Publizierbarer Endbericht

Gilt für Studien aus der Programmlinie Forschung

A) Projektdaten

Allgemeines zum Projekt	
Kurztitel:	SHIFT
Langtitel:	Policy shift for the low-carbon transition in a globally embedded economy
Zitiervorschlag:	
Programm inkl. Jahr:	ACRP 9th Call for Proposals, 2016
Dauer:	01.06.2017 bis 31.05.2020
KoordinatorIn / ProjekteinreicherIn:	Karl-Franzens Universität Graz; Wegener Center für Klima und Globalen Wandel; Prof. Dr. Karl W. Steininger
Kontaktperson Name:	Univ. Prof. Dr. Karl Steininger
Kontaktperson Adresse:	Universität Graz, Wegener Center für Klima und Globalen Wandel, Brandhofgasse 5, 8010 Graz
Kontaktperson Telefon:	+43 316 380 8441
Kontaktperson E-Mail:	karl.steininger@uni-graz.at
Projekt- und KooperationspartnerIn (inkl. Bundesland):	P1 Umweltbundesamt GesmbH, Wien P2 Tilburg University, Tilburg Sustainability Center, NED P3 Karl-Franzens Universität Graz, Institut für Philosophie, Graz Universität München, ifo Institut, GER (KooperationspartnerIn)
Schlagwörter:	
Projektgesamtkosten:	241.202 €
Fördersumme:	246.818 €
Klimafonds-Nr:	B670198
Erstellt am:	28.08.2020

B) Projektübersicht

1 Kurzfassung

<u>Ausgangslage und Projektziele</u>
Mit der Vereinbarung des Pariser Klima-Abkommens Ende 2015 und dessen Ratifizierung im Folgejahr signalisierte die internationale Gemeinschaft sowohl ihr Bekenntnis zu langfristig klimaneutralen Gesellschaften als auch zur Einhaltung einer freiwilligen, „bottom-up" ausgerichteten klimapolitischen Architektur. Österreich gehörte zu den ersten Ländern, die das Pariser Abkommen ratifiziert haben, doch das politische Instrumentenpaket zur Erfüllung seiner Verpflichtung, das in Österreich umgesetzt werden sollte, musste noch entwickelt und verhandelt werden. Aus wissenschaftlicher Sicht war für Österreich der langfristige Übergang zu einer klimaneutralen Gesellschaft vor allem entlang verschiedener physikalischer und technologischer Dimensionen analysiert worden, doch fehlte die Analyse des politischen Instrumentenpakets zur tatsächlichen Erreichung solcher Übergangspfade. Das Projekt SHIFT versuchte, einen Beitrag zur Schließung dieser Wissenslücke zu leisten.

Auf der Grundlage von Kriterien der wirtschaftlicher und normativer Dimension sowie jener der politischen Durchführbarkeit waren die übergeordneten Ziele des Projekts SHIFT die Identifizierung, Gestaltung und Evaluierung von Instrumentenpaketen, die umfassend sind, um Österreichs klimaneutralen Übergang gemäß den Zielen des Pariser Abkommens zu ermöglichen. Diese Ziele wurden beantwortet durch die Einbindung von Stakeholdern in den Forschungsprozess, die Entwicklung eines Evaluierungsinstruments für die österreichische klimarelevante Politik, die Identifizierung von Instrumenten, die einem in die Weltwirtschaft eingebetteten Land zur Verfügung stehen, insbesondere zur effektiven Förderung von Innovationen in einem klimaneutralen Transformationsprozess, die integrative Bündelung von Instrumenten zu alternativen Paketen sowie die Evaluierung und Diskussion dieser Pakete und deren Verbesserung hinsichtlich der Akzeptanz durch ein Co-Design mit Stakeholdern.

<u>Nationale Klimapolitik und der voraussichtliche Bedarf an Kohlenstoffbudget</u>

Unter Berücksichtigung der Ziele der Entwicklung und Bewertung von Politiken zur Erreichung der Klimaziele müssen wir zunächst eine Bewertungsgrundlage schaffen, nach welchen Kriterien zwischen den Politiken auszuwählen sei? In einer ersten Bestandsaufnahme der österreichischen Politik stellten wir fest, dass die derzeitigen Bemühungen zwar die Emissionen zwischen 2016 und 2050 wahrscheinlich auf aggregiert unter 2,5 Gigatonnen CO2-Äquivalent und die vorgeschlagenen Politiken sogar noch weiter auf etwa 1,75 Gigatonnen reduzieren würden, dass sie aber immer noch weit hinter einem Budget zurückbleiben würden, mit dem Österreich einen adäquaten Beitrag leisten würde um das ehrgeizigere 1,5-Grad-Ziel zu erreichen, und nur knapp ans 2-Grad-Ziele heranreichen würde. Auf dieser Grundlage legten wir einen Benchmark-Satz von Politiken fest, die als Beispiel für ein Land gedacht sind, das auf dem besten Weg ist, die Verpflichtungen von Paris zu erfüllen, und skizzierten, was solche Politikpakete erfordern würden.

Für die Bewertung von Politiken wurde ein breiter Rahmen entwickelt, der umfasst (i) wirtschaftliche Effizienz, d.h. das Ziel, dass eine Politik ein Ziel zu den geringsten Kosten erreicht, (ii) Umwelteffektivität, d.h. die Messung, wie gut eine Politik die angestrebten Ziele tatsächlich erreicht, und (iii) Durchführbarkeit, d.h. die Wahrscheinlichkeit, dass eine Politik in Bezug auf administrative Engpässe, öffentliche Unterstützung und politischen Willen Erfolg hat, sowie der zudem das Risiko berücksichtigt, dass eine Politik nicht die erwarteten Ergebnisse liefert. Darüber hinaus konzentrierten wir uns auf die Notwendigkeit ethischer Kriterien und betonten die Achtung der individuellen Autonomie, der Nichtverarmung, der Wohltätigkeit und der Gerechtigkeit.

Schließlich betonten wir die Notwendigkeit, sich auf Interaktionseffekte zu konzentrieren, z.B. wenn die Politik des EU-Emissionshandelssystems und nationale Politiken miteinander in Konflikt geraten, oder Politiken auf verschiedenen Regierungsebenen, wobei ein besseres Verständnis dafür erforderlich ist, wie Instrumente mit unterschiedlichen Ansätzen (wie Information und Bewusstseinsbildung und wirtschaftliche Anreize) miteinander interagieren können. Wir untersuchen auch die Möglichkeit, dass ein Klimaziel wie der Ausbau erneuerbarer Energien durch seinen eigenen Erfolg begrenzt wird, wobei wir die bestehende beträchtliche Durchdringung mit erneuerbaren Energien in Kalifornien untersuchen, um den Kannibalisierungseffekt nachzuweisen, durch den eine zunehmende Durchdringung den Wert von Erneuerbaren untergräbt.

Stakeholder Einbindung und Dissemination

Das Projekt wurde in enger Einbindung von Stakeholdern gestaltet, bilateral und in Teilgruppen sowie kollektiv an zwei Stakeholder-Workshops, anhand derer maßgeschneiderte Konzepte erstellt wurden. Die Stakeholder betonten im ersten Workshop, dass die vorliegende Lücke zwischen klimapolitischen Zielen und bestehenden Maßnahmen nur durch Kombination mehrerer Instrumente aus verschiedenen Maßnahmenkategorien effektiv und effizient geschlossen werden kann. Eine individuelle Bewertung zeigte auf, dass die wichtigsten Maßnahmenkategorien rechtliche Anpassungen als auch ökonomische Instrumente sowie Finanzierungsaspekte betreffen. Die effektivste Kombination besteht exakt zwischen Instrumenten aus den genannten Gruppen, manche Stakeholder haben zudem auf die Wichtigkeit von Sensibilisierung, Bewusstseinsbildung und Informationskampagnen hingewiesen. Informationsbereitstellung ist die Basis für Akzeptanz und Verhaltensänderungen und ihre Wirkung wird oftmals unterschätzt. Im zweiten Stakeholder-Workshop konnten auf Basis der vorläufigen Projektergebnisse mit den Stakeholdern mittels Backcasting-Methoden fünf Transformationspfade erarbeitet werden, jeweils zwei für die Bereiche „Energie“ und „Verkehr“, sowie einer für „Gebäude“. Das übergeordnete Ziel der „Kohlenstoff-Neutralität“ zur Mitte des jetzigen Jahrhunderts wurde intensiv debattiert und zeigt eine starke Polarisierung über Stakeholder-Gruppen hinweg auf. Diese Polarisierung wurde als Ausgangspunkt für ein weiteres der Disseminations-Produkte des Projekts genommen, ein Blog Post[1] in der Zeitschrift „Die Presse“. Dieser diskutiert das Potential zur Überwindung dieser Polarisierung in der österreichischen Klimapolitik.

Policy-Evaluierungstool für eine low-carbon Transformation

Eine umfassende Begutachtung der Literatur unterstützte die Entwicklung der Evaluierungskriterien anhand ökonomischer, normativer und politischer Dimensionen. Viele Kriterien wurden vorgeschlagen und diese schließen Kosteneffektivität, Verteilungseffekte, Fragestellungen der urbanen und ländlichen Entwicklung als auch öffentliche Akzeptanz ein. Mit der Hilfe eines hier entwickelten Evaluierungstools wurden die mit den Stakeholdern ko-entwickelten klimapolitischen Maßnahmenpakete getestet. Zwei substantielle Beiträge zu bestehenden Analysen konnten erreicht werden. Der Großteil bestehender Klimapolitikanalysen fokussiert auf einzelne Instrumente, hier wird der Augenmerk auf Maßnahmenpakete gelegt. Diese sind zudem in ein realitätsnahes Umfeld und damit verbundene Restriktionen eingebettet. Dadurch sind die in SHIFT entwickelten und evaluierten Maßnahmenpakete von hoher praktischer Relevanz.

Ökologische Innovationen

Öko-Innovationen spielen eine wichtige Rolle beim Übergang zu einer CO_2-freien Wirtschaft, welcher für das Erreichen des 2°-Ziels des Pariser Klimaübereinkommens bis 2050 unumgänglich ist. Angesichts von Pfadabhängigkeiten und Marktversagen, die den Prozess des technologischen Wandels kennzeichnen, kommt dem Staat die Aufgabe zu, Anreize zur Entwicklung emissionsfreier Technologien setzen. Um Entscheidungsträger

[1] https://www.diepresse.com/5837463/warten-auf-godot-kann-die-polarisierung-in-osterreichs-klimapolitik-uberwunden-werden

bei Gestaltung und Auswahl geeigneter Politikinstrumente zu unterstützen, wurde ein Bewertungsrahmen entwickelt, der anhand von fünf Fragen eine Anleitung dafür gibt, wie neue Instrumente gestaltet bzw. bestehende verbessert werden können. Vor der Anwendung dieses Bewertungsrahmens auf bestimmte Emissionssektoren Österreichs erfolgte eine detaillierte Bewertung der Öko-Innovations-Performance des Landes im internationalen Vergleich und die Erstellung eines Inventars bestehender Instrumente der Umwelt- und Innovationspolitik. Die Anwendung des Bewertungsrahmens auf den österreichischen Gebäudesektor zeigt, dass eine Reihe bestehender Instrumente angepasst, komplementär dazu Instrumente neu geschaffen und alle in ein kohärentes Maßnahmenbündel zusammengefasst werden sollten, um die Dekarbonisierung des Sektors voranzutreiben.

Politische Maßnahmenpakete

Auch für das andere Hauptaktionsfeld der österreichischen Klimapolitik, den nachhaltigen Personenverkehr, entwickelte das Projektteam mit Hilfe von Co-Kreation mit Experten aus der Praxis Politikpakete. Die sozio-ökonomischen und ökologischen Auswirkungen dieser Pakete wurden mit dem Evaluationsinstrument evaluiert. Ein Kernergebnis deutet darauf hin, dass eine Entkoppelung von Wohlfahrt und negativen externen Effekten des Verkehrs möglich ist, aber Stadt-Land-Unterschiede sowie regressive Effekte die öffentliche Akzeptanz untergraben können, insbesondere wenn nur einzelne Maßnahmen/Instrumente eingesetzt werden. Es hat sich gezeigt, dass das Politikpaket, das mehrere Maßnahmen umfasst, diese Probleme unter Beibehaltung der Kostenwirksamkeit mildern kann.

Bei den umfassenden Instrumenten wurden die langfristigen Auswirkungen einer nationalen Kohlenstoffpreisgestaltung mit verschiedenen Verwendungsoptionen der Einnahmen untersucht, wobei auch Fragen der Gerechtigkeit, des öffentlichen Haushalts und der Netto-THG-Emissionswirkung behandelt wurden. Wir befassten uns mit der Frage, wie öffentliche Einnahmen am besten umverteilt werden können. Unsere Ergebnisse demonstrieren und quantifizieren den bestehenden Kompromiss zwischen Effizienz und Gerechtigkeit und zeigen, dass ein Ökobonus, der die aus der Kohlenstoffbepreisung erzielten Einnahmen auf Pro-Kopf-Basis rückverteilt, aus einer Rawls'schen Perspektive zu bevorzugen ist. Weitere Aspekte eines Politikpakets, das eine Kohlenstoffpreisgestaltung umfasst, beziehen sich auf den Grad der Ambition und den Grad der Zusammenarbeit zwischen Ländern oder Weltregionen. Dies ist besonders relevant, da der kohlenstoffarme Übergang in Österreich - eine kleine offene Wirtschaft - in eine globale Wirtschaft eingebettet ist.

2 Executive Summary

<u>*Background and project objectives*</u>

With the adoption of the Paris Agreement in late 2015 the international community signalled both its commitment to long-term carbon-neutral societies and to adhere to a voluntary, bottom-up climate policy architecture. Austria was one of the first countries to ratify the Paris Agreement, yet the policy instrument package to meet its commitment and to be implemented in Austria was still to be developed and negotiated. Both a draft Climate and Energy Strategy submitted to the EU in 2018 and its revision raised criticism of not being sufficiently ambitious. From a scientific point for Austria the long-term transition to a carbon-neutral society had been analysed mainly along different physical and technological dimensions focusing on emission reduction potentials, but the analysis of the long-term oriented and comprehensive policy instrument package(s) to actually achieve such transition pathways was crucially lacking. The project SHIFT sought to contribute to close this knowledge gap.

Exploring economic, normative and feasibility/acceptability criteria, the overall objectives of the project SHIFT were the identification, design and evaluation of instrument packages that are comprehensive to enable Austria´s low-carbon transition according to the Paris Agreement targets. These objectives were answered by means of integration of stakeholders in the research process, development of an evaluation tool for Austrian climate-relevant policy, identification of instruments available to a country embedded within the world economy, in particular to effectively foster innovation in a low-carbon transition, integrative bundling of instruments to alternative packages, and evaluation and discussion of these packages and their improvement in terms of acceptability by means of their co-design with stakeholders.

<u>*National climate policies and the likely carbon budget*</u>

With consideration of the objectives of developing and assessing policies to progress towards reaching climate goals, we first need to establish a basis for evaluation. In order to create policy packages to reach a goal we first need a common understanding of such questions as what the target should be, what policies are available for use, and how should we differentiate between policies in terms of their results; what are the criteria we use to choose between policies? In an initial stocktaking of Austrian policy, we found that while current efforts would likely reduce emissions to under 2.5 gigatonnes of CO_2 equivalent between 2016 to 2050, and proposed policies even further to around 1.75 gigatonnes, they would still fall far short of a budget for an adequate contribution of Austria to likely meet the more ambitious 1.5 degree target goals, and would only barely approach 2 degree goals. From there, we established a benchmark set of policies thought to exemplify a country on track to meet e.g. Paris commitments, and outlined what such policy packages would require.

In terms of how we assess policies, a broad framework was developed incorporating (i) economic efficiency, the goal of having a policy achieve an objective at least cost; (ii) environmental effectiveness, measuring how well a policy actually reaches the goals it is targeted to produce, and (iii) feasibility, the likelihood of a policy finding success in terms of administrative bottlenecks, public support, and political will; addressing the risk that a policy may not deliver it's expected results. We additionally focused on the need for ethical criteria, emphasizing respect for individual autonomy, nonmaleficence, beneficence, and justice.

Lastly, we highlighted the need to focus on interaction effects, e.g. when EU Emissions Trading System policy and national policies conflict with each other, or policies at different governance levels, finding a need for a better understanding of how instruments with different approaches (such as information and awareness-raising and economic incentives) may interact with one another. We also investigate the possibility that a climate goal such as renewables expansion may be limited by its own success, using the case of California and its substantial renewables penetration to demonstrate the cannibalization effect, through which increasing penetration undermines value.

Eco-innovation

Eco-innovation plays an important role in the transition to a zero-carbon economy, which is essential for limiting global warming to no more than 2° Celsius by 2050 in line with the Paris Agreement. Given the path dependencies and market failures that characterise the process of technological change, government action to stimulate the development of zero-carbon technologies is called for. To support policy-makers in the design of appropriate policy instruments, an evaluative framework was developed, which consists of five questions guiding the design of new instruments and the improvement of existing ones. Before applying this framework to the specific context of individual Austrian emission sectors, we assessed their relative eco-innovation performance compared to other countries and compiled inventories of existing environmental and technology policy instruments in these sectors. We then applied the evaluative framework to the Austrian buildings sector, for which we explored in detail the emission profile, the eco-innovation performance in different technologies suitable for emission reduction, and the existing instrument package. Based on this information, a package of new and revised policy instruments was developed, targeted at stimulating innovation to reduce emissions. An important policy conclusion is that coherent policy packages are key to steer the economy towards zero-carbon at lowest (intertemporal) cost.

Policy instruments

For the other main action field in Austrian climate policy, sustainable passenger transport, the project team used co-creation tools to develop policy packages with experts from the field. The socio-economic and environmental effects of these packages were evaluated with the evaluation tool. A core result suggests that decoupling of welfare and negative external effects of transport is possible but urban-rural conflicts as well as regressive effects can undermine public acceptance, particularly if only single measures/instruments are used. The policy package including multiple measures is shown to alleviate these issues while keeping cost effectiveness.

On comprehensive instruments, the long-run effects of unilateral carbon pricing with various recycling schemes were explored, addressing also issues of equity, public budget and net CO_2 emissions. We addressed how to redistribute public revenues best. Our results demonstrate and quantify the existent efficiency versus equity trade-off and that unconditional eco-bonus recycling of raised revenues from carbon pricing on a per capita basis seems preferable from a Rawlsian perspective. Further aspects of a policy package comprising carbon pricing relate to the level of ambition and the degree of cooperation across countries or world regions. This is particularly relevant, since the low-carbon transition in Austria – a small open economy – is embedded in a global economy.

3 Hintergrund und Zielsetzung

Initial situation

With the adoption of the Paris Agreement in late 2015 the international community signalled both its commitment to long-term carbon-neutral societies and to adhere to a voluntary, bottom-up climate policy architecture. Austria was one of the first countries both globally and within the EU to ratify the Paris Agreement, yet the policy instrument package to meet its commitment and to be implemented in Austria was still to be developed and negotiated. Austria submitted a draft Climate and Energy Strategy to the EU in late 2018, and after the Commissions feedback a revised version at late 2019. Criticism of both versions of not being sufficiently ambitious, along with recent movements such as FridaysForFuture, have highlighted the growing realization that broad and effective policy packages are needed immediately. From a scientific point for Austria the long-term transition to a carbon-neutral society had been analysed mainly along different physical and technological dimensions (primarily identifying emission reduction potentials), but the analysis of the long-term oriented and comprehensive policy instrument package(s) to actually achieve a low carbon transition pathway was crucially lacking. The project SHIFT sought to contribute to close this knowledge gap.

Objectives

Exploring the economic, normative and feasibility/acceptability criteria the overall objectives of the project SHIFT were the identification, design and evaluation of instrument packages that are comprehensive (i.e. address economic, normative and feasibility/acceptability objectives) to enable Austria´s low-carbon transition according to the Paris Agreement targets (as ratified by the Austrian Parliament). These objectives were answered by means of integration of stakeholders, development of an evaluation tool for Austrian climate-relevant policy, identification of instruments available to a country embedded within the world economy to effectively foster innovation in a low-carbon transition, integrative bundling of instruments to alternative packages, and evaluation and discussion of these packages and their improvement in terms of acceptability by means of co-design with stakeholders.

4 Projektinhalt und Ergebnis(se)

Taking stock of policies, policy packages and their carbon budget

In the assessment of future emissions and policy scenarios for Austria until 2050, we compared the likely national carbon budget of Austria, in line with its Paris Agreement commitments, with scenarios of (i) existing policy measures (Umweltbundesamt 2017b) and the (ii) Umweltbundesamt's (2017a) estimates of a package of measures designed to shift the country into a low-carbon society. We found that under a variety of assumptions in regards to emissions budgets, even the ambitious transition scenario would fall short of Austria fulfilling its Paris pledges, as shown in Figure 1, reflecting cumulative emissions to 2050, and emphasizing a need for faster and deeper decarbonisation.

While the Transition scenario as proposed would not be sufficient to fulfil Austria's "fair-share burden" in order to limit temperature rise to well below 2 degrees, it provides a useful blueprint for a vision of policies necessary across different domains to achieve that goal.

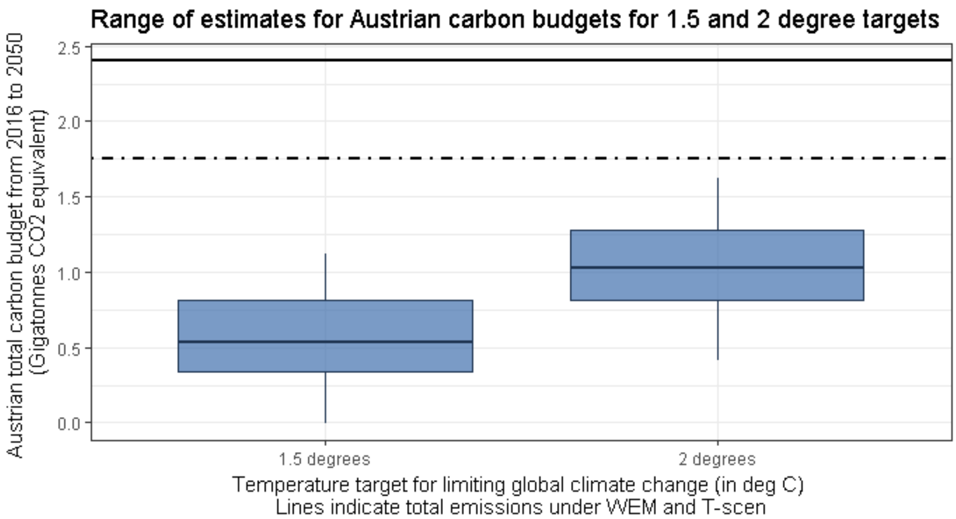


Figure 1. Comparing plausible carbon budgets (own calculations) and total cumulative emissions of two Austrian emission scenarios. The solid line just under 2.5 Gigatonnes indicates the cumulative emissions for the WEM (with existing measures) scenario by 2050, with the dotted line indicating the Transition scenario.

Using the transition scenario as a baseline, a series of a mixture of qualitative and concrete benchmarks was formulated for what is described as "good practice policy benchmarks." Following this definition of good-practice policymaking for individual sectors, benchmarks were aggregated into a proposed package of policy objectives, building on the methodology of Hoehne et al (2011), and clustering benchmarks into four policy areas to identify the key elements to consider when designing policy packages:

- Activity: assessing whether a given policy will influence the demand-side of different sectors
- Energy efficiency: including benchmarks for the sectors involving energy use

- Renewable energy: assessing whether renewable technology is deployed in the energy sectors at the necessary scale and speed
- Non-energy: covering benchmarks regarding emissions not directly linked to energy

The result of this assessment is a good-practice policy matrix for Austria to reach a low carbon economy, broken down by sector and policy area (see Table 1).

Further, three broad criteria for assessing policy packages were outlined, based on literature review. Past assessments have typically followed a common set of criteria, those being:

- (i) economic efficiency, e.g. the goal of having a policy achieve an objective at least cost to society
- (ii) environmental effectiveness, measuring the results of a policy intervention, e.g. ensuring that a policy or package is actually achieving the results it set out to obtain, and
- (iii) feasibility, which speaks to the probability of policy success and addresses risks that policy may not deliver expected results.

Lastly, in order to understand policy effects a thorough understanding of the likely interactions between policies within a package is needed. While some aspects of such interactions, e.g. between federal state and national jurisdictions, or between the EU Emissions Trading System and national policy are well documented, other areas are less well defined. As it has been found that such interactions are highly context-dependent and may vary from country to country given the nation's specific contextual factors, SHIFT attempted to highlight gaps in research where further stakeholder interaction sought to advance the knowledge of how proposed policies may interact with one another. One such area in need of further investigation was found to be the likely interactions of policy instruments with different approaches (e.g. how a policy designed to increase information and awareness may interact with more conventional economic incentives or regulation).

As a more pointed example of interactions, we additionally focused on the challenges of expanding renewables significantly with an analysis of the experience of regions already having a substantial share of renewables, in our case California. Increasing penetration of zero marginal cost variable renewable technologies cause the decline of whole-sale electricity prices due to the merit-order effect. This causes a "cannibalization effect" through which increasing renewable technologies' penetration undermines their own value. We calculated solar and wind daily unit revenues (generation weighted electricity prices) and value factors (unit revenues divided by average electricity prices) from hourly data of the day-ahead California wholesale electricity market(CAISO) for the period January 2013 to June 2017. We then performed a time series econometric analysis to test the absolute (unit revenues) and relative (value factors) cannibalization effect of solar and wind technologies, as well as the cross-cannibalization effects between technologies. We find both absolute and relative cannibalization effect for both solar and wind, but while wind penetration reduces the value factor of solar, solar penetration increases wind value factor, at least at high penetration and low consumption levels (see Figure 2). We explored non-linearities and also find that the cannibalization effect is stronger at low consumption and high wind/solar penetration levels. This entails that wind and (mainly) solar competitiveness could be jeopardized unless additional mitigation measures such as storage, demand management or intercontinental interconnections are taken.

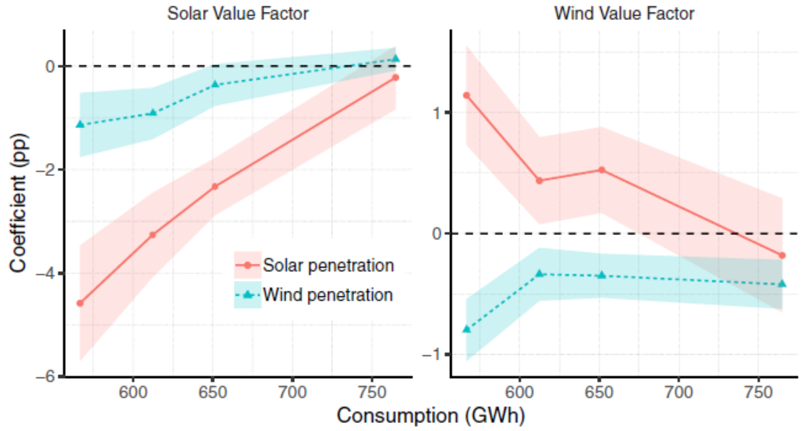


Figure 2. Solar and wind partial effects across consumption levels (consumption in GWh); source: Lopez-Prol et al, 2020.

Table 1. Good-practice policy matrix for Austria to reach a low carbon economy (by sector and policy area)

	activity	Efficiency	renewables	non-energy
cross-cutting	❖ ambitious binding greenhouse gas reduction target consistent with Paris Agreement pathway ❖ comprehensive consistent long-term strategy for 2030 and 2050 ❖ comprehensive framework legislation for 2030 and 2050 ❖ internalisation of external costs for energy sources ❖ socio-ecologic tax reform including a carbon pricing element for the non-ETS sector ❖ compact, space efficient and multifunctional settlement structures to prevent urban sprawl ❖ incentives to encourage greater uptake of co-generation and waste heat opportunities ❖ removal of subsidies that act as barrier to climate policy ❖ removal of non-economic barriers to climate policy			
Energy & Industry	❖ more rigorous implementation of EU ETS ❖ CO2-labelling schemes and carbon price for products	❖ reduce energy use by half until 2050 ❖ circular economy, durability of products, modular construction ❖ material efficient industry	❖ direct reduction in steel sector ❖ electric furnaces for glass production ❖ increase in production of RES	❖ reduced share of clinker in cement and alternative construction materials
Buildings	❖ compact housing settlement structures ❖ cost assessments are done on a life-cycle basis	❖ multi-storey buildings and buildings with higher volume/qm-ratio ❖ reduced m2/person in new buildings ❖ high-quality retrofit requirements ❖ accelerated renovation rate ❖ zero-energy efficiency standards	❖ decrease options to replace oil with gas heating system ❖ prohibit new oil heating systems (starting 2018) ❖ replacement of existing oil heating systems (by 2030)	❖ renewable resources ('nachwachsende Rohstoffe') used in construction
Transport	❖ transport avoided or moved to non-motorized ❖ shift of modal split for passenger and freight from road/plane to rail ❖	❖ freight transport peaks in 2030 ❖ priority investment in public or non-motorized transportation	❖ ensure 100% CO2-emission-free new vehicles (by 2030 for passenger, 2035 for light and 2040 for heavy duty road transport ❖ keep biofuel production at current level	N.A.
Agriculture & Forestry	❖ sustainable and healthier food consumption practices ❖ reduced food waste ❖ raised share of organic agriculture ❖ alternative sources of low-carbon protein	❖ reduced use of mineral fertilizers (-50% in 2050)	N.A.	❖ decrease in livestock ❖ capped milk production ❖ increased share of grazing- and dual-purpose cattle

Waste & F-	❖ sustainable consumption practices and reduced waste	N.A.	N.A.	❖ reduced CH_4 from waste ❖ reduced emissions of f-gases

Stakeholder dialogue and workshops

Throughout the project, two workshops were held. The objectives of the first have been twofold: (i) Identification of institutional, economic and legal barriers and obstacles and the subsequent formulation of concrete, mutually realisable and promising solutions for overcoming them and (ii) collective analysis and evaluation of instrument packages, which are in line with the Paris Agreement, concerning effectiveness of different combinations of (existing and additional) packages and contextual dependencies. The ultimate goal was not to develop a complete checklist of instrument packages but to obtain insight on the interaction of instruments, highlighting synergies/conflicts and contextual factors.

The one-day workshop was structured along three separate but interdependent issues. First, stakeholders had to assess individually the most important category out of five different policy instrument types: (i) Legal regulation, (ii) Strategies, (iii) Economic instruments and finance, (iv) Sensibilisation, awareness and information campaigns, (v) Voluntary action. Second, stakeholders had to decide in two-rounds how and why they would combine it with (instruments of) other categories in order to raise effectivity and efficiency. Third, and individually most extensive, three spatially separated tables invited stakeholders to reflect and get involved in focussing on and discussing the workshop's main objectives as described above (see Section 2.1.4) This main part has been centred on three distinguished topics, one at each table: (i) buildings, (ii) spatial planning and (iii) economic instruments and finance. Stakeholders worked on identifying policy gaps (in terms of missing or to be re-evaluated instruments), associated barriers and obstacles, as well as potential solutions.

Conclusions of the first workshop

Stakeholders stressed that closing the climate policy gap effectively and efficiently needs components of each instruments category (cf. Figure 2). However, according to their individual assessments the most important categories are 'Legal action' and 'Economic instruments and finance'. The strongest combination of categories is exactly between both of them, though some stakeholders put weight on 'Sensibilisation, awareness building and information campaigns'. Stakeholders emphasized the underestimated value of information as basis for acceptance and actual behavioural change.

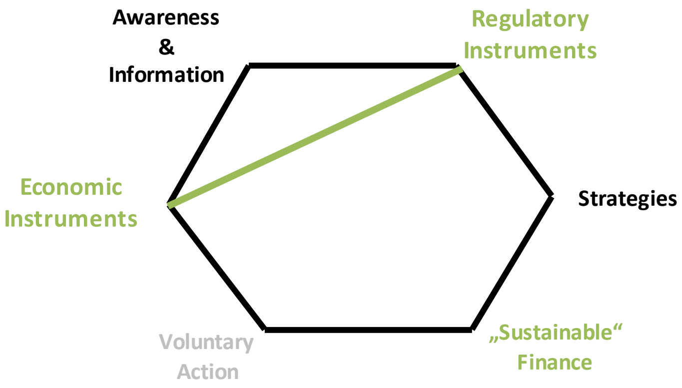


Figure 3. Individual and combination of types of policy instrument, which are most relevant (here in green colour) for the low-carbon transition according to stakeholders.

Stakeholders were ambivalent regarding 'Strategies'. Some argued that determining a strategy is the first and pivotal step for effective and efficient measures. Others countered that there exist enough strategy documents and that they have to be filled with action. However, stakeholders agreed by large that it needs those who write and understand strategies, and those who take hold of it and act/implement. In many cases, barriers exist at the latter level due to vested interests. A critical issue is establishing a democratic consensus to overcome them.

The transition – as of now – is not self-sustaining, according to stakeholders. Hence, the least important category – in terms of stand-alone as well as complementary instruments category – is 'Voluntary action'. It needs external stimulus. Some stakeholders proposed that a further category may be missing, which is 'Redirecting financial markets towards sustainability', which accordingly has been added as a separate, sixth type of policies (cf. Figure 3).

At the second stakeholder workshop, the focus shifted to recent developments in research within SHIFT (namely, modelling an eco-tax reform) as well as the Reference NEKP (Kirchengast et al. 2019), which were presented and discussed in small breakout groups. The goal of the initial interaction was to gauge stakeholder response to the (then) recently published NEKP, highlight missing areas for improvement, and discuss how science can better support such work as the NEKP and inform implementation of climate policy in Austria. The latter half of the workshop emphasized that while broad policies e.g. eco-social tax reform can contribute to climate goals, there remains a large gap between likely reductions and those necessary for meeting Paris commitments. In small groups, the participants developed a vision of the future (Vision 2045, assuming net zero CO2), in general and specifically for the areas of energy, transport and buildings. Based on the Vision 2045, the participants worked on concrete measures, framework conditions and implementation steps by backcasting in time steps 2035, 2030, 2025 up to the present 2020.

Conclusions of the second workshop

While the participants readily acknowledged the need for the NEKP and for having a comprehensive approach, it was seen somewhat as a ambitious and worthy first stage, and a good basis to build upon. Respondents found the work scientifically robust and politically motivating, but highlight that more concrete planning is needed, and e.g. optimization / prioritization of the many options within the NEKP. Respondents also hoped for more specificity in recommendations on policy implementation, highlighting a need for e.g. standardizing a transparent method for GHG emissions calculations within the country, establishing socially-acceptable transformation pathways, and a more 'implementation-oriented' NEKP.

Generally, respondents' reactions were such that while they found the NEKP and Reference NEKP catalog of measures a positive and comprehensive work which can be viewed as 'science' taking a concrete position on the policy issues surrounding climate change, it is still too cautious, and detailed timelines of what should happen by when would be desirable, along with broader, more ambitious goals e.g. ending the influence of fossil fuel lobbying, pushing for political implementation.

The idea of more concrete, direct and emphatic action carried over to discussions on the eco-social tax reform as investigated in SHIFT, as well as how science can better contribute to policy, where respondents highlighted need for more detailed information regarding the transition phase to a low-carbon economy, and the specific policies to arrive there. Another message which carried over was again the need for better translation of results and consequences of (in)actions in terms of science-to-public communication. Outside of more detailed understanding in research terms, participants highlighted a similar need from the political sphere, with emphasis on clear stable policies and framework conditions to provide security for business, and suggestions to establish an independent task force for evidence-based policy, along with increased citizenry involvement via Citizen's Councils.

<u>Development of the WegDyn-AT model</u>

In order to assess the policies identified in the initial stocktaking, as well as documentation such as the NEKP, as well as discussed in stakeholder interactions, the Wegener Center's Wegener Dynamics Austria model (WEGDYN-AT) was developed. The WEGDYN-AT model is a dynamic-recursive computable general equilibrium (CGE) model depicting Austria as a small open economy. Firms maximize profits and private/public households maximize utility. Profits and utility are modelled using nested constant elasticity of substitution (CES) functions. Foreign trade is modelled via the Armington (1969) specification and we close the model by fixing savings rates, tax rates and the current account. We calibrate the model to a social accounting matrix (SAM) of the year 2014, which is based on data provided by Statistics Austria and an input-output table of 72 NACE-classified economic sectors. Several refinements have been made compared to standard CGE models. Addressing the main areas of Austrian GHG emissions in the Non-ETS area, the model has greater resolution in land transport and energy provision and captures twelve heterogeneous groups of households differentiated by income level and residence location. We also included the Austrian CO2 emission inventory based on physical energy use tables (Statistik Austria, 2014) combined with energy-specific CO2 emission factors (UBA, 2014). We furthermore distinguish ETS and non-ETS CO2 emissions (EC directive, 2009) as well as combustion and industrial process emissions (UNFCCC, 2019). Model documentation is made available through respective journal publications (see Annex).

Austria's specialization in climate change mitigation technologies

To reach the target of climate neutrality by 2040, which the current Austrian government has set itself, it will be crucial to have available zero-carbon technologies in all emission sectors. Therefore, eco-innovation – i.e., innovation that results in a reduction of environmental impact – must be further stimulated. Because eco-innovation as a process of technological change towards cleaner technologies is characterised by path dependencies as well as market failures due to externalities, government intervention is called for. For small open economies like Austria, additional considerations arise from the international dimension of the externalities related to innovation and climate change.

Given multiple market failures, multiple instruments are required to correct them (Tinbergen, 1952). Therefore, the task of policy-makers is to devise a portfolio or package of policy instruments which are effective in steering innovation towards the technologies needed for a zero-carbon transition. Indeed, such an instrument portfolio generally reduces emissions at lower costs than a single policy instrument (e.g. Fischer and Newell, 2008). The set of policy instruments that is available to policy-makers to choose from includes technology policy instruments like R&D subsidies, adoption subsidies and technology standards as well as environmental policy instruments such as emission pricing and emission standards. Figure 4 illustrates the complex interplay of technology policy and environmental policy in stimulating eco-innovation to achieve emission reductions.

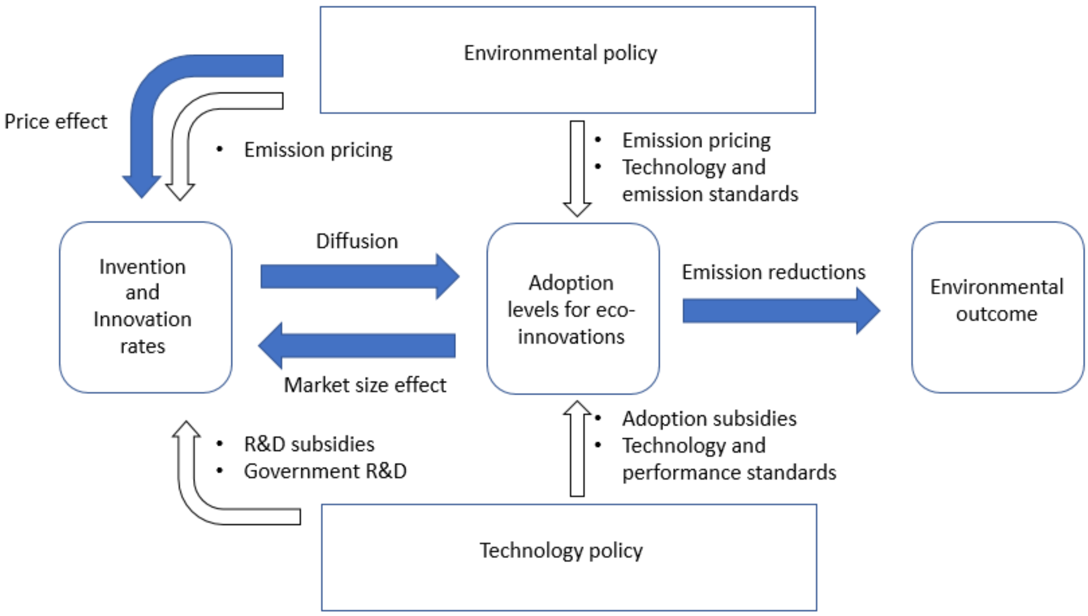


Figure 4. The interaction between environmental policy, technology policy, and the process of technological change

Note: Dark arrows indicate processes; light arrows indicate policies.

Developing an evaluative framework for policy-makers

To guide policy-makers in the design and choice of policy instruments to foster eco-innovation for a zero-carbon transition, an evaluative framework was developed which comprises a set of five questions related to the policy context. Answering these questions should provide clear direction towards policy design in a world in which first-best instruments are difficult to implement:

1. Is the *focus* of the instrument (package) appropriately targeted?
2. Does the *scope* of the instrument (package) provide the right incentives to reach its operational goal?
3. Is the *strictness* of the instrument (package) in line with its operational goal?
4. What are existing instruments and how do they *interact* with a potential new or redesigned existing instrument (package)?
5. What should be the *timing* of the instrument (package)?

Identifying the potential for eco-innovation in Austria

Before applying the evaluative framework to Austria, a detailed assessment of the status quo of Austria's eco-innovation performance compared to other countries was carried out. To this end, a dataset on Austrian patent applications in climate change mitigation technologies related to emission sectors was constructed, using data from the OECD (PATSTAT database and ENV-TECH classification). The patent data were linked to trade flow data in economic sectors related to the respective technology fields, in order to identify areas of technological and/or trade specialization. Two indices were constructed from the patent and trade data to judge Austria's relative performance in climate mitigation technologies related to each emission sector: an index of revealed technological advantage (RTA) and an index of comparative advantage in trade (RCA).

Figure 5 shows the RTA index by emission sectors for Austria, the Netherlands and Germany. This index illustrates each country's relative technological specialization in climate change mitigation technologies compared to the rest of the world. Clearly, Austria's main area of strength lies in technologies related to the waste sector, where the RTA value of 1.7 indicates a strong technological specialization. This is largely driven by reuse, recycling and recovery technologies, particularly of plastics and paper.

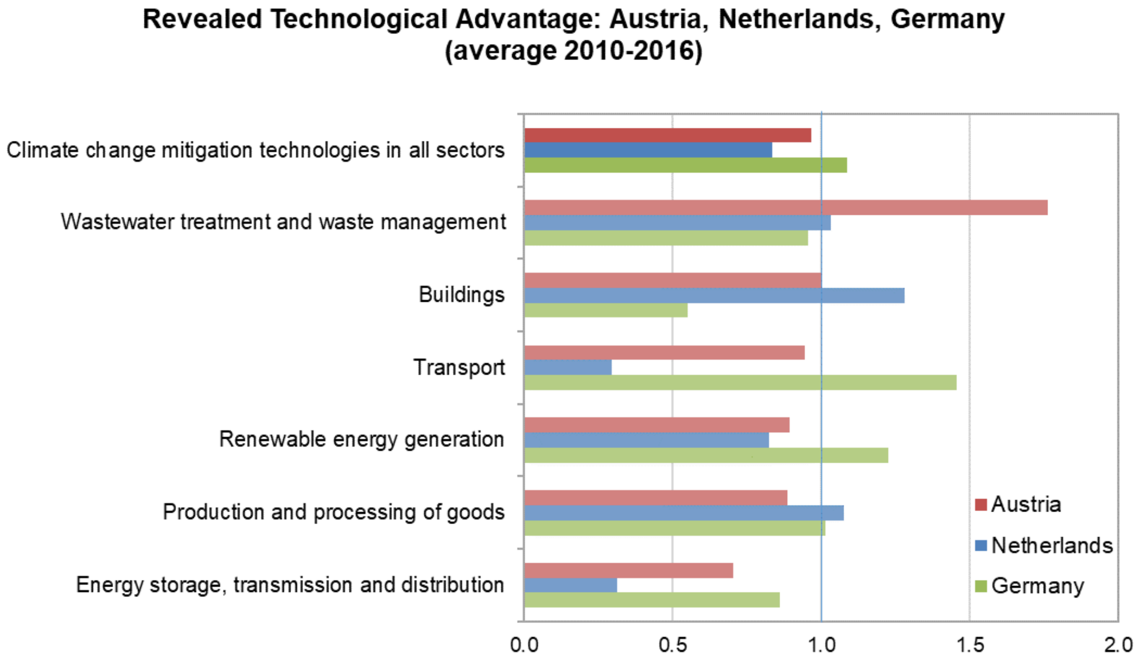
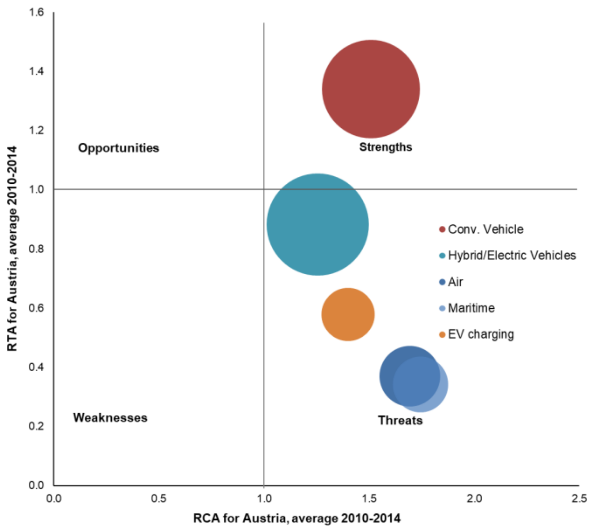


Figure 5. RTA indices in climate change mitigation technologies by emission sectors

Note: Lighter shades indicate technologies related to individual emission sectors

We then examined more closely those emission sectors which national policies can address well (buildings and transport) as well as emission-intensive export-oriented industry sectors. Combining the RTA index with the index of revealed comparative advantage (RCA) based on trade data allows identifying areas of relative strength (RTA and RCA > 1), opportunity (RTA > 1, RCA < 1), weakness (RTA < 1, RCA < 1) and threat (RTA < 1, RCA > 1) in both technology and trade. For transport (shown in Figure 6), the analysis revealed rail as an area of relative technological and trade specialization, i.e. an area of strength.



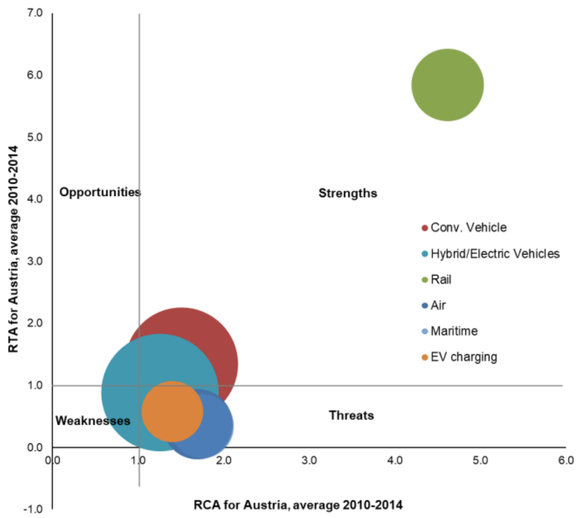


Figure 6. RTA vs. RCA indices in climate change mitigation technologies related to transport, including and excluding rail. Note: Bubble size corresponds to the value of Austrian exports to the rest of the world in the product groups matched to each technology, relative to the other data points in each graph.

In buildings (Figure 7), Austria has a revealed technological advantage in the integration of renewable energy sources in buildings, which includes photovoltaic, solar thermal energy or wind power systems and heat pumps. However, Austria registers no technological specialization in technologies addressing the other key driver of emission reduction in the buildings sector (besides integrating renewable energy sources), namely in technologies improving the thermal performance of buildings.

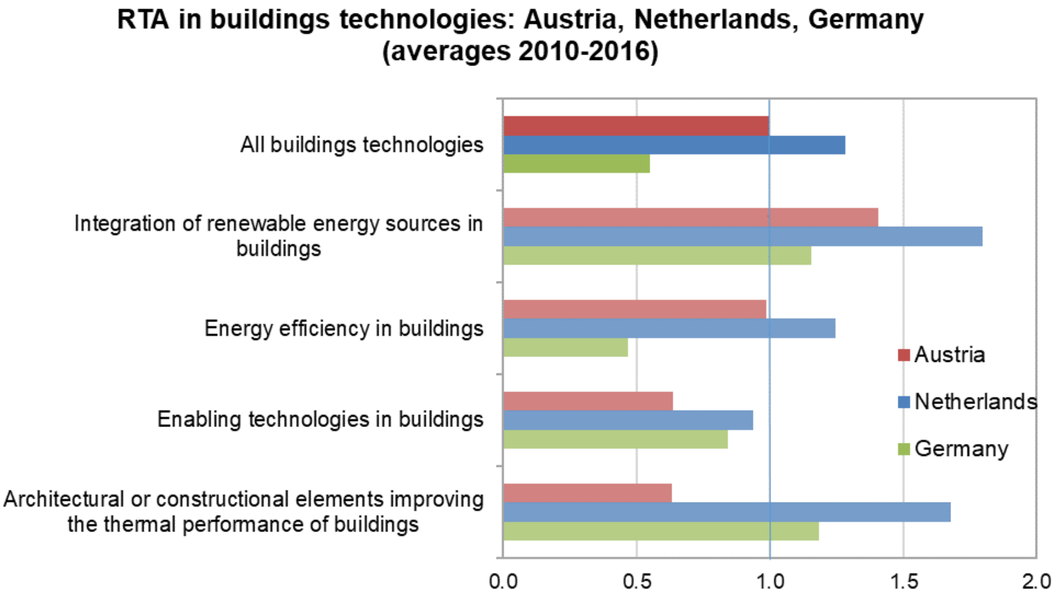


Figure 7. RTA indices in climate change mitigation technologies related to buildings. Note: lighter shades indicate technology sub-fields.

In industry (see Figure 8), the metal processing (steel) industry and the cement industry were revealed as areas of both technological and trade specialization, while the oil and chemicals industries perform less well in terms of innovation and trade.

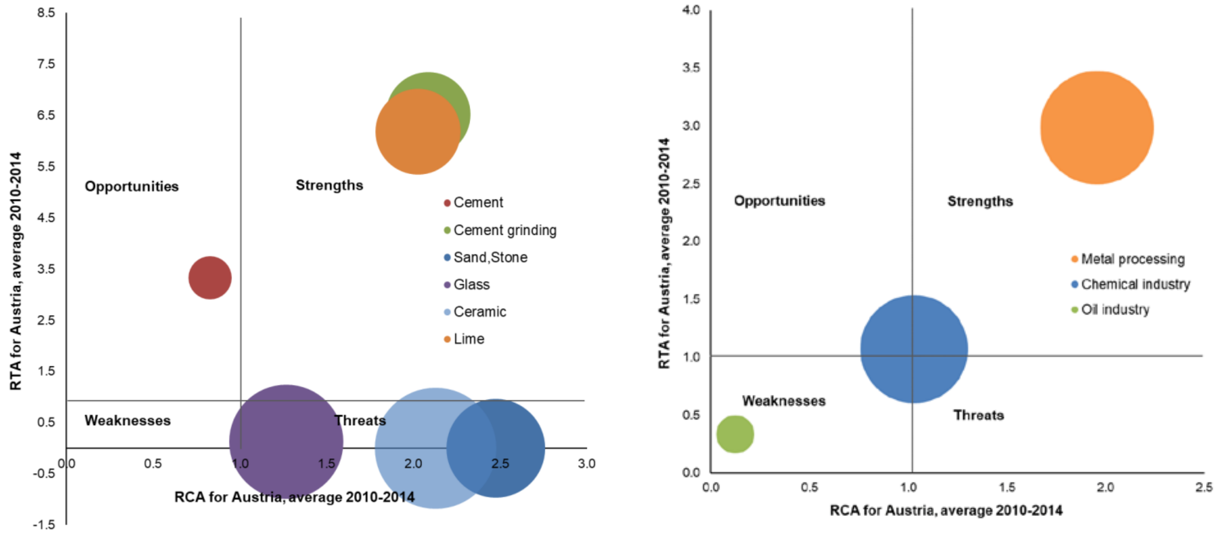


Figure 8. RTA vs. RCA indices in climate change mitigation technologies related to industry. Note: Bubble size corresponds to the value of Austrian exports to the rest of the world in the product groups matched to each technology, relative to the other data points in each graph.

Identifying standards and other instruments currently in use in Austria

An additional step before applying the evaluative framework to Austria consisted of compiling comprehensive inventories of existing environmental policy instruments in Austrian emission sectors. In the buildings sector, the main policies include energy taxes on heating fuels; building codes (which are standards); funding schemes like the federal states' Housing Support, the Domestic Environmental Support and the Climate and Energy Fund; and the information program klimaaktiv. While the inventory for buildings fed into the application of the evaluative framework to Austria (see below), the inventories for transport and industry were used as the basis for qualitative interviews and macroeconomic modelling exercises carried out in the following work packages.

Evaluating current instrument packages and developing new ones

In the final step, the evaluative framework was applied to the Austrian buildings sector. Policy-makers currently view buildings as one of the two key sectors to help achieve Austria's emission reduction target for the sectors outside the EU ETS by 2030 (Federal Ministry for Sustainability and Tourism, 2019). Based on the information gained from analysing Austria's eco-innovation performance and the existing instruments relating to the buildings sector, a package of new and improved policy instruments was developed, targeted at stimulating innovation to reduce emissions. This instrument package includes adjustments to existing energy taxes, R&D and adoption subsidies as well as standards in the buildings sector. In addition, the suggested package includes complementary new instruments like a social policy appropriate to cushion adjusted energy taxes, and a technology standard for biomass combustion to maintain air quality.

Overall, an important conclusion is that coherent policy packages are key to steer the economy towards zero-carbon at lowest (intertemporal) cost.

Uncertainty ranges for policy packages of sustainable passenger transportation

Using the WEGDYN-AT tool, we systematically varied its parameter settings, applied to sustainable policy packages of passenger transportation, in order to test sensitivities of model results. Three parameters are of central interest: (i) carbon prices in the ETS and non-ETS sectors of the Austrian economy, (ii) the flexibility in shifting from motorized individual transport (MIT) to public passenger transportation represented by the elasticity of substation *mipu*, and (iii) the multiplier *RP*, which illustrates how much of the expected cost advantage of electrifying MIT is absorbed by road pricing. We focus on trade-offs shown by three different indicators, which are: changes in economy-wide welfare, changes in total CO_2 emissions and changes in how regressive policies unfold. The benchmark for this evaluation is the policy package "E-Mobility + Road Pricing + Soft measures" and sensitivities are given in Figure 6.

In our core setting, carbon prices for ETS and non-ETS sectors reach 120 EUR/tCO_2 in 2050. We alter the price trajectories and explore changes in model results, when prices are 60 or 180 EUR/tCO_2 in 2050. We do so for both, ETS and non-ETS sectors, simultaneously and separately. To large parts, model results show expected changes with respect to carbon pricing (Figure 7; panels at the top). There is a trade-off between abatement of CO_2 emissions and welfare, which is stronger for ETS-sector emissions than for those of the non-ETS sectors. We also investigate how the initially regressive outcome for the scenario "E-Mobility + Road Pricing + Soft Measures" changes with stronger or weaker carbon pricing. For that, we take the mean outcome of the changes in private consumption expenditures across residence locations and look at the slope of the distribution across income quartiles. If the slope is positive, the policy outcome is regressive and *vice versa*. We find that, and in presence of targeted electrification of MIT, stronger (weaker) carbon pricing leads to distributional effects, which are less (more) regressive. The imminent role of public transfers to low(er) income households drives this result.

Regarding sensitivities in modal split changes of land passenger transportation, we find that under higher flexibility (increasing the elasticity of substitution *mipu* from zero up until a value of 1.35) is connected to no extra costs but also no extra CO_2 abatement (see panels in the middle of Figure 7). Distributional effects derived by the model do not change with altering the preferences unanimously for all household groups. However, the reduction of other negative external effects, when people switch to public transportation (e.g. noise, excessive use of public space, other local pollutants), is outside the model's framework but would add to welfare gains if accounted for.

Two of the core scenarios assume that the cost advantages of electrified MIT are fully absorbed by road pricing. Here, we explore changes in model results if road pricing is chosen to put additional surcharges of up to 20% on MIT (i.e. the road pricing multiplier *RP* takes a value up to 1.2). In the bottom row of Figure 7, we see that cost effectiveness worsens sharply with increased road pricing, i.e. total welfare reduces more than abatement of CO_2 emissions rises. However, and supporting our initial findings, road pricing works progressively in presence of targeted electrification of MIT.

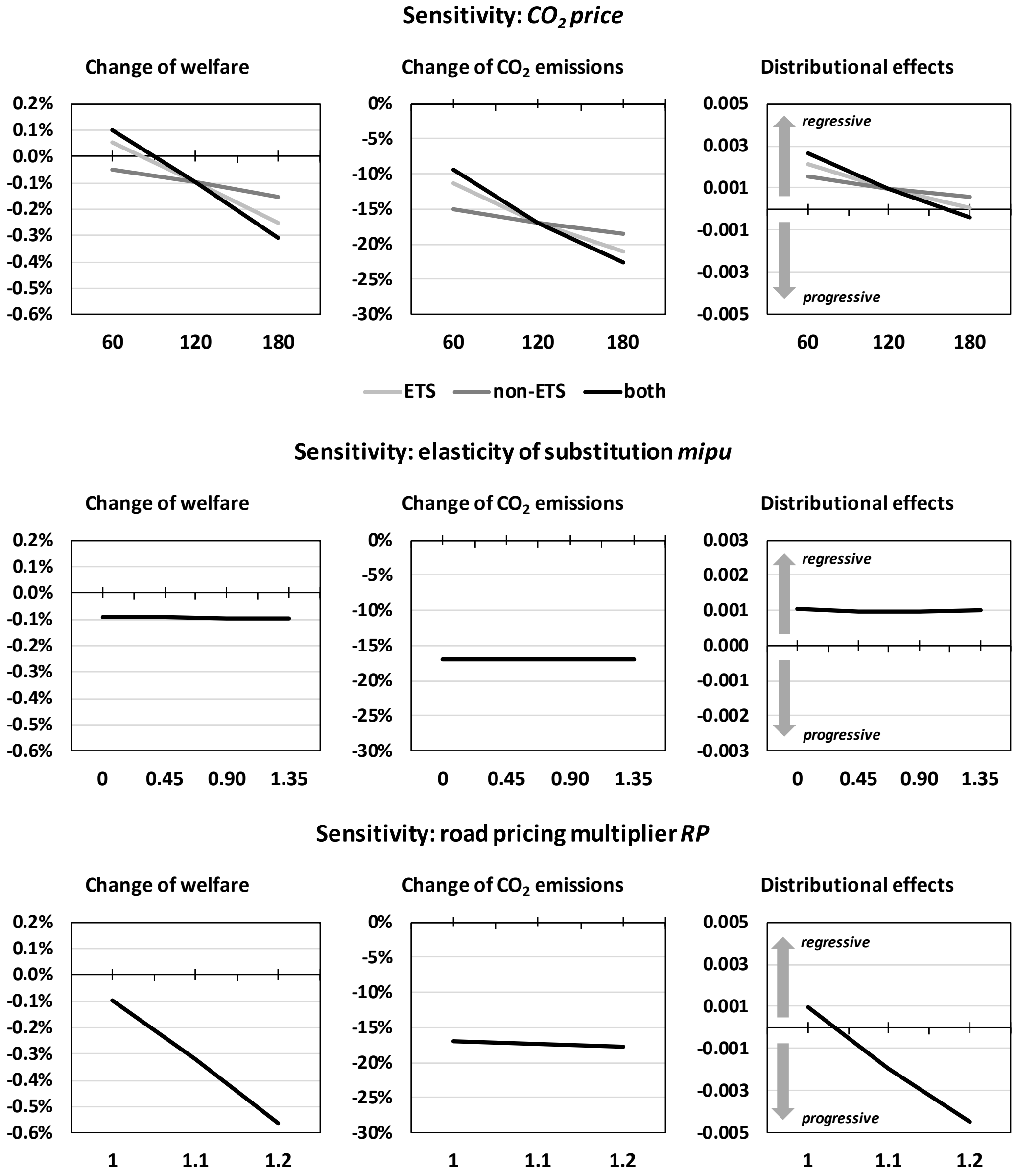


Figure 9. Sensitivity analysis; parameter variations of CO2 pricing [EUR/tCO2], elasticity of substitution (mipu) between motorized individual transport and public passenger transport, and road pricing (RP).

Analysis of carbon pricing schemes

The project team also took advantage of the chance to channel project results into the current Stanford Energy Modeling Forum, in order to analyze how a policy package comprising carbon pricing relates to the level of ambition and the degree of cooperation across countries or world regions. This is particularly relevant, since the low-carbon transition in Austria – a small open economy – is embedded in a global economy. The SHIFT results were thus channeled into the cross-model comparison study of the Energy Modelling Forum (EMF-36) quantifying and narrowing down substantial variation across 19 global CGE models. Key results are: (i) a global carbon pricing scheme cuts global costs by around two thirds compared to nationally separated trading schemes; (ii) the strongest incidence is derived for oil- and gas-exporting countries; (iii) South Korea and Europe are regions, which benefit significantly from trading emission allowances with selected partners, while the PR of China is rather indifferent; (iv) preliminary insight also from partners models regarding incidence on the household level support our initial findings, CO_2 pricing is progressive if its revenues are recycled back lump-sum.

Co-benefits of climate-friendly transport

Climate oriented transport policy ranks high in terms of co-benefits. We quantified co-benefits for different Austrian urban regions. If the city governments of Vienna, Graz and Linz (about 2 million inhabitants) implement their already ambitious plans for passenger transport, as modeled a scenario we term “Green Mobility”, this would lead to a 25% reduction of GHG emissions from passenger transport (minus 0.3 Mt CO_2equ) and about 550 deaths due to better air quality and more physical exercise.

If city governments were to intensify the measures, especially with regard to health improvements, it would be a worthwhile—although politically challenging—endeavor, as 44% of the GHG emissions (minus 0.5 Mt CO_2equ) can be reduced. Due to a further reduced risk of death, the number of deaths decreases by 1200 compared to the baseline.

If, as has already been discussed, combustion engines will be replaced by electric engines as in the Zero Emission scenario, further GHG emissions reductions can be achieved (see Figure 8). Particulate matter produced by means of abrasion and resuspension remain, while particulates due to combustion disappear, as well as emissions of NO_2. CO_2equ emissions disappear completely (reduction of about 1 or 1.2 million t CO_2equ if electricity is generated carbon-neutrally) and 1500 deaths can be avoided relative to the baseline.

Valuated in monetary terms, health benefits account for up to € 11 million relative to the baseline per year. Additional costs for implementation and operation of public transport and bike or pedestrian facilities are mostly compensated by saved costs for motorized individual transport. For the Green Mobility and Green Exercise Scenario, costs are mainly borne by the public sector while benefits are generated by private households. For the Zero Emission scenario, additional costs for e-cars are borne by private households who are, however, compensated by benefits due to the switch from combustion to electric engines. If intangible costs (VSL) are included health co-benefits are substantially higher by a factor around 100.

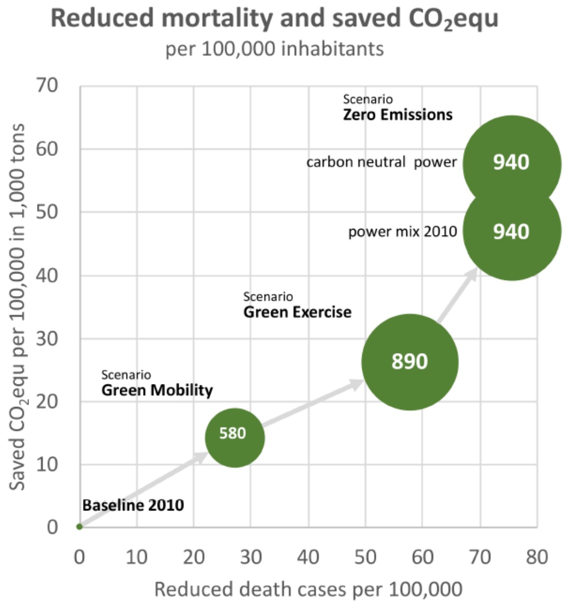


Figure 10. Summary of co-benefits due to CO2equ reduction, reduced death cases (through physical activity and improved air quality) and reduced health costs. The size of the green bubbles correspond to the numbers in white which represent the cost savings due to mortality and morbidity decreases for each scenario in 1000 / 100,000 inhabitants.

5 Schlussfolgerungen und Empfehlungen

(max. 5 Seiten)
Beschreibung der wesentlichen Projektergebnisse. Welche Schlussfolgerungen können daraus abgeleitet werden, welche Empfehlungen können gegeben werden?

While on the path to climate neutrality employment of renewables needs to be enhanced, the energy sector as well as policy have to be aware of the cannibalization effect (expanding renewables to erode their profitability as (variable cost driven) prices decline (due to the merit order effect). This cannibalization effect has far-reaching implications. First, it jeopardizes the competitiveness of variable renewables (VRE) if their value falls faster than their cost. It might increase the policy costs of promoting renewables (since governments must bridge the gap between declining unit revenues and the guaranteed price).Since the VRE electricity has practically zero marginal cost, the stronger the cannibalization effect, the higher the value of flexibility (e.g. storage, demand management and interconnections).Storage and demand management allow the transfer of electricity loads between periods of low/high value, flattening thus the hourly distribution of electricity prices and interconnections allow to geo-graphically link regions of complementary supply and demand patterns. Finally, our results could be useful to adjust the levelized cost of electricity of wind and solar for the value of their electricity and perform more accurate cost–benefit analyses, as well as to calibrate ex-ante dispatch and investment models. Further research should explore how measures to mitigate the cannibalization effect, such as storage, demand management and interconnections, possibly acknowledging seasonal patterns, would affect the value of variable renewables.

Carbon pricing alone is identified as not sufficient for reaching ambitious targets of the Paris agreement. Introducing a CO2 price of 100EUR/tCO2 in the non-ETS sectors would reduce emissions by only 3.5-5.0% in 2030 (assuming that no major cost declines of climate neutral technologies in non-ETS sectors occur). Further incentives are necessary, for instance, through conditional eco-bonus payments in the form of cheques granted for climate-friendly investments (insulation of buildings, replacements of fossil-fuel fired heating systems, et cetera). Currently, ETS revenues are already recycled on a conditional basis (a substantial part flows into the “EU modernization funds”). Next to incentive based (economic) instruments, also other instruments are needed. These might be command and control instruments (such as mandates or standards) and subsidies for research of development for highly needed breakthrough mitigation technologies. Future research needs to focus stronger on these complementary instruments.

For transport-oriented climate policy we find from a macroeconomic perspective that greenhouse gas mitigation policies in urban passenger transport clearly induce a strong positive welfare effect (co-benefits). These effects are remarkably higher when including the reduction of intangible costs, i.e., considering that transport policy due to its health effects is extending life expectancy which we also quantify in monetary terms by means of the value of life years (VOLY). We conclude that it is worthwhile to make the effort to assess co-benefits of climate mitigation policies in urban areas, because the numbers are significant and warrant consideration in decision making.

Distributional issues are a core concern in transport policy. We observed trade-offs with the policy target of distributional equity. Most household groups profit from reduced user costs of motorised individual transport provoked by the mandated phase-out of conventional cars. However, it is only high-income households in all residence locations and medium-income households living in the periphery who profit significantly. The conflict line is drawn against remaining groups of households, which are worse off, particularly households living in urban areas. These regressive effects were not observed with the addition of road pricing and further soft measures, which can be explained by keeping public transfers through additional public income from road pricing almost at initial levels. This ameliorates the reduction from lower excise duties on gasoline and diesel due to pushing conventional cars out of the system. Such distributional focus in transport policy analysis will thus further prove crucial.

Finally, on eco-innovation, an open mind on existing portfolios of environmental and technology policy instruments and their interactions is essential. Instruments often not only have direct but also indirect impacts that might go far beyond their original intention and could therefore even backfire if not well-designed in a coherent package. Second, context of instrument choice matters a lot. For instance, the buildings sector is substantially different from other sectors because it is non-exposed and does not suffer from intense international competition. This also allows policy makers to develop technology niches within their own country and, when successful, with some eco-innovation potential abroad as well. Third, it is important to also have a thorough understanding of existing emission and innovative performance of technologies and sectors in order to find loopholes and provide better targeted incentives. Fourth, scrutinization of each existing instrument for key design elements such as focus, scope and strictness is essential for better targeted instruments.

C) Projektdetails

6 Methodik

Interaktionen nationaler Klimapolitikinstrumente für eine effiziente, effektive und gerechte low-carbon Transformation (Arbeitspaket 1)

WP1 focused on providing a robust policy instrument and evaluation basis for further work in SHIFT, primarily through detailed review of relevant literature and policy documentation. WP1 first gave a detailed overview on the Austrian policy instruments implemented in the electricity supply sector (SHIFT Working Paper 1, September 2017). WP1 then continued by assessing two policy scenarios of Austrian development until 2050. To place the Austrian scenarios in a global context, their projected efficacy in reducing emissions was compared with other countries and with Austria's commitments using a metric developed by the Climate Action Tracker project. The transition scenario was found to not fully reach a target level of emissions compatible with Paris Agreement commitments, setting the bar for the improved or additional policy measures. The transition scenario was used to define a set of benchmarks and good policy options which can be taken forward in the remainder of the project, to optimize a package of policies which reaches Paris-compatible emissions levels.

WP 1 defined criteria for determining what the optimal mix of policies might be, in order to reach the above-stated goals, regarding the assessment of policy packages in terms of (i) economic efficiency, (ii) environmental effectiveness, and (iii) feasibility, The criteria were elaborated upon to incorporate normative measures of justice and different measures of economic efficiency, both static (assuming no innovation) and dynamic (considering the development of new technologies). In terms of normative aspects, as potential climate policies can vary widely in both scope and content by instrument classes, evaluation criteria need to be reasonably broad, with a focus on a pluralist normative framework that draws on common morality theories in non-ideal applied ethics, particularly on the work of Beauchamp and Childress (2013). This approach uses an overlapping consensus (Rawls, 2005) amongst competing normative theories and sets out four main clusters of principles: (i) Respect for individual autonomy/liberty (incl. problems with dignity and sufficiency), (ii) Nonmaleficence, (iii) Beneficence, (iv) Justice.

Stakeholder Integration and Outreach

This Work Package (WP) aimed, firstly, to create an information base for all other WPs through exchange with stakeholders (SH) and, secondly, to discuss the policy instruments developed by the WPs with SH on the basis of their political and public acceptance. Two workshops were held (September 2018 and October 2019), using the former to identify the main category of different policy instruments using socio-economic techniques. Thereupon, in two rounds, SH were able to help determine how and which instruments from other categories need to be combined to increase the effectiveness and efficiency of climate policy measures. Finally, the SH were invited to reflect and discuss different packages of measures on three thematically different tables. The topics were: (i) buildings, (ii) spatial planning and (iii) economic instruments and financing. The SH identified gaps between policy objectives and missing or adaptable measures, as well as related barriers and solutions. The second workshop used project results, especially first estimates of the macroeconomic effects of an eco-social tax reform, and put them into the context of the process surrounding the preparation of the Ref-NEKP for Austria. After a plenary discussion, the participating SH worked on the question how science can support the ongoing socio-political processes towards the preparation of the NEKP in order to make it consistent with the Paris climate goals. The already identified gaps between targets and measures were the basis for "backcasting" evaluations, in which SH designed the necessary milestones with packages of measures to close the gaps.

Policy-evaluation tool for a low-carbon transformation (Work Package 3)

The main focus of Work Package 3 was the development of the WEGDYN-AT CGE model for use in analysing scenarios and policies arising from other portions of the project, as mentioned in the project highlights. The model, a dynamic-recursive CGE model, provides a number of improvements over standard CGE models for Austria. The core model represents Austria as a small open economy. Firms maximize profits and private/public households maximize utility. Profits and utility are modelled using nested constant elasticity of substitution (CES) functions. Foreign trade is modelled via the Armington (1969) specification and we close the model by fixing savings rates, tax rates and the current account. We calibrate the model to a social accounting matrix (SAM) of the year 2014, which is based on data provided by Statistics Austria and an input-output table of 72 NACE-classified economic sectors. Elasticities of substitution are taken from econometric estimates provided in literature. The model equations represent a mixed complementary problem and are written in the MPSGE language using the programme GAMS. We solve the model using the PATH solver (Ferris and Munson, 2000).

The monetary SAM of the WEGDYN-AT model is extended in various dimensions. First, we add CO_2 emissions by production and consumption activities based on NACE-classified physical energy use tables (Statistik Austria, 2014a) combined with energy-specific CO_2 emission factors (UBA, 2014). We furthermore distinguish ETS and non-ETS CO_2 emissions (EC directive, 2009) as well as combustion and industrial process emissions (UNFCCC, 2019). The energy sector of the original SAM is disentangled and represents renewables and fossil-fuel based supply of electricity and heat. Regarding the land transport sector, we differentiate between different freight transport technologies as well as passenger transport including motorized individual transportation and various modes of public transport. The final demand side is split between private and public consumption. The former is disaggregated into twelve heterogeneous household groups distinguished by income quartiles and by residence location (urban, suburban, periphery). For public consumption, one public household collects taxes, funds transfers and subsidies and creates final demand. More details are given in the respective paper, publication (5) (Mayer, Dugan, Bachner and Steininger, see Annex).

Developing the evaluative framework, identifying the potential for eco-innovation, evaluating current instrument packages and developing new ones (WP4)

The evaluative framework developed in Task 4.1 builds on and expands on Vollebergh (2018). A standard goal-instrument perspective is used, since this is particularly helpful to systematically keep track of and present how effects or impacts are linked to interventions, even in the case of complex interactions (see Keeney and Raiffa, 1993; Manski, 2013).

Work Package 4 aimed to apply this framework to Austria in order to suggest new or improved policy instruments to further stimulate eco-innovation. To this end, the country's current eco-innovation performance must be assessed, so that areas of potential can be identified. In addition, a stocktake of the instruments that are currently in use is required. The latter took the form of simple inventories by emission sectors, i.e. lists of instruments classified by type (economic, regulatory, information) for buildings and transport, which were compiled based on desk research.

To analyse Austria's current eco-innovation performance, data on the country's patent applications in climate change mitigation technologies by emission sector were combined with data on the country's trade performance in economic sectors related to these technologies. An index of revealed comparative advantage (RTA) was constructed using data on the number of patent applications by country and technology from the OECD PATSTAT database. The RTA index captures a country's specialization in a particular technology compared to all other countries (OECD, 2013). Climate change mitigation technologies by emission sector were identified using the OECD ENV-TECH classification (OECD, 2016).

The RTA index for country *i* and technology field *d* can be written mathematically as follows:

$$\mathbf{RTA}_{d,i} = \frac{\boldsymbol{P}_{d,i} \Big/ \sum_i \boldsymbol{P}_{d,i}}{\sum_d \boldsymbol{P}_{d,i} \Big/ \sum_{d,i} \boldsymbol{P}_{d,i}}$$

where *P* refers to the number of patent applications. The RTA expresses country *i*'s share of all countries' patent applications in technology field *d* relative to its share of all countries' patent applications in all technology fields. For our indicator of eco-innovation performance, we select technology field *d* in the numerator to be an environmental technology field, specifically a climate change mitigation technology in a particular emission sector.

To identify technologies where Austria has further potential to stimulate eco-innovation, the RTA index was combined with an index of revealed comparative advantage (RCA), constructed using trade flow data by product groups linked to the climate change mitigation technologies from the UN Comtrade database (Balassa, 1965). The RCA index is a standard indicator of countries' relative specialization in international trade.

The RCA index for country *i* and product group *g* can be written mathematically as follows:

$$\mathbf{RCA}_{g,i} = \frac{\boldsymbol{E}_{g,i} \big/ \sum_i \boldsymbol{E}_{g,i}}{\sum_g \boldsymbol{E}_{g,i} \big/ \sum_{g,i} \boldsymbol{E}_{g,i}}$$

where *E* refers to the value of exports. This RCA index expresses a country's share of worldwide exports in a product group relative to the country's share of worldwide exports in all product groups.

Combining the RTA and RCA indices for each climate change mitigation technology in Austria allows grouping technologies into areas of strength, opportunity, weakness or threat (see also Fankhauser et al., 2013, and Dechezleprêtre et al., 2013). Linking the patent data with trade flow data allows for an analysis of both a country's technological and economic specialization. This matters because stimulating eco-innovation is most likely to pay off in sectors where a country already has some industrial activity. Otherwise, one reason why no patenting exists could simply be no industry related to the technology exists, in which case efforts at stimulating innovation would not prove very fruitful.

In all emission sectors analysed, technologies that represent areas of weakness or threat were chosen as initial focus areas for the development of packages of new or improved policy instruments in the following tasks and work packages. However, eventually also areas of opportunity and strength were analysed in emission sectors where large emission reductions are still necessary for decarbonisation, as different policy instruments can be applied at different stages of technological development (e.g. innovation vs. diffusion instruments).

Policy integration and evaluation of low-carbon transformations (Work package 5)

This work package (WP) applies the tool developed in WP3 to evaluate the packages of measures and framework conditions derived and concretised in WP1, WP2 and WP4. Three evaluations were carried out. The first focused on packages of measures for sustainable passenger transport and quantified trade-offs and synergies between individual and combined policy instruments. This evaluation is in preparation for a submission to a professional journal. A second evaluation used the developed tool to assess different options for an eco-social tax reform, a current issue for the political process in Austria. The status of the corresponding working paper is close to completion and a professional journal has already been selected for publication of the results. A third evaluation used another self-developed model (the globally resolved multi-regional, multisectoral CGE model WEGDYN) to place CO2 pricing in a global context and to embed the findings in relation to unilateral eco-social tax reforms. The results of this evaluation will feed into the multi-model comparative study of the 36th round of the Energy Modelling Forum (EMF-36).

References:

Armington, P.S. 1969. 'A Theory of Demand for Products Distinguished by Place of Production'. IMF Staff Papers 16 (1): 159–178.

Balassa, B. (1965), 'Trade liberalisation and revealed comparative advantage', The Manchester School of Economics and Social Studies 33, 99-123

Beauchamp and Childress (2013), Principles of Biomedical Ethics, 7th ed., Oxford University Press.

EC directive, 2009. Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community. Available at: https://eur-lex.europa.eu/eli/dir/2009/29/oj

Federal Ministry for Sustainability and Tourism (2019), 'Integrierter Nationaler Energie- und Klimaplan für Österreich, Periode 2021-2030',

https://www.bmlrt.gv.at/umwelt/klimaschutz/klimapolitik_national/nationaler-energie-und-klimaplan.html, accessed 11 May 2020

Dechezleprêtre, A., D. Grover and M. Sato (2013), 'Position of the Netherlands in the emerging green economy', Report for PBL Netherlands Environmental Assessment Agency. Grantham Research Institute on Climate Change and the Environment, London School of Economics, London

Fankhauser, S., A. Bowen, R. Calel, A. Dechezleprêtre, D. Grover, J. Rydge, and M. Sato (2013), 'Who will win the green race? In search of environmental competitiveness and innovation', Global Environmental Change 23, 902-913

Ferris, Michael C., and Todd S. Munson. 2000. 'Complementarity Problems in GAMS and the PATH Solver'. Journal of Economic Dynamics and Control 24 (2): 165–88. https://doi.org/10.1016/S0165-1889(98)00092-X.

Fischer, C., and R.G. Newell (2008), 'Environmental and technology policies for climate mitigation', Journal of Environmental Economics and Management, 55(2),142-162

Höhne, N. et al., 2011. Climate Action Tracker Country Assessment Methodology.

Keeney, R.L., and H. Raiffa (1993), Decisions with multiple objectives. Cambridge University Press, Cambridge

Kirchengast, G., Kromp-Kolb, H., Steininger, K., Stagl, S., Kirchner, M., Ambach, Ch., Grohs, J., Gut-sohn, A., Peisker, J., Strunk, B. (2019): Referenzplan als Grundlage für einen wissenschaftlich fundierten und mit den Pariser Klimazielen in Einklang stehenden Nationalen Energie- und Klimaplan für Österreich (Ref-NEKP) — Gesamtband, November 2019, 204 S., CCCA Wien-Graz. – Verlag der ÖAW, Wien, Österreich. Available at: https://ccca.ac.at/refnekp

Lopez Prol, J., Steininger, K.W., Zilberman, D., 2020. The cannibalization effect of wind and solar in the California wholesale electricity market. Energy Economics 85: 104552.

Manski, C.F. (2013), Public Policy in an uncertain world. Harvard University Press, Cambridge MA

OECD (2013), OECD Science, Technology and Industry Scoreboard 2013. OECD Publishing, Paris.

OECD (2016), 'Patent search strategies for the identification of selected environment-related technologies (ENV-TECH)', https://www.oecd.org/environment/consumption-innovation/ENV-tech%20search%20strategies,%20version%20for%20OECDstat%20(2016).pdf, accessed 21 July 2020

Rawls (2005), Political Liberalism, Columbia University Press.

Statistik Austria. 2014a. Physical Energy Flow Accounts (PEFA) 2014. Available at: www.statistik.at

Tinbergen, J. (1956), Economic policy: principles and design. North-Holland, Amsterdam

UBA. 2014. Austria's National Inventory Submission 2014. Umweltbundesamt Österreich. Available at: www.unfccc.int

Umweltbundesamt, 2017b. Energiewirtschaftliche Szenarien im Hinblick auf Klimaziele 2030 und 2050. Synthesebericht. Available at: http://www.umweltbundesamt.at/umweltsituation/industrie/einfluesse/energieszenarien/energieszenari en2017/,last accessed 12 September 2018.

Umweltbundesamt, 2017a. GHG Projections and Assessment of Policies and Measures in Austria, Reporting under Regulation (EU) 525/2013

UNFCCC. 2019. Greenhouse Gas Inventory Data - Detailed data by Party. Available at: https://di.unfccc.int/detailed_data_by_party

Vollebergh, H.R.J. (2018), Haasje over? Instrumentering van Transities: Van Uitdaging naar Uitvoering (Leapfrogging? Instruments for Transitions: from challenge to implementation). Tilburg University, Tilburg

7 Arbeits- und Zeitplan

Tasks per Work package	**Finalisation (MM/YY)**
WP 1: National Climate Policy Instrument Interactions for low carbon transition	
Task 1.1: Define plausible scenarios for Austrian development up to mid century	04/18
Task 1.2: Analyse economic and normative criteria related to climate policy instrument classes	05/18
Task 1.3: Identify win-win combinations of instruments to instrument packages and explore international feedbacks	06/18
WP 2: Stakeholder integration and outreach	
Task 2.1: Stakeholder analysis as input for instrument (package) development	05/18
Task 2.2: Instrument discussion with Stakeholders	04/20
Task 2.3: Outreach and dissemination	04/20
WP 3: Low-Carbon Transition Policy Evaluation Tool	
Task 3.1: Develop evaluation criteria	04/19
Task 3.2: Develop consistent evaluation tool	05/20
Task 3.3: Preliminary evaluations of policies and policy packages	05/20
WP 4: Eco-innovation in an open economy	
Task 4.1: Development of evaluative framework	09/19
Task 4.2: Identify potential for eco-innovation in Austria	10/19
Task 4.3: Identify standards and other policy instruments currently in use in Austria	05/20
Task 4.4: Evaluation of currently applied and potential instrument packages	05/20
WP 5: Policy Integration and Evaluation for Low-carbon transition	
Task 5.1:	04/20
Task 5.2:	05/20
Task 5.3:	05/20
WP 6: Project management	
Task 6.1: Project coordination and Scientific Advisory Board	05/20
Task 6.2: Project controlling	05/20
Task 6.3: Publication strategy	05/20

8 Publikationen und Disseminierungsaktivitäten

Tabellarische Angabe von wissenschaftlichen Publikationen, die aus dem Projekt entstanden sind, sowie sonstiger relevanter Disseminierungsaktivitäten.

List of publications:

(1) Wolkinger, B., Haas, W., Bachner, G., Weisz, U., Steininger, K.W., Hutter, H.-P., Delcour, J., Griebler, R., Mittelbach, M., Maier, P., Reifeltshammer, R. (2018), Evaluating health co-benefits of climate change mitigation in urban mobility, *Int. J. of Env. Res. Public Health* 15: 880-907. https://doi.org/10.3390/ijerph15050880

(2) López Prol, Javier, Karl W. Steininger, David Zilberman, The Cannibalization Effect of Wind and Solar in the California Wholesale Electricity Market, *Energy Economics* 85, January 2020, 104552. https://doi.org/10.1016/j.eneco.2019.104552

(3) Dugan, Anna, Mayer, Jakob, Thaller, Annina, Bachner, Gabriel, Steininger, K.W., Developing policy packages for sustainable passenger transport: A qualitative and CGE analysis of trade-offs and synergies, paper under review with *Ecological Economics* (submitted July 2020)

(4) van der Werf, E., Vollebergh, H., Vogel, J., An evaluation framework for eco-innovation policies with an application to Austria, manuscript in preparation for submission to *Energy Policy*

(5) Mayer, J., Dugan, A., Bachner, G., Steininger, K.W., Distributional effects of unilateral carbon pricing under various recycling schemes: Insights from a dynamic-recursive CGE model with heterogeneous households, paper under internal international *review* with the EMF consortium for subsequent submission to *Energy Economics*

(6) Paulo, N., Moral Disagreement in Theories of Practical Ethics, manuscript in preparation for submission

(7) Paulo, N., The ethics of national climate change mitigation. The case of Austria, manuscript in preparation for submission

(8) Mayer, J., Bachner, G., Steininger, K.W., Marginal abatement cost curves, results of core runs and WEGDYN model description, – contribution to EMF-36". Working paper to be published as supplementary material on repository of https://emf.stanford.edu/

Policy Brief (available via: http://wegcwww.uni-graz.at/wp/shift/results/)

(9) van der Werf, E., Vollebergh, H., Towards a policy toolbox for eco-innovation. SHIFT Policy Brief, September 2019.

Working papers (all available via: http://wegcwww.uni-graz.at/wp/shift/results/)

(10) Truger, Barbara (2017). Instruments for a low carbon energy transformation in Austria, SHIFT Working Paper #1, September 2017.

(11) Neyer, Judith and Keith Williges (2018). Designing “good practice” policy packages for achieving carbon neutrality in Austria: Assessment and factors to consider. SHIFT Working Paper #2, September 2018.

(12) Vogel, J., and Geiger, K. (2019). Identifying the potential for eco-innovation in Austria – An analysis using patent data. SHIFT Working Paper #3, May 2019.

(13) Sporer, J. (2019). Identifying standards and other instruments currently in use in Austria: Building sector. SHIFT Working Paper#4, May 2019.

(14) van der Werf, E., Vollebergh, H. (2019). Evaluative framework for policymakers to study the potential of (inter)national standards and other instruments for further development and deployment of eco-innovations, SHIFT Working Paper#5, September 2019.

(15) Mayer, J., Dugan, A., Bachner, G., Steininger, K.W. (2019). Volkswirtschaftliche Effekte und Verteilungswirkungen einer ökosozialen Steuerreform, SHIFT Working Paper#6, Oktober 2019.

Internal Reports

(16) SHIFT Report – Results of Stakeholder Workshop 28th September 2018: The report of the first stakeholder workshop (September 2018) is available on the SHIFT project webpage but access is restricted to participants due to Chatham house rules (for access: http://wegcwww.uni-graz.at/wp/shift/stakeholder-interaction/).

(17) Williges, Keith and Anna Dugan. “Eco-Innovation in the Austrian transport sector: Review of current standards and summary of stakeholder interviews”. SHIFT internal report, May 2019.

Dissemination activities

(1) Two SHIFT Stakeholder workshops:
    - Focusing the research questions: Sept 2018, Vienna (minutes and results: see Appendix)
    - Discussion of draft results: Oct 2019, Vienna (minutes and results: see Appendix)

(2) Steininger, K. W.: Welche Klimazukunft wollen wir und wie wollen wir sie erreichen? (oral), presented at the Klima konkret, Bildungshaus Mariatrost, Graz, Austria, January 2018

(3) Steininger, K. W.: Massnahmen im Verkehrsbereich (invited), presented at the Round Table Mobilität, Forum des BMNT zur Emission 2030, Vienna, Austria, March 2018

(4) Presentation of intermediate SHIFT project results at Klimatag, April 2018 (Salzburg)

(5) Plenary contribution to parliamentary enquete “Austrian Climate and Energy Strategy” Mobilität neu denken - Notwendige Weichenstellungen im Sektor Verkehr (invited keynote) by Karl Steininger, May 23, 2018, Austrian Parliament

(6) Presentation of specific research questions under WP1 and 2 at the “Energie informell”-Conference, May 11th, 2018 (Niederösterreich)

(7) Steininger, K. W.: Klimaziele von Paris - Herausforderungen und Wege für Bund und Land (invited keynote), presented at the Ausschuss für Umwelt und Klimaschutz, Landtag Vorarlberg, Vorarlberg, Austria, May 2018

(8) Presentation (K. Steininger) of Lopez-Prol, J., K. W. Steininger, and D. Zilberman, The cannibalization effect of wind and solar in the California wholesale electricity market, at the 6th World Congress of Environmental and Resource Economists, Gothenburg, Sweden, June 2018
(9) Presentation (K Williges) of Williges, K., J. Sporer, and J. Vass, Economy-wide effects of the Austrian Green Electricity Act: A computable general equilibrium evaluation (oral), at the 6th World Congress of Environmental and Resource Economists, Gothenburg, Sweden, June 2018
(10) Steininger, K. W.: New partnerships as the key to facing climate change challenges (oral) presented at the European Forum Alpbach, Alpbach, Austria, Aug. 2018
(11) Presentation by Steininger, K. W., Vom Wissen zum Handeln - Die ökonomische Perspektive (invited keynote), Oberösterreichischer Klimagipfel, Linz, Austria, Oct. 2018
(12) Presentation by Karl Steininger and Keith Williges on normative criteria relating to the determination of national carbon budgets, University Graz, Environmental students Conference, December 1, 2018
(13) Presentation by Karl Steininger on normative criteria relating to determination of national carbon budgets at the Annual Meeting of the Austrian Economic Association 2019, titled “Fairness is most relevant for country shares of the remaining carbon budget”, April 26, 2019:
(14) Steininger, K.: Eberbacher Klostergespräche zu ökonomischen Grundsatzfragen der Transformation des Energiesystems, Ökonomische Auswirkungen der Sektorenkopplung (invited), presented at the 12. Eberbacher Klostergespräche, Eberbach, Germany, Oct. 2019
(15) Steininger, K.: Ref-NEKP: Referenzplan als Grundlage für einen wissenschaftlich fundierten und mit den Pariser Klimazielen in Einklang stehenden Nationalen Energie- und Klimaplan für Österreich (oral), presented at the Umweltmanagement Austria, Vienna, Austria, Sep. 2019
(16) Steininger, K. W.: Gelungene & innovative Klimastrategien für Sektoren, die von der Dekarbonisierung (stark) betroffen sind (keynote), presented at the Keynote am Austausch zu Umwelt, Klima & Verkehr, Bundeskanzleramt, Vienna, Austria, Nov. 2019
(17) Steininger, K.: Europas Antwort auf die Klimakrise? (oral), presented at the 54. Feldbacher Europagespräche, Feldbach, Austria, Nov. 2019
(18) Steininger, K. W., Ist die Globalisierte Welt noch zu retten? (keynote), presented at the 29th Vienna Roundtable der Österreichischen Kontrollbank, Vienna, Austria, Nov. 2019
(19) Steininger, K.: Klimawandel/Klimakrise als gesellschaftliche Herausforderung und Chance (oral), presented at the Energie Graz, Interne Mitarbeiterfortbildung, Graz, Austria, Dec. 2019
(20) Blog post “Warten auf Godot. Kann die Polarisierung in Österreichs Klimapolitik überwunden werden?“ Die Presse Online. July 2020. Available at: https://www.diepresse.com/5837463/warten-auf-godot-kann-die-polarisierung-in-osterreichs-klimapolitik-uberwunden-werden

SHIFT Final Scientific Conference:

(1) Mayer, J., Distributional effects of unilateral carbon pricing under various recycling schemes: Insights from a dynamic-recursive CGE model with heterogeneous households (oral), presented at the SHIFT Online Conference, virtual, April 2020
(2) Vollebergh, H., What can we learn from EU ETS? (oral) presented at the SHIFT Online Conference, virtual, April 2020

(3) Zapfel, P., Addressing distributional effects to make the European Green Deal a success (oral), presented at the SHIFT Online Conference, virtual, April 2020
(4) Pittel, K., The Need for Reform of National Carbon Pricing – the German Example (oral), presented at the SHIFT Online Conference, virtual, April 2020
(5) Vollebergh, H., and Vogel, J., An evaluation framework for eco-innovation policies for a low-carbon economy (oral), presented at the SHIFT Online Conference, virtual, April 2020
(6) Dugan, A., and Thaller, A., Going beyond market-based instruments: Modal split shift and electrification of individual road transport in Austria (oral), presented at the SHIFT Online Conference, virtual, April 2020

Doctoral dissertations:

Mayer Jakob. Macroeconomic implications of low-carbon transitions. An evaluation of uncertainties. Supervision: Karl W. Steininger. In progress.

Williges, Keith. Economic assessment of issues in the transition to a low-carbon economy - econometric and CGE evaluation. Supervision: Karl W. Steininger. In progress.

Master Theses:

Jakob Sporer, Policy measures to stimulate eco-innovation in the Austrian buildings sector - contribution to making the buildings stock ‚2045-ready', submitted March 2020, supervision: Karl Steininger

Marie Linderoth, E-commerce and the potential effect of changing transport activity on CO_2 emissions, submitted March 2020, supervision: Karl Steininger, co-supervision: Keith Williges

Diese Projektbeschreibung wurde von der Fördernehmerin/dem Fördernehmer erstellt. Für die Richtigkeit, Vollständigkeit und Aktualität der Inhalte sowie die barrierefreie Gestaltung der Projektbeschreibung, übernimmt der Klima- und Energiefonds keine Haftung.

Die Fördernehmerin/der Fördernehmer erklärt mit Übermittlung der Projektbeschreibung ausdrücklich über die Rechte am bereitgestellten Bildmaterial frei zu verfügen und dem Klima- und Energiefonds das unentgeltliche, nicht exklusive, zeitlich und örtlich unbeschränkte sowie unwiderrufliche Recht einräumen zu können, das Bildmaterial auf jede bekannte und zukünftig bekanntwerdende Verwertungsart zu nutzen. Für den Fall einer Inanspruchnahme des Klima- und Energiefonds durch Dritte, die die Rechtinhaberschaft am Bildmaterial behaupten, verpflichtet sich die Fördernehmerin/der Fördernehmer den Klima- und Energiefonds vollumfänglich schad- und klaglos zu halten.