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Towards 2050:

Interconnectivity



in Skellefteå

Executive Summary

Sustainable transitions of urban environments over the coming decades are being undertaken by municipalities around the world. Skellefteå has already adopted several concurrent objectives for sustainable transformation of energy and mobility networks. Transitions challenge incumbent regimes and provide opportunities for new socio-technical arrangements to emerge. This work characterises the evolving landscape of Skellefteå municipality today, with an aim to understand how strong sustainability can most effectively be fostered in the coming decades. In order to provide actionable information that can coexist with active sustainability strategies, interconnectivity between local stakeholders for sustainable collaborations and mutual benefit is explored.

Social, physical, sectoral and nature-culture connectivity criteria are used to formulate a vision of a more accommodating Skellefteå that actively supports innovation and collaboration through social and institutional fabrics. Rigorous solution testing resulted in a short term focus on education and facilitation of novel socio-spatial relationships through the use of multichannel nodes and networks. Through promotion of citizen self governance and participatory information networks, distributed decision making will unburden the municipality from coordinated central planning of many aspects of sustainable transitions. Instead, municipal channels will oversee and facilitate an expanding cybernetic information ecosystem and orient the system towards citywide sustainable objectives.

Radical shifts in social relationships like increased stakeholder collaboration and autonomy will occur slowly at first and will require patience and creativity on behalf of educators and early participants. To increase the longevity and speed of adoption, carefully structured working groups will gather information and experiment. These experiments must iteratively gather feedback and adjust aligned objectives and methods to prevent stagnation. They will be stimulated by a growing and changing city undergoing necessary physical changes. These changes will have diverse impacts, both aggravating some as they disrupt unsustainable regimes, and opening up new collective resources. These changes are inevitable, but the access to information will enable predictive support of those negatively impacted, and allow local communities the ability to consciously redesign their communities to reflect their values and spirit.

As transportation evolves towards fossil fuel independence, small electric and analog vehicles will become more dominant in urban areas without large preexisting train or tram infrastructures. Taking advantage of this, communities can radically transform physical networks to provide seamless connection between urban and exo-urban environments by foot, bike, ski, snowmobile and scooter. Liberated former parking lots and roadways can be utilised for community projects ranging from education and recreation spaces to tool and transport share and repair hubs.

Biodiversity can be invited into the urban context to provide buffers against extreme weather and provide multifunctional common resources. Over time, long term projects will increase investment by local firms and community members in the municipality, building a sense of agency and belonging. Skellefteå's urban renewal will not only be stimulated by exciting economic growth of industry. Services and hospitalities will create a vibrant scene as the city's budding reputation as a sustainable urban model grows, and biodiverse local environments blend into the city.

Investment in horizontal collaboration in industry and education will attract cutting edge transdisciplinary and transectoral research in industrial symbiosis and post normal science to Skellefteå. Campus Skellefteå can benefit from the involvement of dozens of university programmes targeting research of this nature without the cumbersome identity building of traditional educational institutions. Promotion of local collaborations will advance investment in the region while pioneering circular economic relationships and stimulating additional research opportunities.

These visions of a vibrant and sustainable Skellefteå are limited and incomplete, while the future holds myriad challenges and transformative opportunities that will radically change these outlooks. This work and vision serves as a framework for establishment and goal orientation of social arrangements that might be capable of reacting to, and taking advantage of, coming changes. As Skellefteå and the world reorient to new economic and social paradigms, participatory systems of governance and mature information economies will be critical to discovery and implementation of cutting edge innovations in sustainable transitions.

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1.0 Introduction

1.1 Project Background

Urbanisation is a trend that is expected to continue in the coming years. By 2050, the world's urban population is predicted to double, while Europe's urbanisation itself is anticipated to grow to about 83.7% (United Nations, Department of Economic and Social Affairs, 2019). This implies/entails an increase in urban populations and growth of urban areas.. Here, significant consideration should be taken to the fact that cities currently contribute to a major amount of greenhouse gas emissions – more than 60 percent – although cities only occupy less than 2 percent of the planet's surface (UN-Habitat, 2011). With the expected growth of inhabitants in cities, the business as usual scenario would increase the greenhouse gases emitted, which in turn worsens the effects of climate change. The Viable Cities programme was started to try and combat this issue, aiming to engage and guide cities to shift toward a more sustainable future that copes with urbanisation. Currently, 23 Swedish municipalities, including Skellefteå, have participated in Viable Cities' Climate-Neutral Cities 2030 initiative, which aims to stop the emissions that burden the planet in line with the EU goal to be climate-neutral by 2050.

Hence, in accordance with EU and local goals, Skellefteå municipality plans for a sustainability transition by 2050. Skellefteå is one of the municipalities that participated in Viable Cities, aiming to strengthen the ongoing projects and investments in the municipality, to reach goals related to sustainable development. Skellefteå is facing unique challenges, in part due to the establishment of the Northvolt electric battery factory, with the consequentially large influx of inhabitants. This requires many actors' participation and collaboration to develop Skellefteå sustainably. Situated in the north of Sweden, in the Västerbotten region, Skellefteå is considered to have a high level of trust towards each other and the government and also balanced and equal neighbourhoods (Helliwell et al., 2020). This condition should be maintained in order for collaborations to work effectively. The urbanisation trend could possibly lead to social segregation and mistrust in the society if not properly accommodated as the increase of population with people of multicultural backgrounds could be hard to adapt to. Unity and a sense of connectedness would be the core for a common transition and continuous development towards a more sustainable future in 2050 and beyond. Therefore, the project focuses on the interconnectivity within Skellefteå, both physically and socially.

1.2 Aim and Objectives

The aim of this project is to propose possible solutions to improve interconnectivity as a means of achieving sustainable transition in Skellefteå by 2050, using a backcasting framework. The following objectives are constructed to reach the aim, which are to: assess and develop the theme of interconnectivity in

Skellefteå based on the modular participatory backcasting (mPB) framework, formulate experiments for the feasibility of the interconnectivity development, and review the adaptability of mPB framework for the chosen focus.

2.0 Methods

The study is based on the modular participatory backcasting (mPB) framework. The mPB is an integration of the transdisciplinary, modularity, and participatory modelling principles, consisting of different modules that aid the planning process step by step (Pereverza et al., 2019). In this study, mPB framework is used as the main structure, however, with some modifications in the application due to time and resource limitations and to fit with the context identified. Due to this, the module constellation is not a complete imitation of the mPB framework, but in essence follows the same method and structure.

Primary data was gathered from question and answer (Q and A) sessions with Skellefteå municipality representatives, providing the municipal and resident perspective. Secondary data was collected to gain more perspective from the municipality and local residents, and from other stakeholders groups such as companies or research institutions. Secondary data was collected from various sources such as journals, reports, municipality websites, newspapers, and company websites.

Essential to the mPB framework is its non-linear structure. The modules that define mPB can be viewed as more or less clustered, and their relation to each other necessitates switching flexibly between modules to generate relevant results. The first four modules Problem Orientation (PO), System Boundaries, (SB), Current Situation Analysis (CSA) and Stakeholder Analysis (SA) provide an example of such a cluster. These, as well as the remaining modules applied in this study, Needs and Functions, Vision, Criteria, Driver analysis, Internal Scenarios, Scenario Testing, Final combined scenario, Pathway, and Follow-up experiments, presented in Appendix 1.

3.0 Results

3.1 Problem Orientation

Skellefteå is in the midst of expansion, and a plethora of developmental projects within different sectors and fields are underway. Most obvious is the population expansion, where the highest scenario predicts an increase of approximately 20 000 people by 2050, bringing Skellefteå's total population to about 90 000 (Johansson and Ulander, 2022). This is in part due to the establishment of Northvolt and their factory, with high rates of employment of people from all over Sweden and the world.

Large influxes of people require high levels of infrastructural development, especially in a municipality where building development has been halted for the past several decades (Johansson and Ulander, 2022). Skellefteå's aim is to achieve such expansion while also becoming climate-neutral in the near future, a feat that is inherently complicated.

Skellefteå also struggles with the low willingness of young adults to stay in or move to Skellefteå permanently. Tackling this implies many different methods related to city attractiveness, and can be completed in parallel to achieving other goals if taken into proper account.

3.2 System Boundaries

System boundaries (SB) selection proceeded. The spatio-temporal dimensions of SB were set by municipal stakeholders; Skellefteå municipality borders represent the spatial boundaries, and the goal of being carbon neutral by 2050 creates a temporal time-frame. The two other dimensions of system boundaries, social setting and included sectors, were informed by the problem orientation as well as Pereverza et al (2019) suggestions, with the aim of challenging conventional system boundaries. The social setting dimension was chosen to conceptualise a 'space' in which issues related to diversity and emigration could be handled, and was made up of stakeholders (including citizens). The last SB dimension, sectorial selection, enabled identification of the key sectors relevant to the problems and their potential solutions in Skellefteå. Later project processes proved sectorial identification to be of less relevance to the proposed solutions, and this dimension of SB was modified. Instead of including sectors, boundaries were set at a meta-level, where connections between sectors, stakeholders, and issues were included within the system boundaries, while selected single sectors or issues were excluded.

3.3 Current Situation Analysis

The current situation (CSA) analysis module consisted of further elaboration of the key issues identified during problem orientation, as well as a broader outlook to ensure that relevant issues are covered.

First, the problem orientation directed investigation to migration. The demographic structure indicates that its population may significantly decrease within coming years (Skellefteå municipality, nd). Migration occurs mainly among young adults, and although some young age groups show a majority of immigration, emigration is more prevalent (ibid). Emigration among young women is more prevalent than young men, and the expected influx of employees from Northvolt can be expected to further impact this negatively. This poses a threat for integration, as large unplanned influxes of people can create a situation where segregation is likely, especially if the demographic structure is already unstable.

Second, observations related to migration raise questions of diversity. In comparison to many other municipalities. Approximately 10 % of its population were born outside of Sweden (SCB, 2021). Reasons why this disproportion occurs and non-swedish born inhabitants will not choose Skellefteå may be many and complex, and may be highly related to factors external to Skellefteå. The municipality is only able to improve internal factors in order to attract a more diverse set of people, which requires investigation that this and other similar types of studies can aid with. In addition to this, voices of the indigenous population of Sweden, the Saami, have traditionally been silenced, and the importance of uplifting this minority cannot be highlighted enough.

Third, as the current situation analysis shows negative trends related to an unwillingness to stay or move to Skellefteå (permanently), the reasons for this were explored. Reasons behind a decision to move in and out of a place are highly subjective and interconnected to factors internal and external to Skellefteå. Exploration in this analysis was limited to factors internal to Skellefteå, and were based on secondary data supported by municipal stakeholders (primary data), as well as speculation and discussion of the internal factors that may influence decision making.

The trends that show a potential decrease in population can be related to educational diversity and employment opportunities. Research shows that urbanisation trends are gender selective (UN Department of Economic and Social Affairs, 2017), a trend that can be explained in part by the general trend of women having higher education than men (SCB, 2020), and thereby finding appropriate employment (and salary) in urban areas. In addition to this, employment that is stereotypically 'male', is more prevalent in rural areas, and employment that is stereotypically 'female' is more prevalent in urban areas (SOU 2014:6). In line with this, data shows that the municipality labour market for employment that requires higher education is small (Skellefteå municipality, nd). In Skellefteå, there is a Campus, open to students and staff from Umeå University (UU) and Luleå Technical University (LTU). Presumably, Campus holds opportunities for improving educational opportunities as well as local innovation, research and collaboration.

Following this observation, cultural and subjective factors for unwillingness to stay permanently were explored. For newcomers to Sweden, the climate and long

dark seasons may heavily influence decision-making. To attract newcomers and increase their willingness to stay could mean supplying a different type of warmth, such as a welcoming warmth. Furthermore, the municipality and its city centre lacks in providing activities for all citizens, despite age, ethnicity, etc, to fill their free time with. This impacts the level of interaction between citizens, especially between groups that rarely interact, an important aspect in creating socially sustainable communities. For the activities that do occur, distance and travel opportunities are a hindrance. In line with this, meeting places and points of interest for the city requires improvement.

3.4 Stakeholder Analysis

The initial stakeholder analysis (SA) consisted of a selection of various relevant actors and can be generally grouped into the categories: citizens, companies of different sizes, municipality and other authorities, and research and university institutes (including Campus). Their relative power and interest were analysed (Ackermann and Eden, 2011), where special effort was put to understand their informal/formal power to map their roles and networks with each other. This analysis proved low in utility as no stakeholders (besides the municipality) were able to participate.

To combat this, a second stakeholder analysis was performed later in the process, after internal scenarios had been formulated. The SA performed at this stage showed that realisation of the internal scenarios lie heavily with the municipality, and their ability to catalyse projects and subsequently decentralise decision-making. Instead of analysing their power and interest, analysis aimed at investigating the municipal ability to fulfil that role currently, and as it changes in the future. It would require the municipality to initially exercise more of their influence on other stakeholders (incl. citizens) to catalyse projects that the stakeholders and community later take over. At this stage, the municipality would exercise less of its influence and power than previously. Results, based on discussion with municipal stakeholders as well as suggestions in literature, show that it is possible for the municipality to achieve such a role currently and in the future.

3.5 Needs and Functions

The analysis of Needs and Functions can be operated once the outputs of the Problem Orientation and the Stakeholder analysis are defined.. The investigation needs to be separated into two different scenarios: the Actual system configuration and the Future system configuration. Starting from the Present, problems have been decomposed by finding out several different needs; these belong to different dimensions of the system; therefore they have been regrouped according to which dimension they address.

Society: It represents the widest dimension of the system; it accounts for the interest of the city itself, focusing on the dynamics that can mainly affect the whole system. The users of this dimension can be identified in the Municipality.

Community: This dimension focuses on the problems that concern the community of Skellefteå, considering the citizens as an agglomerate of people and, therefore, accounting for the needs that can affect their plurality.

Individual: It represents the most intimate dimension of the system, it considers the needs of each citizen focusing on what can directly affect their life under a social perspective, more than an economic one.

In the actual configuration, from the widest perspective: the societal level; it revealed that Skellefteå needs to encourage young families to move into the city. Targeting this specific age group of population will make the urban reality more dynamic and vibrant, enriching the society with modern values.

On the community level, the investigation highlighted how modest is the quality of public services including this topic in the list of needs, where rethinking and optimising public service would be a solution to it. On the other hand, on this same level the economy is also accounted for, therefore analysing the problems of this component showed how there is a need for a dynamic and optimised economy. Satisfying these two needs will mean raising the living standards, while opening new incomers and new activities to dream and develop their project in the area.

On an individual level, problems mostly concern the social sphere, in this way the most important detected need is a better inclusivity and integration of minorities and new incomers. Without implying that the Skellefteå community is not an inclusive ecosystem, the forecast movement of people approaching the urban area could reveal some mechanisms that are not ready enough to welcome and include people with different values and habits. In addition to that, this need is also justified by the very actual problem regarding the inclusivity and integration of the Sami population.

In the future scenario, the disrupted urban ecosystem will present new problems and, therefore, new needs that might be satisfied. Skellefteå will be a much bigger urban area characterised by a high population density and by a multi-industrial reality.

On the Society level there will be different needs like, for instance, the need of Urban Cohesion. This topic is mainly reflected on the urban structure that will define Skellefteå, according to this vision the city will tend to become much rounder as possible, disrupting the paradigm of centralised cities and overcoming the challenge posed by the presence of the river. Moreover, such a large and dense city

will require a very-high efficient Energy Management, this need is a fact since the provisions of the Green deal stipulate that only renewable energy sources must be used. Another relevant expected need is the necessity of an all-round interconnectivity able to wire all the different aspects of the urban reality, starting from technical fields, such as energy demands, to social dimensions.

On the Community level, the main need is reflected in public services that need to be extremely efficient and accessible to every citizen. The starting point must be the improvement of the healthcare system, which must be properly distributed on the whole urban territory in order to ensure a reasonable proximity to each district. Beyond the healthcare system, another focus point of the improvement on the public services must be the upgrade and modernization of the public transportation system, that must respect the environmental policies and reach all the district, without mainly aiming to connect the suburbs to the core of the city.

On the Individual level, the most important detected need is the diversification of high-quality higher education. In order to create a diversified economy and population, by satisfying this need the urban area will attract students from all over the country and the world giving life to a constant student flow and, thus, to a new economic dynamic of the city. Furthermore, the establishment of diversified higher education will enable companies to search and eventually hire students that graduated in the fields of business interest.

3.6 Vision

Evidently sustainable transitions are needed in Skellefteå. The question then leads to “how do we want to see Skellefteå in 2050?”, in which the answer has to be clear and unified for everyone to understand and to carry out. A common vision is needed to guide everyone who is involved to walk towards the same direction for a sustainable future. Formulating a vision is not completely new for Skellefteå. The municipality’s vision for Skellefteå is ‘A sustainable place for a better everyday life’ (Skellefteå kommun, n.a.). Also, as a part of the strategic innovative programme called Viable Cities, Skellefteå also participates in making Sweden a leader in energy and climate transition by becoming climate-neutral by 2030 (Viable Cities, n.a.).

As the problems and needs identification leads to the focus toward interconnectivity in Skellefteå, therefore the vision formulation should also include what the connection looks like in the desirable future. At the same time, the vision should be aligned as well with the existing visions of Skellefteå which considers nurturing growth and pursuing climate neutrality and sustainability. Therefore, the vision for Skellefteå 2050 is formulated as “A welcoming and accommodating home for everyone, stimulating sustainable collaboration and innovation.”

With the vision formulation, everyone – people who have spent their whole life living in the municipality, new citizens, seniors, children, tourists, and many more – who are in Skellefteå should feel welcomed and accommodated. Skellefteå is

an attractive city, both in day and night, and facilitates various activities and fulfils the different preferences of groups in the municipality. Everyone who lives in Skellefteå should feel a sense of belonging, meaning that Skellefteå is their home – where they can live and grow, not merely to stay or stop by. By considering Skellefteå as their home, residents feel that they deserve and are responsible for the development of the municipality. The developments are continuously pursued by giving different actors and stakeholders related to Skellefteå the opportunity and facility to collaborate and work together towards a more sustainable future.

3.7 Criteria

To make the vision into reality, interconnectivity in Skellefteå is identified as the key element. Criteria are created in relation to this interconnectivity and therefore various aspects in which it can be separated are identified. These aspects constitute the key elements of the vision that will be associated with a criterion. They are Social, Physical, Sectoral and Nature-Culture Connectivity and are presented in Table 1. It is understood that these aspects can overlap in specific areas. Each of these criteria is afterwards associated with multiple indicators or sub-criteria to each of the connectivities.

Social connectivity is the first criterion, it covers connecting individuals and communities in Skellefteå. Social connectivity is measured by the variety and number of interest groups and also the availability of physical spaces for communities. As for indicators of this connectivity, Local ‘Togetherness’ and Mutual Interest Groups are adopted. Local ‘Togetherness’ refers to the amount and closeness of the links between citizens of Skellefteå. In order to quantify both these indicators the following measures and assessments are proposed: utilisation of public shared spaces, number of associations, number of interest groups in the municipality, number of shared and communal spaces.

Physical connectivity covers geographical connections in Skellefteå. It encloses the physical networks between places in the municipality. Indicators for this connectivity cover the Number, Safety, Accessibility, Affordability, and Quality of the physical networks for different modes of transportation. These indicators can be measured by parameters such as the waiting time, travelling time, price of transit, access to parking (bike, car), number of accidents.

Sectoral connectivity intends to measure the connection between sectors, university and research institutions in Skellefteå. It circumscribes connection within a sector as well as intersectoral connectivity. Sub-criteria chosen for sectoral connectivity are Interdisciplinary Collaboration, Industrial Symbiosis. Quantification of it is performed via levels of symbiotic by-product use, which is considered a result of industrial symbiosis.

Nature-culture connectivity is about the harmony between the natural world and the people of Skellefteå. Connectivity means that culture integrates connections

with the natural environment and ecosystems within and surrounding Skellefteå. An indicator of the connectivity between wild nature and culture is Accessibility to Unmanaged Ecosystems. It can be measured by the area of protected municipal wilderness (natural reserves) and physical connections to reach them. For urban nature, an indicator considered is the Biodiverse Urban Landscape. Parameters to assess it are biodiversity within the area and also the surface of parks, gardens.

The four different types of connectivities constituting criteria allows for testing solution performances according to the vision. In the following steps, criteria will be utilised to construct internal scenarios.





	Criteria	Sub-Criteria	Quantification
	Social Connectivity	Local 'Togetherness', Mutual Interest Groups	Use of public shared spaces, Number of Associations, Number of interest groups in the municipality
	Physical Connectivity	Quality of roads for bikes and cars, Safety, Accessibility, Affordability	Waiting time, travelling time, price of transit, access to parking (bike, car), number of accidents
	Sectoral Connectivity	Interdisciplinary collaboration, industrial symbiosis	Symbiotic by-product use
	Nature-Culture Connectivity	Access to unmanaged ecosystems, biodiverse urban landscape	Biodiversity, area of protected municipal wilderness

Table 1. Criteria, sub-criteria and measurements

3.8 Driver Analysis

Key uncertainties are identified after the performance of the impact-uncertainty analysis to a variety of driving forces. These key uncertainties are the Global Health Crisis (GHC) and Mitigation Climate Change (MCC). They are determined as having the highest impact and uncertainty in the studied system. Both are mainly influenced by external factors and thereby qualify as drivers in the mPB framework. High Mitigation Climate Change means that measures to prevent climate

change produce the desired results, they are successful in targeting climate change. In the case of a low Mitigation Climate Change, these measures fail and they do not achieve targets. For the Global Health Crisis, a high value refers to the possible future insufficiency of health systems, likely provoked by a pandemic.

The result of the driver analysis step is a future plane grid where the x-axis is the uncertainty Global Health Crisis and the y-axis is Mitigation Climate Change. The four external scenarios presented in Figure 1 developed are the following:

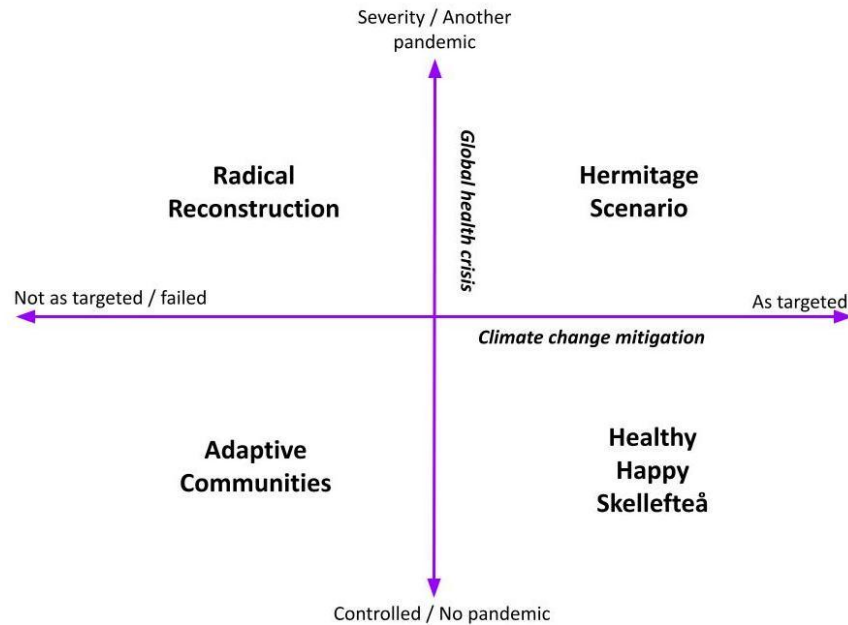


Figure 1. Futures plane with external scenarios

- **Hermitage Scenario (High GHC, high MCC):** Climate change is controlled and nature is preserved; however health crises promote isolation and less social and physical connectivity. There is a preference for outdoor destinations.
- **Radical Reconstruction (Low GHC, high MCC):** In this scenario, climate change is not successfully tackled nor are global health systems in a desirable state. The outcome of simultaneous climate and health crises are communities that are forced to radically adapt to survive the constant critical situation.
- **Healthy Happy Skellefteå (High GHC, Low MCC):** Climate change is targeted and at the same time human health does not suffer a global crisis. Beneficial scenario for people living in Skellefteå, where the health system works and the environment regenerates.
- **Adaptive Communities (Low CHC, low MCC):** In this scenario, climate change is not successfully tackled. The outcome of climate crises are communities that are forced to adapt to the new environmental conditions. These communities grow resilience as an outcome of the worsening mitigation fallout.

Each of these external scenarios represents a possible future situation. The future plane as a whole is a tool for evaluating internal solution alternatives in the following steps.

3.9 Internal Scenarios

Using iterative crowdsourcing of ideas followed by consensus-based review and edits, a morphological table composed of dimensions and likely dimensional states was established. Dimensions represent a given characteristic of socio-technical relationships between assortments of Skellefteå’s stakeholders. Realistic or plausible states of these dimensions were composed by consensus to form the alternative dimensional states (Pereverza et al, 2017). Dimensions need to relate to one or more of physical, social, sectoral or nature-culture connectivity in Skellefteå. Additionally, efforts were made to ensure dimensions reflected similar magnitudes of effect of potential scenarios and each state was judged to be plausible by consensus to allow for the greatest freedom of selection. The final morphological table (Table 2) was composed exclusively of plausible dimensional states that could be combined to generate cohesive internal scenarios.

Five dimensions were ultimately established to generate diverse internal scenarios from; sharing economy power structure (A), primary networking platforms (B), extant habitat vs urban biodiversity investment (C), collaboration and innovation space structure (D) and plurality of geographic interrelationships and mobility in the city

Dimension	Dimensional State		
	1	2	3
A Sharing economy power structure	Direct municipal control over community spaces and organization of involvement (Macro)	Indirect municipal facilitation of communities directing commons and interpersonal involvement (Micro)	Profit driven sharing economies (Gig and performance economies) while municipality runs commons as usual
B Primary networking platforms	Mainly physical networking opportunities and platforms, localized Campus with location based learning	Hybrid, several educational zones near subject matter industry	Highly digitalized networking, digitalized network of community members sharing specialized information, facilities only functional
C Extant habitat vs urban biodiversity investment	Majority investment in non urban habitat areas, biodiversity corridors within managed forests, with typical investment in parks and biodiversity. Increase accessibility from city to exo urban areas	Balance on investment in both. Increase connectivity between urban and exo urban areas nature.	Majority investment in urban nature and diversity. Urban green spaces. Typical investment in exo urban nature.
D Collaboration and innovation space structure	Vertical, with pipeline style collaboration where municipal orgs, researchers and firms in a given sector collaborate and innovate within sector	Horizontal, where collaboration is primarily facilitated within sectors. i.e. firm to firm, researcher to researcher, community org to community org	
E Plurality of geographic interrelationships, and mobility in the city	Division of Skellefteå in smaller parts/clusters because of cultural, economic, religious, and other demographic reasons. Mobility from and to city center is good, otherwise sometimes lacking.	Mobility between different areas is high, however there are still demographic clusters with limited interaction between different clusters. There is option of mobility between neighbourhoods but no necessity/desire. Within demographic clusters, interaction is high.	City open. No division of physical space and no concentration of people with common characteristics. Minority groups' networking is highly interconnected to majority groups. Mobility between different areas is high.

Table 2: Dimensions and dimensional state for internal scenarios

mobility in the city (E). Dimension A was developed to characterise the primary power dynamic in the future development of solutions rooted in evolving concepts within sharing economies. Sharing economies are extremely diverse in their natures, yet are undoubtedly on the rise today and will likely feature in sustainable urban development (Davies, Donald & Knox-Hayes, 2017). Without identifying or prioritising any specific type of sharing economy (gig, performance, community etc.), this dimension governs the way power is applied to develop such economies in Skellefteås future. Will firms like Airbnb and Voi drive these changes, municipal directives like centralised clothing swaps, donations and redistributions, or community projects like tool shares, urban commons and community gardens. One can imagine a project like circular bicycle pools being pioneered by any of these, yet the nature of the resulting relationships would vary dramatically. This dimension primarily relates to social and sectoral connectivity.

Dimension B resulted from a combination of educational and communication structures. As these two elements are intimately associated, states where one was significantly more centralised or diffuse than the other seemed unlikely. Our communication pathways closely govern how we learn and work. Will we attend meetings and lectures on well developed physical premises, teleconnect for most discourse - with hands-on site specific learning across multiple venues, or co-create diverse digital spaces for innovative spatially unconstrained communication and education. Given our recent experience during the Covid 19 pandemic, these options all seemed plausible depending on both internal and external factors within different communities and offered a variety of functionality. This dimension relates to physical and social connectivity.

Dimension C is rooted in the inherent assumption that in any future moving towards more sustainable urban spaces, efforts and investments will be made to increase biodiversity. The nature of that investment could be characterised by two valid arguments, that an urban space is not sustainable unless it embodies biodiversity within its landscapes, or that less urban biodiversity is acceptable so long as protected habitats around the urban space flourish. A third state of shared investment in these ideals can be easily imagined. This dimension governs the relationship between urban residents and the extant biodiversity, heavily impacting nature-culture connectivity while also impacting physical connectivity.

Dimension D characterises the primary development pathway for any investment of time or capital into collaboration, innovation and research. Incumbent regimes in this dimension favour vertical structures that might support researchers collaborating with firms and communities in a given field with community feedback, researcher analysis and firm action to forward a sector-specific function. This format undoubtedly has merits and due to long incumbency will play a role in any future. D then sought to define future focus in this area and introduced the alternative state of horizontal relationship promotion. That is, the potential for communities, researchers or firms to organise and communicate efforts for mutual gain, creating more diverse

coalitions of function that latent vertical structures can be applied to. This option was considered beneficial in some but not all cases, therefore the dichotomy of states was decided upon. This dimension is grounded in sectoral connectivity, with a small role in social connectivity and potential to impact nature-culture connectivity.

Dimension E was an amalgam of several dimensional concepts relating to physical connectivity and city planning. It seeks to identify discrete states of mobility and boundaries between neighbourhoods or districts of the city. Will Skellefteå orient itself around a downtown locus, radially connecting distinct areas in the periphery. Will it adopt a more diffuse network of connections between adjacent areas, either breaking down distinctions and physical boundaries or perhaps reorienting boundary distinctions within a new network? While the layout of mobility options is undoubtedly critical to connectivity in Skellefteå, characterising these states without robust and detailed understanding of Skellefteå city planning and urban culture was impossible. Therefore this dimension served mostly to give our internal scenarios a grounding within possible attractive options that worked best within the scenario. This allows us to motivate recommendations that nudge decision makers in solutions in their area towards layouts that synergise with other characteristics of this vision document.

Together these dimensional states offered a playground of possible combinations, without the burden of any specific solution being tied into them. Composition of these combinations, or internal scenarios, was done first through random selection, followed by characterization of the scenario and editing states that it was agreed would be more in line with a cohesive ideological grounding. This process was done half a dozen times, then four were selected as interesting and distinct for further testing. These four were techno-autocracy (A1,B1,C2,D1,E1), escapist digital networks (A3,B3,C1,D2,E3), anarcho-solarpunk (A2,B2,C2,D2,E2) and extractive ecocity (A1,B2,C3,D1,E1). These scenarios were selected based on maximising diversity while ensuring each was a valuable contribution. The names were formulated to evoke ideological underpinnings and highlight differences, not to characterise governmental structure. None of these options alter the democratic-socialist municipalism Sweden employs for municipal self-governance.

3.10 Scenario Testing

Two tests were conducted as part of further analysis of selected internal scenarios. The goal here was to isolate the strengths of each scenario in order to create a scenario with the greatest chance of forwarding our connectivity criteria, while considering coherency of the final scenario. The first test consisted of establishing scores for each scenario as they related to all four of our criteria. The second test evaluated the robustness of each scenario in terms of their performance over the possible outcomes represented in the futures plane.

Criteria testing involved individual scoring before establishing consensus on an average result. Statistical averaging tools were not used, instead each position was

considered and argumentation provided the weighting that resulted in the final scoring. Results indicated strong reflective performance of anarcho-solarpunk in social connectivity, with notably high scores for escapist digital networks based on the capability of digital spaces to satisfy social connectivity in an alternate capacity. Physical connectivity scores were high across the board, with more centralised scenarios like techno-autocracy and extractive ecocity outperforming the others. Sectoral connectivity showed the reverse, with escapist digital networks and anarcho-solarpunk far outstripping centralised alternatives. One reason for this was that horizontal structures in other parts of the scenario helped to reinforce similar behaviours in industry and education, increasing intersectoral cooperation. Lastly, nature-culture connectivity shared perhaps the most interesting frontrunners with extractive ecocity marginally outperforming anarcho-solarpunk with the third and fourth places significantly behind. Result highlights the plurality of ways to enrich the nature-culture connectivity in society, while demonstrating the importance of presence and access to these criteria.

During robustness testing, the decision was made to cut techno-autocracy from further analysis. This was the result of strong resemblance to extractive ecocity and lack of valuable contributions from techno-autocracy in light of their differences. Robustness testing was therefore limited to the remaining three internal scenarios, which we believe still well cover the best of our internal scenario analysis. Visualisation of our robustness testing was accomplished by overlaying internal scenarios against our futures plane (Figure 2).

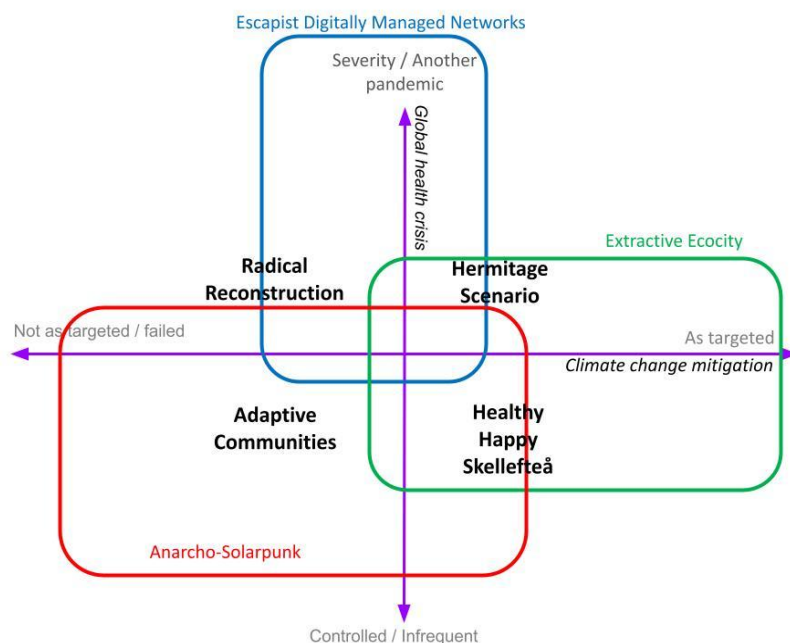


Figure 2. Robustness testing for internal scenarios

Where two or more scenarios occupied the same space in the futures planes, only the scenario that performed better based on consensus was allowed to remain. Overlap is therefore indicative of uncertainty regarding which scenario would perform better. Evaluation of relative robustness of the scenarios was derived from the area occupied by individual scenarios. This evaluation ranked the most robust as anarcho-solarpunk and escapist digital networks as the least. The total area of the future plane covered in this test was encouraging, and the highly variable applicability demonstrated that each scenario had potential to be more applicable than others given uncertain futures.

Notably this result is dependent somewhat on the nature of predictive modelling of uncertainties. The formulation of our drivers and choice of key uncertainties is undoubtedly informed by current events. Climate change and global health challenges are at the forefront of popular debate on future uncertainties. In a way this is part of what makes them so relevant for the future of Skellefteå and this vision document. However, more recent events demonstrate that likely challenges in the future will not take a form that we can easily predict and recognize. These unknown unknowns will no doubt factor into Skellefteå's development. It is therefore our aim to construct frameworks and evolving systems through this work that can be flexible to a changing world and best utilise the input of future stakeholders acting with more relevant information than ourselves.

3.11 Final Combined Scenario for Implementation

The results of our two scenario tests demonstrated high potential from anarcho-solarpunk futures, with meaningful contributions from both the remaining scenarios. At the centre of connectivity criteria, the role of the municipality was evidently critical. Current municipal roles such as managing and directing events, spaces and opportunities would better serve our criteria by fulfilling fostering and facilitation roles. This means fostering structures to educate and empower communities to increase participation in self governance and self organisation, as well as facilitating horizontal networks of actors within the urban socio-technical landscape to maximise innovation and collaboration. In addition, mutual investment in urban and exo-urban biodiversity and physical networking through the use of paths and nodes.

Returning to our vision can help to ground and visualise our solution. Skellefteå should be welcoming and accommodating. Vibrant public forums and sharing economies bring people together and generate diverse and overlapping interest groups to form a robust social web. A cross country skiing or biking commuter in a year will make dozens of connections during commutes which stimulate greater community involvement along physical channels the individual regularly traverses. Evolution of local character within physical space will not only ground residents' identity in the area, but give visitors or newcomers a clearer idea of diverse and exciting community spaces they might prefer to occupy (Smith,

2011). Decentralised networks and nodes can allow city planners to broaden the capacity of attractive neighbourhoods by building out this community infrastructure in tandem with developers such that the proximity to a downtown does not dictate the value of a home. Young families might prefer safe, green spaces for education and recreation to lively shops and bars.

Skellefteå should feel like home. This is the most important and evasive criteria in our vision, and it necessitates the institutionalisation of participatory empowerment of the citizenry. Home is many things to many different people, and those differences should be highlighted and celebrated rather than ironed out into a generic ideal. Engagement by citizens with their physical and social environment and a sense of stewardship for their neighbourhood or district as well as their domicile or building creates long-term investment critical for homebuilding. The city and its citizenry growing together and learning how to adapt and thrive in a dynamic world requires strong connective tissue across our four criteria. Innovation and collaboration are born from these types of connections. Encounters between community members in shared spaces and scheduled meetings between local firms have an equal chance of discovering the next opportunity for mutual growth and benefit. The nurturing of these connections and development of a rich environment of opportunities for connections is the matrix upon which dynamic and successful enterprises develop.

3.12 Pathway

Structural and Institutional Changes

<p><i>1' Stage</i> <i>(from 2022)</i></p>	<ul style="list-style-type: none"> · Firms establish coordination officers that primarily work with similar roles in other firms · Community energy funds match crowdfunded donations by participatory firms to enable neighborhood committees to plan and execute energy storage or production initiatives (artistic, utilitarian, peruse driven) · Companies work together with academic institutions to design and build interest points for the nodes
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<p>2' Stage <i>(after 2030)</i></p>	<ul style="list-style-type: none"> · Community members are engaged with organizing resource sharing and events · Diversification of points of interest in the city (Thematic Nodes) · 'Decentralised' or restructured municipal organization (e.g., environment is integrated into different departments; as well as similar integrations, benefitting structure and decision-making. Holistic approach to structure of organization)
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Cultural Changes

<p>1' Stage <i>(from 2022)</i></p>	<ul style="list-style-type: none"> · Municipality supports community led activities through internal review · Events every spring to increase the sense of belonging of residents and their neighborhood
<p>2' Stage (after 2030)</p>	<ul style="list-style-type: none"> · Culture and feeling of living in a small town is preserved, as citizens desire. Enabled through many small firms, a city center whose architectural culture/aesthetics is kept when building new areas (e.g., not building skyscrapers), many shared spaces for sport, play, art, e.g., path network enabling neighbors to still say hi when they see each other · Increased servicification, where products are rented, borrowed, shared.

Technological Changes

<p>1' Stage <i>(from 2022)</i></p>	<ul style="list-style-type: none"> · Collaboration or symbiosis between companies · Mapping of the potential in each area (points that could stand out) to decide the nodes and network · Assign and build points along the designated network for lease/park/return of shared bicycle/scooter & effective sharing systems
<p>2' Stage <i>(after 2030)</i></p>	<ul style="list-style-type: none"> · Smart Users: every single citizen has a share in an organization that increases municipal supply or storage of energy · Smart electricity grid where supply and demand is controlled even tighter, enabling more storage of electricity and the potential for other investments with saved funds

Techno-structural

<p>1' Stage <i>(from 2022)</i></p>	<ul style="list-style-type: none"> · Car free committee charged with mapping potential for occupation of roadways · Established car free zones over one third of densely populated roads · Innovative paradigm for city planning: decentralization of the city reducing boundaries between districts, communities and social classes
<p>2' Stage <i>(after 2030)</i></p>	<ul style="list-style-type: none"> · Biodiversity Corridors Established that Connect to the City · Symbiosis coordination committee works to facilitate by-product reuse with firm representatives regularly · Development of VR meeting platform reducing transportation load and emissions

Structural-cultural changes

<i>1' Stage (from 2022)</i>	<ul style="list-style-type: none">· The municipality as a catalyst, providing information on the positive effects that nature-culture connection has, as well as on physical spaces that are already available for this (through initial mapping). In relation to establishment of nodal network of paths, outdoor classrooms are established by the municipality available for use (in and outside city).· The municipality also aids in funding school outdoor full-day activities even for students that are in their teens.
<i>2' Stage (after 2030)</i>	<ul style="list-style-type: none">· Citizen's connection to nature is established early on through outdoor daycare, (and daycares that are outdoor) plenty of excursions and outdoor sports in school, repair-bike workshops in school, helping with the familiarity to circularity of nature

3.13 Follow-up Experiments

Initial experimentation for the development of beneficial scenario pathways implementation consists of creating a multi-actor oriented horizontal network consisting of four codependent working groups and one steering committee. This structure seeks to utilise community self-organisation to create a dynamic and flexible framework that is capable of responding to constantly changing goals and providing feedback to optimise goal orientation. These groups will consist of several key components. Relevant actors, including citizenry in all cases, must be identified and involved to ensure that produced initiatives are realistic and motivated. Feedback infrastructure unique to the aims of each working group will not just enable the group to communicate effectively with the steering committee, but ensure unilateral access to information about evolving plans and projects. These first two components are the iterative backbone that will allow communities, firms and the municipality to self-direct over time towards mutually beneficial transitions instead of working off of a static, predictive plan. Collective goal orientation based on backcasting analysis conducted in this research represents ideal initial conditions to give the best chance of this iterative process quickly achieving policy or project

development. In addition, lock-in risk assessment will provide some warning against the possible pitfalls of initial conditions that could bog down transition dynamism.

The maintenance of current municipalism and its structures provides a valuable organisational base that should be utilised to the greatest degree that does not inhibit citizen participation. To this end, the partial centralisation of the horizontal network using a steering committee with a more conventional composition of stakeholders like municipally elected officials, bureaucrats and city planners. This committee will facilitate commons' resource allocation as well as direct and advocate for policy initiatives produced by the network. The administrative goal of this committee is the establishment of a physical, social and digital network in Skellefteå substantiated by a diverse set of nodes of activity constructed alongside and informing network construction. These nodes will vary from public educational resources like outdoor classrooms and parks to busy business quarters taking advantage of high foot traffic through recently liberated street space. City planning projects can use this format to understand the best locations and communities for developments and changes. Potential lock-in risk for any steering group is the centralization of authority and decision making by slow build-up of informational resources that occurs when actors are information hubs and distributors. These risks must be mitigated by differential allocation of authority to working groups in relation to their sector or goals. The first task of the steering committee is to establish the philosophy and values of the transition and the broad organisational principles that will guide those values using this work as a springboard (Snow et al, 2016).

Four working groups have been designed to be interconnected stakeholder networks that work in tandem to facilitate sustainable transitions while building a more vibrant, socially and physically attractive city. The first two working groups regard the urban and exo-urban physical network design, but in doing so have wider interconnectivity implications. In the urban context, a working group to assess and establish multi-use pathways will need to parse many stakeholders' interests, including parking space and modifying existing transportation pathways to accommodate transitions. These pathways will be mapped based on local points of interest and frequently trafficked areas alongside future node development and radial interconnection with different districts or exurbs. Similarly, the connection of exo-urban trails and pathways with this urban network should target connecting areas of natural beauty and nearby communities, while making special consideration for local species needs. This wider network is a crucial artery for biodiversity restoration and nature-culture connectivity for residents. This working group will include land owners, sustainable timber representatives, and rural communities. The co-creation of biodiversity corridors to support local ecosystems also necessitates input from local and locally nomadic indigenous people. This is both for the benefit of the Sami and for their critical insight into the orientation of these corridors.

The remaining two working groups will facilitate sectoral and community collaborations through directed empowerment. Municipal support of local grant funding for symbiotic innovations or projects between firms could be directed by collective review in a working group designed to fit easily into busy schedules. This working group will use digital and virtual spaces to share information and explore possible collaborative projects. Municipal review can then assess the benefits to the population and provide support for less financially viable projects. Firms would undoubtedly make other connections that will be profitable based on mutual resources or logistical data cooperation. One lock in risk here is the profit motive and capital management makes corruption or incumbent firm bias conditions to be aware of during implementation. While working group membership would be elective, eventual institutionalisation of this collaborative sustainability officer coordination will better enable citizen enrichment over profit motives for local firms.

Finally, the last working group is an experimental progenitor to future community specific variations on a theme. The goal of this working group is to implement common resource generation and governance, directing efforts to accommodate challenges introduced by transitions while taking advantage of repurposable space. Sustainable transition will involve transforming our urban architecture and communities are in the most informed position for how best to use those resources. Businesses, artists, gardeners or community energy funds can invest in these liberated spaces grounded in sustainable city planning. Thus communities can help shape their character and diverse voices can have a forum to discuss priorities within general objectives oriented by the steering committee. These working groups could learn and reproduce themselves in other parts of the city if there is a positive community response. The steering committee itself can interface with community working groups for the planning and placement of larger city projects. The degree to which these organisations resemble community trusts or simply open forums will depend on the objectives each community prioritises. There is potential for the organisation of local festivals or celebrations where bike repairs, gardening supplies or pop ups of any kind give periodic access to convenient sustainable services. The important experiment here is how an area would react if given full information about citywide objectives and the way to participate in that decision making.

All five working groups will be interconnected by a necessity for collaboration in mutual work for distinct aims. For instance the city mobility working group will reorient traffic conditions which will change the nature of spatial relations for the community working group. With good communication and telegraphing communities can prepare to generate value from such spaces even as they assist affected or agitated groups. Perhaps a project involving several collaborative firms could help connect workers by tying the project into mobility networks. The potential relationships and interconnections are vast, however the relative success of any is greater with more equitable access to information.

Feedback equally provides for the maintenance of these initiatives as redundant or irrelevant features and procedures can be addressed and changes in priorities and goals understood in real time. In this capacity, a kind of cybernetic network development for better decision making will need to be nurtured. Once established, however, the mutual empowerment and sense of belonging and place can far outpace traditional command and control transition processes (Smith, 2011).

4.0 Discussion and Conclusion

4.1 Non-linearity and clustering

The first four modules, PO, SB, CSA, and SA, were highly clustered in this project, in part as intended by the mPB framework. Their similarity and highly related nature meant that their operationalisation was simultaneous. Some distinctions, such as the level of specificity between PO and CSA, were clear during investigation, but working with one of these four modules aided and supported investigation into another. This non-linear structure of the mPB framework has benefits and disadvantages, especially since the non-linearity is necessitated for some modules, while for other modules it is not necessary, but may be beneficial. For these modules, the user(s) of the framework are encouraged to re-open investigation to allow for iteration and consensus-based decision-making. The benefits of this are clear; for some modules it is necessary and for other modules it enables better decision-making since information is constantly updated. The disadvantages of clustering can include confusion, oversimplification, and generalisation, potentially impacting the quality of results. If managed incorrectly, this may impact stakeholder participation.

4.2 Problem Orientation

The PO module for this project generated a broad overview of the city, necessary as project members are largely unfamiliar with the municipality. This in itself presents itself as a disadvantage, had project members been more connected to the city, the quality of results could be improved. The broad and general approach to PO may have disadvantages, as it potentially lacks detail. However, this holistic approach did prove beneficial to the project as the idea of connectivity and meta-level system boundaries were employed.

4.3 System Boundaries

The approach to choosing system boundaries was in line with the approach to problem orientation, avoiding specification of a single sector or sustainability issue. This approach challenges conventional thinking, and thereby challenges the tendency to use the urban scale and perceive it as preferable when setting system boundaries (Purcell, 2006). The spatio-temporal boundaries of the project could be viewed as in line with conventional thinking and using the urban scale, however as they were set by stakeholders it would not be appropriate to change. Instead, the other dimensions of system boundaries were challenged, and the concept of delimiting/including connections and connectivity between sectors and issues was employed, instead of single sectors or single issues.

4.4 Current Situation Analysis

Operationalising the CSA was relatively straightforward. The concept of connectivity was already manifest by this stage, hence data collection focused on how negative sustainability trends were related. This type of approach illustrates the synergies between trends but also how solutions can have synergetic properties and thereby benefit several issues simultaneously.

4.5 Stakeholder Analysis

Early stage SA proved very low in utility for the project at hand. Recreating the SA in a later stage, and changing the method of analysis proved highly useful in this situation. The power-interest grid had very little utility, and it could be argued that its utility is low even in other projects where mPB is employed. Instead, depending on the project at hand, one suggestion could be to analyse current and future roles, and the ability and willingness of stakeholders to fulfil these roles. This may prove beneficial in determining the possibility of implementing the solutions that are proposed. One necessary improvement in this project, and for the mPB process in general, is whether sufficient weight is put on the involvement of citizen-type stakeholder groups.

4.6 Needs and Functions

The analysis of needs and functions is properly guided by the provided steps in the mPB especially thanks to the iterative application of the “Why?”-question technique. The input given by the Problem Orientation and the Stakeholder Analysis give a good basis to work on to obtain the needs and to be able to address them properly to the stakeholders’ interests. One obstacle that we faced in this module is the huge numbers of needs and functions that we detected applying the suggested approach. The outputs of this phase were very generic, wide and in some cases not really relevant with our goals, the reason why we decided to cluster those needs and functions on different levels/dimensions depending on the typology of the stakeholder addressed by the problem that generated the outputs. This additional step simplified the generation and estimation of our needs and functions list, besides helping us in properly addressing those to the related stakeholders. These approaches worked sufficiently well in both the present and the future analysis, smoothing the laborious work of projecting needs starting from the problems. When we first went through this module, the generation of future needs and function did not result easy and very meaningful, although thanks to the iterative nature of mPB, once we got back to the section, the future visions looked very much defined letting us reformulate and re-think about needs and functions that might appears in our future visions. Something that we found hard was the detection of functions, applying the “Why?”-question technique it was immediate to generate tones of needs, while the generation of functions was very less natural and more forced. In addition to that, the

distinction between needs and functions does not appear clear on the mPB guidelines.

4.7 Vision

Formulating vision at first seems like an easy thing to do. However, the tendency in formulating the vision was jumping to concrete solutions for Skellefteå. Therefore, some early visions that we tried to formulate sounds more like solutions rather than a desirable future. Another challenge was that Skellefteå municipality has already formulated a vision and is also involved in EU programmes which also already have their aim and vision, therefore coming up with something completely new could possibly contradict the existing ones. We therefore narrowed down our vision formulation to stay on track with the existing visions so that it would still be in line. Therefore, the data that we collected for the future vision are the existing vision formulation from the municipality itself or the programmes in which Skellefteå is a part of.

Our focus of “interconnectivity” can also be seen from different perspectives and perceptions, therefore another challenge to formulate the vision is to make it broad and general in the sense that it could cover different types of ‘interconnectivity’ but does not sound very vague and superficial. We followed the mPB framework by brainstorming keywords that we think are important and indicating what changes we want to see in Skellefteå based on our problem orientation. Some of the keywords that we brainstormed are “inclusive”, “sustainable”, “engaging”, “accommodating”, and “interdependency”. Then, we look for synonyms and phrases that could represent these keywords.

Overall, vision formulation was not supposed to be hard in comparison with some other steps in the mPB framework. However, what we found was very hard in the formulation of vision is that we hadn’t fixed our problem orientation and focus that time because due to the time limit of the course, we had to move on to other steps in the mPB framework before really fixing or fully understanding the steps before. Therefore, the vision formulation was not a linear process as we have to go back and forth the steps in the mPB to fix some things for the vision formulation. It is therefore very important to fix the problem orientation and focus first and also look for existing visions or aims which the context already has to formulate a new vision.

4.8 Criteria

Criteria were constructed by analysing the different aspects that our vision encompasses. This was performed by imagining futures of our system in which the vision has been accomplished. These desirable futures had features in common. These features were selected and adopted as the key indicators of our vision. In this way, for example, Social and Physical Connectivities enable the creation of a city that welcomes new citizens and accommodates them into the current communities.

Sectoral Connectivity tackles the aspect of the vision that refers to the stimulation of collaboration and innovation. Nature-culture connectivity is related to sustainability but also concerns the assumption that natural spaces are a necessity for the creation of agreeable living spaces. The four criteria that our group brainstormed and debated cooperate to encompass the entire concept of our vision.

For the selection of suitable criteria and indicators, we also considered that, in the following steps of the participatory backcasting method, these criteria are the starting point for the development of dimensions that will shape the internal scenarios/solutions. To take into account in this step that the criteria will afterwards frame the dimensions was well-founded and permitted us to evaluate these internal scenarios against criteria straightforwardly.

After the selection of the criteria, we discussed and proposed multiple indicators for each criterion. A requirement for a suitable indicator was the possibility of determining a parameter for measuring and assessing them. As an example, for the criterion Physical Connectivity, the train of thought was the following. First, it was identified the importance of having different modes of transportation throughout the city: walking, car, bike, transit etc. At the same time, their prevalence also played a role: number and range of pedestrian paths, roads, bike lanes, bus lines. Finally, characteristics, such as quality, safety, accessibility and affordability are relevant when describing the physical connectivity in a city. The indicators for Physical connectivity were selected through discussion considering that they contemplate all these features needed for enhancing physical networks in Skellefteå.

4.9 Driver Analysis

The first stage that we performed in the driver analysis step was brainstorming multiple driving forces that could influence decisions in our environment. We focus on factors external to our system and in which stakeholders included in the boundaries of our system could not have control over. Covering the social, economic, political, technological and cultural fields some of the proposed external drivers affecting our system were: long-distance working possibilities, distance learning, energy prices, new technology for renewable energy, health systems, climate change mitigation failure, conflict between Russia-Ukraine, quality of ecosystem services.

After a classification of the driver forces in the impact-uncertainty graph, we selected as our first key uncertainties, Energy Prices and Quality of Ecosystem Services. However, during the development of the futures plane, we decided that even when there were factors with high uncertainty there were other driver forces with a higher impact on our particular system.

As an example of how feedback works across the mPB, we realised that the selection of the key uncertainties was lacking in accuracy when creating the four plausible futures. Finally, the chosen external driver forces to utilise as key

uncertainties in the futures plane were Global Health Crisis and Mitigation Climate Change. Both of them were discussed and assessed by the group as the external factors with the highest level of impact and unpredictability on our system.

Finally, the external scenarios were developed. Later on, we employed this futures plane in the evaluation of the performance of the internal scenarios. The names were given to each of the futures to match the consequences of the high or low incidence of the key uncertainties. It was noted that for example in the future with high Mitigation Climate Change and low Global Health Crisis, named Healthy Happy Skellefteå, even when key uncertainties may appear as if they only affect the system positively this is not the occurrence when contrasting with criteria. Low Global Health Crisis, which may appear overall desirable, negatively affects nature-culture criterion.

4.10 Internal Scenarios

Construction of internal scenarios was rooted in a diverse selection of potential imagined futures reflecting growth around the connective basis of our criteria. This accomplished both directives of solution development elegantly. In the first instance, we ensured that our iterative solution generation could be directed and oriented by a collective understanding of the criteria we would test them against. This gave us confidence to independently develop characteristics of the future socio-technical system such that they could coalesce into a coherent set of dimensions to ground our internal scenarios in. In addition, the connectivity theme of our criteria ensured that any conceived dimension would be grounded by interrelationships between stakeholders within Skellefteå, as no connective dimension could have an isolated impact on less than two different stakeholders. This helped to counterbalance the lack of direct information we had to work with regarding the vision those stakeholders had for their city, and give our solutions the best chance of allowing for manipulation and shaping by stakeholders to deliver the most relevant results.

Through iterative conception, discussion and editing of various dimensions, our group was able to reduce nearly a dozen potential dimensions to the agreed upon five. This process necessitated continual refocus by the group on dimensional states so that we all agreed we could conceive realistic situations where they might be preferred. This created a strong force within conversation driving for greater consolidation of dimensions into one another. In order to counter this force, a restriction that no two dimensions could be combined if there was a reasonable case made that the two dimensions have states that do not align with one another after combination. For example, the dimension of “plurality of geographical interrelationships and mobility within the city” involved one of the most contentious dimensional mergers. Compromise had to be achieved in order to create a powerful dimension with comparable impact to the others. The group felt that mobility and geographic compartmentalization were closely related and could be described in one

dimension, however ensuring that no plausible case where mobility and geographic compartmentalization moved between dimensional states in two different directions proved difficult. Eventually a case where mobility was greater and geographic compartmentalization did not inversely decrease was identified. Discussion isolated the city centre-oriented transportation to be the key factor in that scenario, thus consensus was achieved only after such a dimension was included alongside the high mobility-low compartmentalization and the inverse states.

4.11 Scenario testing

The discourse that evolved surrounding scenario testing was one of the more laborious and time consuming components of the mPB framework. In order to prevent strong voices from controlling internal scenario judgement, a series of individual assessments followed by group analysis were performed iteratively. Criteria testing discussions centred around getting to the root motivation of gut feeling score assignments to identify features within each scenario that support high or low criteria scores. This would prove productive for our transition from this module to solutions and pathways, but was cumbersome in this module. Ultimately, high criteria scoring across different scenarios for different criteria was a positive sign for the validity of our morphological analysis. Criteria analysis also revealed greater potential for one scenario that maintained similar strengths and format to another, allowing us to reach a consensus to remove the underperforming scenario prior to robustness testing. Robustness testing was less intensive than criteria testing, and felt more like a self fulfilling prophecy as we reached easy consensus on the strengths of each scenario measured against our key uncertainties. This may have been the result of prefiguring scenarios during development that felt inspired by certain extremes in our key uncertainties. Nonetheless the visualisation offered by the completed robustness test factored significantly into grounding conversations about the potential strengths offered by each scenario for the purposes of creating our final scenario.

One notable group reflection after completion of robustness testing was the predictable nature of evaluating key uncertainties. Initial uncertainties were more Skellefteå specific and further from the popular zeitgeist. These uncertainties were undermined by an ambiguous assessment of whether internal processes could influence them. Further afield uncertainties could not reliably be tied into all of our criteria. The choice to use climate change mitigation and prevalence of global health crises seemed inexorable the more we assessed our options. This presents a crucial challenge of key uncertainties; the easiest key uncertainties to conceptualise impacts from are frequently well-covered concerns in popular culture. While robust information and a wide array of predictive data make these attractive choices, uncertainty analysis should target the challenges that may not be foreseen by planners. Thus while we consider our choices valid, they do not cover more

unknowable unknowns that are likely to impact the development of potential sustainability solutions in Skellefteå.

4.12 Final combined scenario

The process of coalescing the strongest characteristics of each internal scenario into a unified set of institutions and idealised experiences was not straightforward. The internal scenarios were selected partially to highlight their differences, therefore simply mashing them together would have created inherent value-based contradictions and eventual action driven contradictions. To effectively unite them, the iterative component of the mPB process was necessary. Foremost was a return to our criteria and vision. These two modules have to follow easily from one another and be in alignment for a combined scenario to exist. ‘Higher’ values in our scenario testing could only be understood as better to the degree to which they aligned with the spirit of our vision. Therefore construction of the final combined scenario was more of a building out of various characteristics that were imagined by the group to be featured in our independent visions of a sustainable Skellefteå. Our criteria provided unifying perspectives to take on the form and efficacy of these characteristics which brought each more or less into focus. Only at this point could we reintroduce the best of each internal scenario for integration, where contraliation was more or less valuable, how incentives and motivation can be used to drive institutionalisation of beneficial community values like participation and stewardship. The eventual formulation was as much a product of this conceptual milieu as it was the specific ideas that were generated by it.

4.12 Pathway

The iterative nature of this method combined with all the different outputs provided by the previous processes makes the creation of the Pathway a laborious work that requires a global understanding of the system under-study, as well as of the future vision. Through this process it is possible to reflect on what changes need to be satisfied in order to reach the aimed vision, and, at the same time, gives a new perspective on the final combined scenario giving a reflection point that may push to rethink the solution and vision along the way. The application of the Pathway modules on our vision has enabled us to have a better practical perception of how it can be realised. During the brainstorming so many changes have come out, the reason why we proceeded with adding two additional clusters that we identified as more suitable to our perception of them. The second step has revealed the most important and insidious process of the module. Addressing the changes to the related stakeholders has led us to a better understanding of the transformations and has shifted our conception of the system’s dynamics leading us to re-think the way that the changes would have taken place.

4.13 Follow-up experiments

Following pathway exploration and timeline construction, participatory committees or working groups featured prominently in initial steps. As a result, the formulation of these into an experimental style happened quite fluidly. However, challenges arose as more detail and resolution was needed to create concrete goals and risks to be considered during iterative experimental adjustments. It became necessary to examine the amount of direct vs indirect municipal involvement to find an experiment that could form a backbone. This steering group would help bridge the gap between current vertical structures and the desired horizontal power dynamic the experiments sought to create. The resultant risk of centralisation was inevitable. While five experiments have been formulated in this initial round of experimentation, a useful publication from smart city Aarhus in Denmark formulated roughly three dozen working groups before distilling out two thirds of these (Snow et al, 2016). This provides a glimpse at the complexity of a horizontal network in transitions and how important establishing mutually validated goals and iterative learning economies will be to the success of lateral empowerment.

This reproduction for decentralisation will be more applicable to community groups which benefit more from multitudes of diverse voices than sectoral coordination that will be more effective with greater centralisation despite more digitalisation. The city planning working groups will of course strike a balance between diverse discourse and action. The most challenging part of experimental design was the construction of information economies the municipality could energise that would become self-sustaining. This was because any privileged information, even as a result of some stakeholders having more time or energy to review available information, can lead to imbalances that limit diverse participation. This is a very real risk for all the working groups considered and it is considered one of Skellefteå's greatest assets that firms and municipal employees are motivated to distribute power in the interest of benefits to the citizenry. Without such a will, citizens may not have the necessary time to build up a culture of participation that is so critical to social connectivity.

4.14 Conclusion

Interrelationships between municipal, community and economic actors in urban settings will play a major role in the realisation of sustainable transitions. The vision and work of this project represent an experimental design for the empowerment of networks of actors, through iterative goal orientation and feedback. With patient implementation, this approach has the potential to facilitate Skellefteå's sustainable transition in the coming decades to a more welcoming and accommodating home for its citizenry that promotes collaboration and innovation.

5.0 Group Dynamics and Project Management

5.1 Applied approaches to project management

The group agreement decided in the beginning of the project had the following points:

- Communication via whatsapp
- Inform the group if you are unable to make it to the meeting, and if you are going to be late
- Moderately formal reflection after each meeting; regarding teamwork, project work etc.
- Rotating secretary for each meeting, responsible for updating miro and keeping record of project process. Create zoom link if online
- Recurring meeting 1/week
- Create a schedule for project meetings (time and date) and thereby ensuring everyone is able to come prepared, including in-person meetings
- Use brainstorming together as a tool to support mPB, especially at the beginning of each step in the process

Except for designing a secretary for each meeting, all points in this agreement have been followed. In the case of schedule for project meetings the general way has been to talk about what needed to be done during seminars, previous meetings or whatsapp. In the final stages of the process, more than one meeting a week has been required to finalise all the project results and generate deliveries; report and presentation.

5.2 Facilitation techniques used

A combination of online and in-person meetings have been carried out during the duration of the project. In both cases, the platform employed for sharing purposes and as a brainstorming board has been Miro. The incorporation of the course's Miro canvas develop during the seminars and our own personal canvas contains all of the components of the mPB framework. Additionally, gdrive has been used to keep deliveries and data documents used. Finally, for means of communication whatsapp was the preferred application.

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7.0 Appendix 1

Problem Orientation

The PO module intends to specify sustainability challenges and trends (Pereverza et al., 2019), and in this context provided an initial overview and orientation in the municipality and its challenges, goals and objectives. Here, primary data from stakeholder presentations preceded subsequent data collection, and provided the investigation with pointers as to which sustainability challenges are prevalent in the municipality.

System Boundaries

The system boundaries for this project are in part set by stakeholders, municipal borders constitute the spatial boundary, and the temporal boundary being 2050. SB considerably influences the space available for change (Pereverza et al., 2019). Hence, challenging conventional system boundaries enables re-framing and re-grouping of issues, which in turn enables innovation. Therefore, other system boundaries besides spatio-temporal, were set with this in mind.

Current Situation Analysis

The CSA provides further and more specific knowledge and data of Skellefteå, thereby reinforcing the PO module. Here, focus lies with socio-technical systems (STS), their configuration and relation to each other (Pereverza et al., 2019). Data was collected mainly from secondary sources, but was supported by Q & A sessions with municipal stakeholders (primary sources).

Stakeholder Analysis

The selection of stakeholders were collected using secondary data, and their relative power and interest was analysed using a power-interest grid, as proposed by Ackermann and Eden (2011), and used in the mPB framework (Pereverza et al., 2019). The mPB process places weight on the participatory aspects, justifying stakeholder analysis early in the process. However, due to project time and resource constraints, stakeholder participation was limited, which limited the utility of the analysis that was made. The stakeholder analysis was recreated later in the process, after internal scenarios had been formulated. Stakeholders' current and potential future roles were assessed to identify and allocate responsibilities, in favour of a power-interest analysis.

Needs and Functions

The investigation of needs and functions is an iterative procedure, whose goal was to break down a problem in order to find the needs and functions that are generated by it. The means by which it was possible to obtain needs and functions, starting from problems, is called "Why?"-question technique; it mainly consisted of

tentatively questioning every problem until it unravels up to the reasons of its presence, and so to the needs that are required to deal with problems. The utility of such a method was that it didn't limit itself to analysing the actual system configuration, instead it could be applied to the future possible configuration finding out needs and functions that we shall experience as time moves forward.

Vision

'Incrementalism with perspective' is an approach that can be used to plan for societies within an already existing built urban environment, in which the 'perspective' element refers to an image of the future – a vision (Neuvonen & Ache, 2017). Therefore, the formulation of vision using mPB aimed at defining a desirable future based on the identified problem that was focused on. Since the vision would be shared by the actors involved – in which there are many actors in a municipality – the vision formulation needed to be relatable to the actors and considered the existing norms and values.

Criteria

In this step of the participatory backcasting method, the goal was to create a strategy for evaluating the scenarios that would be devised in the following steps (Pereveraz et al., 2019). For this, functional criteria are generated to validate that all aspects of the vision are considered. Criteria and sub-criteria have the property of being quantifiable or qualitatively assessed. They also had to provide coverage and reflect multiple aspects.

The first stage was to identify the key elements of the vision. These key elements were associated with a criterion. Criteria specified how the solutions proposed must be. The next step was to associate multiple indicators or sub-criteria to each criterion. These indicators assessed how the solutions performed and how well they connected with the vision. Measuring the indicators allowed demonstration that a solution could align with the vision, and could cooperate in approaching the problems at hand. The final step was to decide how the measurements or assessments of each indicator were going to be carried out.

Driver Analysis

In the driver analysis step, the goal was to identify the more impactful and uncertain driving forces external to the system. With these, four possible external futures were developed to constitute a futures plane.

In this step, the stages to perform are the following:

- Perform Impact-uncertainty analysis to the driving forces. After having identified through brainstorming or document analysis a number of drivers, they are classified according to their impact and uncertainty level. The Impact-uncertainty analysis allows dividing drivers into key uncertainties (high impact and high uncertainty) and trends (high impact and low uncertainty). Key uncertainties are

applied afterwards for sensitivity analysis and the two with the higher uncertainty and impact will be the axes of the future plane. Trends are employed in the future plane as a way to understand the different futures.

- Develop external scenarios. External scenarios are possible futures based on the key uncertainties. A “futures plane” grid is constituted by four external scenarios. Key uncertainties correspond to the axes of the grid; four different spaces are created matching each of the four external scenarios which will be given a title and a description. The consequences of identified trends will be different for each of the futures and therefore influence their description.

Internal Scenarios

Development of internal scenarios within mPB is grounded in the two principles of criteria adherence and prioritisation of stakeholder participation. To construct solutions that satisfy these axioms while simultaneously reaching beyond the conventional limits of brainstorming solutions, morphological tables were employed (Pereverza et al, 2017). Construction of morphological tables was consensus-based. First, crowdsourcing potential dimensions individually by imagining features of possible futures and grounding them in one or more criteria, then discussing these dimensions to expand their scope to cover the most realistic states. Scenario construction was accomplished similarly, by random selection of a given set of dimensional states, then discourse to first characterise the features of the scenario and then tweak states that were misaligned with the groups collective vision.

Scenario Testing

Scenario testing is used as in-depth analysis of the potential each internal scenario has to contribute to an amalgamation that represents the most attractive characteristics of all analysed scenarios. This resulting set forms the foundation for formulating solutions that will have robust, criteria-driven results. Not all features within different internal scenarios will be compatible, therefore this development is contingent on compatibility consensus. Testing is evaluated against criteria and relevant uncertainties. Criteria testing involves consensus-based scoring of each criteria for each internal scenario, to highlight scenarios that support strong progress within each criteria. Discussion as to the roots of this relationship lead to generating solutions grounded in these traits. Robustness testing involves analysing internal scenarios against our constructed futures plane. First all valid areas on the plane were filled, then overlaps were minimised by deferring the space to the scenario that it was decided handled the given uncertainty better. Scenarios with large resulting areas were considered more robust.

Final combined scenario

The method for producing a coherent final combined scenario is one of grounded brainstorming. Group members repitched projects, policy and concepts with various histories in the project. Some ideas had been kicking around conversations since day one, while others were generated first in this brainstorming. What enabled confidence in this discourse and the conclusions that emerged was a strong foundation in the vision and criteria that had not been present in previous conversations and throughout litmus testing by scenario testing, to screen well-reviewed concepts for applicability. The results of this were categorically smattered onto a venn diagram according to their nature, with many occupying multiple roles due to the interdisciplinary nature of this vision. Merging and diversification followed iteratively, until session momentum wound down and energy seemed more invested in organising than producing ideas. This was the role of developing a pathway to introduce a time dimension and generate more minute relationships within ideas.

Pathway

Pathway creation is an iterative method that consists in the development of a path that is defined by a set of necessary changes and related actions, which can realise the vision by means of the chosen solution. This method is anticipated by the analysis of the current situation, the stakeholder analysis, the vision and the solution testing. The creation of the pathway needs to be powered by the outputs of the previous modules since it will provide a set of changes that are required in order to achieve the desirable vision by means of the chosen solution. This process is divided into four different steps.

The first one consisted in identifying what changes were necessary to be made in order to safely realise the final vision. These changes can refer to the actual configuration, as well as to a future one; these changes then need to be clustered by types (Cultural, Structural and Technological).

Secondly, it was necessary to identify all the stakeholders that needs and may be involved in the implementation and/or facilitation of the changes. The proper stakeholder identification is crucial since it may indicate the potential of different strategies to enable the same change.

In the third step, a timeline that went from the future to the present day was created. The previously identified changes would be placed accordingly on the timeline to create a visualisation of the pathway.

Finally, analysis of the whole pathway enabled identification of possible barriers and drivers that could affect the implementation of each change.

This process aimed at the creation of pathways, but also represented an opportunity for reflection. Deliberating over how the vision could be realised invoked out of the box thinking of the solutions and vision along the way.

Experimental Follow Ups

At the core of the initiation of the solutions pathways is the establishment of working groups. Working groups and their organisational managerial equivalent, the steering committee, represent a horizontal framework for collaboration towards mutual objectives. The framework is actor oriented and is composed of three vital components that must work in tandem for operations to proceed successfully. *Actors* must have the opportunity and drive to self-organise. *Commons*, or accumulated shared resources, must be made available and demonstrate communal governance. *Protocols and procedural infrastructure* must guide actor behaviour and create collaborative networks that can ensure equitable distribution of information (Snow et al, 2016).

These principles are critical to design community infrastructure to transition from municipal to communal self governance in order to create a more active and vibrant Skellefteå. Municipal willingness to participate in this transition is vital, which offers an exciting opportunity for successful implementation. The facilitating and guiding role of the network steering group will be the most municipally focused experiment, with community working groups forming a halo of horizontally active initiatives, capable of self differentiation and reproduction to meet the changing needs of stakeholders during Skellefteås sustainable transitions. The implementation of democratic feedback and goal orientation information will be vital as iterative changes constantly adjust the developing transition pathway.