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Backcasting for sustainability: Introduction to the special issue

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ABSTRACT

In this introductory paper we introduce the special issue on "Backcasting for Sustainability". We present briefly a historical background, and position backcasting in the wider context of future studies, in which it can be related to "normative forecasting" and normative scenarios. We reflect on the diversity and variety of backcasting studies and experiments, as presented in the ten papers for this special issue. After summarizing the papers we formulate a future research agenda.

1. Introduction

Backcasting can be defined as "generating a desirable future, and then looking backwards from that future to the present in order to strategize and to plan how it could be achieved" [1,2]. It has gradually become more popular and more widely applied over the last decade. This is related to the rising popularity of the strongly normative concept of sustainability. As backcasting is about desirable futures—the futures we would like to get—it has a strongly normative nature too, and therefore it is especially well equipped to be applied to sustainability issues. Backcasting works through envisioning and analyzing sustainable futures and subsequently by developing agendas, strategies and pathways how to get there. This has attracted attention from policy-makers in many countries, as well as scientists outside foresight and sustainability studies. For instance, Giddens [3] has suggested backcasting as a sustainable alternative to traditional planning and considers backcasting a tool for moving toward alternative futures when dealing with climate change.

Although the history of backcasting studies goes back many decades, it is only recently that backcasting got more prominence among future studies and among sustainability studies. One of the aims of this special issue is to show the variety in backcasting studies, the geographic spread (Europe, USA, Australia, Japan), the variety in methods, and the issues addressed. The special issue also focuses on the relevance of current backcasting research for the broader discipline of foresight and forecasting as served by this Journal. Other aims are: to show the state of the art; to develop a research agenda based on the state of the art and on open questions; and to contribute to more interaction and collaboration with other foresight and forecasting research traditions.

Many of the papers in this special issue were first presented at the 2009 Sustainable Development Research Conference in Utrecht, Netherlands, in a conference track called "Forecasting and Backcasting". Three sessions were dedicated solely to new developments in backcasting. Even before the conference, the conveners of the backcasting track wrote a call for papers and announced the plan for this special issue. After the conference, a few more papers were invited that fitted well in this special issue. Unfortunately, several papers could not make it because of time constraints; the organizers hope that they will be published in a later stage. The papers presented in this special issue give a fairly accurate and up-to-date overview of the present state of this emergent field of research.

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2. Backcasting for Sustainability and its origin

Before backcasting emerged in the 1970s, exploring normative futures was known in the foresight and forecasting communities as normative forecasting [4,5]. It was for instance discussed in the very first issue of this Journal [5] and seen as one of multiple perspectives that can be applied to forecasting [6]. According to Jantsch [4] normative forecasting should be used for setting goals in technology development, as was for instance done in the Apollo Space programme. However, in the 1970s backcasting was developed as a new kind of normative future studies, growing out of discontent with regular energy forecasting that was based on trend extrapolation, an assumed ongoing increase in the energy demand and a disregard for renewable energy technologies and energy conservation. Early ground-breaking work on energy backcasting and soft energy paths took off especially in the USA (by Amory Lovins, e.g. [7]), Canada (by John Robinson, e.g. [8]) and Sweden [9,10], and focused on developing and comparing the feasibility of different normative future options and their policy implications.

The focus of backcasting was shifted towards sustainability [11] after in 1987 'Our Common Future' was published. In the 1990s participatory backcasting emerged [12–16], in particular in the Netherlands, Sweden and Canada; it was also applied for the first time in a major government policy program in the 1990s (the Dutch Sustainable Technological Development program, STD [17,18]. In this program, sustainability future visions were developed for key societal 'needs' like housing, transportation, food, and chemicals; and backcasting projects were set up to develop strategies to achieve those future visions. Also in the 1990s, more participatory backcasting projects have been carried out in a variety of domains, for instance for households (the SusHouse project [19,20]), climate policy [21], the hydrogen economy [22], for industrial coatings [23] and local or regional planning [16,24,25]. Most of those projects and programs were directly related to and inspired by sustainable development and sustainability. Each of these projects assumed implicitly or explicitly that a systemic societal transformation is necessary in order to achieve sustainability.

The concept of "sustainability" has of course been defined many times; and it is beyond the scope of this introduction to repeat and discuss those definitions. One of the salient characteristics of sustainability is that it is a systemic multidimensional concept that encompasses the environment, human well-being, equity, human development, and the economy; and that it is mostly conceptualized as a long-term societal goal or objective. In some cases it has been reduced and simplified to a quantitative target in order to create either more clarity or appeal; for instance in the factor 4 [26], factor 10 [27], or factor 20 [17,18]. These factors refer to the reduction of materials, energy, and waste per unit of need fulfillment that could or should be achieved in a sustainable society. In each of those cases the factor also refers to a *desirable* future to be achieved in the long term; and the importance of socio-economic aspects in sustainability is acknowledged (though not explicitly incorporated) in the eco-efficiency improvement target. These factors thus assume both technology development and social change. A typical time horizon used in many backcasting studies is 50 years. This time horizon is appealing because it is both realistic (it spans two generations, and thus everyone can imagine it as the time when our grandchildren are about our age); and it is far enough away to allow major changes and even disruptions in technologies, lifestyles, and even cultural norms and values (compare the world now with the world 50 years ago…..). A sustainable future can be envisioned on many scales, ranging from global to local. The power of those visions, in the sense of becoming guiding images to a range of stakeholders, and the many ways to achieve them, are described in various publications [28,29].

Visions are closely related to utopias, and also to dystopias, which are futures that we want to avoid [30]. Backcasting can be used to analyze to what extent such undesirable futures can be avoided [11]. This is not widely done, though it can be traced in the climate change scenarios of the IPCC. However, a major difference between visions and backcasting is that backcasting is not only about developing a vision, but also about developing strategies and pathways how to eventually achieve those visions.

3. Three classes of scenarios

The development of strategies and pathways to the future has been for a long time the subject of future studies, especially through the development of scenarios. Most scenarios are forward looking; they extrapolate from the present towards the future. Three classes of scenarios or futures can be distinguished, [6,31,32], answering to the questions: what *will* happen (trend extrapolations; business as usual scenarios); what *could* happen (forecasting; foresighting; strategic scenarios) and what *should* happen (normative scenarios like those used in backcasting). Normative scenarios are also called desirable futures, visions, or future visions.

The first class of trend extrapolating scenarios (what *will* happen?) is often called business as usual (BAU); in those scenarios it is assumed that no major changes occur, and that societies, technologies, and cultures develop according to a continuous path from the past towards the future. BAU scenarios do not take into account uncertainty and complexity, whereas the future is inherently uncertain, and society is inherently complex and ambiguous. Consequently, it is widely acknowledged that relevance of BAU scenarios is mostly for the short-term and for well-defined and rather stable systems. Though BAU scenarios can be useful to show what happens if no actions are undertaken (see for instance the BAU scenarios by the IPCC), many scholars [30] argue that BAU is not an option in present society, because of many reasons. One of them is that, looking backwards, societal development has never been without shocks and major transitions; and that great transitions are accelerating in modern times [30]. Another reason that is often mentioned is that present society is highly unsustainable and thus unstable; that the recent crises (financial, economic, ecological, equity, development; and nuclear arms) are only the manifestations of deeper structural and cultural unsustainabilities of present society.

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The present 'modern' society is characterized by a high level of technological development, high consumption levels and materialistic life styles in the global north; lack of equity within and between countries as well as ubiquitous poverty in both the global north and south; a fast and accelerating depletion of resources, pollution of the ecosphere including greenhouse gas emissions; and accelerated deterioration of the environment [33]. These crises are intensified by the present dominant economic system which does not recognize environmental boundaries; and by the dominant neoclassical economic paradigm which underpins and reinforces that economic system [34–36]. Under these conditions, it seems highly improbable, even for the short term, that society will develop according to a business as usual scenario.

The second class of future studies (what *could* happen?) finds its origin in the Shell scenarios of the 1970s and beyond. Shell has been the frontrunner in this type of scenario development [37–39]. It created a special unit of highly skilled and innovative scenario builders, and consulted around the globe to sample trends, expectations, cultural shifts, and other context variables. The strategic relevance of developing such context scenarios showing uncertainty by developing a range of possible futures was confirmed when Shell was much better prepared for the oil crisis in the 1970s than their competitors, which led to competitive advantage [40]. Shell's aim was to anticipate all kinds of unexpected developments; ranging from natural disasters to government interventions and economic crises. However, it did not always help: when the crisis around the Brent Spar took place in the 1990s [41], and around oil winning in Nigeria in the 2000s [42] Shell was highly surprised and unprepared. It had not foreseen these crises and the societal responses to them.

Shell's scenarios are not at all normative; they are contextual (to the company) and create a number of possible worlds in which Shell should still be able to operate profitably. This approach is essentially at the root of the bulk of the present scenario studies: by mapping trends and uncertainties quite different future "worlds" are created. The functions of those scenarios are manifold: most often they stimulate creative ("out of the box") thinking; and they try to anticipate the unforeseeable. They can also stimulate policy development, such as the IPCC scenarios seek to do for climate change.

At the present time the most influential forward-looking scenarios are the IPCC scenarios [43], which model what could happen to the climate as a consequence of greenhouse gas emissions to the atmosphere; and the Global Environmental Outlook (GEO) scenarios created by UNEP [44]. Forward looking scenarios sometimes have an impact on the present; for instance undesirable IPCC climate change scenarios have had impact on public opinion and policy makers, who have developed policies in order to mitigate undesirable outcomes. In that sense the IPCC scenarios have clearly certain "normative" characteristics, but the emphasis is currently still more on raising political awareness for instance, than on selecting and pursuing the most desirable scenario.

The third class of future studies is normative scenarios including backcasting scenarios (what *should* happen). Backcasting scenarios are also different because they better recognize the systemic nature of the challenges ahead, and often assume that systemic societal transitions are necessary in order to achieve desirable futures. In this sense they have some similarities with the more recent developments in "transition studies"[45–48]. Transition management with its underlying multi-level perspective seeks to develop a methodology, an approach, a toolkit, as well as policies and governance structures for purposeful societal transitions towards sustainability. In the past, similar multidimensional transitions have taken place in many societies, but more often than not they were not purposefully planned; they happened because of technological developments and related social change (examples include: the transition from sailing ship to steam ship [49]), government planning like the stimulation of natural gas extraction and use in the Netherlands [45]; or to react to societal developments such as the transition in public health and hygiene in the 19th century [47]. Just as in backcasting, transition management presupposes a desirable future, which is not quite clearly articulated, more as a vision than a blueprint; but clear enough to develop purposeful actions to achieve that.

The difference between backcasting and transition studies is that backcasting does not assume that the seeds of transitions are in socio-technical niches; it is agnostic about strategic niche management [50]. It only presupposes that desirable future visions, and pathways potentially leading towards such desirable futures, can be developed. In its essence backcasting is a reflexive and iterative methodology: it does not assume that a group of experts or a group of stakeholders can develop a finalized vision of the future, which then will act as an immovable utopia. Rather, it assumes that both vision development and pathway development encompass processes of higher order learning [16,51], in which participants learn not only about preferable futures and their contradictions, but also about the present, about each other, about barriers and incentives, about the change agents, and about how to improve the future vision to make it more appealing and resilient. In this sense, backcasting could be a never ending iterative process. Of course, in actual practice of time and budget limits, these iterations are often not realized in backcasting studies themselves. Moreover, a vision generated in a backcasting study can become a guiding image for actors and networks, who will subsequently influence and adopt the vision.

4. Variety and diversity in backcasting

A large variety and diversity in backcasting studies and backcasting methodologies can be found, which reflects that in different countries different backcasting traditions and practices have evolved. This diversity and richness should be seen as strength, though the implication is that in every new study terms, concepts and methods need to be defined properly. For instance, differences can be found in whether and how stakeholder involvement is organized, in the topics and the scales of the systems addressed, in the number of visions developed, and in the methods that are employed. In addition, sometimes the term backcasting is used for the entire methodology and sometimes just for the backcasting step in the methodology. In the subsequent section we will discuss several of these issues, as illustrated by the papers in this special issue.

One of the key questions in backcasting is: who develops the future vision? Can it be left to experts, or should it be a democratic or a deliberative process involving stakeholders and citizens? One of the major problems with vision development is that either

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experts or stakeholders have severe difficulties getting disengaged from the present. W. Ascher has called this "assumption drag" [6,52]. Experts are bound by their knowledge, which reflects by definition the knowledge and paradigms of today. Stakeholders represent present-day interests and values, and have great difficulties disengaging from them. In many backcasting experiments, researchers bring together experts or stakeholders, or both, in visioning workshops, and try to create situations in which they are encouraged to distance themselves from present societal constraints, without completely losing their present expertise and their experience. It is a balancing act between complete science fiction (which is sometimes useful but more often not) and being caught in present-day constraints. In that sense, the difference between vision development by experts or by lay people (often stakeholders of interested parties) is not that great. However, in actual practice it makes an enormous difference if future visions are developed by stakeholders, by lay people, or by experts. In this special issue on "Backcasting for Sustainability", we have ordered the papers somewhat (but not entirely) according to this criterion. Thus we start the issue with papers by John Robinson et al. [53] and Malcolm Eames et al. [54], who are both strong proponents of participatory or "second order" backcasting.

5. Papers in this special issue

The first paper by John Robinson et al. [53] makes a plea for what they call second-order backcasting, which is basically an elaborate form of participatory backcasting. Their work is characterized by an on-going process of tool development which allows participants to make choices in real time about desirable futures, and get nearly instantaneous feed-back about the consequences of their choices. As the authors state it, this is expected to yield "….participant buy-in and also broaden the scope from discrete goals to systemic development path changes." (p2). They also mention increased social learning. Their hypothesis is that by integrating participatory backcasting techniques, 3D visualization tools, criteria and indicators, and multi-stakeholder participation in a blend of qualitative and quantitative analysis, complex problems can be addressed in such a way that they permit participants to articulate viable course of action. Most of their backcasting work have been done in the Georgia Basin in British Columbia, Canada. Through six different project described in their paper, they gradually develop more sophisticated tools for visioning, path development, and interaction. For instance, in the South Okanegan Land Use Modeling Project they demonstrate the importance of lining multi-scale backcasting scenarios with well-structured community engagement processes. In another project, the Local Climate Change Visioning project, they demonstrate the ways in which partnerships can be forged between politicians, municipal staff, and scientists in order to better communicate the complexity of local climate change impact and response options, and stimulate locally-specific and integrated adaptation and mitigation options. In this project, through intense participation, the process led to visions which embodied local values and priorities. In another project (Circuits) the researchers demonstrate the impact of different social setting on scenario development. Scenarios were developed in a "clinical setting" and in a "socially warm setting" emphasizing dialogue, which led to quite different reactions by the workshop participants. This led to more insight in the conditions for full and meaningful participation in scenario-building and decision-making.

The authors identify five key themes emerging from their work. The first is intense stakeholder participation through sophisticated tool development. The second is the importance of process over outcome, and the importance of contextual elements in this process. The third is that this enhances the ability to explore highly complex and uncertain futures. Fourth is how this can be used to drive action and support decision making. Fifth key theme is the desired nature and quality of participation in backcasting. The authors also identify inherent tensions, for instance between their criteria of 'fun to use' and 'true to life', and how to connect the analysis to real world action. Another issue is the question of scale. The authors also point at the earlier mentioned key difference between backcasting from the preferred futures of participants vs. expert-driven visions of the future.

The next paper, by Malcolm Eames et al. [54], also describes a participatory backcasting process. Maybe even more than the previous paper, it claims that expert-led backcasting could lead to an "elite-led technocratic process". Instead, they advocate an inclusive bottom-up foresight process known as the "Community Foresight" methodology. They situate this methodology within the debate of moving citizens' participation and public engagement in technological innovation "upstream", meaning more towards the R&D and design phases. They also situate it within the environmental justice debate. Another interesting context is that the process they describe, SuScit or Citizens Science for Sustainability, is designed to contribute to the R&D agenda of the British Research Council, more specifically for a community-led agenda for urban sustainability research.

The paper describes a project in Mildmay, a socially and economically deprived urban area in Islington in North London. The aim of this project was both to develop a vision of a sustainable future, and a research agenda for the Research Council that would endorse this vision. Three groups participated: a Researchers' panel, a Practitioners' panel, and a Residents' panel. The latter was itself made up of three panels: a Young Peoples' panel, a Women and Lone Parents' panel, and an Older People's panel. One of the most appealing activities were the Community Film Projects, in which each of the panels were provided with the opportunity to make several short films exploring their own stories of living in their local community, and what the environment and sustainability mean to them. Based on these, the workshops explored communal sustainability future visions. Based on these visioning workshops, the practitioners and researchers panels drew up a research agenda, consisting of ten key themes, which were further developed iteratively with the community panels. In this way, more traditionally sustainability research agenda items like energy, housing, transport, recycling, and green space, were placed in the perspective of this socially and economically deprived area. For instance, issues like Crime and Safety, Urban Food Production and Consumption; and Community Cohesion did not feature prominently on the Research Council's research agenda.

The paper finally reflects on a number of aspects, and concludes that this and similar methodologies could empower and give a voice to lay citizens from marginalized and excluded communities. Great attention is necessary to reflexivity, social dynamics and power relationships; and the potential value of participatory film making and other visual and artistic tools. More open bottom-up

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foresight and dialogue processes could contribute to the inclusion of marginalized and excluded communities in visioning and in reflexive governance of science and technology.

The paper by Asa Svenfelt et al. [55] also describes a participatory backcasting process, this time through the use of focus groups. The aim is a reduction of energy use in residential housing in Sweden. According to the Swedish National Quality Objective, the total energy use per built area in the residential and commercial building stock should be reduced by 50%. The authors again follow a stepwise approach, in which the first step consists of a problem definition, and the establishment of system boundaries. In the second step the existing scenarios and forecasts were analyzed; from this step it became clear that reaching the goal by technical means is theoretically possible if all available technologies would be deployed; in practice this depends of course highly on human behavior. In the third step the researchers, with inputs from a reference group, developed scenarios of target-fulfilling future images: one more technological, in which the building sector was the driving force; and one which depends much more on behavioral changes by citizens-residents. These images were discussed in five focus groups, consisting of authorities, residents, users of commercial properties; builders/contractors; and property owners/managers. Each of those focus groups found the images not too challenging, and asked for more challenging scenarios. Interestingly, the authorities group had low expectations of residents' behavioral changes, and much higher confidence in technological solutions from the building sector. In contrast, residents had high expectations of their behavioral change, and low expectations from the building sector. The paper summarized a large number of measures that could be taken in order to achieve the objectives.

One of the outcomes of this research is that in order to achieve systemic changes more knowledge is necessary about potential change agents. The work also shows how to achieve collaboration and coordination among the various actors (this issue is addressed by the paper by Wangel [60]). Notably, most participants expected the other stakeholders to be key agents of change. Methodologically, this study claims that it put more emphasis on processes how to actually achieve future images than in previous Swedish studies, which put more emphasis on visions development. The authors conclude that collaboration and communication between stakeholders; and a concerted approach in which stakeholders and their potential activities are identified, are important.

The paper by Damien Giurco et al. [56] stands out by combining industrial ecology with backcasting. It develops three scenarios for the Latrobe valley in Australia: Bio-industry and renewables; Electricity from coal; and Products from coal. Each of those scenarios is based on a future vision of the Latrobe Valley with low CO_2 emissions and low water consumption, in combination with several other social, economic, and environmental sustainability criteria. The paper explains how Industrial Ecology, and more specifically regionally situated Industrial Symbiosis, in combination with an (industrial) cluster approach, can contribute to a different type of backcasting. Based on backcasting methodology and on Industrial Ecology the authors develop a 7-stage methodology: review of drivers, local contexts, and resources; identifying potential industrial ecology linkages as well as lessons for success and failure in IE projects; identification of core cluster elements; development of regional goals and scenario "themes" (alternative visions); scenario development, based on all elements from the earlier stages; stakeholder review and validation; and scenario sustainability assessment and transition pathways. For the Latrobe valley case study this results in three fairly detailed scenarios with a minimum of overlap, which embody industrial ecology aspects and life cycle approaches, and which fulfill the sustainability vision for the region. The authors view this methodology as 'iterative backcasting': they see it as a first step for a broader process of participatory second order backcasting, as advocated by Robinson. They also recommend that further research should include carbon property rights and water access rights as constraining factors.

The paper by Mattias Höjer et al. [57] develops scenarios for a low-energy future of Stockholm. The paper is mainly based on a forthcoming book [58]. Notably, it develops future visions based on three dimensions: a spatial dimension, a time-use dimension; and a technological dimension. In the dimension of spatial city planning, three visions are described: Urban Cores; Suburban Settlements; and Low-rise Settlements. Each of those visions could be implemented taking the present city development as a starting point; but obviously very different planning decisions would have to be taken to realize those visions. In the second dimension, two visions are developed: a high-tempo and a low-tempo lifestyle. The high-tempo lifestyle needs faster transportation and better connections, while the low-tempo lifestyle reflects a more localized lifestyle. The combination of these two dimensions creates some internal tensions, and the authors reflect on the issue of internal consistency in the scenarios. Each of the six resulting scenarios needs strong technological innovations, but different innovations are necessary depending on the specific scenario. The authors show that a 60% per capita energy reduction, which would be consistent with sustainability requirements, could be achieved by very different combinations of spatial, temporal, and technological visions. Their case study is an example of what they call target-oriented backcasting, in which the development of a future vision is more elaborate than the specific pathways how to get there.

The paper by Kaspar Kok et al. [59] combines explorative scenarios with backcasting, and addresses the possible long-term implementation of the European Union Water Framework Directive. A panel of European stakeholders convened in five workshops; they started with developing qualitative explorative scenarios through the "Story and Simulation" approach, by combining narrative stories with mathematical model results in an iterative procedure. A key element was starting from existing scenarios, in this case the GEO-4 scenarios. Another methodological element was derived from the Millennium Ecosystem Assessment approach. Through this approach, four narrative storylines were developed. Backcasting was then used in the form of concrete backward-looking analysis, looking back from the year 2050 storylines towards the present. Through a stepwise approach, stakeholders identified obstacles and opportunities; and milestones and interim objectives for each of the storylines; followed by the identification of political actions to be taken. Finally stakeholders identified robust strategies, i.e. combinations of milestones and actions that would be effective in each of the four scenarios. One of the results of this methodology is a list of 17 main factors that are relevant but different in each of the scenarios. In addition, 71 obstacles and opportunities were identified. Finally, a storyline is developed which is robust, i.e. it includes elements that are common in each of the four scenarios. The paper

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ends with the outcomes of a questionnaire in which the degree of satisfaction among the stakeholders with the process is measured. The authors conclude that the satisfaction was high, although there was some criticism on the backcasting part of the process. The development of scenario-independent outcomes was an important goal which has been reached through this process; main elements were awareness raising, implementing economic instruments (water pricing); and investing in technological innovations in a number of directions. However, the authors acknowledge that there is a gap between the list of robust elements and policy recommendations. There are also unresolved inconsistencies and even contradictions in the scenarios.

The paper by Kei Gomi et al. [60] could be best described as a quantitative backcasting study. The case under consideration is a low-climate scenario for the city of Kyoto in 2030. The starting point was an earlier developed vision for the city of Kyoto. The study focuses on roadmaps how to get there. For this, the authors develop a methodology of eight steps; four of them develop the desired goal, using the "Extended Snapshot" tool; the other four develop the roadmap. Together, they form the backcasting model (BCM) that consists of a system of low-carbon options and a transition path for implementation of these options in a given year. The Extended Snapshot Tool is a set of equations with exogenous variables and parameters that describe consistent values of socio-economic variables, energy demand, CO2 emissions, and low-carbon measures in a future sustainable society. To determine the implementation trajectories an option tree is constructed, after discussions with all stakeholders. This option tree consists of options, their years of implementation and completion; and their mutual dependencies. This model thus describes wide-ranging individual actions towards a low carbon society, including technology development and deployment, policies, economic instruments, education and public awareness building. The detailed construction of this action tree is an iterative process, in which stakeholders are compelled to consider long-term and detailed actions of government bodies, residents, and business. The paper present six roadmaps, each leading to the envisaged low-carbon city of 2030. The paper stipulates that it would be better to apply the methodology in an earlier stage of policy making, i.e. in the vision or "Action Plan" development. A more user-friendly version of this highly abstract modeling exercise is under construction.

The paper by Josefin Wangel [61] explores the ways in which recently published backcasting studies relate to social structures in society, including social objects of change, non-technical measures, and change agents. She makes the explicit claim that backcasting addresses the question "…how a certain target can be met when contemporary structures block the changes sought for…" (citing Börjeson et al. [32]). She creates a new categorization of participatory backcasting studies: target-oriented backcasting (*what* can change); pathway-oriented backcasting (*how* to change); action-oriented back casting (*who* could make change happen); and participation-oriented backcasting (to enhance *participation* and buy-in by stakeholders). She then investigates 21 papers and classifies them by making use of the new categorization scheme she developed. The majority of the investigated papers concentrate on either target-oriented or pathway-oriented backcasting, with also several concentrating on participation-oriented backcasting. Only a few papers concentrate on action- and actor-oriented backcasting, concentrating on the actors who might bring about change. In addition, most studies are based on existing social structures rather than questioning them. The author argues why "the social" should be included in backcasting studies.

The paper by Jaco Quist et al. [62] examines the impact of participatory backcasting studies five to ten years after their completion. Another aim of the paper is to develop a framework to encompass most of the variety found in backcasting studies. The paper focuses on three backcasting experiments that were conducted in the Netherlands in the second half of the 1990s. The backcasting studies take different perspectives to food and agriculture: multiple land use; meat replacements; and food in household settings. The underlying premise is that backcasting studies should not only focus on participation and buy-in by stakeholders, but also on implementation.

The impacts include networks that are involved in follow-up and spin-off activities in line with the visions, diffusion of visions to other societal domains and networks, orientation (where to go) and guidance (what to do) by visions and institutionalization (are there instances of embedding in existing practices and structures?). Backcasting experiments are analyzed in terms of participation, vision, learning by stakeholders and by the way backcasting has been applied. For three backcasting cases in the Netherlands from the food system (meat alternatives, sustainable food consumption by households and multiple land-use in rural areas) they conclude that they were all good examples of participatory backcasting leading to vision development, follow-up action agendas, and higher order learning, but that this is not sufficient to achieve follow-up and spin-off after five to ten years. The two cases on meat alternatives and multiple land-use led to significant follow-up, whereas this was not found in the sustainable household consumption case. By comparing the cases with and without impact a list of possible enabling and constraining factors has been identified and is discussed. The authors were not able to identify a single main factor, or to rank them; they argue that several factors may together lead to a constraining or enabling impact, but that should be further investigated. Finally, they also discuss relevance for system innovation theory, monitoring the impact of intervention instruments in general and governance of system innovations and transitions.

In summary, the backcasting studies compiled in this Special Issue address a range of topics, systems and scales. Several papers address geographically bound systems, such as sustainable cities or regions (Robinson et al. [53], Giurco et al. [56], Höjer et al. [57], and Gomi et al. [60]), but in very different ways. Robinson et al. develop a variety of tools enabling lay citizens to directly participate in vision development, with direct feedback from interactive models to show them the consequences of their choices in a constrained world. In contrast, Giurco uses industrial ecology to help develop visions of a sustainable Latrobe region in Australia. Höjer et al. and Gomi et al. both use externally defined future goals or targets to develop visions of future cities: Höjer et al. develop a combination of spatial and tempo-related future visions of Stockholm, while Gomi et al. develop a methodology for how policy interventions could help achieve a policy goal of greenhouse gas emission reduction in Kyoto. Other papers in this issue concentrate on other topics: Kok et al. [59] concentrate on visions that could help achieve the EU water framework directive; and Svenfelt et al. [55] concentrate on reaching emission reductions in housing. Quist et al. [62] concentrate on agriculture and food,

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through evaluating three different backcasting projects and their impact. Wangel [61] investigates the questions of social structure and agency in backcasting scenarios, for which she conducted a literature review.

Several papers propose innovative methodologies: Robinson et al. have developed a range of sophisticated tools, in which citizens interactively use models. Eames et al. develop innovative participatory methods, including film making, to engage local stakeholders in a visioning process; Gomi et al. develop a quantitative model which allows multiple runs in order to reach quantitative targets; Svenfelt et al. develop a focus group methodology to discuss multiple visions; while Giurco et al. incorporate industrial ecology concepts into backcasting. Kok et al. [59] combine explorative scenarios with backcasting scenarios, while also relating scenarios at different scales, which is quite innovative; in a certain way the former has also been pioneered by the scenarios by the Global Scenario Group [30]. Quist et al. [59] develop and use a method to evaluate the impact of participatory backcasting studies.

6. Towards a research agenda

The papers in this special issue on "Backcasting for Sustainability" present a rich overview of the present state of backcasting studies, methodologies, and results. By no means is this overview complete or exhaustive; we are aware that many important authors on backcasting are missing in the present collection of papers. For instance, the UK tradition in backcasting for energy [62,63] and transportation [64,65] is not represented. In addition, there is also the widely applied methodology of "The Natural Step", which uses backcasting too [14,15]. Still the contours of the future research agenda emerge. Below we briefly discuss it.

First, the rich diversity in backcasting cases, tools and practices, as well as in definitions and when and how the term backcasting is used, calls for follow-up efforts in comparing backcasting studies and practices across countries. Such comparative studies will lead to a better understanding of how backcasting can be applied in different settings, how different methods can be used in backcasting studies, and under what conditions what kind of results can be achieved. This special issue has started this, but more work is needed in order to improve the current and future backcasting practices.

A major issue is how backcasting studies relate to socio-technical transition studies [45,46,48,66]. In socio-technical transition studies, and especially in the Multi-Level Perspective (MLP), future visions are also used to orient transition processes. In contrast with backcasting, socio-technical transitions assume in their conceptual model that innovations occur in *niches*, which then may grow to destabilize the incumbent unsustainable socio-technical regime. It is worthwhile to explore further these differences; for instance, could the spin-off of backcasting experiments be conceptualized as niches, as has been argued by (one of) us [2]? Or, alternatively, because backcasting requires systemic changes in society, are such systemic changes too complicated to be pioneered in niches; and do they instead require coordinated action by many different stakeholders?

A third item for the research agenda is the emerging differences between participatory backcasting and expert-led backcasting. It appears from this special issue that expert-led backcasting is more often used to reach policy objectives (papers by Höjer, Gomi, Kok, et al.), while participatory backcasting is more used to achieve stakeholders' and lay-persons' buy-in (Robinson et al.; Eames et al.; Svenfelt et alt; Quist et al.). It would be worthwhile to investigate if these differences could and should be bridged, and how to overcome the tensions between expert-driven backcasting without apparently losing a lot of buy-in by stakeholders; and participatory backcasting which runs the risk of losing the deep policy objectives. A related issue is how to increase the impact and buy-in. Despite several examples reported by several authors in this special issue, it appears that buy-in does not automatically lead to implementation and inclusion in policy programs.

A fourth question is how higher order learning could become more deeply explored in the context of backcasting studies. As argued by us before [2,51], higher order learning occurs when participants in projects change their interpretive frame and/or problem definition as a result of interaction with other participants; or through feedback from the problem at hand. Both in the process of developing a future vision together with other stakeholders and in the process of developing pathways or strategies towards those future visions, higher order learning among participants may take place; it should take place if those visions and/or pathways and strategies are to be transformative. Otherwise backcasting would become another form of forecasting. Our hypothesis for further research is that mapping those higher order learning processes would give additional insights in how to bring about systemic change.

Next, a completely open question is the question of change agency as addressed by Wangel [60]. In the case of desirable or necessary systemic changes it is hard to imagine that individual actors could be change agents all by themselves; instead non-disruptive systemic change should be brought about by major coordination and cooperation between major stakeholders. This is a wide open field of research that has been explored in the abstract by system thinkers; and is tried out in actual practice by many change agents in society that aim to achieve systemic changes. As argued above, it is unclear how much can be expected by experimentation in niches [50], and by higher order learning processes that could accompany those experiments [51]. We are looking forward to the next special issue that addresses some of these questions.

Finally, an interesting question is asked by Linstone [68] with respect to the changing nature of technology itself. In the era of increasing possibilities of custom-made nanotech and biotech materials with highly specific characteristics, as well as genetic recombinations and self-assembly options, the new normative question is how to set "priorities in needs" in this vast array of possibilities. This question goes beyond the "backcasting for sustainability" question, and may lead to new tools and techniques, as well as to a reappraisal of Constructive Technology Assessment.

7. Uncited reference Q2

[67]

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