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Sociotechnical configurations of home heating: Insights from Swedish oral histories

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Stories of Transforming Cities, Stories from the Bike - A Festschrift for Harald Rohracher

Editors:

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Foreword

This is a Festschrift to Professor Harald Rohracher at Tema Technology and Social Change (TEMA T), Linköping University.

Harald finished his PhD in Social Sciences in 2002 at the University of Graz. He has a background in Sociology and Science and Technology policy. Harald has been a Professor at TEMA T and Linköping University since 2012. The years before were spent at the University of Klagenfurt, Graz University of Technology and Karl-Franzens-University Graz as a research fellow, lecturer and associate professor.

Through his years at TEMA T Harald has achieved many things. He has been head of division - managing over 50 persons; successfully supervised more than 10 PhD students and supported them through their defense acts; acted as deputy head of Department; contributed to development of the PhD Education at Tema T; been an integral part of developing both the Bachelor program in Urban and Regional Planning and the Master's program in Strategic Urban and Regional Planning; been an important part in developing the weekly STRIPE seminar (Sociotechnical research of infrastructures, politics and the environment); developed the International Lecture Series – Planning in Transition which has hosted a number of prominent international scholars; founded the Tema Research Fellow program in Urban and Regional Climate Transition; been part of a number of scientific boards; been Co-Editor of 'Science, Technology and Innovation Studies' and associate editor of 'Environmental Innovation and Societal Transitions' and been part of several boards, like EUN at the Energy Agency, CMTS (Centrum för människa, teknik och samhälle) and CKS (Centre for Local Government Studies). And of course, Harald has published a number of papers and book chapters in reputable journals and books, lectured in courses, along with all other duties that professors do.

And the list can go on... But an important aspect is that Harald, despite being busy and successful in his endeavors, has always been a sociable, highly present and generous person in the work environment. There are numerous people that have Harald to thank for support, advice, being invited to and thus part of new networks, proposals, and projects. He always takes a broad perspective on his work, and on how he can involve and support both junior and senior research colleagues. All of this

demonstrates Harald's immense strength and generosity as a colleague. This is all reflected in different ways in the chapters in this book, both in relation to his early work and carrier in Graz and Klagenfurt in Austria, but also later in relation to his work together with colleagues and PhD students (both present and former) at TEMA that all witness of his willingness to support and give of his time.

The work with this anthology was initiated sometime in 2024, we believe, or maybe 2023, when the editors of the book realized that Harald would soon turn 60. It has been a pleasure to work with this project, which was initiated by going through Harald´s CV to invite possible authors and collaborators to contribute to this book. The project has evolved and was carried out in the usual chaotic manner (except for our last meeting when it all came together, and we also needed to put it all together…). Even though there was no budget and limited amount of time, we are very happy that so many authors had the opportunity to contribute, which also reflects the fact that Harald is an appreciated colleague by lots of people around the globe.

We would like to thank all the contributors of the anthology for their work and contributions to realize this book. The instructions from us were rather simple; "would you like to contribute to a book that celebrates Harald turning 60? It can be a personal contribution, or a more theoretical, traditional chapter based on Harald´s work." We got several interesting contributions in return, which we have divided into three sections.

The first section of the book focuses on how it is to work with Harald. In the first chapter Michael Ornetzder introduces us to 25 years of doing research with Harald. The chapter also provides an insight into Haralds earlier carrier and as a researcher and lecturer in Austria. In the following chapter, Kristina Trygg and Ida Grundel discusses how their current research with urban and regional planning has been influenced by Haralds work and thus the impact his work has on transformative planning (and geography!). Dick Magnusson uses concepts from Large Technical Systems Theory as a way to describe the processes of getting to know Harald. Linus Burgman Ekman writes about Harald from a positive relational ontology. He bases his chapter on a survey that was sent out to the colleagues at TEMA T asking what they associate Harald with.

The second part of the book involves a number of theoretical contributions that has been written by many of Haralds closest colleagues throughout

the years and that can be seen as a lens and insight to much of the work that they have been doing together with Harald. Thomas Berker writes about technology studies building on Haralds contribution about users, households and sustainable innovation. Bernhard Truffer builds on Haralds influence on institutional analysis in innovation and transition studies going back historically. Klas Kubeczko and Mattias Weber contribution is a translation from a book chapter in German that served as a basis of the published article Legitimizing research, technology and innovation policies for transformative change by Weber and Rohracher (2012). Jenny Palm discusses the importance of households in energy transition studies. She has been inspired by Haralds work on households as arenas where sociotechnical systems are reconfigured and focuses in this chapter on grand technological transitions and what implications it has for households.

The third and final part of the book is a dedication to Harald from both his former and current doctoral students, who share their insights and reflections on Harald as a supervisor. Adam, Stella, Giorgi, and Gavin— current doctoral students—share their experiences of having Harald as a supervisor during different phases of their doctoral journeys, highlighting how his guidance has shaped their paths. Amelia, Johan, Nancy, Darcy, Anna, and Fredrik—former doctoral students—contribute with a collection of stories and reflections on what it was like to be mentored by Harald

For full transparency, we have also taken help from various software tools to generate pictures over how to fold a Brompton, Harald´s PhD Students, and others for different matters.

The editors would especially like to thank Giorgi Kankia for his help with the illustration of the cover of the book.

Finaly we would like to thank all the authors for their hard work filling this book with their thoughts and final chapters, which is what has made this book to Harald possible.

The book *Stories of Transforming Cities, Stories from the Bike - A Festschrift for Harald Rohracher* is a gift and a tribute to Harald.

Dick, Ida, Kristina

Linköping, 12th of May 2025

Part 1
Working with Harald

From green buildings and innovative users to mission-oriented innovation policy: Celebrating 25 years of joint research

Michael Ornetzeder

> *"You and I have memories, longer than the road that stretches out ahead"*
> *(Two of Us – Lennon/McCartney)*

Introduction

I don't remember the first time I met Harald, but I do remember our first research collaboration. In 1999, a new sustainability research programme was launched in Austria. We submitted two projects, both of which were funded. One was led by Harald, the other by me. This was the beginning of our research journey, leading to many more projects, conference participations and joint publications - and a friendship. In this article, I want to look back on that journey by highlighting some of the prominent milestones. I will recall the projects we worked on together, share some key findings from that research, and wonder what drove us, what we learned, and what conclusions we can draw today.

Our joint 'project history'

At the end of the 1990s, a decisive structural change took place in the Austrian research landscape. Contract research was shifted from individual project funding to programme funding. More importantly, this was accompanied by an increase in funding. The model for this was the European Union, which Austria joined in 1995. In 1999, a new programme was launched in Austria, the Technologies for Sustainable Development (at:sd) research programme, which was an excellent thematic match for what Harald and I had been doing independently before – Harald in Graz,

I in Vienna – namely social science research on socially and environmentally sound technologies. Luckily, we were successful in the very first call for the sub-programme "Building of Tomorrow" with two projects dealing with ecological buildings from a user's point of view. The programme was intended to run for five years, but as no one could have predicted at the time, it ended up running for more than 20 years. It later even became our research topic, where we used our own experiences to investigate why this programme was able to run successfully for so many years. The programme started us working together and allowed us to carry out several other joint research projects in the following years.

But scientific research also needs places where people can meet and exchange ideas, spaces for scientific discourse. Again in 1999, the first International Summer Academy on Technology Studies took place in Deutschlandsberg, Styria. The initiator and organiser of this week-long event at Deutschlandsberg Castle was the Inter-University Research Centre for Technology, Work and Culture (IFZ) in Graz. Harald was one of the driving forces behind the Summer Academy and played a major role in bringing together the European STS community in rural Styria. We met with Jane Summerton (see Figure 1), Andrew Jamison, Knut Sörensen, Johan Schot, Rene Kemp, Sampsa Hyysalo, Bernhard Truffer, Matthias Weber, Elisabeth Shove, Kornelia Konrad and many others. We were able to present our own research and place it in a broader international context. The academic exchange and the opportunity to build personal relationships were extremely helpful. Also unforgettable was the obligatory social programme: a ride on the Flascherlzug (narrow-gauge railway) and a visit to a local winery to taste Schilcher (the special wine of the region).

Figure 1. Harald Rohracher and the Author in Deutschlandsberg, 1999

These two events in 1999 laid the foundation for our following project collaboration, which has now lasted for 25 years. In total, there have been 10 joint projects (see Table 1), resulting in several publications and conference presentations. Already in the summer of 1999 in Deutschlandsberg we had the idea – at least that is how I remember it – to submit a joint application, i.e., to submit two project ideas in order to increase our chances of success. To our surprise, however, both projects were deemed worthy of funding, and so in 2000 we began working in parallel on two projects in which our institutes were mutually involved (#1 and 2). This experience led to a close relationship between the IFZ and the Centre for Social Innovation (ZSI), where I had started working in 1998, which in turn led to many other joint projects, including some in which Harald and I were not personally involved. But our joint project history is also quite impressive. The first two projects were immediately followed by another project (#3) in the Building of Tomorrow programme, where we looked more closely at the potential of smart building technologies.

Shortly afterwards, work began on a study on participatory technology development (#4), this time funded by the Jubilee Fund of the Austrian National Bank. A few years later, another project followed for the Building

of Tomorrow programme (#5), in which we were able to critically evaluate the findings of all the social science studies funded by the programme to date, as a kind of interim summary of what the social scientists had learned in the Building of Tomorrow programme. At around the same time, we were working on a new project, funded under the new Factory of Tomorrow programme, which critically examined the potential of two important national technologies from a CTA perspective (#6). This was followed by another project, also funded in a sub-programme of at:sd, in which we developed qualitative future scenarios for the Austrian energy system in a participatory process together with our colleagues from the AIT (#7). After a short break we continued with another Building of Tomorrow project. Here we investigated the relationship between building performance and user satisfaction (#8 and Ornetzeder et al., 2016). Harald was still involved in this project at the beginning, but by the time we wrote the final report he had already taken up his professorship in Linköping.

We tried to fill the resulting gap with a project idea to study the mainstreaming of Passive Houses in Austria (#10). It was our first self-financed project, and it would keep us busy for many years (no contract, no hurry). However, this collaboration led to a number of presentations at scientific conferences. And as time went by, the topic changed, shifting the focus from passive houses to the institutional framework for the successful development and diffusion of energy-efficient buildings in Austria. Thus, the programme that laid the foundation for our research partnership became more and more the focus of our interest. As recently as last year, we were able to publish the results of this research in Science and Public Policy (Rohracher & Ornetzeder, 2024). Already in 2021, another joint project on the governance of Positive Energy Districts was launched (#9), funded by the Joint Programme Initiative Urban Europe and led by Andy Karvonen. One of the results of this collaboration has just recently been published (Karvonen et al., 2025).

Table 1. List of joint research projects

#	Title	Duration	Client/Funder
1	Erfahrungen und Einstellungen von NutzerInnen als Basis für die Entwicklung nachhaltiger Wohnkonzepte mit hoher sozialer Akzeptanz	2000-2001	Ministry for Science and Transport, Building of Tomorrow Programme (at:sd)
2	Akzeptanzverbesserung von Niedrigenergiehaus-Komponenten als wechselseitiger Lernprozess von Herstellern und AnwenderInnen	2000-2001	Ministry for Science and Transport, Building of Tomorrow Programme (at:sd)
3	Intelligent and Green? Nutzerzentrierte Szenarien für den Einsatz von Informationstechnologien in Wohngebäuden unter dem Gesichtspunkt ihrer Umwelt- und Sozialverträglichkeit	2001-2002	Ministry for Science and Transport, Building of Tomorrow Programme (at:sd)
4	Partizipative Technikgestaltung und nachhaltige Entwicklung. Eine sozialwissenschaftliche Analyse	2002-2003	Anniversary Fund of the Austrian National Bank
5	Wohnen im ökologischen ‚Haus der Zukunft': Eine Bestandsaufnahme sozio-ökonomischer Projekte im Rahmen der Programmlinie „Haus der Zukunft"	2007-2008	Building of Tomorrow Programme (at:sd)
6	Open Innovation: Instrumente und Strategien zur aktiven Einbeziehung von NutzerInnen und anderen relevanten sozialen Gruppen in technische Innovationsprozesse am Beispiel Brennstoffzellen-Technologie und Wood-Plastic-Composites	2007-2008	Ministry for Transport, Innovation and Technology, Factory of Tomorrow Programme (at:sd)
7	E-Trans 2050: Nachhaltige Energie der Zukunft: Soziotechnische Zukunftsbilder und Transformationspfade für das österreichische Energiesystem	2008-2010	Austrian Climate and Energy Fonds, Energy of Tomorrow Programme
8	Build to satisfy – Modellierung des NutzerInnenverhaltens in Niedrigst- und Plusenergiegebäuden: Auswirkung auf Gebäudeperformance und Zufriedenheit	2012-2013	Ministry for Transport, Innovation and Technology, Building of Tomorrow (at:sd)
9	TRANS-PED: Transforming Cities through Positive Energy Districts	2021-2023	JPI Urban Europe, FFG
10	Mainstreaming Passive Houses in Austria	2017-2024	internally financed

To better understand our collaboration, it is worth taking another look back into the past. This reveals that we had much in common even before we met. In 1988, politically active students in Graz, including Harald, founded the IFZ to critically reflect on the preconditions and implications of technology and to develop practical approaches for a socially and environmentally sound design of technology (Wächter et al., 1998). Two

years earlier, students at the Vienna University of Technology had founded the Gruppe Angepasste Technologie (GrAT), which had similar aims and was interested in alternative perspectives on technology in the tradition of E. F. Schumacher, who had originally coined the term "intermediate technology" (Schumacher, 1973). As a student of sociology at the University of Vienna, I came into contact with GrAT through a joint study on the attitudes of scientific staff at the Vienna University of Technology towards science, the environment and society. In the early 1990s, GrAT carried out a number of social science technology studies, including one on the highly successful do-it-yourself solar collector movement in Austria (Ornetzeder, 2001) – a topic that eventually led me to the Summer Academy on Technology Studies in Deutschlandsberg in 1999 and even further afield.

Areas of interest and findings: What did we learn?

In the following I will give a brief overview of our joint research. Drawing on interviews, surveys, case analyses, focus group discussions, workshops and theoretical reflection, we have explored the role of users and grassroots initiatives in promoting sustainable solutions, as well as societal learning processes and urban governance challenges. We have shown how successful transitions towards greater sustainability depend not only on technological advances, but also on social learning, participatory processes and adaptive policy implementation. Key examples include green building projects, the emergence of passive houses, grassroots movements, urban sustainability experiments and lessons from mission-driven innovation programmes such as the at:sd initiative in Austria.

Energy-efficient and environmentally friendly buildings

Drawing on the literature on social learning in technology development, we argued that the success of green buildings is put at risk by focusing too narrowly on technological optimisation and expected user behaviour based on constructed 'user images' (Rohracher & Ornetzeder, 2002). Instead, we showed that when mutual learning and exchange processes connect users with technology producers and architects, there can be substantial gains for the development of sustainable buildings in terms of technical improvements and diffusion rates, as well as the environmental effectiveness of buildings.

Based on a survey of about 400 occupants of environmentally advanced buildings in Austria and a qualitative case study on balanced ventilation systems with heat recovery, we were able to show that users of green buildings are competent to develop their own views and perspectives on energy efficient buildings and the technologies involved. In particular, the case study revealed that there are certain user expectations and practical experiences that differ significantly from those of designers and architects. We found controversies between users and designers about user autonomy, building automation and mechanisation of the home, and different definitions of comfort. In certain cases, these controversies and experiences have fed back into the design of green buildings, leading to a learning process between the different groups of actors involved, where design and use are coupled in a mode of co-evolution.

We could also show that these forms of mutual learning are mainly to be found in the context of ecological co-housing projects. These projects were pioneering green architecture in Austria, in which even extremely unusual technological concepts were successfully implemented. In these projects, the planning and construction of the buildings was typically organised as a multi-year, self-organised process of discussion, negotiation and opinion-forming. However, green buildings in other socio-technical contexts, such as single-family homes and large-scale housing projects, with much fewer opportunities for learning, could also benefit from these experiences. In order to show how such learning from practical experience could be improved in the context of large-volume residential buildings, we have outlined basic principles for user participation, covering different stages of development (Rohracher & Ornetzeder, 2002).

Since our first joint projects, we have been working on Passive Houses, the most energy-efficient building concept at that time. The case was interesting because the market for Passive Houses in Austria had grown rapidly since the first experiments in the mid-1990s. Statistics indicated that at the end of 2006 there were more than 4,000 residential units with about 10,000 passive house residents. This was more per capita than in any other country in the world. Given this success, the fast-growing niche of highly energy-efficient buildings seemed to have the potential to fundamentally change the existing construction regime, at least in countries like Austria. In a paper (Ornetzeder & Rohracher, 2009), first presented at the eceee Summer Study in 2009, we explored the emerging socio-technical niche of Passive Houses by analysing the role that intermediary actors have played in facilitating the growth of this niche.

An important conclusion to be drawn from the analysis was that the socio-technical system that developed around the Passive House concept was very much a bottom-up development. But these activities also required a high degree of coordination and intermediation. For example, technical standards had to be defined, visions and guidelines for the further development of the Passive House niche had to be formulated, certification procedures for components had to be developed and information had to be disseminated. These activities were facilitated by a number of organisations of different types: public and private research organisations involved in energy efficient building design; private non-profit or commercial organisations, regional or national energy agencies providing energy advice, information dissemination and support for the growth of actor constituencies; and semi-public institutions such as management agencies for research programmes or stakeholder organisations coordinating the already stabilised Passive House community and lobbying for better regulation and support structures. We were also able to show that the development and growth of the Passive House niche was characterised by a succession of significantly changing intermediary needs, which could be met by a succession of different intermediary organisations with a changing focus of activity. Overall, intermediary activity was an important part of the growth of the Passive House niche and was spread over a large number of organisations over a period of 15 years.

User led innovation and the role of grassroots movements

In Ornetzeder and Rohracher (2006), we aimed to complement the literature on user-led innovation with empirical case studies of solar thermal collectors and domestic biomass heating systems. Both technologies were strongly promoted in Austria by 'do-it-yourself' groups, i.e., potential users who collectively assembled and improved these technologies. In both cases, the strong involvement of users led to a number of technical improvements, resulting in specific design features that were highly functional and attractive to a much wider market sector. To complement the analysis, we discussed a third case of collective planning of green buildings by potential users. These examples were highly instructive in both their similarities and their differences. In all three cases, potential users worked together in temporary groups, using similar organisational structures, and in all three examples the activities were related to energy technologies in the domestic sector.

Our analysis showed that users were involved in the design and diffusion of technologies at different levels of intensity. Early adopters initiated entirely new technologies and designs, found and tested new applications for products, were the source of incremental technological modifications, and adopted unconventional building technologies and design solutions in the course of collective planning processes.

Such extreme forms of active appropriation and redesign of technology seem to be limited and at the same time enabled by a number of preconditions. First, there are technical characteristics that limit the scope and influence of this active mode of appropriation. Technologies that are not too technically complex and whose production does not demand highly specialised and expensive tools or technical skills appear suitable for collective self-building. We also concluded that the chances of successful self-building are higher in the early stages of technology development and diffusion. At these stages, it is much easier to develop solutions that are in some way superior - or at least equivalent - to commercial products in economic and technical terms. Collective self-building also depends on a specific and highly motivated user community. We have found that the work of the organisers and coordinators of such groups, in addition to practical and individualistic motivations, can itself be linked to a mission and to broader social goals such as 'environmental protection', 'regional development', 'energy saving' or 'the use of ecological and healthy materials'. It also became clear that self-building activities depend on specific structural preconditions. In the case of solar collectors and biomass heaters, the rural milieu had a tradition of neighbourly help and the joint purchase and sharing of expensive tools and machinery, especially among farmers. In the case of the Green Co-housing projects, however, the activities were rooted in the academic culture of a German university town.

In another paper (Ornetzeder & Rohracher, 2013), we compared the solar self-building movement in Austria with the development of wind turbines in Denmark (Garud & Karnøe, 2003) and the first efforts towards car sharing in Switzerland (Truffer, 2003). The aim of this paper was to provide a comparative account of the dynamics of successful grassroots initiatives over longer periods of time. We concluded that in order to be successful in the long run, grassroots initiatives need to go through a number of critical phases, resulting in new niche characteristics. One of these critical phases seems to be the transition from loose networks of friends and other interested people to more formalised forms of

organisation. Another phase, at the end of the life cycle of grassroots initiatives, is the transition from non-profit and voluntary involvement to more professionalised and/or profit-oriented settings. In our cases, the main drivers of these developments were the growing demand for technologies and services offered by the initiatives and the willingness of new participants to participate in and/or contribute to ongoing activities. We have also seen that niches have grown interdependently with the development of their respective outcomes. Solutions have either become black-boxed working business models or have been translated and modified into new contexts by a variety of actors.

We have also seen that, in contrast to market-based or science-based contexts, grassroots innovations are characterised by a culture of doing new things based on democracy, openness, diversity, practical experimentation, social learning and negotiation. A culture that is attractive to and reproduced by a wide variety of civil society actors who mobilise and bring together a distinctive combination of knowledge, including locally embedded, practical, artisanal, technological, scientific and cosmological (i.e., broader orientations and worldviews) forms of knowledge. Because of the grassroots nature of these niches, solutions have to be developed from the bottom up, step by step, after critically evaluating practical experiences. In doing so, they do a good job of what in the context of constructive technology assessment is called broadening and enriching the design (Van Merkerk & Smits, 2008), helping to avoid one-sided technological or commercial biases at an early stage and resulting in solutions that are appropriate to local contexts of use from the outset.

Sustainable innovation and urban governance

Sustainable innovation in urban contexts is another topic that has been on our minds for many years. In the Handbook of Sustainable Innovation (Rohracher & Ornetzeder, 2019) we explored the role of cities as key arenas for sustainable innovation using the empirical example of Seestadt Aspern in Vienna. Cities are critical sites for transformation due to their population density, resource consumption and environmental impact. At the same time, they offer favourable conditions for innovation, such as the spatial proximity of actors and infrastructures. In the article we have introduced the concept of transformative urban sustainability innovation (USI), defined as systemic, city-based innovation that aims at profound changes in urban infrastructures and lifestyles. USIs are distinguished

from market-driven or grassroots innovations by their political mission, their focus on public goods and their organisation through temporary partnerships, often involving public actors. Cities often have limited legislative and financial powers, but can use 'soft' governance approaches such as partnerships, experimental settings ('living labs') and urban innovation networks. Urban sustainability experiments create protected spaces for socio-technical solutions, promote learning and foster network building. As innovation processes are inherently conflictual, negotiations between competing interests, visions and understandings of sustainability need to be facilitated.

As an empirical case, we analysed the large-scale development project Seestadt Aspern in Vienna, that was consciously designed as a model for sustainable urban development. The case illustrates how governance structures, the cooperation between city authorities, researchers and businesses, and long-term visions can successfully interact – despite challenges such as conflicts of interest or limited transferability to existing urban contexts. Based on these findings, we have argued that transformative innovations in urban sustainability require new forms of governance that focus on collaboration, experimentation, and social learning to enable deep and lasting change in urban settings.

Looking at the city as a space for innovation, we have also used specific technologies as research cases. For many of the reasons mentioned above, municipalities can be seen as 'natural' niches for exploring new technologies in realistic contexts of use on a limited scale. In Schreuer et al. (2010) we explored this potential by reflecting on the results of a case study of fuel cell technology in the city of Graz, Austria. Based on the experience of our case study, however, it became clear that the implementation of technology learning processes at the municipal level has to be aware of the limited scope of action of municipalities as well as the importance of coordination between different levels of government. Municipalities, even if they see themselves as technology leaders, are limited in terms of financial resources and relevant policy and institutional frameworks.

Based on a number of workshops we have been able to show that when dealing with technology learning at the municipal level, it is important to be aware of the variety of roles a municipality can play in learning processes: it can be an early user of a technology, a promoter and funding body, a policy maker considering longer-term strategies as well as passing

relevant legislation, or a combination of these different roles in the longer term. In any case, working with municipalities in niche experiments carries the risk of becoming part of a political debate with an uncertain outcome. Also, while municipal technology learning projects can serve to mobilise stakeholders and thus form new coalitions of actors in the innovation field, the effort of coordinating a potentially large number of actors needs to be taken into account.

In a recently published paper (Karvonen et al., 2025), we investigated the reconfiguration of the heterogeneous infrastructures of three Positive Energy Districts (PEDs) in Sweden, Belgium and Austria. For the analysis, we used the notion of socio-technical dispositifs as being a heterogeneous ensemble of technologies, discourses, institutions, and other elements that come together in a system of correlation (Jaglin, 2014). By introducing the concepts of layering and orchestrating, we extend existing research and provide tools to characterise how PED actors transform energy systems at the district level. Our paper highlights how new modes of governance emerge through the embedding of energy systems in urban contexts.

Findings from Hammarby Sjöstad, Abattoir and Graz Reininghaus illustrate the place-specific nature of PED development. Layering and orchestrating processes show how PEDs can pluralise energy systems and achieve decarbonisation through new forms of governance. However, realising this transformative potential requires going beyond technical solutions and integrating energy systems into the socio-material fabric of neighbourhoods. PEDs are an essential approach to advancing climate goals while improving urban life. Their district scale focus links energy to broader sustainability issues and introduces horizontal governance models. However, PED proponents often underestimate the contextual and emergent nature of PEDs, which is essential for realising their transformative potential. Ideally, PEDs would serve as heterogeneous spaces of political possibility that reshape energy systems, governance, and urban life.

Mission oriented innovation policy

Finally, we began to look more closely at the research programme that had provided us with the necessary resources and normative guidance at the beginning of our collaboration. We wanted to learn more about the factors and dynamics that contributed to the programme's remarkable success

and helped to maintain its momentum over a period of more than 20 years. The at:sd programme has not only been important for some of our own projects. The programme and its direct successors have had a significant impact on the national construction sector. Our analysis has been informed by a wealth of personal experience, supplemented by literature studies and a series of interviews with relevant individuals. In the recently published paper (Rohracher & Ornetzeder, 2024) we highlight the history of the programme, trace the important stages of its development and, on this basis, discuss why the mission pursued by the programme has been able to maintain itself over such a long period of time.

Our analysis of the at:sd programme shows clear parallels with mission-driven innovation policies. It had a significant impact on the building sector, creating an innovation ecosystem and setting passive houses as an informal standard, with influence reaching European and national levels. A key lesson is that the implementation of the programme was a strategic, emergent and contingent process. Practical conditions and adaptability, rather than a fixed mission design, proved crucial. The programme built on existing structures, emphasised demonstration projects and public communication, and helped a fragmented research community to consolidate. Dedicated ministry officials ensured continuity across successive programmes, adding complexity and maintaining political momentum.

Rather than following a strict mission design, the programme evolved through sense-making and co-production, forming an adaptive 'policy assemblage'. The practice was adaptive and opened up spaces for negotiation between a range of actors involved. The programme started with a well-defined problem (unsustainable building stock) and its solution (Passive Houses), but both the problem and the solution were constantly redefined over the years, as the problem of sustainable buildings was eventually extended to settlement structures or local energy system integration, and the solution was no longer just the Passive House concept. The focus on Passive Houses lost importance, while a wider variety of solutions came to the fore. In a sense, we could observe a 'problem-solution dance', rather than a move from various uncertainties to an alignment of problem and solution.

Conclusion and outlook

In this article I have tried to look back on 25 years of joint research. A lot has happened in that time. Harald and I have worked together on 10 projects and in many more ways – in workshops, at conferences, in teaching, as editors and in numerous joint publication projects. Our joint research history is characterised by a kind of 'programme-project dance'. The programme that helped to establish our collaboration, at:sd, had to evolve in order to survive, and so we were also forced to turn to new topics. However, the need to move on also corresponded to our interest in developing new ideas and our curiosity to find out why certain developments are successful and what can be learned from them and transferred to other areas.

Our research has always sought to be both academic and politically relevant. Sustainability as a normative orientation was and still is an important part of our work. This common orientation goes back a long way to the 1980s, when, largely independently of each other, we both began to be interested in exploring a 'different kind of technology'. The mission of social science research on technology has not changed much over the years: it is to reflect critically on the emergence, diffusion and wider social and environmental impacts of technology in the context of a highly technological world. The only thing that has changed is the awareness that we live in a time of multiple crises (Bader et al., 2011). And this means that reflection can easily come into conflict with the urgency of the transformative change that is needed.

Over the past 25 years, we have had the opportunity to work on numerous interesting topics and to contribute our insights and perspectives to the scientific debate. Of course, there have also been ideas that could not be realised – either because proposals were not successful or simply because there was not enough time. Now it is more a question of passing on experience and inspiring a new generation of technology researchers. I am sure that we will not run out of worthwhile research topics in the future.

Acknowledgements

First and foremost, my thanks go to you, Harald. You are not only a great researcher, but also a motivator, mentor and source of creative ideas. And you are a person with a tremendous energy for scientific work. I am very

lucky to do research with you and to be your friend. Thank you for everything!

But I would also like to thank all of those who have researched and published with us over the past 25 years. The team at the Inter-University Research Centre for Technology, Work and Culture (IFZ) in Graz with Daniela Freitag, Brigitte Kukovetz, Anna Schreuer, Jürgen Suschek-Berger, Philipp Späth, Anita Thaler, Wibke Tritthart and Magdalena Wicher. Our friends at the Institute for Building Biology (IBO) Thomas Zelger and Gerhard Enzensberger, Johannes Gadner and Josef Zelger from the University of Innsbruck, and Renate Buber from the Vienna University of Economics and Business. Thanks to our team in the Open Innovation project Asta Eder (Wood-K-Plus), Helmut Loibl (Fotec) as well as Simone Strobl and Stefan Weinfurter (University of Natural Resources and Applied Life Sciences, BOKU). Thanks to our colleagues at the Austrian Institute of Technology (AIT) for the excellent cooperation on the E-Trans 2025 project: Markus Knoflacher, Klaus Kubeczko, Manfred Paier and Matthias Weber. Of course, I would also like to thank our very large team in the TRANS-PED project: Andy Karvonen from Lund University, who led the project, and his colleague Monika Topel Capriles from KTH in Stockholm. Dick Magnusson from Tema Teknik at Linköping University. Our partners from Brussels, Dieter Bruggeman, Griet Juwet and Fabio Vanin from the Free University of Brussels, Jo Huygh from DUSS-explorers and Tessa Boeykens from Confluences ASBL. Eva Dalman, Christoffer Karlsson, Markus Paulsson, Avenberg Rosell and Christian Willke from the City of Lund, and Josefin Danielsson and Jörgen Lööf from ElectriCITY Innovation. Many thanks also go to the team from Austria: Svitlana Alyokhina, Shima Goudarzi and Simon Schneider from the University of Applied Sciences Technikum Wien, Andreas Kleboth and Stefan Milenkovic from Kleboth und Dollnig ZT GmbH, Barbara Hammerl, Elisabeth Oswald, Hans Schnitzer, Iris Pierer, Katharina Schwarz and Gosia Stawecka from StadtLABOR Graz, as well as Gerald Babel-Sutter and the Urban Future Team. Many thanks to my colleagues at the Centre for Social Innovation (ZSI), Judith Feichtinger, Josef Hochgerner, Uli Kozeluh, Bernd Kumpfmüller, Bernhard Saupe, Irene Schwarz, and to Steffen Bettin, Leo Capari, Julia Haslinger, Livia Regen, Gloria Rose, Barbara Saringer-Bory, Andreas Steinberger and Petra Wächter at the Institute for Technology Assessment (ITA) of the Austrian Academy of Sciences (ÖAW). It was and is an honour to work with you.

I am also very grateful to the people behind the at:sd programme. Michael Paula, who made it all possible, but also Michael Hübner, Hans-Günter Schwarz, Theo Zillner and the entire team.

Last but not least, I would like to thank all the experts, stakeholders and citizens who made themselves available for interviews or took part in workshops, and all those who responded to surveys and answered our questions. This is essential for social science research.

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Harald as an agent of change

Kristina Trygg

Ida Grundel

Introduction

Tackling the climate crisis is one of the greatest challenges of our time. Therefore, the ways in which we, as researchers, can contribute with new ideas and perspectives to support local communities, cities, and regions around the world in addressing such complex issues are of vital importance in the transformation toward more sustainable futures. In driving this change, Harald's work has been highly significant—not only within academia, where he has developed new theoretical perspectives to analyze drivers and catalysts for change, but also in practice, influencing how cities and regions respond to climate change.

Much of Haralds work departs from a socio-technical perspective. Analyzing the climate crisis from a socio-technical perspective involves understanding the complex interplay between social systems and technological development. This approach recognizes that technological solutions alone are insufficient to address the climate crisis; instead, it requires a holistic understanding of how social, political, economic, and cultural factors interact with technological innovations. Interdisciplinary research is essential to understand the multifaceted nature of the climate crisis.

Socio-technical systems have further been studied using the concept of socio-technical networks to study interrelated social actors and technical elements to manage networked infrastructure systems, such as energy and transport systems. All of them point to different aspects of society shaping technology. Early on, Harald argued that the change of socio-technical systems can be situated and studied as a triangle of technology and innovations, institutional structures and interactions of and between actors, as shown in the figure below (Rohracher, 2001, p. 140).
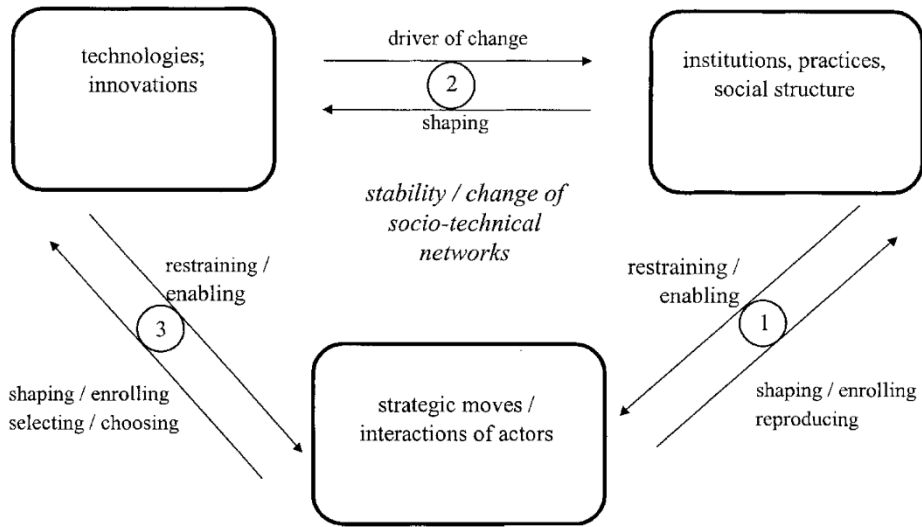
Figure 1. Dimensions of the analysis of the socio-technical networks (Rohracher, 2001)

Building on Harald's work on analyzing the transformation of socio-technical systems and networks, we will use this perspective in the following text to reflect on Harald's role within our research and as a colleague.

Bringing in the social

An important part of studying socio-technical networks is the role of social actors and society, which can also be seen as one of Haralds main contribution, highlighting the importance of the social context. As Harald himself wrote:

The required change of technologies can only be managed by simultaneously taking into account technical potentials and their social context (Rohracher, 2001, p. 137)

Social and technical elements are intrinsically dependent on each other in socio-technical systems ... (Rohracher, 2001, p. 139)

The integration of social aspects into socio-technical systems is crucial for the successful transformation of both transport and energy systems toward sustainability. Understanding how social and technical components interact remains a central theme in Harald's research. His

work has explored emerging transport technologies—such as electric vehicles (EVs), autonomous vehicles, and electric car charging infrastructure—and their implications for an increasing energy demand.

Harald has also shown a strong interest in encouraging a shift away from private car use toward more sustainable modes of transport, such as public transport, cycling, and walking. This interest is evident not only in his academic work but also in his personal life, where he actively embodies the changes he advocates—often traveling with his Brompton bike and consistently choosing sustainable transport options. His lifestyle serves as a compelling example of how such a shift is both feasible and impactful.

Another significant contribution of Harald's work lies in the field of energy systems, particularly the transition to renewable energy sources like solar and wind. Several of his research projects have focused on how social factors—such as behavior, norms, and values—influence this transition. A recurring theme in his work is the involvement of diverse actors and stakeholders. Harald has collaborated with a wide range of groups, including local communities, businesses, policymakers, and regional authorities. This inclusive approach has not only enriched his research but also influenced the policy landscape, particularly in shaping energy policy and promoting stakeholder engagement in its development.

Harald's work on socio-technical systems and networks in the fields of transport and energy offers valuable insights into the governance and dynamics of sustainable transitions. By emphasizing the interdependence of social and technical elements, the role of users and local communities, and the importance of interdisciplinary approaches, his research provides a comprehensive framework for understanding and managing the complex processes involved in achieving sustainable, low-carbon futures.

Change has also been a recurring theme in Harald's work. The socio-technical perspective supports the idea that the implementation of sustainable technologies is inherently linked to institutional change.

However, what has been most significant for us—as authors, geographers, and urban planners—is the inspiration we have drawn from Harald's contributions to the field of urban planning. This will be the focus of the following discussion.

Connecting Urban Planning with Socio-Technical Changes

In our studies on urban planning, it has become clear that socio-technical change is both central to and often a prerequisite for achieving a sustainable society. Many of our infrastructure systems — particularly in the energy and transport sectors — are currently undergoing significant transformations in response to challenges such as climate change, digitalization, and the urgent need for a more sustainable future. Emerging technologies and services in energy, transport, and the built environment are expected to reshape cities in the coming decades. Examples include radically decentralized energy solutions such as microgeneration, local energy storage, mini-grids, energy communities, and peer-to-peer energy trading. We are also witnessing the development of zero- or plus-energy buildings, the electrification and digitalization of transport systems, autonomous vehicles, mobility-as-a-service platforms, and advanced traffic management systems. Moreover, new inter-connections are forming between infrastructure systems — for instance, the integration of transport, electricity, and energy storage through electric vehicles, as well as the convergence of electricity, heating, and renewable energy production. These developments highlight the growing complexity and interdependence of urban systems in the transition toward sustainability.

The aforementioned technologies not only significantly influence the spatial organization of our cities and regions — affecting traffic flows, mobility patterns, residential density, local renewable energy production, and infrastructure solutions — but also reshape the social fabric. They change how we move through society, how we communicate, and how we consume and produce energy. However, these transformations also have broader societal implications, including impacts on inequality, social segregation, and democratic participation. New technologies will not automatically lead to a more sustainable or climate-friendly society unless they are actively embedded within systemic socio-technical change processes. These processes must include new social practices (e.g., within households), innovative services and business models, the emergence of new actors (such as intermediary organizations), and the development of new institutions, regulations, and administrative procedures. Urban and regional planning plays a critical role in shaping the conditions that enable socially just and ecologically sustainable energy innovations.

The above-mentioned changes have significant implications for urban and regional planning, which is fundamentally concerned with maintaining and enhancing social life in cities and regions. It becomes increasingly clear that planning and socio-technical change must be interconnected. Urban planning and transition research share a common goal: understanding how cities and regions can meet climate objectives and contribute to a more sustainable future.

Coming from the field of geography, Harald's work has had a profound impact—particularly within economic geography — on understanding the role of actors and intermediaries in regional transformations (Grundel & Dahlström, 2016; Martin et al., 2023). His contributions have been especially influential in the field of the Geography of Sustainability Transitions, with a strong emphasis on multi-level governance perspectives (e.g Hansen & Coenen, 2015). Harald's research on transitions has, from early on, incorporated spatial dimensions and examined the role of cities and regions in advancing sustainability, resource efficiency, and climate resilience (Rohracher & Späth, 2014; Späth & Rohracher, 2010). He recognized the need for research into the involvement of diverse actors and the role of policy in shaping these processes (Pereverza et al., 2025).

Through influential publications — such as the papers with Späth, "Energy regions: The transformative power of regional discourses on socio-technical futures" and "Beyond localism: the spatial scale and scaling in energy transitions"— as well as numerous studies on institutions and users, Harald has helped expand the scope of traditional evolutionary economic geography. His work has introduced new perspectives, highlighted the importance of diverse actors, and brought a stronger focus on sustainability, thereby advancing the field.

Despite these advances, the institutional systems and capacities of urban and regional planning to drive transformative change have remained underexplored in transition research. This gap inspired us to further develop this area in several of our own studies, focusing on municipal planners and their ability to address sustainability challenges in planning for the cities of tomorrow (see Grundel et al., 2022; Grundel & Trygg, 2024; Trygg & Grundel, 2025; Trygg & Wenander, 2021). Similarly, urban and regional planning strategies have yet to fully integrate the tools and approaches of transition research to effectively manage long-term socio-technical change. To bridge this gap — and to explore how planning can

support sustainable socio-technical transformation — we have combined insights from strategic planning with literature on sustainability transitions and transformative change (Grundel & Trygg, forthcoming). This research addresses fundamental, long-term, and systemic change processes in infrastructure and socio-technical regimes, such as mobility, energy, and the built environment. Technological shifts toward a more sustainable society are deeply intertwined with the social practices of various actors (households, municipalities, businesses, and civil society), cultural values, and institutional frameworks for regulation and standardization.

By drawing on socio-technical studies, we have been able to better understand and reflect on how new technologies and their social contexts shape urban environments. Addressing today's grand challenges requires fundamental and radical changes in the structures, systems, and norms that underpin the built environment, as well as our transport and energy systems. There is broad consensus that these challenges cannot be met through traditional planning approaches, which are often rigid and static (Albrechts et al., 2020). This underscores the need to revise existing planning and decision-making practices (Albrechts, 2010; Healey, 2009) to guide urban development toward both local and global sustainability goals (McCormick et al., 2013).

We have adopted transformative planning as both a conceptual tool and a practical response to better understand societal challenges and the evolving role of planning. Unlike conventional planning, transformative planning emphasizes proactive, innovative approaches (Albrechts et al., 2020). It highlights the need for radical and systemic change to address long-term sustainability issues (Hölscher et al., 2019) requiring planners to envision futures that are fundamentally different from the present (Albrechts et al., 2020). This perspective also encompasses how cities are engaging with transformative change, particularly through urban experimentation — a strategy increasingly used across European cities experimentation (Trygg et al., forthcoming). Urban experimentation involves real-world testing of new ideas, technologies, and policies. These initiatives can range from small-scale pilots to large-scale projects and typically involve a diverse array of actors.

The implementation of new technologies and urban experimentation is often linked to the development of smart cities and smart mobility, reflecting broader societal trends. At the same time, these developments

offer new opportunities for studying the interplay between technological innovation and societal transformation. While many of these innovations are essential for driving change and achieving climate neutrality in cities, they must be managed in a just and inclusive manner. This includes addressing shifts in norms, values, and behaviors across society.

> *Since we have not yet combined our research with you Harald, this is an open invitation to do that further, maybe in an upcoming article...?*

Analyzing Harald

We would like to conclude with a reflection on Harald's work through the lens of a socio-technical network. In many ways, Harald himself represents a vital node in this network — a set of inter-connected components that brings researchers from around the world together. As with all complex networks, the structure is intricate, dynamic, and constantly evolving.

Harald has been actively engaged in a wide range of research areas, including energy, transport and mobility, digitalization, food systems, and sustainability. He skillfully navigates these diverse fields, always with a focus on sustainability challenges. One could argue that sustainability transitions are not only studied through Harald's network but are also enacted through it. Being part of this network — and being his colleague — often feels like participating in a radical transformation.

Harald is, quite simply, a changemaker. His work enables and inspires sustainable transition pathways in multiple ways. To follow in Harald's footsteps requires a deep understanding of change, action, policy, vision, imaginaries, organizations, users, and institutions, among many other dimensions.

Beyond academia, Harald's research has had practical implications for policymakers and practitioners. His insights into the governance of socio-technical change offer valuable guidance for designing effective policies and interventions. For instance, his work on urban energy policy and eco-cities provides important lessons for cities striving to transition toward more sustainable energy systems. Approaching these challenges from a socio-technical perspective equips decision-makers with a nuanced understanding of how society and technology are deeply intertwined — and how both must be addressed to drive transformative change.

From a social point of view Harald plays an important role at the department of TEMA T. He is a consistently positive and supportive colleague who, in many ways, connects the diverse strands of research within the department. Always welcoming and open, Harald makes both new and long-standing colleagues—as well as visiting scholars — feel at home.

This sense of community is especially evident during the cherished Swedish tradition of fika. Over a cup of coffee, Harald often sparks lively discussions, introducing both new and familiar themes. A recurring favorite is the quirky world of Swedish municipal slogans, such as:

> *Hjo – I love Hjo*
>
> *Trosa – The End of the World*
>
> *Säter – Crazy in Säter*

Another beloved topic is Swedish roundabouts—particularly the one in Mjölby, famously adorned with a giant potato that changes costumes with the seasons.

As in many Swedish workplaces, fika and the weekly rotating "fika responsibility" are important rituals. Harald takes this responsibility very seriously (as the photo below illustrates). He has even been known to leave important meetings to fulfill his duty of bringing sweets to the Tuesday afternoon fika — a true testament to his dedication to both tradition and strong sense of community.

Figure 2. Harald taking the Fika-responsibility duties seriously

In conclusion, and returning to the figure at the beginning of this chapter — Harald can be seen as both a stabilizing force and a change agent within socio-technical networks. He is simultaneously a driver and enabler of transformation. Through his extensive networks, his support for social structures, and through his social skills, Harald not only fosters change but also provides a sense of continuity and stability to his colleagues and the department as a whole.

To put it simply: Harald is an agent of change.

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Getting to know Harald Rohracher through the Large Technical Systems-framework

Dick Magnusson

Introduction

Harald Rohnacher's research has been important and influential in the fields of sociotechnical and transition studies. Significant preceding studies have focused on Large Technical Systems (LTS), an area of research that I discovered and (kind of) fell in love with, albeit 20 years too late. While everyone else was moving on to focus on transition studies or something more contemporary, I decided to incorporate the concepts into my dissertation. Not the best decision, but that is how it goes sometimes.

The LTS field emerged from Thomas P. Hughes's seminal work in his book Networks of Power, in which he analyzed the development of electrical systems in Berlin, Chicago and London (Hughes, 1983). Over the next decade, a wide range of studies were conducted using and developing the different concepts and, in particular, the phases proposed for sociotechnical system development. At Tema Technology and Social Change, several dissertations, books and articles were written based on Hughes' work, often, but not always, adopting a history of technology perspective. For example, Arne Kaijser studied the rise and fall of Swedish gasworks in his book *Stadens ljus* (Kaijser, 1986), and Jane Summerton analyzed how a small municipality in Sweden established a district heating system (Summerton, 1992). Summerton also edited an important text on Changing Large Technical Systems (Summerton, 1994), which followed a conference on the subject (have the conference binder containing the texts, in mint condition, in my office). My dissertation, which focused on the later phases of system development, is probably the

last to use the concepts in such detail (Magnusson, 2013). Once again, it was an excellent move to be the last person to enter a theoretical field.

In this text, I aim to apply some of that seemingly useless knowledge by using the LTS concepts and the concepts developed by Kaijser (1994) to try to understand how one can get to know Harald, but also simultaneously analyzing Harald´s development. Bear with me…

Harald as a Large Technical System?!

Of course, I understand the problematic and halting nature of comparing Harald to a technical system. He is not an electrical system. Not even a district heating system. I want to make that clear.

However, as I will argue, poorly, Harald has developed and expanded his career and his connections, or couplings to use LTS-lingo (Kaijser, 1994), to the point where he is almost a Tema-division in his own right, acting as a system builder and gaining substantial momentum over the years. I therefore think it works, and since I'm editing this book myself (together with Ida and Kristina), I'll let it pass.

The initial phases

In the LTS theory, both Hughes and Kaijser discuss the importance of different phases in system development. Hughes's concepts include invention, development, system growth, technological transfer, momentum, and consolidation (cf. Hughes, 1983, 1987). As Bladh (2003) argues, these definitions differ between books and chapters, but they are the most commonly used. Kaijser (1994) uses three phases: establishment, expansion, and stagnation. Kaijser focuses more on the latter phases of system development as an important contribution to the field. In this chapter, I will primarily use Kaijser's phases, incorporating concepts from Hughes.

During the establishment phase, inventors experiment with new technologies in protected environments with investor support. The argument is that, although technological development is crucial, the key components are the possibility of receiving investments, enrolling other actors, and adjusting to legislation and institutional settings. This allows a technology to grow from a technology to a system.

Using these phases, the establishment phase with Harald started in 2010 (at least that is when I enter the picture). The first email containing his

name I could find was from when Harald became the international advisor of the interdisciplinary research school I was part of, Energy Systems. My supervisor, Jenny Palm, told me that it was great Harald had accepted the role since "he's just so nice." This does not mean that she thought he would be easy on us; rather, she meant that he is genuinely a nice person.

Using these phases, the establishment phase with Harald began in 2010, at least according to my recollection. The first email I could find was from when Harald became the international advisor of the interdisciplinary research school I was part of, Energy Systems. My supervisor, Jenny Palm, told me that it was great Harald had accepted the role since "he's just so nice." This does not mean that she thought he would be easy on us; rather, she meant that he is genuinely a nice person.

After the formal advisory board meeting, at which I believe I presented my thesis project, I spent a long time talking with Harald. I had recently discovered the splintering urbanism theory and applied it rather uncritically to my research. I remember it being an extremely rewarding discussion. In a polite way, he questioned whether district heating in Sweden, especially in Stockholm, could be considered splintered. He knew very well that Jonathan Rutherford had already written about that (Rutherford, 2008). His polite way of telling a naïve Ph.D. student that the idea needed more thought was helpful in that phase (see what I did there?!) of the journey.

This was early in the establishment phase. An important concept from Hughes is the reverse salient. It is a military term used as a metaphor to describe bottlenecks or lagging parts of a system as it develops. These bottlenecks may be technical components that are not adjusted to the system, or production capacity that cannot match demand. This slows down the system's development. In my case, there were some early moments that could be labeled as reverse salients.

The second time we met was at the Annual IAS-STS Conference in Graz in 2011. Harald was a keynote speaker, and I was happy to see him again, especially since I knew he had applied for a professorship at Tema T.

I didn't realize it was a secret, but when I saw him at the conference, I blurted out, "Oh, great that you have applied for the professorship!" in front of others. He handled it impressively, just smiling and moving on seamlessly (a seamless web? (Hughes, 1986)) to another topic. I realized

I was a complete idiot and had to apologize later, but he just laughed and shrugged as he always does.

Another strange moment occurred when, feeling nervous and stressed, I managed to squeeze between Harald and Michael Ornetzeder at a conference session before getting to know either of them. Obviously, they should have sat next to each other since they were about to give a presentation together. Yet somehow, I managed to squeeze into the tight folding chair between them. Everyone was confused, including me. When I asked Harald about it a few years later, he of course remembered, laughing.

The third reverse salient, or a sign of it, is something with which many are probably familiar. Although Harald seldom expresses frustration directly in emails, he does so when needed. Sometimes, however, there are signs. Really obvious ones. When the two dots appear after a sentence, you know you're in trouble.. (not really, but thread lightly).

The expansion phase

During the expansion phase, technology develops into a system, with a wide range of actors dependent on it. Technological transfer may occur when a technology and system have been established in one place and can be moved and adopted elsewhere. This is clearly what happened when Harald moved to Sweden and Tema T. According to Hughes and Kaijser, important adjustments to the local context need to be made. For Harald, this meant learning Swedish and the Swedish funding system, which was extremely fast. It took a little over a year before we could have conversations in Swedish. Or rather, before he could converse with those who speak Swedish more clearly and with less småländsk dialect than I... Or I mean..

An important concept in the LTS vocabulary is the system builder. This actor plays a central role in enrolling participants, securing capital, convincing politicians, and championing system development. System builders have strategies for growth and overcoming obstacles. This actor plays a central role in both the establishment and expansion phases.

Harald became one of Tema T's most important system builders early on. He has an amazing ability to invite others to participate in projects and applications and fairly distributes opportunities among Tema T's staff. While some criticize system builders for having a calculated and

sometimes Machiavellian approach to developing systems (Summerton, 1998), Harald is not one of them. He doesn't work without strategy, but he has never seemed opportunistic to me, only great at identifying relevant research topics and funding opportunities.

According to the LTS theory, expansion depends on achieving a high load factor and economic mix. The load factor is the ratio of a system's average usage to its maximum capacity. For the best economic return, the load factor should be as high as possible. One way to achieve this is through a high economic mix, such as having both industrial and residential buildings connected to a district heating system. These have different usage patterns, which balance peaks and valleys.

So, how does this relate to Harald? Could one argue that his system (of researchers?) consists of different competencies and skills that, when combined, develop a high load factor? Since I just established that he is neither Machiavellian nor strategic, the answer is no. But one starts to wonder...

Throughout the years at Tema T, Harald and I have worked together on several projects, such as the ReFlex project and others with Julia and Mohsen. We also supervised Fredrik together. However, that is only a small part of what Harald has done. Recently, we calculated that he had around fifteen running projects, which is probably some kind of record.

According to the LTS theory, this would definitely qualify as having reached momentum. Despite Bladh's (2007) critical examination of more than 20 definitions of momentum in Hughes's publications (e.g., a sytem has reached momentum when the number of actors is so large that the system is difficult to change and political influence helps the system develop and survive), we can now definitively identify momentum, or at least add one more definition: Harald Rohracher's research activities at Tema T. Following the chapter's theme, Harald and I have also achieved momentum through our collaborations.

Stagnation phase?

It is difficult to use the concept and vocabulary of LTS without addressing what happens in the later phases when momentum is reached. One critique of the LTS theory is that Hughes paid too little attention to these phases and that some of the characteristics suggest systems are too autonomous and difficult to change (Summerton, 1998). However, much

of the subsequent research has focused on this very question: How do systems change? This is the core question in transition studies and several other fields examining sustainability.

An important aspect of the stagnation phase is that it does not indicate regression of a system. Högselius and Kaijser (2007) used the Swedish electricity system as an example. Its demand plateaued in the mid-1980s after several decades of constant growth. This change occurred due to economic restructuring in industries and increased energy efficiency following the oil crises. They also argue that a system's future development depends on the trust of the involved actors in the system's future. If these actors lose faith in future development, a decline can occur. However, there are several ways to analyze system development because demand is only one parameter. No one can say that the electricity system has stagnated, especially in terms of decline.

Given this background, how can we understand Harald's approach to system building in relation to stagnation? Well, there are very few signs of it. Based on his citations (see Figure 1 below), there has been a steady increase. It looks much better than the development of the Swedish district heating system, I can assure you.
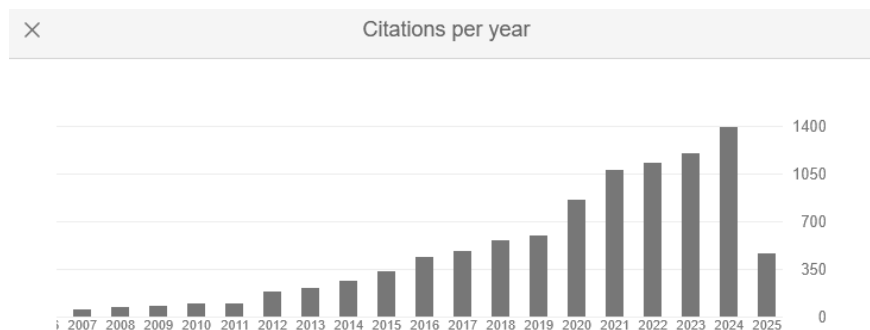
Figure 1. Harald citations in google scholar on the 8th of May 2025. Source: https://scholar.google.com/citations?hl=en&tzom=-120&user=f3ivvv0AAAAJ#d=gsc_md_hist&t=1746733609849

As mentioned, the number of projects has not stagnated, although economists might want it to. However, I, as the head of the division, do not agree, and there are very few signs of stagnation.

Conclusions

Once again, just to be clear, Harald is not a technical system. He is a professor at Linköping University's Tema T. This is one of the main limitations of this study, as the comparison could not and should not be made. But I at least tried.

In summary: Harald is one of the true role models in academia today. He is always friendly, helpful, and generous with his time and encouragement. He is also a fun and sympathetic person. At the same time, he is extremely sharp in his writing, capable of remembering and explaining things, and able to maintain an advanced train of thought in a way that is easy to understand. Many could learn from his approach to his career. He shows that it's possible to perform at a high level and remain humble and a great colleague.

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Who is Harald? – a positive relational ontology

Linus Ekman Burgman

Introduction

Most students in the social sciences encounter the dichotomy between a positive and relational view of knowledge at some point. In this chapter, I question the sharp division to show that this demarcation is not so obvious and perhaps not very constructive, except to simplify methodological positions. I use my former supervisor, Harald Rohracher, as an example of this. Not based on his published works, however, but through him as a multiple object.

I will not make any longer theoretical exposition about the infinitely long discussion about positivism and other more relational scientific traditions with a lot of exciting references. Instead, I simply note that disciplines that are traditionally labeled as positivist or relational carry elements from both of these currents. My argument is that loosening the traditional division of philosophy of science would open up curiosity and reduce distancing based on stereotypical simplifications of other disciplines.

My own background is in perhaps the most positivist-labeled social science, economics, where experiments and quantitative data are important parts of the discipline. At the same time, it is commonplace that money has no intrinsic value, but only gets its value and role in relation to users and others. The same applies to the very diffuse concept of utility, which is central to almost all economic theory, but which at the same time cannot be quantified or clearly defined, it is only an abstract expression of needs, longings, status, knowledge, feelings, dependencies and everything else that we humans are driven by.

As a doctoral student, I replaced this in many ways predictable tradition of philosophy of science with the sprawling and constantly questioning field of science and technology studies. Without making a more detailed review, I would argue that the core of the field lies in questioning what is

taken for naturally given, all that is seen as indisputable facts constructed through a canon of methodological rules. A field where neither markets nor experiments are seen as natural phenomena or golden standards. And at the same time, the "guilty secret in STS is that really we are all technological determinists. If we were not, we would have no object of analysis; our raison d'être would disappear" (Wyatt, 2008, p. 175). There is a great fascination for objects and materials: waste, power plants, vehicles, microorganisms, diagnostic instruments, uranium, oceans, laboratories, all which are often surprisingly stable at the center of the analysis.

The dichotomy of the philosophy of science can lead to the other side being dismissed as blind to the role of one's own preconceived notions in the knowledge process, or to one side being dismissed as fuzzy and biased. These lines make conversations difficult and land on what knowledge is and how truth can be sought or not. And in the long run, you learn very little from each other.

Harald as a study object

So, what does all this have to do with Harald? In addition to being my guide through the inspiring world of multiple ontologies and large infrastructures, where waste becomes a resource, I have found a completely detached quote that is completely taken out of context where he and others write that "an ideal typical dichotomy between [the] argumentative/constructivist and positivist/summative […] is necessarily crude." (Rohracher et al., 2023, p. 338). Using quotes out of context may be a common way of using references in academia, but perhaps not very satisfactory.

Perhaps a better reason is to fill a knowledge gap. First, I asked Microsoft co-pilot (in March 29, 2025) what Harald Rohracher is and was told that he is a professor with a summary of his research topics. Then I asked "what do Harald Rohracher's friends and colleagues think of him", the answer was:

> *There is no specific information about what Harald Rohracher's colleagues think of him. However, based on his distinguished career and extensive research in socio-technical change processes, it is likely that he is highly respected in his field. His work has had a significant impact on research in energy, transport, and food*

systems, which has probably earned him great appreciation among his colleagues.

Based on this assessment, no one seems to have really dug into who Harald is, at least not in relational terms, and thus it could be excellent to use him as an empirical object to study what happens if you use a positivist and relational perspective at the same time. Although, this way of using generative AI as an oracle is perhaps a guaranteed time marker that will make this text hopelessly dated in just a few years. And as some wise person has probably said to me on several occasions, the fact that no one has written about a phenomenon does not mean that it is interesting. Rather, the reason may be that it is completely uninteresting.

Therefore, my final motivation for why Harald would be an interesting example to study can simply be traced to my own work. Although the self-quoting academic is one of the more questioned archetypes in higher education, I am now guilty of this. I simply think it would be fun to see if one of my theoretical frameworks for analyzing the multiple ontology of sewage sludge is also applicable to Harald (Ekman Burgman, 2022). And with that, it's time to move on to how this has happened.

Doing a survey among colleagues

Since the amount of data describing who Harald is tends to be small and short biographies that are used in connection with applications, presentations and articles, these are quite unsatisfactory in scope. They mostly concern what he has done in the form of assignments and publications. Therefore, conducting a survey would be another option to gather more comprehensive material. However, a larger one might not generate as many and useful responses. Despite Harald's distinguished career and significant impact, he may still not be fully known among the general public.

Therefore, I have made a small survey aimed at Harald's colleagues at Tema T. This population consists of a group of people who spend a large part of the waking hours of the day in Harald's vicinity. They have different relationships with him as a supervisor, peer, colleague, project manager, opponent, lunch companion, conversation partner and others.

The survey is simply structured around what I call the association game. The person who answers is asked to tell what they associate Harald with and has the opportunity to state five different things. The survey was sent

out on March 10, 2025, and ended on March 16, 2025. It was sent out to everyone who is listed as employees on Tema T's website (except Harald), which at that time was 47 people. Of these 22 responded.

To give a quick overview, I have made a word cloud where the most common words are written in larger fonts. The result of this can be seen in Figure 1. For those who want to find out what answers were given by all who responded to the survey, these can be found in Appendix 1. However, the purpose of the survey was to use a framework that I used to analyze sewage sludge and not to study the frequency of words used by Harald's colleagues to describe him.
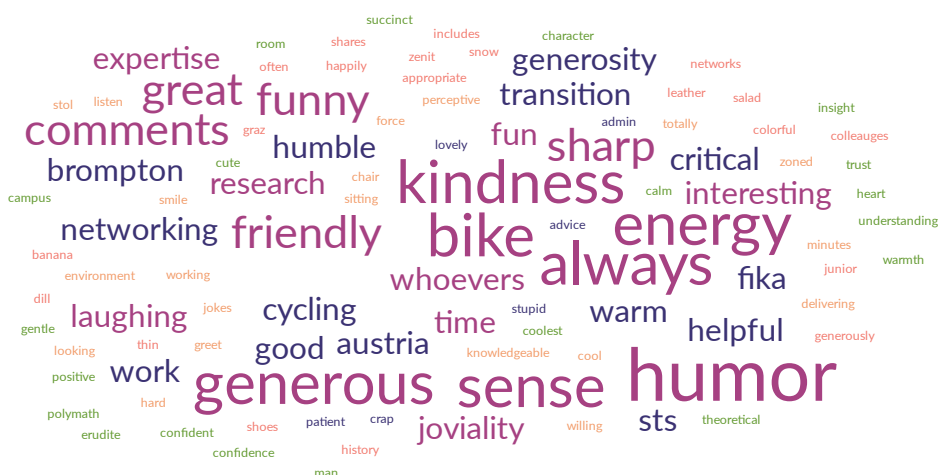
Figure 1. Word cloud generated by Free Word Cloud generator (https://www.freewordcloudgenerator.com/generatewordcloud)

Analyzing Harald multiplicity

The framework on which I base the analysis consists of a 2x2 matrix divided along two axes. On the first axis, I distinguish between the associations that are positive and relational, those that are descriptions of what Harald is like and what he becomes together with others. On the other axis, I distinguish between stable and changeable, where the associations with Harald are about someone who is there and who affects the state of things. In Figure 2 I summarize the results of this analysis and then follow up with a brief description of the different quartiles.

	Positive	**Relational**
Stable	Jovial, Austrian, Handsome, Bike, Knowledgeable	Friendly, generous, warm, good conversation partner
Changeability	Laughing, in trim, self-deprecating	Funny, good reader and commentator, helpful,

Figure 2. Summary of the survey responses based on the two dimensions, positive – relational and stable – changeability.

Positive and stable

This is the quartile under which I sort the largest proportion of survey responses and they include descriptions of characteristics that are linked to Harald and that are more independent of those around them. Many respondents associate him with a cheerful person with a cool bike. While there is a potential for a happy smile and a bike to affect others in different ways, they are also possible to use completely in their isolation. The fact that Harald is described as an Austrian with a good style, even if it may mean that he wears far too thin shoes when the weather is cold, is also something that is relatively stable and predictable. He is described as knowledgeable and sharp based on his broad knowledge of science and technology studies and transition studies. That knowledge could of course affect others, but I'll get to that.

Relational and stable

Some associations emphasize more what Harald becomes in relation to others. He is described as a kind and generous person who shares his great knowledge. In this way, it is in the relationship with others that he becomes. It is mainly as a stable party and a good conversation partner who is there for his colleagues at work as well as at Ölstugan.

Positive and changing

Although the bike and the handsome style are stable traits in Harald, he is also associated with a person who stays in shape and who can be self-deprecating. He is associated with someone who can change himself and even if he is knowledgeable in transition studies, he is also in transition himself, laughing in the break room, thinking about bottomless pits.

Relational and changeable

It is not only himself that he changes, but some associate Harald with someone who, in relation to others, changes both himself and others. It's not just that he laughs, he makes others laugh. He reads and comments on others work which affects them in their writing and intellectually. Even though he seems to have zoomed out for 45 minutes, he suddenly delivers the sharpest comments. There are several who connect that it is through this ability to both make others laugh and the sharply intellectual helpfulness that he creates a good balance at Tema T.

Harald is, according to his colleagues, a jovial and intellectually sharp Austrian with a nice bike. He is a generous colleague who invites with warmth and a smile to good conversations. He is in continuous development and jokes about himself while keeping his body in shape. With his humor and helpfulness, he makes his colleagues both laugh and develop intellectually.

The usefulness of undichotomization

Using Harald as an example, I want to show that with a positive and relational understanding of the world, you can appreciate both the stable and the changeable. Dividing knowledge traditions into being either relational or positive risks missing that most things can be described in both ways, and these can inform each other. Dismissing one would generate an unsatisfactory picture. Try with Harald by excluding any of the quartiles and something important would be missed.

Of course, one can object to the fact that my little survey cannot say anything about what Harald really is, but what his colleagues state in a survey that he is. In addition, those who answer the survey know that it will be used for a chapter in a book that he will receive on his birthday. These conditions could potentially have some impact on the answers; it may not be the time to write out your less flattering thoughts. On the other hand, the purpose is not to give a complete picture of Harald but to emphasize that it is both the positive and the relational aspects that are important, and that these are both stable and changing.

In addition to this, it is I who sorts and chooses the analytical framework. Others might have sorted differently or chosen completely different dimensions (or not done the study at all). But few who try to create knowledge about something would claim that their way is the only way

there is. Maybe they would argue that theirs is the best, something which I would not claim. But maybe it could be an interesting way to inspire some thoughts? If nothing else, I have had the chance to analyze Harald as I analyze sewage sludge.

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Appendix 1 – All answers to the survey

funny (in the sense of a lovely sense of humor)	generous (with time/advice)	patient (with all the stupid admin crap I have had to force him to do)		
Joviality	Perceptive	Knowledgeable	Hard working	Always willing to listen
Sitting cool on a 'stol' (chair)	Jokes and a fun environment to be in	kindness!	sharp and interesting comments on (whoevers) research	Looking totally zoned out for 45 minutes before delivering the sharp and interesting comments on whoevers research
Always greet you with a smile and often laughing	His colorful bike	Thin leather shoes not always appropriate for snow	Banana salad with dill from Zenit	Generously and happily shares his expertise and includes junior colleauges in his networks
Graz	History of STS	Brompton		
calm	sense of humor	cute	gentle	confident
Joviality	Confidence	Theoretical understanding/Insight	Warmth	Trust
Laughing in the fika room	Succinct comments	Coolest bike on campus		
His bike	Always positive	In transition	Energy	Humble
A man with a warm heart.	A polymath and erudite character.	He is indefatigable dedication to his career.	An vintage-style bicycle with sophisticated but funky finish.	Bottomless pit.
great humour!	cycling	energy	Austria	Tema T

He is funny	He is friendly	He is a good colleague	He keeps fit	He is sociable
good energy	wise	critical	helpful	connected
Skratt	Cykel	Örhänge	Generositet	Självironi
A sunny disposition	A warm presence	Helpfulness	Sharpness	Contributing to a great balance between serious and fun
Friendly	Constructive	Diverse knowledge		
Generosity	Friendly	Intellectually sharp	Transition studies	Brompton bike
Humor	Pragmatic	Critical	Generous	Present
humor and positivity	broad expertise	STS	generosity	curiosity
Kindness	A little giggle	A forward-leaning style of walking, if not biking	An ability to primarily see possibilities and opportunities, rather than obstacles	Humble and world-connected scholar
Kindness	Sense of humor	Generous	Intelligent	Excellent researcher
Cycling	Bread and fika	Austria	Energy Transitions	
Curious of different topics and disciplines	Funny!	Generous towards guests, colleagues, and PhD students	Inviting - great at networking	Engaging - makes time to engage with other people's work and give feedback
Joyful approach to work	Helpful and cooperative	Afterwork at Ölstugan	Seminar series and fellowships, networking	Resilience
Kindness	Ambitious	helpfull	social	smart
Rolig	Stabil	Bra samtals- och diskussionspartner		

Step-by-Step Guide to Folding a Brompton Bike

This is a very helpful text on how to fold and maintain a Brompton bike. It is generated by the AI-tool Microsoft Copilot (2025). We found it necessary to include it in the book.

Figure 1. This picture is an AI–generated image of how to fold your Brompton bike (Microsoft Copilot, 2025)

1. Lower the Saddle: Release the seat post clamp and push the saddle down to its lowest position.
2. Fold the Rear Wheel:
   a. Lift the bike slightly and fold the rear wheel underneath the frame. The bike will now stand on its own.
3. Fold the Front Wheel:
   a. Release the front wheel clamp and swing the front wheel around to align with the rear wheel.
4. Fold the Handlebars:

a. Release the handlebar clamp and fold the handlebars down to the side of the bike.
5. Lower the Pedals:
   a. Fold the pedals inward to minimize the bike's width.
6. Secure the Fold:
   a. Ensure all clamps are securely fastened to keep the bike compact.

Maintaining your Brompton bike

Maintaining your Brompton bike is essential to keep it running smoothly and extend its lifespan. Here are some tips to help you with regular maintenance:

Keep It Clean: Regularly clean your bike, especially the chain, sprockets, and braking surfaces. This helps prevent dirt and grime build-up, which can cause wear and tear

Lubricate the Chain: After cleaning, apply lubricant to the chain to ensure it runs smoothly. Avoid over-lubricating, as excess oil can attract dirt

Check Tire Pressure: Maintain the recommended tire pressure (usually between 60-100 psi). Properly inflated tires improve performance and reduce the risk of punctures

Inspect Brakes and Gears: Regularly check the brake pads and gear cables for wear. Adjust or replace them as needed to ensure safe and efficient operation

Examine Hinges and Clamps: Ensure that all folding hinges and clamps are clean and well-lubricated. This helps maintain the bike's folding mechanism and prevents stiffness

Monitor Wear and Tear: Keep an eye on components like the chain, sprockets, and brake pads. Replace them when they show signs of significant wear

Regular Servicing: Schedule regular servicing with a professional to keep your bike in top condition. This can help identify and fix issues before they become major problems.

By following these tips, you can ensure your Brompton bike remains reliable and enjoyable to ride.

Part 2
Theoretical contributions

How users matter in 2025: Of attachments and passings

Thomas Berker

Introduction

The worry about what users do is at least as old as industrialization itself, which drove a wedge between producers and consumers [12, p.5]. But at the end of the 20th century, the recognition that users and their actions matter beyond their decision to buy a product—or not—was a new discovery. STS, traditionally more interested in scientists, engineers, designers, and other innovators, turned "downstream" and found active users worthy of study and discussion. On this observation that users creatively and actively shape what they use, both normative and pragmatic arguments were based: to support technological democracy one ought to listen to users (or user experts); and (sustainable) innovations will receive quicker and more widespread uptake and perform better if they are based on more realistic accounts of end-users' activities.

In this short chapter, mainly following in Harald Rohracher's footsteps, I begin with a discussion of the term "user" as it was used in the early 2000s, its contributions and potential pitfalls. What I aim to understand here is what this term has contributed and what has been lost when it— for good reasons and not only in Rohracher's texts—was gradually replaced with other terms. Then I present the 'new production of users' [13] as a direct continuation of user research in STS and discuss some of this literature's more pessimistic analyses of how users do not matter any longer. In the third part, I allow myself to be inspired by Rohracher's more recent discussions of how households matter in sustainable innovation and propose a way to salvage some of the contributions of user studies without returning to simplistic notions of user agency. The sociology of attachments [8] is utilized in this work. The text concludes with a short discussion of a possible research program that takes critical STS user studies into the next 25 years.

The term user and its uses

Alasuutari [2], writing about the audience studies of media studies, provides one possible point of entry to understand early user studies in STS: Stuart Hall's seminal encoding/decoding [10] established the idea that the messages of mass communication are "encoded" and then "decoded" by audiences and that these two processes are independent from each other. Audiences matter through their relative independence when decoding, where they in fact may completely disregard the encoded messages. In technology studies, not coincidentally also in the context of a semiotic turn, a similar idea is present in Latour's anti-programs [16] and Akrich's scripts [1]. Yet another parallel development between media studies audience research and STS user studies is what Alasuutari calls "audience ethnography," the careful study of the role of mass media in everyday life of its audiences. These studies, which have found their counterpart in STS in studies of the embedding of new technologies in everyday life [17], focused on the different rationalities involved. Both in media studies and in STS, this kind of ethnographic work—avoiding preconceptions of what media and technology "do to people"—was motivated both pragmatically and normatively. It was argued that the empirical user activities observed could inform better technology design, i.e., design which is in line with users' rationalities both in practical and in normative terms.

The contributions of the early user studies in STS are exemplarily represented by Rohracher's early work. Being mostly concerned about how users can matter for the introduction of sustainable technologies, he started with the proposal that a "closer interaction of suppliers, professionals, and users" [23, p.143] would be needed before he zoomed in on the users in a series of publications that were consistently pitched against one-sided engineering approaches, which tend to ignore users' potential contributions. According to Rohracher [24], especially in the early diffusion stage, users matter in three respects: by shaping actor-networks, by appropriating technology, and by shaping visions of the technology in question.

The discovery of end-users' agency, especially when it is normatively charged, but also in its more pragmatic versions, is not without conceptual pitfalls. When reading Rohracher's introduction to his anthology on user studies [25], the arguments against this kind of user studies take a lot of space. Where in 2002, the heterogeneity of users still was an argument for

why users matter [30, p.75], in 2005 it is introduced as a caveat along with warnings against overestimating the actual agency that users can have. Moreover, the question of user representation and who speaks for the user is given much more attention in 2005, which shifts the focus from users to those who represent them, such as intermediaries, which become important in Rohracher's work later [e.g., 27]. Additionally, in a later text [26] the users' direct contributions to the creation of common visions of technologies are toned down and replaced with users' participation in social learning and constructive technology assessment, which points toward a future in which Rohracher would abandon the explicit focus on users and their agency.

Has critical user research run out of steam?

As older readers will know, using technology in everyday life in the 1990s was a very different activity from the 2020s. First, the average household—and here we are obviously talking about the Global North—had fewer devices and was much less connected to technical networks than it is today. In addition, the speed of innovation has noticeably increased, with new versions of existing technologies and also new technologies with new capabilities entering users' everyday life more often than before. And third, new forms of active use have entered the scene forcefully, where the boundaries between producing, selling, and using have become more and more blurred. How do these changes align with the ideas of the mattering user discovered in the early 2000s?

Around 2016, the whole spectrum of user activities described in user research, covering moral negotiations of good use, hidden refusals and tweaks, and explicit co-production became the topic of studies of the so-called 'new production of users' [13]. As research into this 'new production' showed, users' active contributions have been transformed into something that is no longer hidden—both to the users themselves and to society at large. In the context of the 'new production', the fact that users are actively appropriating what they use is explicitly expected and increasingly seen as necessary. This means that users are more and more drawing on their own resources—above all time and knowledge about their specific contexts—to produce a good user "experience."

The 'new production of users', whose contours became just visible in the mid-2010s, is the result of a confluence of many developments: the rise of online user groups [14], neoliberal efforts to transform consumers into

market participants as 'prosumers' [15], the potential relocation of public service work into households in 'consumption work' [11, 7], and new digital innovation strategies, which strategically enroll users as content producers, be it paid minimal amounts of money in the gig economy or rewarded through attention or other immaterial prizes. As Hyysalo et al. [13, p. 23] state, referring to Thrift [34], the more dystopian visions of mattering users that characterize the 'new production of users' may even be supported by the very studies of how users matter that were driven by a desire to improve technology so that it serves its users better. It is obvious that platforms that are hyper-aware of users' activities through real-time data collection and analysis are nothing more than a way of harnessing users' activities to produce more profit for the platform owners. What is worse, however, is that in these new constellations we are not looking at a kind of active appropriation of devices, which can be refused, but we rather encounter infrastructural dependencies, which are defined through their relative invisibility in use [33] and where refusal is connected to punishments that comprise societal exclusion [22].

Given this dystopian version of how users matter, has critical user research with this invisible coercion run out of steam?

The end-users' attachments

At the end of the previous section, we arrived at a dystopian image, where user agency, once the object of critical user research, is relentlessly registered, anticipated, and harnessed in the service of everyone but the user. With this dystopia, a new round of concerns for what technologies do to users commences. Indeed, Bakardjieva [3] asks 'where the agents went', and concludes that "the resistances driven by the moral economy of the household are no match to the Big Other" [3, p. 262], the Big Other here being Zuboff's term for the subject of surveillance capitalism [35], which among other things relies on 'personalization and customization' as instruments of control.

Fortunately, as every active researcher doing empirical research on technology use in everyday life can confirm, studies of use and users bring just as much reflexivity and efforts to regain and retain user agency to light in the 2020s as the qualitative user studies of the 1990s. In fact, there is reason to believe that the stakes have been raised by active users when

they start to negotiate not only ownership and use of devices but target infrastructural attachments in the name of sustainable change and the defense of civic freedoms [6, 21]. In the remainder of this short chapter, one more time inspired by Rohracher—this time reading Rohracher and Köhler [29] and Rohracher et al. [31]—I will try to sketch the contours of a new take on critical user studies, which takes seriously the massive increase of infrastructural attachments and the challenge of the 'new production of users' that characterizes daily life in the 2020s.

Of junctions and assemblages

User studies in the 1990s and early 2000s were predominantly conducted in relation to technology use in private homes. If we return to the household and home when looking for an updated concept of agentic use, the terms "junction" [29] and "infrastructural assemblage" [31] are proposed by Rohracher and his colleagues. Regarding 'junction', the argument is that households matter because they are linked to various infrastructural systems—electricity, heat, waste, water, etc.—which become integrated in practices of everyday life. How these practices are performed, then, will enact different connections, and changes in the provision of infrastructural services will have to be integrated into a household's practices. This weaving together of several infrastructural linkages as activity is focused on even more in Rohracher et al. [31, p.3], where the claim is that household agency

"[...] emerges through the assemblage work that occurs in the space defined by what could be called the 'home-energy-infrastructure assemblage' – the physical space in which people live and the energy infrastructure that becomes part of this space, and the 'local' rearrangements of heating and electricity infrastructure."

Rohracher et al. [31] study situations in which infrastructures change, e.g., through the introduction of new energy technologies. Arguably, with more rapid innovation cycles, the active negotiation of infrastructural attachments found among the households studied—both stabilizing new ones and destabilizing old ones—has become a rather common skill among users [7], as has the need to become a maintainer of the existing ones [20].

Attached users

Is it possible to reframe the work of re-assembling infrastructures from below in the tradition of critical user studies? In my own work I have relied heavily on the idea that there is something which could be called "infrastructuring from below," which involves "infrastructural inversion in the wild," i.e., the ability of users to deliberately focus on their infrastructural background as part of their everyday practices. This is first and foremost related to small and big failures and breakdowns—which happen more often the more technologies are introduced into everyday life. But 'inversion in the wild' can also result from the intention to adapt infrastructures to one's own everyday life, and in some cases, it is related to a pure interest in understanding and improving how socio-technical networks work [6]. Rohracher et al. [31]'s empirical observations and in fact the whole of the classic literature of end-users' appropriations written some 20 years earlier—if the latter is read against its device-centered bias [5]—support the claim that end-users are in fact engaged in infrastructuring from below.

But why are some users more involved in infrastructuring their own everyday life than others? Is there are a 'will to infrastructure' that can be summoned? To address users as "households," i.e., to look at individuals in a specific socio-material context, goes a long way in leaving behind a naively voluntarist and individualist understanding of user-agency, which has held back classic user studies in the 2000s and which has become completely untenable in the 'new production of users'. And focusing on assemblages, be they user assemblages [18] or household-energy assemblages [31], decenters the subject even more. However, in what follows, I will allow myself to zoom in on the individual again— hopefully without reverting to the "act-of-will" fallacy. I will be helped in this endeavor by the sociology of attachment.

Gomart and Hennion [8] discuss and develop actor-network theory's approach to action, which they distinguish from other theories that seek to decenter the subject by distributing action from humans to their relations or to other actors. They argue that with actor-network theory it is possible to move from 'action' to 'events,' and from there to ask which heterogeneous networks become 'that which lets/makes happen.'

The difference between a focus on what originates action and a focus on how and where action 'arrives' becomes clearer when it is exemplified. Gomart and Hennion [8] have picked their examples—drug users and music lovers—deliberately to make it easier to avoid the temptations to search for the origin of action in either the subject or its relations to music/drugs or the piece of music or the drug itself. The goal is to describe "the tactics and techniques which make possible the emergence of a subject as it enters a 'dispositif'" [8, p.220].

Gomart and Hennion [8, p.221] write, drawing parallels between music love and drug use:

"The attachment each involves takes the form of a surprising consensual self-abandonment. Both have to do with entering into a world of strong sensations; of accepting that 'external' forces take possession of the self; of being 'under the influence' of something else; of bracketing away one's own control and will in order to be expelled or rendered 'beside oneself.'"

When we now return to the question of use and users, and look closer at everyday life saturated by large-scale infrastructures, apart from the "strong sensations", additional parallels emerge: are people not walking dream-like through daily life while delegating fundamental cognitive and physical activities to the machines, norms and standards that hold infrastructures together? And as demonstrated for example by Rohracher et al. [31], this delegation is not enforced by external powers but sought actively and prepared for in active negotiations of infrastructural attachments. And finally, regarding the "strong sensations", there is certainly emotion in everyday use of technology as well: not often passion, but rather in the domesticated form of comfort and maybe mild amusement when endlessly scrolling through feeds—which both are powerful emotions, powerful enough to keep users addicted to their infrastructural attachments! And if these examples appear too whimsical, we should be reminded of how powerful the negative passions are that are awakened when infrastructures fail to support their users.

Passings

Introducing the empirical analysis of music lovers and drug users, Gomart and Hennion [8] describe five "passings" that they have identified in the interviewees:

"With a peculiar form of reflexivity, she [the drug user or music lover] writes her sociology for us. She circulates in different registers and in both directions: from collective to individual; physical to ritual or symbolic efficiency; discretionary freedom to determinism by external causes and higher collectives. These registers are not infinite, and they can easily be related both to theoretical debates in the sociology of culture or on drug addiction."

Indeed, looking back at the last thirty years of end-user research in domestic settings, the specific 'passings' found by Gomart and Hennion [8] in relation to music lovers and drug users are easily identified for technology end-use in everyday life, particularly if 'technology' is seen as a set of infrastructural relations instead of as discrete devices.

First, the passing "from the body to the head" reminds of a common situation when household members interviewed about their energy use refer to sensations of freezing or being hot (=the body) and then quickly switch register, reflecting on these experiences and the practices that surround them (=the head). This oscillation between "sensing" and "making sense of" has been described as "energy sensibility" [4].

The second passing, "from the lone actor to the socio-technical dispositif," is mirrored in situations when interviewees talk about their often highly idiosyncratic ways of configuring their own household technologies—which is part of the display of one's own individuality (called 'conversion' in domestication research)—and then quickly refer to other household members or neighbors to explain their actual infrastructure use and to compare it.

Third, the "passing from striving to 'make' an effect to laying back and feeling the effect," is equivalent to the constant circle of deliberate infrastructuring and the forgetting of the infrastructures when they fade into the background supporting whichever practice they are supposed to support. In the fourth passing, "from the objectivity of objects to objects as mediators," the parallel to infrastructure-use is probably strongest. Gomart and Hennion [8, p. 237] refer here to boundary objects and their oscillation between being general and local at the same time. Infrastructuring is indeed the work to create this passing, which arguably also could be called domestication and de-domestication [17].

The fifth passing, finally, "from the technical mastery of time and organization to a loss of control," in the context of research on everyday technology use strongly reminds of how infrastructure users' lives are structured by infrastructural rhythms (e.g., train tables) and at the same time are supported in their efforts to control time, e.g., through the freezer which decouples buying and preparing food, see Shove et al. [32].

These five passings, while part of a limited repertoire, form a non-exhaustive list. In the case of infrastructures and use, the topic of time in the fifth passing, for instance, may very well be complemented spatially in how infrastructures enable movement through space, demarcate and divide space, and prevent movements. Moreover, knowledge-related passings, e.g., the passing from not knowing to knowing and back again, would describe how users learn about what they use and depend on, how they are kept from doing so. This passing then would be about learning and forgetting about how infrastructures work, and how much users are able to perform either when they need or want.

Choosing attachments

The massive liberalizations of public infrastructures that have happened in the final decades of the 20th century have made some people very rich, they have weakened universal access and increased inequalities, e.g., in the context of splintered urban infrastructures [9], and they have participated in the 'new production of users' described above. Daily life in the 2020s has become an endless series of choices where the lucky inhabitants of affluent societies must negotiate infrastructural attachments 'that let/make their everyday lives happen'. This transformation has always been heavily steeped in the language of choice, insinuating freedom. But these choices obviously bind the chooser—hence infrastructural *attachments*—and both enable actions and prevent others from happening. This is nothing new: the generously funded and constantly expanding public infrastructures of the first half of the 20th century bound the users to the state and its priorities.

Be it in the context of public infrastructure works or privately owned platforms, the ability of negotiating attachments neither means that users are in control of their everyday lives, nor that their limited influence on the larger infrastructures is an expression of their powerlessness. Instead,

what we can learn from the sociology of attachments is to focus on "passings" between passive use and active reassembling, between individual and dispositif, between embodied sensation and detached reflection, domestication and de-domestication, being structured and structuring, learning and forgetting, etc., which cannot be avoided when infrastructural attachments are performed.

Better infrastructures?

What does all this potentially mean for the question of technology design, and more specifically for the design of infrastructures?

Neither can an infrastructure be controlled at any time and completely by its users, nor are intelligently sensing, fully automated infrastructures feasible that invisibly provide users with exactly what they want at any time. However, we can distinguish infrastructures that impose active choice, producing friction that prevents the passing towards the flow state in which infrastructures 'just work' as intended. Think of the well-intended cookie warnings that force users to decide whether they want to be surveilled. And there are infrastructural attachments that reduce choice and promise, in return, smooth operation, which for example is one argument used to keep walled infrastructural gardens such as the Apple ecosystem closed to competitors. In the language of the sociology of attachments, these prevent the passing from use to active infrastructuring.

Observation of the many ways in which users sabotage the best intentions of technology designers was the bread and butter of studies of use in the 1990s and early 2000s. Indeed, infrastructures that are designed to prevent the passing from passive use to user-driven infrastructuring have to be intransparent, rigid and controlling to enforce their intention against the adaptations made by users. The infrastructures enabling commercial flight are a good example of this, where "users" are quickly thrown out of planes if they break the rules. Are these controlling infrastructures good infrastructures? In the case of flying, most users are easily convinced of the need to delegate control as they do not want to crash. And there are many similar examples, where an intense desire to take back control would resemble more a pathology than a legitimate wish. However, for the platforms of surveillance capitalism [36], the bargain where control is

exchanged for a good time with cat videos and connections with remote friends is somewhat more Faustian even though it still seems to be acceptable for most users. Here the existence of alternatives is significant, e.g., the social networks of the so-called Fediverse, which presuppose active curation of the user experience by the user themselves. These and similar spaces, such as alternative mobile phone operating systems [6], are characterized by lively experimentation with different degrees of rigidity, openness, and support for the passing between passive use and active infrastructuring and back again. Much of this experimentation is enabled by open-source software, which embodies the possibility of a passing towards active modification particularly clearly: the source code does nothing when not compiled, and the compiled program hides its complexities behind its binary form which is optimized for performance. But the availability of the source code means that it *could* be changed by users (or their allies; in practice, it is often the maintainer of the software itself who makes the changes proposed by users) if the need should arise.

The strength of the metaphors of attachment and passings is that they free us from having to choose between passive use and active infrastructuring, between bodily experience and abstract reflection, between individual and dispositif, etc. Should users be involved in technology design? Yes, but more importantly users should be free to pass from passive use to a modification of the technology and back again. Should infrastructures cater for carefree, bodily comfort or rather force reflection on resource use through friction? Both: users should be enabled to pass from one to the other. Should infrastructures structure spaces and times of everyday life or should they enable users to structure them? Both, and users should be able to pass between them. And so on.

Each of these passings probably deserves its own chapter in a book, where it could be illustrated with more empirical examples, theoretical underpinnings, and where its consequences for design could be discussed. For now, this sketch of a possible revival of user research, inspired by Harald Rohracher, which retains some of the normative and pragmatic commitments of the early 2000s but hopefully avoids a naive understanding of action, may suffice.

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Doing Institutional Analysis: Lessons from a paper that never got published but still had big impact

Bernhard Truffer

Prelude

Dear Harald, you certainly remember the start of our self-defined project to write an "ultimate" paper on how to do institutional analysis in innovation and transition studies.[1] It started almost twenty years ago in early 2007 when you, Jochen Markard and I started to formulate first ideas on how such a dearly needed contribution could look like. We invested substantial time into this endeavor, leading us through two rounds of major revisions in Research Policy (with reports from seven reviewers!), just to finally give up on it in late 2009. While this may have sedimented in our shared memories largely as a failed project, the ideas still inspired me ever since and I could not understand for long, why we had not been able to pull it off then.

Twenty years later and for the occasion of the present celebratory book for your career, I found it very worthwhile to look back at our original motivations and ideas and how they had inspired a lot of research that came after it. From today's point of view, it feels like this manuscript actually had a number of major impacts, even if it is not retrievable in any academic repository, nor has it gathered any citations.

With this short elaboration, I would like to honor our past intellectual struggles, as well as all the intellectual inspiration and wise support on which I could count on over all these years. Beyond this personal aim, reconstructing the aftermath of this project enables retracing how institutional analysis has actually panned out in much of sustainability-

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[1] The latest version that I found on my computer can be referred to as: Rohracher, Truffer and Markard (2009): The Analysis of Institutions in Technological Innovation Systems: A conceptual framework applied to biogas development in Austria. Unpublished manuscript.

oriented innovation and transitions research over the last two decades, at least from my very personal perspective.

Structural approaches to doing institutional analysis

Institutions have been a key explanatory variable in the field of innovation studies since their inception. Arguing against the rather mechanistic and atomistic ontologies of earlier accounts on what drives economic development, already Freeman and colleagues had pointed at the role of institutions structuring the context of innovation processes. In particular, national level institutions adding up to what got known as national innovation systems, was supposed to enable nations to generate innovations and maintain economic success (Freeman, 2000). Nelson and Winter (1982) emphasized more a micro-level perspective focusing on the empirical inadequacy of the perfectly rational actor paradigm, which had become the dominant micro-foundation in economics in those years. Instead, they pointed at the rules and routines that actors actually derived from past experiences to inform their decision-making. This culminated later in the famous technological paradigm view on how institutions shape the course of innovations (Dosi, 1982). He stressed the importance of cognitive structures and biases that drive technology development and adoption. The starting point for much of what later became known as the field of transition studies emerged from partly extending the cognitivist stance towards a broader institutional perspective that would also include normative and regulative besides cognitive aspects of institutions (Rip & Kemp, 1998).

While these arguments had been developed in sufficient detail up to the mid-2000s, when we formulated our publication project, it remained an open question on how this broad emphasis on institutional structures could actually and systematically be implemented. Scholars typically focused on the most salient institutions emanating from their empirical cases and missing out on providing more systematic accounts beyond the blanket observation that "institutions matter". Consequently, much of the research remained at the level of amassing evidence for isolated cases making equally isolated claims about the relevance of institutions but lacked impact in terms of broader cumulative theory building. This is perhaps a fair summary of what drove us to the project, which had more

of an epistemological and methodological ambition than developing a broader understanding of the institutions concept per se.

The specific approach that we elaborated in the manuscript started from the founding sociologists that had elaborated on institutions. In particular Scott (1995) with his tripartite concept of regulative, cognitive and normative pillars of institutions, but also North (2005), Hollingsworth (2000) or Ostrom (2005). We then proposed to start from Scott's pillars to identify basic dimensions of institutional structures as a fundamental layer, on which diverse institutional arrangements could build like Ostrom's governance structures or those proposed by the new institutional economics (Ménard, 2011; Williamson, 1981). At the most aggregate layer we put the institutional macro structures that constitute varieties of capitalism (Hall & Soskice, 2001). Even institutional sectors like the financial, legal, political, research or educational systems, which have as a core mandate to maintain, renew and enforce rules on actors. Based on these earlier works, we proposed an analytical template to identify and map TIS internal and external institutional structures, the latter one differentiated for technological, sectoral and spatial contexts. We illustrated the usefulness of this template on a case of biogas development in Austria.

Given these rather well-intended starting points, why did the specific paper project ultimately fail? One of the major reasons was perhaps that we took a rather static, structuralistic approach for identifying and mapping institutions. The established analytical frameworks in transition studies such as the multi-level perspective (MLP; Geels (2002)) and the technological innovation systems approach (TIS) (Bergek et al., 2008; Hekkert et al., 2007) did not provide any methodological guidance on how to identify institutions and largely limited themselves at pointing at different social realms in which institutions would play an important role. Our approach tried to unpack the institutional dimension systematically.

This template had an immediate successor in a later paper elaborating on the "context" of TIS, where we elaborated different contextual systems that may have an impact on a specific technological field (Bergek et al., 2015). But perhaps an even more important step forward was when we started to engage with the neo-institutional sociology literature and mobilized concepts like organizational fields, institutional logics, work and complexity (Lounsbury & Crumley, 2007; Powell & DiMaggio, 1991; Thornton et al., 2012), mostly in the context of the work with Lea

Fünfschilling (Fuenfschilling & Truffer, 2014). This provided an explicit link between different types of institutions and how they are connected to values and interests of different actor groups. One insight that emerged from this approach was that institutional analysis must consider differences among actors that are engaging in the development of new technologies or even transitions, while we had tried to map all the institutions that are "just out there". Hence, pointing at the agency that is necessary for these structures to even exist.

This work later sparked a number of refinements on how to map out institutional structures such as the splintered regimes concept (van Welie et al 2018) or the work on how to conceptualize the context outside of a more or less clearly delimited TIS (Bergek et al 2017). In these contexts, the structural mapping of institutional structures proved highly multi-dimensional and context dependent, cutting across multiple sectoral and spatial contexts that would be hard to boil down to a single procedural framework. The most recent interest in multi-system transitions in the transitions field exemplifies this movement into more complex problem settings in which institutional couplings are among the key explanatory factors.

However, mapping institutional structures is not sufficient to grasp the role of institutions in any deeper sense. The research lines that unfolded over roughly the next two decades can be presented as hovering around three main research questions: i) How are institutions constructed, mainstreamed, maintained and dismantled by actors, highlighting an agentic approach to structures. ii) What is transitioned and where does it happen, which points at the geography of socio-technical transformation processes. And most importantly, iii) the "so what" or "what for" question pointing at questions of directionality and steering of these dynamics. You have been active in all these three realms, and I will in the following section try to retrace the most important developments in the field and reflect on why it had been difficult to bring the project to a good end.

Who and how? - Agency and structure

One of the key insights from engaging with institutions as an explanatory factor for innovation success in a wide range of contexts is that institutions do not just exist out there as rule-based artefacts but they are recursively constructed, maintained, challenged and dismantled by actors. If a majority of media starts to spread misinformation and lies, the formerly

upheld norm of truthfulness of public broadcasters just disappears without anyone being able to do much about it. Just to refer to recent developments in the largest Western democracy. Put in more epistemological terms, institutions can often be observed through how they impact actions and rationalizing statements of actors, but would be hard to identify outside of these performative acts (Jones & Murphy, 2011). This is not the same as saying that such institutions cannot have very strong binding effects on actors or that they can be changed easily by any single actor. Quite substantial research effort therefore went in later years into analyzing how actors address institutions through targeted forms of agency mobilizing frameworks such as institutional work or institutional entrepreneurship (Fuenfschilling & Truffer, 2016).

At the same time, addressing the agentic dimension more explicitly made us realize that an overarching approach to doing institutional analysis would be confronted with daunting efforts that can barely be done in any single project. Rather mechanisms had to be analyzed for specific realms through which innovations were promoted and transitions unfolded. An early example was the analysis on how markets for new products would emerge, or rather how they were constructed through engaged agency of building up the institutional conditions, which are necessary for markets to function in the first place (Callon, 1998; Fligstein, 2002). For TIS studies, we analyzed how the early formation of markets for roof mounted photovoltaic panels in Germany underwent such an active construction process driven by local citizen initiatives (Dewald & Truffer, 2012). The establishment of these local markets provided the necessary basis on which very potent national support policies could be built later, because there was an existing constituency to support this policy innovation. Compared to the conventional wisdom which would have explained the German market wonder as a direct effect of strong national policies, we could show that it was a much more agentic process of local institution building that enabled the formulation and implementation of these policies. When trying to do institutional analysis in our original paper, we would most likely have missed these interdependencies of existing and emerging institutions.

Another direction in which our own research developed centered around processes of technology legitimation suffering from a liability of newness (Binz et al., 2016; Fuenfschilling & Truffer, 2016; Markard et al., 2016). Legitimation refers to processes by which new options become aligned with existing institutional structures such as regulations, norms and

values as well as cognitive structures like narratives, worldviews and identities to understand the world. Again, legitimation is very dynamic and driven by actions by different actors, even if the ultimate achievement of technology legitimation will seem like a strong structural feature. The focus on legitimation in particular proved very fruitful for understanding barriers for technology development that went beyond mechanistic or psychological understandings of "acceptance" (Binz et al. 2016; Harris-Lovett et al 2015). It turned into a very productive framing of a multidimensional object of legitimation where different actors intervene in different institutions to mainstream a technology or failed at doing so. Again, doing institutional analysis would require an explicit account of all these activities, while the ultimate institution would largely be the end-state of a process that was the core problem of what to explain. This problem pervaded in particular the research on technological innovation systems, where legitimation was both seen as a core process happening within the system while also representing a major indicator for maturation of the technology, ending up almost in a tautology (Bergek et al., 2008).

More recently, we brought the transitions frameworks to bear in informal settlement structures in the Global South where informal institutions play an important role in guiding the actions of actors. In particular, we looked at how newly delivered technological and infrastructure solutions create "structural tensions" with the prevailing institutional fabric for the livelihoods of residents (Cherunya et al., 2020; Wainaina et al., 2023), how this limited the ability of utilities to provide public services to residents in informal settlements (Van Welie et al., 2019) and how the agentic lens of "appropriation" strategies explained why many informal settlement upgrading projects fail (Wainaina & Truffer, 2024).

More recently, transitions research turned towards processes and mechanisms of valuation, i.e. the institutional arrangements by which value concerns get incorporated into innovation decisions and by this influence the course of technology development (Boltanski & Thevenot, 2006 (1991); Jeannerat & Kebir, 2016). Here too, we are confronted with a multitude of value concerns that may be raised at any moment of time and in specific regional contexts. The transitions field mostly occupied itself with value concerns associated with the term 'sustainability', often limited to mitigating CO_2 emissions. More recently, awareness grew that a much broader array of value concerns needs to be considered in order to judge any specific course of innovative action as contributing more or less

to the overarching goal of a just and equitable society not harming the natural and social resource base of humanity in the long run. However, the specific mechanisms through which these values find their way into the rationales and decisions of individual actors were rarely analyzed in much detail. For the goal of doing institutional analysis, we would have to have considered all these value related structures and dynamics in a systematic way.

With hindsight we may therefore say that we underestimated the epistemological challenge of developing a systematic analysis of institutions that would at the same time be able to grasp the intimate interaction between structure and agency. Given the complexities and long-term characteristics of most transition processes, we may question whether this was indeed a feasible project in the first place. Nevertheless, working on the paper certainly made us aware of the very many multi-faceted dimensions that institutions are made of, and which ultimately determine the course of technological development.

What and where? – The geography of institutions

A second major dimension that we had already identified in our original framework relates to spatial variations of institutional configurations. Again, it was only through later work that we became aware of the true complexities that come with spatial variation in cultures, mentalities, regulatory frameworks, and varieties of capitalism. What makes it even more complex is that it is not only about a partitioning of the institutional landscape into a hierarchy of sub-configurations. Rather the different subunits, countries, regions, cities, places work in manifold interactions across scales and contexts (Coenen et al., 2012).

A foray into these spatial complexities was our joint paper with Steffen Wirth and Jochen Markard (Wirth et al., 2013), where we looked at how professional cultures of farmers impacted the innovation activities in agricultural biogas in different Austrian regions. Similar external pressures on a sector would be mediated by the technological configurations that predominate in any single region, but also the formal and informal institutions that guide actor strategies and interests. While this highlighted an early comparative analysis, it also proved to be challenging in terms of grasping this rapidly exploding number of institutional structures that would have to be taken into account in any overarching analysis of the whole institutional fabric.

This line of argument aligned very well with concerns of economic geographers who emphasize how institutional resource profiles shape the economic success of a region (Moulaert and Sekia, 2003). A very salient school in economic geography emphasized the evolutionary character of innovation success but reverted to the original "Dosian", cognitivist explanatory models focusing mostly on related knowledge and capabilities (Boschma & Frenken, 2006). We argued that institutional resources and the ability of regional actors to tap into them and proactively change them was necessary for a broader understanding of transitions at a regional level (Boschma et al., 2017). Later more specific analyses elaborated a "system construction" approach of new industrial pathways (Binz et al. 2016), or how institutional work would explain different industrial trajectories such as in photovoltaics that could be observed in different Chinese regions (Yang et al., 2021). In its most elaborate form, we explained how the very peripheral, agricultural and coastal region Ningde in China could become the globally leading center of battery manufacturing by attracting critical knowledge to the region, while simultaneously working on its institutional fabric (Gong et al., 2024).

The fact that regions are not spatially siloed entities but rather embedded in manifold trans-regional and international networks was reflected in the concepts of global innovation systems (Binz and Truffer 2017) and global regimes (Fünfschilling and Binz 2018). Both relate to the many ways in which institutional structures are interrelated to each other across space. We could show how technology legitimation is generated through coupled processes of legitimation strategies across many places, which reinforce or attenuate each other and get activated by different actors in a selective way (Heiberg et al., 2020). Therefore, innovation dynamics even in a single region cannot be exclusively understood by the specific institutional structures that emerged in these places but must account for the many way actors mobilize institutional resources from different places for specific purposes. Again, doing institutional analysis in such complex constellation proves to be highly complex.

A last challenge for doing institutional analysis in space relates to the actual geography; how widely conditions may vary locally and by this betray any simple understanding of how specific rules influence the strategies of actors. In the context of informal settlements in Kenya, we got painfully aware that the established template of how institutional structures aggregate into coherent superstructures had to be reconsidered. That's why we developed an understanding of different

degrees of complexities of regime structures from monolithic, to polycentric, fragmented and ultimately splintered regimes (van Welie et al., 2018). This gradient indicates an increasing complexity in the rule configurations that apply to actors even within a given spatial setting depending on their age, gender, income level, health status, ethnic affiliations etc. This insight provided us with new views also on institutional structures in Western countries, where equal levels of complexity have to be considered (Schippl & Truffer, 2020).

Summarizing the geographical explorations, we had to acknowledge that the constellations of institutional structures were likely to explode as soon as we took spatial variation seriously. Any systematic attempt to identify broad classes of institutions was likely bound to fail.

So what and what for? - Directionality

This leads us to the third realm where institutional analysis proved to be vital and to which you made a very early, seminal contribution jointly with Matthias Weber (Weber & Rohracher, 2012): directionality. One of the core tenets – or perhaps even THE core tenet of innovation studies – is that social processes substantially influence the direction and content of technology development. There is no such thing as the fully convincing, outcompeting technological solution in history of technology but the success of designs depends on the institutional contexts in which the different alternatives competed, and the institutional strategies actors engage in. Optimality is therefore a social construct in a deep sense and there is no case for a techno-deterministic view on technology development (Bijker, 1995; Misa, 1998).

You made the point that success conditions of innovation processes leading to transitions depend not only on the classical structural innovation system failures but also four types of transformational system failures: directionality failure, demand articulation failure, policy integration failure, and reflexivity failure. To my knowledge, this was the first time that directionality had been put on the agenda, and it opened a field of research, which only has gained prominence since.

We had engaged with directionality first and of all through a deeper scrutiny of the TIS function guidance of the search (Yap & Truffer, 2019). By disentangling the institutional work strategies that actors employed to make a specific technological trajectory win over its rivals proved to be highly inspirational. While this early study focused on wastewater

technologies in China, later work also analyzed diverging trajectories in transport in Germany (Schippl & Truffer, 2020), diverging trajectories of photovoltaics in China (Yang et al., 2021) or diverging interests in a Swiss innovation system in modular water technologies (Heiberg & Truffer, 2021).

In terms of methodological contributions, we engaged with the Technology Assessment literature highlighting the role of future institutional conditions influencing technology development (Truffer et al., 2017). And finally, we developed a methodology to derive institutional configurations from statements of actors collected from the collection of document series, which we called socio-technical configuration analysis (Heiberg et al., 2022; Truffer, 2024)

Most recently, we argued that valuation processes influence directionality by shaping the selection environment for innovating actors through valuation ecosystems encompassing all sorts of institutional arrangements to convey value considerations on products and technologies – called valuation devices. These frameworks have been developed and applied to cases in the chemical industry (food packaging, (Hoos et al., 2025)) and transitions in global value chains of the textile industry (Nesi & Truffer, 2025).

Last but not least when talking about directionality, the role of policy frameworks that are able to inform attempts at steering technology development gained prominence over the past couple of years in the form of transformation oriented industrial policies (Schot & Steinmüller, 2018) or of course mission oriented policy frameworks (Elzinga et al., 2023; Mazzucato, 2018).

Wrapping up this third dimension, we may say that doing institutional analysis is key for identifying mechanisms that shape directionality. However, the manifold contexts, interests and value related tradeoffs that need to be overcome defy any simple methodological template.

Impacts of a paper that was never published

Coming back to the original conundrum of why we have not been able to pull this paper off in the late 2000s even though it had looked like a very timely and necessary contribution, we may conclude that the intuition was indeed very honorable. A systematic approach to analyzing institutional structures for innovations is still a rather unresolved problem. Some of

the reasons were listed already at the end of each section: there is the epistemological problem of how to assess institutions that often don't have a material reality and that can easily be "measured", but that show only through their effects on the discursive and material acts of different actors. A second point is that we probably underestimated the sheer complexity of the different forms and shapes in which institutions may manifest themselves, the granularity in terms of spatial, sectoral but also actor contexts in which these institutions hold and are upheld and the manifold interdependencies among the different institutional structures. As elaborated above, this complexity would likely end up in a monstrous framework that would be very difficult to handle or alternatively be highly abstract such as the famous tripod of regulatory, normative and cognitive institutional dimensions. A third point is that institutions show their existence often in relation to specific intentional projects of actors in either prohibiting or directing the actual course of activities. Therefore, institutional analysis can only be done with an orientation of specific goals that actors want to achieve. All three points together suggest that our original project was well-intended, but probably too simple in its approach to appreciate all these different complexities.

On the other hand, I still refuse to feel bad about the time we had invested in the project. The extended discussions and writing periods that went into this project provided solid ground on which all those later activities could build. The fact that we had not been able to pull this off indicated to me that there were some deeper challenges that needed to be unpacked, and that a more humble, stepwise approach was probably appropriate. Now, almost twenty years later, it looks like things are starting to connect again. A more encompassing picture of the role of institutional structure for orienting innovation and transition processes has emerged even if we are still not able to do the analysis in fully-fledged systematic way as originally intended.

This leads me to a final observation about impactful research. It is probably not only those publications that actually get published, read and highly cited that constitute the basis for a successful research agenda. It is more like there is need for many layers of interactions, inspirations, rediscoveries, dead ends, and confusions that provide this solid ground, even if individual pieces remain hidden. In that sense, I consider our joint project having had substantial impact on my own research and by this perhaps even on the field, even if it has never emerged in an academic journal and hasn't attracted any citations whatsoever.

Thanks, Harald, for having been a reliable and inspiring partner on this journey over all these years.

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Proactive legitimation of R&I policy interventions: beyond market and system failure

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Introduction[2]

The EU's Lisbon objectives have propelled research, technology development, and innovation (R&I) to the forefront of public debate. As the subject matter attracts increasing attention, expectations are also on the rise as to what research and innovation should contribute to mastering key societal and economic challenges. At the same time, there is pressure to justify increased funding for R&I policy measures, not least due to growing R&D expenditures. This also involves a growing need to account for state intervention in R&I policy. While in recent years policy measures were mostly justified on grounds of overcoming market and structural deficiencies, R&I policy is increasingly expected to help provide innovations that are instrumental in mastering the challenges society faces (e.g. global climate change, aging society, etc.).

The complex innovation system approach (CIS approach) presented here attempts to contribute to the legitimation of R&I policy. It proposes viewing the role of state actors as part of a complex system, which is governed based on self-organization and escapes individual actors'

attempts at exerting top-down control. Providing arguments in support of R&I policy interventions geared toward tackling societal challenges that reach beyond economic growth targets only is an especially difficult task. In this article, we concentrate on attempts at rational legitimation that promise to provide either some common ground for achieving a consensus at the parliamentary level or a firm academic foundation to justify resource needs in the face of the demands of other policy areas in budgetary negotiations.

Typically, political action is legitimized with reference to perceived dangers, risks, or uncertainty. Contrary to such a defensive approach, political intervention, in principle, can also be justified on grounds of its ability to provide opportunities and to enable utilizing potential. In this article, we distinguish motives for political action according to whether they emphasize problems or opportunities; based on this distinction, we speak of *reactive* and *proactive* legitimation respectively. Reactive legitimation means that a perceived problem is taken as the reason or at least as a justification for a political intervention. Proactive legitimation means that the main reason given for R&I policy action relates to chances of seizing available opportunities.

A discussion of policy legitimation must also take into consideration whether problems and opportunities in the immediate R&I policy area form the starting point (for instance an insufficient R&D rate) or whether the stimulus for political action comes from other areas, such as climate change or the aging of society. In the latter case, R&I policy can contribute to mastering societal challenges by opening up new opportunities and chances. This we call a mission-oriented R&I policy. Thus, we contend that a R&I policy aimed at successfully tackling societal challenges should be supported by a proactive line of reasoning to substantiate the need for interventions and, on this basis, develop the tools required to help implement suitable innovations. In our view, sole reference to current or future problems concerning the capacity of the innovation system will not suffice.

This article examines currently available approaches to rational and procedural legitimation as to whether they are capable of providing sufficient arguments for the legitimation of measures aimed at mastering societal challenges. Market and system failure are the academic concepts most frequently referred to in accounting for R&I policy interventions. Both are reactive approaches to legitimation since they focus attention on

problems of innovation systems and not on the opportunities that innovations offer. A look at the literature suggests that we currently lack of a theoretically well-founded approach providing a coherent argumentation capable of legitimating interventions on grounds of opportunities instead of failures We attempt to carve out the building blocks for such a proactive legitimation strategy. Our approach is based on a theoretical understanding of innovation systems that takes the mode of operation of complex systems into account while incorporating the need to consider society's problems and opportunities at the same time. The empirical section of this article gives an answer to the question as to whether the patterns of argumentation underlying such an approach have already entered the Austrian debate on the justification of R&I policy intervention.

The article is organized in the following manner: The starting point is an analysis of market failure and system failure arguments with regard to their ability of legitimating mission-oriented R&I policy measures. In the course of this analysis, we also address the recent debate about the functions of innovation systems. Subsequently, we outline the complex innovation system (CIS) approach and its contribution to the debate on legitimation. Several basic functions of complex innovation systems are identified on the basis of which we derive the main lines of reasoning for justifying R&I policy measures. We then pursue the question of whether those lines of reasoning can also be found in practice using several recent examples from Austria. We conclude by summarizing the main results and discussing the practical implications to be drawn.

Argumentation patterns for legitimating R&I policy interventions

This section introduces the predominant patterns of reasoning in legitimating R&I policy interventions. We start with market failure as the most common yet most restrictive approach. In the past fifteen years, the obvious need for political action has led to devising alternative approaches that direct attention to the systemic interaction of various elements in the innovation process (system failure) and the functions that innovation systems are expected to provide for individual actors (functional failure).

Market failure

Market failure refers to a misallocation of monetary resources resulting in inefficient markets for knowledge and innovation. It is frequently argued that market failure provides sufficient legitimation for R&I policy action. We must, however, consider which market is referred to. Are we talking about a market for products and services or for certain knowledge? Arrow (1962) and Nelson (1959) originally considered the failure of "knowledge markets" as a sufficient legitimation for science policy intervention, and many have taken up the argument for political interventions addressing research, technology development and innovation. Reference is given to, three fundamental problems pointed out by neo-classical economic theory: uncertainty, inappropriability, and indivisibility (Hauknes and Nordgren 1999; Arrow 1962; Nelson 1959).

"Product-markets", however, especially those that might hold potential for tackling the challenges society faces, are generally not referred to in market failure-based reasoning pertaining to R&I policy. In other words, the market failure argument proper applies to research, technology development, and innovation only to the extent that the mechanisms internal to knowledge production process are involved, not, however, to innovation as outcome of the system of knowledge production.

Arguments based on the notion of market failure may be sufficient to legitimize certain policy measures. However, the arguments put forward are frequently too unspecific to guide action, and they address only part of the challenges decision-makers face in the field of R&I policy. An intervention triggered by solving a fundamental problem for markets to work is of a reactive nature. It is greatly restricted in the way societal challenges are approached and is thus only partially useful in providing guidance for policy action.

System failure

The concept of system failure allows overcoming some of the limits of the market failure argument and points to a host of aspects that reach beyond those considered by neo-classical economics. For two decades now, various approaches to innovation systems have been discussed, ranging from Freeman (1987) and Lundvall (1988) with a focus on national innovation systems, to Bresci and Malerba (1997) who pursue a sectoral approach, and Cooke (1992) who adopts a regional innovation system approach. The said approaches place an emphasis on the composition of

actors, their interactions, and the institutional aspects of innovation. On this basis, the notion of system failure was introduced to the debate on the legitimacy of political intervention in the R&I field (Woolthuis et al. 2005; OECD 2002). Evolutionary and institutional economic theory (Dosi et al. 1994, Hodgson 1988) along with social network theory (Granovetter 1973) provide the main foundations. Those theories direct attention to a wide range of phenomena, such as the significance of institutions and networks, the problem of path dependency, as well as variation and selection mechanism.

Against this background, Woolthuis et al. (2005) identify eight failure arguments that have found their way from theory into practice. These are

1. infrastructural failure (Smith 1999; Edquist et al. 1998),

2. transition failure (Smith 1999),

3. lock-in/path dependency failures (Smith 1999),

4. hard institutional failure (Smith 1999),

5. soft institutional failure (Smith 1999; Carlsson and Jacobsson 1997),

6. strong network failures (Carlsson and Jacobsson 1997),

7. weak network failures (Carlsson and Jacobsson 1997), and

8. capabilities' failure (learning) (Smith 1999; Malerba 1998).

All these system failure arguments concentrate on the generic features of the innovation system and refer to the innovation process. They do not address whether innovation activities have (or have not) achieved a certain outcome or impact. Thus, for how to tackle societal challenges, the same limitations with respect to policy guidance apply as in the case of market failure.

In this context, Chaminade and Edquist (2006) suggest an approach to legitimation that includes both market and system failure and thus bridges the gap between the two paradigms. This is to emphasize that innovation systems need improvement both in terms of efficiency and effectiveness. They see a need for political intervention only if market mechanisms fail to guarantee solutions to the identified problems or innovation systems fail to function properly. Beyond that, the authors see scope for legitimate public policy only in cases where such policy has a proven potential for solving or avoiding the problem of concern and can

be expected to accomplish the objective more efficiently than by "the market".

Legitimation through functional innovation systems approaches

In recent years, efforts have been made to further elaborate the innovation systems approach that intends to go beyond a system failure rationale. The literature increasingly focuses on the functioning of innovation systems (David and Foray 1994; Galli and Teubal 1997; Liu and White 2001; Jacobsson and Bergek 2004; Borrás 2004; Kuhlmann and Smits 2004; Chaminade and Edquist 2005; Hekkert et al. 2006; Bergek et al. 2008). Those functions must be performed for innovations to emerge irrespective of the concrete shape of the innovation system.

The various functional approaches focus on different aspects characteristic of the dynamics of innovation systems. They are devised for different purposes, describe different functions of systems, and draw on different theories. Yet, there is no agreement in the literature to date as to what set of functions innovation systems must fulfill (Chaminade and Edquist 2005). Thus, some approaches place emphasis on phenomena that directly support actors' innovation activities along the value chain (Liu and White 2001; Kubeczko et al. 2006). Other authors focus on the process of knowledge creation and, specifically, on activities of intermediary institutions between industry and science (Galli and Teubal 1997; Borrás 2004). Bergek et al. (2008) can also be mentioned as representing an approach aimed at developing new technological innovation systems. Against this background, state intervention can then be justified on grounds that actively contributing to performing these functions offers new opportunities for shaping innovation processes.

Interim conclusion

If we compare the three approaches to legitimation described above and relate them to our main research question, we find that market and system failure can be interpreted as representing reactive arguments of legitimation whereas functional approaches can be used for the purpose of proactive legitimation. Legitimation arises from expectations of (re-)establishing an efficient "knowledge market". However, such a view only covers a limited subset of all conceivable sources of failure. In reaction to this, the literature for many years concentrated on describing the structure of systems of innovation (actors, interactions, and institutions)

and deducing failure arguments from economic and sociological theories. For instance, failure arguments related to inadequate organization, network problems, absence of institutions, or lock-in effects play a key role. The traditional innovation systems approach clearly have major strengths in this respect, which has led to R&I policy frequently relying on system failure arguments for legitimation. Yet, since these approaches center on system failure only, they provide few cues as to how innovation activities might be stimulated proactively.

Although the performance of certain functions can also be conceived of in terms of failure arguments (for instance, as failure to mobilize resources), reference to such functions opens up a whole new range of arguments in support of proactive legitimation by demonstrating the functions that an innovation system performs for society. If we wish to go beyond failure arguments to emphasize the opportunities an efficient and effective system of innovation offers, a proactive approach to legitimation is called for. Functional approaches facilitate a line of reasoning from the vantage point of available opportunities as opposed to the traditional identification of problems. Already existing instruments can be utilized for this purpose and new ones can be developed as well. Thus, an argument can be made on these grounds that R&I policy measures can help in mastering a societal challenge. This provides an opportunity for legitimating a mission-oriented R&I policy as has been increasingly discussed in recent years.

The weakness of functional approaches currently lies in their heterogeneity and lack of a consistent theoretical foundation. This new form of legitimation has not yet gained sufficient acceptance in practice. The CIS approach has been developed to help overcome this deficiency. It will be described in the following.

Complex innovations systems as the foundation for the legitimation of R&I policy interventions

As shown in the previous section, the predominant approaches to rational legitimation (market and system failure) – also considered sufficient in practice – are too unspecific to justify political intervention aimed at tackling societal challenges. Only functional approaches allow departing from a purely reactive in favor of a proactive reasoning in support of R&I policy interventions, thus laying the argumentative groundwork for mastery of societal challenges to become an accepted R&I policy task. So

far, however, a theoretical explanation has been missing as to how an innovation system and R&I policy can be expected to actively come to grips with the challenges society faces. How do problems become challenges for the innovation system? How can individual system functions be explained theoretically? We attempt to devise a conceptual framework for further developing the innovation systems approach in order to give answers to these questions.

Characteristics and function of complex innovation systems

The heuristics of complex innovation systems (CIS) (Weber 2005; Czerny et al. 2007; Weber et al. 2008), which will be outlined below, explicitly builds on the theoretical and conceptual framework of the innovation systems approach and shares some common ground with the functional approaches that exist so far. Moreover, our approach takes the multi-level models from the science and technology studies discourse into account (Geels 2004; Kemp and Rotmans 2005) as well as insights gained from the study of social systems dynamics (Luhmann 1984).

A complex innovation system is defined as a socio-technical multi-level system embedded in a larger social context (the system environment). It consists of actors – who engage in concrete activities and, in so doing, can build on a societal knowledge base – as well as communicative interactions in the innovation process and in networks. Institutions, in the sense of rules that apply to the innovation system, represent structural components, which are familiar from existing approaches (Edquist 1997).

In describing CIS, we distinguish two different kinds of functions that take effect at different levels. On the one hand, we define *system functions* that a system needs to perform internally, so to speak, by means of innovation-oriented activities. Functions of this type largely correspond with the understanding found in functional innovation systems approaches.

On the other hand, our heuristics is based on the consideration that an innovation system, as a closed social system, performs specific functions for other social systems in society (such as economic, political, scientific systems) that are regarded as *societal functions*. We thereby subscribe to an understanding of social systems that draws on Luhmann's theory of social systems as autopoietic systems of communication (Luhmann 1984, Czerny et al. 2007). The functions performed by the CIS for other social systems are additional elements of legitimation inasmuch as they define the role of the innovation system for society. In this way, target groups

outside of the innovation system can be identified as beneficiaries of the societal function and, in consequence, of the internal system functions necessary for providing that function.

CIS performing societal functions

Being a complex system, we think of CIS as being capable of reflexivity and thus of self-observation. This involves the ability to flexibly respond to environmental conditions in order to operate efficiently and effectively as a system – not just as individual actors but also as a collective[3]. We hypothesize that the communication occurring in the context of innovation activities can be thought of as a communication subsystem among others in society, such as the economy, politics, science, law, the mass media, etc. In accordance with Luhmann's classic description of social systems (Luhmann 1984, 1998) – although he does not intend for an innovation system – the innovation system can be conceived of as performing societal functions to the benefit of other subsystems. Accordingly, the system must (internally) provide certain functions to perform societal functions toother the social systems, in the sense of Luhmann.

Moreover, we assume that a complex innovation system facilitate change by generating innovations. This also includes mastering challenges to society by making use of new technologies in the broadest sense. Viewing CIS in this way implies that innovation cannot be gauged on criteria of economic efficiency and effectiveness alone, but non-economic (social, ecological, military) criteria must be equally considered (also see Chaminade and Edquist 2006). Luhmann's theory of social systems assists us in accounting for the role that the innovation system plays for society. Thus, we are in a position to argue that the CIS, apart from its significance for the economy, also provides functions for other societal sub-systems.

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[3] Luhmann (1998) did not consider an autonomous subsystem for providing innovation. He nevertheless raises the question as to the role of innovation for society and in which subsystem it occurs. The notion of technology, which in Luhmann's work is connected with the system of science, provides a starting point (Krause 2005). In our view, conceiving of the provision of technology as the form in which a system of science performs its function is, however, too narrow a conception. Yet, here we do assume, in terms of heuristics, that it is useful to speak of an autonomous societal subsystem of its own, focused on innovation.
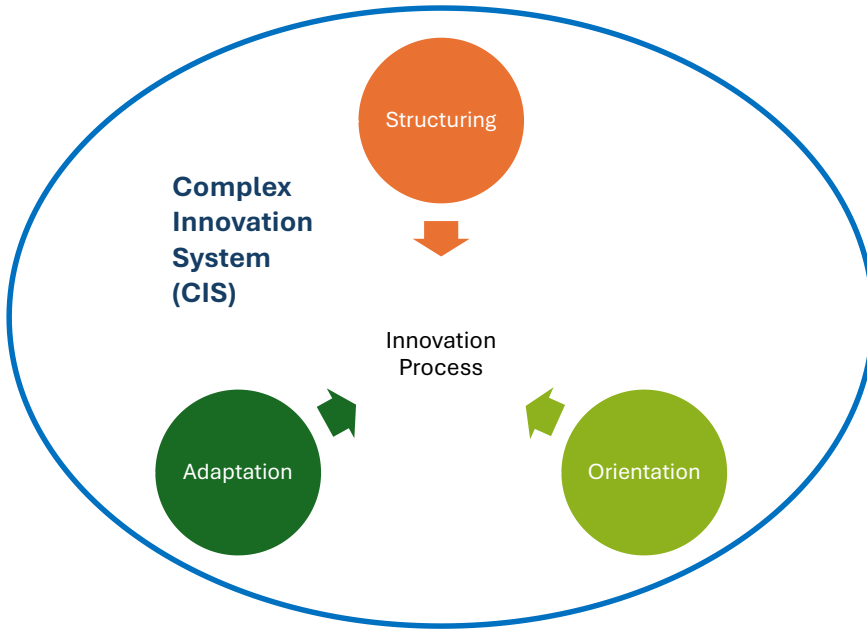
CIS functions:

In order to produce innovations and fulfill societal functions, complex innovation systems must satisfy two main conditions. First, CIS structures, processes, and actors must prove effective in terms of individually or collectively producing a high level of innovation activity. Second, the reflexive nature of the CIS is essential for its structural components to be externally effective in terms of society's functional requirements. Since reflexivity pertains to both the CIS itself and the system environment, we distinguish three types of functions of innovation systems:[4] Structuring; Orientation; Adaptation.

Structuring, as the first category of system functions, refers to the great majority of generic functions also mentioned in the predominant functional innovation system approaches.[5] Among those generic functions are the provision, dissemination, and exchange of knowledge, the provision of a research infrastructure and human resources, establishment, change, and abolition of institutions and organizations, the provision of monetary resources, and actor networking (Chaminade and Edquist 2005). Different coordination mechanisms (markets, networks, hierarchies) can be involved in performing the various functions within the innovation system. Structuring can be viewed as a system function ensuring coordination. In other cases where network structures do not allow effective solutions, market mechanisms may be effective, for instance, by exchanging intellectual property rights. Since we cannot suppose that all innovation systems are structured in the same manner or that there exists a "best-practice structure", we may conclude that coordination mechanisms also can be applied in different ways.

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[4] The types of functions of systems we are concerned with here are not unlike the functions Parsons (1951) refers to in his AGIL (adaptation, goal-attainment, integration, latency) scheme for conceptualizing action systems. Parsons' action theory can indeed be turned to for the further theoretical elaboration of these considerations.

[5] What is referred to by the term "functions" in those approaches for the most part equals what we have defined as internal system functions. According to Bergek et al. (2008, 409), functions are *"key processes ... which have a direct and immediate impact on the development, diffusion and use of new technologies."*

Figure 1: System functions of a complex innovation system. Source: own illustration

The internal and societal aspects of system self-reference are mirrored in the two other dimensions of internal system functions – adaptation and orientation. Adaptation and orientation serve to maintain the reflexivity of an innovation system. To the extent that internal system functions support adaptation or orientation, they lend flexibility and effectiveness to the innovation system.

Orientation plays a crucial in that it opens the possibility for normative reasoning to enter the innovation system. The orientation function indeed seems to be capable of elevating the task of mastering societal challenges to a status of greater importance in the innovation process. This specific orientation of demand, however, depends on how the demand is interpreted in the CIS context and which internal system functions are available. Innovation systems are not restricted to effectively and efficiently producing innovations of any kind. Rather, by generating innovations, they can contribute to providing solutions to societal challenges (as the societal function of the CIS). The issue of sustainable development is a case in point: the CIS framework allows combining the orientation function with sustainability objectives.

Adaptation is the third dimension of system functions. The adaptation function is essential for an innovation system's ability to cope with inherent dynamic change. For this purpose, as for the orientation function, a CIS requires capacity for reflection. It puts the CIS in a position to recognize relevant internal or external developments and flexibly respond to them. This stresses a key characteristic of complex, self-organizing systems, namely the ability to flexibly adapt to changes in their environment – either reactive (e.g. in response to external developments) or proactive (e.g. by means of strategic action and anticipating external developments). Most notably, a world marked by globalized knowledge production and innovation reinforces the need to foster the innovation system's adaptive capacities. Moreover, the changing perception of societal challenges also demands responses from innovation systems and the ability to anticipate long-term effects by means of reflexive innovation processes. Strategic intelligence (Smits and Kuhlmann 2004), involvement of users in innovation processes, or adaptive foresight (Eriksson and Weber 2008) are possible means of maintaining this system function.

Legitimation based on the CIS approach

The CIS approach can serve to legitimize R&I policy interventions in a number of ways. Nonfulfillment of system functions can be couched in terms of failure arguments or can be viewed as a prerequisite for the CIS to perform its societal function.[6]

Failure arguments, such as institutional failure, network failure, or infrastructure failure, are absolutely compatible with insufficient system performance, for instance, in terms of provision, dissemination, and exchange of knowledge, provision of research infrastructure, or actor networking.

[6] In either case, there is insufficient justification for political interventions in the event that one of the functions is not fulfilled or is already fulfilled to an extent that allows providing a contribution to the solution of societal challenges. Political interventions thus can only be justified in situations where R&I policy instruments can be expected to provide the appropriate means for remedying the causes of failure or ensuring system performance.

Table 1: Comparing reactive and proactive concepts of legitimation

Reactive concept of legitimation	Proactive concept of legitimation (CIS)
Market failure System failure	Structuring
	Orientation Adaptation

Thus, it is basically possible to determine appropriate measures for improving system performance based on the three functions of the innovation system:

1. Structuring function: the measures and instruments are for the most part the same as the ones already in use.

2. Orientation function: guidance of search and research processes; coping with anticipated myopia (Salmenkaiti and Salo 2001); offering legitimation; demand-side involvement and innovation-oriented public procurement.

3. Adaptation functions: platform for inter- and transdisciplinary cooperation; strategic intelligence (technology assessment, monitoring and benchmarking, reflexive governance (Voß et al. 2005).

Another advantage of the CIS approach is that it does not limit its focus to the structuring function alone. Instead, the CIS approach stresses the need for anticipation and reflexivity to ensure orientation and adaptation. We thus speak of reflexivity failure. In particular, new and previously non-essential system functions are required in light of developments that not only have a huge impact on society but where efforts at addressing them also involve lengthy preparation and start-up periods, as in the case of climate change. Policy makers are becoming increasingly aware of the urgent need for R&I support for climate-related mitigation and adaptation strategies. In that case and others demanding a long-term transformation

process under conditions of uncertainty and danger, the coordination of collective expectations is a relevant issue for a coherent R&I policy. In such cases, new arguments for legitimation may also be conducive to the development of innovative instruments.

In our view, the greatest benefit of the CIS approach lies in the fact that legitimating intervention must no longer primarily rely on failure. In light of the societal challenges to come, a reactive line of reasoning stressing failure in terms of insufficiencies of the innovation system is also overly rigid and conservative. We thus should also be able to base legitimation on the assumption that internal system functions are ensured.[7]

Legitimation via system functions – the Austrian experience

The following section pursues the question as to which system functions have been referred to as examples in legitimating R&I policy measures in Austria from the late 1990 to the end of the 2000s. This phase of Austrian R&I policy is particularly interesting because it covers most major reforms and novelties that characterize the Austrian innovation system until today. We are especially interested in whether in this phase all three internal system functions (structuring, orientation, adaptation) have actually been referred to justify policy interventions but also to what extent external requirements of research and innovation have been invoked in support of R&I policy initiatives. Our analysis allows us to draw conclusions as to whether currently debated new initiatives can be legitimized with reference to previously neglected system functions. This is a highly relevant topic because, after fifteen years of relative stability, the Austrian innovation system is in need of a major overhaul to take into account recent changes in geopolitical, economic and technological context conditions for R&I.

Structuring function

The beginnings of an active R&I policy in Austria dates back to the mid-1960s when – after lengthy birth pangs (see Pichler et al. 2007) – two funding institutions were established: the Austrian Science Fund (FWF) and the Austrian Fund for the Promotion of Applied Research (FFF).

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[7] In practice, putting forward both failure arguments and proactive arguments at the same time would seem appropriate since failure can occur in certain areas of the innovation system even though legitimation may rely on proactive reasoning in principle.

Whereas the former is dedicated to funding basic research, the latter is active in promoting applied research and development. In creating these institutions – next to the already existing base funding for universities and a few research institutions outside the university landscape, such as the Austrian Academy of Sciences (Österreichische Akademie der Wissenschaften), Ludwig Boltzmann Society (Ludwig Boltzmann Gesellschaft), Austrian Research Center Seibersdorf (Österreichischen Forschungszentrum Seibersdorf) – funding opportunities were established that are open to a wider range of applicants from the ranks of science (FWF) and business (FFF).[8] While the FFF drew legitimation from the most traditional of all market failure arguments, namely (industrial) underinvestment in R&D, the FWF can claim to provide funding aimed at strengthening excellence in research – an argument that can also be interpreted in terms of performing a structuring function.

The next surge of measures geared toward improving structuring efforts was launched in the 1980s by establishing technology transfer institutions and an innovation agency. Those measures were mostly devoted to promoting the diffusion of new R&I findings to small and medium-sized enterprises in Austria. Those measures were also meant to overcome structural shortcomings of the Austrian innovation system, specifically to improve the dissemination of knowledge to small and medium-sized enterprises (SMEs).

This was the situation in the middle of the 1990s, when, inspired not least by the findings from research on national innovation systems, a new generation of instruments was introduced aimed at overcoming insufficient cooperation between science and industry by way of structural development. Especially, the competence center programmes Kplus, Kind and Knet were meant to foster cooperative linkages in the Austrian innovation system. Other stimuli for improving the internal structure of the innovation system came from programs like AplusB (for regional cooperation between academia and business), protec (for stimulating innovation in SMEs), FHplus (for developing excellence at universities of applied sciences). The Kplus program, in particular, was based on a very competitive bottom-up application procedure aimed at forming priority areas and concentrating scientific expertise at single locations in Austria.

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[8] The Ludwig Boltzmann Society Gesellschaft was established at about the same time as the two funding organizations FFF and FWF and is engaged both in project funding and in establishing independent institutions, for the most part as university affiliates.

It did not pre-determine any thematic subject areas but left it to the applicants to build collaborative arrangements that could give Austria a competitive edge in key areas of research and hence strengthen its international visibility (Sturn 2003). In essence, however, they were designed as measures to structure the innovation system in a way that would allow overcoming the still existent shortcomings in the cooperation between science and industry and achieve a high level of excellence.[9]

In the early years of the 21st century, the emphasis in Austrian R&I policy was put on major institutional reforms that draw their legitimation from the need for structural change in the Austrian innovation system. Both the university reform (BMBWK 2002) and also the reform of the funding organizations in 2004 (BMBWK et al. 2006) were designed to improve the structures of the research and innovation system in terms of effectiveness and efficiency. The Austrian Fund for the Promotion of Applied Research (FFF) was merged with other smaller funding bodies and the Austrian Office for International Research and Technology Cooperation (BIT) to the new Austrian Research Promotion Agency (FFG). Next to FWF and the equally newly created Austria Economic Services (AWS), in charge of economic subsidies and some innovation-oriented funding schemes, FFG became the third main funding agency for R&I in Austria.

In both reforms, however, redefining the relationship between politics, on the one hand, and funding and research institutions, on the other, was also an issue. The reforms implemented the organizational separation of R&I politics and strategy from the implementation of funding programs and, since then, autonomous universities. The transfer of funding responsibilities to organizations outside of the hierarchical system of public administration created the need for new steering mechanisms capable of controlling the proper flow and use of the indeed considerable volume of funding. With a share of 50 %, the Austrian universities are by far the major recipients of public R&D expenditures (BMWF et al. 2007). By concentrating funding options in the hands of three major funding organizations (FWF, FFG, and AWS), the intention was to separate responsibilities for strategy and conceptual planning (government departments) and implementation (funding agencies) and, above all, to improve the overall efficiency of the funding system (WIFO 2009). Since

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[9] The Kplus centers specifically are considered a particularly successful and internationally recognized model (see the center of excellence assessment report, ISI Frauenhofer and KMU Forschung Austria (2004)).

the two funding organizations established in 2004, FFG and AWS, and the still existent FWF distribute the major proportion of public funding, it is safe to say that the two key institutional reforms affected 90 % of the public R&D expenditures (BMBWK et al. 2006) and were legitimized based on structural arguments.

The Austrian National Foundation (Österreichische Nationalstiftung) was also established in 2004 mainly to ensure a steady flow of funds to the large funding organizations as well as to a few research institutions outside of the university system (BMBWK et al. 2006). Based on funds made available by the national bank and the ERP Fund, a yearly amount of 100-150 million euros of funding was made available, which represents a significant contribution toward accomplishing the important structuring task of stabilizing the resource base for R&I in Austria.

Indirect tax subsidies, which were first introduced in 1980 and have evolved into a major funding instrument, are another important measure of major financial significance to businesses involved in R&D – estimates assume that, by the end of the 2000s, they account for an approximately 20 % share of overall expenditures for public funding (WIFO 2009). As a measure designed to benefit the allocation of resources to R&D activities in businesses by way of tax relief, such indirect funding also counts as a measure aiming to improve the structuring function of the innovation system.

Towards the end of the 2000s, Austrian Research Centers Seibersdorf was the last major building block undergoing institutional reform. Confronted with either a dismantling of the research center or re-organizing it fundamentally, the Austrian Federal Ministry for Transport, Innovation and Technology (BMVIT) decided in 2008 to focus the R&I mission of the by then re-named Austrian Institute of Technology (AIT) onto a limited number of major infrastructure systems in areas like energy, mobility, health, digital security and innovation. Since then, AIT has evolved into a very successful Austrian lighthouse for applied R&I, which is very active both at European and at national level. Through its engagement in the EU framework programs for research and innovation, it provides an important gateway to the European research and innovation landscape for Austrian firms and public sector organizations.

Without laying claims to an exhaustive treatment of the issue[10], it seems safe to argue that matters of structuring have dominated the R&I policy agenda in the 2000s. Many important tasks have been tackled, and the results indicate that the Austrian innovation system has made some significant advances in terms of the structural conditions of research and innovation – a development that is also reflected in international comparative research and international benchmarks.[11]

All the initiatives mentioned were launched with reference to structural deficiencies of the Austrian innovation system. This has been the dominant focus of Austrian R&I policy during the 2000s. The goal of those measures has been to improve the overall capacity of the research and innovation system to produce "novelties", irrespective of questions concerning the purpose of the novelty. This approach was based on the well-founded reasoning that innovation stimulates growth in the long term, and structural measures can improve the capacity of the innovation system to innovate. The economic impact of publicly funded research clearly stands at the center of such reasoning (see RFT 2005; BKA 2007; BKA 2005).

With the beginning of the 2010s, the argument can be made that the basic structural conditions for research and innovation in Austria meet high standards in international comparison, both in qualitative and quantitative terms.

Orientation function

The structuring function is geared towards providing conducive conditions for research and innovation in general, independently of thematic or disciplinary fields where knowledge and novelty are created. The orientation function primarily concerns the question as to what kind of research and innovation, and in what topics are actually to be pursued. This concern can be approached with a skeptical mindset by arguing that the state should generally abstain from attempts at determining the contents of research, maybe except for those domains where the state is the primary source of demand for research and is the one to make use of its results (for instance, in the military domain and in many countries also

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[10] For instance, we have not considered measures in the field of venture capital or securing the economic future of business locations (Headquarters Program). Although they can also be classified as serving the structuring function, they nevertheless are of minor financial significance.
[11] See, for instance, the EU's Innovation Scoreboard: http://www.proinno-europe.eu.

in the areas of health and infrastructure). Yet, we must bear in mind that the state is also the guardian of important long-term collective responsibilities, for the mastery of which the results of research can and should be put to use.

A look at the overall volume of research funding reveals that the vast majority of public funds were spent in the 2000s in absence of any specific focus, with the largest share going to university funding. Also the growing weight of indirect tax subsidies needs to be taken into account in this overall picture. But even in terms of 'flexible' direct R&D funding through programs, only less than 15 % of this direct funding can be considered as having an explicit thematic focus.[12] This was due especially to the weight of the FFG basic and structural programs (which indirectly favored the funding of the country's established scientific and industrial strengths and hence lead to the emergence *de facto* priorities) and FWF funding of basic research.

Thematically focused programs and certain elements of institutional funding (e.g. ÖAW and ARC) are suitable top-down instruments for thematically orientating R&D activities. The volume of the thematically focused programs, however, is small compared to the sums involved in bottom-up funding, independent institutional funding, and structural programs. The former made up only about 10-15 % of direct funding during the 2000s. Neither was a forceful top-down process of defining priority research areas in the large public research institutions used.

Among the thematically focused programs, we can distinguish technological priority areas (often in the area of generic technologies, such as the life sciences, new materials, and information and communication technology, but also in special niche areas) from new mission-oriented topics (e.g. climate research, health, sustainability, security, etc.). From an orientation perspective, mission-oriented programs are of particular interest, that is, promotional measures that explicitly support important political objectives. Some of the thematically focused programs were explicitly dedicated to such mission topics (e.g. cultural landscape research, building of tomorrow); in many cases, their objectives were linked to innovation or industrial policy goals along the lines of "double dividends" (e.g. the programs Intelligent Transportation Systems or

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[12] That estimate is mainly based on the detailed report on funding across the various national funding programs for the period 1997–2006 (BMBWK et al. 2006 and own research).

Sustainable Economy). Although this approach may seem plausible at first glance, it runs the risk of industrial policy arguments dominating over mission-oriented ones, and technological R&I objectives superseding social, organizational and institutional innovation needs.

Difficulties in incorporating thematically focused programs into sectoral policies where they might act as a driving force for wider system changes, are partly responsible for the difficulties in establishing mission-oriented approaches in the field of R&I policy. The argument is indeed a convincing one that research and technology policy should not be completely subordinated to sectoral politics for there to be scope for R&D projects that reach beyond the political priorities and agendas of sectoral politics (an important task in times placing high demands on the capacity to adapt to new developments!). Especially in the case of long-term transitions (e.g. in connection with sustainable production and infrastructure systems), close coordination of R&I policy and sectoral politics is imperative (Weber et al. 2005).

The debate on setting priorities in R&I policy, sparked by the Austrian Council for Research and Technology Development (Rat für Forschung und Technologieentwicklung (RFT)) at the beginning of the 2000s, had little impact in terms of shifting the emphasis away from unfocused R&I policy measures (see Dachs et al. 2003 and RFT 2002, 2005). At least, RFT recommendations concerning the amount of funding for programs financed through special funds resulted in relatively small allocations especially to those thematically focused programs explicitly devoted to specific missions. Only in the field of generic technologies was thematic orientation provided by recommending programs with substantial funding. Especially the life sciences and information and communication technologies were singled out as priorities, and a recommendation was given to allocate 30 % and 34 %, respectively, of the funds intended for targeted technology initiative to those areas (RFT 2004).

Summing up, we may state that the orientation function was only to a modest extent advanced as an argument for the justification and conceptual design of R&I policy measures in Austria during the 2000s.

At the European level, too, consideration was given to more strongly aligning the framework programs with the so-called "grand challenges" (HLG 2008), which subsequently led to the 'societal challenges' pillar in Horizon 2020. The reason offered is that due to the long-term nature and complexity of the challenges ahead a proactive and coordinated approach

is required. However, the prospects of success for such initiatives also depends on whether they can be effectively implemented and coordinated with the respective sectoral policy actions within a common framework for a long-term transition strategy both at the horizontal level (i.e. between policy areas) and in terms of the multi-level coordination of regional, national, and European policies.

The debates about an innovation-minded public procurement also attest to a growing awareness of the role of the state in stimulating and orienting research, technology development, and innovation from the mid-2000s onwards. The reformulation of the Austrian public procurement law in 2006 at least allowed for taking aspects related to innovation into account in the procurement process. First steps at implementation were also made at the state and municipal level where procurement issues play a significant role.

The fact that the debate about the orientation function of the innovation system was not being waged more prominently at the thematic level was not only due to the existence of centers of excellence and cluster initiatives but also to the debate on the importance of a high-tech strategy for Austria. For Austria to establish itself among the leading countries in the field of technology and innovation after having completed the catch-up process, so the reasoning goes, a focus on high technology sectors (WIFO 2006) and a bolstering of high technology elements in traditional sectors (Schibany et al. 2007) was required. To accomplish this, efforts in industry as well as in the field of human resources were needed and had to be complemented by public initiatives in research and education. This concerned, for instance, education and training of young academics. Apart from the (structural) question concerning the proportion of graduates from tertiary education among the workforce, the main issue was the frequently voiced concerns over a foreseeable shortage in the upcoming generation of scientifically and technically qualified academics. In spite of a number of initiatives to increase the attractiveness and popularity of scientific-technical professions and eliminate gender discrimination (BMBWK et al. 2006; BMWF et al. 2008), there remained a need for strengthening the orientation function of the innovation system.

Adaptation function

The adaptation function is to ensure that the innovation system – which we conceive of as a self-referential system – is capable of responding to

changing internal and external requirements and to do so in ways that enable it to sustain and expand its operations.

A structural prerequisite for maintaining the adaptation function is access to adequate resources for basic research to generate the necessary wide range of new knowledge for practical applications. Especially, a prompt exchange between basic research and applications makes a fertile ground for rapid responses to changing requirements. The above-mentioned large proportion of thematically unfocused institutional and program funding and the many initiatives directed at intensifying relations between science and economy during the 2000s make it safe to argue that this aspect was already been extensively addressed by means of R&I policy measures in those years.

Apart from this inherent adaptive mechanism, there is also a heightened need for reflexivity and anticipation of future demands upon the innovation system to enable proactively positioning oneself in the accelerating and globalized competition for innovation and to allow for adjusting to new societal demands on research and innovation. In other words, reflexivity and anticipation are not only crucial requirements for the above-mentioned orientation function to be performed, but also for the adaptation function. Over the years, several attempts were made in Austria in the late 1990s and early 2000s to provide strategic orientation with an eye to new opportunities (e.g. in terms of scientific and technological development) and future needs (e.g. at the societal level). Among them are the Delphi process in the second half of the 1990s (Tichy 2001) as well as the strategy processes launched by the BMVIT and the City of Vienna[13], a few individual foresight processes focused on specific sectors, and more comprehensively with the research dialog of BMWF (2008).

Monitoring the current state of the national innovation system as well as the surrounding national and international environment is a prerequisite for forward-looking strategic action. In Austria, the annual research and technology reports along with the intensive involvement in international monitoring and benchmarking projects (OECD 2005, Erawatch Network,

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[13] Also see http://www.wiendenktzukunft.at.

Innovation Scoreboard) provide a solid basis in this respect since the last 1990s.[14]

An evaluation culture conducive to processes of learning from the experiences of past initiatives was successfully established in Austria during the 2000s (Zinöcker 2007). There are probably only but a few countries in Europe that go to such great lengths in evaluating their programs and institutions as Austria. There is criticism, though, that evaluations often tend to focus on legitimation instead of learning.

The ability to adapt, however, also crucially depends on the ability to put insights gained from strategy processes and evaluations into practice. The structural reforms of the 2000s at least give evidence that new and profound policy initiatives can be implemented, and obsolete activities can be brought to an end even in the face of opposition by those affected.

Especially in cases where the task to be accomplished requires cooperation across several policy areas, adaptive capacity also depends on the coordination of the policy areas involved. This capacity for "strategic governance" in the field of R&I policy was an issue in Austria but its significance was not fully recognized in the policy debates of the 2000s, as in most other European countries, although there were first positive examples in a select few countries (see Whitelegg et al. 2008).

Overall, a number of activities were implemented in Austria in the 2000s that derive from the need for adaptive capacity. These, however, were concentrated as general strategic intelligence aspects such as strengths, weaknesses and benchmarking, but neglected forward-looking activities required for political strategies that seek to address future opportunities and risks.

Fulfillment of societal functions

The considerations above concerning the performance of internal system functions of the Austrian innovation system still say little about the assessment of system performance from an external perspective, that is, from the vantage point of societal subsystems that rely on research and innovation output and make demands on it accordingly. This is a question that was rarely raised in Austrian R&I policy in the 2000s, when high R&I

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[14] In this respect, see, in particular, the country reports for Austria by ERAWATCH (http://cordis.europa.eu/erawatch) and the INNO-Policy Trendchart (http://www.proinno-europe.eu).

performance *per se* was considered an important step forward]. It is telling that in the process of system evaluation questions were posed as to the efficiency of the funding system, not, however, whether the funding system supports the research and innovation system in meeting the demands society places upon it. It seems that, satisfaction with system performance was sufficient to an extent that the steady increase in private and public R&D expenditures was not drawn in question, at least not as long as economic growth was considered the dominant purpose of R&I.

This points to concerns about the prominent role of the economic system as the main source of demand for the output of the research and innovation system. "Socially responsible prosperity"[15], based on innovation and knowledge, also plays a crucial role in achieving key societal goals, from employment to sustainability, but it only became a major issue a decade later. Still, from the broader angle of societal rather than just economic needs, the contribution of the complex innovation system in terms fulfilling its societal function consists of enabling change in institutions, conditions of production, use of nature, etc. through technology. Therefore, we need to be aware that the economic impact of research and innovation is merely one pathway amongst many others of addressing issues of long-term concern to society and that the innovation system should be expected to provide a greater contribution toward negotiating these challenges. Some glimpses of this change in perspective became already visible at the end of the 2000s, when the debates about the role of research and innovation for resolving major societal challenges set on. Issues explicitly mentioned in the 2008 research dialog were, for instance, aging, climate change, and migration. Other topics, such as security, sustainable development, and health, had already been the object of political initiatives for quite some time.

To sum up the development of R&I policy in Austria during the 2000s, we may conclude that the research and innovation system showed a quite poor responsiveness to external demands. Addressing structural deficits was the top priority agreed upon with overwhelming political consensus, and hence the focus was clearly on improving the structural conditions of the research and innovation system. This structural consolidation process was quite successful, and at the beginning of the 2010s the conditions

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[15] Thus the English translation of "Wohlstand in gesellschaftlicher Verantwortung", which is the title of the BMVIT's RDI policy strategy in the area of innovation.

were ripe for making greater efforts to implement R&I policy initiatives attuned to the needs of other societal subsystems.

Conclusions

New options for Austrian R&I policy

In the Austrian case, we may state that arguments related to matters of structuring have dominated the debate on political interventions in research and innovation systems during the 2000s. Considering the many insufficiencies at that time, this was certainly a reasonable approach. The most important initiatives and stimuli identified reflect this line of reasoning. It was a development that can also be explained based on the national innovation system approach and the resulting combination of market and system failure arguments for the legitimation of R&I policy.

In this perspective, policy instruments with an explicitly thematic focus or that take the requirements of other societal subsystems as a starting point are only accepted to the extent that they refer to generic areas of technology or immediate political needs (see Dachs et al. 2003). In Austria, this was mirrored in the limited funding of thematically oriented programs in general, and mission-oriented programs in particular – compared to bottom-up R&I programs focused on key technologies – as well as in linking thematic goals to industrial policy objectives and establishing funding programs support the formation of centers of excellence that - although thematically neutral - nevertheless primarily promoted and strengthened existing priority areas.

The need to solve fundamental societal problems paired with expectations regarding the international positioning and networking of national research and innovation capacities nourished doubts about the adequacy of a R&I policy mainly geared towards structural concerns. This explains the reinvigoration of interest both in policy instruments for supporting a renewed mission orientation in R&I policy and in the capacity for launching strategic initiatives in selected areas (see BMVIT 2006).

The conditions for such a new generation of strategically oriented R&I policies were indeed quite promising at the end of the 2000s, since the structural reform efforts in Austria in previous years had established a by-and-large well-functioning research and innovation system. Although there remained a need for regular structural adaptation and adjustments,

the groundwork was laid for effective mission-oriented and strategic R&I policies that corresponded with economic as well as other societal needs.

However, other important issues were still to be resolved: innovation-oriented procurement was still largely under-developed, and the forward-looking element of strategic intelligence in need of consolidation. In both regards, new forms of governance needed first to be established to facilitate horizontal policy alignment across policy fields and vertical harmonization between policy strategy definition at ministerial level and the implementation of a suitable policy mix by the respective agencies in charge.

Legitimation via system functions

The approach presented here emphasizes the role of internal system functions and external societal functions in the legitimation of R&I policy interventions. It provides a repertoire of rationales for justifying R&I policies that, apart from tackling structural tasks, are also more attuned to addressing societal needs and demands.

The dominant market and system failure arguments are suited to account for state interventions in research and innovation designed to remedy internal problems of system efficiency and effectiveness. Legitimation of R&I policy on grounds of market failure, however, only addresses problems of knowledge accumulation and knowledge exchange within the system. Interventions on this basis are of a reactive nature in that they respond by offsetting deficient market mechanisms or by creating knowledge markets.

The existing innovation system approaches already go beyond market failure arguments based on system failure reasoning. Of key significance are system failure arguments related to the effectiveness of structures (inadequate organization, network problems, absence of institutions, lock-in effects, etc.). However, system failure arguments solely refer to the characteristics of the system itself and thus resemble market failure arguments in that they also serve the purpose of reactive legitimation. Unlike the market failure argument, system failure does not explain problems of efficiency but problems of effectiveness, which can be remedied by developing or improving the structures of an innovation system. System failure reasoning, nonetheless, cannot address how external demands can be met.

If we wish to go beyond market and system failure arguments to fully open up the possibilities a developed innovation system offers, a different approach to legitimation is required – one that we have distilled into the notion of proactive legitimation.

We argued that the innovation system performs certain *societal functions* for other subsystems of society. The CIS's function for other subsystems is to *provide innovations* according to the requirements of these subsystems. In this respect, the economic system often plays a special role as a mediator of demand-side requirements.

In terms of the conceptual repertoire introduced here, legitimation of R&I policy measures is given in situations where non-governmental actors prove incapable of performing system functions at sufficient levels. The three system functions (structuring, orientation, adaptation) provide a framework based on which both reactive and proactive policy interventions in research, technology, and innovation can be justified. Based on the societal function that we attribute to the CIS, this framework allows, for instance, to address societal challenges looming on the horizon at an early stage.

The approach presented in this article has laid the groundwork for substantiating a strategic and mission-oriented R&I policy for mastering societal challenges and seizing the opportunities to come in the global knowledge. Further elaboration of the approach requires additional theoretical substantiation of the structuring, adaptation, and orientation functions in order to establish the CIS approach in the debate on R&I policy legitimation.

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Sociotechnical configurations of home heating: Insights from Swedish oral histories

Jenny Palm

Introduction

The interest in the role of households in the energy transition has evolved both in policy and research in recent years, moving beyond that of passive consumers to active participants in the energy systems. Households play an essential role in configuring a sustainable energy system by making choices that influence energy use, technology adoption, and infrastructure development (Rohracher et al., 2025). In this chapter the role of the households in configuring energy transitions or more precisely heat transitions will be in focus.

Sociotechnical configurations refer to the associations of technologies and institutions that are aligned by actors to fulfil a societal function, such as the provision of sustainable low-carbon energy (Heiberg et al., 2022). Earlier studies theorising sociotechnical configurations are often broad in scope, examining the alignment of actors, technologies, and institutions over long periods within a sector (e.g. Markard et al., 2012; Geels, 2004). Following this tradition, the chapter would have focused on grand technological transitions, such as Sweden's shift from burning wood to coal, then to oil, and finally to biofuels. However, this will not be the storyline here. Inspired by Harald Rohracher's work on households as arenas where sociotechnical systems are reconfigured, this chapter will analyse the role of households in configuring and reconfiguring the heating system.

As societies strive to decarbonise their energy systems and move towards more sustainable models, understanding the agency of households becomes increasingly important. This chapter explores how individuals and families engage with heating systems, examining the ways in which they reflect on and interact with heating technologies as part of their daily

lives. Through this lens, the aim is to shed light on the broader transformations occurring within energy infrastructures and the shifting responsibilities placed upon households in this transition. Households can create bottom-up pressure for broader structural change, prompting policymakers and energy providers to adapt to their new demands and practices.

The important role of households in energy transition have been discussed in several of Rohracher's early studies (e.g. Rohracher and Köhler, 2019; Rohracher et al., 2025). By focusing on the lived experiences of households, this chapter extends Rohracher's approach, offering an empirical investigation into how people engage with heating practices over time and how their choices, constraints, and reflections influence the development of sustainable heating solutions.

Heating systems are particularly relevant in the context of energy transitions due to their significant contribution to residential energy consumption and carbon emissions (IEA, 2024). The shift towards low-carbon heating technologies, such as heat pumps, district heating, and biomass solutions, is not merely a technical substitution but a socio-cultural transformation (von Platten et al., 2025). Rohracher has underscored the need to examine how various actors, institutions, policymakers, businesses, and everyday citizens, contribute to shaping technological pathways and infrastructure developments (Klitkou et al., 2022; Rohracher, 2008; Späth and Rohracher, 2015). Householders' perspectives on heating transitions, how they experience, adopt, and adapt to changes in heating systems, provide valuable insights into the broader energy transition and potential future sustainable pathways (Palm and Ambrose, 2023). By capturing personal narratives of heating experiences across different life stages, this chapter analyses patterns of engagement, resistance, and adaptation that influence how user configuring the heating system by developing and re-developing different heating practices.

To achieve this, the study employs an oral history methodology, gathering and analysing personal accounts of heating practices and experiences. This approach provides a unique lens for understanding the evolution of energy practices over time, offering rich qualitative insights into how individuals perceive and navigate their roles within the energy system. (Ambrose et al., 2024b). By foregrounding these narratives, the aim is to move beyond traditional techno-economic analyses and instead focus on

the lived, situated experiences of householders. This perspective is essential for developing more inclusive and citizen-oriented energy policies that recognise the diversity of household engagements with energy systems.

Overall, this chapter positions households not as passive recipients of technological change but as active participants in the ongoing transformation of energy systems. By examining how people interact with and reflect upon their heating practices, it contributes to a deeper understanding of how sociotechnical configurations are shaped in everyday life. In doing so, the chapter pays tribute to Harald Rohracher's research and its enduring influence on the study of sustainability transitions, while also providing new empirical insights into one of the most pressing challenges of our time: the transition to sustainable energy systems.

Sociotechnical configurations and home heating

Space and water heating account for nearly half of the total global energy consumption in buildings, highlighting home heating as a critical issue for climate policy. These energy services, essential for maintaining indoor warmth during winter months and providing hot water for sanitation purposes, are fundamental to household comfort and hygiene. Approximately 40% of the households globally require space heating at various points throughout the year, significantly contributing to residential energy demand, particularly in colder climates (IEA, 2024). Sweden, characterised by its cold climate, experiences among the highest numbers of heating-degree days within the European Union, despite having relatively energy-efficient housing infrastructure. District heating is particularly significant in Sweden, representing around 50% of the total heat market, compared to an average of only 12% across the EU33 countries (Energimyndigheten, 2023b). Additional prevalent heating methods in Sweden include electricity-based systems such as heat pumps and wood-based heating solutions (Energimyndigheten, 2023a).

Home heating transitions in Sweden have been deeply intertwined with sociocultural practices, technological advancements, and shifting power dynamics. While energy policies primarily focus on efficiency and decarbonisation, they often overlook the human dimensions of heating transitions, including the lived experiences of individuals and households (von Platten et al., 2025). Thomas et al. (2024) argue that heat transitions

are not merely technological shifts but involve deeply embedded social, emotional, and economic relationships. Households play an active role in shaping sustainability transitions, rather than being passive recipients of infrastructure changes (Rohracher and Köhler, 2019). Rohracher et al. (2025) discuss that the increasing integration of renewable energy sources, digitalisation, and electrification is transforming energy systems, leading to new roles for households as active agents in the energy transition.

Sociotechnical systems are frameworks that integrate both social and technical elements within a system to achieve a common goal. These systems emphasize the interaction and mutual shaping of social and technical elements (Geels et al., 2018; Büscher et al., 2018). Sociotechnical configurations refer to specific arrangements or setups within sociotechnical systems that define how social and technical components are organised and interact with each other (Madsen et al., 2022). Different configurations can lead to varying transition dynamics and interactions between components. Configurations can influence the level of agency and potential conflicts among actors within the system, emphasising the multidimensional nature of energy transformation (Madsen et al., 2022).

According to Ornetzeder et al. (2023) sociotechnical configurations are defined as structures with emergent properties, which means they possess properties or powers as a whole that are not present in their individual parts. These configurations include both social elements (e.g., typical users, necessary skills, rules, contracts) and technical elements (e.g., end-user devices, interfaces, connections to existing infrastructure). They are designed to accomplish specific intentional functions, such as the efficient distribution of locally generated electricity.

Sociotechnical configurations cannot be observed directly because many of the relevant rules are not codified anywhere. These configurations are framed on a semi-generic level, representing real-world and context-sensitive solutions without being too specific. They can however be derived from analysing narratives or practices of key actors (Miörner et al., 2022). Configurations evolve over time as technologies, policies, and social structures change, reflecting processes of transition and transformation. They also vary across regions and contexts, depending on local institutional, political, and economic conditions (Miörner et al., 2022). Configurations are stable over time due to strong path-dependencies, but it can change over time when for example user

preferences change or if policies or technologies change (Heiberg et al., 2022).

Despite the dynamic nature of heating configurations, earlier research has shown that political narratives around heating transitions largely ignored the lived experiences of households (von Platten et al., 2025). The grand narratives often emphasise technological advancement while ignoring social and cultural complexities of energy transitions (Ambrose et al., 2024a). Against this backdrop, this chapter investigates how households actively configure and reconfigure home heating systems.

Method and data

While much of the energy transition literature focuses on technical and economic aspects, this chapter centres on the lived experiences of households, using oral history as a method to capture personal, social, and cultural aspects of home heating. Oral histories facilitate 'effective histories,' which emphasize detailed and complex narratives rather than streamlined stories, thus allowing alternative perspectives to surface. These narratives provide an essential counterbalance to conventional research on domestic heating, which often exhibits 'presentism' as bias towards contemporary rationalisations that overlook the historical contexts shaping our existence (Ambrose et al., 2024b). Several studies demonstrate the effectiveness of applying oral history to home heating research. Goodchild et al. (2017) and Butler et al. (2014), for example, identified significant links between childhood experiences of home heating and current routines, habits, and preferences, highlighting the enduring influence of historical heating practices and technologies. Collectively, these studies convincingly illustrate oral history's potential for enriching our understanding of human experience, as well as illuminating interactions between everyday practices and sociotechnical transformations (Ambrose et al., 2024a).

The oral histories discussed here were collected within the broader research project JustHeat, which compares heating practices across four countries. However, this chapter focuses exclusively on the Swedish narratives. Between 2023 and 2024, a total of 44 oral history interviews were conducted. It was a diverse participant sample concerning rural and urban settings, housing type, tenure, age, gender, income level, occupation, and both historical and contemporary heating experiences. Participants were encouraged to reflect on their memories and

experiences of maintaining warmth at home from their earliest recollections to the present day. Consistent with oral history practices, interviewees guided the conversation, emphasizing topics they found particularly meaningful, with minimal interviewer intervention. The interviewer primarily facilitated deeper reflection on themes raised by participants and supported the chronological progression of their heating experiences across various homes and life periods. These interviews will here be analysed through the lens of sociotechnical configurations.

Configuring and reconfiguring home heating practices

The following section explores home heating through the lens of configuration, drawing on oral history data to examine how households engage with and transform heating practices over time. The analysis focuses on three key dimensions: historical configurations, stable and persistent configurations, and crisis-induced reconfigurations. Together, these dimensions illustrate how heating is an ongoing, adaptive process rather than a fixed practice.

Historical configurations: wood, coal, and oil as structuring elements

Heating practices have evolved significantly over the past century, with different energy sources and infrastructures shaping domestic routines and relationships. Historically, wood and coal served as primary fuels, requiring intensive labour and engagement from household members. Sociotechnical configurations were defined by direct interaction with fuel sources, including wood collection, storage, and combustion management together with gendered divisions of labour, with men responsible for fuel preparation and women maintaining household heating routines (von Platten et al., 2025).

Historically, heating systems in houses were manually operated. The introduction of oil heating in the mid-20th century marked a significant shift in configuration. Oil boilers provided a more stable and autonomous heating solution, reducing the need for daily manual labour. In response, households adapted by reconfiguring their homes to accommodate oil tanks and boilers, thereby transforming both the material and social dimensions of heating. (von Platten and Palm, 2023).

District heating which was introduced in the 1960's on a broader scale and electric heating, which became prevalent in the 1980s (Magnusson, 2013), further reduced household involvement in managing heat production, as automated thermostats and heat pumps replaced the manual effort of tending to wood or oil burners. While this shift facilitated greater comfort and ease, it also led to a diminished awareness of heating systems, reinforcing passive consumption patterns (von Platten and Palm, 2023).

Centralised systems and loss of configurability

The transition to district heating and centralised automated systems represents a paradigm shift in heating configuration, where households became increasingly detached from active engagement with their heating infrastructure. Elderly people experienced the urbanisation and in the 50s or 60s when they moved from the countryside to the city to a flat with district heating. It was an easy system where they did not need to do anything to have their home heated.

> *But I think that's because it was district heating. It's very positive in the sense that you don't have to think about it, it just works, it feels like. (Hampus)*

> *My parents moved into new apartments in an area called Katrinelund, and they were overjoyed. The apartments offered all the modern conveniences, essentially like the one I live in now. That marked the beginning of no longer needing to heat manually. These modern apartments were cleaner, with significantly less coal dust and less reliance on kerosene. (Alfred)*

When interviewing households in Sweden around their heating system a common pattern is that households connected to district heating and those having direct electricity heating have less interaction with their heating system. The interaction happens mainly when adjusting the temperature on the radiators or a device connected to e.g. the heat pump. District heating infrastructures reduce household control over temperature regulation, fostering a reliance on external providers or the landlord. Multi-family dwellings are often connected to a district heating system and the heat is turned on centrally at a set date in the autumn and then turned off in the spring. These buildings usually also have a cap, and they cannot increase the temperature above this cap, which most often is set to around 24-25 degrees. In rented apartments in Sweden, a cold or

warm rent system can be applied. If a warm rent system is used, the heating costs are included in the rent. If a cold rent system is used, the heating costs are paid by the tenants. Most rented apartments, 95%, have a warm rent system (von Platten and Palm, 2023). It contributes to hidden heating costs for the tenants, but also very convenient systems:

> *Yes, it was warm, really warm. But since the heating was included in the rent, there was nothing to reflect on; it didn't seem unusual in any way. So no, it felt completely fine. (Karin)*

Automated thermostats and central controls minimise hands-on interaction with heat production, in contrast to traditional heating systems. These have contributed to a practice where households historically played an active role in configuring warmth rather than passively receiving it from external heating providers.

The warm rent system, which typically capped indoor temperatures at approximately 24–25 degrees Celsius, was often experienced as uneven in its heat distribution. This led some households to adopt compensatory practices, such as using electric heaters, thereby highlighting tensions between imposed infrastructural configurations and individual agency.

> *Yes, we had functioning radiators, but they weren't sufficient. So, we bought additional heaters, the kind with a rotating fan. We used them throughout the apartment: in the kitchen, the rooms, one in the living room, and one in the hallway. It was extremely cold."* (Samya).

> *Later, we bought a small electric stove, the type that includes a fan heater. (Moa)*

These examples highlight the friction between infrastructural efficiency and household autonomy, illustrating how passive heating models challenge previous configurations based on active participation in warmth production.

Stability and persistence: long-standing configurations in heating practices

While heating technologies have evolved as we saw above, some practices have remained stable over time, demonstrating configurations that persist despite infrastructural change. There were actually many practices mentioned that have been used over decades. These include among others

layered clothing and quilts to keep warm, the use of slippers, bake and cook to keep warm, indoor movement and activity to generate warmth, furniture placement strategies, such as positioning seating near radiators and avoid covering radiators and take a warm shower.

A practice many mentioned was to light candle:

> *I often use tea lights, they add a bit of warmth and comfort. (Samya)*

> *I light candles, five or six placed around the apartment, and after a while, the temperature rises to around 21 or 22 degrees. Then it feels comfortable. One evening, it became so warm that I didn't light any candles at all. These indoor temperatures are unpredictable, sometimes it's cold, sometimes it's hot. (Solveig)*

Another tradition that seems to persist is to use alcohol to keep warm:

> *We were cold, so my husband and I each had a whisky. It did the trick and warmed us right up. (Lotta)*

These long-standing configurations suggest that domestic warmth is not solely dependent on centralised heating but is actively shaped by householders through a combination of technical and behavioural adjustments.

Lost practices and crisis-induced reconfigurations of forgotten heating practices

Elderly people had rich memories to share from the era of wood and coal, including insights into practices no longer common today. One such practice involved children sharing a bed to maintain warmth. Other abandoned practices included placing newspapers inside shoes as insulation against the cold, a strategy employed during periods of scarcity or when shoes were intentionally purchased oversized to prolong their usability. Additionally, households installed extra glass panes in windows during winter months to enhance insulation. Newspapers were also rolled, soaked in water, dried, and subsequently utilised as slow-burning fuel:

> *We didn't throw away newspapers either. What we learned was that you'd dip them in water, roll them up into balls, let them dry, and then use them to make a fire. Not to light the wood, but to*

actually make the fire. It worked kind of like charcoal or gave off a cooking effect. It lasted longer, so to speak. (Alfred)

Periods of energy crisis, such as the oil crises of the 1970s and recent electricity price spikes due to the Ukraine war, prompt a reactivation of dormant heating practices. In response to the recent economic constraints, households said that they had started to engage in spatial reconfigurations by closing off unused rooms, concentrating heat in select living spaces. This was a common practice before the introduction of central heating but was then forgotten for a period.

But then we also closed the bedroom doors and focused on that, because the kitchen and living room were all in one big, open-plan room. So we tried to keep the heat in there. (Moa)

We closed off those two big rooms, so we kept the kitchen and two rooms warm, and the bedrooms were just a bit warm. (Helena)

Respondents also indicated that the rising cost of electricity had reactivated firewood heating, shifting its role from an aesthetic or supplementary function to a primary heating strategy. These reconfigurations illustrate how heating infrastructures are not fixed but fluid, shaped by economic realities and household decision-making:

Gunnel: Yes, we burn wood every evening, so I guess we're real environmental villains. But it's dry wood, you know. Interviewer: Is it mostly for warmth, or because it's nice? Gunnel: For warmth.

I tried to cut back a bit, partly because electricity was so expensive, but I didn't freeze. I did reduce my usage a little last winter, just like that. Yes. But now... it's gotten cheaper again, so next winter I will not increase the heating. No, instead I'll burn wood. Yes, I'll do that. (Astrid)

These practices highlight how households have an active role in configuring warmth rather than passively receiving it from external heating providers.

Conclusions

Rohracher has contributed significantly to the understanding of sociotechnical configurations, particularly in the context of sustainability

transitions and energy systems. His work emphasizes the intricate interplay between social and technical elements within these systems, highlighting the need for a holistic approach to analyse and manage them effectively (e.g. Rohracher, 2004). A significant portion of Rohracher's work focuses on the transformation of energy systems towards sustainability. He explores how sociotechnical configurations in energy systems can be restructured to support renewable energy technologies and distributed generation (Späth and Rohracher, 2010). This involves analysing the roles of various stakeholders, policy implications, and the potential for new governing models to facilitate this transition (Späth and Rohracher, 2012; Rohracher and Konrad, 2024, pre-print).

Rohracher identifies several challenges in managing sociotechnical transitions, such as the need for coordination among diverse stakeholders, the complexity of integrating new technologies, and the resistance from established systems. However, he also points out opportunities for innovation and the development of new sociotechnical configurations that can lead to more sustainable practices. In this spirit the configuration and reconfiguration of heating practices has been discussed.

This chapter highlights households' active roles in configuring heating systems and underscores the importance of understanding lived experiences within energy transitions. Consistent with earlier studies (Rohracher and Köhler, 2019; Rohracher et al., 2025; Wahlund and Palm, 2022), the findings affirm that households are not merely passive recipients of technological changes but actively shape the adoption and integration of sustainable heating technologies and practices. The results provide empirical support for Rohracher's (2008) conceptualisation of sustainability transitions as embedded sociotechnical processes, illustrating how everyday actors significantly influence these transitions.

This study expands upon earlier research emphasising sociotechnical configurations by focusing explicitly on households as central actors rather than broader system-wide transitions (Geels, 2004; Markard et al., 2012). Whereas prior studies have often prioritised macro-level technological shifts, such as transitions from wood to coal to oil and to biofuels, this chapter emphasises how individuals and families actively configure and reconfigure their heating practices. This shift aligns with recent scholarship advocating for more detailed and inclusive approaches to understanding sociotechnical change (Klitkou et al., 2022; Miörner et al., 2022).

The oral histories presented here confirm earlier research indicating that heating transitions involve more than technological shifts; they are deeply embedded within social practices, cultural norms, and everyday experiences (von Platten et al., 2025; Thomas et al., 2024). Consistent with Ambrose et al. (2024a), the findings highlight that householders lived experiences and personal narratives provide critical insights often overlooked by traditional techno-economic analyses. The oral history methodology effectively captured these rich, detailed narratives, uncovering persistent and evolving practices that shape energy use within the home.

The findings align with Goodchild et al. (2017) and Butler et al. (2014), who demonstrated the long-term impact of childhood heating experiences on present-day heating preferences and practices. Respondents in this study also revealed a continuity of certain practices, such as layered clothing, furniture arrangements near heat sources, and candle lighting, underscoring the persistent socio-cultural dimension of domestic warmth despite technological advancements. These enduring practices illustrate the importance of socio-cultural continuity in shaping heating behaviours and underline the limitations of purely technical approaches to energy transitions.

Additionally, the study found critical tensions between infrastructural efficiency and household autonomy, especially regarding central heating systems such as district heating. As highlighted by von Platten and Palm (2023), automated systems often reduce household interaction with heating infrastructure, fostering passive consumption patterns. However, households exhibited agency by developing compensatory practices, such as purchasing electric heaters, to regain control over their thermal comfort, reflecting the friction between imposed configurations and individual agency.

The reactivation of forgotten or dormant heating practices during crises, such as energy price spikes, further emphasises the adaptive and dynamic nature of household engagement with energy systems. Respondents described reconfiguring their spatial practices, such as heating fewer rooms or reviving firewood heating, demonstrating flexibility in adapting to economic pressures. These findings resonate with earlier literature, emphasising the fluidity and adaptability of sociotechnical configurations in response to changing external conditions (Heiberg et al., 2022; Miörner et al., 2022).

In summary, this chapter further existing research by centering households within sociotechnical configurations of heating practices. By utilising oral histories, it put light on the nuanced, lived realities of heating transitions, reinforcing the call for inclusive and socially embedded approaches to energy policy and practice (Ambrose et al., 2024b). Ultimately, this research emphasises the necessity of integrating household perspectives into broader discussions on sustainability transitions, moving beyond techno-economic frameworks toward an approach that fully acknowledges the complexity and diversity of household experiences and agency.

Acknowledgement

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Part 3

Harald as a PhD supervisor

Beyond the Horizon: A Collective Journey with Harald Rohracher

Amelia Mutter

Johan Niskanen

Nancy Brett

Darcy Parks

Anna Wallsten

Fredrik Envall

Prelude

What follows is a collection of stories and reflections written between a group of Harald's previous doctoral students. The six of us worked under Harald at The Department of Thematic Studies: Technology and Social Change during a period from 2012–2024 with various periods of overlap. Here are our letters:

Wednesday, February 12, 2025

Uppsala

Dear Johan,

 One of my most vivid memories from my time at Tema takes place in the office that Darcy and I shared. In my memory (and with all the artistic license time gives) it was late spring 2017 and we were sitting in our office drinking some contraband whisky. You, Darcy, and I were sitting side-by-side on the couch and Ivanche was sitting in one of the office chairs, feet propped up. I feel like we were waiting for someone or something and killing time until we could take our activities elsewhere. We were doing

our best to entertain ourselves by catching up on the latest gossip, but there wasn't much to share, so Ivanche started asking about Harald: "Is it weird that you all have the same supervisor? Like, who do you think is Harald's favorite?". To which you and I answered in unison "obviously it is Darcy", which cracked us all up. Not that Harald ever played favorites, but Darcy always seemed so on top of things.

I think, in fact, Harald would actually sometimes suggest I ask Darcy for advice on administrative or other matters. He would suggest I go to you sometimes as well, if he thought you could give better advice or information. I think this is one way he instilled a sense of mutual worth in his students and reinforced the fact that we were essentially equals in the academic ecosystem of the department. For me, this recognition of the intellectual value I brought to the department was essential for building confidence in my ideas and expertise, which was necessary to succeed in academia. I don't know if I gave off that impression, but I felt pretty out of my element when I first came to Tema. I remember sitting in STRIPE seminars (back when it was called TEVS) and feeling totally lost (ahem…probably at least partially due to my unwillingness to admit my Swedish wasn't up to snuff early on…). But Harald always helped me to find the value in my ideas and in sharing them with others. I also valued how he would share his own vulnerabilities and confusions (sometimes also in relation to trying to learn Swedish). These interactions have not only been important for my sense of my own worth, but also for the legacy they provide in the way I interact with my own students and colleagues: encouraging and emphasizing the important input each has regardless of their position or experience.

I have often reflected on how much your PhD supervisor can shape your research career. It feels like a bit of a draw in terms of what kind of supervisor you will get, at least in my case where I only met Harald once prior to being offered and accepting my PhD position. As such, I feel really lucky with how things turned out, because I think Harald was an excellent model of what it means to be a 'good researcher'. He taught me to stay curious and to choose research questions, settings, and theories that I was excited by. He taught me to be generous with my time by finding a way to give me all the support I needed no matter what else he had on his desk at the time. He taught me that research is about more than just writing papers; building a community with your students and colleagues is also important. In these ways, I think Harald modeled his values as an academic, colleague, and person. I view this modeling as very much in line

with how Harald is as a supervisor. In a sense he is low-key, radiating cheerful realism regardless of the challenges his students face.

This year I am essentially 10 years into my academic career (not sure how that happened), so I have worked about as long rather removed from Harald (at a different university, in a different subject and a different city) as supervised by him. This has given undoubtably given me the time and space to become a truly independent researcher, but I know I will always be shaped by his advice and his example and for that I am very grateful. I figure if we are as well liked, regarded, and respected when we turn 60 that would be something pretty special. Perhaps we can celebrate with a contraband whisky toast if we get there?

Hope you and your family are well and thriving!

Sending you all the best from snowy Uppsala,

Amelia

Tisdag, 19 januari, 1935

Östersjön

Kaptenens loggbok, 15 maj 1931

Eller ja, inget av det är sant – jag är ingen kapten, och känslan är att detta varken är skeppets eller resans första dag. Ändå är jag ensam ombord, och dessa ord är lika mycket en hälsning till dig, Nancy, som ett försök att hålla mig själv borta från galenskap. Igår var jag hamnsjåare vid Lunde varv; idag färdas jag med detta spökskepp, insvept i dimma, bort från skotten som föll, söderut längs Ångermanälvens breda fåra.

Kaptenens loggbok, 18 december 1931

I kaptenens hytt finns inget av värde förutom ett brev, adresserat till mig, från Amelia – ett brev fyllt av avlägsna men brännande frågor. Jag känner dess innehåll väl, och ändå utspelar det sig i en annan tid, långt från detta skepps långsamma färd. Ångorna från smuggelspriten känner inga gränser, varken i rum eller i tid.

Skeppet, förresten, är en brigg, härjad av seglatser från Kap till Hull. Se där – ännu en korsande tidslinje. Ingen syns vid rodret, ändå undviker vi alla grund och faror, glider majestätiskt, men nästan omärkligt, ut ur södra Norrland. Jag är ensam ombord – det är jag säker på. Och ändå fylls mässen dagligen med ny mat. Termosar märkta "Östgöta Kök" tycks föröka sig i tysthet.

Kaptenens loggbok, 19 juni 1932

Jag är inte ensam ombord.

Han presenterade sig som Herr H. Plötsligt stod han där på däck, motljuset dolde konturerna av hans ansikte. En inte särskilt stor man, med ett vänligt utseende – och något annat. En egenskap som, utan att vara hotfull, ändå tränger sig på.

Han talar engelska och förklarar att jag ska greppa pennan. "Skriv vad du ser". Han räcker mig penna och papper. "Vi ska tala mer längre fram".

Kaptenens loggbok, 3 januari 1933

Skeppet är plötsligt fullt av liv. Som om det befolkats ur tomma intet.

Idag visade jag min första text för Herr H. Han var inte nöjd. Jag ursäktade mig – engelska är inte mitt modersmål. Han avfärdade det argumentet, märkbart irriterad.

Fyra år senare, när vi slutligen anlöper vår destination, inser jag att det var enda gången under resan han visade det humöret.

Kaptenens loggbok, 25 augusti 1933

Nyfikenhet! Det är vad Herr H. utstrålar. Nej, något bortom det: nyfikenhet som strategi, som metod. Nyfikenhet som livsåskådning. Jag

såg det först när han rörde sig bland skeppsfolket – han vill veta allt. Häromdagen insåg jag mitt under vårt samtal att han talade svenska till mig. Man kommer mycket långt bara genom att vilja någonstans. Själv funderar jag mest över en annan gåta: Hur har vi färdats så här länge och ändå bara nått Gävle? Trettio mil på två-och-ett-halvt år. Vad än värre är – min text rör sig lika långsamt. Det bådar inte gott.

Kaptenens loggbok, 14 mars 1934

Det här är Herr H:s skepp nu. Det är han som styr.

Han påminner inte om männen vi växte upp med i Kramfors eller Newfoundland, Nancy. Inga nävar i bordet, inget gormande. Ändå följer alla. Kanske för att han inte vill leda, och just därför gör det. Eller för att han, i sin natur, förväntar sig mer av världen än den kan ge.

Kaptenens loggbok, 19 januari 1935

Min text är färdig. Jag söker upp Herr H. på däck och ger honom den. Det är bitande kallt i januarinatten.

Han studerar orden noggrant, tyst. Hans ansikte förblir oläsbart.

"Vad tycker du?" frågar jag.

Vi närmar oss land.

"Är det Stockholm?" frågar jag, medan jag inväntar hans dom.

Han ler knappt, och svarar lakoniskt: "Det är Norrköping. Det får duga".

Jag vet inte om han syftar på destinationen – eller min text.

Åh, Nancy!

Innan vi går i land river jag ut sidorna ur denna loggbok, stoppar dem i en butelj och kastar den i havet. Nu lever jag på hoppet. Hoppet att flaskposten når dig. Och att någon hämtar termosarna.

Johan

Wednesday, February 19, 2025

Linköping

Dearest Darcy,

Time, that relentless sculptor of memories, had carved deep valleys between our last correspondence, when suddenly, by one of those mysterious coincidences that seem to mock our belief in chance, I found myself in Balbec, that seaside town where the very air seems heavy with remembrances. It was there, among the weathered stones and whispers of the past, that I encountered a yellowed note from the 1930s – a decade whose very mention now sends tremors through our collective memory, like the distant rumble of approaching thunder.

The letter, penned by Johan, spoke of a journey and a figure who, even before I reached the telling passage, had already begun to materialize in my mind's eye with the inevitability of dawn. "Still, everyone follows. Maybe because he doesn't want to lead, and that's exactly why he does. Or because, by his very nature, he expects more from the world than it can give" – words that could only describe Harald, whose surname, like a complex glutenous Austrian pastry, has always resisted my tongue's attempts at proper pronunciation, yet whose reputation, like the scent of madeleines, requires no such formal introduction to evoke instant recognition.

My own first encounter with Harald unfolded like one of those small comedies that fate arranges to humble us: I had, with the casual certainty of the ignorant, declared him German, only to be met with what I now recognize as his characteristic response – that slight, knowing smile, like sunlight breaking through Viennese clouds, as he gently corrected my error with the word "Austrian." How strange it seems now, looking back through the telescope of time, that this moment of potential awkwardness (which we Canadians, forever mistaken for our southern neighbors, understand with particular poignancy) should have been the prelude to such profound connection.

For in Harald, I discovered what Johan too must have found: a mind like a vast European library, where every question led to unexplored wings of knowledge, and every conversation opened onto new vistas of understanding. His warmth, reminiscent of the golden afternoon light in

a Klimt painting, transformed what might have been mere academic guidance into something far more precious – a fellowship that sustained me, as it had Johan before me, through the uncertain territories of our respective journeys, those paths whose destinations remain forever unclear until, looking back, we realize we have already arrived.

Time, that great alchemist of memory, transforms even our most steadfast guides into something akin to the church steeple of Saint-Hilaire in Combray, seemed to follow one's progress through the town while remaining immutably fixed, its presence both constant and ever-shifting with each new angle of approach. So it was with Harald, whose guidance through the labyrinth of doctoral studies possessed that same quality of omnipresent mutability: one moment discoursing on the intricate mechanics of bicycles (those modern horses of steel and rubber that so fascinate the Austrian spirit), the next moment leading us through the winding paths of sociological theory with the same assured precision with which he navigated the great rail routes of Europe, each journey, whether physical or intellectual, illuminated by his encyclopedic knowledge that seemed to span the entirety of human endeavor.

Like those ethereal Nordic summer evenings, when the endless light of the Swedish sky strikes in such a way as to reveal previously unseen patterns – patterns that might have remained hidden in the deep shadows of winter darkness – Harald possessed the remarkable ability to cast new illumination on whatever subject caught his attention, transforming even the most mundane conversation into an opportunity for discovery. That he should have taken a chance on me, a non-traditional candidate for doctoral studies (though it was Harald himself who first taught me, with that characteristic mixture of gentle amusement and philosophical insight, that tradition in intellectual pursuit is merely an illusion we construct, as fluid and indefinable as the play of light on water), speaks to that particular quality of his character which, like the great mentors of history, could perceive potential in its nascent form, before it had fully articulated itself.

But it is his humor, that most elusive of qualities that has left the most indelible impression on those who know him well. How often have I witnessed him perform that most delicate of intellectual acrobatics: balancing on the knife-edge between cynicism and hope, his wry observations about the state of academia or the world at large somehow

managing to leave his listeners both clearsighted about reality's imperfections and yet somehow more optimistic about humanity's potential? This talent for illuminating the absurdities of existence while simultaneously suggesting their hidden possibilities seems to me now, in our present age of extremes and worrying times, more valuable than ever – a quality as rare and precious as those moments of pure understanding that occasionally grace our pursuit of knowledge.

Nancy

Friday, March 14, 2025

Linköping

Dear Anna,

When Nancy mentions her first encounter with Harald, it made me think of something that you and I have in common: our first encounters were not with Harald-my-supervisor, but rather Harald-my-colleague, before he became supervisor to either of us.

In my case, Harald and I were both new. Having just started at Tema T as a research assistant, I was part of the regulars in the fika room: a couple other research assistants, a new administrator, two teachers approaching their retirement...and Harald, the new professor. I got to know him as someone who always had time to chat, who was curious and keen to get to know our colleagues, the Swedish academic system, and Sweden in general. While many of us know Harald as a supervisor who gives constructive yet critical comments on our texts, I think everyone knows the Harald in the fika room who is happy to put 'business' aside for a while.

That being said, all of us writing this chapter know Harald-the-supervisor quite well. In my case, not only as a supervisor, but also as project manager for my postdoc. So, who is Harald-the-supervisor? One thing that I remember is being supervised without being told what to do. I had a PhD project whose description was loosely formulated, and even then, there was nothing he forced me to do; I also remember him suggesting theoretical ideas that could be interesting, without any requirement to use them. In both cases I think the route I chose fit quite well with the suggestions from Harald-the-supervisor, but I remember it as a route I

was allowed to choose on my own. This is something I will bring along with me in my career in academia.

Something else I will bring with me fits somewhere in between the fika room and the supervisor's role. Johan mentions curiosity as a method, and I would like to point out another of Harald's methods: relationships as a method. Here I don't mean the theoretical 'relational perspective' from his professor's installation lecture, but rather his approach to developing and maintaining relationships with those around him. For me, the clearest example was early in my PhD studies when we organized a week-long summer school with Wiebe Bijker as the main speaker. To prepare for the week, three of us—Harald, Jenny Palm and I—flew to Maastricht for a couple days to talk about the course content and get to know Wiebe. I distinctly remember a nice dinner at a French restaurant with Wiebe, his partner and the three of us. In the current world of Zoom meetings, it seems positively foreign to make such a trip in preparation for a summer school. But still it wouldn't surprise me to hear of Harald doing it again, given the strength and breadth of his relationships within various academic communities.

I would guess that it's partly because of his work with relationships that Harald is one of few foreign researchers to learn Swedish so well. He must be one of the few people with whom I don't have a 'default' language. We certainly started out speaking English, and did so throughout my PhD during one-on-one meetings. Usually when you meet someone in one language setting, it's hard to switch languages over time—I have the colleagues I speak English with, and the ones I speak Swedish with. Harald and I don't have many one-one-one meetings anymore now that we don't work so closely together, but sometimes we end up being the last ones in the fika room. When that happens, I don't think we switch languages; we just keep talking in the same language as before people left. It's a testament to the effort he spent learning Swedish, and it's especially uncommon for anyone moving to Sweden for a professorship. But it's quintessentially Harald, regardless of whether you're talking of Harald-the-fika-room-buddy, Harald-the-supportive-supervisor, or Harald-the-networker.

Back up to you in Uppsala!

Darcy

Thursday, March 20, 2025

Uppsala

Dear Fredrik,

I received a letter that awakened memories of a time long past. Darcy wrote to me, and his words pulled me back into our shared history—long conversations in the lunchroom, coffee breaks where discussions extended beyond academia. I remembered a trip with Darcy to Toruń in Poland, a ferry, a Spotify playlist. I recall reading your dissertation, where, in your preface to me, you wrote that our smart grid triad—you, Darcy, and I—was now complete. The details have faded, but the memories intertwine, forming a web that binds us together. And in the background, as present then as now, is Harald. Our supervisor. Our guide into academia.

Only later did I realize how unique the environment at Tema was, where equality and flat hierarchies were not just ideals but actively put into practice. Perhaps it was the interdisciplinary nature of the department that made heterogeneities so highly valued; there was always room for other perspectives. But above all, I believe it was the people who created that atmosphere, people who showed, in theory as well as in practice, what academia could be. One of them was Harald.

Like Darcy, I first got to know Harald as a colleague. I remember the quiet curiosity that spread when he arrived in Linköping, the new professor from Austria we all wondered about. Who was he? That curiosity soon turned into a sense of belonging. The first time he read my texts, I experienced that rare moment of genuine understanding. Where others saw confusion, he saw a unifying thread. He taught me how to create meaning. He helped me put my thoughts into words and to write with greater clarity. His comments were never mechanical or superficial; they could be critical, but they were always encouraging and marked by a genuine interest in the questions I struggled with. I remember the small wooden installation in the lunchroom window, the one that, in the shape of a bird, illustrated the PhD student's journey, from hesitant steps to confidence. Back then, stability felt at first distant, but Harald's guidance helped me find my footing.

Just as Darcy mentions, I was impressed by his remarkable progress in the Swedish language. I saw his effort to make himself understood in the language of this small northern country as a sign that he was here to stay, but also as part of his personality—a constant desire to learn and explore.

He taught me that academia is not just about analysis but also about relationships, responsibility, and care. I remember a trip to Umeå in snow and slush. We sat in the backseat, listening to practitioners share their experiences while driving through the streets of Umeå. Harald could easily have dominated the conversation, but he chose to listen. When he spoke, he chose their mother tongue, Swedish, over the language he was most fluent in—English—strengthening the impression that he wanted others to feel at ease. His humble approach is rare in academia, and something I try to follow.

Over the years, we have met at conferences and dissertation defenses, and each time, I am filled with the same warmth. Harald's voice and intellectual sharpness remain the same. He reminds us that what we do matters—that we must question what we take for granted, that academia has a responsibility. I sometimes find myself in conversations with people who, without knowing my academic background, refer to Harald's research, and I say with pride, *Harald, yes, he is great—he was my supervisor.*

What kind of person emerges from these memories? A supervisor who weaves people together, who sees connections where others see a lack of coherence. A researcher who demonstrates that academia is not merely about analyzing the world but also about actively engaging with it—about giving voice to those who are seldom heard and exposing the invisible forces that shape our present and future.

At a time when academic freedom is under threat in many places and the academic world can feel increasingly constrained, with shrinking space for slow, reflective reasoning, we must remind ourselves of the core essence of scholarly work and its vital role in society. I see the PhD years as a niche, a place where future researchers are shaped. A space, where supervisors like Harald are crucial for us to find our own voice and to be given the courage and tools to contribute to change.

With this letter, I hope that you, Fredrik, like me, are inspired to wander through the archives of memory. Memories are not just threads that tie us to the past; they are also material we can use for the future. Harald showed

us that science never arises in a vacuum. Research is not a solitary act but a relational practice, one that can become a web of care.

So let us continue this chain of correspondence and strengthen the web of relationships that Harald helped us initiate. And let us do so with the same intellectual curiosity, the same humility, and the same care that Harald taught us.

With warmth,
Anna

<div align="right">

Friday, March 21, 2025

Linköping

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Dearest Amelia,

Let me tell you a story. It will by necessity be short, as the empty backside of this otherwise fully scribbled note I happened upon is the only parchment available. Happened upon is misguiding, it seems to have found its way to me, addressed to me by my former Smart Grid Cave co-inhabitant, the fabulous Anna. She in turn seems to have been reached by a similar letter from Darcy, making this a chain letter of sorts. (Am I diving into the genre of chain letter writing now? Do I have to posit demands, lest a worm burrow deep into our work computers' hard drives and eat all our juiciest empirical material?)

Anyhow, as I began: let me tell you a story. Much like I suppose chain letter writing has its conventions, variations of threats including garden or digital worms and all, a story well told must also abide by the conventions of storytelling. The central ingredient in such a story is a great protagonist. Coincidentally, the content of Anna's text on the other side of this letter upon which I write to you, Amelia, seems to paint the picture of precisely a great protagonist – Harald. The major protagonist of all our shared Tema PhD stories, I dare say. There are other central components of storytelling, according to the conventions of said genre. There must be an obstacle to overcome for the protagonist – were we the obstacles to overcome for Harald? I strongly doubt he has ever felt so, but I myself often found it hard to shake that feeling during my PhD story.

Not that Harald ever said anything to that effect. Being the great protagonist of both mine and all our PhD stories, he rather instilled the opposite feeling – of being able to overcome any adversities the PhD story could throw at us. My doubts lingered rather because of my own constant straying afar of the PhD genre conventions, such as developing a clear argument and writing in a concise language. No matter our protagonist's kind-hearted (yet sometimes firm) attempts at pushing me towards such conventions, I continued walking astray countless times. This must have been frustrating for our protagonist, but he never showed any signs of such frustrations. At least not unless accompanied by a sly smile and words of encouragement. This is one of Harald's finest characteristics as a protagonist – his enormous patience.

There are several other important elements of storytelling, such as the point of no return (submitting our PhD theses to LiU Press? Harald's travel agency rubber stamping the details to arrange travel and accommodation for opponents and grading committees?). According to the grand repositories of the internet, story structures can in fact be divided into five key elements. But in keeping with my penchant for meandry writing I will not weave these into this letter. Instead, let us linger with some characteristics that make a great protagonist.

Because the moral of this story, dearest Amelia, is that becoming a great protagonist is something of a craft, or an art. Harald, this common protagonist of all the PhD stories in this chain of letters, seems to me to have mastered this craft. Let us now examine some traits which make a protagonist great, drawn from the example set by Harald. First, strive always to be generous. There has never been nor will ever be another protagonist as generous as Harald, and this generosity is one of our protagonist's most important powers. This generosity includes keeping an open door, always taking time out of busy days to discuss anything and everything, and extends to inviting students along for travels to exciting locations and people. Harald's generosity has greatly enriched our PhD stories, and I am certain also the path of anyone lucky enough to have their story, Ivory Tower or otherwise, intertwine with Harald's protagonist pathway. I would go so far as to say that generosity is the defining characteristic of our great protagonist.

For a protagonist to be great, Amelia, they must also be curious. Harald seems to possess a never-ending curiosity towards all facets of the world, always finding new angles to understand but never afraid to problematize.

His curiosity is equally extended towards his PhD students, keen to explore thoughts and listen to ideas. However, a protagonist must never shy away from challenging their allies. I remember during a discussion over a thesis chapter, Harald cracking a sly smile and telling me dryly "aiming to be more square when writing is probably a good target for you."

Finally, a great protagonist remains clear-sighted even in situations where everything seems to be crumbling down, be that the absurdities of our contemporary political landscape or the frail confidence of a PhD student. Speaking of eyesight, I almost forgot: a twinkle in the eye and tongue-in-cheek is vital for a great protagonist. Harald knows there is never a bad time for a good joke.

I vividly remember Harald telling me after the thesis defense that despite not being on the same wavelength from the start of the PhD story, we found each other and I grew to his heart. As you well know, dearest Amelia, Harald grew to all our hearts, as the major protagonist in our separate PhD stories and as a positive influence in the world surrounding him. If this does not constitute the resolution of a story, I cannot tell what does.

As for resolution as a storytelling element in general, this if anything is a convention that deserves to be frequently broken. Any story is always a limited cut of space and time, the world within the story will always move on after the particular story has been told. Beyond the PhD story I sincerely hope that all of us in this chain of letters will have the opportunity to write new stories with Harald, our protagonist, in whatever genre and shape they may come. Perhaps in the form of more chain letters.

Now, Amelia, please finish this chain of letters to appease the Gods of Convention (I assume such non-human entities watches from afar to safeguard any genre and its conventions, much like in *The Cabin in the Woods*). The safety of all our hard drives rests upon your shoulders.

Fredrik

PS. Look Harald, I found a red thread! ----------

Thursday, March 27, 2025

Uppsala

Dear Harald,

I cannot help feeling a poetic sense of symmetry writing you this letter today, which also happens to be exactly five years since I defended my thesis and became a Doctor in the hazy dawn of the Corona pandemic. That symmetry has imbued the experience of reading these letters with an extra sense of nostalgia from my side, as I reminisce on the good old days through the letters of your former doctoral students.

This chain has gone full circle now, and you have read the revolving door of thoughts of six of your previous doctoral students. Six of us who you have led from a stage of complete puzzlement to fully fledged research colleagues. You have taken part in our memories and our fantasies, and our impressions of you as a colleague, friend, and supervisor. These letters reflect our unique personalities, sometimes sentimental, sometimes a bit more tongue-in-cheek but always sincere in our appreciation and admiration of you.

Through this journey we have learned that you advocate (explicitly or implicitly) curiosity and relationship building as methods, encouraged us to seek knowledge from each other and within ourselves, and pursue our own paths. You have helped us to find our voices, our red threads, and our courage to contribute to change.

I hope in reading these letters you get a glimpse of the impact you have made on all of our research careers, and consequently our lives. All six of us remain in academia, a surprising coincidence suggesting we will also pay your lessons forward as we take on our own supervisory roles, or at least share your lessons with our friends and colleagues. As such, your legacy stretches far beyond the impact you have made on your doctoral students.

We will always hold you as the protagonist of our academic hearts and will do our best to use your lessons as our own driving force. To do what matters, even when it is hard. To work at the knife-edge between cynicism and hope. And to expect more of the world than it can give.

Warm wishes,

Amelia

A retrospective as a PhD-student: an introduction to academic life with Harald as supervisor

Stella Huang

Giorgi Kankia

Gavin Nilsson Lewis

Adam Svensson

Introduction

In this chapter, the PhD students Adam, Stella, Giorgi and Gavin give our stories of how the beginning phases of a PhD candidacy can look like and how our experiences have been shaped Harald as our supervisor. In this chapter, we give a personal perspective on how Harald has played a vital role as a guide to academic life and the PhD process. The focus is on our personal, but nonetheless shared, experiences of the first 1-2 years as a PhD student with Harald as either main or co-supervisor to our projects. We want to highlight what has stood out as inspiring moments in our supervision process, but also what makes Harald's supervision style unique.

Stella's perspective

Harald = A Walking Encyclopedia

A great PhD supervisor is not just a mentor but a walking encyclopedia of survival strategies, ensuring that their students go through the unpredictable episode of academia with resilience. Drawing from Nassim Taleb's insights on survival, I want to outline what makes Harald exceptional—one who doesn't just produce graduates but fosters scholars who grow in the very critical uncertain circumstances.

What impresses me most about Harald is how realistic he is. This reminds me of Taleb's idea that humans are often unaware of the existence of randomness (*cf.* his work *Fooled by Randomness*). Instead, they tend to impose order on chaos, explaining random outcomes as non-random. Although Taleb originally used this idea to highlight survivorship bias in financial markets—where we celebrate the few lucky winners while ignoring the many who failed—Harald applies the same principle to academia. He often reminds me that for every PhD student who finishes on time, there are many who do not, but their experiences are also valuable.

For example, when I get frustrated about my research not progressing as expected, Harald doesn't sugarcoat things. Instead of feeding me the comforting illusion that success follows a neat, linear path, he lays it out as it is—chaotic, messy, and at times, outright maddening. He reminds me that setbacks and failures — especially in the beginning — are not signs of incompetence but natural, even necessary, parts of the journey.

"Don't put too much stress on yourself, you've come so far," he often tells me. Simple words, yet profoundly encouraging. They make me feel as though persistence alone is an achievement, that just staying in the game is half the battle won. While many prefer to stay within their pink bubble, crafting a vision of academia where success is predictable and meritocratic, Harald presents the reality: progress in research is inherently uncertain, and survival—just continuing to push forward— plays a far greater role than most people realize.

This perspective has saved me from countless spirals of self-doubt. Instead of obsessing over *pumping out* papers just to chase some arbitrary publication count, I now recognize that quality is still valued in certain corners of academia. More importantly, I've learned to focus on what I'm truly good at—conducting thorough, thoughtful research and deeply understanding my field. After all, as Harald frequently reminds me, survival itself is not just an outcome but a virtue in academia.

The other thing that impresses me most about Harald is his effortless ability to handle heavy academic work while somehow making it entertaining — even laughable at times. While many academics take pride

in drowning their students in jargon and complexity, Harald has a rare talent for cutting through the noise, distilling difficult ideas into something clear, sometimes absurdly so.

While others chase the latest academic fads—whether it's the hottest AI model or the moon governance—Harald reminds me to focus on what truly matters: *my own intellectual curiosity. "Ask yourself,"* he once said with a smirk, *"who will read your paper? Probably only your supervisors and very few others"* A brutal truth, yet freeing in its own way. Instead of obsessing over chasing citations or impressing an imaginary audience, he urges me to ground my work in ideas that genuinely fascinate me. He pushes me to engage deeply with foundational theories, to build strong arguments backed by rich empirical evidence, and to craft research that is both rigorous and meaningful—especially in my field, where context matters more than fleeting trends.

Instead of pressuring me to churn out disposable, buzzword-laden papers, he encourages me toward work that has lasting relevance. In doing so, he doesn't just train me to be a researcher for today, but a thinker whose contributions will hold their value long after the latest academic hype has faded. With Harald, I've learned that true spirit isn't about being fashionable, it's about being *timeless*.

Another striking quality about Harald is his vast knowledge across a multitude of fields, like a walking encyclopedia, effortlessly drawing connections between unrelated areas of study. Whether we're discussing the latest advancements in social science, the implications of a new historical discovery, or even the intricacies of a cutting-edge algorithm, Harald always has something to say. It's not just that he knows a lot, it's how deeply versed he is in so many disciplines, blending them in ways that most human beings wouldn't even think to explore.

What I find particularly impressive is his ability to reference a wide range of books (yes, I am talking about his bookshelf) without ever seeming like he's showing off. He doesn't just quote famous thinkers or pull from textbooks—he distills vast bodies of knowledge into something applicable and relevant to my own work. I've lost count of the times he's linked STS perspectives to something happening in modern research or suggested an

unrelated historical event as a way to think about a present-day problem in my field. This cross-pollination of ideas has become one of the most enriching aspects of working with him, opening my mind to new perspectives and teaching me how to approach my research with a far broader toolkit.

Rather than limiting me to the narrow confines of my specific discipline, he encourages me to look outside, to explore, and to constantly make new connections. His breadth of knowledge ensures that every conversation is an opportunity to learn something new. Under his guidance, I've come to realize that the path forward isn't just about mastering one area, it's about being able to make connections in a wide variety of fields and integrating insights from them.

Giorgi's perspective

I met Harald on my very first day at the department when and have been impressed ever since – not only by his academic mentorship, but also by his sincere willingness to help and guide in every possible way.

I remember our brief chat in the fika room that day. "Have you already found an apartment and settled in the city?" he asked. Judging by his tone, I could tell that this was not just small talk but a genuine curiosity coming from someone I had just met minutes ago. During our conversation, he also mentioned an external course in the Just Transitions research school ha was coordinating, that could be relevant to my research, even though I was not part of the programme.

Later that day, I received a very detailed email from Harald with tips and instructions on navigating the local housing market. He suggested trying my luck with the guest researcher's apartment while looking for a place to settle. He also did not hesitate to put me in touch with the research school to inform them about my case.

Amid the inherent feeling of uncertainty and anxiety of moving to and settling in a new place, it was really comforting to meet someone as caring as Harald on my first day of the PhD journey. Indeed, the suggestions he made that day, have positively impacted both my research and life trajectory in Linköping. After over a year and a half of working with him,

my initial impressions of him as a humble and caring person have only been proven right.

Initially, I found it difficult to comprehend how someone could keep track of and most importantly, even care for seemingly tiny details, especially with so many work duties – from teaching to research, supervision, administrative tasks, and constant meetings – while still remaining composed. However, upon further reflection, it almost feels like a jedi practice in how Harald approaches his work with a calm, yet very proactive and cheerful perspective.

For a PhD student navigating various research-related challenges and uncertainties, it is reassuring to know there is a mentor and colleague who is knowledgeable about the dangers of falling into the dark side. At the same time, he is eager and capable enough to help you master the force – conduct proper research and keep your cool while doing it.

Gavin's perspective

Unlike Adam and Giorgi, I unexpectedly met Harald before I knew who he was, before I was familiar with his work, and even before I thought about pursuing a PhD myself!

He had come to my office in Stockholm, where I was working at the time, and I was spontaneously asked to present the project I was working on. I will not name this project, but let's just say it was *challenging* and I was not confident in myself or the work we had done so far.

Still, I did my best to walk through our scattered array of ideas and strategy for how *our* project was going to *radically transform cities and lead to systemic change!* Despite the many potential limitations in our work, Harald listened intently, smiled and made some jokes, and asked genuine and valuable follow-up questions. I realise it sounds chic, but I do remember thinking afterwards, *"this would be a great person to work with."*

And here we are now. I am a year and a half into my PhD, Harald is one of my advisors, and importantly, I am thoroughly enjoying the journey! At every stage of my work, I feel comfortable going to Harald for advice, to

discuss ideas, and brainstorm next steps. Just like on the first day we met, Harald continues to listen intently, smile and make jokes (which is essential for me!), and asks genuine and valuable follow-up questions.

I will admit, sometimes a single question from him will leave me momentarily speechless and completely rethinking my research. However, I am learning that this is an essential part of the process and that it will most likely happen again, for the better! I am grateful for Harald's honesty in offering such advice, and for his trust in us as PhD students to develop our ideas, engage with tensions and feedback, and shape our research in our own way.

To conclude, I do not know how Harald balances everything he does, but he does it with grace and a smile on his face. I think that is something we can all learn from that. While I am still in the early stages of my journey, I am incredibly happy that my initial instincts were right and that I made the jump to do a PhD at Linköping with Harald and Ida.

I am looking forward to what is to ahead!

Happy Birthday Harald!

Gavin

Adam's perspective

Before I had even first met Harald, his reputation had preceded him. I had learned of an accomplished professor who had made significant contributions to a field of literature I knew little about. I had also learned he was a kind person and a great supervisor, which had me feeling both lucky about getting to interview for this position and a bit unsure as to what expectations were involved.

All this being true, what really stands out about Harald is his joviality. That is not just to say he can crack a good joke whether it be in a meeting or during lunch, but that Harald brings a positivity into the room that feels genuine. I think just seeing the veteran researcher on the one hand putting in immense effort in his job, and on the other laughing and smiling his way through the day makes the PhD-learning process a lot easier to manage.

Writing can be daunting as any fellow PhD student knows, with your confidence going up and down as you move back and forth between grasping what you're doing and not. Harald´s positivity and relaxed approach has boosted my confidence, especially when I have felt the most lost. Despite him leaving it up to you to find your path through this academic jungle, you never feel alone as Harald is always there when you start questioning if what you're doing makes sense.

One afternoon I looked at my data and thought it does not make sense, it would need more coding to be meaningful, but at the same time I felt like I should be writing and that this coding process could go on forever. I did not really have a question, but I knocked on Harald's door, who opens and tells me that he is in a digital meeting.

Of course, I just say I will e-mail back with the question or a suggested time to talk, but Harald just asks me to share what I am struggling with. I ask him what I should do and get the immediate response that structuring codes is part of the process and writing takes time.

Now, this was not necessarily news to me and I likely would have decided on what to do myself, but when you're overthinking things, it is not clear how to decide on what to do in the moment. At that time some simple pointers were enough to get me back to progressing on my dissertation and I am sure Harald was very aware. I say this, because otherwise I have been encouraged to progress my work through my own ideas and to take plenty of time to consider what I want to contribute to. Much of this is still unanswered and I think if I did not have the first year to learn and throw ideas around, I would have fewer moments of inspiration and more moments of uncertainty, though I´m sure Harald would not hesitate to help.

Finished PhD students under Harald´s supervision

Linus Burgman Ekman. Between Waste and Resource Enacting Sewage Sludge as Useable Good

Anna Wallsten. Assembling the smart grid On the mobilization of imaginaries, users and materialities in a Swedish demonstration project

Darcy Parks. The Sustainable City Becomes Climate-Samrt. How Smart City Ideas Reshape Urban Environmental Governance

Nancy Brett. Swedish Biogas Markets Bridging Local Constraints and Global Priorities

Fredrik Envall. New networks of power on the emergence, diffusion and impact of alternative electricity system architectures

Kirsten Ulsrund. A strategy of South-South transfer of social and technology innovations

Doctoral Dissertations

Thomas Berger. Energy Poverty An Environmental Sociology Approach

Amelia Mutter. Competition and Complementarrity between renwable fuels - imaginaries of biogas and electric propulsion in Sweden

Ravi Jayaweera. Urban Sustainability Transition in the Global South Evidence from Cambodia

Steffen Wirth. Institutional analysis of technological innovation systems Teh case of biogas

Johan Niskanen. Mainstreaming passive houses. A study of energy efficient residential buildings in Sweden

Selected publications by Harald Rohracher

Karvonen, A., Bruggeman, D., Magnusson, D., Ornetzeder, M., & Rohracher, H. (2025). Heterogeneous energy infrastructures in Europe: layering and orchestrating Positive Energy Districts. *Sustainability Science*, 1-16.

Pereverza, K., Rohracher, H., & Kordas, O. (2025). Fostering Urban Climate Transition Through Innovative Governance Coordination. *Environmental Policy and Governance*, 1-16.

Rohracher, H., Velkova, J., Magnusson, D., & Farhangi, M. (2025). Re-assembling infrastructures from below. The agency of households in the sustainable energy transition. *Environmental Innovation and Societal Transitions*, *54*, 100943.

Farhangi, M., Rohracher, H., Magnusson, D., (2024). More than wires and screens: Assumptions about agency of devices in smart energy projects. *Energy Research & Social Science,* 114, 103592.

Wieczorek, A.J., Rohracher, H., Bauknecht, D., Kubeczko, K., Bolwig, S., Valkering, P., Belhomme, R., Maggiore, S. (2024) Citizen-led decentralised energy futures: Emerging rationales of energy system organisation. *Energy Research & Social Science* 113, 103557.

Rohracher, H., Ornetzeder, M. (2024) Navigating missions: Experiences from a long-term R&I programme to transform the building sector in Austria. In: *Science and Public Policy* 51(1), 2024, pp. 67–79.

Farhangi, M., Rohracher, H., Magnusson, D., Trygg, K., & Skill, K. (2023). Planning education and transformative capacity for climate-neutral cities. *Journal of Planning Education and Research*, 1-16.

Jayaweera, R., Rohracher, H., Becker, A., Nop, S., Waibel, M. (2023) Urban transition interventions in the Global South: Creating empowering environments in disempowering contexts? *Energy Research & Social Science* 106, 103312.

Envall, F., & Rohracher, H. (2023). Technopolitics of future-making: The ambiguous role of energy communities in shaping energy system change. *Environment and Planning E, 7*(2), 765-787.

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Tarasova, E., Rohracher, H., (2023). Marginalising household users in smart grids. *Technology in Society* 72, 102185.

Rohracher, H., Coenen, L., & Kordas, O. (2023). Mission incomplete: Layered practices of monitoring and evaluation in Swedish transformative innovation policy. *Science and Public Policy*, *50*(2), 336-349.

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