ICT environmental impact evaluation at sixes and sevens: leveraging social studies for better use of quantification

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Computer Scientists approach environmental sustainability by developing and using quantitative environmental impact assessment methods. These methods include energy consumption measures [e.g., 1], *Life Cycle Assessment* (LCA) [e.g., 2] and carbon footprint assessment for the industry (e.g., environmental reports of the GAFAM). Obtaining quantitative metrics is consistent with the culture of structured evaluation in computer science and provides an informed view of sustainability issues, which is essential for meaningful action according to certain authors [e.g., 3].

This approach however seems to show diverse limitations. First, lack of quality quantitative data renders very complex proper accounting of impacts at hardware end of life for instance [4]. Lack of quality quantitative data also challenges accounting for additional impact categories such as toxicity to human and non-human life. There is also a difficulty of establishing standard practice for assessments. This difficulty might delay action [5]. Existing works often focus on ICT impact reduction potential while known important effects that could have negative consequences such as induction or rebound effects have seldom been considered [6, 7, 8, 9, 10]. Critiques have also addressed unfitness of current approaches for accounting for the role and place of assessed systems in future society. This leads to difficulties tackling questions such as path dependencies [11] or the fitness of assessed systems within a desirable sustainable future [12].

We thus want to ask the question of why, when and how should we use or not environmental quantification. This reflection aims at participating to a critical theory [13, 14] for sustainability and computing. As *Information and Communication Technologies* (ICT) are not isolated, we want to consider them as integral part of the social world; we want to approach them in an interdisciplinary matter; and we want to produce knowledge that serves social critique.

To that end, we turn towards the field of social studies of quantification. As suggested by its name, the field of social studies of quantification centers on the notion of *quantification* or "Using numbers to formulate or make exist what was previously expressed with words and not numbers." [15, p.38][1])

The field is rapidly developing, as indicated by the important number of literature reviews [16, 17, 18, 19, 20].These reviews concord on the fact that it is an highly interdisciplinary field (with contributions for instace coming from sociology, accounting, history, law and data science). Objects of study are also varied, with studies on topics such as administrations, markets, the quantification of everyday life, and a growing body of work on big data. Through this variety of disciplinary viewpoints and studied forms of quantification, no general theories of quantification have emerged. Numerous results exist in a more situated manner however. Our aim is to use them to better understand what are the stakes, processes and effects of environmental quantification for ICT.

Environmental quantification (re)-frames sustainability issues and is a tool for governance. Rhetorical power of quantification builds on a perceived scientificity of numbers. This perceived scientificity leads to the frequent attribution of three key properties to the produced

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[1]"Exprimer ou faire exister sous une forme numérique ce qui, auparavant, était exprimé par des mots et non par des nombres " In French, our translation

number: they appear to be true, neutral and indisputable [20, p. 80-81]. The idea that numbers are objective underpins a form of public "trust in numbers" [21].

As noted by Desrosières [15], public statistics both serves to inform society and is a tool of power. For activist groups for instance, producing their own data allows them to make their knowledge count and evidence the presence of a problem [22]. Quantification also serves to measure, control and justify action, fostering a governance by numbers. In other words, quantification practices are both a tool for proof, as well as a tool for governance. Environmental quantification practices are in that manner no different, and we can find both aspects in current practices.

As a tool for proof, environmental quantification was used to render the (un-)sustainability of ICT a matter of public concern in the last few years [23]. Narratives such as the twin transitions, where ICT go hand in hand with environmental sustainability, are challenged by the importance of the environmental damages of the sector. Public attention has for instance been recently drawn to the question of *Artificial Intelligence* (AI) development and its ever increasing energy and water consumption [24].

As a tool for governance, environmental quantification often takes the form of *performance measurement systems* [25] through for instance carbon footprint monitoring and enforcement of eco-design practices through LCA or Science based targets. The interest of such systems primarily lies in their "function to define performance, direct management attention and induce behavioural change". In that regard, their ability to represent phenomena faithfully is secondary as long as they produce insightful information.

Environmental quantification is grounded in social processes. There are two key processes involved in quantification: *convention* then *measurement* [15].The first step of establishing convention determines what is to be measured and the phenomena and aspects to be accounted for. Measures thus depend on the established conventions, and quantification is an inherently social process.

The study of carbon accounting practices and controversies reveals their deep conventionality. Pasek et al. [26] for instance shows how controversies on the assessment of the carbon footprint of the ICT sector are grounded in disagreements on methodological choices, choice of metrics and assessment scope (conventions) and uncertainties and lack of consensual data (measures).

As for any description, the process of establishing quantification conventions implies a form of *reductionism*. This means that environmental accounting will be perpetually incomplete [11]. One important implication is that phenomena or aspects that are considered to be important but not currently quantifiable tend to be excluded from quantitative assessments.

When quantification succeeds, it paves the way to *commensuration*. It is a key process allowing governance by numbers and can be defined as "the transformation of different qualities into a common metric" [27]. It leads to numerous forms of comparison, notably including: rankings such as in eco-scores; definition of reference points for understanding impact as when comparing carbon emissions to the distance travelled in a car for instance; establishing equivalency conventions as in an avoided impact calculation, or in the definition of carbon credits.

Stakes, risks and limitations of environmental quantification Having sketched a few important processes of environmental quantification, we can better understand some stakes, risks and limitations of environmental quantification.

First, quantification embeds social choices and disparities. As previously mentioned, quantification, notably through its conventions is a social process. In particular, there are power plays and political stakes in defining conventions [20, p. 41]. Not all interested actors have the same weight in the creation of the standards for environmental quantification of ICT. The choices of accounting methods for attribution of global carbon emission allowances provide an important example, with multiple possibilities that reflect various ethical and political choices and interests [28]. So called science-based targets have been criticized for the choices they embed that favor best resourced countries and companies [29]. There is furthermore a deep information asymmetry [30] between companies producing environmental assessments, and, researchers and regulators. These situations open the way to strategies of doubt by ICT companies [23].

Second governance by numbers can backfire. Performance measurement systems serve at the same time both to measure current performance and to orient action to increase performance.

Blurring the boundary between the time of assessment and the time of action risks prompting inadequate or even adverse action. One important concept to explore the effects of using measures for governance is the notion of *reactivity*. It describes how people take action based on being measured [31]. Among the dangers of reactivity are focusing on optimizing targets with accrued risks of *gamification* (i.e., action taken to increase the measured performance but that does not increase or even decrease actual performance). Another important risk is, especially for benchmarks, focusing action on accomplishing minors changes with threshold effects [32].

Finally, quantification is also prone to diffusing responsibility and depoliticising issues. Some authors put forth the idea of *data treadmill* [22]. They notably show how pollution governance through quantitative data can lead to dilution of responsibility and a focus on identifying bad eggs instead of questioning systemic issues. Also, a narrative on the fact that effective action requires more precise data can lead to delaying action and constrain it to the creation of ever more precise numbers.

Towards a thoughtful use of quantification   More than a question on whether environmental quantification of ICT is a good endeavour or not, we ask the questions on when is it the best strategy, and when is it not the case. Furthermore, when we choose to use quantification, we should be aware of what we want to quantify, and how.

Based on a deepened knowledge of environmental quantification requirements, processes and risks and limitations, our reflections orient our practices in the following directions. First, in a *statactivist* manner [33], we want to harness the argumentative power of numbers to critique the unsustainable state of ICT. Our approach centers on contesting environmental quantification conventions by highlighting the materiality of ICT, to work towards exposing the exploitative and unsustainable systems ICT depends on. Also, we propose the study of time series to highlight trends within ICT development thereby challenging the reassuring narratives put forth by major technology corporations.

Second, as these methods also have their limitations and difficulties, we also propose to critique when environmental quantification is not the right tool, and explore how qualitative approaches can bring a complementary viewpoint and help fill the blind spots of our practices. We for instance explore how the study of healthcare digitalization policies in France allows to better understand trends in digital healthcare environmental impact and challenges the notion of rebound effect.

Conclusion   Computer scientists mostly approach environmental sustainability through quantitative environmental assessment methods. Some authors go as far as equating meaningful understanding and action with environmental quantification. This framing complicates exploration of other approaches and questions on the effectiveness of systematic environmental quantification. Reflexively examining our approach on sustainability issues around ICT could allow to avoid deepening forms of undone computer science.

Insight from the field of the social studies of quantification helps reflexivity on ICT environmental quantification practices. Other types of assessment methodologies in computer science where quantification practices are dominant could also benefit from insight coming from humanities and social studies of quantification in particular.

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