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A Method for Analysing Ethical Issues in Emerging Technologies – the TechEthos Approach (TEAeM)

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A Method for Analysing Ethical Issues in Emerging Technologies – the TechEthos Approach (TEAeM)[1]

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Abstract

This paper presents an approach which aims to build on earlier approaches to the ethical study of emerging technologies. The ethics of emerging technologies is a growing field, as the range and potential impact of technologies is ever expanding in our increasingly technological world. The ethics of emerging technologies and their study is first reviewed by examining a number of key ethical frameworks (including ATE, eIA, Future Studies and ATE+). However, these approaches lack some elements, which the paper looks to strengthen by integrating policy and empirical elements. The resulting approach is the TechEthos Anticipatory ethics Matrix (TEAeM) framework. This framework provides a methodological foundation for the study of ethical issues, especially for emerging technologies. In this way the TEAeM framework contributes to the field of emerging technologies ethics analysis.

Keywords: ethics, emerging technologies, ethics issues, frameworks, method, TEAeM

1.0 Introduction

Technologies in the 21st century are emerging all the time. Most of this aims to enhance the world and society that we live in and hopes to benefit people in their everyday lives, in some way. However, there is also the possibility that these technologies can, intentionally or otherwise, have a negative effect on society. If we drill down into this, it might be that it benefits one part of society while it disadvantages another part, and so we need to be aware of the wider implications of each of these emerging technologies. For example, facial recognition enables a plethora of technologies to function more easily, such as unlocking a smartphone or laptop, but might have biases built in causing it to have trouble recognising darker-skinned females (Buolamwini & Gebru, 2018). Other examples of potential negative social impacts of emerging technologies include; an increase in social inequality, exacerbation of existing power asymmetries, creation of bias and job displacement.

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The central problem for the ethics of emerging technologies is that we humans cannot predict the future, and therefore do not know which ethical issues will play out once the technology is fully developed and entrenched in society. As the emerging technology is still evolving, many questions can arise about its nature, its future use, and its social consequences. However, if an ethical framework is to be useful in an area of emerging technology.

This paper, therefore, argues for the development of a method to analyse the ethical issues involved that emerge as the technologies themselves are emerging, thus anticipating potential inequalities and concerns, rather than just reacting to them. Further, to suggest the possibility of building a greater ethical sensitivity into the people playing a role in shaping the development of the technologies themselves, or at least avoid the worst of the potential fallout.

TechEthos (www.techethos.eu) is an EU-funded project that deals with the ethics of the new and emerging technologies anticipated to have high socio-economic impact. The project involves ten scientific partners and six science engagement organisations and ran from January 2021 to December of 2023. TechEthos aimed to facilitate "ethics by design", namely, to bring ethical and societal values into the design and development of new and emerging technologies from the beginning of the process. Technologies covered are "climate engineering", "digital extended reality" and "neuro-technologies". The project aims to produce operational ethics guidelines for these technologies for users such as researchers, research ethics committees and policy makers. To reconcile the needs of research and innovation and the concerns of society, the project explores the awareness, acceptance and aspirations of academia, industry and the general public alike and reflects them in the guidelines.

In presenting a method to approach the ethics of emerging technologies, this paper distils some guidance for a method for analysing ethical issues in emerging technologies, from existing frameworks such as Anticipatory Technology Ethics (ATE), Ethical Impact Assessment (eIA), Future ethics and the nascent Anticipatory Technology Ethics plus (ATE+).

2.0 Existing Ethical Frameworks

Starting with the review of existing ethical frameworks and following the example set by Brey (2012a) this paper first defines emerging technologies, then examines key existing ethical approaches.

2.0.1 Existing Approaches to Ethics of Emerging Technologies?

Technologies are developing and expanding all the time, and as they say, it is an 'ever expanding field'. However, there does need to be some way to define what we mean by the term, "emerging technologies", at least to create a shared understanding of the boundaries around them (Haessler et al., 2022). One of the most quoted approaches to this discusses five key attributes that appear to help identify a technology as emerging, as derived from a review of relevant literature by (Rotolo et al., 2015):

a) radical novelty,
b) relatively fast growth,
c) coherence (persisting over time),
d) prominent impact (on the socio-economic domain), and
e) uncertainty and ambiguity (as we don't really know what the future holds and therefore what the impact of a technology will bring).

In the TechEthos horizon scan task (carried out as the first part of the project), we use the term new and emerging technologies to identify any type of technology that performs a new function or improves some function significantly better than other commonly used technology, which is expected to be developed and deployed in the next 5 to 10 years (adapted from the Organization for Economic Co-operation and Development, (OECD, 2017)).

Emerging technologies are also generally seen as having higher risk (in a general sense of risk arising from the uncertainties associated with the unknown), from both the uncertainties around their impact and also the potential issues with timely 'fixing' of any unwanted consequences which might arise from these impacts (Munoko et al., 2020). This paper, along with others (Stahl et al., 2017; Wright, 2011), looks to find a way to identify and analyse the ethical issues that arise from these risky emerging technologies (in the sense of identifying what the potential ethical risks might be early on).

2.1 Key ethical frameworks

The paper first briefly reviews three approaches to ethical analysis that exist in the literature and have previously been applied in a range of technology contexts. While this is not a comprehensive account, it aims to identify the key criteria in each approach. The three approaches selected for review are: Anticipatory Technology Ethics (ATE), Ethical Technology Assessment (eTA) and Future Studies.

2.1.1 Anticipatory Technology Ethics (ATE)

This approach focuses on emerging technologies from the perspective of trying to identify what is both good and bad about them. However, as these technologies are being developed, it is one thing to say what ethical issues are known, or can be reliably expected, but then there are also the ethical issues that will emerge over time as a consequence of use. Brey (2012a) reviews four approaches to technology assessment focused on ethics, namely ethical Technology Assessment (eTA) (Palm & Hansson, 2006), ethical Impact Assessment (eIA) (Wright, 2011), techno-ethical scenarios (Boenink et al., 2010; Stahl, 2011), ETICA approach (Stahl, 2011). additional insights on the other ethical frameworks can be found in TechEthos deliverable D5.1 (Bhalla *et al.*, 2023). Based on his analysis of these four approaches, Brey proposes a fifth approach, ATE, which he says has "the potential to meet all the criteria that a sound approach to ethical analysis of emerging technologies should have" (Brey, 2012a).

ATE has three levels of ethical analysis: technology, artifact and application level (Figure 1). It then defines what it calls 'objects of ethical analysis' for each of these levels, as properties or processes that might lead to ethical issues.

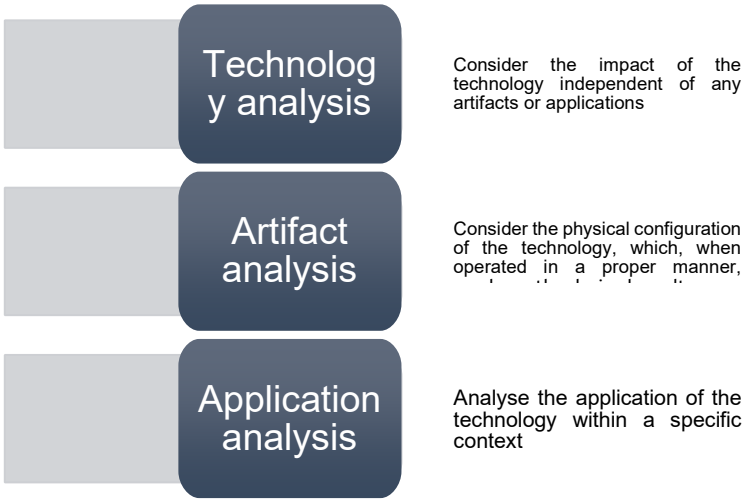

Figure 1: Original ATE levels *(Brey, 2012a)*

One of the issues for the early stages of ATE is how to identify the appropriate ethical values to be mapped with the specific technology. Brey (2012b) proposes an ethics checklist (see Table 1), which encompasses a range of ethical values and principles, based on ones that have been seen in earlier ethical approaches and commonly found within society (and also acknowledges that variations in culture and/or specific types of technology, might need a more specific list). The four categories of ethical principles are: Harms and risks, Rights, Justice (distributive) and Well-being and the common good.

Table 1: The anticipatory technology ethics checklist (Brey, 2012b)

• Harms and risks ○ Health and bodily harm ○ Pain and suffering ○ Psychological harm ○ Harm to human capabilities ○ Environmental harm ○ Harms to society	• Rights ○ Freedom ○ Freedom of movement ○ Freedom of speech and expression ○ Freedom of assembly ○ Autonomy ○ Ability to think one's own thoughts and form one's own opinions ○ Ability to make one's own choices ○ Responsibility and accountability ○ Informed consent ○ Human dignity ○ Privacy ○ Information privacy ○ Bodily privacy ○ Relational privacy ○ Property ○ Right to property ○ Intellectual property rights ○ Other basic human rights as specified in human rights declarations (e.g., to life, to have a fair trial, to vote, to receive an education, to pursue happiness, to seek asylum, to engage in peaceful protest, to practice one's religion, to work for anyone, to have a family, etc.) ○ Animal rights and animal welfare
• Justice (distributive) ○ Just distribution of primary goods, capabilities, risks and hazards ○ Non-discrimination and equal treatment relative to age, gender, sexual orientation, social class, race, ethnicity, religion, disability, etc. ○ North–South justice ○ Intergenerational justice ○ Social inclusion	• Well-being and the common good ○ Supportive of happiness, health, knowledge, wisdom, virtue, friendship, trust, achievement, desire-fulfilment, and transcendent meaning ○ Supportive of vital social institutions and structures ○ Supportive of democracy and democratic institutions ○ Supportive of culture and cultural diversity

Munoko et al., (2020) summarise the 5 steps for the researcher to follow in ATE as:

- "First, at the *technology level*, the researcher considers the features of the technology of ethical concern, independent of its current or potential use. This level involves the identification of the inherent and consequential risks of the technology.
- Secondly, at the *artifact level*, the researcher considers the "physical configuration that, when operated in the proper manner and the proper environment, produces the desired result." At this level, the researcher focuses on the artifacts independent of their actual applications and identifies the risks associated with the intended use of the artifacts.

- Third, at the *application level*, the actual use of an emerging technology's artifact is studied. At this level, the researcher considers the unintended consequences for the users of the applications and other stakeholders (for example, ChatGPT).
- Fourth, the researcher evaluates the potential importance of the issues identified.
- Finally, the fifth part of the ATE framework is optional, where the researcher can design a feedback stage.
- There are additional optional stages beyond the fifth step. One optional stage is the responsibility assignment stage, where "moral responsibilities are assigned to relevant actors for ethical outcomes at the artifact and application levels." Another optional stage is the governance stage, which provides policy recommendations."

Munoko et. al., (2020) then combine ATE with the ETICA approach (Stahl, 2011), as they feel that each of the methods, while closely linked, contributes something that the other does not. More recently, ATE has been cited as one example of 'technology oriented assessment methods', including eTA, eIA, as well as value-sensitive design (VSD), privacy for design, socially responsible design (SRD), eco-design, ethics by design (Gurzawska, 2021).

One critique of ATE is that trying to predict what might be the impact and outcomes of emerging technologies, will be problematic, as until people take up and use those technologies it is difficult to recognise what might be the unintended and emergent properties. However, it is still possible that likely outcomes can be conceptualised and recognised, within a framework such as ATE.

2.1.2 Ethical Impact Assessment (eIA)

The framework identifies key social values and ethical issues, provides some brief explanatory contextual information which is then followed by a set of questions aimed at the technology developer or policymaker. The aim of this framework is to facilitate consideration of ethical issues, in consultation with stakeholders, which may arise in their undertaking. In addition to consultation with stakeholders, the framework includes a set of ethical tools and procedural practices which can be employed as part of the ethical impact assessment. The ethical tools help the technology developer to get a better idea of how the technology is perceived ethically by stakeholders. Furthermore, the framework provides a diagrammatic pathway which is useful to technologists to

check and review potential ethical challenges and to mitigate some of the risks. The EIA framework consists of the following steps:

1) conducting an EIA threshold analysis,
2) preparing an EIA plan,
3) identifying ethical impacts
4) evaluating the ethical impacts (step 3 and 4 are to be carried out in consultation with stakeholders),
5) formulating and implementing remedial actions,
6) reviewing and auditing the EIA.

The EIA framework does not account for emerging technologies in the future but investigates continuously the ethical implications of what is known about the technology under development. However, as there are often inherent privacy issues such as equality and human dignity etc. in new and emerging technology, research has also been carried out to integrate privacy impact assessment into EIA (Wright and Friedewald, 2013).

2.1.3 Future Studies

Prediction, foreseeing of the future is a key feature of all human cultures and was traditionally expressed by oracles, and augurs who could gift the future in the present. In modern scientific societies, prediction moved from the professions of clairvoyants, fortune tellers and prophets to professionals, academics who would develop techniques and methodologies for 'seeing the future'. So, when thinking about the ethical implications of these emerging technologies, one is in a sense trying to predict the future impact of these technologies and their potential consequences.

Future Studies emerges as an interdisciplinary field, recognising that the 'future' is not produced by one agent, but a number of intersecting, often colliding and reacting processes, which is often also seen as technologies emerge. A critical problem for it is the role of *time* – not understood as linear and singular but, with the future seen as an outcome of gestures and properly studied as 'interval crossers' and 'interval openers' (Schneider, 2019). Future Studies also accounts for the role of imagination, and 'the

imaginary as resources for (re-) shaping our world and imagining new relations' and prioritising the role that stories play in constructing human existence, (Spengler, 2019).

Future Studies goes beyond prediction, as it aims to shape the future according to principles and values that are important to humans. But what is the future – is it anytime that is beyond the present, or a place that is always shaped by fictional imaginaries and any prediction must consequently be partly, a work of fiction.

Sociologist Zygmunt Bauman noted that the future is not always a desired goal, and he coined the term "*retrotopia*" as an umbrella term (Bauman, 2017) for those movements and trends that seek to get back to something, rather than moving somewhere else (cited in Paul (2019)). Hence ideas of the future are intrinsically connected to the past and present, imagined and factual, as opportunities, and destruction are feasible outcomes of any process.

Future Studies is not without its critics, for to have a future must imply a desired or imagined state of existence, calling into question who decides this future? Who is left out or excluded from future imaginings? The question is whether technology innovation is the solution to the problems developed in tech-capitalist societies? Technology, as the engine of capitalist innovation, opening up the possibilities of creating new products, processes and practices, underlying a belief in unfettered creativity and flexibility of the human species to adapt to any technologically inspired living arrangement.

Höjer and Mattsson (2000) identified four critical problems with a Future Studies approaches: 1) identifying 'cyclic behaviour in socio-technical changes'; 2) viewing one technology to be crucially reliant on the development of another (in their case it was transport and communication that entangled and connected), 3) interrogating basic assumptions about a field (in their case it was the 'hypothesis of constant travel time' as a stable), and 4) human and resource relationships (613). The future is a 'fiction' of sorts, shaped by practices, ideas and, extrapolated into some undefined future point – problematically producing a determinism – if this, then that – view. Moreover, they suggest that 'backcasting' as an alternative and better predictor than 'forecasting' in cases where future scenarios are seen as detrimental, and harmful. Sardar prefers the

term ‘alternative futures’ due to the possibility of plurality, identity crises and meaning (Sardar, 2010).

Ethically speaking, the ‘future’, if it exists at all, is a contested domain, heterogenous, and diverse (and contested), while ethics also can be seen to propose a set of standards to be recognised and incorporated into technological practices and artefacts. Artificial Intelligence (AI) is a case in point, with a past littered with inaccurate accounts – and yet evidence of failed predictions are passed over, as new ones form and develop (Sundvall, 2019).

What all these approaches to ethical analysis of emerging technologies show is that it is difficult to predict the future. However, as techniques and approaches they each demonstrate that it is possible to develop some guidance on how to assess the possible ethical issues associated with a specific technology, so that developers and users may reflect on this and potentially incorporate those reflections into their design, development and use.

2.1.4 Anticipatory Technology Ethics plus (ATE+)

While ATE shows a lot of value in evaluating the ethics of emerging technologies, it does have some limitations when used in practice. While the TechEthos project adopted the ATE approach as the starting point for its ethical analysis (Buchinger et al., 2022), given the limitations, an expanded version of ATE, named ATE+, has been developed (Umbrello et al., 2023). This augments the analysis taxonomy, creating a more detailed framework that is less abstract and so aims to be more useful in applied settings, in particular complementing ethics-by-design approaches.

ATE+ begins by identifying 4 gaps in ATE that need to be addressed. These are: a) the identification stage begins with culturally and personally situated values of ‘what is good’ which is rather removed and abstract compared with looking at practice. b) The question of ‘whose values’, in terms of the values adopted as the starting point. c) Moving from the identification stage to the evaluation stage is complex/subjective and needs engineering and user expertise, plus contextual understanding. d) The main focus of an ATE analysis is on what does not work/negative impacts, which means the

potential to be gained from positive impacts can be missed. These shortcomings are observed across, "1) levels and objects of ethical analysis; 2) approach to foresight methods; 3) methods of ethical analysis" (Umbrello et. al., nd).

2.1.4.1 Enhanced Levels and Objects of Ethical Analysis

Having identified the range of gaps in the original ATE formulation and noting the strengths of ATE, the authors of ATE+ propose some "modifications to the levels and objects of ethical analysis, the methods of foresight included; and the methods of the ethical analysis themselves" (Umbrello et al., 2023). First there is a revised version of levels and objects of ethical analysis (see Figure 2), to enable a more fine-grained analysis. This brings in a broader and more general picture, starting with a 'technology family' level ("collections of technologies sharing common goals, or formal or functional features"), then technology and finally a collection of techniques, which the specific technology could employ. The specific technique might be used in specific applications in the context of a specific use case.

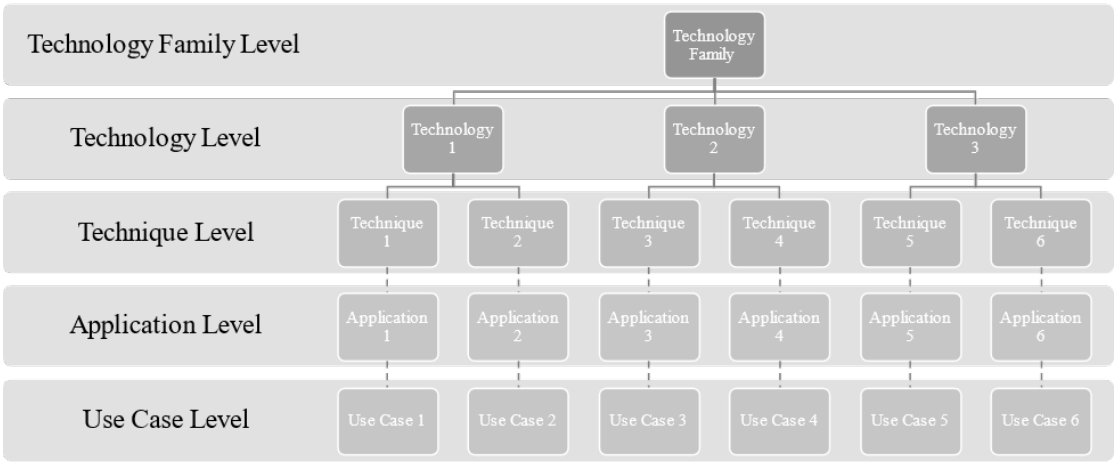

Figure 2: TechEthos level and objects of ethical analysis. Dotted lines from the Technique Level down to the Application Level and Use Case Level signify that not all technologies will have application or use cases as a condition of their readiness level

At the highest level, focus on families of technologies: collections of technologies sharing common goals, or formal or functional features. For example, a technology family bound by the term "climate engineering" might include technologies with the common goal of advancing carbon dioxide removal. At the middle, second and third levels, they propose focusing on specific technologies, which may combine various techniques or domains sharing formal or functional features and goals. At the lowest

two levels, focus is on techniques in specific applications and use cases. At these levels material artefacts, products and actual procedures come in.

Example applications of the ATE+ levels of ethical analysis applied to climate engineering is shown in Figure 3 (Umbrello et al., 2023). Further, to better identify the potential positive outcomes of a technology, and better engage with a wider range of stakeholders, a landscape of ethical concerns, relevant to both intended users and others was identified (see Table 2).

Table 2: Landscape of ethical concerns in the ATE+ framework

Ethical concerns related to…	**Levels of analysis**		
	High	**Middle**	**Low**
Main goals or features…	**…***of technology families*	**…** *of technologies*	*…of technique (or application or use case, as appropriate)*
Desirable or undesirable unintended side-effects for intended users…	*…of technology families*	**…** *of technologies*	*…of technique (or application or use case, as appropriate)*
Potential contribution to enabling future morally controversial developments if…	*…technology families are purposed to different goals*	*…technologies are purposed to different goals*	*…techniques (or application or use case, as appropriate) are purposed to different goals or with different procedures*
Unintended side-effects for non-users (desirable or undesirable), when considering uncertainties and risk perceptions…	*…of technology families*	*…of technologies*	*…of techniques (procedures, actions, or goals) in application or use case, as appropriate)*

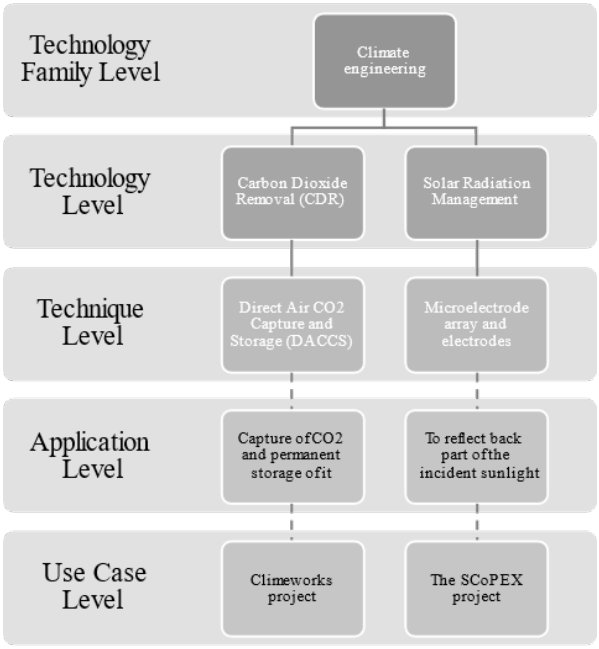

Figure 3: ATE+ levels of ethical analysis applied to the climate engineering technology family

To augment the original landscape of ethical concerns covered by ATE, reference to "likelihood" was removed and instead focused on "desirability." Doing so allowed first, to give the levels and object of analyses a balance to the potentially implicitly negative/undesirable term "consequences." In addition, the terms "desirable" and "undesirable" provided a more substantial warrant for engaging the diverse public, stakeholder, and expert groups and drawing explicit analytical attention to tensions related to potentially conflicting values of different parties. Such concerns can be surfaced for intended users and non-users alike, allowing for casting an even broader analytical net.

One of the issues noted for ATE+, is that in the reconceptualization of the levels of ethical analysis, direct reference to the concept of 'artifact' has been lost. However, one might argue that it is subsumed within the new levels, between Technique and Application.

2.1.4.2 Enhanced Foresight Methods

Within the context of the TechEthos project, there was an element of future perspective, in which a variety of future social and ethical issues were surfaced by creating

contrasting future scenarios. Whereas ATE had focused on 'likely futures', ATE+ replaced this with a focus on questions of 'plausible futures', where plausible aims to stimulate reflection on social, ethical, environmental, economic and other impacts (and where plausible refers to something 'able to be believed', rather than likely which is about the expectation that something will happen[2]). This plausibility focus is combined with the narrative method (or narratological approach) which can then accommodate some lack of transparency in ethical argumentation (Grinbaum, 2020). This in turn reflects how the public perception of a technology (current or emerging) is shaped by the social debates around them (cf. the shaping of AI by the current public debate and media discussion around ChatGPT).

2.1.4.3 Enhanced Methods of Ethical Analysis

In response to the original ATE ethical analysis and based on results elicited within the TechEthos project (Adomaitis, Grinbaum and Lenzi, 2022), ATE+ proposes the following cross-cutting steps as their enhancement to the ATE ethical analysis method (which itself had only two stages, a. identify ethical issues, and b. evaluate ethics issues (Brey, 2012b)):

1) Describe objects of interest, procedures, techniques, approaches, applications, use cases of interest, etc. (e.g., natural language processing in health);
2) Investigate core philosophical notions and dilemmas that serve as conceptual scaffolding for the ethical issues (e.g., Is there an inherent preference for material reality over virtual reality?);
3) Identify values and principles (e.g., transparency, dignity) and return to step 4 for clarification if necessary;
4) Use narrative analysis to demarcate both transparent ethical considerations and morally opaque presuppositions in technological judgement concerning the values and principles identified in step 5 (e.g., "Be careful what you wish for");
5) Ethnographically engage with critical stakeholders associated with technologies based on narratives instead of an addition to open-ended questions.
6) Formulate a set of operationalised design questions to be asked regarding the implementation of techniques (or applications and use cases) (e.g., does the XR

[2] https://dictionary.cambridge.org/dictionary/english/

system take stock of the potential changes of behaviour in its users? Who profits from the changes in behaviour and how are the changes incited?).

Given the importance of these issues, the TechEthos project proposes to further develop its approach to ethical analysis, using the five levels of ethical analysis (from ATE+) as guidance.

2.2 Integrating academic ethical frameworks with policy and primary data

The approach proposed in this paper integrated the theoretical ethical frameworks with two types of 'hands-on' information: 1) policy documents, and 2) empirical data concerning ethical issues of the technologies, as drawn from industry and academic experts.

2.2.1 Integrating ethics with policy - scan of existing ethical codes, frameworks and guidelines

2.2.1.1 The search strategy

Starting with integrating ethics with policy documents, the aim was to collect and map policy documents that would allow capturing of the policy landscape surrounding each technology family. Wright's (2011) methodological considerations were taken as a starting point which explicitly included the work of policymakers as a means to shape technology's ethical impact assessment. This approach includes policy documents in the form of a scan of existing ethical codes, frameworks and guidelines cited or proposed in the academic literature as well as in the grey literature. The methodology for this literature review began with a mixture of search contexts. First it identified published reports, academic journal articles, books, and working papers that examined guidelines, ethical codes, codes of conduct, and governance frameworks as used within the three TechEthos technology families (climate engineering, digital extended reality and neurotechnologies) on standard academic databases as JStore, ACM Digital Library, IEEE Xplore Digital Library, AIS eLibrary as well as Google scholar.

The key terms used for the literature review are:

- ‘ethical codes’
- ‘ethical frameworks’
- ‘ethical guidelines’

These terms were searched for in the abstract, as the aim was for the ethical guidelines’ to be the article’s key focus. To ensure relevance, the search included references to the technology family (e.g. digital Extended Reality) and specific instances of technological artefacts (e.g. NLP) in the body of the text.

Once the ethical frames were retrieved, the next step was to review the results further based on a number of fundamental ethical principles (namely the impact on Human rights, Freedom, Autonomy, Integrity, Responsibility, Privacy and Security (Brey, 2012b) to gain an idea o the extent to which these principles were covered in the documents gathered. For example, concerning the principle of integrity for Climate Engineering documents, we noted that “Integrity was an ethical issue mentioned within a number of research documents from both academic and research organisations. Hubert and Reichwein (2015) argue that there are limits to scientific freedom.” (Cannizzaro et al 2021). The resulting set of ethical principles for each technology family varied considerably and different results were returned.

The research also carried out a general Google search identifying reports from companies, or organisations that are traditionally excluded from academic databases (‘grey literature’).

The aim was to obtain a set of at least 20 documents per technology family, comprising both published academic literature and grey literature from industry, government, non-academic and non-governmental (NGO) research and policy organisations that would have ethical guidelines, codes and frameworks relating to the technology families as a key content in their text. The search did not seek to include texts which mentioned ethical principles in general without reference to specific guidelines, codes and texts.

Through this search, the study wanted the specific technology type and the keywords ‘guideline/code/framework’ to be present in the abstract or at least the keywords, to

ensure it would obtain documents that were specifically *about* ethical guidelines for the technology families and their specific technologies.

2.2.1.2 Mapping of extracted codes, guidelines and frameworks

The next step was to map the characteristics of the extracted codes, guidelines and frameworks to make sure there was a sufficiently diverse variety of policy documents - particularly to ensure that a mix of academic as well as grey literature articles had been captured (Table 3). The strategy used in this mapping exercise follows Rothenberger, Fabian and Arunov (2019) who reviewed ethical guidelines for Artificial Intelligence. They included the type of organisation issuing the guideline and a definition for each.

Table 3: Example of sample based on selected sources within the neurotechnologies technology family which illustrate instances of codes, frameworks, and guidelines, as well as the diversity of type of organisation covered, including academic sources and non academic sources.

Neurotechnologies: ethical guidelines, codes, frameworks and issues (based on Rothenberger, Fabian and Arunov (2019))			
Guideline	**Type of organisation**	**Definition**	**Extract of source guideline**
Ethical code	Academia	Ethical codes set forth responsibilities to which individuals and groups or organisations hold themselves to account.	...professional self-regulation […] should start within a company, institution or other work unit with a code of ethics or set of clearly articulated principles to which leadership adheres... (Chang et al 2019)
Ethical frameworks	Academia, other research organisation	Ethical frameworks set forth general or specific principles to which countries, organizations, or research communities hold themselves to account.	Australia currently lacks a clear regulatory framework for ensuring that individuals are informed about how their data are captured, stored, analyzed, and shared (Australian Brain Alliance 2019) The degree of perturbation of advanced neurotechnology on the current ethical legal framework is quantitatively higher than non-computational techniques (Ienca and Andorno 2017).

Neurotechnologies: ethical guidelines, codes, frameworks and issues (based on Rothenberger, Fabian and Arunov (2019))			
Guideline	**Type of organisation**	**Definition**	**Extract of source guideline**
Ethical guidelines	Academia, other research organisation	Ethical guidelines collect general or specific principles specifying how a technology or field ought to develop	The clinical research organizing team has also created guidance for any necessary modifications needed in ethical protocols due to revisions of research guidelines (Sadato et al 2019). To develop national guidelines for responsible neuroinnovation to assist neuroscientists, engineers, and developers to translate research into effective and ethical products. (ABA 2019).

2.3 Integrating ethical frameworks with primary data - digital ethnographies and expert interviews

Collecting and mapping the policy documents allows for capturing of the policy landscape surrounding each technology family. Following this, the ethical frameworks could be integrated with primary data. The rationale for this primary data gathering was to "stay in contact with technology developers during the whole developmental process", as prescribed in Ethical Technology Assessment (eTA) (Palm & Hansson, 2006). To do so involved extracting empirical data consisting of ethical speculations on future ethical issues that the technology families might bring. This was done through a methodology consisting of digital ethnographies and expert interviews. In addition Brey (2012a) argues in favour of future studies of technology. This is given that "the possibility for a viable future depends on the imagination and on the imaginary as resources for (re-)shaping our world and imagining new relations (Spengler, 2019). Therefore, both data-collection techniques - digital ethnographies and expert interviews - and analysis procedures were framed by a broad future ethics consideration.

Thus, in order to preliminary map out the socio-economic impact of the emerging technology families of climate engineering, extended reality and neurotechnologies, we carried out a preliminary, systematic literature review of ethical issues thought to affect these technologies. To do so, we aimed to find 10 academically influential papers on ethics of the said technology family and identify the key ethical issue outlined.

The ethical principles guiding the collection and analysis of primary data are supported by TechEthos' key objective to promote 'ethics by design' i.e. to bring ethical and societal values into the design and development of technology from the very beginning of the process.

2.3.1 From ethnography to digital ethnography

A classic definition of traditional ethnography is provided by Ingold who defines it as an approach with the objective to "describe the lives of people other than ourselves, with an accuracy and sensitivity honed by detailed observation and prolonged first-hand experience" (Pink & Morgan, 2013). Hence *information, emotions, observership* and *subjectivity* appear to be key traits of this research methodology. Another key trait is the focus on *context* by means of reference to the concept of thick "description", borrowed from anthropology (Geertz, 1973). Context here refers to the web of meanings, which constitute a culture and within which objects as cultural signs are situated. Prasad (1997) argues that it is the ethnographer's task to uncover and present these multiple meanings and their complex connections with each other in the course of analysing any social event. He reminds readers that meanings are sometime shared but other times contradictory and contested. Greenhalgh and Swinglehurst (2011) refer to three more concepts characterising ethnography, which they term key interpretive criteria i.e authenticity, plausibility, criticality. Authenticity is gained through immersion of the ethnographer within the culture, plausibility amounts to developing explanations, which make sense to participants and are arranged in a coherent narrative, and criticality refers to questioning assumptions.

Time is a central concept within ethnography. This approach to research is usually intense and long, for example it would require a one year of fieldwork immersion. However, in short-term ethnography the "immersion" of the ethnographer is for only a short period. These ethnographies are characterised by research activities being

undertaken in a shorter time frame (Pink & Morgan, 2013). This approach has also been dubbed "quick and dirty" as it recognises the impossibility of gathering a complete and detailed understanding of the setting at hand" (Pink & Morgan, 2013). Alongside a compressed notion of time, place and space are a key feature of short-term ethnography. Ethnographic places are not simply fieldwork localities, but rather entanglements through which ethnographic knowing emerges. This is significant for the purpose of this project because in times of Covid-19 pandemics, lockdown and remote working conditions, places, including ethnographic, have become virtual, hence the emergence of short term *digital* ethnographies. This type of ethnography considers how humans live in a digital sensory environment. Horst et al (2015) define digital ethnography as a way to research practices that are reported or demonstrated, for example through participants" own digital media biographies and capturing the language that is used when speaking about their area of concern. Referring to Algorithmic ethnography, during and after COVID-19, Christin (2020) defines digital ethnography as a collection of methods that entail identifying, gathering, and analysing digital data.

2.3.2 Ethnography of technologies

Ethnography tends to become shaped by the discipline it is being engaged through, and the research evolves in dialogue with theory rather than being led or structured a priori by it (Pink & Morgan, 2013). Technology and particularly, technological innovation (such as that which comes from emerging technologies), can be investigated "in-the-making" through ethnography (Petschick, 2015). Thus, the ethnography of technology Prasad (1997) explains how the anthropological tradition within which ethnography is situated treats technologies as a cultural artifact accomplishing specific social functions as well as both reflecting and structuring social practices. In other words, in the ethnographic approach, technologies are seen as more than merely functional instruments fit for specific purposes, but they are seen as cultural and symbolic object/artifact e.g., they may be ceremonial, embedding the myths of the culture in which they are situated or they may exert social control (Prasad, 1997). Ethnography can uncover the symbolic function of a technology within the context of the culture in which it is embedded, Because of this, this proposed method seeks to examine this symbolism under the perspective of ethics, that is, by looking at what some of the elements of the ethnographic objects may mean in relation to ethics and specifically ethical issues brought about by the technology families in the future.

Table 4 shows a sample of ethnographic objects analysed, comprising the material for analysis. A search for businesses' proposing applications within the technology families has been made from the business platform Linkedin. This was reputed to be a better source than Google for search thanks to its filters which helped to gauge the relevance of the results rather efficiently as it contains filters such as companies, people, region, industry and company size. A mixture of web pages and YouTube videos were selected to use as ethnographic objects of analysis. YouTube videos were selected when they included talks at a conference or interviews by media agents rather than solely promotional videos which are more staged and may have hindered the detection of any spontaneity of emotions triggered when talking about the future.

Table 4: List of references to the digital ethnographic objects (video or company website) systematically- selected for the digital ethnographies. The names of the companies have been withheld to ensure anonymity.

Company Reference Number	Ethnographic Object Type	Technological application	Country in which the company is based
1	Website page	Electroencephalography (EEG) and Brain-Computer Interface	Lithuania
2	Website Page	Wearable medical Device for monitoring Parkinson's disease	Greece-UK
3	YouTube Video	Neuromodulation through prismatic lenses	Italy
4	YouTube Video	Brain-Computer Interface (implant)	US
5	Website page	Carbon Dioxide Removal and Utilisation	Sweden
6	Website page	Carbon Dioxide Removal	US
7	YouTube Video	Carbon Dioxide Removal and Geological storage	Switzerland
8	YouTube Video	Carbon Dioxide Removal	US
9	Website page	XR – holographic display	Denmark
10	Website page	XR - extended reality experience	UK

Company Reference Number	Ethnographic Object Type	Technological application	Country in which the company is based
11	YouTube Video	VR social platform	US
12	YouTube Video	VR and AR	Portugal

2.3.3 Expert interviews

The ethical frameworks were further integrated with empirical data coming from expert interviews, specifically, through semi-structured expert interviews (Table 5).

During the expert interviews, ethical dilemmas, questions informed by epistemological analysis, future studies, as well as the 'guiding questions' method suggested by Stahl, Timmermans and Flick (2017) have been used in order to open ethical reflection on new and emerging issues. In addition to this, the interviews have followed a similar structure to that of the literature review where questions around future ethical issues and impacts have been explored, as well as the ethical principles and values that arise when analysing each technology family.

The TechEthos project focuses on the ethical issues associated with the three technology families, therefore the criterion for interviewee selection was technical and ethical expertise associated with Climate engineering, Extended Digital Reality and Neurotechnology. During the first round of expert interviews, eight interviews took place online, using MS Teams.

The contact details of the interviewees was identified through collaboration with the TechEthos project partners. The interviewees were contacted via a template email and, after agreeing to an interview, each interviewee was sent a TechEthos information leaflet and a consent form to complete, sign and return as their acceptance to participate in the interview.

Table 5: List of experts interviewed during the first round of interviews in the project.

Technology area	Expertise	Country
Neurotechnology	Neurology, Ethics	France
Extended Digital Reality	Academic, Ethics	US
Extended Digital Reality	Academic, Ethics	UK
Climate Engineering	Academic	Netherlands
Neurotechnology	Academic, Neuroethics	Sweden
Climate Engineering	Academic	Netherlands
Extended Digital Reality	Policy maker, ethics	US
Climate Engineering	Academic	Norway

Follow-up email contact was made with all potential interviewees who had not responded by return of the completed and signed consent form, within seven days of the original email being sent.

The semi-structured but flexible interviews were approximately 30 minutes duration with anticipated scope for extension beyond, given interviewee active/engaged participation and willingness to continue. Accordingly, the interview protocol consisted of a minimum of eight essential, open questions (see Appendix 1). Much like the digital ethnographies, these questions were also framed by a broad future studies perspective. The interviews were audio and video recorded via MS Teams, and the insights have been captured as a summary of each question.

2.3.4 Expert consultation and interviews

The consultations with experts was conducted through qualitative interviews and workshops that were set up to receive feedback on the following questions:

- Clarity: Is the meaning of the value in the context of this technology family clear and comprehensible?
- Completeness: Is the main argument in the subsection complete? What should be added?

- Operationalization: Are the questions at the end of the subsection helpful operationally? Is anything missing in that aspect?
- What else do you find interesting and worth mentioning about this technology family?

The consultations took part as a form of an online workshop in June 2022, which began with a discussion of the overall structure, followed by three plenary sessions dedicated to each of the three TechEthos technology families. The workshop was attended by ten European technology ethics experts, drawn from Academia and Industry (see Table 6).

Table 6: List of experts consulted during the consultation.

Ref No.	Role (academic, policymaker, industry)	Country
1	Interdisciplinary research Centre	Switzerland
2	Networks	Lithuania
3	Academia	USA
4	Academia (former science funding org.)	Ireland
5	Standards	Italy
6	Academia	UK
7	Industry	Switzerland
8	Academia	Spain
9	Research Centre	Germany
10	Ex Academia	Russia

2.4 Discussion

With awareness of existing policy documents, as well as empirical data concerning ethical issues coming from digital ethnographies and expert interviews, developers, policymakers and scholars, can act on those specific areas in the present, foregrounding an ethics by design approach in order to contribute to the safest possible outcome that is the responsible future development and deployment of the given technology families.

2.4.1 Towards a 'TechEthos Anticipatory ethics Matrix' (TEAeM)

Having reviewed a number of key ethical frameworks and the stages developed as part of the ethics analysis in the TechEthos project, these can now be combined to create a more developed 'TechEthos anticipatory ethics matrix' or TEAeM (Figure 6). This integrates the stages of the proposed ATE+ approach (Umbrello et al., 2023), which has also emerged from the research done within the TechEthos project, together with a number of elements derived from the analysis in this paper drawn from other established ethical frameworks, notably the link to policy via policy documents (drawn from ATE, Brey (2012b)) and ethical impact assessment eIA (drawn from previous research, (Wright, 2011)), the link to empirical data (drawn from eTA, (Palm & Hansson, 2006)) which maintains contact with the technology developers and hence the potential for ethical influence on them and the link to future ethics (Angheloiu & Tennant, 2020; Spengler, 2019), which provides a future orientated approach, which is appropriate for these families of emerging technologies. While this can seem like a lot of elements to combine, it does allow for a very flexible and integrative approach.

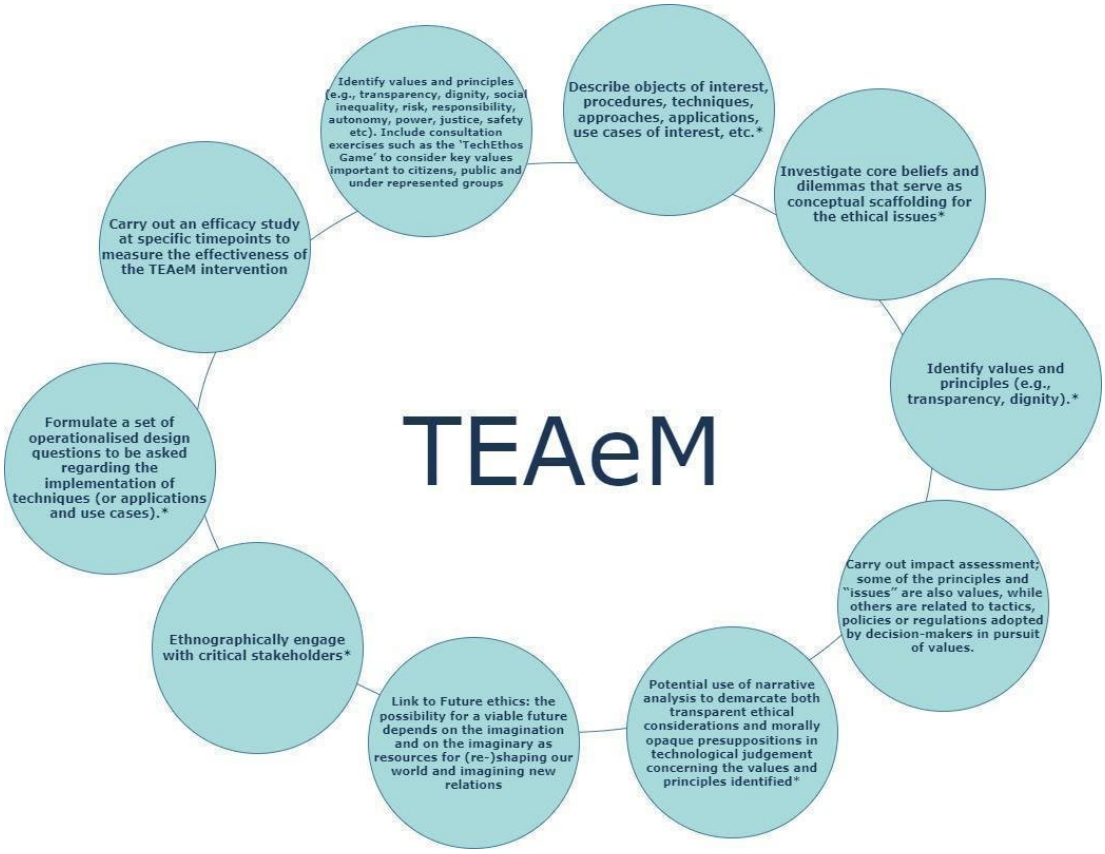

Figure 6: The TechEthos Anticipatory ethics Matrix (TEAeM). Note * denotes a step detailed in ATE+ (Umbrello et al., 2023)

2.4.2 Testing TEAeM on Quantum Cryptography

The qualitative testing of the TEAeM framework, and to demonstrate its broad applicability (Table 7), was done by showing how it relates to a specific emerging technology. The chosen emerging technology is 'quantum cryptography', which is seen as a potentially transformational technology that could significantly impact society (Seskir *et al.*, 2023).

Table 7: Application of TEAeM to Quantum Cryptography

TEAeM	TEAeM applied to Quantum Cryptography
Describe objects of interest, procedures, techniques, approaches, applications, use cases of interest, etc.	"Based on quantum bits that can be zero and one simultaneously and on instantaneous correlations across the device, a quantum computer acts as a massively parallel device with an exponentially large number of simultaneous computations. There already exist algorithms overcoming the speed and capacity of any classical supercomputer." Examples include, "communication links whose security is underwritten by unbreakable laws of physics (breakthrough compared to conventional encryption)". (Porcari et al., 2021)

TEAeM	TEAeM applied to Quantum Cryptography
Investigate core philosophical notions and dilemmas that serve as conceptual scaffolding for the ethical issues	As this is an essentially as yet un-developed technology, so the following are based on the 'promise' of what the technology might provide: Errors and misunderstanding Encryption Natural ethics Control on research (Wakunuma & Stahl, 2014)
Identify values and principles (e.g., transparency, dignity)	The development and deployment of quantum technology raise specific ethical issues, such as justice, fairness, equity, inclusion, respect for persons, ESG, human rights, etc. (https://coruzant.com/quantum/impact-of-quantum-on-the-digital-economy-and-society/)
Carry out impact assessment. Some of the principles and "issues" are also values, while other issues are related to tactics, policies or regulations adopted by decision-makers in pursuit of values (like data protection). The identification of values and policy design are two different needs (Wright, 2011). (Anticipatory Technology Ethics (ATE)).	Use of one of a range of impact assessment tools to identify what are the potential impacts of the technology, as it currently stands. Use of academic and grey literature, as well as potentially relevant policy documents, to establish the set of values that have been linked to quantum computing to date (for example, de Wolf (2017) identifies ethical aspects of quantum computing including: cryptography, increased inequality and making the impact positive).
Use narrative analysis to demarcate both transparent ethical considerations and morally opaque presuppositions in technological judgement concerning the values and principles identified	For example, creation of scenarios around various quantum computing near and middle future contexts to help developers, users and others think about the range of issues, both transparent and opaque. For example, whether in the air or on the ground, quantum computers will help to streamline traffic control; they will be able to quickly calculate the optimal routes concurrently which allows for efficient scheduling and would reduce traffic congestion, and while generally positive, what other issues might this incur, such as who controls the traffic flow or aspects such as surveillance.
Link to Future ethics: the possibility for a viable future depends on the imagination and on the imaginary as resources for (re-)shaping our world and imagining new relations.	Use of future oriented analysis in the digital ethnography, to establish what kind of future is being envisioned by the quantum computing technology developers and application experts and organisations.
Ethnographically engage with critical stakeholders associated with technologies based on narratives.	Use LinkedIn to search for companies working in 'quantum computing' and then review websites/videos, etc., using digital ethnography approach, eg. https://www.quantumcomputinginc.com/
Link to empirical data: aim to stay in contact with technology developers during the whole developmental process and discuss different approaches to problems that arise. … continuous dialogue and repeated assessments are preferable to one single large-scale assessment (Ethical Technology Assessment (eTA)).	Engage with Quantum Computing developers and users to engage in ongoing dialogue with them about problems that arise in the development and application processes. Use of databases, such as Cordis, to identify research projects in the appropriate field and contact them to establish a set of experts in Quantum Computing that can also be consulted with, for example a quick search of Cordis projects database (https://cordis.europa.eu/projects/en) shows 1,177 results for 'quantum computing'.

TEAeM	TEAeM applied to Quantum Cryptography
Formulate a set of operationalised design questions to be asked regarding the implementation of techniques (or applications and use cases).	Use the results from the various analysis carried out in the previous stages to create the set of quantum computing relevant design questions.

This was a first attempt at applying this version of the TEAeM framework to a specific emerging technology, to evaluate the ease of use and usefulness. Therefore, the decision was to apply this to a specific sub-field of quantum computing, namely 'quantum cryptography', which can be defined as "a technique that involves the use of the laws of quantum mechanics to enable the parties involved to exchange random strings of qubits with one another. These qubits may be used as a key to encrypt and decode messages that are being sent between the parties." (Alhayani et al., 2023). The application of TEAeM was reasonably good, with some research needed to unearth specific information required by different elements. This was also reviewed by an expert in the field and it seems clear that one of the limitations of the approach is a deeper understanding of the conceptual limits and pragmatic limits of an emerging technology. In the case of quantum computing and quantum cryptography, while some elements are conceptually possible, many are still seen as 'promises' of what might come. Hence, looking for the ethical issues is even more difficult.

As noted above, due to the theoretical nature of quantum cryptography, there are strong limitations and challenges when applying a framework such as TEAeM to technologies that are more conceptual than realised. However, as technologies progress, then having the early insights into the ethical issue and considerations needed for that technology is a good starting point. We do feel that the further development of the TEAeM framework could be a positive step towards guiding emerging technologies towards a more ethical road.

2.5 Conclusion

This paper has presented the results of part of the EU funded TechEthos project, which deals with the ethics of new and emerging technologies anticipated to have high socio-economic impact. Combining the method that flows out of a review of existing ethical frameworks used for analysing technology, especially future oriented anticipatory ones, with existing policy documents and empirical data coming from digital ethnographies

and expert interviews, developers, policymakers and scholars, has led to the first steps in the development of the TechEthos Anticipatory ethics Method (TEAeM). This was then applied to another high socio-economic impact emerging technology, namely quantum cryptography, which was used as a first test application.

In this way it is hoped to show that the paper has achieved what it set out to do. Namely to develop a first step towards a method that analyses the ethical issues involved that emerge as the technologies themselves are emerging, and which also allows for greater ethical sensitivity through the use of techniques such as scenarios and the development of questions that prompt deeper ethical insights to be surfaced.

Appendix 1

The interviewees were asked the following questions in a semi-open format:

1. Can you tell us about your area of expertise, how many years have you worked in your field of interest?
2. As a result of technological innovation in the area of (technology family) how do think the world will change by 2045?
3. In your view, what do you think are the benefits associated with this technology by 2045?
4. Can you anticipate what risks and harms might arise?
5. Who are the main beneficiaries of this [technology family]? And who will be excluded in your view?
6. Considering the global interest in the issue of ethics, what do you predict to be the ethical issues that could arise by 2045?
7. Do you think we have gone past the point of reversibility & irreversibility of this technology? And please explain why?
8. Is there anything else you would like to add which we have not covered already?

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