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A chance to redefine global technology assessment? A relational framework for impact reflexivity

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ABSTRACT

This paper argues that impact in Technology Assessment (TA) has become linked to global interdependence, increasing technological complexity, and contested futures. Building on the 2004 project 'Technology Assessment in Europe: Between Method and Impact,' which aimed to connect methods and impacts, it introduces a relational framework for impact reflexivity in TA. The framework centers on seven interconnected design principles: relational impact assessment, pluralistic co-production, power-sensitive inclusion, ethical and normative reflexivity, adaptive temporalities, situated globality, and reflexive transparency. Rather than viewing impact as a simple output or success metric, the paper sees it as a contextual process through which TA influences what is known, debated, and acted upon in institutional and public spheres. The contribution provides a clearer conceptual vocabulary and practical guidelines for designing TA within real institutional constraints. The paper concludes by discussing implications for TA institutions, commissioning bodies, and practitioners, and highlights priorities for empirical testing and refinement.

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Rethinking impact reflexivity in Technology Assessment

More than 50 years ago, Technology Assessment (TA) was institutionalised as a practice of responsible stewardship of technological change, aiming to illuminate the complex interplay between technological innovation and societal transformation (conceptually emerging in the mid-1960s and formalised in the US Office of Technology Assessment, 1972–1974; Ely, Van Zwanenberg, and Stirling 2014). Historically, TA positioned itself as a support system for national policymakers, providing empirically grounded insights to facilitate rational, democratic, and accountable governance (Grunwald 2011, 9ff., 13ff.).

Yet, the twenty-first-century landscape confronts TA with challenges that require more than just refining existing methods or meeting institutional demands for predictive certainty. Technologies like artificial intelligence, synthetic biology, and renewable energy systems do not simply cross policy boundaries; they transgress national borders, reconfigure global supply chains, and are entangled in the geopolitics of competition, security, and economic sovereignty (e.g. Kudina and van de Poel 2024; Zhai et al. 2024). The development and deployment of these technologies are no longer simply matters of citizen preferences or scientific consensus, but about strategic positioning by states and multinational actors.

Against this backdrop, the limits of a nationally oriented, policy-advisory model of TA have become starkly apparent. It is not that the original aspirations of TA, to inform decision-making and democratise technological futures, have become obsolete. Rather, they are insufficient on their own. Globalisation and politicisation have changed the very terrain on which these aspirations must be pursued (e.g. Hennen et al. 2024).

This is exactly where impact assessment becomes crucial. In this paper, I see Technology Assessment as a socio-epistemic practice: a type of research that creates and tests knowledge about socio-technical futures while being institutionally embedded within advisory and participatory structures. Impact assessment is neither a technical afterthought to TA nor a replacement for it. Instead, it serves as a reflective partner

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to assessment practices, helping to account for how TAs' framings, alliances, and forms of evidence travel, what effects they have, and for whom. TA has long posed such questions during scoping, participation, modelling, and communication. The point here is that these reflective questions need to be explicitly designed and directed towards a world where impacts are spread across borders, institutions, and time.

This paper argues that to transform TA from a national advisory service into a genuinely global, reflexive, and anticipatory practice of governance, its conceptual and methodological foundations for assessing impact must be fundamentally reworked. While the 2004 project 'Technology Assessment in Europe: Between Method and Impact' (TAMI) (Decker and Ladikas 2004) provided an important starting point by recognising diverse impact pathways and emphasising dual quality assurance (scientific and communicative), its conceptual framework remains shaped by the institutional and epistemic assumptions of its time.

TAMI's impact framework helps to clarify its ongoing relevance and its limitations. In Table 2.1: Typology of impacts (Hennen et al. 2004, 63–64), the project organised impacts along two axes, namely issue dimension and impact dimension, and distinguished between raising knowledge, forming attitudes or opinions, and initiating actions. This resulted in a typology of nine impact types and a range of TA roles in policymaking, such as scientific assessment, social mapping, agenda-setting, mediation, policy analysis, and decision-making. The value of this matrix lies in making visible that impact is plural and processual rather than reducible to direct policy change. Its limitation, from the perspective of the present paper, is that it remains primarily a typology of impacts and roles, rather than a framework for reflexively designing how impact is constituted under conditions of global interdependence, institutional asymmetry, and normative contestation.

The main point is not that TAMI was conceptually weak by 2004 standards. Nor is it that its authors failed to recognise uncertainty, side effects, attribution problems, or institutional mediation. The key issue is that assumptions which were still useful in nationally bounded and relatively stable parliamentary TA contexts become less fitting in today's environment, characterised by transnational infrastructures, platform power, supply-chain externalisation, and geopolitical interdependence. What now matters is not only whether impacts occur but also how they spread, are redistributed, and gain significance across institutions, jurisdictions, and publics.

My aim is not to dismiss TAMI's insights but to critique them constructively and develop them into a more ambitious relational framework for impact reflexivity in TA. This framework should be capable of engaging with the politics, pluralities, and uncertainties that characterise contemporary technological governance. By providing both critical reflection and practical guidance, this paper aims to support the evolution of TA from a narrowly advisory role to a reflexive, participatory, and explicitly political practice of collective orientation.

State of research

Contemporary discourse on impact assessment in TA has experienced a clear epistemic and institutional shift. Early models frequently emphasised linear causality, measurable outputs, and instrumental uptake as approaches that aligned well with national policy frameworks but were ill-suited to the recursive, emergent, and often contested dynamics of technological change (Grunwald 2018; Stirling 2008). Over the past two decades, scholarship has delivered a sustained critique of this reductionism, advocating for frameworks that are more reflexive, integrative, and politically sensitive, recognising that technologies are deeply embedded in social imaginaries, institutional logics, and geopolitical tensions (Blok and Lemmens 2015; Hahn and Ladikas 2019).

Increasingly, TA is seen not merely as an advisory activity but as a governance practice whose legitimacy hinges on its ability to account for power relations, contested values, and divergent visions of the good life (Grunwald, 2021; Kopfmüller and Rösch 2021; Rösch 2024). Key themes include globalisation and politicisation. Responsible Research and Innovation (RRI), Sustainable Development (SD), and resilience thinking each provide ways to expand TA's ethical and anticipatory scope. However, they also raise the challenge of translating shared principles, such as justice or sustainability, across diverse and occasionally conflicting cultural and political contexts. For instance, integrative sustainability assessment demonstrates how TA must navigate normative commitments that are neither universal nor easily reconcilable (Kopfmüller and Rösch 2021).

At the core of this shift is a rethinking of impact itself, not as a linear outcome to be measured but as a dynamic, co-constructed, and negotiated process. Frameworks such as Anticipation, Inclusion, Reflexivity, Responsiveness (AIRR) (Stilgoe, Owen, and Macnaghten 2013) operationalise this insight, reframing impact assessment as a site of participatory sense-making rather than managerial prediction.

Meanwhile, the field of evaluation studies has also begun to scrutinise its own evaluative rituals and institutional incentives. Scholars such as Dahler-Larsen (2011) show that evaluation is not merely an instrument of learning or control but a performative practice that shapes legitimacy and power. These critiques resonate with debates in TA about the need for reflexivity in confronting its own normative assumptions and institutional interests. Furthermore, while tools such as Multi-Criteria Decision Analysis (MCDA) promise more inclusive deliberation by integrating diverse knowledge and stakeholder values, they do not resolve normative disagreements so much as reveal them, reinforcing the need for transparency and reflexive design (Haase, Baumann, and Wulf 2021; Rösch 2024). Similarly, enthusiasm for alternative metrics (altmetrics) as faster, broader indicators of impact has prompted warnings against replacing quantification with genuinely situated, contextualised understandings of uptake and engagement (Bornmann and Haunschild 2019; Haustein 2016; Robinson-Garcia, Thed, and Rafols 2017).

These developments signify not only a methodological refinement but also a growing interest and a conceptual shift: from viewing impact assessment as merely a technical addition to recognising it as the essential arena where TA's responsibilities, commitments, and political complexities are negotiated and made explicit.

Purpose of the paper

With these shifts in view, this paper begins with a simple yet far-reaching proposition: impact assessment is not a secondary technical activity within TA, but a central site for reflexive and normative negotiation. Consequently, it is part of TA's constitutive responsibility as an intervening practice. Early conceptualisations within European TA, most notably in the TAMI project, deliberately defined impact in minimal terms as the capacity to 'make a difference', while also warning against linear attributions of policy change. This stabilisation was analytically productive. However, it does not examine how 'difference' itself is normatively shaped, institutionally endorsed, and politically influential.

My argument begins here. Impact assessment is where TA must confront not only its knowledge but also its actions, asking which interests are prioritised, whose voices are heard or silenced, and which futures are opened or closed. However, inclusion alone is insufficient. Questions about who is included, under what conditions, and with what capacity to influence outcomes remain normative and political. In the face of globalisation and politicisation, these issues have intensified. Technological decisions are no longer limited to national policy cycles or expert advisory channels; they occur within contexts of geopolitical rivalries, transnational supply chains, and unequal power relations. Therefore, impact cannot simply be understood as a linear output neatly delivered to domestic policymakers, as is often demanded by commissioning and funding regimes. Even in earlier European TA research, impact was never convincingly reduced to a straightforward delivery model. Analyses of parliamentary integration and commissioning settings revealed how timing, institutional expectations of neutrality, and procedural formats influence what can be seen as 'impact' and what remains unseen. Global inequalities do not avoid these institutional filters; they are expressed through them. Impact must be understood as a contested, contextual, and inherently political process of co-production and negotiation, shaped by and shaping global technological orders.

Therefore, this paper argues that Technology Assessment can no longer afford to treat impact as a managerial problem to be solved solely through better measurement or stakeholder engagement. Instead, it proposes a relational framework for impact reflexivity, treating impact as a design and accountability question across institutional and public arenas. This also implies that impact cannot be taken as self-evident from the outset. In many cases, it may first be necessary to reflect on how causal assumptions, uncertainty profiles, evaluative framings, and epistemic exclusions are shaping the very terms in which impact is imagined.

The aim here is to develop exactly that framework. By re-examining TAMI's distinction between methodological design and impact evaluation as a matter of reflexive accountability, and by drawing on the AIRR

framework (Stilgoe, Owen, and Macnaghten 2013), this paper provides a clearer vocabulary and a set of practical guidance points for TA within real institutional constraints.

It does not promise technocratic mastery over uncertain futures. Instead, it aims to better equip TA practitioners, policymakers, and scholars to inhabit the complexity of those futures, enabling them to navigate contested terrains characterised by plural values, shifting geopolitical logics, and evolving ethical demands.

In this way, this paper presents TA not merely as a service to policymakers, but as a scientific discipline in its own right: one responsible for theorising and experimenting with the conditions under which democratic, equitable, and sustainable technological futures might be collectively envisioned, contested, and negotiated.

Revisiting TAMI 2004

The project ‘Technology Assessment in Europe: Between Method and Impact’ (TAMI) (Decker and Ladikas 2004) remains one of the most systematic efforts to relate TA’s methodological repertoires to the effects they produce in policy, public debate, and institutional learning. It was developed within a European context where parliamentary TA and nationally bounded policy cycles formed the main horizon of relevance, and where ‘Europe’ functioned as the key transnational space for comparison and mutual learning. This historical positioning matters because it influenced what was considered ‘impact’, where it could be reasonably observed, and which actors were deemed most significant. TAMI defines impact, at a minimum, as ‘making a difference’ and explicitly warns against attributing policy change to linear causes. This pragmatic approach was analytically effective. However, it also offers fewer opportunities to explore how ‘difference’ is normatively constructed, institutionally legitimised, and made meaningful.

Precisely, TAMI defines ‘impact’ broadly as ‘any change with regard to the state of knowledge, opinions held, and actions taken by relevant actors in the process of societal debate on technological issues’ (Hennen et al. 2004, 61). The purpose of this expansive definition was not to suggest easy measurability. Instead, the authors openly acknowledge that impacts are often indirect, diffuse, and difficult to trace (Hennen et al. 2004, 61–62). They also register the attribution problem, namely that many influences shape societal debate and political outcomes, making causal claims uncertain (Bütschi et al. 2004, 53).

Two additional aspects of TAMI merit emphasis because they are often overlooked in later readings. Firstly, the project does not regard uncertainty as an embarrassing residue. It explicitly inquires where key areas of uncertainty and ignorance exist, and it advocates for ongoing ‘situation appreciation’ and monitoring of social reality, including attention to potential side effects of policy options (Bütschi et al. 2004, 51–52; Hennen et al. 2004, 62). Secondly, the project differentiates between temporal layers of impact, from immediate reactions to longer-term, more diffuse effects such as credibility and trust (Bütschi et al. 2004, 53).

This becomes especially clear in TAMI’s Table 2.1, which cross-tabulates the issue and impact dimensions. The matrix distinguishes technological or scientific, societal, and policy aspects on one side, and the raising of knowledge, the formation of attitudes or opinions, and the initiation of actions on the other. In this way, TAMI offers a typology of impacts that connects TA practice to a range of policy roles, including scientific assessment, social mapping, mediation, agenda-setting, restructuring the policy debate, and decision-making. What the matrix captures very effectively is the diversity of ways in which TA can influence policy making. However, it is less developed in its discussion of how power asymmetries, distributive harms, temporal spillovers, and transnational circulations should be integrated into the design of impact work.

If TAMI already incorporates these reflexive motifs, then what is the significance of revisiting it now? This does not imply that TAMI has simply overlooked these issues; rather, it concerns their position within the framework and the methodological implications of that placement. The problem is less that TAMI ‘forgot’ power, politics, or negative consequences, and more that these concerns are only weakly integrated into the structure that connects methods to impacts. Political contexts primarily appear as enabling or constraining background variables, such as party structures or levels of centralisation (Cruz-Castro and Sanz-Menéndez 2004, 119, 121), rather than as constitutive elements that shape what impact is possible and for whom. Similarly, unintended and distributive harms are recognised, but they are not central to impact analysis.

This becomes consequential when the conditions of technological governance change. Since 2004, key sociotechnical infrastructures have been reorganised through platform economies, transnational data and supply chains, and intensified geopolitical rivalry. Effects spread across borders, connect to distant sites of extraction and labour, and circle back via regulatory spillovers and standard-setting. Under such conditions, ‘local relevance’ and ‘global entanglement’ are not separate levels; they are interconnected.

Concretely, this means that impact work now unfolds in arenas that extend beyond the parliamentary and nationally bounded settings presupposed by much earlier TA practice: transnational standard-setting bodies, multilateral and regional regulatory forums, cross-border research and innovation funding programmes, and the governance of supply chains and platform infrastructures. The proposal presented in this paper considers TAMI an enabling baseline whose ambitions remain instructive, but whose application horizon was shaped by its time. Building on TAMI’s broad conception of impact, the framework outlined below highlights three key conceptual shifts. It regards power relations and geopolitical asymmetries as integral to impact. It emphasises negative and distributive consequences as central to analysis rather than marginalising them. Additionally, it advocates adaptive timescales that enable revisability, follow-up, and learning, rather than the traditional one-off project approach that still dominates many assessment processes.

In this way, the critique here is not a retrospective reproach but a reframing of what ‘impact’ must signify if TA is to remain relevant under today’s global conditions. The subsequent sections translate this reframing into seven interconnected design principles and a matrix outlining their practical implications. This re-interpretation also clarifies the intended audiences. Many of the practices discussed below are already adopted by TA practitioners, often despite institutional constraints. The sharper question is how TA institutions, commissioning bodies, and funders can restructure those constraints so that reflexivity, inclusion, and long-term accountability are not regarded as optional extras.

In this reading, the task is not to replace TA with impact assessment, but to treat impact reflexivity as a design question for TA practice. The next section explains why this demands more than methodological refinement.

Methodological limits and the complexities of impact assessment

Talking about methods in Technology Assessment involves venturing into uncertain territory, where knowledge is incomplete, certainty is hard to achieve, and the very act of assessment intervenes in contested sociotechnical futures. These tensions are especially sharp in impact assessment, where the goal of measuring or guiding technological outcomes clashes with a world that is more complex, ambiguous, and resistant to prediction than many methods acknowledge.

The Collingridge Dilemma remains a key theoretical point: interventions are most feasible when knowledge is least certain, and least feasible once consequences become visible and institutional commitments are set (Grunwald, 2020; Collingridge 1980). This is not just about timing; it reflects a deeper epistemological issue: anticipation must happen without the benefit of hindsight. Therefore, assessment relies on incomplete data, speculative models, and frameworks that can never fully represent the emergent properties of socio-technical systems.

Traditional methods such as Life Cycle Assessment (LCA), Techno-Economic Analysis (TEA), and risk modelling offer solid analytical rigour. However, they also create an illusion of comprehensiveness while ignoring their own blind spots (Lucivero, Swierstra, and Boenink 2011; Rösch 2024). By standardising what is measurable, they often overlook what cannot be measured – such as justice, equity, cultural significance, and epistemic diversity.

What are called soft impacts – like changes in trust, autonomy, dignity, or cultural identity – are not merely side effects but are fundamental to how technologies are experienced, negotiated, and contested. Yet, they tend to be under-analysed, not because they lack importance, but because dominant methods prioritise what can be measured over what is meaningful (Borup et al. 2006).

This limitation is not only technical but structural. Mainstream assessment methods oversimplify complex feedback loops, institutional entanglements, and emergent behaviours characteristic of sociotechnical systems. They often yield analyses more stable than the realities they seek to describe, risking the naturalisation of particular viewpoints, favouring certain values and interests while hiding others.

Efforts such as Multi-Criteria Decision Analysis (MCDA) aim to foster a more inclusive dialogue by integrating diverse knowledge and stakeholder perspectives (Haase, Baumann, and Wulf 2021). Nonetheless, such tools do not fix the core tensions; the choice and weighting of criteria are inherently normative acts influenced by institutional cultures, political pressures, and epistemic assumptions. They often reduce disagreements to calculations, creating an illusion of consensus while masking real contestation.

More generally, normativity remains an unavoidable yet under-theorised aspect of impact assessment. Evaluating impact involves not only observing outcomes but also shaping their significance, deciding what counts as benefit, risk, or an acceptable trade-off (Lucivero, Swierstra, and Boenink 2011; Stirling 2008). Frameworks like Responsible Research and Innovation and Sustainable Development offer guiding principles but are also subject to negotiation, contestation, and strategic use. The practice oscillates between normative ideals and procedural pragmatism, often without enough institutional backing to manage these tensions openly.

Adding to these difficulties is the pragmatic challenge of data. For new or speculative technologies, empirical evidence is often limited, uncertain, or confidential. Assessment often relies on proxies, analogies, or expert judgment – methods that introduce their own uncertainties and require accountability that institutions rarely support. Moreover, expert knowledge is diverse, partial, and context-dependent. Yet, policy systems frequently demand clear, definitive advice, which can push assessments toward premature closure, even when openness might better support democratic debate.

These observations imply that the call for better methods should not be mistaken for a pursuit of definitive techniques. Instead, it requires a reconsideration of TA's epistemic commitments. Rather than aiming for certainty and prediction, assessment must accept indeterminacy and diversity as fundamental aspects of technological futures. Before concrete methods are selected or impact claims stabilised, it may therefore be useful for TA to clarify which assumptions are structuring the case at hand. In particular, a reflexive approach can ask how causality is imagined, which forms of uncertainty are present, which evaluative or institutional order frames the assessment, and which forms of knowledge are recognised or marginalised. Such preliminary reflection does not replace methods. It helps to situate them more carefully and to make explicit why certain designs, indicators, or participation formats appear plausible in one context but not in another.

However, reflexivity faces its own challenges. In many cases, especially within parliamentary or policy-oriented TA, there is institutional pressure to deliver clear, actionable advice and to minimise controversy rather than exacerbate it. Reflexive approaches must therefore carefully balance this demand for closure, supporting decision-making while also revealing uncertainties, contestations, and value conflicts that might otherwise be hidden.

This requires methodological pluralism: intentionally combining quantitative and qualitative approaches, participatory and expert-led processes, scenario analysis, and narrative inquiry. Such pluralism does not guarantee a single, definitive solution but allows space for multiple ways of knowing, contesting, and imagining.

It also advocates for reflexive design: making the assumptions, exclusions, and values embedded in assessment itself visible. For practitioners and policymakers alike, this means resisting the temptations of technocratic certainty in favour of practices that remain open, critical, and responsive to diverse publics and changing contexts, while staying attentive to the real-world need for timely, usable advice.

More fundamentally, TA must learn to see itself not only as a technology for prediction and control, but also as a practice of collective orientation: an institution that enables societies to reflect on, deliberate over, and negotiate the uncertain terrain of their own technological development. This requires not rejecting decision-making needs but reimagining them as practices of provisional orientation: capable of informing timely decisions while keeping uncertainty, disagreement, and plural futures open to further scrutiny.

A relational framework for impact reflexivity

If Technology Assessment is to remain credible and effective in the twenty-first century, amidst increasing globalisation, deep uncertainty, and normative pluralism, it cannot settle for minor refinements or incremental adjustments to established methods. The issue is not simply that current tools are imperfect, but that their impact and uptake are shaped by institutional conditions such as commissioning arrangements, timing, and the expectations associated with parliamentary and advisory settings. These shape what can be regarded as relevant knowledge and actionable advice. Therefore, a more comprehensive reorientation is

necessary; one that regards assessment not as a neutral tool for prediction and control but as an inherently situated, participatory, and reflexive form of collective sense-making (Grunwald 2018; Stirling 2008). This paper contends that what is needed is not just incremental methodological changes but a relational framework for impact reflexivity in TA, one that engages with the complexities of knowledge production, institutional interests, and political contestation.

What follows is not a prescriptive checklist or universal template, but a set of interconnected design principles that guide practice while recognising its limitations. In this sense, the framework does not assume that impact is self-evident. Before operationalising design principles, it may be helpful to clarify how the case is initially framed: what kinds of causal assumptions are made, which uncertainties are involved, what evaluative framework determines relevance, and which forms of knowledge are included or excluded. Such prior reflection is not a separate method, but rather a reflexive calibration of the conditions under which impact is being conceived, negotiated, and evaluated. The principles treat assessment as an intervention into socio-technical worlds, not a detached observation of them.

At its core, it is a *relational understanding of impact* (1). Impact is not simply any change or adoption but the multi-directional, contextual contribution of assessment processes to how societies perceive, debate, and collectively shape technological futures (Sörgel et al. 2025). It requires tracing resonances across ethical, ecological, political, and cultural spheres (Grunwald 2018). This viewpoint calls for methods sensitive to context and meaning, such as contribution mapping (Coombs, Meister-Broekema, and Meijer 2025), narrative analysis, and controversy mapping (Venturini and Munk 2022), that can track not only direct outcomes but also subtle, recursive shifts in public debate, institutional practices, and cultural imaginaries.

Equally crucial is a commitment to *pluralistic co-production* (2). Rather than treating participation as a tokenistic consultation, TA must become a civic practice for negotiating technological futures. TAMI rightly stressed interactive quality criteria such as fairness, transparency, and argumentative rigour (Bütschi et al. 2004, 50–53). However, contemporary practice must go further: asking whose knowledge counts, whose perspectives are heard, and how conflict is managed rather than smoothed over (Chilvers and Kearnes 2015; EC 2007; Sörgel et al. 2025). Good practice values dissent as constructive rather than a failure. It fosters deliberative spaces (from citizens' dialogues and juries to speculative design exercises) in which conflict is surfaced and negotiated. This demands careful attention to who is invited, how representation is ensured, and how diverse forms of knowledge, including experiential and marginalised perspectives, are valued alongside expert analysis (Blok and Lemmens 2015; Sörgel et al. 2025).

Participation alone cannot substitute for attention to *power-sensitive inclusion* (3). Without confronting asymmetries in expertise, voice, and institutional authority, even participatory exercises risk reproducing existing hierarchies (Chilvers and Kearnes 2015; Stirling 2012; Wynne 2007). Good practice requires sustained reflection on who defines the scope of assessment, whose interests are prioritised, and how exclusions are produced or challenged. This means intentionally designing processes that map and address power asymmetries, redistribute deliberative resources, and cultivate spaces where marginalised perspectives can speak with authority (Felt & Fochler, 2010; Wynne 2007).

Any robust framework for impact must also prioritise *ethical and normative reflexivity* (4). Assessment is never value-neutral (Krüger 2022). TAMI recognised this but remained cautious when implementing these dimensions. Contemporary TA must go further, making its normative commitments, such as sustainability, precaution, and justice, clear, contestable, and open to revision (Grunwald 2011; Owen et al. 2013; Stilgoe, Owen, and Macnaghten 2013). This involves asking whose futures are being envisioned, which values are being prioritised, and encouraging discussion about desirable change. Ethical reflexivity is not private reflection but an institutionalised process of revealing, negotiating, and adjusting value commitments in response to changing contexts and stakeholder input.

Adaptive temporalities (5) are equally essential. Technological change is rarely linear or predictable; social impacts unfold in non-linear, recursive ways. This principle emphasises iterative feedback loops, follow-up, and long-term attention to capture emerging evidence and shifting priorities, rather than viewing assessment as a one-time, final report.

Furthermore, TA must cultivate *situated globality* (6). While TAMI emphasised cross-European cooperation and institutional learning, today's TA faces truly global challenges, from climate change to AI governance. Good practice requires resisting universal, technocratic solutions that flatten cultural differences. Instead, global frameworks such as sustainability, precaution, or justice must be treated as heuristics to be

Table 1. Interdependent design principles for impact reflexivity in TA.

Principle	Core Orientation	Illustrative Practices / Organisational Supports	Constitutive Entanglements
Relational Impact Assessment	Tracing multi-directional, situated effects	Contribution mapping, narrative analysis, controversy mapping	Links knowledge production, policy design, and public imaginaries
Pluralistic Co-Production	Collaborative framing and option generation	Citizens' juries, deliberative workshops, speculative design	Surfaces dissent, negotiates conflicting values
Power-Sensitive Inclusion	Addressing asymmetries and exclusions	Stakeholder mapping, conflict mediation, facilitated dialogue	Challenges institutional biases, redistributes voice
Ethical and Normative Reflexivity	Making value commitments explicit and contestable	Structured deliberation, normative reflection protocols	Enables debate over visions of desirable futures
Adaptive Temporalities	Embracing iteration and learning over time	Scenario planning, longitudinal monitoring, feedback loops	Resists closure, supports preparedness for surprise
Situated Globality	Translating universal principles locally	Contextual calibration, co-design with local actors	Prevents epistemic extraction, fosters mutual learning
Reflexive Transparency	Exposing assumptions and framings	Internal review, public justification, open documentation	Builds trust, institutionalises accountability

collaboratively translated into locally meaningful practices (Kuhlmann and Rip 2018). This demands sensitivity to local meanings, histories, and institutional arrangements, as well as transnational knowledge ecologies that foster mutual learning without epistemic extraction (Medvecky and Leach 2017).

Finally, the framework insists on *reflexive transparency* (7). Transparency is not merely disclosing methods and results but making visible the assumptions, value commitments, and framings that underpin assessment itself. This involves documenting and communicating choices about problem definitions, stakeholder inclusion, and methodological rationales. Reflexive transparency also demands institutional practices that invite peer review, external scrutiny, and public engagement, not simply for outputs but for the processes that shape them. It is through such honesty and rigour that TA can earn trust and maintain its legitimacy (EC 2007; Grunwald 2018; Hagendijk and Irwin 2006; Stirling 2012; Wilsdon and Willis 2004).

These principles form an interconnected set of commitments that need to be interpreted and negotiated in relation to local institutional constraints and global relationships. To clarify these interdependencies, Table 1 translates the seven principles into a heuristic matrix. It does not prescribe a standard procedure or assign fixed methods for specific impacts. Instead, it highlights illustrative practices, process formats, and organisational supports through which impact reflexivity can be designed, documented, and revised over time. In this way, the table differs from TAMI's Table 2.1 (63). Rather than classifying impacts, it maps the conditions under which impacts are framed, negotiated, made visible, and held accountable in TA practice.

The table, therefore, does not categorise impacts after the event. It illustrates the conditions under which impacts are framed, made visible, contested, and held accountable. Its main argument is that impact in TA is influenced not only by the methods employed but also by how relations are organised across participation, temporality, documentation, and institutional responsibility.

Each principle in this matrix carries consequences for practice that go beyond method choice. For example, embracing relational impact assessment entails tracking not just uptake but subtle shifts in debate and institutional behaviour. Pluralistic co-production demands resources and skills to facilitate disagreement rather than suppress it. Power-sensitive inclusion requires attention to how participation is structured and who is excluded. Ethical reflexivity must be institutionally embedded, with structured opportunities to question assumptions and revise goals. Adaptive temporalities challenge funders to support monitoring beyond project cycles. Situated globality asks for partnerships and translation work to make shared principles locally meaningful. Reflexive transparency calls for robust, ongoing practices of peer review and public accountability.

These principles offer more than a revised set of techniques. They propose a conceptual architecture for understanding and designing impact in TA as a reflexive, participatory, and value-sensitive practice of collective governance in an entangled and uncertain world.

Implications for TA practices

If Technology Assessment is to respond to the unruly nature of our times, characterised by technological excess, planetary emergencies, and fragile social fabrics, it cannot be content with simply refining its methodological skills or producing increasingly polished deliverables. The core issue is not just about improving

tools but about fostering an ethos of a practice willing to engage with trouble and to accompany societies in deciding how to govern, constrain, transform, or refuse technologies whose futures are uncertain, contested, and shared. Here, support should not be confused with acclimatising the public to deficient or unsafe systems. It involves keeping questions of acceptability open, including options for redesign, withdrawal, moratoria, or refusal.

Institutional transformations

A practical complication needs to be stated plainly. Much of what follows will sound familiar to practitioners because many TA projects already work in these directions. The friction lies less in professional ignorance than in institutional settings: commissioning logics, funding cycles, contractual deliverables, and political timelines. For that reason, the addressees are differentiated. Practitioners can adjust project design and facilitation choices. TA institutions can negotiate mandates, build partnerships, and defend longer temporalities. Commissioning bodies and policy clients can revise what counts as a good outcome, including the tolerance of documented uncertainty and disagreement.

TA practitioners can make framing decisions explicit, document exclusions and uncertainties, and, where possible, build modest follow-up loops into project designs. TA institutions can negotiate for time, access, and continuity, invest in participatory and transnational capacities, and protect spaces where disagreement can be recorded rather than smoothed away. Commissioning bodies and funders, in turn, need to recognise that impact is contested and partly outside TA's control, to support iterative engagement and monitoring, and to reward reflexive transparency over performative 'proof'. This matters because evaluative regimes do not merely register impact neutrally. They also stabilise particular causal expectations, reduce some forms of uncertainty while amplifying others, and privilege certain kinds of relevance over others. A more reflexive TA practice, therefore, depends not only on better projects but also on institutional settings that allow competing interpretations of impact to remain visible rather than being prematurely narrowed by indicators, deliverables, or audit logics.

At the institutional level, the first demand is therefore structural. TA cannot enact reflexivity or participation while operating under funding regimes that reward speed over depth and certainty over doubt. Grant cycles and project evaluations must make space for the temporalities of learning and iteration, resisting the tyranny of one-off reports whose primary virtue is closure.

Institutions must cultivate what Stengers (2018) calls 'slow science': practices willing to slow down in order to pay attention. This implies investing in training not just in expert modelling but in facilitation, conflict mediation, and intercultural translation. It asks for organisational cultures that can hold discomfort, invite critique, and welcome heterogeneity without rushing to domesticate it.

Accountability, too, must become something more than formal reporting. Reflexive transparency means institutionalising practices (internal audits, peer review, public engagement) that not only display outputs but also examine assumptions, framings, and interests. Institutions must learn to be accountable not for delivering the right answers, but for making visible the questions they chose to ask and those they refused.

Methodological sensitivity

Methodologically, these principles reject the fantasy of universal methods that can tame complexity through standardisation. Instead, they call for a pluralism that holds space for contestation, ambiguity, and divergent ways of knowing.

TA must learn to integrate systemic modelling with narrative inquiry, participatory workshops with scenario analysis, and quantitative data with qualitative interpretation. This is not eclecticism in methodology for its own sake but rather a response to a world in which technological change is emergent, recursive, and infused with emotions and values (Law, 2004). Such combinations are already being tested in participatory foresight and parliamentary TA projects, for example, CIMULACT's (2018)¹ multi-country citizen visioning and scenario co-creation (Fraunhofer ISI, n.d.; European Commission CORDIS 2016) and scenario-based work by the Norwegian Board of Technology (Norwegian Board of Technology, 2025).

CIMULACT is particularly instructive because it brought citizens into agenda formation across multiple national settings rather than restricting participation to downstream reactions. In that sense, it exemplifies

pluralistic co-production at scale while also showing that inclusion alone does not resolve asymmetries of translation, agenda-setting, and institutional uptake. The point is not that participatory design automatically generates impact, but that it can render problem framings more contestable and socially grounded when supported by formats that allow inputs to travel across institutional settings.

Similarly, scenario-based work by the Norwegian Board of Technology² shows how anticipatory TA can open up debate before technological trajectories harden into policy defaults. Its value lies less in precise prediction than in making assumptions, alternative pathways, and normative commitments visible at an early stage. At the same time, such exercises expose a recurring limit of reflexive TA practice: exploratory inquiry often enters institutions that still reward short-term clarity more readily than sustained openness.

Crucially, uncertainty must be welcomed, not eliminated. Adaptive approaches (scenario planning, longitudinal monitoring and iterative feedback) are less about predicting futures than about cultivating preparedness for surprise. This becomes especially visible in long-term governance fields such as nuclear waste disposal. Projects such as TRANSENS³ (2019–2024) show that impact cannot plausibly be reduced to a single outcome or decision moment, but unfolds through repeated engagement, shifting problem definitions, and contested forms of trust over time. Such cases also demonstrate how strongly reflexive formats depend on continuity of funding, institutional patience, and the willingness of commissioning bodies to sustain participation beyond standard project cycles. As STS scholarship has long insisted, from Stengers' call for 'slow science' (2018) to Latour's 'politics of nature' (2004) and Serres' reflections on parasitic complexity (2007), the task is not to manage complexity into submission, but to learn how to think with it without falling back on managerial simplifications.

Participatory design, then, must likewise move beyond polite consultation. It must become a genuinely collective process of framing problems, imagining options, and negotiating values, a space in which disagreement is not a failure to be smoothed over but a resource to be worked with.

Political and global commitments

TA cannot afford to be naive about the politics of knowledge. Power-sensitive inclusion demands explicit attention to who is invited, who is excluded, and under what conditions participation occurs (Sörgel et al. 2025). This is not a matter of bureaucratic box-ticking but of crafting spaces where divergent knowledges and interests can clash productively.

This also requires acknowledging the geopolitical asymmetries that haunt global knowledge practices. Situated globality means resisting the seductions of universal solutions that flatten difference in the name of technocratic convenience. It instead calls for collaborative translation, working with local actors to interpret principles such as sustainability or justice in ways that resonate with specific histories, cultures, and institutional arrangements.

Such commitments are not ornamental additions. They are a guard against the epistemic extraction that too often accompanies well-meaning global governance. They demand institutional humility, the willingness to recognise the partiality of one's own knowledge and to engage in mutual learning without presuming mastery.

Critical reflexivity and limits

However, even this is not enough. There is always the risk that reflexivity becomes ritualised, participation becomes performance, and inclusion becomes co-opted. Institutions may adopt the language of transformation while leaving untouched the structures that sustain exclusion and technocratic closure.

For TA practitioners, this demands an ethic of continuous self-interrogation. Not to wallow in guilt or paralysis, but to remain vigilant against the comforts of certainty and the seductions of authority. It requires the courage to ask uncomfortable questions: Whose futures are being imagined? Whose fears are being ignored? Whose losses are being justified?

There are limits to what TA can achieve. It cannot guarantee consensus or produce universally acceptable solutions. But it can offer spaces for disagreement to be voiced, for futures to be negotiated rather than imposed. It can make the invisible visible, the taken-for-granted contestable, and the excluded audible.

Especially during politically uncertain times, this innate capacity is a vital strength of TA. By consistently questioning its assumptions and institutional stance, impact assessment enables TA to analyse shifting

power dynamics and responsibilities rather than merely reacting to them. This reflective accountability may not always result in agreement, but it fosters a form of governance based on public justification and collective discussion. Therefore, TA's commitment to self-examination and relational learning is essential for democratic technological governance.

Conclusion

Technology Assessment stands at a crossroads. In contexts marked by planetary crises, technological acceleration, and geopolitical rivalry, its advisory role must be understood as more than the provision of ostensibly neutral expertise. TA has never simply operated outside politics; its credibility has long depended on how evidence, values, and institutional expectations are held accountable to public reasoning. Its legitimacy today, therefore, depends on making disagreements, values, and power relations explicit and on enabling collective decisions about what to build, how to govern, what to slow down, and what to refuse.

This paper offers a relational framework for impact reflexivity in Technology Assessment, organised around seven interdependent design principles. They form a conceptual ecology that helps practitioners design assessments that are pluralist, power-attentive, and ethically grounded, without pretending to provide a universal method or a tidy route from evidence to policy. In this respect, the framework extends rather than rejects TAMI. The earlier matrix clarified that TA can matter through different issue dimensions and different modes of impact. The present proposal builds on that insight but shifts the analytical centre from classifying impacts to designing the reflexive conditions under which impacts are constituted, contested, and held accountable.

The point is not to deliver better answers more efficiently, but to ask better questions more honestly and to keep futures open. Impact is treated less as a linear output and more as a contested process that assessments partly enact through their framings, alliances, and exclusions. This, in turn, suggests that reflexive TA cannot begin with methods or indicators alone. It first requires a more explicit consideration of how assumptions about causality, uncertainty, evaluative frameworks, and epistemic plurality shape what can count as impact in the first place.

Staying with trouble is not an ethic of accommodation. It is a commitment to keep acceptability contestable, to trace unintended effects over time, and to make room for redesign, withdrawal, moratoria, and refusal when the costs of continuation are borne by others.

Operationally, the framework implies differentiated responsibilities. Practitioners can adjust framing, facilitation, and documentation. TA institutions can defend longer temporalities, build capacities for translation and conflict work, and institutionalise reflexive transparency. Commissioners and funders can revise deliverables and evaluative criteria so that documented uncertainty and disagreement count as work rather than failure.

Future work should test and refine these principles empirically across domains and institutional settings, with particular attention to transnational collaborations that avoid epistemic extraction. Comparative studies of how mandates, funding structures, and governance cultures shape what TA can do would be especially valuable.

If Technology Assessment has a promise, it is not to solve the future, but to help societies deliberate on it with open eyes, and to keep the possibility of acting otherwise alive.

Notes

1. <http://www.cimulact.eu>.
2. <https://teknologiradet.no/en/homepage/>.
3. <https://www.irs.uni-hannover.de/forschung/transens>.

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CRedit: **Franziska Sörgel**: Conceptualization, Methodology.

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