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European University of Technology

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Foreword

The European University of Technology (EUt+) is the result of the alliance of eight European partners which underpinned the European Universities Initiative. The European Universities initiative responds to a long-term vision that has the potential to transform the institutional cooperation between higher education institutions and bring it to the next level. Within the European University of Technology, technological foresight is understood both to be a speculative leap forward and one grounded in the practice of technological development which is embedded in the cultural, social and political context. There is a conceptual precision work in the definition of "foresight", which needs to be distinguished from predication, probability, innovation and invention.

This 'Technological Foresight' Document in EUt+ alliance combines three associated deliverables. They are presented in three successive sections, which correspond to three incremental iterations over the three years of the project. These sections/iterations are:

I. State of the art
II. Methodology of the ECT Lab+ for technological foresight
III. Policy implementation

This work has several objectives, that are time-related. The immediate short-term object is to develop a technological foresight methodology which is interdisciplinary and policy document for the European University of Technology. This is presented in this deliverable. In line with the long-term vision of the EUt+ initiative, this deliverable lays the foundations for future development. The mid-term objective is to have a clear strategy for technological innovation and technological education within the European University of Technology. Finally, the long-term outcome is to influence technological innovation at a policy level within the European University of

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Technology and the wider social and political context of technological innovation within the European Union.

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Introduction to the deliverable

Building on the work carried out over the first two years of the EUt+ pilot phase and the activity of the European Culture and Technology Laboratory (ECT Lab+) it was decided that the ECT Lab+ could try to experiment with the development of its own methodologies to predict technological innovation. The fundamental presupposition is that culture and technology are not in opposition to each other, but rather technological development is rooted in its locality or milieu. We have argued that this cultural locality or milieu includes forms of imagination and fiction or poetic conceptualisation of the technical objects, that are relevant when it comes to developing a methodology.

In addition to standard modes of prediction from Futures Studies, we decided to look to the areas of Systems Theory and the Delphi methods and we also recognised that it is necessary to include those imaginary or poetic elements within the cultural background to the technical or technological expertise. The purpose of the methodological development within the ECT Lab+ is to explore methods and methodologies related to technological foresight. Over the last 40 years, there has been the development of specific forms of technological foresight which are based on modes of speculation about technological innovation. In the Section II of this document (D4.3.3b) we have set out an overview of the literature related to technological foresight and in this phase of the ECT Lab+; it was decided to explore how we could develop our own technological foresight methodologies. The methodologies we chose are based on what we could call a mixed methods approach, using elements from Systems Thinking, Delphi methodologies and more speculative methodologies such as Speculative Fabulation. The premise for the mixed methods approach was based on the recognition that standard methodologies for predicting the future of technological innovation needed to be aligned with research coming from technological innovation where science, art and technology have come together.

Section 1 (D4.3.3a)

Introduction

The European Universities initiative responds to a long-term vision that has the potential to transform the institutional cooperation between higher education institutions and bring it to the next level. EUt+ is not a project with a defined life cycle, but an ongoing initiative, that is built around a common vision - a central pillar "Think human first" from which the following principles are derived:

Technology is first and foremost human. Technology is more than a set of techniques or applied sciences. It is our essential human ability to express, think and understand the world through artefacts. In this sense it is an engine of human progress where arts and science meet. The human sciences are at the heart of the EUt+ curriculum in order to shape engineers and technicians who are aware of global issues but also technologically responsible citizens.

Diversity and multilingualism as an opportunity. EUt+ aims to ensure that every student feels at home on all the alliance's campuses and can move freely from one country to another. Immersive technologies allow a first exposure to the multicultural environment in order to overcome psychological, economic and physical barriers.

An inclusive university. Founded on the principles of fairness, respect for human rights and European citizenship, EUt+ is committed to providing every student with the resources to achieve the necessary requirements and realise their potential across European campuses.

Through EUt+, the partners are committed to creating a sustainable future for students and learners in European countries, for the staff of each of the institutions and for the territories and regions where each campus is anchored.

This document presents the first iteration of the 'Technological Foresight' Document in EUt alliance.

1 The objectives

The long-term outcome of the work initiated in this deliverable is to influence technological innovation at a policy level within the European University of Technology and the wider social and political context of technological innovation within the European Union. The mid-term objective is to have a clear strategy for technological innovation and technological education within the European University of Technology.The immediate short-term object is to develop a technological foresight methodology which is interdisciplinary and policy document for the European University of Technology. This is presented in this deliverable.

Outcome: is Technological Foresight methodology which is interdisciplinary and is policy orientated for EUT+.

The development of technological foresight methodology is premised on a number of presuppositions and presumptions which are in place namely the relation between technology and society.

The development of 'Think Human First' or 'Human Centred' philosophical approach presupposes that technology is not built in a vacuum but in and for society and by developing a specific philosophy of technology which sets out distinctions between *techne*, techniques and technology. Hence technology is no longer understood simply as tool or instrument from an anthropological perspective but as a process of becoming human, a process of mediation in the world of the becoming human.

The second set of presuppositions is an embedded relation between technology and ethics, technology has ethical consequences (ante, during mid res and after). The presupposition is that ethics is a form of praxis in the world aligned with technology as a form of praxis, therefore practical wisdom (*phronesis*) is needed. This leads to influencing technological foresight as ethical responsible innovation, therefore influencing technological innovation through the methodologies of foresight, foreseeing by influencing the future and not simply accepting passive, or disruptive role of technological development.

Question: Can we have a way of influencing technological development within the University which takes on board the think human first approach, responsible innovation and impacts on society?

However, the Expert is influenced by cultural imaginaries of technological development and innovation, including technological dystopias – hence Cultural Imaginaries influence the Expert and the field. The Expert is embedded in a milieu (individual, collective and technical), this milieu is also a location. These different locations include universities, technological innovation hubs and industry. Therefore, to critique how technological foresight functions it is necessary to determine the social and cultural milieu of the expert within technological development. This document sets out the initial phases of technological foresight within the European Culture and Technology Lab.

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2 How is Technological Foresight envisaged within the European University of Technology?

One of the central tenants of the approach taken within the European Culture and Technology Lab is that of ethical innovation or responsible innovation, or hermeneutic responsible innovation. Responsible innovation includes the entire cycle of innovation, from the extante methods (identifying emerging technologies, evaluating impacts) and intra methods (embedded values in design, disclose issues) to ex post methods (ethical decision making with technologies, analyse ethical impacts). (Rejers 2020).

Within the European University of Technology, technological foresight is understood both to be a speculative leap forward and one grounded in the practice of technological development which is embedded in the cultural, social and political context. Therefore, technological foresight is not a simple inductive process based upon the evidence of empirical data demonstrating certain areas of technology prevalence, whilst it is that, it is not only that. Within the ECT Lab+ the premise is that technological foresight is also speculative and imaginary process whereby the technologies of the future can be speculative fabulations (Donna Haraway). The presupposition is that technology is here understood as forms of mediation in the world, that is equally building on social technology (Searle), postphenomenology (Don Idhe), Narrative Technology (Ricoeur, Cockelburg), Cosmothecnics (Yuk Hui), Organology (Stiegler), integrative objects (Schmid). In this sense, technologies are understood not simply as tools or instruments but also systems of mediation in the world. Therefore, Technological Foresight involves not only the prediction of forms of techno-science to make into new technical objects but also how technical objects themselves are embedded within technological systems (individual, collective and technological systems). For example, one could imagine a plane as a technical object compromising other technical objects and systems, including the seats, seat belts, pressurised doors, navigation systems, compromising software systems, digital objects, codes etc., but also integrated into planetary technospheres (Stiegler) of GPS systems, aviation management systems, airport

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management, traffic management in airports, passenger identification systems, boarding passes etc. Hence, the technical object in and of itself is a part of a technical system. In addition, the technical system does not exist in and of itself, it is embedded within an environment (milieu) which is cultural, technological, economic, social and political (Simondon). Technological foresight, is therefore, presented here not as the predication of forms of technical objects but the foreseeing of technical objects within technological systems.

It is also necessary to set out from the beginning distinctions in vocabulary, distinctions between predication, probability, foresight, innovation and invention. The ability to predicate what will happen next is based on inductive logic, if A and B then C and most predicative modelling will take this format. The looking to the future from the past and the present is the method used across probabilistic reasoning, whereby the past and the present are used to develop high probable future scenarios. The low probable and the highly probable are distinguished. However, it has been argued that the contingency element of low probability (Hui) needs also to be included. Something which is highly unlikely contains within a certain level of possibility *probability which is contingency. The use of the term foresight is problematic as it implies the ability to foresee something. The ability to foresee has a certain mythico-poetic resonance of the fortune teller, the sphinx who can foresee the future and tells us in riddles (Homer). The foresight to see before the future brings into perspective other modes of seeing, other imaginaries, the ability to imagine the future possible, to imagine things differently, a poetics of possibility (Ricoeur, Kearney). The development of technical objects within technical systems has been traditionally presented as modes of invention and innovation, invention holding the connotation of 'out of the blue' whilst innovation is from general usage linked to the economic mode of exploitation; innovation implies the development of something new to be exploited anew. Here the distinction between invention and innovation can be simplified to innovation within current technical systems, economic and social systems whereas invention tends to be linked to techno-scientific invention.

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The first phase of the task set in 2020-2022 has been a gathering of information and the development of a shared literature review on technological foresight. The initial discussions looked at existing examples of standard technological predicative modelling such as the Gartner Hype graph. It was quickly ascertained the limitations of such an approach the group began to look at alternative models such as the Delphi Method. As there was particular expertise in relation in the subgroup in relation to Delphi methodologies as a way of capturing expert opinion on developments within specific field it was decided that the first phase of the technological foresight group was to investigate alternative methods of prediction. This would include standard European Commission discourses on applied technological development such as the Horizon programmes, Horizon Europe, The Green Deal etc but also to look at more speculative methodologies such as Future Studies and imaginary futures.

Within the Technological Foresight the ECT Lab+ is proposing that technology is a form of technical practice, as social and collective practice (Bordieu) and practice as form of becoming in the world (Aristotle), the repetition of action which defines practice, this understanding of action in the work is also a narrative description of the technical practices from an individual, collective and technical point of view. This is in line with the development of a virtue ethical framework (Ricoeur's 1990 little ethics) and then developed as the ethics of technological practices (Rejers, Cocklebergh 2020). The technological foresight is therefore linked to technical practices but also speculative futures such as articulated under Future Studies (see below). In an effort to see how applied funding models instigate the development of certain technologies we examine the Horizon Europe programme. This is beyond the cluster II pillar dedicated to SSH but looks at the overall applied funding programme; this is outside the fundamental research funding which can be allocated under ERC or the MSCA programmes. In a similar vein the Green Deal gives an opportunity to envisage how technology and technological development is envisaged by the European Commission under the headings of the Green Deal. "The sociology of expectations distinguishes between generic, or weak, and effective, or strong, performances of expectations.

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Strong societal expectations can influence the dynamic, direction and focus of technological innovation"[1].

2.1 Futures Studies

After numerous iterations, and with a presence in the UNESCO (with Riel Miller and Sohail Inayatullah as representatives), the field of Futures Studies is increasingly moving in the direction of futures literacy and anticipatory systems in the sense that global, national and organisational policy making will be based on anticipatory science rather than political whims. "Futures literacy is the ability to read the future with greater effectiveness so that tomorrow's problems can be solved today; so that emergent opportunities can be used to enhance well-being. Prevention of disease, of calamities,

of social problems, is crucial in this work." (Inayatullah, 2020, online, np.). The Technological foresight methodology of the ECT Lab+ will include elements of the future studies approach to ensure that the methodology will move beyond a standardised quantitative Delphi method.

Futures Studies is a term used to tag a vast collection of mainly multidisciplinary research dealing with a set of issues and questions regarding how the future might unfold. Modern Futures Studies span from the 1960's right through to the present and although their common purpose is to cast an informed opinion on the (uncertain) future and influence the course of events, their approaches differ and often mirror the zeitgeist of the time when they were conducted (Amara, 1991, Puglisi 2001). From a focus on predicting the future, the modern discipline of Futures Studies has broadened to an exploration of alternative futures and deepened to investigate the

[1] https://journals.sagepub.com/doi/full/10.1177/2053951720915939 Sociology of Expectation AI and expectations

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worldviews and mythologies that underlie possible, probable, and preferred futures (Inayatullah, 2017, online, np.). This preliminary literature review reflects that diversity and is presented as a conversation between different approaches. For the purpose of this report the breath of Futures Studies is organised into three categories:

- Dominant, preferable and probable Future (note the singular)
- Alternative/disruptive Futures
- Visions

Projecting the future has been linked to power since time immemorial. From seers guiding princes' actions in wartime to predictive analysis and high-frequency stock trading, the ability to predict/foresee the future has been linked historically to the rich and powerful and the capacity to design and control what-is-yet-to-come toward self-fulfilling prophecy. At first glance, Futures Studies might appear simply as a collection of modes and methods ranging in sophistication and success, using both quantitative and qualitative methods to "see" beyond the here-and-now. Approaches can be situated in a continuum ranging from models seeking scientific legitimacy and robustness through the "imitation" of the language of the natural sciences - the mathematization of discourse in early renditions of Rand's corporation Delphi method for example (Amara, 1991, p.645, Glenn, 1994) and Trend Based Scenarios (Miller, 2006) - to post-humanists and situated feminism models seeking the decolonisation of preferred futures, these include narrative forecasting, speculative fabulation and back casting (Truman, 2019; Milojević & Inayatullah, 2015, Haraway 2012; Inayatullah, 2020).

One possible way to approach Futures Studies is on a continuum between more and less "desired" (to some social group or stakeholder) futures. For instance, critical/non-solutionist approaches to design research (Dunne, 2013) or future-related art such as science fiction (von Stackelberg and McDowell 2015) can function as a probe to speculate on alternative/possible futures (rather than just market-feasible ones). Alternatively, accelerationist theories (MacKay & Avanessian, 2019) intend to function as political motors to bring forth (self-fulfil) particular (techno-capitalist, techno-socialist, or other) futures.

Predictive approaches are perhaps the dominant paradigm in Futures Studies at present. In this category, discourses of futurology remain technologically focused and are predicated on risk reduction. Originally based in the economic and defence disciplines they have shifted more recently to broader social concerns such as anthropogenic climate change (Inayatullah, 2019; Facer & Sandford, 2010). Given the appearance of legitimacy and accuracy by their use of quantitative analysis and big data, these models are favoured for their air of certainty in a field that is often criticised as lacking scientific robustness. However, there has been a move to more alternative epistemic frameworks that problematize the dominant narratives. For instance, how the methods may make basic assumptions on time, economics, politics, and ideological-cultural concerns that are naturalized through the constructive forces of the past, power, history, colonialism, and language. Cultural, Sociological, Feminist, Queer, and Race Studies theories position predictive futures studies models as always already politically constructed, a triumph of one discourse over others. An emphasis on the situatedness of knowledge (Haraway, 1988; Paul, 2019) and its impact on realizations of the future point to both implicit and explicit biases in the mapping of futures and therefore the construction of it. Possible futures produced by these methodologies are seen as merely prolonging existing trends through a radical constriction of variables and as a model that always moves toward the simplified, the desirable, and the normative (Selin, 2008). Alternative approaches examine issues of power and legitimacy and the role of the expert in influencing technological policy and development. Who exactly gets to be an expert and how are these identities created in spaces of knowledge? (Inayatullah, 1998) What exactly is seen as a desirable future - normative Futures Studies often sees itself as a force for good - the triumph of liberal western democracy, individuality, capitalism, and rationality.

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Speculative Fabulation (Haraway, 2012) is a methodology of generative science-fictional storytelling that allows other vocabularies, possibilities, and necessary contestations of situated knowledges. It is a toolkit that opens up spaces of experimental friction between the sciences, the humanities and the arts to create mutually constitutive conceptions of future technologies and ecosystems (Ptqk, 2021). The potential to imagine alternative modes of collective living is particularly urgent in the current global extinction crisis.

Science fiction literature as a form of future studies typically deals with sociotechnical imaginaries, understood as “constructed landscapes of collective aspirations” (Jasonoff, 2015 pp. 1-33, p. 6). In this sense it serves as a repository of a collective vision of the future, which includes the aspirations, hopes and fears of a community shaping and shaped by technoscience. Science fiction has also succeeded in predicting, pollinating, and co-shaping the future, as discussed in Hayles (2000), Manovich (2002) and Shaviro (2016).

Alternative Futures Studies stresses the availability of diverse alternative trajectories; the need for participatory scenario building to shape technology; and the importance of continuously re-stating the openness of the future. They address the range of cultural and cosmological backgrounds that can produce interpretations of probable and desired futures, an openness that presupposes change and a reconfiguring of power structures. They are based in uncertainty however, and as such are far less desirable to solution-focused management.

Artists and creative technologists also pose questions of ethics, ecology, politics, and the possibilities and impossibilities of future societies. Annual art festivals such as Ars Electronica and Transmediale act as hubs for both innovation and critical examination of everything technology related – from smart cities to biological augmentation and from artificial intelligence to virtual reality displays. Techno-scientifically driven artistic research, and media arts in general, actively speculate on and act to forge and shape the future, creating new kinds of phenomenological experiences that resonate through culture and society. Artistic research or practice based artistic research is now an established research methodology also participate in the speculative processes of socio-technical imaginaries and participate in the establishment of imaginary epistemologies which equally influence the environment of technological innovations. More recently, the development of contributive or contributory research includes aspects of socially engaged artistic practice methodologies coupled with those of citizen science (Fitzpatrick, 2020, 2021). Contrbutory research places questions of imaginary future or possible futures within its methodologies.

2.2 Delphi Methods: Application to Technological Foresight

As mentioned above when describing the range of approaches to predictive studies, at its core Delphi would be closer to the one end that aims at imitate exact and natural sciences in its methodology. Thus, it can be described as an iterative method that utilises questionnaires administered to experts in a particular field, to capture opinion on the state of the art, or to forecast future events. Typically, a questionnaire is administered anonymously to experts in the first round, from which the statistical summary of opinions from the entire sample is distributed to participants. Following this dissemination of opinions from round one, a second round of questionnaires is completed to capture the changes in orientation of the participants, and after which, the opinions of the participant experts tend to converge (Dayé, 2018). As Delphi has developed as a critical tool in forecasting under constrained circumstances, we have explored its merits and demerits and we outline its potential application to the objectives of the ECT Lab.

Originally the Delphi Method can be seen as an instrument that allows for collective knowledge sharing, lending itself in those cases to solve problems where analytical techniques are difficult to apply. However, since its origin it has been used in different fields such as industry sectors including health care, defence, business, education, information technology, transportation and engineering (Skulmoski, Hartman and Krahn, 2007).

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While Delphi began its life under the aegis of the Rand Corporation it has had a wide range of uses including in forecasting public policy, identifying technological trajectories, and for firms wishing to gain expert field knowledge to inform production and design decisions (Bloem et al, 2018). Its origins reach back further in spirit as its name is associated with the oracle of Delphi where scholars collected information and involved experts in deliberative discussion. In its contemporary use, Delphi is used as a survey technique where the data and feedback can be carried out digitally (Steurer, 2011). In the process of feedback, Delphi derives an advantage from anonymity, which is a key driver of the group opinion building process; leads to less disagreement and moves towards consensus (Kauko & Palmroos, 2014).

The purpose of Delphi is to analyse complex problems and is not concerned with generalising to populations. As such the sampling frames are purposive, driven by the need to capture expertise primarily, and sample sizes tend consequently to be low given the small base of knowledge that may exist in relation to the problem to be defined. The Policy Delphi variant of the method was conceived as a means of 'disrupting received wisdom in order to generate rival insights' in order to forecast public policy problems (Edwards et al, 2020, p. 4).

Although the opinions of the participant experts usually move towards consensus, the literature has few examples of where there is disagreement and divergence. An example of this can be seen in a policy Delphi research of energy futures in the UK which noted that we are now in a period of 'post-normal science', in which expert expectations of energy futures will differ in accordance with experts' 'assumptions, heuristics and values' (Kattirtzi and Winskel, 2020 p.3). The findings of this study stressed the salience of epistemic diversity and that policy-makers may indeed value the scoping of the range of divergence in expert opinion. Agreement or disagreement is based upon values such as who should be the driver of technological change. Policy Delphi methods can be used therefore to reliably assess disagreement and consensus.

Table 1: A Delphi Six-Step Procedure

Step 1: Setting up Delphi Process	Set goals; choose panel of experts (n=5 to 20 min); Decide on geographic dispersion; brainstorm issues to be addressed by survey; pilot
Step 2: Developing Questionnaire / Instrument items	Focus issues to be explored; design questionnaire using simple response categories; decid on what scaling used e.g. Likert
Step 3: How Delivered (software)	Paper, web, email or real-time?
Step 4: Providing Feedback	Median responses to be used; utilise qualitative data to reveal rational for responses; continue to next and subsequent rounds
Step 5: Preventing Drop-out from panel	Develop retention strategy to prevent attrition of panellists; communication strategy.

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Step 6: Data Analysis and Presentation	Use descriptive statistics; note small sample sizes; present graphically; integrate results with other methods / techniques used.

Adapted from Belton et al, 2019, p.73.

2.3 Horizon Europe - technological scanning

Within European Commission documentation there is no direct place to look for predicative modelling, however, implicitly the European Commission does influence applied policy research through the framework programmes such as FP7, H2020 and now through the Horizon Europe programme. The European Commission has moved on from Horizon 2020, a programme with a specific deadline embedded in its title, to something that seems to look further and potentially shape the progress of European research and innovations not for years, but decades to come. One can assume that the technological foresight vision for Europe is embedded in the programme or that it was fundamental to the strategic planning leading to what is now Horizon Europe. Hence, Horizon Europe should hold the answers to many, if not all, questions related to the future of European technologies and provide guidelines as of where European technological development is headed.

Foresight was employed in the development of Horizon Europe Strategic Plan by exploring "global megatrends, their interactions with the Sustainable Development Goals, and the implications of different future scenarios for EU R&I policy and its future orientations" (European Commission, 2020). The foresight activities, along with interim evaluation of Horizon 2020, revision of different thematic foresight reports, as well as identification of expected impacts, lead to the creation of five missions, putting additional emphasis on open science policy and establishing a new approach to partnerships (European Commission, 2020). The five missions of Horizon Europe are Adaptation to Climate Change; Cancer; Climate-Neutral and Smart Cities; Ocean,

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Seas and Waters; Soil Health and Food. Five mission boards consisting of experts from different backgrounds helped the European Commission identify the aforementioned missions. Although there is no doubt that experts are necessary for technological foresight and similar exercises, one has to take into account the risk of them being subject to different biases, because on which different studies emphasize that expertise per se is not the solution (Apreda et al., 2019) when it comes to technological foresight.

One of the key strategic orientations for EU research and innovation for the period 2021-2024, defined in the Horizon Europe Strategic Plan, focuses on "promoting an open strategic autonomy by leading the development of key digital, enabling and emerging technologies, sectors and value chains to accelerate and steer the digital and green transitions through human-centered technologies and innovations" (European Commission, 2021). The aim of making technologies human is emphasized throughout the Strategic Plan, notably, throughout Cluster 4 - Digital, Industry & Space. Human-centered technologies and the necessity to ensure ethical development of technologies appear in the key strategic orientations for EU research and innovation and are particularly emphasized throughout the expected impacts within Cluster 4. The European Commission has also stated that "the approach to research and innovation investments builds especially on the green and digital transitions by supporting innovation-based competitiveness and fostering technological sovereignty in key strategic areas" (European Commission, 2020) including artificial intelligence, 5G/6G, space technologies, renewable energy and others (European Commission, 2020).

A notable difference in comparison to its predecessor is that Horizon Europe will follow up with a restricted Swafs programme. For example, the only made available European Alliances [MO2] does not see a follow up to the 'Science With and For Society' programme known as SwafS (Gerber et al., 2020). This generated numerous concerns as the SwafS programme used to be one of the main embodiments of Responsible Research and Innovation (RRI), which serves as a connector between science and the interests of European citizens (Robinson et al., 2020). It is yet to be seen how successfully the new programme will tackle the absence of SwafS especially as according to the Horizon.

Europe Work Programme 2021-2022 for the missions to succeed they have to be carried out "in close synergy with funding, programmes and strategies both at Member State/ Associated Country and regional level, as well as with civil society and the private sector" (European Commission (WP), 2021). Although "RRI is integrated in Horizon Europe as an overarching principle" (Robinson et al., 2020), taking into account how essential civic engagement has been and continues to be in solving major societal challenges within the EU and beyond, concerns over the lack of a dedicated funding programme might not be without reason.

In addition, a danger persists that the new funding landscape will diminish the role of social sciences and humanities (SSH) when it comes to innovations. This is because "the emphasis on the contribution of research to economic growth fosters a technocratic paradigm in which the translation of fundamental research into innovative 'products' is seen as the benchmark of success" (Bell, 2019), which is too simplistic of an approach that belittles the role of SSH (Bell, 2019). As already mentioned, the new Horizon Europe programme puts significant emphasis on innovations and, even though often overlooked, it is critical to acknowledge that SSH can contribute to innovation in different ways. For instance, by challenging the ways social problems are approached, offering a possibility to explore hypothetical alternatives, considering the non-material features of human existence, challenging contemporary norms and others (Bell, 2019). The strategic plan does emphasize the importance of an effective integration of SSH in all clusters, describing SSH a key constituent of research and innovation, especially regarding the twin green and digital transitions (European Commission, 2021).

2.4 Twin Transitions- Digital and Ecological - The Green Deal

It is worthwhile to start with a definition of the foresight. One of the definitions used in foresight studies is: "Foresight is a method to see in the distance in time, broadly,

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analysing in depth, thinking to human, allowing to take risks" (Lacroix *et al.*, 2019). The study of 99 recent foresight studies, including 307 scenarios and dating back not more than 15 years revealed that science and technology appears as the dominant factor only in 15% of those studies (Lacroix *et al.*, 2019). The dominant drivers are governance, the economy and society. One of the roles devoted to science in narratives of the scenarios is to alert and enlighten decision makers. Science also could supply solutions for limiting waste of resources, reducing greenhouse gas emissions or improve agriculture yields. Many scenarios are quite pessimistic regarding environmental future, i.e. considering that degradation of water and land resources is inevitable, and risk of irreversibility being very high. Again, the science is seen as a tool for remediation or adaption. However, researchers in (Lacroix *et al.*, 2019) note that the foresight studies are limited by representatives, coming mainly from western part of the world. Networks of citizens (participatory sciences, crowdfunding, etc.) were not seen as being able to influence the future of their environment over those past 15 years. On the other hand, the foresight scenarios can help working groups and decision makers to adjust research programs and define research priorities for a given organization, region or horizon.

Competitiveness of companies largely depends on success of digitalization. Due to variety of digital technologies available, efficient individual technological sensemaking is required from managers for technology selection, implementation and management (Klos and Spieth, 2021). Findings from qualitative study of managerial sensemaking during and after foresight activities for technology selection and implementation in German construction sector show that foresight activities are too weak to influence the individual technological frames for a long period of time (Klos and Spieth, 2021). The results show that the relationship between individual and organizational technological frames is close and complex. The individual frames tend to gravitate towards the organizational technological frames after technology foresight activities in the context of digital transformation. The foresight activities also influence managerial learning process, cognition and capabilities but change of the individual technological frames have to be monitored with continuous data collection (Klos and Spieth, 2021). Companies should be allowed to deviate from the organizational technological frames to accelerate digital transformation. The study is limited to the construction sector which may consider that use of AI, VR, augmented reality or 3-D printing which can be limited in the near future. Therefore, similar studies should be made in other industry sectors (Klos and Spieth, 2021).

Digital transition enables new forms of "sharing economy" which are not limited by local and social proximity (Pouri and Hilty, 2021). Digital sharing allows the scale-up of sharing practices to large communities and can lower entry barriers. These new digital qualities along with change in consumption patterns with giving preference to shared use rather than ownership promotes this new phenomenon of the "sharing economy." Since the new quality of the phenomenon is related to the digital transition, it can be called "digital sharing economy." Digital technologies provide one of the three fundamental aspects of the digital sharing economy – digital online platforms that provide coordination mechanisms for matching demand and supply at nearly zero costs (Pouri and Hilty, 2021). The other two fundamental aspects are the technical aspect of sharing, referring to characteristics of sharable resources, and the social aspect of sharing that relates to rules of social interactions. The digital technologies transformed both of the other fundamental aspects, i.e. technical and social, by opening up a domain of sharable resources and providing new forms of sharing practices.

One of the biggest challenges and systemic failures of economic activities of our society has been inability to decouple economic growth from resource use. The European Green Deal is the strategy for overcoming this challenge of the decoupling and achieve zero net greenhouse gas emissions by 2050 (European Commission, 2019). The Green Deal is not only about climate but about transforming the economic development and society to follow sustainable, just and an inclusive path. It is about putting people first. The transition will require profound changes in all sectors, rethinking of policies, investment in research and development as well as in digital transformation. The digital transformation is seen as an enabler of the required changes, and ambition of EU is to put sustainability “at the heart” of digitalization.

Apart from setting new policies, regulation and standardization, the EU will have to ensure that the existing policies and legislation related to the Green Deal are effectively implemented. However, the existing policies are able to bring down greenhouse gas emissions only by 60% by the year 2050. Therefore, more ambitious actions are needed in the coming decades. These will affect also carbon pricing and environmental taxation with the ultimate purpose to change consumer and business behavior. Novel approaches, such as carbon border adjustment mechanisms, avoiding replacement of domestic production with carbon-intensive imports, could be implemented. Since energy sector accounts for circa 75% of EU greenhouse gas emissions, large emphasis will be placed on clean energy transition. Energy efficiency improvements, closure of coal power plants, decarbonisation of gas supply, use of renewable energy sources, integration and digitalization of the energy sector are among the most important steps.

Putting people first will mean that costs of energy to consumers and energy poverty will have to be properly addressed. Sustainable economic model and inclusive growth means that circular economy, providing new workplaces will have to be implemented, and that is an ambition of the European Green Deal. A particular challenge of implementing the circular and decarbonized economic model lies within energy intensive industrial sectors such as steel, cement and chemical, which are all very important for EU and other countries. Circular design, new business models (e.g. renting and sharing rather than owning of products), extended producer responsibility and similar initiatives all should help to implement the circular economy model. Digitalization will provide with data and information required to distinguish “green washing” from real improvements of environmental performance of products and services. Availability of the objective information is critical for making an informed purchasing decision. “Right-to-repair”, avoiding pre-mature obsolesce of products would be a significant step towards sustainable development of product systems, especially in electronics sector.

The EU Emissions Trading System Innovation Fund will provide funding for large-scale innovative projects related to energy and energy-intensive industry sectors. New technologies, disruptive innovation, large scale demonstration and deployment are needed in clean technology sector to achieve the objectives of the Green Deal. Sectors of transport, built environment, carbon-intensive industries, energy storage, clean hydrogen and circular bio-based sectors are some examples of the particular focus. Artificial intelligence, cloud computing, ultra-fast networks and internet of things are example of digital enabling environment needed for evidence-based decisions, predicting and managing environmental disasters, adaptation to climate change and creating very high precision digital model of Earth. The transition to decarbonized economy will also require considerable investment, re-skilling programs and adjustment of various practices. Long-term signals and taxonomy of sustainable activities should promote private investment in sustainable transition.

2.5 Emerging predicative modelling

Within of the areas of technological growth predicative modelling itself has become a means of technological foresight, predicative modeling itself as a form of machine learning or deep learning, using neural networks as ways of building models of statistical probability. In this area of growth the technologies are technics of mathematization and computer science such as natural language processing and semantic modeling. The ethical implications of such predicative modeling are only beginning to emerge as an area of reseach.

Critical Data Studies (CDS) explore the unique cultural, ethical, and critical challenges posed by Big Data. Rather than treat Big Data as only scientifically empirical and therefore largely neutral phenomena, CDS advocates the view that Big Data should be seen as always-already constituted within wider data assemblages. Assemblages is a concept that helps capture the multitude of ways that already-composed data structures inflect and interact with society, its organization and functioning, and the resulting impact on individuals' daily lives. CDS questions the many assumptions about Big Data that permeate contemporary literature on information and society by

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locating instances where Big Data may be naively taken to denote objective and transparent informational entities. In this introduction to the Big Data & Society CDS special theme, we briefly describe CDS work, its orientations, and principles.

Sensor-based technologies are increasingly integrated into diverse aspects of our everyday lives. Despite the importance of understanding how these technologies are adopted and exploited by businesses and consumers, the information systems (IS) community has thus far devoted relatively little attention to the topic.

Surveillance has become a crucial component of all environments informed or enabled by ICTs. Equally, almost all surveillance practices in technologically 'advanced' societies are enhanced and amplified by ICTs. Surveillance is understood as any focused attention to personal details for the purposes of influence, management, or control.

Five broad categories of digital marketing techniques that are used routinely by fast food, snack food, and soft drink companies to target children and adolescents. Some of these practices are inherently unfair, others raise serious privacy concerns, and still others are deceptive. Several of the techniques are purposely designed to tap into unconscious rocesses, thus bypassing the rational decision making that is at the heart of our system of fair marketing.

These categories are:

1. Augmented reality, online gaming, virtual environments, and other immersive techniques that can induce "flow," reduce conscious attention to marketing techniques, and foster impulsive behaviors;

2. Social media techniques that include surveillance of users' online behaviors without notification, as well as viral brand promotion;

3. Data collection and behavioral profiling designed to deliver personalized marketing to individuals without sufficient user knowledge or control;

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4. Location targeting and mobile marketing, which follow young peoples' movements and are able to link point of influence to point of purchase;

5. Neuromarketing, which employs neuroscience methods to develop digital marketing techniques designed to trigger subconscious, emotional arousal.

The critical literature on commercial monitoring and so-called 'free labour' (Terranova 2000) locates exploitation in realms beyond the workplace proper, noting the productivity of networked activity including the creation of user-generated-content and the profitability of commercial sites for social networking and communication. The changing context of productivity in these realms, however, requires further development of a critical concept of exploitation.

More and more aspects of our everyday lives are being mediated, augmented, produced and regulated by software-enabled technologies. Software is fundamentally composed of algorithms: sets of defined steps structured to process instructions/data to produce an output. This paper synthesises and extends emerging critical thinking about algorithms and considers how best to research them in practice. Four main arguments are developed.

First, there is a pressing need to focus critical and empirical attention on algorithms and the work that they do given their increasing importance in shaping social and economic life. Second, algorithms can be conceived in a number of ways – technically, computationally, mathematically, politically, culturally, economically, contextually, materially, philosophically, ethically – but are best understood as being contingent, ontogenetic and performative in nature, and embedded in wider socio-technical assemblages. Third, there are three main challenges that hinder research about algorithms (gaining access to their formulation; they are heterogeneous and embedded in wider systems; their work unfolds contextually and contingently), which require practical and epistemological attention. Fourth, the constitution and work of algorithms can be empirically studied in a number of ways, each of which has strengths and weaknesses that need to be systematically evaluated. Six methodological approaches designed to produce insights into the nature and work of algorithms are critically appraised. It is contended that these methods are best used in combination in order to help overcome epistemological and practical challenge.

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Section 2 (D4.3.3b)

Introduction

This document sets out the expected outcome from the tasks and activities associated with the development of the Technological Foresight deliverable (4.3.3b). There are three associated deliverables which are a) state of the art b) methodology and c) policy implementation over the three years of the project. This Section presents the Methodology, based on the state of the art.

1 The objectives

The long-term outcome is to influence technological innovation at a policy level within the European University of Technology and the wider social and political context of technological innovation within the European Union. The mid-term objective is to have a clear strategy for technological innovation and technological education within the European University of Technology. The immediate short-term objective is to develop a technological foresight methodology which is interdisciplinary and a policy document for the European University of Technology.

Outcome: A Technological Foresight methodology which is interdisciplinary and is policy orientated for EUt+.

The development of technological foresight methodology is premised on a number of presuppositions and presumptions which are in place, namely the relation between technology and society. The development of 'Think Human First' or 'Human Centred' philosophical approach presupposes that technology is not built in a vacuum but in and for society and by developing a specific philosophy of technology which sets out distinctions between techne, techniques, technics and technology; hence technology is no longer understood simply as, tool or instrument from an anthropological perspective but as a process of becoming human, a process of mediation in the world of the becoming human. The second set of presuppositions is an embedded relation between technology and ethics, technology has ethical consequences (ante, during, mid, res and after). The presupposition is that ethics is a form of praxis in the world aligned with technology as a form of praxis, therefore practical wisdom (phronesis) is needed. This leads to influencing technological foresight as ethical responsible innovation, therefore influencing technological innovation through the methodologies of foresight, forseeing by influencing the future and not simply accepting passive, or disruptive role of technological development.

Question: can we have a way of influencing technological development within the University which takes on board the think human first approach, responsible innovation and impacts on society?

However, the Expert is influenced by cultural imaginaries of technological development and innovation, including technological dystopias—hence Cultural Imaginaries influence the Expert and the field. The Expert is embedded in a milieu (individual, collective and technical), this milieu is also a location. These different locations include universities, technological innovation hubs and industry. Therefore, to critique how technological foresight functions it is necessary to determine the social and cultural milieu of the expert within technological development. This document sets out the initial phases of technological foresight within the European Culture and Technology Lab.

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2 How is Technological Foresight envisaged within the European University of Technology

Within the European University of Technology, technological foresight is understood both to be a speculative leap forward and one grounded in the practice of technological development which is embedded in the cultural, social and political context. Therefore, technological foresight is not a simple inductive process based upon the evidence of empirical data demonstrating certain areas of technology prevalence, whilst it is that, it is not only that. Within the ECT Lab+ the premise is that technological foresight is also speculative and imaginary process whereby the technologies of the future can be speculative fabulations (Haraway, 2012). The presupposition is that technology is here understood as forms of mediation in the world, that is equally building on social technology (Searle, 1995), postphenomenology (Ihde, 2017), Narrative Technology (Reijers and Coeckelbergh, 2020), Cosmothecnics (Hui and Lemmens, 2021), Organology (Stiegler, 2021), and integrative objects (Schmid, 2012).

In this sense, technologies are understood not simply as tools or instruments but also systems of mediation in the world. Therefore, Technological Foresight involves not only the prediction of forms of techno-science to make into new technical objects but also how technical objects themselves are embedded within technological systems (individual, collective and technological systems). For example, one could imagine a plane as a technical object compromising other technical objects and systems, including the seats, seat belts, pressurised doors, navigation systems, compromising software systems, digital objects, codes etc. but also integrated into planetary technospheres (Stiegler, 2021) of GPS systems, aviation management systems, airport management, traffic management in airports, passenger identification systems, boarding passes etc. Hence, the technical object in and of itself is a part of a technical system. In addition, the technical system does not exist in and of itself, it is embedded within an environment (milieu) which is cultural, technological, economic, social and political (Simondon, 2012). Technological foresight, is therefore, present here not as the prediction of forms of technical objects but the foreseeing of technical objects within technological systems.

It is also necessary to set out from the beginning distinctions in vocabulary, distinctions between prediction, probability, foresight, innovation and invention. The ability to predict what will happen next is based on inductive logic, if A and B then C and most predictive modelling will take this format. The looking to the future from the past and the present is the method used across probabilistic reasoning, whereby the past and the present are used to develop high probablility future scenarios. The low probability and the highly probable are distinguished. However, it has been argued that the contingency element of low probability (Hui, 2019) needs also to be included. Something which is highly unlikely contains within a certain level of possibility/probability which is contingency. The use of the term foresight is problematic as it implies the ability to foresee something. The ability to foresee has a certain mythico-poetic resonance of the fortune teller, the sphinx who can foresee the future and tells us in riddles (Homer). The foresight to see before the future brings into perspective other modes of seeing, other imaginaries, the ability to imagine the future possible, to imagine things differently, a poetics of possibility (Ricoeur, 1995; Kearney, 1998).

The development of technical objects within technical systems has been traditionally presented as modes of invention and innovation, invention holding the connotation of 'out of the blue' whilst innovation is from general usage linked to the economic mode of exploitation, innovation implies the development of something new to be exploited anew. Here the distinction between invention and innovation can be simplified to innovation within current technical systems, economic and social systems whereas invention tends to be linked to techno-scientific invention.

The first phase of the task set in 2020-2022 has been a gathering of information and the development of a shared literature review on technological foresight. The initial

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discussions looked at existing examples of standard technological predictive modelling such as the Gartner Hype graph. It was quickly ascertained the limitations of such an approach the group began to look at alternative models such as the Delphi Method. As there was particular expertise in relation to Delphi methodologies as a way of capturing expert opinion on developments within a specific field it was decided that the first phase of the technological foresight group was to investigate alternative methods of prediction. This would include standard European Commission discourses on applied technological development such as the Horizon programmes, Horizon Europe, The Green Deal etc. but also to look at more speculative methodologies such as Future Studies and imaginary futures.

Within the Technological Foresight the ECT Lab+ is proposing that technology is a form of technical practice, as social and collective practice (Bourdieu, 1990) and practice as form of becoming in the world (Aristotle, 2009), the repetition of action which defines practice, this understanding of action in the work is also a narrative description of the technical practices from an individual, collective and technical point of view. This is in line with the development of a virtue ethical framework (Ricoeur, 1995) and then developed as the ethics of technological practices (Reijers and Coeckelbergh, 2020). The technological foresight is therefore linked to technical practices but also speculative futures such as articulated under Future Studies (see below). In an effort to see how applied funding models instigate the development of certain technologies we examine the Horizon Europe programme. This is beyond the Cluster II pillar dedicated to social sciences and humanities (SSH) but looks at the overall applied funding programme, this is outside the fundamental research funding which can be allocated under ERC or the MSCA programmes. Understanding that the European Commission engages in foresight activities that may shape its policy and planning into the future, we also provide a review of the horizon scan method, a foresight method of interest which is used to detect early signals of change.

In a similar vein the Green Deal gives an opportunity to envisage how technology and technological development is envisaged by the European Commission under the headings of the Green Deal.

It is understood, as argued by Aphra Kerr, Margeurite Barry, and John Kelleher (Kerr, Barry and Kelleher, 2020) that institutions (such as the EC through its Horizon programmes for example) and other actors create expectations about the future of technology and innovation, including responsible innovation, but that these expectations can diverge from the reality of technical practice and progress. With this in mind, it becomes increasingly important to explore and utilise methods of foresight to help both understand and shape expectations in relation to responsible innovation.

State of the art

2.1 Futures Studies

After numerous iterations, and with a presence in the UNESCO (with Riel Miller and Sohail Inayatullah as representatives), the field of Futures Studies is increasingly moving in the direction of futures literacy and anticipatory systems in the sense that global, national and organisational policy making will be based on anticipatory science rather than political whims.

Futures literacy is the ability to read the future with greater effectiveness so that tomorrow's problems can be solved today; so that emergent opportunities can be used to enhance well-being. Prevention of disease, of calamities, of social problems, is crucial in this work (Inayatullah, 2020).

The Technological foresight methodology of the ECT Lab+ will include elements of the future studies approach to ensure that the methodology will move beyond a standardised quantitative Delphi method.

Futures Studies is a term used to tag a vast collection of mainly multidisciplinary research dealing with a set of issues and questions regarding how the future might unfold. Modern Futures Studies span from the 1960s right through to the present and although their common purpose is to cast an informed opinion on the (uncertain) future and influence the course of events, their approaches differ and often mirror the zeitgeist of the time when they were conducted (Amara, 1991; Puglisi, 2021). From a focus on predicting the future, the modern discipline of Futures Studies has broadened to an exploration of alternative futures and deepened to investigate the worldviews and mythologies that underlie possible, probable and preferred futures (Inayatullah, 2020). This preliminary literature review reflects that diversity and is presented as a conversation between different approaches.

For the purpose of this report the breadth of Futures Studies is organised into three categories:

- Dominant, preferable and probable Future (note the singular)
- Alternative/disruptive Futures
- Visions

Projecting the future has been linked to power since time immemorial. From seers guiding princes' actions in wartime to predictive analysis and high-frequency stock trading, the ability to predict/foresee the future has been linked historically to the rich and powerful and the capacity to design and control what-is-yet-to-come toward self-fulfilling prophecy.

At first glance, Futures Studies might appear simply as a collection of modes and methods ranging in sophistication and success, using both quantitative and qualitative methods to "see" beyond the here-and-now. Approaches can be situated in a continuum ranging from models seeking scientific legitimacy and robustness through the "imitation" of the language of the natural sciences—the mathematization of discourse in early renditions of the RAND Corporation's Delphi

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method for example (Amara, 1991, p. 645; Glenn, 1994) and Trend Based Scenarios (Miller, 2006)—to post- humanists and situated feminism models seeking the decolonisation of preferred futures, these include narrative forecasting, speculative fabulation and backcasting (Haraway, 2012; Milojević and Inayatullah, 2015; Truman, 2019; Inayatullah, 2020).

One possible way to approach Futures Studies is on a continuum between more and less “desired” (to some social group or stakeholder) futures. For instance, critical/non-solutionist approaches to design research (Dunne and Raby, 2014) or future-related art such as science fiction (von Stackelberg and McDowell, 2015) can function as a probe to speculate on alternative/possible futures (rather than just market-feasible ones). Alternatively, accelerationist theories (Mackay and Avanessian, 2019) intend to function as political motors to bring forth (self-fulfil) particular (techno-capitalist, techno-socialist, or other) futures.

Predictive approaches are perhaps the dominant paradigm in Futures Studies at present. In this category, discourses of futurology remain technologically focused and are predicated on risk reduction. Originally based in the economic and defence

disciplines they have shifted more recently to broader social concerns such as anthropogenic climate change (Facer and Sandford, 2010; Inayatullah, 2019). Given the appearance of legitimacy and accuracy by their use of quantitative analysis and big data, these models are favoured for their air of certainty in a field that is often criticised as lacking scientific robustness. However, there has been a move to more alternative epistemic frameworks that problematize the dominant narratives.

For instance, how the methods may make basic assumptions on time, economics, politics, and ideological-cultural concerns that are naturalized through the constructive forces of the past, power, history, colonialism, and language. Cultural, Sociological, Feminist, Queer, and Race Studies theories position predictive futures studies models as always already politically constructed, a triumph of one discourse over others. An emphasis on the situatedness of knowledge (Haraway, 1988) and its impact on realizations of the future point to both implicit and explicit biases in the

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mapping of futures and therefore the construction of it. Possible futures produced by these methodologies are seen as merely prolonging existing trends through a radical constriction of variables and as a model that always moves toward the simplified, the desirable, and the normative (Selin, 2008).

Alternative approaches examine issues of power and legitimacy and the role of the expert in influencing technological policy and development. Who exactly gets to be an expert and how are these identities created in spaces of knowledge? (Inayatullah, 1998). What exactly is seen as a desirable future—normative Futures Studies often sees itself as a force for good—is the triumph of liberal western democracy, individuality, capitalism and rationality. Speculative Fabulation (Haraway, 2012) is a methodology of generative science-fictional storytelling that allows other vocabularies, possibilities, and necessary contestations of situated knowledges. It is a toolkit that opens up spaces of experimental friction between the sciences, the humanities and the arts to create mutually constitutive conceptions of future technologies and ecosystems. The potential to imagine alternative modes of collective living is particularly urgent in the current global extinction crisis.

Science fiction literature as a form of futures studies typically deals with sociotechnical imaginaries, understood as "constructed landscapes of collective aspirations" (Jasanoff, 2015, p. 6). In this sense it serves as a repository of a collective vision of the future, which includes the aspirations, hopes and fears of a community shaping and shaped by technoscience.

Alternative Futures Studies stresses the availability of diverse alternative trajectories; the need for participatory scenario building to shape technology; and the importance of continuously re- stating the openness of the future. They address the range of cultural and cosmological backgrounds that can produce interpretations of probable and desired futures, an openness that presupposes change and a reconfiguring of power structures. They are based in uncertainty however, and as such are far less desirable to solution-focused management.

Artists and creative technologists also pose questions of ethics, ecology, politics, and the possibilities and impossibilities of future societies. Annual art festivals such as

Ars Electronica and Transmediale act as hubs for both innovation and critical examination of everything technology related to biological augmentation and from artificial intelligence to virtual reality displays. Techno-scientifically driven artistic research, and media arts in general, actively speculate on and act to forge and shape the future, creating new kinds of phenomenological experiences that resonate through culture and society. Artistic research or practice based artistic research is now an established research methodology which could be considered to be a part of the speculative processes of socio-technical imaginaries and participate in the establishment of imaginary epistemologies which equally influence the environment of technological innovations. More recently, the development of contributive or contributory research includes aspects of socially engaged artistic practice methodologies coupled with those of citizen science (Fitzpatrick et al., 2021). Contributory research places questions of imaginary futures or possible futures within its methodologies.

Conclusion

Futures Studies trends that are speculative, experimental, poetic/artistic, or disruptive in some fashion put under some profound pressure other canonical, quantitative, and techno-scientific approaches. The former stress the availability of diverse alternative trajectories, foreground the need for more daring ways to (fore)see and fumble about the world of tomorrow, and set out the importance of continuously re-stating the openness of the future. They address the range of cultural and cosmological backgrounds that can produce interpretations of probable and desired futures, an openness that presupposes change and a reconfiguring of the power structures and of the dominant epistemological frameworks of today. They, nevertheless, draw upon grounds that are ambiguous, uncertain, speculative, critical—even ironic, ludic, or altogether nonsensical. While this is exactly why they suggest themselves for more daring encounters with the futures to come, they lack the clear-cut and readily implementable logic of quantitative and predicative approaches so that they are far less desirable—if at all suitable—in solutionist and functional contexts.

Advantages

- Offering alternative epistemic frameworks that problematise the dominant narratives and that put under scrutiny the implicit assumptions on time, economics, politics, and ideological concerns (that are naturalized through the constructive forces of the power, history, colonialism, and language)
- Investigate techno-socialist, techno-feminist, queer, decolonial, and other alternative (desired/utopian/disruptive) futures
- Suggest themselves for the collective/participatory imaginary; may inspire audiences and may resonate the cultural sphere; investigate (utopian) visions of collective living that are particularly urgent in the current global crisis
- Examine issues of power and legitimacy and the role of the expert in influencing technological policy and development
- Account for a number of important questions within the very practice of speculating about the future: Who exactly gets to be an expert ‘futurologist’ or ‘forecaster’ and how are these identities created? What exactly is seen as a desirable future?
- Allow for other vocabularies, possibilities, and—eventually—of other ways of knowing that are more enactive, poetic, and exploratory than readily available in the languages of cultural theory, philosophy, or science
- Open spaces of experimental friction between the sciences, the humanities and the arts to create mutually constitutive conceptions of future technologies and ecosystems
- Serve as a repository of collective visions of/for the future
- Comprise a set of already established and mature research methodologies that actively take part in the construction of socio-technical imaginaries (through cultural practices and popular culture)
- Compatible with non-representational-theory and related epistemological frameworks
- Can function as a bridge between sciences, humanities, engineering, and popular culture.

Disadvantages

- Not applicable/relevant whenever accurate calculations are demanded—in strictly solutionist contexts
- Comprising numerous sub-methods and epistemological underpinnings that are not necessarily related nor complimentary
- Are often frowned upon by scientists, engineers, and policy makers
- Raise political, ideological, and socio-cultural concerns that are often hard to discuss or tackle
- Fail to quantify data, measurements, and metrics
- Are difficult to evaluate.

2.2 Delphi Methods: Application to Technological Foresight

As mentioned above when describing the range of approaches to predictive studies, at its core Delphi would be closer to the one end that aims to imitate exact and natural sciences in its methodology. Thus, it can be described as an iterative method that utilises questionnaires administered to experts in a particular field, to capture opinion on the state of the art, or to forecast future events. In Conventional Delphi, typically a questionnaire is administered anonymously to experts in the first round, from which the statistical summary of opinions from the entire sample is distributed to participants. Following this dissemination of opinions from round one, a second round of questionnaires is completed to capture the changes in orientation of the participants, and after which, the opinions of the participant experts tend to converge (Dayé, 2018).

In its original conception, a Policy Delphi differs from a Conventional Delphi since the goals of utilizing a Policy Delphi are to identify all perspectives on an issue, to

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reveal the range of considerations for decision-making, and to identify points of agreement and disagreement. These goals stand in contrast to the original goals of the conventional Delphi, which focused on forecasting or building consensus to arrive at a decision (de Loë et al., 2016). As in both versions Delphi has developed as a critical tool in forecasting under constrained circumstances, we have explored its merits and demerits and we outline its potential application to the objectives of the ECT Lab+.

Originally the Delphi Method can be seen as an instrument that allows for collective knowledge sharing, lending itself in those cases to solve problems where analytical techniques are difficult to apply. However, since its origin it has been used in different fields such as industry sectors including health care, defence, business, education, information technology, transportation and engineering (Skulmoski, Hartman and Krahn, 2007).

While Delphi began its life under the aegis of the RAND Corporation it has had a wide range of uses including in forecasting public policy, identifying technological trajectories, and for firms wishing to gain expert field knowledge to inform production and design decisions (Bloem da Silveira Junior *et al.*, 2018). Its origins reach back further in spirit as its name is associated with the oracle of Delphi where scholars collected information and involved experts in deliberative discussion. In its contemporary use, Delphi is used as a survey technique where the data and feedback can be carried out digitally (Steurer, 2011). In the process of feedback, Delphi derives an advantage from anonymity, which is a key driver of the group opinion building process; leads to less disagreement and moves towards consensus (Kauko and Palmroos, 2014). In contrast, the Policy Delphi is well suited for inquiry into complex problem areas where there are multiple perspectives and solutions with no one clear normative solution. This quality distinguishes Policy Delphi from conventional Delphi where inquiry is often geared toward identifying a specific solution (de Loë et al., 2016), and make them both complementary tools for our purposes.

Thus, although the opinions of the participant experts usually move towards consensus, the literature has few examples of where there is disagreement and divergence. An example of this can be seen in a Policy Delphi research of energy futures in the UK which noted that we are now in a period of 'post-normal science', in which expert expectations of energy futures will differ in accordance with experts' 'assumptions, heuristics and values' (Kattirtzi and Winskel, 2020, p. 3). The findings of this study stressed the salience of epistemic diversity and that policy-makers may indeed value the scoping of the range of divergence in expert opinion. Agreement or disagreement is based upon values such as who should be the driver of technological change. Policy Delphi methods can be used therefore to reliably assess disagreement and consensus.

Step 1: Setting up Delphi Process	Set goals; choose panel of experts (n=5 to 20 min); Decide on geographic dispersion; brainstorm issues to be addressed by survey; pilot
Step 2: Developing Questionnaire / Instrument items	Focus issues to be explored; design questionnaire using simple response categories; decide on what scaling is used e.g. Likert
Step 3: How Delivered (software)	Paper, web, email or real-time?
Step 4: Providing Feedback	Median responses to be used; utilise qualitative data to reveal rationale for responses; continue to next and subsequent rounds
Step 5: Preventing Drop-out from panel	Develop retention strategy to prevent attrition of panellists; communication strategy.
Step 6: Data Analysis and Presentation	Use descriptive statistics; note small sample sizes; present graphically; integrate results with other methods / techniques used.

Table 1: A Delphi Six-Step Procedure (Adapted from Belton et al., 2019, p. 73)

Conclusion

Both Conventional and Policy Delphi, or even a combination of them, could be useful for the ECT Lab+ Technological Foresight purpose. Indeed, there is not a clear distinction between the variants and continuous innovation in its application has been made. Such flexibility and space for creativity can positively serve to our aims, as far as the designers of the methodology are able to target the desired qualitative/quantitative-consensus/disagreement degree of the expected results. The continuous and growing application of Delphis in different fields since 2000 supports its potential as practical tool for technological foresight.

Advantages

Specific advantages of the Policy Delphi method are that it can effectively reveal options and alternatives, clarify arguments, and uncover the strength of evidence associated with diverse viewpoints.

+ it allows for a hybrid of qualitative and quantitative methods.
+ Is well suited to investigating problems that require inputs from multiple, different, and often conflicting points of view
+ The iterative nature of the method permits panelists to engage with, evaluate and respond to the ideas of other panelists.

Disadvantages

+ Little consistency in how studies have been designed and executed
+ Methodological issues, such as oversimplified structured inquiries into complex issues
+ Ambiguous questionnaire designs

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+ Practical concerns such as the amount of time that is required to complete studies (de Loë *et al.*, 2016).

Examples of concerns specific to Policy Delphi studies include biased participant selection and the inability to capture the full diversity of views as well as indifference towards disagreements.

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2.3 The European Commission - Influence, Foresight and Horizon Scanning

At the European institutional level, both the European Commission and European Parliament have dedicated resources to foresight activities (Tsakalidis et al., 2021). The European Parliament in 2009, for example, launched the European Strategy and Policy Analysis System[2] which itself hosts the Orbis global foresight hub (Tsakalidis et al., 2021). The European Commission, as another example, hosts the JRC Competence Centre on Foresight[3], launched in 2018 and charged with the responsibility for identifying and monitoring emerging issues (Tsakalidis et al., 2021). The European Commission both monitors for emerging issues through foresight activities and creates funding environments for RRI that can catalyse technological and societal change. In this section, we will provide an overview of the EC's attention to foresight, its influence over change, its status as a potential source of foresight, and particularly on the use of the Horizon Scanning methodology. By evaluating EC influence and its own tools of foresight, valuable lessons can be learned about early signals detection and anticipating future trends with relevance for RRI.

Horizon Europe

The European Commission has moved on from Horizon 2020, a programme with a specific deadline embedded in its title, to something that seems to look further and potentially shape the progress of European research and innovations not for years, but decades to come. One can assume that the technological foresight vision for Europe is embedded in the programme or that it was fundamental to the strategic planning leading to what is now Horizon Europe. Hence, Horizon Europe should hold the answers to many questions related

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[2] https://espas.eu/

[3] https://knowledge4policy.ec.europa.eu/foresight_en

to the future of European technologies and provide guidelines as to where European technological development is headed.

Foresight was employed in the development of Horizon Europe Strategic Plan by exploring "global megatrends, their interactions with the Sustainable Development Goals, and the implications of different future scenarios for EU R&I policy and its future orientations" (European Commission, 2021a, p. 6). The foresight activities, along with interim evaluation of Horizon 2020, revision of different thematic foresight reports, as well as identification of expected impacts, lead to the creation of five missions, putting additional emphasis on open science policy and establishing a new approach to partnerships (European Commission, 2021a). The five missions of Horizon Europe are Adaptation to Climate Change; Cancer; Climate-Neutral and Smart Cities; Ocean, Seas and Waters; Soil Health and Food. Five mission boards consisting of experts from different backgrounds helped the European Commission identify the aforementioned missions. Although there is no doubt that experts are necessary for technological foresight and similar exercises, one has to take into account the risk of them being subject to different biases, as different studies emphasize that expertise per se is not the solution (Apreda et al., 2019) when it comes to technological foresight.

One of the key strategic orientations for EU research and innovation for the period 2021-2024, defined in the Horizon Europe Strategic Plan, focuses on "promoting an open strategic autonomy by leading the development of key digital, enabling and emerging technologies, sectors and value chains to accelerate and steer the digital and green transitions through human-centered technologies and innovations" (European Commission, 2021b). The aim of making technologies human is emphasized throughout the Strategic Plan, notably, throughout Cluster 4 - Digital, Industry & Space. Human-centered technologies and the necessity to ensure ethical development of technologies appear in the key strategic orientations for EU research and innovation and are particularly emphasized throughout the expected impacts within Cluster 4. The European Commission has also stated that "the approach to research and innovation investments builds especially on the green and digital transitions by supporting innovation based competitiveness and fostering technological sovereignty in key strategic areas" (European Commission, 2021a, p. 9) including artificial intelligence, 5G/6G, space technologies, renewable energy and others.

A notable difference in comparison to its predecessor is that Horizon Europe will follow up with a restricted SwafS programme. For example, the only made available European Alliances does not see a follow up to the "Science With and For Society" programme known as SwafS (Gerber et al., 2020). This generated numerous concerns as the SwafS programme used to be one of the main embodiments of Responsible Research and Innovation (RRI), which serves as a connector between science and the interests of European citizens (Robinson, Simone and Mazzonetto, 2021). It remains to be seen how successfully the new programme will tackle the absence of SwafS, especially as according to the Horizon Europe Work Programme 2021-2022 for the missions to succeed they have to be carried out "in close synergy with funding, programmes and strategies both at Member State/Associated Country and regional level, as well as with civil society and the private sector". Although "RRI is integrated in Horizon Europe as an overarching principle" (Robinson, Simone and Mazzonetto, 2021), taking into account how essential civic engagement has been and continues to be in solving major societal challenges within the EU and beyond, concerns over the lack of a dedicated funding programme might not be without reason.

In addition, a danger persists that the new funding landscape will diminish the role of social sciences and humanities (SSH) when it comes to innovations. This is because "the emphasis on the contribution of research to economic growth fosters a technocratic paradigm in which the translation of fundamental research into innovative 'products' is seen as the benchmark of success" (Bell, 2019), which is too simplistic of an approach that belittles the role of SSH. As already mentioned, the new Horizon Europe programme puts significant emphasis on innovations and, even though often overlooked, it is critical to acknowledge that SSH can contribute to innovation in different ways. For instance, by challenging the ways social problems are approached, offering a possibility to explore hypothetical alternatives, considering the non- material features of human existence, challenging contemporary norms and others (Bell, 2019). The strategic plan does emphasize the importance of an effective integration of SSH in all clusters, describing SSH as a key constituent of research and innovation, especially regarding the twin green and digital transitions (European Commission, 2021a).

Horizon Scanning

Within the EC, Horizon Scanning (HS) has been conducted on topics including on energy, blockchain, security, agriculture and transport (Tsakalidis et al., 2021). Furthermore, the European Parliament Research Service has produced Horizon Scans on topics including agriculture, and the ethical aspects of cyber-physical systems (Tsakalidis et al., 2021), demonstrating growing interest in and evidence of utility of this method. Horizon Scans can be conducted across a wide variety of topics or themes (Hines et al., 2019), and have been used as a means of forecasting across a variety of topics and have been implemented by organisations internationally (Cuhls, 2020).

What a Horizon Scan is, is usually defined as is a method for weak signal detection or identifying and monitoring (and evaluating the importance of) emerging issues in a domain, including with novel technologies in their earliest stages of development (Hines et al., 2019; Cuhls, 2020; Tsakalidis et al., 2021). The process entails the "systematic examination of information sources to detect early signs of important developments" (Hines et al., 2019, p. 1). The Horizon Scan can have goals including identifying opportunities and threats, or providing early warning in the selected domain area (Hines et al., 2019; Cuhls, 2020; Tsakalidis et al., 2021). Hines et al. (2019, p. 1) describe the full process of a horizon scan as involving:

+ **Signal detection**: this is the search for signals from a variety of sources not limited to surveys, patents, the media (and social media), literature review, conferences, government bodies and so on. Notably, a Delphi (or scenario workshops), can also be utilised
+ **Filtration**: signals can be filtered for relevance based on defined criteria including impact, evidence, media interest, policy priority, ethical and social issues and so on. Methods can notably be automatic (text mining/classification), semi-automatic, or manual (including expert feedback/input) (Hines *et al.*, 2019; Cuhls, 2020; Tsakalidis *et al.*, 2021)
+ **Prioritisation**: The signals that meet the defined criteria of the preceding stage can be prioritised by additional criteria including impact on outcomes, affected

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population size, desirability, factual basis and so on. Methods can include risk analysis, a Delphi study, public consultation, and expert involvement as some examples

- **Assessment**: Signals can be assessed by further criteria including (but not limited to) again, impact, level of innovation, risk assessment, ethical and legal issues. Methods can include expert, user and policymaker participation, peer review, scenario planning, and so on
- **Dissemination**: The final stage of the Horizon Scan is dissemination of results. Outputs can be diverse, including newsletters, social media posts, platforms (Cuhls, 2020), or other documents with Hines et al. (2019, p. 6) indicating the following format:

In terms of dissemination, the assessment of an individual signal can be summarised in a document with the following elements: authors, lay summary, assessment objectives and methods, background and current practice, signal description, impacts and other issues, estimated time to impact, comparator signals (innovations), expert opinion and declaration of any conflict of interests. It may also be beneficial to include policy recommendations which are linked to decision-making priorities, structures and individual and cross-cutting policies.

The HS process is not necessarily supposed to be in-depth or comprehensive (Cuhls, 2020), yet can still provide a useful method for detecting signals of events that warrant further exploration and monitoring as part of a greater foresight strategy, and moreover, can be used complementary methods including Delphi studies as outlined above (Cuhls, 2020).

Conclusion

This section explored the role of the European Commission and Horizon Europe in shaping the future direction of responsible research and innovation (RRI), how foresight has influenced the strategic direction of Horizon Europe and its contribution to technological change and, moreover, how the EC's strategic direction is a source in itself of knowledge of what kind of innovations may yet come and whether they will

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be socially and ethically robust.

Here we have also provided an account of the action of Horizon Scanning, a concrete example of one of the tools of growing interest within the EC's repertoire for exploring possible futures and potentially helping to pre-emptively respond to them in the face of early signs of change.

By exploring the EC's current strategic vision and funding environment for the future, we can note that whilst salient issues remain on the agenda including human health, human-centred technology, and environmental sustainability, there remains a potential for the reduced role of the arts, humanities and social sciences in EC funded projects, disciplines which are crucial for understanding the ethical, legal and societal implications of new technologies and helping to adapt them to societal needs. The absence of a SwafS programme additionally threatens to close some opportunities for civic engagement, which is essential for fostering societal acceptance of technology and is thereby an important source of input and influence for helping to shape the direction of new technologies so that they respond to real human and environmental needs. Contrasting to this is the expert contributions to the EC's foresight activities and strategic direction, which whilst necessary might be subject to bias and drown out the voices of other "non-expert" persons with essential situated knowledge.

In doing this, we note that the body of EC documents outlining its future vision is a source of knowledge on which to base some foresight work, due to the EC's powerful influence in shaping technological change, and the need to remain vigilant and critical of the presence or absence of different stakeholders or approaches (such as SwafS) from the EC's thinking and implementation of its innovation programmes. Noting that the EC's strategic direction has been informed by foresight activities, yet remains open to critique and concern from the standpoint of commitment to civic engagement and robust RRI, does indicate the importance of calibrating foresight activities with these issues in mind as a priority, as well as proactively and responsibly responding to identified needs and emerging trends.

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The method of Horizon Scanning demonstrates a concrete tool used by the EC and other European institutions which could have contributed to its policy on shaping and influencing innovation responsively and competitively. This is a method with practical use which can be used in EUt+ foresight activities, using reasonably non-prescriptive approaches, and can indeed be used in some part through document analysis of EC and other European institutional documents, which represent, as we have stated, an important body of knowledge potentially containing the early signals that HS seeks to detect. Nevertheless, the concerns raised about Horizon Europe, for example, do show that any successful and responsibly implemented Horizon Scan should be sufficiently calibrated with ethical and societal concerns in mind, and that biases can be present that lead to these being overlooked.

Advantages

+ Analysis of EC documents and Horizon Scanning (potentially of EC documents and EC funded project deliverables as source material) can help identify emerging and novel issues in technological innovation with ethical, societal and legal consequences for humans and the environment
+ Horizon Scanning has a level of flexibility and can facilitate engagement with experts and non- experts and permits the analysis of a plurality of sources through diverse means
+ Horizon Scanning itself is possible to automate and can contribute to efficient threat identification and lends itself to further innovation as a technological foresight activity
+ Horizon Scans present flexible opportunities for participation, and accommodate Delphi methods within their framework, meaning they are compatible with other methods explored in this deliverable
+ Following that point, early signals detection may invite methods including speculative fabulation by providing the basis for creative exploration of identifiable future issues.

Disadvantages

+ Undertaken manually, a Horizon Scan features many steps and whilst not intended to be in- depth, may still be an involved and resource intensive process, especially when done in conjunction with other foresight activities
+ While flexible, the literature does appear to skew towards expert involvement in the Horizon Scan process meaning they have to be designed with care to recognise different and
diverse sources of knowledge
+ Automated Horizon Scans may raise their own ethical questions, where automated and deploying AI.

2.4 Twin Transitions- Digital and Ecological - The Green Deal

What is twin transition and where are the challenges?

A study of 99 recent foresight studies, including 307 scenarios and dating back not more than 15 years revealed that science and technology appears as the dominant factor only in 15% of those studies (Lacroix et al., 2019). The dominant drivers are governance, the economy and society. One of the roles devoted to science in narratives of the scenarios is to alert and enlighten decision makers. Science also could supply solutions for limiting waste of resources, reducing greenhouse gas emissions or improve agriculture yields. Many scenarios are quite pessimistic regarding the environmental future, i.e., considering that degradation of water and land resources is inevitable, and risk of irreversibility is very high. Again, the science is seen as a tool for remediation or adaptation. However, researchers in (Lacroix et al., 2019) note that the foresight studies are limited by representatives or experts, coming mainly from western part of the world. Networks of citizens (participatory sciences, crowdfunding, etc.) were not seen as being able to influence the future of their environment over those past 15 years. On the other hand, the foresight scenarios can help working groups and decision makers to adjust research programs and define research priorities for a given organization, region, or horizon.

Digital transition enables new forms of “sharing economy” which are not limited by local and social proximity (Pouri and Hilty, 2021). Digital sharing allows the scale-up of sharing practices to large communities and can lower entry barriers. These new digital qualities along with change in consumption patterns with giving preference to shared use rather than ownership promotes the phenomenon of the “sharing economy”. Since the new quality of the phenomenon is related to the digital transition, it can be called “digital sharing economy”. Digital technologies provide one of the three fundamental aspects of the digital sharing economy—digital online platforms that provide coordination mechanisms for matching demand and supply at nearly zero costs (Pouri and Hilty, 2021). The other two fundamental aspects are the technical aspect of sharing, referring to characteristics of sharable resources, and the social aspect of sharing that relates to rules of social interactions. The digital technologies transformed both other fundamental aspects, i.e., technical and social, by opening up a domain of sharable resources and providing new forms of sharing practices.

One of the biggest challenges and systemic failures of economic activities of our society has been the inability to decouple economic growth from resource use. The European Green Deal is the strategy for overcoming the challenge of this decoupling and achieve zero net greenhouse gas emissions by 2050 (European Commission, 2019b, 2019a). The Green Deal is not only about climate but about transforming economic development and society to follow a sustainable, just, and inclusive path. It is about putting people first. The transition will require profound changes in all sectors, rethinking of policies, investment in research and development as well as in digital transformation. The digital transformation is seen as an enabler of the required changes, and the ambition of EU is to put sustainability “at the heart” of digitalization. Apart from setting new policies, regulation and standardization, the EU will have to ensure that the existing policies and legislation related to the Green Deal are effectively implemented. However, the existing policies are able to bring down greenhouse gas emissions only by 60% by the year 2050. Therefore, more ambitious actions are needed in the coming decades. These will also affect carbon pricing and environmental taxation with the ultimate purpose to change consumer and business behaviour. Novel approaches, such as carbon border adjustment mechanisms, avoiding replacement of domestic production with carbon-intensive imports, could be implemented. Since energy sector accounts for circa 75% of EU greenhouse gas emissions, large emphasis will be placed on clean energy transition. Energy efficiency improvements, closure of coal power plants, decarbonisation of gas supply, use of renewable energy sources, integration and digitalization of the energy sector are among the most important steps. Putting people first will mean that costs of energy to consumers and energy poverty will have to be properly addressed Sustainable economic models and inclusive growth mean that supporting the circular economy, and providing new workplaces will be necessary, and that is an ambition of the European Green Deal.

A particular challenge of implementing the circular and decarbonized economic model lies within energy intensive industrial sectors such as steel, cement and chemical, which are all very important for EU and other countries. Circular design, new business models (e.g., renting and sharing rather than owning of products), extended producer responsibility and similar initiatives all should help to implement the circular economy model. Digitalization will provide the data and information required to distinguish “green washing” from real improvements of the environmental performance of products and services. Availability of objective information is critical for making an informed purchasing decision. “Right-to-repair”, and avoiding pre-mature obsolesce of products would be a significant step towards sustainable development of product systems, especially in the electronics sector.

The EU Emissions Trading System Innovation Fund will provide funding for large-scale innovative projects related to energy and energy-intensive industry sectors. New technologies, disruptive innovation, large scale demonstration and deployment are needed in the clean technology sector to achieve the objectives of the Green Deal. Sectors of transport, built environment, carbon-intensive industries, energy storage, clean hydrogen and circular bio-based sectors are some examples of the particular focus. Artificial intelligence, cloud computing, ultra-fast networks and internet of things are example of digital enabling environments needed for evidence-based decisions, predicting, and managing environmental disasters, adaptation to climate change and creating a very high precision digital model of Earth. The transition to a decarbonized economy will also require considerable investment, re-skilling programs and adjustment of various practices. Long-term signals and taxonomy of sustainable activities should promote private investment in sustainable transition. Digitalization is seen as an important help for solving energy-water-food nexus (Mondejar et al., 2021). For example, remote sensing, GIS techniques as well as mobile applications help to use agricultural land more efficiently and thus, increase food supply, which is one the pressing global challenges. Use of digital data and “Internet-of-Things” (IoT) enhance building-up of smart cities, with more efficient use and supply of energy and water. As energy supply systems become more integrated, having increasing share of intermittent supply sources and thus, more complex, digital tools for load forecasting, demand side management and flexibility solutions will play a critical role.

Understanding the energy transition and the reasons for it being slower than desired requires an understanding of how the future energy systems are imagined. Sociotechnical imaginaries reflected in pop culture, e.g. digital games, can be used to characterize how these future energy imaginaries can shift the energy transition (Wagner and Gałuszka, 2020). The energy transition in these games is portrayed as a technological transition, i.e., considering technological development as a priority. An urgent need for radical changes in social organization or individual practices is not underlined in the imaginaries of energy transition reflected in these digital games. These energy imaginaries support the idea of centralization, economic growth and control over resources. Nature is presented as a reservoir of goods to make human lives more convenient and energy secure production forces providing human comfort

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(Wagner and Gałuszka, 2020). Energy is not viewed as a right in terms of social justice and decentralized community governance is not considered. These imaginaries may hamper the implementation of more radical ideas and gravitate development toward the existing fossil-fuel-based imperatives and set of rules (Wagner and Gałuszka, 2020).

Considering a tight interdependency between sustainable development and digital transformation, co-design of this twin transition is required. The co-design process would have to take place on the systems' level, consider the alignment of path dependencies, policies, lifestyle, business models and infrastructure developments (Pauliuk *et al.*,).

Conclusion

Understanding and more importantly, stimulating green and digital transition could be essential for sustainable living of humankind. That is quite well understood and accepted. Digital transition may be seen as an enabler for the green transition. On the other hand, green transition requires the digital transition to take place and many other key enabling technologies to be developed.

However, apart from transformation in the technological sphere, changes in society-technology interaction, institutional settings (e.g., regulatory regimes, market design and business models) and value-behaviour domains are needed and will most likely happen. Therefore, the twin transition can be portrayed as co-envolvement of technologies, business models and markets, institutional capacity, knowledge, climate awareness, behaviour, etc. The rate of the twin transition is limited by the slowest rate of development of the critical element in that system. There are many important feedbacks and interrelations between those co-development chains. System dynamics modelling is the method that provides systems' level/ holistic and quantitative approach to studies of potential dynamics of the "twin transition system". System dynamics modelling has been used as a tool for the technological foresight to assess possible paths and rate of technology diffusion (Chen, Yu and Wakeland, 2016). However, the study addresses the issue by focussing only on a certain technology, and using the diffusion model approach, not co- evolvement of parallel stock-and-flow structures for a broader system. Thus, the system dynamics modelling still remains an unexploited resource and could be added to the tools for the technological foresight.

The Green Deal can be considered as the outcome of expert analysis of our societal needs and challenges. The needs and challenges are probably the most important drivers of technological development. The "dynamic problem" to be solved with help of the system dynamics modelling could be formulated in the following way: how can we increase a probability of development of the technologies we need and diffuse them into society at sufficient rate? And what are the "blind spots" that could be overlooked?

Advantages

+ Quantitative method based on mathematical modelling

+ Possibility to study complex systems (with feedbacks, accumulation) that change over time by extracting potential dynamic behaviour of the system based on a structure

+ Intuitive approach to mathematical modelling of complex systems that allows to involve relevant stakeholders in the modelling process as experts.
+ Possibility to model technical, economical, societal and institutional factors can be applied to quantitative and model-based policy design for the purpose of changing problematic behaviour and trends.

Disadvantages

+ All relations between elements of the model must be quantitatively characterized

+ The modelling process requires extensive training and practice

+ Software tools are needed and the modelling process may be time consuming.

Conclusion to Section II

From the outset of this document we affirmed the EUt+'s long term objective of influencing innovation at a policy level in Europe, and our mid-term objective of developing a strategy for technological innovation and education in the EUt+. The short-term objective is to develop a technological foresight methodology and document for the EUt+, one which is interdisciplinary and policy oriented, as a first step towards our long-term objective. The preceding supports these efforts by providing a state of the art in foresight methods.

The ECT Lab+ understands innovation and technology not in terms of the development of discrete and value neutral technological objects or tools, nor does it consider these tools as context and value neutral in their use. The ECT Lab+ appreciates a multi- and interdisciplinary understanding of technology and technological innovation as being enmeshed in processes and systems of practices (indeed moreover, processes of becoming human, of mediation in the world of the becoming human) featuring many drivers of influence and containing multitudes of different sources of knowledge and expectations. In this deliverable, we have identified a cross-section of foresight activities and methods (Future Studies, the Delphi Method, the Horizon Scan) and drivers of change that are important to understand technological change and the future of technological practice (Horizon Europe, and the Green Deal), as an initial step in supporting interdisciplinary work and alternative methodologies. Such methods can be incorporated in future work experimentally, that is, we will seek to add value to these methods through adaptation and innovative methods.

Each approach documented here is distinctive, some are qualitatively skewed and others quantitative, others more subversive.

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Future Studies challenges established or dominant narratives and methodologocal approaches and invites more subversive and alternative approaches to predicting and imagining the future, which can be collective, participatory and steeped in cultural practices. The domain of Future Studies provides fertile ground for critiquing dominant viewpoints and questioning norms about prediction and indeed what makes a desirable future and is conducive to interdisciplinary dialogue and experimentation. Nevertheless, it may not be as useful whereby accurate predictions are required, comprises some irreconcilable sub-methods, its outputs are difficult to evaluate or quantify, and it is often frowned upon by scientists, engineers, and policy makers. Nevertheless, Future Studies lends itself to connecting with wider audiences and influencing pop- culture, making it accessible.

With the Delphi method, we saw an example of a flexible method that supports creativity and can use qualitative and quantitative (or hybrid) approaches. It can help define complex problems and invites honest answers through its anonymous structure, from multiple (and often conflicting) perspectives. Nevertheless, the Delphi can be time-consuming, oversimplified, and inconsistent in design and execution.

The Horizon Scan method has been used to detect early signs of change in order to help prepare necessary responses—it is a largely qualitative approach but one which can be automated or semi-automated through text mining, for example, and can involve quantitative or hybrid approaches in theory. A Horizon Scan can help identify emerging and novel issues in technological innovation with ethical, societal and legal consequences for humans and the environment. The Horizon Scan can complement Future Studies and the Delphi method, however it may be time and resourcing consuming and raise its own ethical issues where it itself relies on experimental technologies.

We have also shown how the European Commission sets an agenda that influences change in technological innovation and practices through its policy and funding environment, and how studying the EC's strategy and documents can help predict the

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direction of change, and that EC strategy should be monitored to detect whether its commitment to social and ethical issues is sufficient in its funding programmes.

In reviewing Twin Transitions and the Green Deal, we have argued that the digital transition can be an enabler for the Green transition and hence that technological innovation can be a source of improved sustainability practices. Systems dynamics are a mathematical modelling technique deployed in technological foresight to help assess paths of technology diffusion to support this. Many factors can be modelled (technical, economic, societal, etc.). The Green Deal was offered as a potential example of the outcome of expert analysis of societal needs, therefore foresight activities can concretely contribute to responsible and sustainable policy developments. Nevertheless, the process of modelling is quantitative only, it requires extensive training, specialised software, and may be time-consuming.

The ECT Lab+ will now turn to the specific methodological questions associated with technological foresight; this includes the adaptation and experimentation with the questions of methodology itself. The ECT Lab+ proposes to carry this out under the following categories, firstly an adaptation of the Delphi method where the expert and expertise are conceived as forms of phronesis (Practical wisdom) and secondly, through an extension both historical and future facing of the techno-social imaginary. There is a link between both approaches which is made by situating the alternative epistemological approaches within the context of the social milieu of the expert practice. The ECT Lab+ in the coming months will, therefore, focus specifically on the development of the technological foresight for the European University of Technology as mode of experimental methodological iterations, these will take place through the ECT Lab+ network and will be framed by the questions of Responsible Technological Innovation.

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Section 3 (D4.3.3c)

Introduction

Building on the work carried out over the first two years of the EUt+ pilot phase and the activity of the European Culture and Technology Laboratory (ECT Lab+) it was decided that the ECT Lab+ could try to experiment with the development of its own methodologies to predict technological innovation. The fundamental presupposition is that culture and technology are not in opposition to each other, but rather technological development is rooted in its locality or milieu. We have argued that this cultural locality or milieu includes forms of imagination and fiction or poetic conceptualisation of the technical objects, and when it comes to developing a methodology. In addition to standard modes of prediction from future studies we decided to look to the areas of Systems Theory and the Delphi methods and we also recognised that it is necessary to include those imaginary or poetic elements within the cultural background to the technical or technological expertise.

The purpose of the methodological development within the ECT Lab+ is to explore methods and methodologies related to technological foresight. Over the last 40 years there has been the development of specific forms of technological foresight which are based on modes of speculation about technological innovation. In the previous document (D4.3.3b) we have set out an overview of the literature related to technological foresight and in this phase of the ECT Lab+ it was decided to explore how we could develop our own technological foresight methodologies. The methodologies we chose were based on what we could call a mixed methods approach, using elements from Systems Thinking, Delphi methodologies and more

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speculative methodologies such as Speculative Fabulation. The premise for the mixed methods approach was based on the recognition that standard methodologies for predicting the future of technological innovation needed to be aligned with research coming from technological innovation where science, art and technology have come together.

1 Systems Thinking approach to technological foresight

1.1 Introduction

Systems Thinking takes a holistic approach to characterization of a system that may be responsible for certain technological developments over time. For our purposes, it was important to conceptualise the complex system of technological innovation as co-evolutive process involving humans as part of the complex system. We hold that a structure of the system and interrelation between elements of the system defines the behaviour (innovation as behaviour). By applying systems thinking as a tool, the elements and cause-effect links between these elements are identified and portrayed by causal loop diagrams (CLD).

The benefit of this approach is twofold. First, constructing CLDs facilitates collaboration and consensus building on what the system might be and what elements it could consist of. That process employs collective knowledge and becomes a valuable learning process. Second, CLDs define a structure that may be quantitatively analysed by using system dynamics modelling (SDM). Actual behaviour over time of complex systems can be assessed only by SDM since intuition falls short of being able to do that without quantitative models. SDM is outside scope of this study and could be considered in the future studies. However, a process of constructing CLDs, done in the workshop is an important part of the Technological Foresight Methodology since it helps to reach consensus on very

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important factors of technological development, and the approach can be combined with other methods, primarily, the Delphi method.

Energy transition was taken as a case for the workshop on systems thinking for technological foresight. The reason is that the energy transition covers a broad spectrum of aspects related to climate change, water-food-energy nexus, green and digital transition, socio-technical and institutional transformation, sustainable mobility, smart cities, and alike. A pressing need to transform our energy systems will require technological and also social transformation on a large scale. That need will be a strong driving force for technological development.

1.2 Goal and description of the 1st workshop on using Systems Thinking to the case of energy transition

The goal of this workshop was to test the applicability of the Systems Thinking and causal loop diagram methodology for technological foresight, as well as:

- identify the elements and feedback links of the system responsible for the dynamics of the energy transition (CLDs provide a holistic view and capture our mental models of the system)
- identify what technologies and practices are needed to foster energy transition.

The dynamic problem addressed in the workshop was: “how can we increase the probability of development of the technologies we need for energy transition and diffuse them into society at a sufficient rate? What are the ‘blind spots’ that could be overlooked?” Since most of the participants of the workshop were new to Systems Thinking and constructing CLDs, introduction to Systems Thinking and principles of constructing CLD was given in the beginning (see Table 1). A presentation about Systems Thinking and principles of CLDs is appended to this report.

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Table 1 Program of the 1st workshop on using Systems Thinking to the case of energy transition

	Activity	Duration
1.	Definition of the problem and aim of the workshop	5 min (workshop starts at 14:00 o'clock CET)
2.	Introduction to principles of constructing the causal loop diagrams (CLDs)	20 min
3.	Information about organizational issues, i.e., program and including using the MIRO platform	10 min
4.	Working on the 1st question: 1) what do we need to do to make our energy systems sustainable (i.e., to foster energy transition)? Try to represent actions with single words, i.e., nouns or noun phrases.	15 min
5.	Working on the 2nd question: 2) what are the barriers and limitations to making our energy systems sustainable (in relation to what is needed)?	15 min
6.	Working on the 3rd question: 3) what technological (or other) solutions would help us to overcome these barriers and limitations?	15 min
7.	Working on the 4th question: 4) can you identify causal relations and feedbacks between the identified activities, barriers, and solutions? Are there any "blind spots", i.e., unforeseen adverse effects that could be overlooked?	15 min
8.	Discussion of the results	20 min

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9.	Conclusions and wrapping up	5 min
	The total duration of the session	**120 min**

Collaborative work was done in Miro platform, and it consisted of 4 parts, each part related to one specific question (see the Table 1 above). The first question "what do we need to do to make our energy systems sustainable (i.e., to foster energy transition)?" aims at identifying a broad spectrum of elements of the system that may be related and responsible for the energy transition, including social and culture elements, e.g., change of behaviour. The second question "what are the barriers and limitations to making our energy systems sustainable (in relation to what is needed)?" was designed to trigger thought about bottlenecks in transition to sustainable energy systems, including a required change of consumption patterns and behaviour. That question led to the third question "what technological (or other) solutions would help us to overcome these barriers and limitations?" which is set to think about technological solutions that may help to overcome the barriers and limitations. The fourth question "can you identify causal relations and feedbacks between the identified activities, barriers, and solutions? Are there any 'blind spots', i.e., unforeseen adverse effects that could be overlooked?" frames discussion and work on constructing a system that may create a certain path of technological development. That system, consisting of CLDs and reflecting the most important feedback mechanisms should be the main result of the whole exercise.

1.3 Results of the 1st workshop (from Miro platform)

Results of the 1st workshop are represented as exported figures-areas (see Figures 1 - 4) reflecting work done for each of the four questions.

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Figure 1 Results of the discussion about the first question "what do we need to do to make our energy systems sustainable (i.e., to foster energy transition)?

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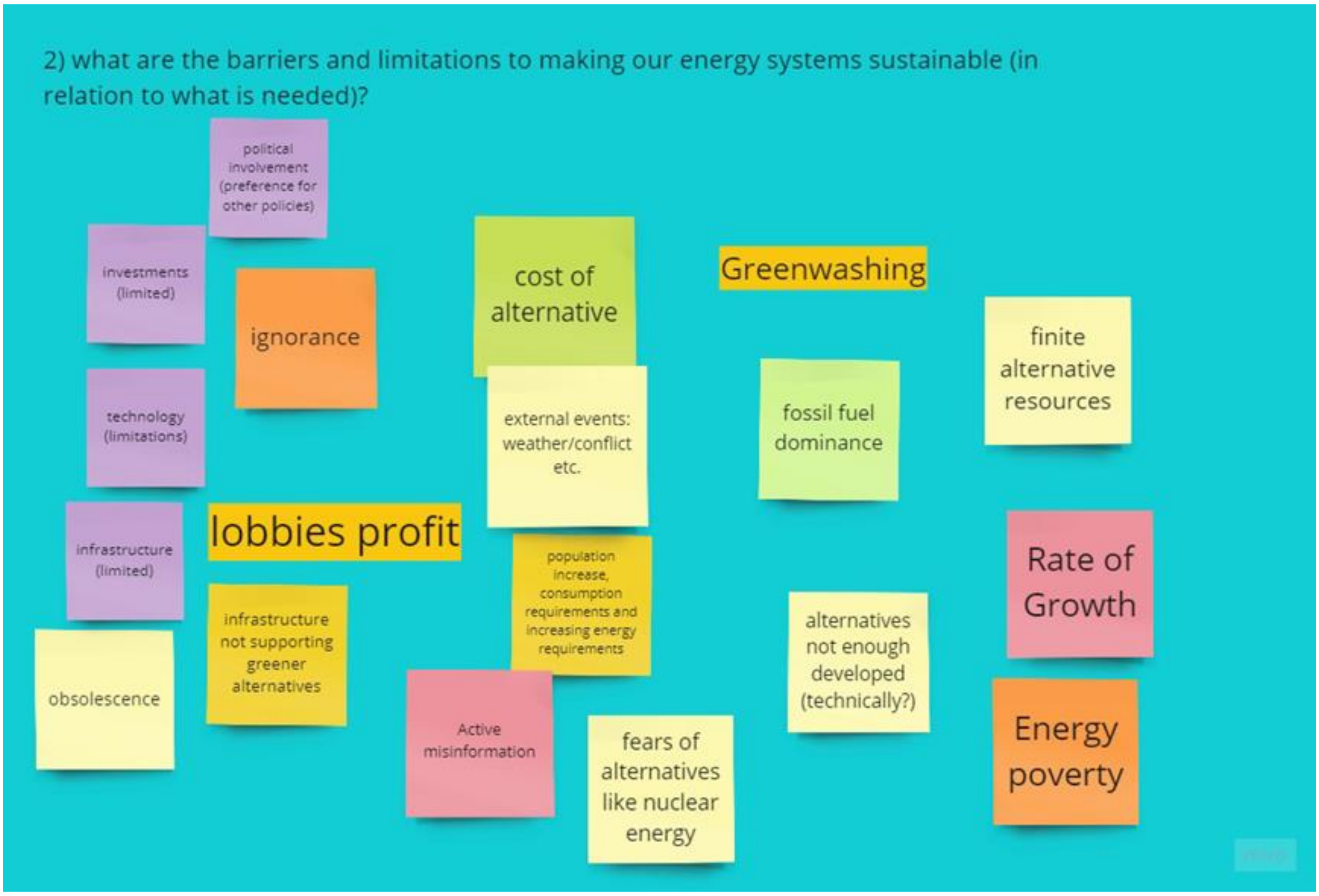

Figure 2 Results of the discussion about the second question "what are the barriers and limitations to making our energy systems sustainable (in relation to what is needed)?"

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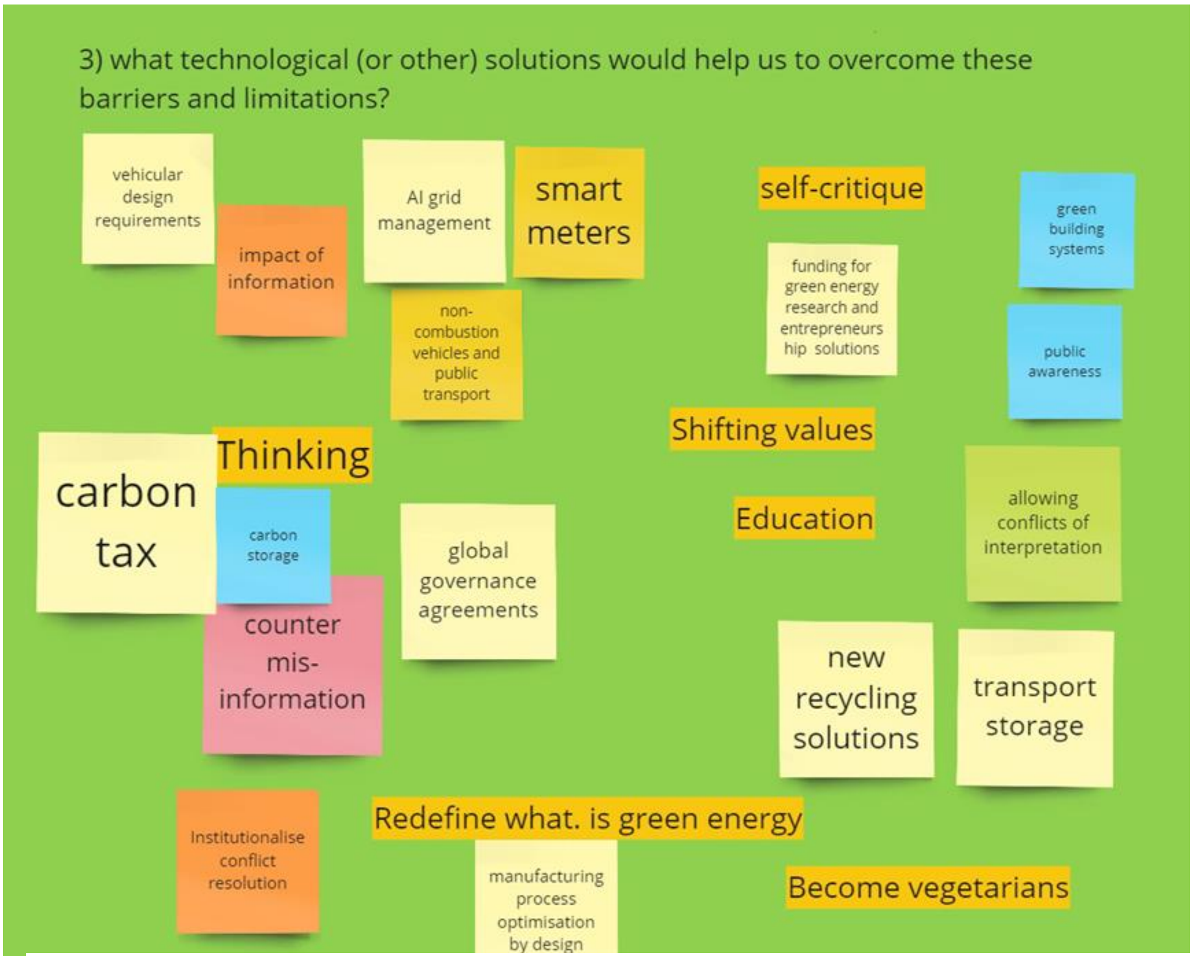

Figure 3 Results of the discussion about the third question "what technological (or other) solutions would help us to overcome these barriers and limitations?"

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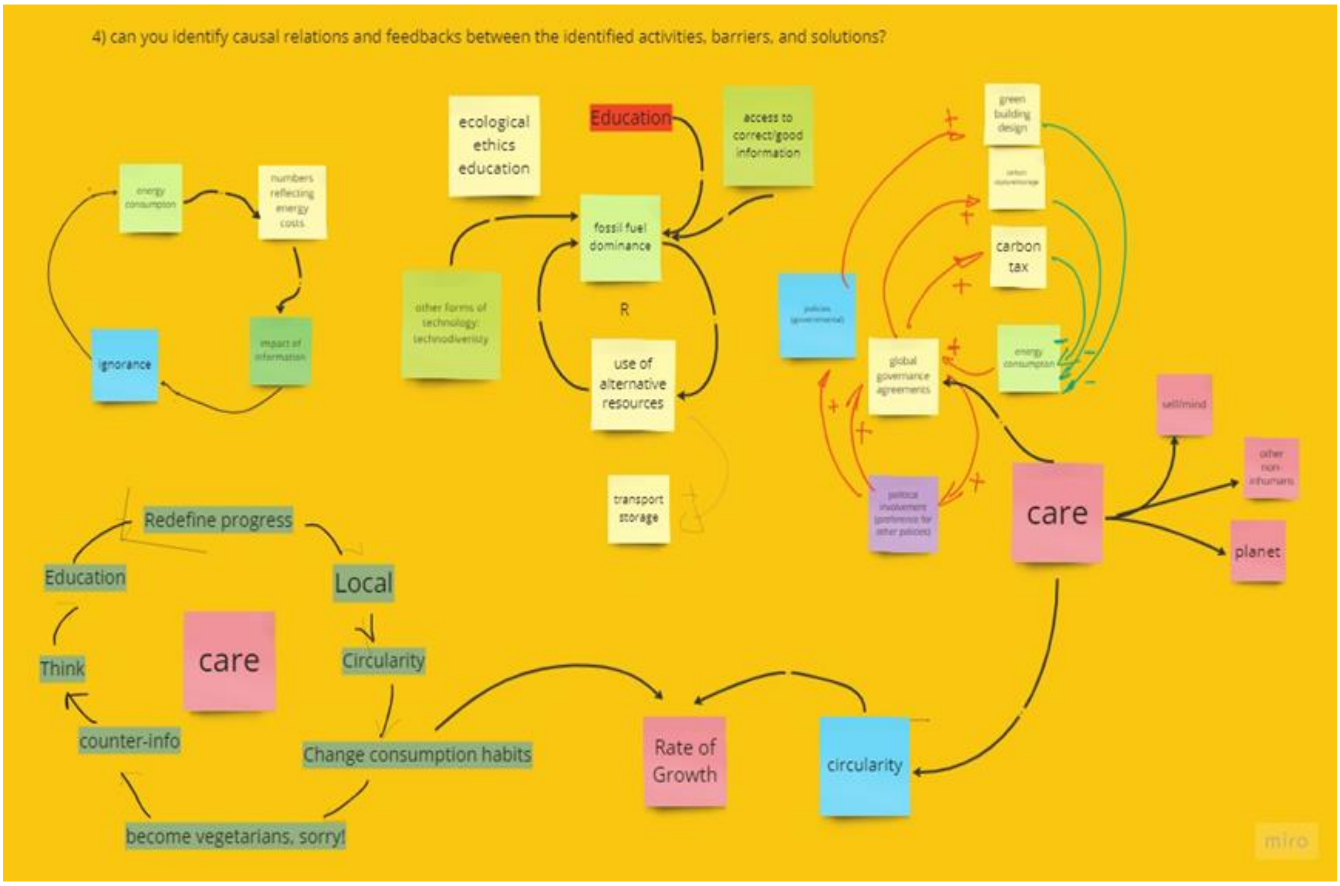

Figure 4 Results of the discussion about the fourth question "can you identify causal relations and feedbacks between the identified activities, barriers, and solutions? Are there any "blind spots", i.e., unforeseen adverse effects that could be overlooked?"

As we see in Figure 4, "care" is one of the central elements in the cause-effect relations. That can be "care about environment and people." However, CLD around that element is not constructed according to the principles of system thinking. It must be redesigned to agree with the following principles:

+ A positive link means that if the cause increases, the effect increases above what it would otherwise have been, and if the cause decreases, the effect decreases below what it would otherwise have been.

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- A negative link means that if the cause increases, the effect decreases below what it would otherwise have been, and if the cause decreases, the effect increases above what it would otherwise have been. When assessing the polarity of individual links, assume all other variables are constant (the famous assumption of ceteris paribus).
- Link polarities describe the structure of the system. They do not describe the behaviour of the variables. That is, they describe what would happen IF there were a change. They do not describe what actually happens.
- The variable names in causal diagrams and models should be nouns or noun phrases. The actions (verbs) are captured by the causal links connecting the variables.
- Choose names for which the meaning of an increase or decrease is clear, variables that can be larger or smaller. Without a clear sense of direction for the variables you will not be able to assign meaningful link polarities.
- If the disturbance propagates around the loop to reinforce the original change, then the loop is positive. If the disturbance propagates around the loop to oppose the original change, then the loop is negative.

These principles were taken from the source: Sterman J.D, Business Dynamics: Systems Thinking and Modelling for a Complex World, McGraw-Hill Education; February 23, 2000.

When re-designing loops appropriately (see Figure 5), additional discussion and analysis is initiated regarding the actual causes and effects of real systems. This is an important step towards a better understanding of the underlying structures and relations, and consensus on the primary causes of certain dynamics of the system. With increased “Care”, the “Focus on sustainable progress” increases as well, resulting in more “Use of local resources” (ceteris paribus). Increased use of local resources leads to higher level of “Circularity” of a certain economic system, and increased circularity has a positive impact on “Sustainable consumption habits.”

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Transformation to sustainable consumption habits has a positive effect on "Education level about sustainable lifestyle" by creating larger demand for such education. With an increased level of education, care about the environment and people becomes even stronger than before, and reinforces the focus on sustainable progress and all other effects represented by the loop. This is "positive" or reinforcing loop.

"Positive" causal loop does not mean that it is beneficial. In this case, it is, but very often "positive" loops can escalate damaging or disastrous effects (the reinforcing loops lead to exponential growth). Therefore, systems are normally balanced by the "negative" or "balancing" loops that "calm down" initial disruptions of the system (the balancing loops lead to a goal-seeking behaviour). In this case, the balancing loop represents the effects of resistance to growing tendencies of sustainable consumption habits. These effects may gain strength with the sustainable consumption habits becoming increasingly popular. The resistance effects counteract the positive loop and may eventually lead to "S-shaped" behaviour of the system with equilibrium reached at a certain level of sustainability.

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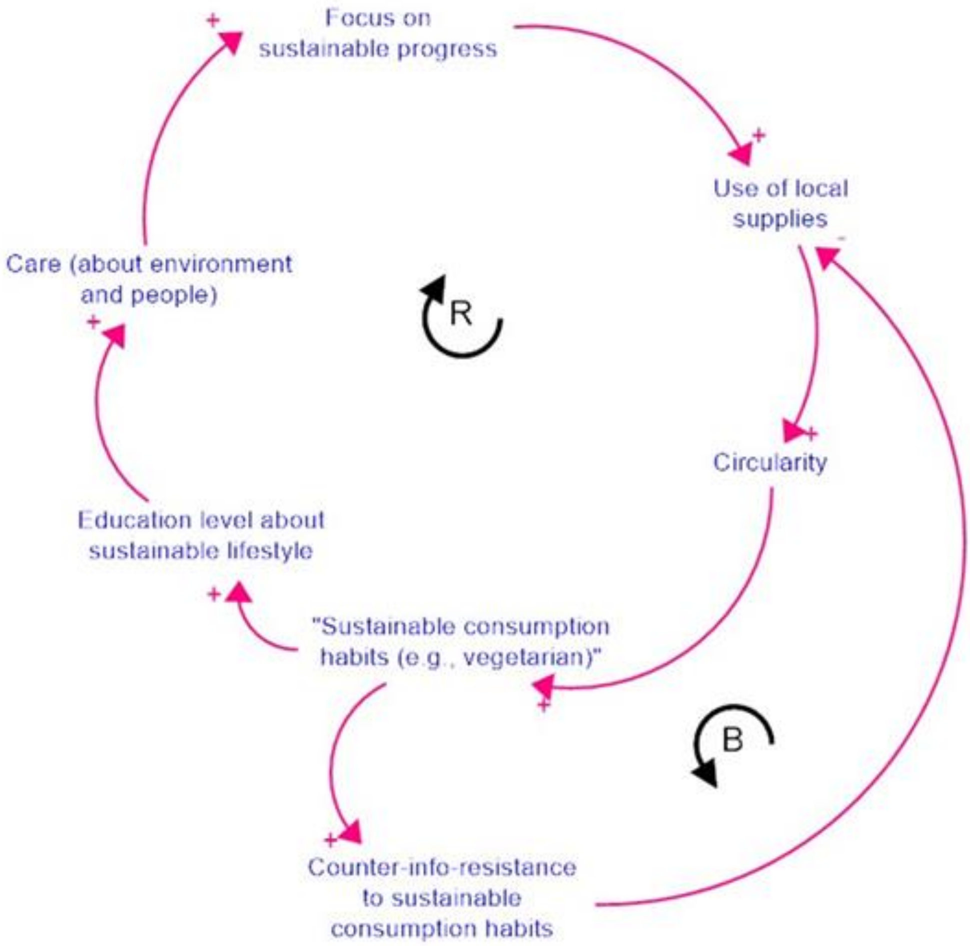

Figure 5 Causal loop diagram of cause-effect feedback loops around "care". The system is represented by one reinforcing (R) and one balancing (B) loop.

A similar approach for re-designing loops can be done for other elements, identified as important during the workshop. Work on creating CLDs and system's characterization can be done in combination with using the Delphi method, as there are good synergies. Questions for the Delphi method can be framed to facilitate design of CLDs and vice versa.

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2 Delphi method applied to Technological Foresight

2.1 Introduction

Delphi methods are typically utilised within the social sciences to gather data from situated experts where access to field sites is remote, restricted because of conflict or disaster, or because the source of knowledge is dispersed and/or abstract. Delphi methods require purposive sampling of a panel or panels of experts using a quantitative approach and survey methods in a series of rounds. Experts are asked to respond to standard survey questions and are given feedback of the results to each other on an anonymous basis. This anonymity enables the expert to respond to questions using their own values rather than those of their employers. The responses to the first round are used to form a second and third round of short questionnaire based surveys. In theory, as rounds advance (typically there are 2-3 rounds) the responses tend towards consensus and hence the research captures a picture of the state of the art as experts see it. Delphi methods have been deployed consistently in technological forecasting whether by governments or within industries.

2.2 Goal and description of the 2nd workshop on using Delphi method to the case of energy transition

The purpose of the workshop was to enable ECT Lab+ colleagues to collaborate to identify the focus of a Delphi based project to forecast futures on energy transition. Brainstorming using the Miro platform addressed four key questions.

- What are the issues in respect of energy transition that we want experts to address?
- What are the specific questions that we should ask them?
- What do we mean by an expert? Are these external, internal or a combination of both?

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- Who are the experts? What broad categories of expertise do we wish to include in a purposive sample?

In addition to these four questions, the workshop aimed at the formation of a work package within the ECT Lab+ and to deploy resources aimed at carrying out the practicalities of a Delphi based research project.

Table 2 Program of the 2nd workshop on using Delphi method to the case of energy transition

	Activity	**Duration**
1.	Definition of the problem and aim of the workshop	5 min (workshop starts at 14:00 o'clock CET)
2.	Introduction to principles of the Delphi method (Matt Bowden)	20 min
3.	Information about organizational issues, i.e., program and including using the MIRO platform	5 min
4.	Working on the 1st task: 1) identify the key issues that we wish technological experts to help us to answer.	15 min
5.	Working on the 2nd task: 2) construct a list of questions that can be designed into a questionnaire.	15 min
6.	Working on the 3rd task: 3) define what we mean by an expert; and decide if this was something we do with external expertise, internal experts in EUt, or a combination of both.	15 min

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7.	Working on the 4th task: 4) develop a list of categories for a purposive quota sample.	15 min
8.	Discussion of the results	25 min
9.	Conclusions (next steps) and wrapping up	5 min
	The total duration of the session	**120 min**

2.3 Results of the 2nd workshop (from Miro platform)

Results of the 2nd workshop are represented as exported figures-areas (see Figures 6 - 9) reflecting work done for each of the four questions.

Figure 6 Results of the 2nd workshop (from Miro platform)

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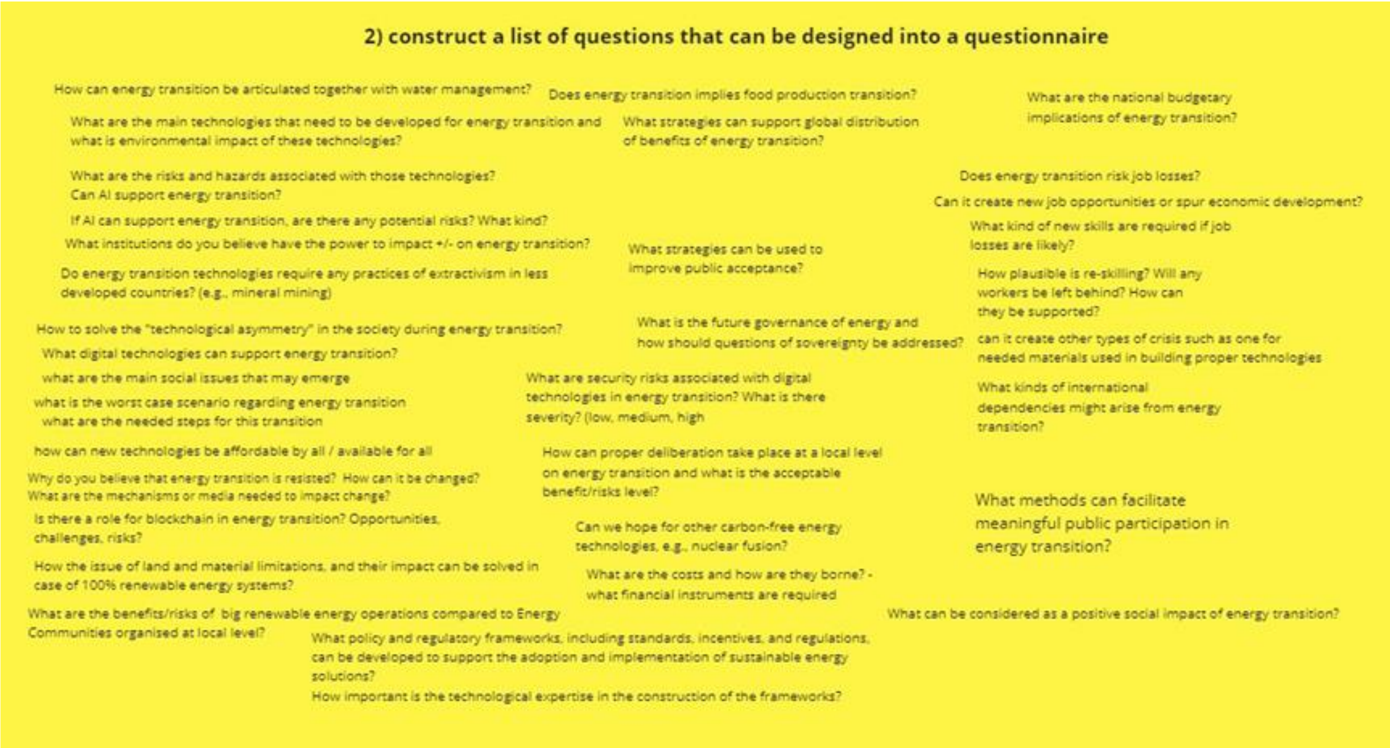

Figure 7 Results of the discussion about the second question "construct a list of questions that can be designed into a questionnaire"

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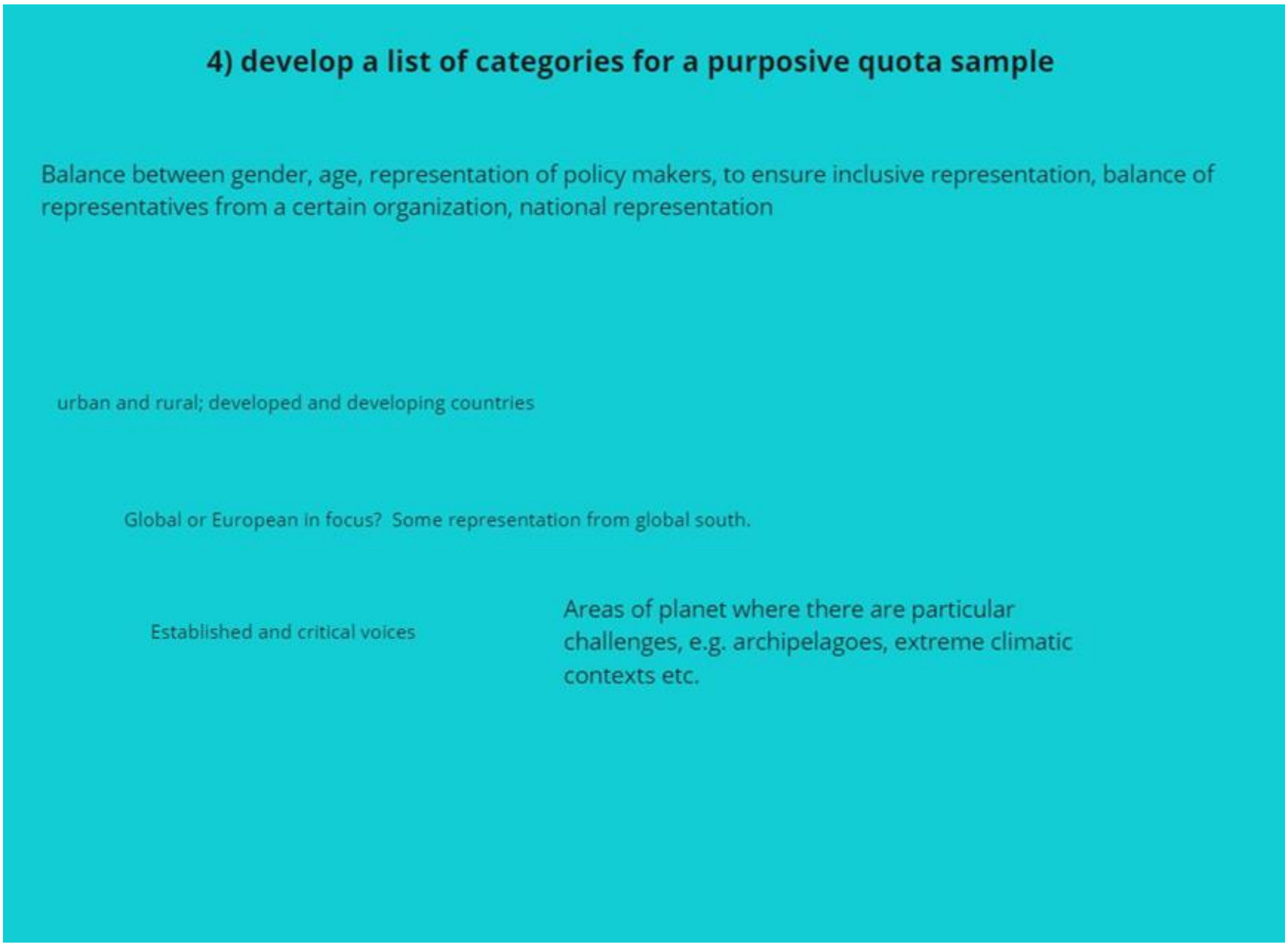

Figure 8 Results of the discussion about the third question "define what we mean by an expert; and decide if this was something we do with external expertise, internal experts in EUt+, or a combination of both"

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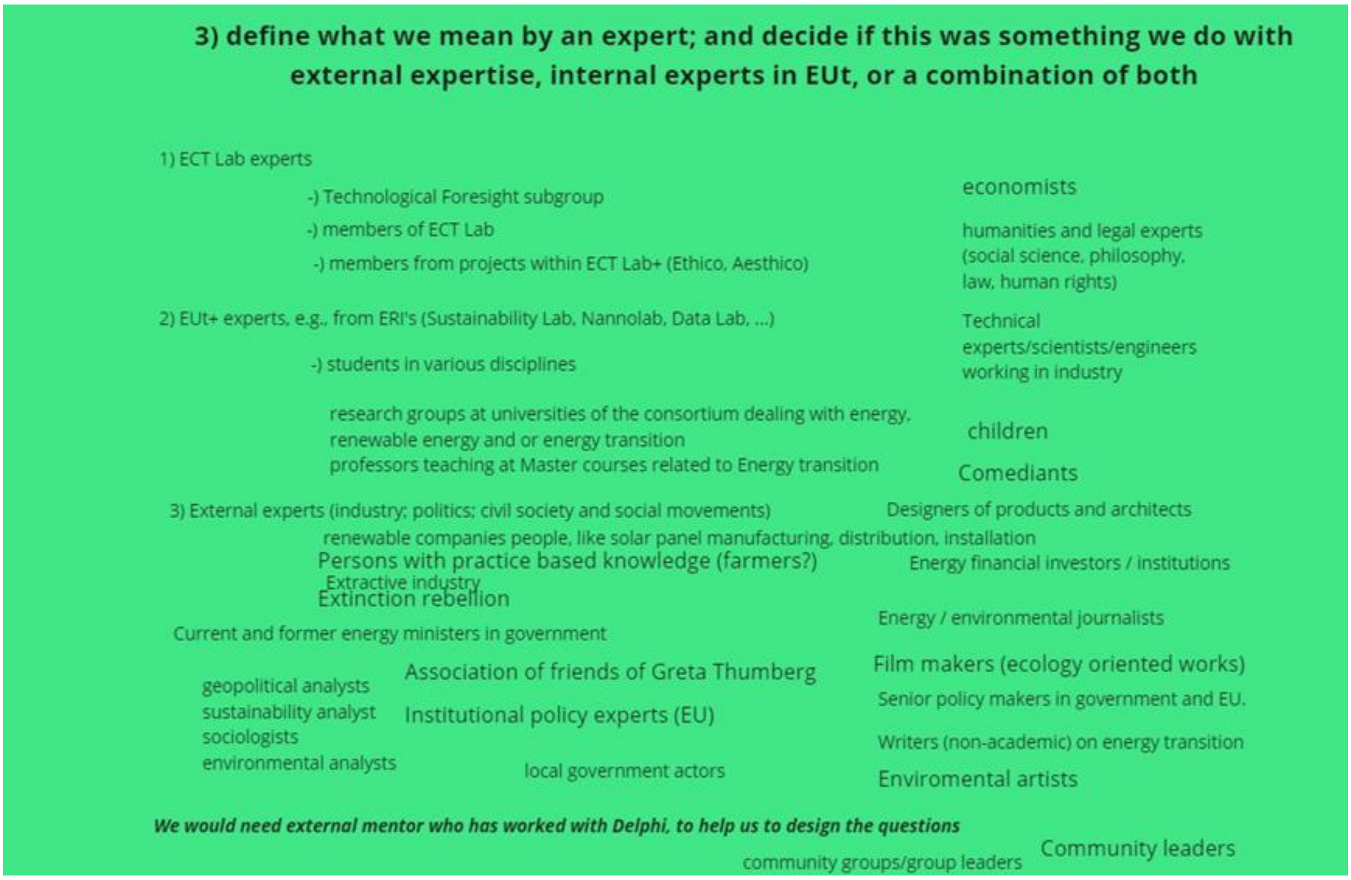

Figure 9 Results of the discussion about the fourth question "develop a list of categories for a purposive quota sample"

The workshop identified a range of issues at micro, macro and meso levels that experts could address including the behavioural changes that are required at institutional and subjective levels, together with the roles of mediating professionals at the intermediate level (Figure 6). In addition there are several challenges in relation to regulation and governance of energy transition together with the role of key decision makers at elective and executive levels in government. In setting out some specific questions to address these issues in a standardised survey instrument, participants identified questions around strategies to improve public acceptance for energy transition alongside the role of digital technologies

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and artificial intelligence in transition (Figure 7). The workshop identified a very wide range of “experts” including those in policy making and government alongside activists and those working in the arts as commentators on questions of science and technology in the context of climate change (Figure 8). The experts to be sampled (Figure 9) should be drawn from as wide a global reach as possible including representation from the Global South. A combination of those with expertise in a variety of different settings where there are specific challenges e.g. Archipelagoes and extreme climate issues should be included in the sample, alongside a gender balance, age and location vis-a-vis government and institutions.

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3 Futures Studies

3.1 Speculative Fabulation as technological foresight methodology

The human species' appetite for exploration, discovery, and foresight can be fulfilled through narratives that transport us into imaginary worlds. These worlds of fiction can take various shapes, ranging from simple narratives focussed either in the past or the future to more dynamic ones capable of engaging with the present through speculative storytelling or speculative fabulations. This practice of the human imagination offers a means to grapple with the blind corners of our current models of living and knowing while presenting alternative approaches to contemporary socio-political, environmental, and economic challenges.

Speculative Fabulation (SF), as methodology, is a transformative tool. In this approach, SF enables a departure from prevailing anthropocentric technoscientific and economic worldviews thereby facilitating the reconfiguration of harmful human-driven activities. In this sense, SF blends elements of science fiction storytelling with critical analysis, allowing for a reshaping of established knowledge paradigms into unfamiliar and innovative configurations. While these narratives are rooted in fiction, they collaborate with empirical knowledge systems to yield unique and unconventional insights, ultimately offering alternative lenses through which to perceive our world and build a better future for everybody, including the planet. The essence of Speculative Fabulation lies in challenging traditional boundaries that segregate humans, animals, and technologies, thereby contesting the human-centric perspective that often sidelines non-human entities. These speculative fabulations prompt us to contemplate the agency and interconnectedness of diverse forms of existence, fostering a more inclusive and ethically sound approach to our relationships with more-than-human entities, including technology. By underscoring the potential of alternative narratives, we anticipate that human-

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driven activities can be reimagined to better align with the intricate web of relationships that constitute our world.

With this aim, the technology foresight Speculative Fabulations subgroup works towards the incorporation of more-than-human voices into broader discussions about our shared world, thereby catalysing a shift from a human-centred perspective towards a more inclusive one.

To date, members of this working group have carried out three experimental workshops to test the methodology of Speculative Fabulation applied to complex problems. The first two workshops focus on the topic of language shaping our understanding of the world and our relationships with perceived 'others.' Both workshops were oriented to the identification of personal and cultural blind spots.

The first workshop took place at the Institute of Research and Innovation at the Centre Pompidou in Paris, France with a group of PhD students and proposed the analysis of the problem of climate change from the perspective of an expert group of terralinguists. Terralinguistics is a discipline devised by science fiction writer Ursula Le Guin and broadly, is dedicated to the study of THE language of the planet. Terralinguistics therefore, can read the signs from any entity on the planet, either living or dead, carbon or silicon etc… and thus, giving a voice to what is more-than-human.

For the workshop, a series of cues were given to help participants piece together a possible scenario (Figure 10). At the end of the exercise, the participants realised the difficulty of stepping outside their human-logos-centred perspective and understood the importance of incorporating other points of view into the comprehension of any situation.

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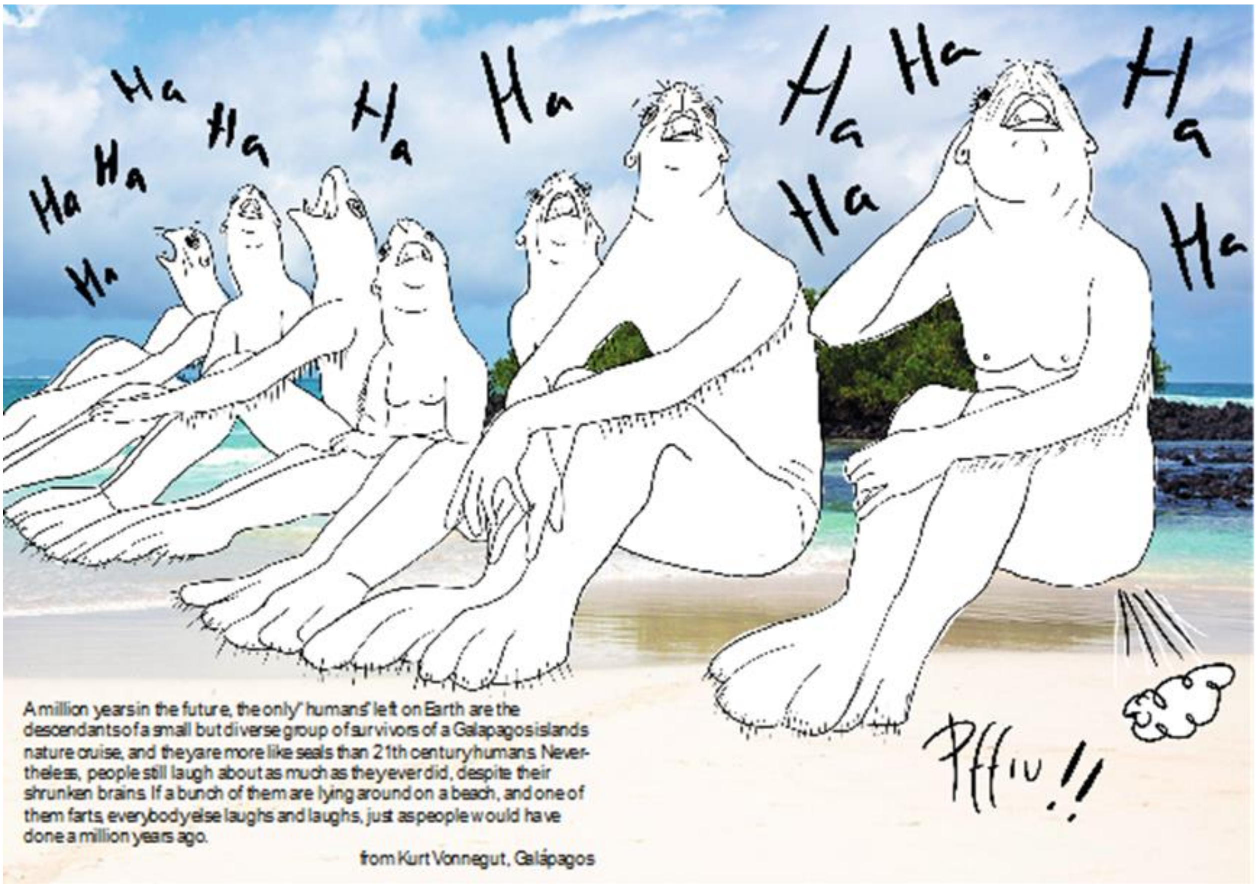

Figure 10 Evolution of human species as per Kurt Vonnegut 1985 sci-fi book Galapagos. Illustration by Ester Toribio-Roura

The second workshop took place in Dublin with the participation of a group of third-level teachers and researchers. With a similar premise, we took a step further by asking the participants to communicate by any means other than the spoken or written word. By eliminating from the equation any human logo-centric language, we intended to challenge anthropocentric frames on the interpretation of climate change and Terra formation. We encountered greater resistance to entering the game of speculation since most of the participants felt that they were asked to carry

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out too complex a task while given inadequate tools/instructions to face it. We learned that we needed to be more precise in both framing the questions and giving concrete instructions if we were to open our logos-constrained repertoire. We understood too that we had to live with the dilemma of expressing with words what cannot be expressed with them. We had made the quite common mistake, like Goethe's dove, of protesting the friction of the air, without realising that it is the only thing that allowed us to fly.

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Figure 11 Poster announcing the workshop Making Futures that took place in Dublin May 2022. Illustration by Ester Toribio-Roura

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The third experimental workshop took place at the Technological University of Cluj Napoca with a group of academics from diverse disciplines including, philosophy, architecture, engineering, and fashion. This workshop was on the subject of food production and the difficulty of balancing human and more-than-human interests. It was posed as a roleplay in which participants adopted the role of different stakeholders including animals, technologies and the environment. With very precise instructions, the task was to analyse the problem from different points of view and propose alternative ways of producing food taking into consideration human and animal needs, health and welfare, and environmental sustainability. In the second part of the workshop, participants were invited to speculate on how food production would look like when balancing the interests of the different stakeholders. The participants took an ethics of care approach and produced a series of posters mapping the future of food production. This exercise of speculation retrieved a more inclusive future in which ethics and care for the planet were at the centre of any scenario of food production. The main insight of the workshop was that by de-centring the human is possible to imagine alternative futures, enabling us to move on from the tunnel vision offered by current technofixes and techno apocalypses of the Anthropocene.

The structure and execution of the third workshop gave us the best template for Speculative Fabulation as a methodology. The next step for the coming months will be to apply this template to a fourth workshop this time focussed on energy transition. The insights arising from it will be then analysed in conjunction with the findings from the previous sections on the application of Delphi and Systems Thinking methodologies to energy transition and as a mode of triangulation.

The joint analysis of the three workshops under the lens of an ethics of care can offer valuable insights into the potential of technological advancement on the topic of energy transition, its societal impacts, and policy changes needed to balance

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progress with responsible practice. This can translate into actionable policy recommendations and strategic plans for organisations and governments involved in the transition. At the same time, this analysis will help develop more refined iterations and a more structured methodology to test the plausibility of the speculative scenarios. This may involve conducting feasibility studies, technological assessments and further expert interviews (Delphi). These refined scenarios can be then shared with the public and citizen organisations such as Fridays for Future and presented to forums such as the United Nations to stimulate further discussion and awareness about the future of energy transition. Engaging in dialogue will allow us to gather public input and concerns that will help a more nuanced monitoring of technological development in relation to societal needs and changes.

3.2 Beyond the topic of energy transition and in a more general context of technological foresight

The bringing together of different perspectives, in a sort of technological multiculturality or technodiversity along with constant feedback/iterations will translate into the ongoing refinement of scenarios or in other words, into a dynamic technological foresight or tech-mosaic (as in culture-mosaic). The purpose of the constant friction is to achieve a global (not finite or final) vision of how the technological foresight model works, effectively placing it in the epistemological and methodological frameworks of cybernetics and systems theory paradigms.

By integrating Speculative Fabulation into the broader framework of methodologies for tech foresight, we are including more-than-human perspectives and therefore queering dominant anthropocentric techno-scientific and economic worldviews into unfamiliar configurations and thus enabling the reconfiguration of harmful anthropogenic activities into more ethical ones.

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4 Discussion and next steps

4.1 Combining Delphi and Systems Thinking on building expert consensus

Both methods, Delphi and Systems Thinking use collective knowledge and mental models of experts and involved stakeholders. The difference is that using Systems Thinking is a participatory process, i.e., work on CLDs is preferably done in simultaneous collaboration between participants, while in the Delphi method experts may work individually. Nevertheless, a consensus on the results is reached in both cases. One method can facilitate reaching that consensus in another method and make collaboration more efficient. Namely, questions in the Delphi method can be designed to help identification of elements and relations for constructing CLDs of a system. There could be an iterative approach, when the questions, designed by applying the Delphi method are used to construct CLDs, and after work on CLDs, the questions for the Delphi method are re-designed in order to get deeper insight about the elements and causal relations of the analysed system.

4.2 Speculative Fabulation as methodology for technological foresight

We contended that Speculative Fabulation as a methodology has the potential to encourage humans to reflect on the capacity and interconnectedness of diverse forms of existence, promoting a broader and more ethically sound way of engaging with what is human and more-than-human. By emphasizing the condition of possibility that diverse stories of our shared world can offer, we foresee that human actions can be reconfigured to better harmonise with the complex network of relationships that make up our shared existence on the Planet.

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We envision the next steps of Speculative Fabulation as a methodology and in the context of Future Studies within the ECT Lab+ Technological Foresight subgroup framework, as the condition of openness of technological progress towards more-than-human sensitivities and therefore towards more inclusive ethics of care (for the individual, communities and the Planet). This openness towards the more-than-human is currently gaining momentum due to the extent of the ecological crisis as a consequence of harmful technology and practices and the modes of production (capitalist and/or otherwise) characterised by both savage extractivism and unrestrained consumerism that endanger the continuity of life on the planet.

We argue that in the current situation if anything, progress is more ethical (in the sense of an ethics of care) than technological. With this idea in mind, we intend to bring the more-than-human perspective into technological foresight. We believe that if we manage to fertilize technological progress with an ethics of care, the Anthropos, will begin to see under a different lens the more-than-human perspective(s) and therefore will have a chance to progress-with instead of progressing at-the-expense- of the more-than-human.

In general terms, one of the first affirmative steps we can take is mapping the diversity of human and more-than-human technologies and 'savoirs' (savoir faire, savoir vivre, savoir theorique) that are already there. To create a repository of the technologies and practices that are ecologically and ethically sensible and examine and challenge others claiming ecological sensitivity but that intentionally or inadvertently have fallen into the manipulation and negation of what is more-than-human, in fact cancelling it in their practices.

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Conclusion to the deliverable

As we move into the next phase of the EUt+ initiative, which is called EUt Accelerate, the ambition is to continue the research into the development and implementation of the ECT Lab+ technological foresight methodology. This will be done through continued work on Delphi, Systems Thinking methods, and Speculative Fabulation. It is hoped to allocate a resource to help this in the next phase. The development of the ECT Lab+ methodologies is a spectrum of activity which on the one hand has Systems Thinking and on the other has forms of artistic research methodologies which are more experimental and speculative. The next phase of the development of technological foresight will be underpinned by the allocation of resources to help this activity grow and this will be aided by the development of externally funded projects. The MSCA Staff Exchange project EPISTEAM includes areas of experimental exploration of technological innovation. This will be an opportunity to continue the work of the technological foresight group. The inclusion of questions of ethics and sustainability with technological foresight has been very fruitful and we are proposing to continue this work by taking some of the results from the EthiCo project and bringing them together with some of the methodological questions related to technological foresight. The work on Speculative Fabulation is also included in the WP3 of the EPISTEAM project where questions link to experimentation--this will be done through specific workshops of Speculative Fabulation, fiction and speculation all together. In the EUt Accelerate the activity of technological foresight will come under WP 2 which is focused on the green and digital transition and the work of the group will continue to be led by the ECT Lab+.

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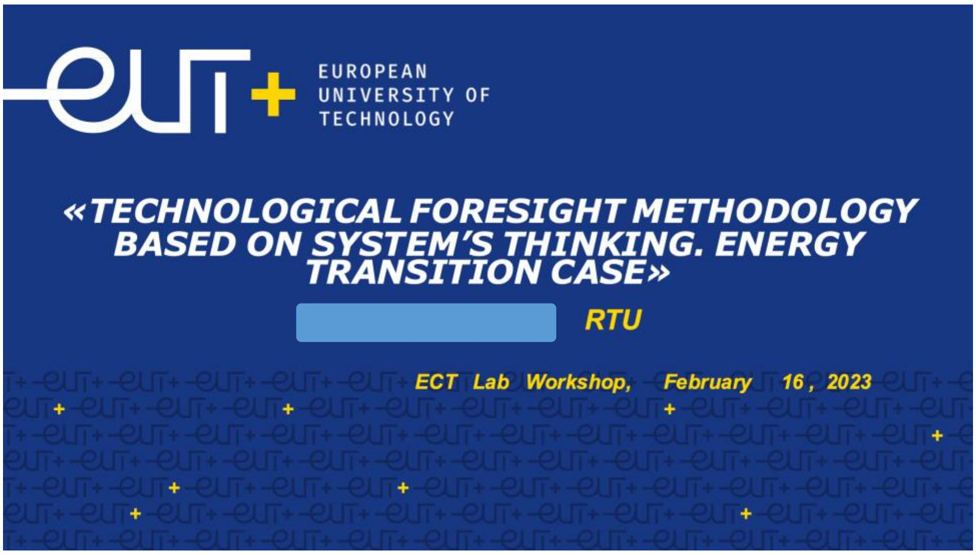
Appendices

Presentation of the 1st on using systems thinking to the case of energy transition

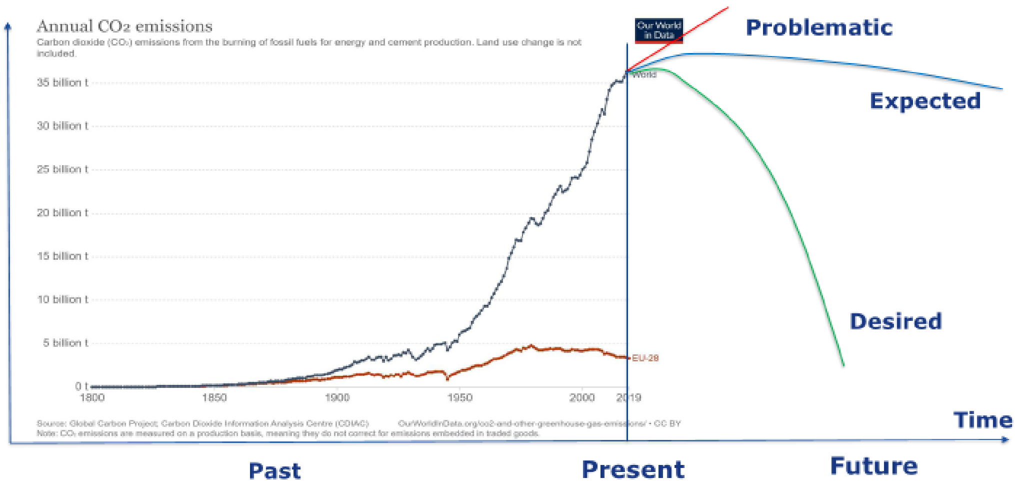


PROGRAM OF THE WORKSHOP

	Activity	Time
1.	Definition of the problem and aim of the workshop	5 min
2.	Introduction to principles of constructing the causal loop diagrams	20 min
3.	Information about organizational issues, including MIRO platform	10 min
4.	Working on the 1st question: 1) what do we need to do to make our energy systems sustainable (i.e., to foster energy transition)? Try to represent actions with single words, i.e., nouns or noun phrases.	15 min
5.	Working on the 2nd question: 2) what are the barriers and limitations to making our energy systems sustainable (in relation to what is needed)?	15 min
6.	Working on the 3rd question: 3) what technological (or other) solutions would help us to overcome these barriers and limitations?	15 min
7.	Working on the 4th question: 4) can you identify causal relations and feedbacks between the identified activities, barriers, and solutions? Are there any "blind spots", i.e., unforeseen adverse effects that could be overlooked?	15 min
8.	Discussion of the results	20 min
9.	Conclusions and wrapping up	5 min
	Total duration of the session	**120 min**

2 WORKSHOP OF ECT LAB ON TECHNOLOGICAL FORESIGHT METHODOLOGY - 16 / 02 / 2023

DYNAMIC PROBLEM-PROBLEMATIC BEHAVIOR OVER TIME



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STRUCTURE - BEHAVIOR

We need to understand structure to change behavior

SOURCE OF PICTURE: WIKIPEDIA

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DYNAMIC PROBLEM ADDRESSED

- How can we increase the probability of development of the technologies we need for energy transition and diffuse them into society at a sufficient rate?
- What are the "blind spots" that could be overlooked?

AIM OF THE WORKSHOP

- Test the applicability of the system's thinking and causal loop diagram (CLD) methodology for technological foresight
  - identify the elements and feedbacks of the system responsible for the dynamics of the energy transition (CLDs provide a holistic view and capture our mental models of the system)
  - identify what technologies and practices are needed to foster energy transition.

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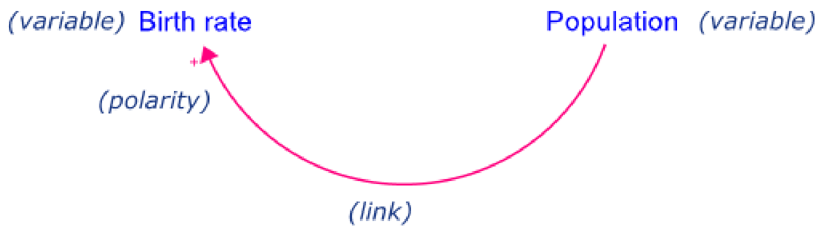
INTRODUCTION TO PRINCIPLES OF CONSTRUCTING THE CAUSAL LOOP DIAGRAMS (CLD)

- CLD helps to represent important **feedbacks** that may cause a dynamic problem
- CLD are mental models of the **structure** of the studied systems
- CLD consists of **variables** connected by **arrows - links** representing causal influences

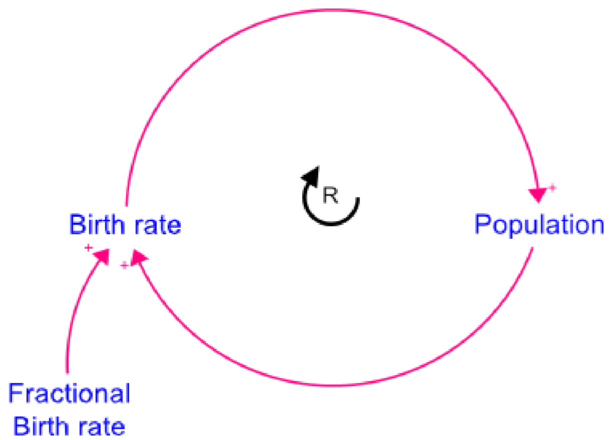


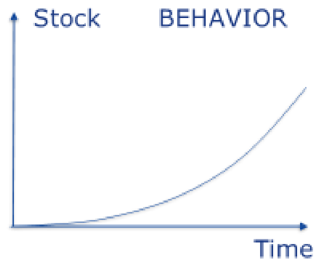
+ polarity means that if the **cause increases** then the **effect also increases** (above what it would have been) *if everything else remains the same*

or

that if the **cause decreases** then the **effect also decreases** *if everything else remains the same*

Variable names should be such that it can both increase or decrease





R - Loop identifier: **positive** or **reinforcing** loop

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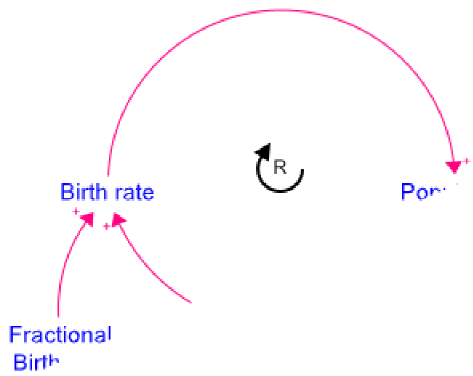
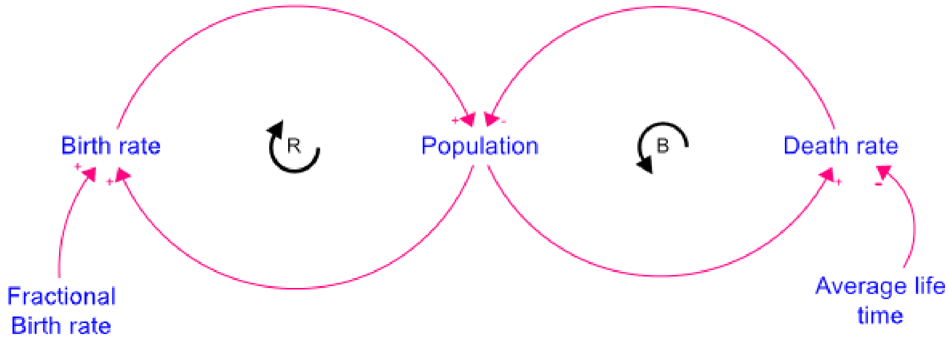


10 WORKSHOP OF ECT LAB ON TECHNOLOGICAL FORESIGHT METHODOLOGY - 16 / 02 / 2023

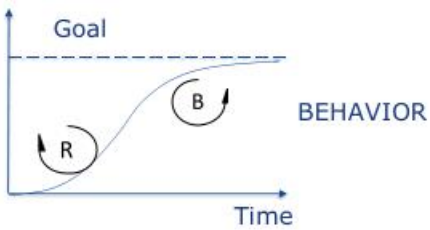
- Loop identifier: **negative** or **balancing** loop



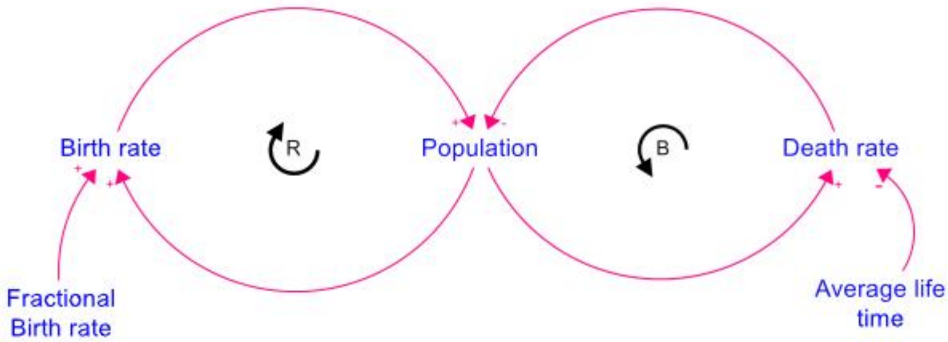
- polarity means that if the **cause increases** then the **effect decreases** *if everything else remains the same*

or

that if the **cause decreases** then the **effect increases** *if everything else remains the same*



Source: www.clipartpanda.com



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SUMMARY OF GUIDELINES FOR CONSTRUCTING THE CAUSAL LOOP DIAGRAMS (CLD)

- A **positive** link means that **if** the cause **increases**, the effect **increases above what it would otherwise have been**, and **if** the cause **decreases**, the effect **decreases below what it would otherwise have been**.
- A **negative** link means that **if** the cause **increases**, the effect **decreases below what it would otherwise have been**, and if the cause **decreases**, the effect **increases above what it would otherwise have been**. When assessing the polarity of individual links, assume all other variables are constant **(the famous assumption of *ceteris paribus*)**.
- Link polarities describe **the structure** of the system. They do not describe the behavior of the variables. That is, they describe what would happen **IF** there were a change. They do not describe what actually happens.
- The variable names in causal diagrams and models should be **nouns or noun phrases**. The actions (verbs) are captured by the causal links connecting the variables.
- Choose names for **which the meaning of an increase or decrease is clear**, **variables that can be larger or smaller**. Without a clear sense of direction for the variables you will not be able to assign meaningful link polarities.
- If the disturbance propagates around the loop to **reinforce the original change**, then the **loop is positive**. If the disturbance propagates around the loop to **oppose the original change**, then the loop is **negative**.

Source: Sterman J.D, Business Dynamics: *Systems Thinking and Modeling for a Complex World*, McGraw-Hill Education; February 23, 2000

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Presentation of the 2nd workshop on using Delphi method to the case of energy transition

Paper originally developed in June 2021 by Ect+ collaboration with...

- Matt Bowden, Technological University Dublin
- Inocencia María Martínez León, Universidad Politécnica de Cartagena
- Antonio Juan Briones Penalver, Universidad Politécnica de Cartagena
- José Luis Serrano Martínez, Universidad Politécnica de Cartagena

Critical Features

- Series of rounds with feedback in between
- Anonymity - critical for enabling situated experts to respond according to their values, not their role obligations:
    - "Such anonymous deliberation liberates respondents to express genuine views and particularly benefits those who are professionally or even (in the case of civil servants) constitutionally obliged to represent certain positions in open forums rather than expressing their own informed opinions and values (Edwards et al, 2020 p.4)".
- Move towards consensus between respondents as essence of 'state of the art' – and their projects on the future (FORECASTING)
- Disagreement also can be captured – but the point here is to specify what is the focus of dissensus?
- Importance of outliers in the distribution

Delphi method

- The method can be seen as a technique that allows for collective knowledge sharing, lending itself in those cases to solve problems where analytical techniques are difficult to apply
- Iterative method that utilises questionnaires administered to experts in a particular field, to capture opinion on the state of the art, or to forecast future events.
- Sampling – small, purposive sampling involving expert panels – not concerned with generalizing to a population
- Used in industry and in society to forecast future technologies, health challenges, innovation…

Six Step Procedure

Step 1: Setting up Delphi Process	Set goals; choose panel of experts (n=5 to 20 min); Decide on geographic dispersion; brainstorm issues to be addressed by survey; pilot
Step 2: Developing Questionnaire / Instrument items	Focus issues to be explored; design questionnaire using simple response categories; decid on what scaling used e.g. Likert
Step 3: How Delivered (software)	Paper, web, email or real-time?
Step 4: Providing Feedback	Median responses to be used; utilise qualitative data to reveal rational for responses; continue to next and subsequent rounds
Step 5: Preventing Drop-out from panel	Develop retention strategy to prevent attrition of panellists; communication strategy.
Step 6: Data Analysis and Presentation	Use descriptive statistics; note small sample sizes; present graphically; integrate results with other methods / techniques used.

Three Stage Delphi

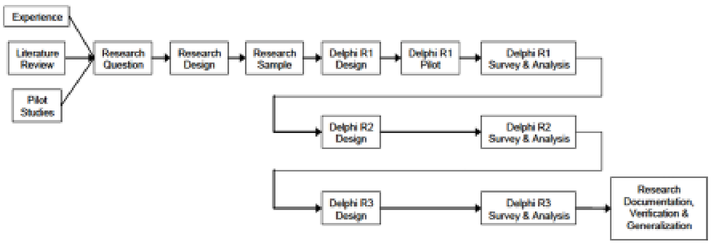

Figure 1: Three Round Delphi Process

Two distinct types

Group Delphi – uses a conference / seminar format

- Collects all data over a short, concentrated period (Plus)
- Loses anonymity (Minus)

Policy Delphi

- Disrupts perceived wisdom (i.e. values over roles)
- Forecasting public policy in particular but not exclusive in its application

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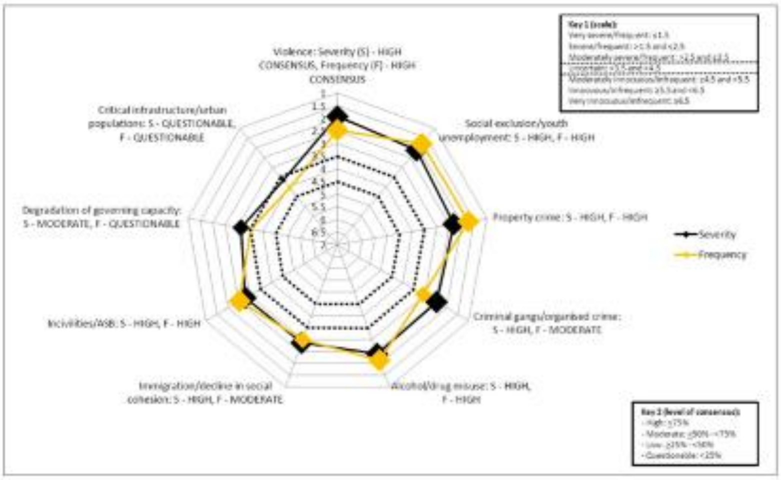

Figure 1. ESC – Severity and frequency of identified problems.

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