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Comparing sustainability transition labs across process, effects and impacts: Insights from Canada and Sweden

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ABSTRACT

Purposeful transformative change on a level of societal systems, structures and practices is called for in response to contemporary sustainability challenges. Sustainability transition labs and arenas represent a particular set of governance innovations seeking to foster systemic change based on deliberate engagement of multiple actors around complex issues of concern. Most labs aim for long-term contributions in addressing persistent societal challenges and transitioning into sustainability, yet are seldomly evaluated on whether, how and to what extents such contributions become realised in practice. In this paper, we further an analytical framework for comparatively analysing sustainability transition labs and arenas with emphasis on their processes, effects and impacts. The framework is applied on two cases: Energy Futures Lab initiated in Alberta, Canada and the arenas for a Fossil Independent West Sweden - Climate 2030. In particular, the comparison showcases how contextual difference in terms of urgency and turbulence may influence lab activities and how ownership and governance conditions may influence the various directions outputs, effects and wider impacts took. The comparison further illuminates how backcasting and the multi-level perspective may serve as complementary frameworks and tools in lab processes, whose respective role may depend on aspiration and context. We end the paper by providing a series of key considerations in furthering the comparative analytical framework and its application in practice. They orient around the three guiding questions on the why's, what's, and how's of doing comparative research on sustainability transition arenas and labs across their processes, effects and impacts.

1. Introduction

Purposeful transformative change on a level of societal systems, structures and practices are increasingly being called for in response to contemporary sustainability challenges [1,2]. Transformations and transitions represent journeys into the unknown where resulting futures are fundamentally different compared to what was before [3–5]. Due to their open-ended complexity, such change processes cannot be planned in traditional ways [6], requiring reflexive modes of governing that are learning-oriented, exploratory and experimental [7–9]. As no single actor holds full knowledge, mandate or control over how entire systems develop or should develop, such governance approaches benefit from bringing in a diversity of actors and perspectives with attention to e.g. dynamics of power, co-creation and ownership [10–13].

Sustainability transition arenas and labs (from here referred to as 'labs') represent a particular yet diverse set of governance innovation that focuses on deliberate engagement and participation of multiple actors around complex challenges, issues and questions of concern [14–18]. While most labs promise long-term contributions in addressing persistent sustainability challenges and supporting transitional change, it remains unclear to what extent such effects become realised in practice, including how to meaningfully capture the same [19–21]. In addition, important knowledge gains into the often-messy practices of navigating complex change processes risk remaining tacit among those doing it, or at best reported on a level of experience and lessons learnt.

In this paper, we aim to address challenges of capturing transition effects and learning by furthering knowledge on how complex systems change can be purposefully navigated via labs. We seek to do this by (i) furthering and adapting an analytical framework to capture contribution to transitions and (ii) applying (parts of) it on two cases for comparison and analysis across their respective processes, effects and impacts, and finally (iii) reflecting and reasoning upon observed similarities and differences to generate insights of those directly involved in 'doing' labs in various contexts. These three aspirations are summarised

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in the following research questions:

(1) How can sustainability transition labs be compared across their processes, effects and impacts?
(2) What insights on the practice of sustainability transition labs and their associated evaluation may emerge from such comparison?

We base the paper on engagement with two concrete cases: the Energy Futures Lab (EFL) initiated in Alberta, Canada and the arenas for a Fossil Independent West Sweden – Climate 2030 (C2030). The study thus resembles a literary replication [22] where cases show similarity in setting but play out in different contexts: they both seek to navigate transitions in their respective regional context, thematically address climate-energy challenges, engage multiple stakeholders and work with backcasting and socio-technical systems change guided by the multi-level perspective on transitions [23,24].

Comparative research into efforts that seek to navigate transitions in practice is commonly pointed out as an important avenue to generate meaningful knowledge, not least in distinguishing the studied processes from their surrounding contexts. In his work on transformation governance as systemic practice, Ison [25] notes that an "explosion of social change, whole system change and innovation labs…" call for a "…cross-fertilization of experiences, especially in terms of effecting systemic transformations of human-environment relations" (p. 9). In a review on experimentation in sustainability transitions, Sengers et al. [26] point towards the value of cross-case learning by going deeper into micro-cases and broader in comparison to identify critical success- and failure factors (including governance and policy conditions). They put primary emphasis on such research to support in better understanding similarities and differences between various experiments' transition pathways and possible relations across contexts. Such research interests are also reflected in the recent sustainability transitions research network agenda [27] where "the increasing wealth of case materials creates demands and opportunities for methodological approaches that reach for generic insights across cases" (p. 8).

The paper is organized around a meta-reflection on the three questions of "why compare?", "what to compare?", and "how to compare". On top of contributing an empirical comparison on transition labs, we thus intend to make a methodological contribution. Here, empirical insights and experience from doing the comparison as such are used as a springboard for theoretical and practical reflection. This reflection seeks to generate insights of relevance for further (comparative) research on effects of labs as well as for those involved in 'doing' sustainability transition labs in practice.

2. The why and the what of comparing sustainability transition labs

Sustainability transition labs and arenas can be understood as a particular form of governance experiment or as an organizing entity that in turn host a bundle of experiments [16,17,28]. While sustainability-oriented labs vary in shape and form, they can in common be viewed as organizing entities that foster exploratory spaces and processes, facilitating experimentation and learning with a normative orientation [29]. Transition-oriented labs tend to combine systems analysis, futures visioning and purposeful experimentation in efforts to challenge the status quo, explore alternatives, empower frontrunners and mobilising resources as well as larger actor-networks [7,8,30]. Such work may include exploring ongoing transition dynamics in search for strategic 'acupuncture' interventions that may induce, guide, and accelerate transitions into sustainable and desirable pathways [12].

2.1. Sustainability transition labs and comparative research - the 'why'

While there is a general call for comparative case-based studies within sustainability transformations and transition circles,[1] several contributions have already been made in such directions (see for example [30,33–38]). Based on the studies outlined in [30,33–38], we identify that choice of multi-case research designs are mainly motivated as (i) capturing variety in how some design or practice play out in different contexts and circumstances, (ii) providing additional methodological, empirical, analytical rigour and robustness in contrast to single case study and (iii) opportunistic in the sense that researchers are involved in or have experience from particular cases deemed worthy of comparison. Methodological approaches and analytical frames show diversity across studies, ranging from intrinsic to instrumental case studies, with or without explicit analytical framework and research design. Knowledge claims from multiple case studies tend to be oriented towards audiences of research, practice, and policy. Studies that focus on experience-sharing, insights and lessons learned from concrete involvement in cases tend to focus on practical insights and establishing questions for further research. More analytically-oriented work showcase additional care for methods and analytical grounding of knowledge claims. In addition of engaging with comparative research as an attempt to generate knowledge on a level of comparative findings, we also note that important reasons for cross-case designs may be their empowering function across researchers and practitioners to access experiences of others and extend their own.

We do, however, note some general tendencies and issues in studies made. First, sharing knowledge and experience on a level of lessons learnt and best practice neglects important contextual considerations including the situated nature of practical and tacit knowledge. Second, comparison with sole emphasis on similarity and difference in process tends to assume a transformative potential on a level of aspiration and intent, without empirical backing of actual effects. In the same way, focus on assessing and comparing effects from various labs risk overlooking the processes generating those effects which make knowledge transfer on a level of practice less meaningful. Thirdly, there seems to remain a general tendency towards outlining 'ideal-type' processes by positioning ready-made designs and toolkits that tend to overlook the contextual contingency of lab design and practice.

Recent developments in sustainability-transitions and related research communities position evaluation frameworks as key for guiding further systematic evaluation attempts to (1) further ground, deepen and support in cumulating knowledge gains across cases, with the addition that they also tend to seek comprehensiveness asking for research that (2) look into potential, possible and eventual effects and impacts in relation to intended and actual process, where cross-case comparison may particularly support in isolating out contextual factors [19,21,27,39–41]. Below, we further elaborate on one such framework which we adapt to this particular study.

[1] We note that transition research is primarily engaging with socio-technical and -institutional systems and change, whereas transformation research puts emphasis on socio-ecological or human-environment relationships as primary object of focus [13,31,32]. It may be further understood that a series of delineated system transitions may result in wider societal transformations. In this paper we use the terms interchangeably as we orient towards any deliberate efforts to purposefully induce, guide or accelerate systemic change in society in response to some complex challenge or question of concern.

2.2. Analytical frameworks and framing - the 'what'

In this paper, we move forward with Williams and Robinson's [21] three-part evaluation framework for evaluating transformative attributes of sustainability transition experiments such as labs. The framework includes the three categories of process, societal effects, and sustainability transition impact as follows:

- Process – fairness and inclusivity of the process, the quality and appropriateness of the tools and methodologies used, and the adaptive and reflexive capacity of the process.
- Societal effects – short term outputs and medium term or outcomes of the process such as individual capacity development, networks and relationships, and institutional (policy or organizational) changes.
- Sustainability transition impacts – longer term impacts that reflect societal transition such as changes in socio-technical systems and governance, interlinking regime rules and behaviours, reinforcement at multiple levels, changing relationships in actors and practice, and (more) sustainable socio-ecological systems.

The framework uses a development pathway approach [42] to capture sustainability transition impacts which allows inclusion of external context shifts and impacts in multiple domains. A development pathway approach allows us to organize elements of sustainability transition impacts into a coherent framework that highlights the interrelationships between levels of scales in systems transition and foregrounds the role of changes in governance roles and relationships and the role of politics in transitions. The distinction between effects (short and medium term) and impacts (long term) is important to note as changes in sustainable systems often take place over longer time periods than short term labs projects. The categories within each level (process, effects, impacts) with associated elements thus point towards central elements that are involved in transitional/transformational change to sustainability [43]. The categories are presented in detail and exemplified in Table 1.

3. Methodology and methods - the 'how'

Below we present the methodological approach taken in this study, guided by the research aim of capturing effects and learning in sustainability transition labs. We do this by adapting an analytical framework, apply it comparatively on two cases and use observed similarities and differences as a springboard for theoretical and practical reflection related to ongoing debates in research on experimental governance for sustainability transformations and transitions. As already outlined in the introduction of this paper, these research aims were sought to be captured in the two research questions of:

(1) How can sustainability transition labs be compared across their processes, effects and impacts?
(2) What insights on the practice of sustainability transition labs and their associated evaluation may emerge from such comparison?

3.1. Research setting, design and analytical framework

Two sustainability transition labs: EFL and C2030 were studied to illustrate and reflect upon the application of the analytical framework for comparing and analysing process, effects and transition impacts. According to Bryman [44], comparative research designs "allow the distinguishing characteristics of two or more cases act as a springboard for theoretical reflections about contrasting findings" (p. 75). This study thus seeks to generate results on two levels, as is common in cross-case research [45,46]: (i) analytically-oriented knowledge resulting from the actual empirical case comparison and analysis, and (ii) reflective-oriented knowledge emerging from the experience of being involved

Table 1
Overview of process, societal effects and sustainability transition impact categories and elements (For further detail see Williams & Robinson, 2020 and Williams, 2019).

1 Process categories	2 Societal effects categories:	3 Sustainability transition impacts and development pathways
1.1 Inputs (capacity of the project designers and facilitators, the level of in-kind and financial support available, funding levels and sources, and motivations of project participants)	2.1 Individual capacity (e.g. Development of problem solving, complex systems thinking, dialogue and reflexivity capacities in participants; New forms of knowledge, values, and social relations)	Socio-technical systems and governance 3.1 Governance role and relationships (e.g. *Changes in practices of participation and new forms of participation in governance)*
1.2 External context (political context, socio-economic factors)	2.2 Usable products (e.g. new technologies, action plans, reports)	3.2 Reduced barriers to transition (e.g. *Reduction in incumbent actors actions to resist, delay or derail low-carbon transitions)*
1.3 Enabling conditions (fairness, inclusivity, transparency)	2.3 Networks and Relationships (e.g. new and strengthened relationships and networks)	Interlinking Regime rules and behaviours 3.3 Justice Distribution of benefits and costs of transition is equitable, stakeholders are meaningfully engaged in transition governance, and historical (and current) marginalization of peoples has been reduced
1.4 Methods (iterative, reflexivity, dialogue, negotiation, collective problem solving)	2.4 Institutional change – Policy (e.g. new or changed policy instruments, new actors part of policy deliberations)	3.4 Changes in regime practices Regime routines or socio-cultural landscape norms (as embodied by materials, competencies and meanings) that "normalize" sustainability are embedded within institutions and cultures
1.5 Supporting transition (niche-regime interaction, aligning innovations, experimentation and learning, conceptualizing sustainability)	2.5 Institutional change – Organizational (e.g. new organizational forms, changes in investment strategies)	Reinforced at multiple levels 3.5 Niche-Landscape Alignment *Niche innovations developed in STE aligned with broader social, political and cultural trends supporting sustainability*
1.6 Scope	2.6 Climate/Energy/ (Sustainability) (e.g. Observed or projected reduced energy demand, increased renewable energy supply, increases in energy efficiency, reduction in GHG emissions)	3.6 Multi-level *Observed cross-scale changes and reinforcing links (e.g. national policy supporting regional niche innovation)*
1.7 Governance (stakeholder capacities, power relations, engaging future and non-human actors, recognition)		Actors & practices 3.7 Actor roles and relationships Shifts in actor (individual and organizational) roles and relationships 3.8 Changes in collective practices Embedding of low carbon or sustainable behaviours in collectives (networks, organizations, societies)
		Social & Ecological systems

(*continued on next page*)

Table 1 (*continued*)

1 Process categories	2 Societal effects categories:	3 Sustainability transition impacts and development pathways
		3.9 Multi-dimensional (contingent 2.6) *e.g.* Viability and integrity of the atmosphere, biosphere, hydrosphere and cryosphere; Meeting SDG goals; Climate change impacts e.g. GHG reduction, integrating climate policy with broader sustainability goals relating to economics, social dimensions, technology, and environment

in the cases and doing the comparison as such.

As mentioned in the introduction of this paper, the case selection comes from an identified similarity in setting between C2030 and EFL that in turn operated in different contexts. These conditions provided a possibility of exploring how the respective lab unfolded in their respective context, where similarity and difference in process, effect and impact as well as context may spark valuable dialogue and further insights on lab research and practice. The choice of cases is also opportune in the sense that the authors of this paper have been directly involved in researching and evaluating the respective cases used, using similar frameworks for data collection with similar research aims. Both cases have been reported separately elsewhere [43,47–49] in papers led by the co-authors, which is why in-depth accounts into each particular case are sparse in this paper to instead leave space to present comparative findings and reflections. This is a general strategy taken in multi case research where comparative findings are at the forefront [46]. It is also stressed that making connections across cases not only may lead to additional knowledge emerging from the cases in combination, but also augment or challenge existing knowledge and experience on each respective case that may be viewed in new light [45].

To approach the comparison in a systematic manner, the analytical framework presented in Section 2.2 was used as a starting point (in line with RQ1). The framework guided data collection, structuring, comparison, analysis and reflection across categories and elements related to (i) process, (ii) effects and (iii) impacts. The choice of this framework was due to it being (a) comprehensive, covering multiple relevant dimensions of evaluation; (b) strongly rooted in the theoretical literature, and provides a clear theoretical rationale for the evaluation categories we propose; (c) was developed and tested in multiple case studies; and (d) provides a systematic attempt to conceptualize longer term sustainability impacts, and integrate that into an evaluation framework.

Rather than comparing both cases across all categories and elements as would typically be an objective for an in-depth single case study (or even as part of a larger research programme or PhD dissertation [43], a sub-set of analytical categories were chosen deemed worthy of comparison (Cf. [46], in line with RQ2). In this paper, categories were chosen based on a screening of both cases across all categories in the analytical framework. Categories were selected where interesting similarities and differences could be observed as a basis for further analysis. Again we note that the main goal of our paper is to illustrate cross-case comparison methods rather than replicate the deep case study work that has already been completed on each case.

3.2. Data and analysis procedure

In gathering data, we built upon pre-existing data sets separately gathered for each case. As the cases represent complex processes in authentic social settings, it is generally recommended to rely on multiple sources of data to build an as accurate understanding of the cases as possible [22]. While EFL had pre-existing data from participant and design team surveys and interviews, internal planning documents, and workshop observation on process, effect and sustainability transition impacts following ref. [21],[2] C2030 builds on a data-set on process, effects and societal impact based on Walter et al. [41] and Wiek et al. [39]. All data items used were initially gathered to capture participants' perspectives, potential added value and effects from the processes studied, which aligns well with the aim of this particular study. The C2030 dataset was complemented with additional data oriented towards transition impacts in line with the elements of the evaluation framework.

Data items include process-related documents such as facilitation plans and meeting protocols, evaluation surveys, participant interviews and observation, design- and process team interviews and external documents such as debate articles and news articles. A full account of all data items is presented in Appendix A. These data items had previously been thematically analysed to capture process, effects and possible impacts as reported separately in the sources.

For the case of C2030 indications of potential impact primarily relied on a scanning of debate and news articles as well as semi-structured interviews with those responsible for designing and facilitating the process and its follow-up activities. Statements and observations that corresponded with the elements of interest in the comparison were then selected, described and compared. Along those lines, we set up three primary steps in conducting the comparative analysis (RQ1), seeking to provide analytical width as well as depth while opening up for reflective insights (RQ2):

1. Analytical width: Organizing data across cases according to (selected) categories of analytical framework, followed by comparison of similarity and difference (reported in the comparative results section)
2. Analytical depth: Deepening inquiry into explanation and implication of the observed similarity and difference across cases and context, related to transitions research (reported in the discussion section)
3. Reflective insights: Sharing experiences on doing the comparison and connecting back to the organizing questions providing perspectives on “why compare”, “what to compare” and “how to compare” (part of the conclusion section)

4. Introduction to cases

4.1. The energy futures lab in Alberta, Canada

The EFL was a multi-stakeholder process in Alberta, Canada (Phase 12,014–2018) comprised of participants from across the energy system who participated in a collaborative 5-year leadership development and rapid prototyping program designed to answer the question “how can Alberta's leadership position in today's energy system serve as a platform for the energy system the future requires of us?” [50]. The EFL consisted of over 60 energy system leaders (known as Fellows) coming from oil and gas companies, renewable energy firms, municipal, provincial and federal government agencies, academics, First Nations and NGOs. Convening partners of the EFL were the Natural Step Canada (TNSC), the Suncor Energy Foundation (SEF) (funded by one of Canada's largest oil companies), the Pembina Institute (an environmental NGO), the Banff Centre (leadership and development organization), and the Government of Alberta. The majority of the funding for EFL came from SEF. The EFL

[2] A complete list of data sources consulted may be found in Williams, 2019 Appendices A-H (pp. 364–406)

was designed and facilitated by a core design team largely made up of TNSC staff and consultants. The design team was supported by an Advisory Council and Steering Committee. The Steering Committee was a group of senior influencers in the Alberta energy system and served a largely hands-off role. The Advisory Council was a smaller group of energy system leaders and played a more hands-on role. The Advisory Council provided feedback to the Design Team on EFL design and received regular updates from the team on progress. Partners also played a role in shaping the EFL design.

The EFL design and process framework emerged from The Natural Step Canadas' experience with backcasting [51] and their desire to engage with sustainability principles along with design and facilitation techniques to systems transitions challenges. Backcasting is an approach to the future where one starts from articulating a desired future state followed by an analysis of how it might be achieved [52].

The EFL set out to achieve their goal of energy system transition through three streams of activity. The first was a cohort of Fellows that met for 2–3 day long workshops 3–4 times per year. These workshops were organized around different methods and tools or themes such as prototyping, backcasting, and initiative development. Primary outputs of the Fellowship cohort were a co-produced vision of the future Alberta energy system and a portfolio of initiatives organized around a set of innovation pathways. Initiatives ranged from highly technical such as new uses for carbon materials, new collaborations such as that between an organization re-training oilsands workers in renewable skills and First Nations communities, and policy-focused such as consultation on government renewable technology roadmaps. The second stream was an organizational engagement process that conducted workshops inside participant organizations such as Suncor and the National Energy Board delivering customized versions of EFL content. The final stream was public engagement that connects EFL to the public through media, events and public workshops.

4.2. Fossil-independent West Sweden arenas (Climate 2030)

Fossil-independent West Sweden was a regional policy process (2014–2016) that involved over 100 stakeholders from various societal sectors to outline strategic areas with leverage for transitioning into a sustainable, desirable low-carbon region aligned with the goal of *"ensuring a good life for all region's inhabitants in a fossil-independent region by 2030"* [53]. The process had joint ownership between the Regional Council and the County Administrative Board with a design- and process team consisting of civil servants, researchers (as a form of trans-disciplinary co-design) and an external facilitator. This process resulted in a politically adopted climate strategy 'Climate 2030'.The methodology used in giving shape of Climate 2030 took inspiration from the backcasting approach used at Challenge Lab at Chalmers University of Technology in Gothenburg [54] that had also recently been used in forming a strategic innovation and research agenda 'Transport 2050' issued by the Swedish Innovation Agency [55].

The most intense phase of the process engaged 100 stakeholders in five parallel thematic 'arenas' of (A) energy systems, (B) consumption of goods and services, (C) live work travel (mobility, housing), (D) bio-innovation and green chemistry, (E) infrastructure (cross-cutting). Each thematic area had 2 or 3 half-day sessions over a period of six months, preceded and followed by ongoing analysis work. Participating stakeholders came from the public and private sector, academia and civil society, identified as having innovative, transformative and reinforcive power (cf. [56]). These arenas were methodologically guided by an adapted version of the backcasting steps outlined by Holmberg [57] and Holmberg and Robèrt [51] organized via various formats including dialogue, world café, brainstorming, intense work in smaller groups guided by various frameworks and group reflection. In addition to these arenas, the process encompassed dialogue workshops with youth representatives, continuous anchoring with all 49 municipalities in the region via 5 local federations, internal connection to e.g. the Regional Development Strategy, analysis work performed by a small group of experts, and external communication efforts.

The process resulted in 80 areas of interventions where there was assumed mandate to act and emission reduction potential, categorized into 12 broader prioritized efforts within 4 focus areas (transport, food, products and services, housing) that together with a suggested "four ways of working" (we come back to this in the effect comparison) forming the core of the 2030 Climate Strategy – West Sweden in transition [53].

5. Comparative results

This section presents comparative results between EFL and C2030, summarised in Table 2. As described in Section 2, our comparison is based on a sub-set of the criteria described in Table 1.

5.1. Process comparison

This section highlights two key findings: (i) In comparing the contexts in which EFL and C2030 were operating, we found that context differs in terms of turbulence in landscape developments and sense of urgency. Yet, both cases hosted processes motivating the necessity for urgent change in energy and related systems to achieve sustainable and desirable futures. [2] In comparing the methods and associated scope of EFL and C2030 we found that whilst both cases engage with backcasting and socio-technical systems guided by MLP, they do so in different ways that had deep implications for process design and effects. Setting an adequate scope for the processes was carefully considered and debated in both processes, particularly in EFL.

5.1.1. Context including governance conditions

West Sweden is a transportation hub hosting the largest port in Scandinavia and a heavily industrialized region, with 1.7 million inhabitants and Gothenburg being the biggest city. Regional greenhouse gas emissions have experienced a 16% decrease over the last 25–30

Table 2
Summary of main comparative findings for selected criteria based on observed similarity and difference between EFL and C2030.

	EFL	C2030
Process		
Context including governance conditions	Contextual turbulence, sense of urgency, divergence of viewpoints	Contextual stability, sense of urgency, convergence of viewpoints
Methods and scope	Multi-level perspective framing, backcasting as tool (among others)	Backcasting framing, multi-level perspective as tool (among others)
Societal effects		
Individual capacity and relationships	Interpersonal focus: negotiating roles, exploring diverse perspectives, awareness of arguments, systems understanding	Analytical focus: system-, target- and transformation knowledge. Trust and alignment, challenging assumptions
Institutional change: policy and/or organization	Constrained by organizational structures and inertia	Willingness to negotiate new role in regional climate policy
Sustainability transition impacts		
Governance, actor roles and relationships	Recognition of procedural, distribute and recognition-based justice Institutionalising broadened systems-based practice, potentially spilling over to regime routines	Actor and resource mobilization in four focus areas for synergistic innovation and scaling Illustrating need for further cross-sector integration to deal with countervailing factors from e.g. infrastructure planning

years (since 1990), where production-based emissions lie at approximately 7 t per capita, and emissions from a consumption-based perspective lie at approximately 11 t per capita [58]. While Sweden has successfully transitioned into low-carbon district heating from oil into primarily biomass and other renewable energy sources since the 70's [59], notable climate challenges remain within sectors of transportation, industry and consumption. In West Sweden, refineries and other industries account for approximately half of the regional emissions (increased since 1990), followed by transportation accounting for approximately 25%.

Sweden in general, and West Sweden in particular, positions itself as 'proactive leader' hosting a variety of strategic programmes mobilizing actors and resources on sustainability challenges [60,61]. Regarding climate change, urgency to act is normally motivated by highlighting that current trajectories from historical emission reductions are deemed insufficient in meeting future targets (independent of fossil fuels 'fossil independent' in 2030 and climate neutral by 2045) – *"despite efficiency measures and structural changes in industry accompanied with a growing service sector"* [58]. In contrast to Alberta, there is no immediate pressing and turbulent urgency to act in broader coalitions: Social welfare is generally experienced as high, and important policies regulating most carbon emissions are in the hands of EU/ETS. Nationally, Sweden has had a carbon tax in place for most emissions that fall outside the EU/ETS system that has been operating since 1995 (~100€ per tonne CO2).

In contrast, the fossil fuel industry has been at the heart of Alberta's economy for over 100 years. Recent years have seen great changes in the energy system. Since 2015, Alberta has experienced an oil price crash, floods and forest fires, a new Climate Leadership Plan by new Provincial government, US President Obama blocking Keystone XL pipeline which would deliver Alberta oil to the South, the introduction of the Pan-Canadian Climate Framework with carbon pricing introduced by new Federal government, COP Paris agreement with goals to limit global warming to 2C, protesters blockading the Dakota Access Pipeline, newly elected US President Trump approving the Keystone XL pipeline, Trump pulling out of the Paris climate agreement, the Federal government announcing plans to phase out coal production by 2030, the Federal government buying the TransMountain pipeline for $4.5B to ensure expansion is built, newly elected Ontario Premier Ford cancelling carbon tax and climate programs, Alberta introducing mandatory production cuts to shore up oil prices, and the newly elected Alberta Premier Kenney introducing Bill 1 to repeal the carbon levy.

While the topic of transition was of shared interest among all actors across the energy system in Alberta, there were wildly divergent views on the desired direction, pace, and sustainability orientation of the transition. The rapid drop in oil prices in 2014–2015 led to discussion on the future of energy in Alberta across the province and country in NGO, corporate, and government circles. However, there were great tensions between different levels of government in their assessment of the nature of transition and the level of urgency in addressing transition. Municipal governments were generally supportive of progressive transition policies while the conservative Provincial government was strongly supportive of the oil and gas sector. The Federal government displayed mixed messages with sustainable policies such as a national carbon tax while at the same time investing billions of dollars in pipeline construction to get Alberta oil to market more quickly and support expansion of oilsands production.

While context differs between C2030 and EFL in terms of lived urgency and presence of shifting landscape developments, both processes included attempts in mobilising urgency in making actions happen towards sustainability transition. In the C2030 case, rather than coming from contextual developments, urgency was motivated by facts and figures highlighting the gap between future climate targets and the historically slow progress towards achieving the same in attempts to mobilise urgency in its process. In EFL, participants experienced urgency in context as fostering the transition away from fossil fuels, while others saw an urgent need to maintain a role for the fossil fuel industry in the energy system of the future. Contextual urgency also had an impact on activities of the EFL. In early sessions, there was a tension between participants who wanted to "just get on with it" and start working on projects vs. those who saw the value of stepping back and embracing systems analysis methods and processes. These contextual circumstances provide vastly different conditions for the engagement process within the labs.

5.1.2. Methods and scope

Both EFL and C2030 engaged with backcasting as part of their process, emphasising its potential in letting go of patterns in the present and the past when exploring future alternatives. Backcasting typically takes its starting point in negotiating visions and/or principles for sustainability and then letting these guide systems analysis, intervention development etc. However, the way the backcasting processes played out in practice differ between the cases, including its relation to other frameworks, methods, tools and techniques.

C2030 adopted backcasting as an overall approach and methodology guiding the stakeholder engagement process, where much emphasis was put on framing sustainable futures in multiple sustainability dimensions at its beginning, before analysing systems in the present or suggesting interventions. Such framing was sought to

> "connect (the climate issue) to a good life in a positive future vision [...] not in the context where we have been for maybe too long that it is complicated, it is difficult, it is a big threat and we show lots of statistics" [project leader].

Although the climate strategy was oriented towards the 2030 goal of fossil independency, the backcasting process took its starting point in 2050 to mark the end-point of the low-carbon transition where climate neutrality had been achieved. This was intended to support participants in letting go of present constraints and lock-ins such as long industrial investment cycles, at risk making 2030 feel too close in time for transition to be feasible. In addition, a futures-oriented framing into sustainability rather than low-carbon was believed to support in identifying measures with co- and ancillary benefits by e.g. bringing alternative measures not normally on the table to the agenda. It was also aspired to support the formation of new actor constellations around novel challenge framings and interventions. In all, the backcasting process was divided into the following four steps:

1. Framing a sustainable and desirable regional future in 2050 on a level of principles for social, economic, ecologic sustainability and human needs/well-being
2. Analysing present systems on a basis of principles to identify gaps and challenges
3. Identifying areas of intervention for sustainability transition
4. Shaping strategic pathways for a good life in a fossil independent region

The process also sought to support participants in moving beyond a sectoral framing of the climate issue into a socio-technical systems framing. Here, the multi-level perspective on transitions (MLP) [24] played a heuristic role during the second backcasting step. Here, analysis is oriented towards understanding (i) niches understood as sources of radical innovation, (ii) regimes understood as the dominant socio-technical configurations orienting around a particular societal function and (iii) landscapes understood as exogenous factors and wider societal development trends. Transitions are understood as unfolding in a complex interaction across those three levels [23]. Socio-technical system thinking was introduced to direct attention to lock-ins and systems innovation across not only technology but also markets, behaviour, infrastructure, legislation and so forth.

In contrast to this minor role of MLP as a tool and bigger role of

backcasting in framing C2030, EFL showed an opposite emphasis. In EFL, MLP was used throughout the design process to assess the current state of the system, identity intervention points, map the portfolio against MLP to check the alignment to transition, and informed a number of process design elements such as building niche-regime networks, creating space for innovation, supporting mutually reinforcing dynamics between niche innovations and embedding landscape context monitoring and adaptation into the EFL itself [43,48].

Backcasting, on the other hand, was used to develop a shared vision of a sustainable energy future followed by an identification of action points towards achieving that future. The vision was the focus of a dedicated workshop that identified gaps between the current state of the system, the desired future, and potential intervention points or initiatives that could be launched to move towards the vision.

The EFL process, framed by MLP, followed the steps of:

1. System sensing - understanding the present system and prototyping to learn
2. Developing future vision - using backcasting process to co-develop a vision of the energy system of the future
3. Identify gaps - Identify the gaps between the current system and desired future and define intervention points
4. Prototype development and scaling - develop and scale prototypes for systems intervention

Scope was somewhat more contested in EFL, which may relate to its ownership and mandate (we return to this issue in the Discussion section). C2030 was initiated by public authorities in outlining a regional climate strategy where its scope including geographical and organizational boundaries were clearly defined, whereas EFL emerged out of ongoing disruptive changes in energy systems including underlying e.g. socio-economic developments and concerns inevitably calling for transition.

Whilst being partly hosted by private interests, EFL attempted to achieve legitimacy through diversity of participants and partners from different sectors and different interests (i.e. NGO. corporate, First Nations, and government). However, without a strategy to address issues of power and equity within the EFL, the process was at risk of co-option and stakeholder capture. In fact, a small sub-set of EFL participants argued that this was the case. Support for Fellows to participate in the EFL was provided however the lack of financial support (directly from the EFL) for initiatives led to an over-reliance on funding from fossil fuel companies and initiatives were closely tied to the day-to-day work of regime institutions. C2030 experienced no direct skepticism among its participants regarding legitimacy and ownership. On the contrary, the regional focus shaped the way interventions were developed and evaluated (although the backcasting process sought to support breaking free from these constraints).

In the C2030 process, participants experienced that some of their suggested interventions with high transformative potential were not provided sufficient space to be further developed. In some instances, interventions were considered too open and vague to be brought forward in the process, and thus discarded. In other instances, they were considered politically infeasible, either by participants themselves or by the civil servants that were part of facilitating the process, and thus discarded. In that regard, some participants expressed disappointment in the process where politicians asked for transformative interventions that were directly implementable within current structures, posing dilemma, tension or even contradiction. For example, during a workshop when participants presented their interim results, a policy official expressed a "thank you for the input to our ongoing climate strategic work" – an instrumental framing making many participants react on their roles and ownership of the work. However, the interventions that fell outside the seemingly narrow political scope in the formal policy procedures were still provided space in the follow-up forums emerging from the climate strategy once it had been adopted (see the effects comparison section).

An observation is that participants in C2030 largely seemed to agree with the set scope as focussing on efforts where West Swedish actors could play an important role and make a difference within its geographical boundaries and mandate in e.g. supporting early market formation and acting as an innovative and leading example in the global arena – leaning towards an ecological modernisation agenda. However, most participants experienced the ambitions and expectations of delivery as too high related to the dedicated time.

The bio-innovation group experienced additional pressure, not only because they only had two backcasting sessions rather than three or four as the other groups, but also a concern with Preem refinery who were not present (yet they have signed the climate strategy). Preem is the single biggest emitter in the region and thus considered a key stakeholder. Many participants spent considerable time expressing their disappointment about the absence of Preem, including statements such as *"as long as Preem still emits it makes no real difference to the transition whatever we other actors do"*, and *"it would be good to hear the perspectives of Preem, what plans do they have?"*

Participants had varying views on the appropriateness of the scope of the EFL. One dimension of the challenge was on the appropriate geographical scale of the EFL. The EFL wrestled with questions such as: would it even matter if we shut the oilsands down (representing 0.1% of global GHG emissions)? Would it not be a bigger global impact if we focused instead on producing natural gas that can displace Chinese coal consumption thereby impacting 24.5% of global GHG emissions? The EFL Fellowship and Design Team collectively decided to focus on Alberta, working on what was within their sphere of influence. While the decision to confine the geographical scope of the EFL was understandable given resources, partners, and participants, this may prove to be a limitation in facilitating systems transition. Alberta is inescapably part of national and international energy systems. In addition, the vast majority of the fossil fuels extracted in the Province are exported for use (mainly combustion) beyond Alberta's borders [62]. Similarly, the scope of initiatives of the EFL focus mainly on energy supply rather than demand. This narrowing of scope is problematic as it does not encompass the demand for, and impact of, Alberta's fossil fuel resources.

5.2. *Effect comparison*

This section highlights our findings in comparing effects of EFL and C2030. Both EFL and C2030 showcase individual capacity development that show limited possibility of extending beyond the timeframe of the process of engagement itself. Both processes orient towards institutional change in terms of policy and organization, in various ways and to various degrees of success.

5.2.1. *Individual capacity and relationships*

The pre-post evaluation survey based on Walter et al. [41] and Wiek et al. [39] (results reported in detail in [47]) adapted to C2030 showed indications that participants on an aggregated level experienced a build-up of target-, systems-, and transformation knowledge through the process. In other words, participants expressed having a clearer vision for a sustainable, fossil-independent region, improved understanding of the present systems related to climate intensity, and better understanding of what needs to change for the region to transition into fossil-independency. In addition, participants reported a slight increase in perspective awareness; implying that they better emphasise that people might hold different views on the climate issue. Indicators towards empowerment and agency were high even prior the process and showed little change pre-post, as with levels of trust, networking effects and how climate issues were prioritized in e.g. decision making (see also Holmén [63] for a more in-depth explanation of these particular results).

The EFL evaluation indicates an experienced increase of learning and understanding among participants – particularly related to reflexivity on participant roles in energy system transition – along with noticeable

effects across all evaluation categories. However, participant interviews and case analysis show that a lack of clarity on defining transition made it more difficult for Fellows to put their new knowledge into practice. In addition, due to organizational structures and inertia, participants may not be able to effectively influence their organizations and leverage their new knowledge and understanding. Where individual capacity development has been perhaps most effective is in facilitating knowledge and understanding of perspectives of different stakeholders, systems thinking and awareness of oppositional arguments. These changes have led participants to report new insights into the need to, and methods to, engage different stakeholders in transition projects.

In comparing individual capacity development and associated experiences from the EFL and C2030 processes, EFL oriented towards raising interpersonal understanding (empathizing with a diversity of perspectives, awareness of different arguments) as well as systems understanding, whereas C2030 showcased less change in interpersonal indicators (scoring high from the beginning) and instead oriented towards analytical knowledge domains on governing transitions including systems understanding, transformation knowledge and futures-oriented knowledge in terms sustainability-related visions and targets.

5.2.2. Institutional change: policy and/or organization[3]

C2030 showed some institutional change as an effect of the process, most notably within the regional council itself. Based on experiences from hosting the process via backcasting arenas inviting multiple-stakeholders and supporting participants in connecting and developing areas of intervention, the region started sketching on what such a facilitating role would mean for their future climate strategic work. The importance of negotiating a new role came especially clear when the invited experts who were to quantify the emission reduction potential of the areas of intervention found it difficult to do so: the suggested areas of intervention were not only oriented towards the technical but also the social, and were motivated not only for mitigating carbon emissions but multiple sustainability aspects.

Eventually, four 'ways of working' were conceptualised and became part of the climate strategy together with the 80 areas of interventions, prioritized efforts and focus areas, hence resulting in a climate strategy not only outlining what to do and with whom (areas of intervention) but also how to go about it (ways of working). The ways of working sought to horizontally integrate four roles the region can play in governing sustainability transitions through: Forerunning – taking responsibility and inspiring others by leading the way; Climate planning – prioritize mitigation and adaptation in regional infrastructure development and municipal construction; Innovations – investing in technological test-beds and collaboration in pilots, as well as incubators and innovation support, and; Attractive communities – strengthening the local level by involving and empowering citizens in giving shape of living and attractive societies. Whenever the region supports a particular area of intervention within a focus area, the strategy states that measures should span across all four ways of working. The focus areas and ways of working outlined in Climate 2030 have become part of the wider Regional Development Strategy that allocates resources within prioritized areas for regional development.

As an effect of the process, the region also initiated a climate council consisting of 'influential leaders' across sectors in the region, where the main roles for the council is to (i) be frontrunners and take responsibility, (ii) mobilise and empower and (iii) remove obstacles and influence. C2030 also keeps mobilising organizations in signing the petition of reducing their respective emissions. In a 2018 follow up survey, $^{1}/_{3}$ of the signed organizations stated that signing the petition had affected their work in further prioritizing climate and enhancing engagement on the same [64].

[3] Due to space limitations in this paper, we have conflated the policy and organizational effects categories in our analysis.

We can see evidence of both policy and organizational effects as a result of the EFL. The EFL has shown tangible evidence of introducing new ideas and evidence to policy makers and in having direct and indirect influence on policy. The design of the EFL has contributed to this influence as in the City of Edmonton Energy Transition Strategy where individual capacity development (learning about systems thinking) contributed to policy and organizational decisions. Development of networks within the EFL prompted City leaders to broaden the scope of stakeholder engagement. A second example is with Emissions Reductions Alberta (ERA).[4] In this case, the EFL directly influenced the ERA's technology roadmap by introducing concepts of systems thinking and technology interdependencies into investment strategy decisions. The example illustrates how the process elements of inclusivity, collaboration and development of social capital (along with content and process learning) led to meaningful influence on future ERA investment strategies. However, the policy influence of EFL has been limited to a few specific cases.

There are many examples of the EFL contributing to institutional change within organizations in the form of new positions being created, changes in organizational focus, and changes in investment decisions. However, it remains unclear the extent to which these changes have been embedded within institutions and will last over time. It is also unclear the extent of EFL contribution. For example, most organizations mentioned as examples of organizational change do not publicly reference the EFL other than in funding announcements.

In comparison across the included elements, we see that both EFL and C2030 showcase effects that may last beyond the immediate process of engagement itself. However, the longevity of and additional 'effects' following these effects remains unknown.

5.3. Impact comparison

While it is difficult to accurately capture long-term impacts of such projects, our comparison of impacts led to two main insights (rather than findings as in 5.1 and 5.2). First, both EFL and C2030 show impacts among sustainability transition categories, but it remains unclear to what extent and in what scale related to ongoing countervailing developments. Second, it is generally problematic to set boundaries and count impacts as the labs may generate additional processes that in turn produce their own set of effects and impacts and so forth. Note that our impact comparison is oriented towards illuminating the quality and direction of the impacts from the two cases, rather than assessing similarity and difference in terms of scale.

Assessing contributions of sustainability transition labs to systemic change is fraught with challenges. A first is disentangling the impacts of a lab from ongoing development pathway change within the system. A second is the long time frames over which development pathway change is manifested. Despite these challenges, it is critical to attempt to assess these contributions as, in most cases, this is the stated goal of the Labs.

Impacts from C2030 most notably relate to actor roles and relationships via further actor-mobilization coordinated via the four focus areas. These mobilization efforts seek to gather actors in constellations where synergies can be identified, encourage innovation and measures with transitional potential, and support scaling and transfer of initiatives to be adopted by more actors. Part of this effort is also to attract additional organizations to sign the climate strategy. These mobilization efforts may, in turn, produce additional effects and impacts that lie outside the scope of the paper, including additional institutional readiness for transition and strategic alignment among actors.

Climate 2030 and the fossil-independency target are also used to motivate the acceleration of transitions in debate articles published in

[4] ERA is an Alberta Government agency responsible for investing revenues from the Provincial Carbon Levy into Alberta based businesses developing emissions reductions technologies. See https://eralberta.ca/about-era/

local news magazines. For example, a 2017 debate article in the region's largest newspaper highlighted how the region's new transport infrastructure plan shows little alignment with the climate 2030: *"On the one hand, the region wants via Climate 2030 to take the lead and be an important actor in the low-carbon transition. On the other hand, one seeks with the regional transport plan to continue as one has done before"* [65]. The climate strategy with particular focus on the fossil independency target and ongoing work within the focus areas was recently referred to by the County Administrative Board submitting a support and regional perspective on a permissibility trial regarding an investment by Preem refinery in West Sweden that essentially would "erase all emission reductions occurred in the region since 1990" [66]. Despite their plans to expand their current operations, Preem frames themselves as a proactive actor and take part in the focus area work led by the region.

The EFL has played the role of modelling new forms of governance and actor engagement. For example, the EFL embodies procedural, distributive, and recognition-based justice [49]. The EFL's success in supporting development of agency within Fellows and their ability to exercise that agency within regime institutions provides an avenue through which elements of practice may become formalized in policy. An example of this is seen in the ERA engagement. In a recent interview, a representative from ERA stated that EFL feedback on the technology roadmap has prompted ERA to embed a

> "focus on a complete solution" – in other words taking a systems approach to energy transition funding. In the case of a funding call for geothermal energy, this entailed the "need to also consider grid, storage … [a] complete solution and broad perspective."

Further, while the EFL input was "not influencing individual investment decisions, [it] helped inform the [ERA] business plan and broader focus of calls" in sectors such as methane, food/farming/forestry, and geothermal. This illustrates how a policy effect has become embedded in regime routines, albeit within one regime institution.

While there was certainly a unique confluence of events that supported the development of the EFL, the project by no means reflects ongoing, or at least coherent, development pathway change. For example, the United Conservative Party (elected in 2018) has continued Alberta's historical support of the fossil fuel sector and directly invested in new pipeline projects to foster growth in oil and gas exports. As we discuss further in the next section, this contextual turbulence poses both governance and assessment challenges for labs.

6. Discussion

Below we discuss the main contributions of the study, namely key insights emerging from the actual comparison (RQ2) related to (i) the role of context and (ii) backcasting and MLP as processual tools, followed by reasoning on potential and pitfalls on the evaluation framework in supporting comparison on effects and impacts (RQ2).

6.1. Contexts of urgency, turbulence and ownership implications

Deliberate sustainability transition and transformation initiatives argue for the importance in mobilising a shared sense of urgency to motivate short term actions in line with long-term sustainability ambitions [30]. Both C2030 and EFL experienced and leveraged urgency but did so in different ways. EFL sought to counteract contextual urgency and turbulence by creating space for exploration into alternatives with care for the long-term, whereas C2030 sought to establish a higher sense of urgency due to its contextual stability which in turn was a main reason for mobilising the process. Urgency has political implications, regardless if it is inherent to the labs' wider context (external) or socially mobilised by the lab itself (internal). Urgency tends to close down searches into various options and alternatives by focussing on e.g. accelerating transitions in a certain direction [67]. A key issue is hence in who's interest it is to counter, balance or reinforce urgency in terms of what conversation spaces that are opened up and kept closed. A main realisation in C2030 was that sole focus on accelerating transitions towards climate neutrality was perceived as neither possible nor desirable in its current context, and as an attempt to indeed accelerate towards climate neutrality, there was a need to connect with a broader sustainability agenda and wider actor-networks.

In discussing political implications of deliberate transition initiatives more generally, ownership, accountability and legitimacy become key concerns [68,69]. From a view of transdisciplinary co-production [70,71], a key element of deliberately guided transition processes is a well-trusted actor holding neutrality with an orientation towards the common good to stand as host for such initiatives. To date, most labs- and arenas are initiated by researchers or at least driven by research-interests [29,36], whereas the two cases studied in this paper are primarily driven in other constellations. EFL had major funding from a private institution where ownership remained with Natural Step Canada (NGO) and C2030 had public ownership.

In addition, both processes held ownership where established actors rather than alternative niches were at the centre. Such ownership configurations pose challenges as well as opportunities in terms of regime proximity [72]. This include the possibility to influence perceptions of regime actors and actively create cracks, and general struggle with creating protective spaces where 'deviant' solutions are allowed to be developed (Ibid.). Participants experienced that a range of radical interventions emerged from the backcasting process in C2030, but deemed unfeasible to adopt politically as part of the official climate strategy. Instead, the hope was that these interventions would be provided further space in follow-up on-the-ground meetings once the strategy had been adopted. EFL was less dependent on public authority for institutionalising its intervention developments, and in addition to spending more time in their engagement process, the setting showcased more freedom in letting out-of-the-box alternatives emerge and become part of the official work of the lab.

6.2. Backcasting and the multi-level perspective for sustainability transitions

As illuminated in the comparison, both C2030 and EFL engaged with backcasting and the multi-level perspective (MLP) as part of their processes. They did so in different ways and with various emphases. Below we highlight some potential implications of these choices.

Quist et al. [73] note a tendency in transitions management frameworks where backcasting is reduced to a particular tool in linking a future vision with the present. A risk with such instrumentalization is that the approach loses its deeper ambitions to re-think the way we approach and discuss the future in transitions [74,75]. EFL moved towards a more instrumental take on backcasting where it was engaged with as a particular tool among others, whereas in C2030 backcasting served as the overall frame for the engagement process.

At the same time, C2030 lacked political readiness for adopting some of its suggested interventions emerging from the backcasting process into the official climate strategy. Interestingly, this was a politically espoused ambition in suggesting backcasting and launching Climate 2030 at the first place – to not produce traditional descriptive analyses showing that one is far from achieving sustainability targets in time given the current measures and policies in place, but rather seeking to learn from and outline what changes would be necessary to achieve a sustainable and low-carbon future, be them conceived as feasible or not. Here, one inevitably operates in the tension between achieving legitimacy within established systems and structures and seeking to challenge and transform the same (Cf. 71).

In contrast to C2030, EFL paid more attention in situating its activities in its transitional context and circumstances. MLP played a role as an overarching framework and approach guiding several instances of the process. EFL highlights how MLP played an important practical role

as heuristic and in situating the lab in its proper context and supporting actors in making sense of the same [48]. This was shown not least important when actors disagreed or have different stories and assumptions of what is currently going on and why.

In all, we see that both backcasting and MLP have legitimate reasons for framing transition initiatives, and combinations are commonly part of conceptual designs of transition lab methodologies and the like [17] but as this particular study illustrates, what may be more interesting is to understand for what reasons various frameworks and tools are employed and what implications it has for their immediate processes and beyond.

6.3. A reflexive account on effects and impacts

While this paper illustrates a small set of examples where C2030 and EFL might have influenced characteristics of development pathway change, the evidence is not strong enough to make claims that they have done so at this stage. However, the following processes that have been established or augmented as partly resulting from these labs point in the direction towards sustainability transition impacts. It is too soon to tell whether this resonance will be amplified or silenced. Based on MLP reasoning, the turbulence within the landscape and regimes, in particular in the EFL context, provides windows of opportunity for niche innovations where projects such as EFL has potential to make an impact. In these terms, C2030 can be understood as an experiment seeking to explore potential in creating regime cracks, identifying broader landscape developments and supporting establishment of niches and niche-regime alignments.

As the comparison shows, the visions, actions and strategies of labs are often at odds with the political, economic, and social trends of their respective (governance) contexts. The EFL was the source of many emergent niche innovations – technological, process, and social, and was a protected crucible in which these ideas were formed, shaped and scaled (i.e. a process of emergence) under conditions of contextual urgency. C2030 emerged in a stable context in need for further transitional change, attempting to mobilise sense of urgency in process attempts for achieving a low-carbon sustainable region in time. That the effects of these labs in terms of how new ideas and concepts appear to be resonating within wider (new) actor-constellations is perhaps the best way to characterise their respective impacts, rather than a too early search for particular or eventual sustainability transition impacts that tend to be dispersed in time and space. Below, we provide a brief reasoning into how impacts of lab activities meaningfully can be captured and understood.

6.3.1. On embedding change

Key to achieving sustainability transition impact is the embedded nature of institutional changes [77]. Societal effects provide markers that changes of the type desirable for sustainability transition impact are occurring. However, the crucial question is whether those changes are becoming embedded in system practices and are durable over time. In addition, these elements point to changes not only within the system but also in its overall character and form. Changing from a rigid and inflexible *unsustainable* system to a rigid and inflexible *sustainable* system may not be experienced as durable or desirable change by some. However, a system that embeds characteristics of adaptive capacity, reflexivity, understanding of complex systems, and inclusion of a wider array of actors in decision making processes may be better suited to navigating the inevitable yet unforeseeable challenges we will collectively meet in the future.

6.3.2. On markers of transition guiding designers and facilitators

Many impacts may be far removed temporally from a given lab process. To meaningfully assess sustainability transition impacts, it is helpful to think of 'markers' in addition to elements. While elements (or indicators) tend to refer to a specific thing that can be measured, markers refer to any kind of early sign that transitions might be happening. For example, do changes seen in the categories described above point to transitions? Do they incorporate features that might be expected to support transitions? These markers can be derived from both process and societal effects evaluation elements. While this is a pragmatic approach to assessing sustainability transition impact, it runs the risk of assuming a simplistic and linear conception of systemic change i.e. that a given set of processes and societal effects will lead to sustainability transition impacts. This may be mitigated by selecting markers that have a theoretical grounding for their role in supporting, fostering, or indicating sustainability transition. Each of the categories of sustainability transition impacts carries with it implications for process and societal effects evaluation. In other words, by backcasting [4,51,78] from desired sustainability transition impacts, we can derive the processes that are best suited to achieving such impacts, and the societal effects that provide markers to indicate that such transitions may be underway.

7. Conclusions

This paper has situated, adapted and applied an analytical framework for cross-case comparison and analysis of sustainability transition labs across their processes, effects and impacts. On a surface level the two cases seemed to be rather similar in terms of their orientation towards sustainable energy transitions, bringing multiple stakeholders together, working with backcasting and MLP and seeking to influence systems change on a strategic level. We hope that our work helps demonstrate the need for cross-case comparison and analysis in the transitions field along it providing a methodological-practical illustration of how one might do so. We now return to the three guiding questions posed in the introductory section: "why compare?", "what to compare?", and "how to compare?" before suggesting avenues for further research.

Why compare? The cross-case comparison and analysis illuminated similarity and difference across the two cases in a way that highlighted significant attributes of sustainability transition labs in an empirically grounded way; including contextual contingencies, governance conditions, process-methods and the plurality of effects and impacts that may result from labs in their context. Apart from the comparative findings, the paper also supported a deepened understanding of the particular cases in a different way compared to single-case designs. Contrasting EFL with C2030 sparked further attempts in trying to understand each particular case in deeper and new ways as we sought to explore reasons and implications of the observed differences, often by means of drawing from our knowledge and experience from the respective cases' setting and circumstances.

We especially bring with us insights into how context manifested concretely on the level of how the labs were set up and unfolded in practice. This also leads to a realisation that when evaluating 'sound methodology' [40] in a lab process, we must move beyond "success" and "failure" across cases (c.f. [26]) and conduct careful analysis with care for context, including empathizing with e.g. a lab's internal aims and ambitions, capacities to host certain forms of processes and consideration for their participating actors. This may not read as radically novel, but marks a loosening up from some developments oriented towards outlining ideal-type lab processes. We are in favour of methodological pluralism (c.f. [79]) by considering choices that position choice of process as political and context-dependent, calling for increasing attention to understanding underlying reasons and qualities sought after in deliberate transition initiatives. In such work, one may put emphasis on how dominant worldviews and frames may influence processes, the generative mechanisms that produce outcomes in context, underlying qualities and features including the craft of emergent scaffolding; rather than prescribing certain designs on a level of tool and method – as is often asked for by some practitioners and funders (Cf. 12), present in grey literature (e.g. 18,78) as well as in ideal-type process development [36,81].

What to compare? This paper was guided by an analytical framework consisting of 'process', 'effect', and 'sustainability transition impacts' with an associated set of categories that supported data structuring and the following comparison and analysis [21]. The broad set of categories adapted served helpful in initiating conversations of interest that illuminated similarity and difference of interest calling for a deepened analysis to unpack reasons and implications of the observed differences and similarities. Shared categories for data collection has been argued by others as key to support further comparison on transition labs and experiments [40].

How to compare? Frameworks for joint data collections may address the question on 'what to compare', where frameworks can either be preset or let emerge from the study design or combinations thereof. However, frameworks require methodological guidelines and support to be operationalised. The reasoning in adapting the analytical framework for cross-case comparison in combination with the methods section in this paper may be used to further inspire and develop methodological approaches in doing cross-case research into sustainability transition labs. In our experience, the way the analytical framework was applied on the two cases provided conceptual orientation in delineating the cases, and supported our efforts to pay attention to significant attributes of labs for sustainability transitions, including their effects, how they were generated and their possible and potential contribution to transition impacts.

While this paper only touches upon a few topics of concern, it marks one step towards better understanding the why's, what's and the how's of empirically comparing labs with attention to their processes as well as eventual and potential contributions to sustainability transition. Further research is needed to investigate how underlying philosophies and theories of change play out in practice when working with backcasting and the multi-level perspective of transitions as frameworks, methods and tools respectively in lab processes. As the comparison highlighted the ways in which contextual urgency and turbulence vastly differed across and influenced the labs in various ways, further research should pay attention to exploring roles of context (among other factors) in determining framing choices, systems boundaries, and how stakeholders and other participants engage in labs. Further topics worthy further comparative research include implications from various forms of ownership (public, private, NGO, transdisciplinarity etc.), roles of research and research institutions in labs design and facilitation, and implications of differing funding sources (e.g. research grants, government agencies, NGOs, or corporations).

The analytical framework and its methodological application are an attempt to understand, through the characteristics of development pathways, what change is happening and whether it is moving in a more sustainable direction. However, there are still open questions: is a development pathway simply the sum of categories or elements in the various categories? Complexity theory would say no – explanation into how a complex system develops cannot be reduced to a discrete set of components. It is also not clear how development pathways shift direction – does change in all categories co-occur? Or does one follow the other? What are the inter-relationships between (and within) categories? Further investigation of these question would benefit lab researchers and practitioners in better understanding how their processes contribute to, are embedded with, and are shaped by contextual systems change.

The reflexive nature of the cross-case approach has led to theoretical and practical insights for labs as well as opening up new directions for further research and we look forward to further research that includes additional cases and comparative categories as well as studies posing specific questions addressed via comparative designs. Despite the risks of applying generalizations to specific contexts, process designers and facilitators need guidance in their work. We propose our approach as a set of heuristics, packaged contextual insights or guiding questions that may be adapted to local circumstances. It is easy to say 'context matters' but that does not help those who are designing, facilitating, and researching sustainability transition labs. Despite the challenges of translating generalizations to specific contexts, we as researchers are responsible for providing the guidance we can to support such transition efforts. We hope that the methods and empirical insights we have presented here will support this guidance and contribute to the world's much needed sustainability transition.

Uncited references

[76,80]

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Complete account on data items for C2030 and EFL. All data sources consulted may be found in further detail in [43] Appendices A-H (pp. 364–406) and in [63] Appended Paper II

Data item	C2030	EFL
Process-related documents	Political decisions Process design documents Meeting protocols Outcome documents and follow-up evaluation	Design documents Design-team meeting minutes Planning documents Internal evaluation reports
Evaluation surveys	Pre-post evaluation survey combining 1–5 Likert-scale statements with open-ended questions to gather experiences and impressions from process	Post-workshop evaluation surveys
Participant interviews	Interviewing participants informally throughout participation of process, and during reflection sessions during each session. Documentation as fieldnotes	Semi-structured participant interviews Participant interviews were conducted at roughly six month intervals spanning August 2015 – April 2018. An additional set of interviews was conducted with Indigenous participants of the EFL Attended all participant and design workshops

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(*continued*)

Data item	C2030	EFL
Participant observation	Attending all meetings throughout design, conduction and evaluation of the climate strategic process including its 13 half-day stakeholder engagement sessions in five parallel thematic areas. Documented as field notes	
Design/process team interviews	Semi-structured interviews with main process designers/responsible before and after the process	Semi-structured interviews with main process designers/responsible after the process
External documents	Debate articles and political documents related to regional climate policy and wider regional development issues.	In order to capture EFL effects and transition impacts, external documents provide a mechanism to validate where and how the EFL has had an effect with, for example, regime actors. E.g. publicly available documents on the partner websites, corporate news releases and executive speeches, government press releases and reports.

References

[1] European Environment Agency, Perspectives on transitions to sustainability, in: Luxembourg, 2017 (Report No.: 25/2017).
[2] United Nations, Transforming our world: the 2030 Agenda for Sustainable Development, United Nations, New York, 2015.
[3] I. Fazey, N. Schäpke, G. Caniglia, J. Patterson, J. Hultman, B. van Mierlo, et al., Ten essentials for action-oriented and second order energy transitions, transformations and climate change research, Energy Res Soc Sci. 40 (2018 Jun) 54–70.
[4] J. Robinson, Future under glass - a recipe for people who hate to predict, Futures 22 (8) (1990) 820–842.
[5] B. Turnheim, F. Berkhout, F. Geels, A. Hof, A. McMeekin, B. Nykvist, et al., Evaluating sustainability transitions pathways: bridging analytical approaches to address governance challenges, Glob. Environ. Change. 35 (2015 Nov) 239–253.
[6] H.W. Rittel, M.M. Webber, Dilemmas in a general theory of planning, Policy Sci. 4 (2) (1973) 155–169.
[7] J. Rotmans, R. Kemp, M. van Asselt, More evolution than revolution: transition management in public policy, Foresight 3 (1) (2001 Feb) 15–31.
[8] A. Smith, A. Stirling, F. Berkhout, The governance of sustainable socio-technical transitions, Res. Policy 34 (10) (2005 Dec) 1491–1510.
[9] Voß J-P, Bornemann B. The politics of reflexive governance: challenges for designing adaptive management and transition management. Ecol. Soc. [Internet] 2011 [cited 2017 Jul 4];16(2). Available from: http://www.ecologyandsociety.org/vol16/iss2/art9/main.html.
[10] L. Delina, A. Janetos, Cosmopolitan, dynamic, and contested energy futures: navigating the pluralities and polarities in the energy systems of tomorrow, Energy Res. Soc. Sci. 35 (2018 Jan) 1–10.
[11] J. Iuel-Stissing, T. Pallesen, P. Karnøe, P.H. Jacobsen, Governing system transitions in the context of scattered agency: flexibility, action, and ecologies of epistemic equipment, Energy Res. Soc. Sci. 69 (2020 Nov) 101730.
[12] D. Loorbach, N. Frantzeskaki, F. Avelino, Sustainability transitions research: Transforming science and practice for societal change, Annu. Rev. Environ. Resour. (2017) 42.
[13] Scoones I, Stirling A, Abrol D, Atela J, Charli-Joseph L, Eakin H, et al. Transformations to sustainability: combining structural, systemic and enabling approaches. Curr. Opin. Environ. Sustain. [Internet] 2020 (Jan [cited 2020 Jan 28]; Available from:) https://linkinghub.elsevier.com/retrieve/pii/S1877343519300909.
[14] H. Bulkeley, L. Coenen, N. Frantzeskaki, C. Hartmann, A. Kronsell, L. Mai, et al., Urban living labs: governing urban sustainability transitions, Curr. Opin. Environ. Sustain. 22 (2016 Oct) 13–17.
[15] Z. Hassan, The Social Labs Revolution: A New Approach to Solving our Most Complex Challenges, Berret-Koehler Publishers, Inc., San Francisco, California, 2014, p. 190.
[16] D. Loorbach, Transition management for sustainable development: a prescriptive, complexity-based governance framework, Governance 23 (1) (2010) 161–183.
[17] F. Nevens, N. Frantzeskaki, L. Gorissen, D. Loorbach, Urban Transition Labs: co-creating transformative action for sustainable cities, J. Clean Prod. 50 (2013 Jul) 111–122.
[18] K. Papageorgiou, Labs for social innovation, in: ESADE Institute for Social Innovation and the Robert Bosch Stiftung, 2017, p. 72.
[19] N. Forrest, A. Wiek, Learning from success—toward evidence-informed sustainability transitions in communities, Environ. Innov. Soc. Transit. 12 (2014 Sep) 66–88.
[20] Loorbach D, Avelino F, Haxeltine A, Wittmayer JM, O'Riordan T, Weaver P, et al. The economic crisis as a game changer? Exploring the role of social construction in sustainability transitions. Ecol. Soc. [Internet]. 2016 [cited 2018 Mar 15];21(4). Available from: http://www.ecologyandsociety.org/vol21/iss4/art15/.
[21] S. Williams, J. Robinson, Measuring sustainability: an evaluation framework for sustainability transition experiments, Environ. Sci. Policy 103 (2020 Jan) 58–66.
[22] R.K. Yin, Case Study Research: Design and Methods, 2nd ed., Sage, London, 1994.
[23] F.W. Geels, Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study, Res. Policy 31 (8) (2002) 1257–1274.
[24] F.W. Geels, The multi-level perspective on sustainability transitions: responses to seven criticisms, Environ. Innov. Soc. Transit. 1 (1) (2011 Jun) 24–40.
[25] R. Ison, Governing the human–environment relationship: systemic practice, Curr. Opin. Environ. Sustain. 33 (2018 Aug) 114–123.
[26] Sengers F, Wieczorek AJ, Raven R. Experimenting for sustainability transitions: A systematic literature review. Technol. Forecast Soc. Change [Internet]. 2016 Sep [cited 2019 Jun 11]; Available from: https://linkinghub.elsevier.com/retrieve/pii/S0040162516302530.
[27] Köhler J, Geels FW, Kern F, Markard J, Onsongo E, Wieczorek A, et al. An agenda for sustainability transitions research: State of the art and future directions. Environ. Innov. Soc. Transit [Internet] 2019 Jan [cited 2019 Apr 2]; Available from: https://linkinghub.elsevier.com/retrieve/pii/S2210422418303332.
[28] H. Bulkeley, Broto V. Castán, Government by experiment? Global cities and the governing of climate change, Trans. Inst. Br. Geogr. 38 (3) (2013) 361–375.
[29] G. McCrory, N. Schäpke, J. Holmén, J. Holmberg, Sustainability-oriented labs in real-world contexts: an exploratory review, J. Clean Prod. 277 (2020 Dec), 123202.
[30] D. Loorbach, J. Rotmans, The practice of transition management: examples and lessons from four distinct cases, Future 42 (3) (2010 Apr) 237–246.
[31] K. Hölscher, J.M. Wittmayer, D. Loorbach, Transition versus transformation: what's the difference? Environ. Innov. Soc. Transit. 27 (2018 Jun) 1–3.
[32] G. Feola, Societal transformation in response to global environmental change: a review of emerging concepts, Ambio. 44 (5) (2015 Sep) 376–390.
[33] C. Culwick, C.-L. Washbourne, P.M.L. Anderson, A. Cartwright, Z. Patel, W. Smit, CityLab reflections and evolutions: nurturing knowledge and learning for urban sustainability through co-production experimentation, Curr. Opin. Environ. Sustain. 39 (2019 Aug) 9–16.
[34] L. Pereira, N. Frantzeskaki, A. Hebinck, L. Charli-Joseph, S. Drimie, M. Dyer, et al., Transformative spaces in the making: key lessons from nine cases in the Global South, Sustain Sci. 15 (1) (2020 Jan) 161–178.
[35] E. Puerari, J. de Koning, T. von Wirth, P. Karré, I. Mulder, D. Loorbach, Co-creation dynamics in urban living labs, Sustainability 10 (6) (2018 Jun 6) 1893.
[36] N. Schäpke, F. Stelzer, G. Caniglia, M. Bergmann, M. Wanner, M. Singer-Brodowski, et al., Jointly experimenting for transformation? Shaping real-world laboratories by comparing them, GAIA – Ecol. Perspect. Sci. Soc. 27 (1) (2018 Jan 1) 85–96.
[37] T. von Wirth, L. Fuenfschilling, N. Frantzeskaki, L. Coenen, Impacts of urban living labs on sustainability transitions: mechanisms and strategies for systemic change through experimentation, Eur. Plan. Stud. 27 (2) (2019 Feb) 229–257.
[38] Y. Voytenko, K. McCormick, J. Evans, G. Schliwa, Urban living labs for sustainability and low carbon cities in Europe: towards a research agenda, J. Clean Prod. 123 (2016 Jun) 45–54.
[39] A. Wiek, S. Talwar, M. O'Shea, J. Robinson, Toward a methodological scheme for capturing societal effects of participatory sustainability research, Res. Eval. 23 (2) (2014 Apr 1) 117–132.
[40] C. Luederitz, N. Schäpke, A. Wiek, D.J. Lang, M. Bergmann, J.J. Bos, et al., Learning through evaluation – a tentative evaluative scheme for sustainability transition experiments, J. Clean Prod. 169 (2017 Dec) 61–76.
[41] A.I. Walter, S. Helgenberger, A. Wiek, R.W. Scholz, Measuring societal effects of transdisciplinary research projects: Design and application of an evaluation method, Eval. Program Plann. 30 (4) (2007 Nov) 325–338.
[42] S. Burch, A. Shaw, A. Dale, J. Robinson, Triggering transformative change: a development path approach to climate change response in communities, Clim. Policy. 14 (4) (2014 Jul 4) 467–487.
[43] S. Williams, The splash and the ripples: assessing sustainability transition experiments [Thesis for the Degree of Doctor of Philosophy], University of British Columbia, [Vancouver, Canada], 2019.
[44] A. Bryman, Social Research Methods, 4th ed., Oxford University Press, Oxford; New York, 2012 (766 p.).
[45] S. Khan, R. VanWynsberghe, Cultivating the under--mined: cross--case analysis as knowledge mobilization, Forum Qual. Soc. Res. 9 (1) (2008) 17.
[46] R.E. Stake, Case studies, in: Strategies of Qualitative Inquiry, 2010.
[47] J. Holmén, J. Holmberg, Thinking beyond, broad and together: exploring features and value of guiding principles for sustainability in backcasting, Chalmers University of Technology, 2021.
[48] S. Williams, The Alberta energy futures lab: a case study in socio-cultural transition through public engagement, in: S. Wiebe, T. Ney (Eds.), Creating Spaces of Engagement, University of Toronto Press, Toronto, Canada, 2020.
[49] S. Williams, A. Doyon, Justice in energy transitions, Environ. Innov. Soc. Transit. 31 (2019 Jun) 144–153.
[50] Energy Futures Lab, About the EFL [Internet] [cited 2018 Feb 24]. Available from: https://energyfutureslab.com/about-the-efl/, 2018.

[51] J. Holmberg, K.-H. Robèrt, Backcasting from non-overlapping sustainability principles - a framework for strategic planning, Int. J. Sustain. Dev. World Ecol. 7 (2000) 291–308.
[52] J. Robinson, S. Burch, S. Talwar, M. O'Shea, M. Walsh, Envisioning sustainability: recent progress in the use of participatory backcasting approaches for sustainability research, Technol. Forecast Soc. Change. 78 (5) (2011 Jun) 756–768.
[53] Region West Sweden. Klimat 2030 Västra Götaland Ställer om - Climate strategy [Internet]. 2016. Available from: http://klimat2030.se/content/uploads/2018/02/klimat2030klimatstrateginenga5lowres.pdf.
[54] J. Holmberg, Transformative learning and leadership for a sustainable future: Challenge Lab at Chalmers University of Technology, in: P.B. Corcoran, B. P. Hollingshead, H. Lotz-Sisitka, A. Wals, J.P. Weakland (Eds.), Intergenerational Learning and Transformative Leadership for Sustainable Futures [Internet], Wageningen Academic Publishers, The Netherlands, 2014, pp. 91–102 [cited 2015 Jul 16]. Available from: http://www.wageningenacademic.com/doi/pdf/10.3920/978-90-8686-802-5_4.
[55] Vinnova. Nationell Kraftsamling Transport 2050 [Internet]. 2012 [cited 2017 Feb 24]. Report No.: 2012–01876. Available from: http://www.diva-portal.org/smash/record.jsf?pid=diva2:649258.
[56] F. Avelino, J. Rotmans, A dynamic conceptualization of power for sustainability research, J. Clean Prod. 19 (8) (2011 May) 796–804.
[57] J. Holmberg, Backcasting: A natural step in operationalising sustainable development, Greener Manag. Int. 23 (1998) 30–51.
[58] Region West Sweden, Faktaunderlag med klimatutmaningar för Västra Götaland. Ett gott liv i en fossiloberoende region, 2016, p. 122 ((Fossiloberoende Västra Götaland). Report No.: 1).
[59] L. Di Lucia, K. Ericsson, Low-carbon district heating in Sweden – examining a successful energy transition, Energy Res. Soc. Sci. 4 (2014 Dec) 10–20.
[60] Five Clusters, Five Clusters in West Sweden with Strength and Potential for the Future, Chalmers University of Technology, The City of Gothenburg, University of Gothenburg, Region West Sweden, West Sweden Chamber of Commerce, Gothenburg, 2013.
[61] M. Polk, Sustainability in practice: the interpretation of sustainable development in a regional planning arena for dialogue and learning in western Sweden, Plan Theory Pract. 11 (4) (2010 Dec) 481–497.
[62] Government of Canada, Crude Oil Facts [Internet] [cited 2020 Sep 2]. Available from: https://www.nrcan.gc.ca/science-data/data-analysis/energy-data-analysis/energy-facts/crude-oil-facts/20064, 2020.
[63] J. Holmén, Navigating Sustainability Transformations: Backcasting, transdisciplinarity and social learning [Thesis for the Degree of Doctor of Philosophy], Chalmers University of Technology, [Gothenburg, Sweden], 2020.
[64] Region West Sweden, Årsberättelse 2018. Klimat 2030 – Västra Götaland ställer om, 2018.
[65] Göteborgs-Posten, Miljöexperten dömer ut regionens klimatpolitik [Internet] [cited 2020 Sep 2]. Available from: https://www.gp.se/nyheter/milj%C3%B6experten-d%C3%B6mer-ut-regionens-klimatpolitik-1.4770698, 2017.
[66] County Administrative Board West Sweden, Regionalt perspektiv på tillåtlighetsprövning av Preemraff Lysekil. Göteborg: Länsstyrelsen Västra Götalands län, 2019 (Report No.: 420-27382–2019).
[67] A. Stirling, 'Opening Up' and 'Closing Down': Power, Participation, and Pluralism in the Social Appraisal of Technology, Sci. Technol. Hum. Values 33 (2) (2007 Nov 12) 262–294.
[68] E. Shove, G. Walker, CAUTION! Transitions ahead: politics, practice, and sustainable transition management, Environ. Plan A. 39 (4) (2007) 763–770.
[69] J. Meadowcroft, What about the politics? Sustainable development, transition management, and long term energy transitions, Policy Sci. 42 (4) (2009 Nov) 323–340.
[70] D.J. Lang, A. Wiek, M. Bergmann, M. Stauffacher, P. Martens, P. Moll, et al., Transdisciplinary research in sustainability science: practice, principles, and challenges, Sustain. Sci. 7 (S1) (2012 Feb) 25–43.
[71] R.W. Scholz, The normative dimension in transdisciplinarity, transition management, and transformation sciences: new roles of science and universities in sustainable transitioning, Sustainability 9 (6) (2017 Jun 9) 991.
[72] J. Grin, 'Doing' system innovations from within the heart of the regime, J. Environ. Policy Plan. 23 (2020 Jun) 1–13.
[73] Quist J, Wittmayer J, Van Steenbergen F, Loorbach D. Combining backcasting and transition management in the community arena. In: Proceedings of SCORAI Europe & InContext Workshop, Rotterdam, The Netherlands, 7-8 October 2013; Sustainable Consumption Transitions Series, Issue 3 [Internet]. 2013 [cited 2015 Jul 11]. Available from: http://repository.tudelft.nl/view/ir/uuid:abde24ee-a1c4-4a9b-929c-9d5c48f4fb36/.
[74] K.H. Dreborg, Essence of backcasting, Futures 28 (9) (1996) 813–828.
[75] J. Robinson, Unlearning and backcasting, Technol. Forecast Soc. Change 39 (5) (1988) 325–338.
[76] J. Rotmans, D. Loorbach, Transition management: Reflexive governance of societal complexity through searching, learning and experimenting, in: J.C.J.M. van den Bergh, F.R. Bruinsma (Eds.), Managing the transition to renewable energy: Theory and practice from local, regional and macro perspectives, Edward Elgar, Cheltenham, 2008, pp. 15–46.
[77] A. Shaw, S. Burch, F. Kristensen, J. Robinson, A. Dale, Accelerating the sustainability transition: exploring synergies between adaptation and mitigation in British Columbian communities, Glob. Environ. Change. 25 (2014 Mar) 41–51.
[78] J. Quist, Backcasting for a Sustainable Future: The Impact After 10 Years, Eburon, Delft, 2007.
[79] M.C. Jackson, Critical systems thinking and practice, Eur. J. Oper. Res. 128 (2) (2001 Jan) 233–244.
[80] J. Meadowcroft, D. Layzell, N. Mousseau, The Transition Accelerator: Building Pathways to a Sustainable Future 1(1), 2019, p. 65.
[81] R.W. Scholz, G. Steiner, The real type and ideal type of transdisciplinary processes: part II—what constraints and obstacles do we meet in practice? Sustain. Sci. 10 (4) (2015 Oct) 653–671.