/projects/downloads/D5_2_Socio-environmental_Innovation_Housing.pdf?v=1608736752
12.2020	Decarb Inclusive publizierbarer Endbericht	https://eeg.tuwien.ac.at/research/projects/decarb-inclusive

Furthermore, the medial reach of the "NaWo Award" is summarised in Table 15.

Table 15: Medial reach of the "NaWo Award" of the ACRP Decarb inclusive project.

https://www.klimabuendnis.at/na-wo-award
https://www.klimabuendnis.at/aktuelles/na-wo-award-preistraeger
https://www.wu.ac.at/vw3/news-vw3-details/detail/verleihung-des-nawo-awards-an-die-4-nachhaltigsten-wohnprojekte-in-oesterreich
https://www.vol.at/na-wo-award-kostenguenstig-und-nachhaltig-bauen-in-vorarlberg/6165921
https://www.bikesandrails.org/wp/wir-haben-den-na-wo-award-gewonnen/
https://www.nachhaltigkeit.steiermark.at/cms/beitrag/12671592/22241068/
https://www.energieinstitut.at/na-wo-award-fuer-klinawo-zukunftsfaehiger-wohnbau-kostenoptimiert/
https://www.sonnengartenlimberg.at/na-wo-award-klimaaktiv/
https://vbg.arbeiterkammer.at/service/presse/Preisverleihung_Na-Wo_Award.html
https://www.tirol2050.at/de/home/detail-termine/news/detail/674/
https://www.strobl.at/aktuelles/na-wo_award_verleihung_emilie-floege-weg_wien_09-2019/
https://www.facebook.com/klimabuendnis/posts/nawoaward-nachhaltigeswohnen-gemeinsam-mit-der-tu-wien-der-wu-wirtschaftsunivers/10157760721761757/
https://www.ksoe.at/decarb-konferenz
http://www.reinberg.net/info/preise?en=1
https://www.kommunalnet.at/2019/08/23/nachhaltig-wohnen-bei-jedem-budget/
https://eeg.tuwien.ac.at/fileadmin/user_upload/projects/downloads/Decarb_Inclusive_Zusammenfassung.pdf?v=1592464462
https://www.standort-tirol.at/page.cfm?vpath=veranstaltungen&genericpageid=26002
https://www.meineraumluft.at/neuer-kooperationspartner-dr-heinz-fuchsig/
http://www.zellamsee.salzburg.at/Sonnengarten_Limberg_gewinnt_den_Na-Wo_Award_fuer_nachhaltiges_Wohnen_1
https://www.hillebrand.at/unternehmen/presse/hillebrand-auszeichnungen/
https://web.ecogood.org/de/menu-header/blog/gemeinwohl-taglich-leben/
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