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TRANSFORMING CITIES THROUGH POSITIVE ENERGY DISTRICTS

REPORT ON **RESPONSIBLE INNOVATION IN PEDS**

Livia Regen and Michael Ornetzeder
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FOSTERING URBAN TRANSFORMATIVE CAPACITY IN POSITIVE ENERGY DISTRICTS (PEDS): RRI, MOMENTS OF REFLECTION, AND THE IMPORTANCE OF SECOND-ORDER LEARNING[1]

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Livia Regen and Michael Ornetzeder
with the support of Gloria Rose, Leo Capari and Andrew Karvonen

1 This report serves as a point of departure and backbone to the co-created Responsible Innovation in and for PEDs Framework that is targeted at PED stakeholders and aims to support them with engaging responsibly and reflectively with innovation.

1. INTRODUCTION

A SET (Strategic Energy Technology) Plan publication from 2016 foresees the introduction of 100 positive energy districts (PEDs) in the European Union by 2025 (European Commission, 2016) in response to the multiple social-ecological crises, cities' central contribution to global GHG emissions and ongoing (unsustainable) urbanisation.

While PEDs are highly ambitious in their aim of achieving a surplus energy balance in urban contexts, innovation in PEDs tends to often focus too narrowly on technology, without necessarily considering social and ecological implications. As the programmatic goal connected to the realisation of PEDs is slowly being translated into practice, a substantial number of learnings can be expected along the way towards responsible, and thus socially and ecologically viable, innovation in PEDs.

The overall aim of the TRANS-PED project, as part of which this report has been created, is to increase the transformative capacity of PEDs. A central aspect of this, which has been pointed out previously as an undernourished element in urban transition processes, is to enhance reflexivity through novel self-assessment techniques (Wolfram et al., 2019). The report at hand and the connected Responsible Innovation in and for PEDs Framework aim to address this gap and make the case for reflexivity and learning (in particular second-order learning) to be essential components for the enhancement of urban transformative capacity for urban energy transitions. Second-order learning can be regarded as complementary to monitoring (which is linked to first-order learning), and which is dealt with in a different deliverable. While reflexivity is a core element of RRI, the application of RRI in practice so far has come with its limitations. As an alternative that can be translated into practice comparatively easily – and is thus relevant for the context of PEDs -, we introduce "moments of reflection" to foster second-order learnings for urban energy transitions.

The report at hand is organised as follows: First, we briefly introduce the concept of urban transformative capacity (UTC), which serves as an umbrella vision, or goal to strive towards, in the exploration of responsible innovation[2] in visionary urban development processes. UTC makes clear that successful urban transformations depend on a variety of functions, competence and types of responsibility. A core element of transformation – besides restructurings – is innovation in its various forms. In the context of positive energy districts (PEDs), innovation is often of a technological kind given the focus on new means of providing, sharing and using energy. For innovations in PEDs to have a long-lasting meaningful social-ecological impact, it is essential that innovation processes are accompanied by critical reflection. Critical reflection has the purpose of minimising unintended social and ecological side-effects, avoiding unsustainable path dependencies and engaging with risks such as rebound effects. The core concept emerging from the EU context that is concerned with precisely this is Responsible Research and Innovation (RRI). We move on to discussing RRI and do not spare the readers from its shortcomings and related critique. Departing from the gap between policy-level visions of RRI implementation and real-life techniques to realise the concept, we turn towards so-called "moments of reflection" and connected identities, as a low-key, more workable means to establish spaces that can generate second-order learnings, i.e., learnings that go beyond the operational level of making a system work, but question systemic choices themselves vis-à-vis other alternatives. Regarding second-order learning, we explore conditions, circumstances, tools and contexts in which it may occur, and explore how different project types lend themselves more or less well to reflection and the generation of learnings. We conclude by foregrounding the relevance of second-order learning processes for further PED development and consequently for urban transformations, and share some potential ways to foster reflection in connection with innovations for PEDs.

2 By "responsible innovation" we do not solely refer to the concept of RRI as shaped in the context of the European Union, but to a vision of innovation that is responsible in that it is considerate of potential social and ecological implications and unintended side-effects, and addresses these risks at an early stage and in a reflective manner. RRI we consider as only one concept that may help bring about "responsible innovation".

2. RESPONSIBLE INNOVATION IN THE PED CONTEXT

As the European Commission has foreseen an intensification of responsibility concerns in innovation processes (van den Hoven et al., 2013), it is of core importance that also innovations in and for PEDs are facilitated with a high degree of responsibility, meaning that social-ecological aspects are taken into consideration and learning occurs on several levels throughout the PED creation process. Since PEDs usually involve substantial infrastructure investments and lead to social, economic, technical and ecological restructuring, it is essential that the creation of unwanted path dependencies be avoided that possibly slow down the transformation towards a climate-neutral future and intensify social inequity. Structural decisions made at the beginning of a PED project can have enormous impacts, in that they may rule out alternative pathways that might have been preferable from a social-ecological long-term perspective, and likely create path dependencies in line with initial investments. PEDs can be successful in achieving high levels of self-sufficiency from local renewable sources, but such achievements may be associated with undesirable side effects and emerging risks in other areas, such as social equity or ecological long-term effects. Such undesirable developments should be identified early and, if possible, addressed constructively. In particular, before PEDs are upscaled, i.e., they are replicated, or grown in size or complexity (Naber et al., 2017), it is necessary to draw learnings from local experiences made so far.

Learnings derived from innovation processes at specific PED sites can then be better transferred to other sites, both resulting in collective knowledge generation on functional innovations, positive co-benefits, as well as an awareness of dysfunctional innovations with unintended negative side-effects. These learnings can serve the city development/planning community and allow for the avoidance of repeating the same experiences in different places. The knowledge gained may be useful for the further development of an existing PED or can inform different PED projects. Knowledge can be passed on during discussions, site visits, and workshops but also in a written form. Finally, the gained insights can inform researchers, policy-makers, funding bodies, and developers, and thus contribute to the overarching goal of the decarbonisation of the energy system (e.g., lessons learnt as a form of agenda-setting and input for more in-depth investigations). Similarly, learnings from PEDs may, ideally, spill over effects into “normal city development”.

2.1. APPROACHES TO SUPPORTING RESPONSIBLE INNOVATION

As transformative urban development, such as the creation of PEDs, represents a complex task, connecting a range of perspectives that emerge from a variety of actors, resources to guide the innovation process are essential. Here becomes relevant what Wolfram refers to as “urban transformative capacity” (UTC), i.e., “the collective ability of the stakeholders involved in urban development to conceive of, prepare for, initiate and perform path-deviant change towards sustainability within and across multiple complex systems that constitute the cities they relate to” (Wolfram, 2016, p. 126). This is particularly relevant “when ecological, economic, or social (including political) conditions make the existing system untenable” (Walker et al., 2004, p. 4).

The term, having its origin in socio-ecological system dynamics and resilience studies (Holling, 1973) was later on adapted for urban contexts, and encapsulates the following dimensions: actors; existing and missing capacities that in their fulfilment contribute to transformation; and means of capacity-building. The ten key elements that are central to the development of UTC are: inclusive and multiform urban governance; transformative leadership; empowered and autonomous communities of practice; system(s) awareness and memory; urban sustainability foresight; diverse community-based experimentation with disruptive solutions; innovation embedding and coupling; reflexivity and social learning; working across human agency levels, thus including different units of society in the public and private domain as well as in civil society; and working across political-administrative levels and geographical scales (Wolfram, 2016). UTC, thus, represents a comprehensive and multi-faceted approach to support deep urban transitions. It sketches an ideal case, which in reality, however, has rarely existed in its totality.

UTC is explicitly normative in that it intends to transform systems from an unsustainable state into sustainable urban environments, partly based on the identification of deficits in the fulfilment of social needs. Core to UTC is the inclusion and participation of wider segments of society for the mobilisation of transformative capacity. Similarly, reflexivity and social learning are central to the concept, thus including dedicated monitoring, assessment and evaluation activities and generating transformational knowledge that can ignite radical change. Employing anticipation and foresight methods, collective visions are created, combined with innovation governance that includes the identification of innovation barriers, the support of innovation with monetary and non-monetary sources and the facilitation of decision-making processes to enable the meaningful embedding of innovation. Additionally, exnovation i.e. the abandonment of detrimental path-dependencies, has a role to play in concert with innovation, among others emerging from experiments (Wolfram et al., 2019).

Wolfram et al. (2019, p.437) have identified four needs regarding the reality of UTC based on the analysis of empirical work, one of which is to "enhance reflexivity through novel self-assessment techniques". This realisation has been empirically backed up by a study conducted by Castán Broto et al. (2019) who looked into 400 sustainability initiatives of over 200 city governments and other local actors to assess to what degree UTC indicators can be detected in practice. They found that "the least frequently satisfied criteria by far is reflexivity and social learning" [sic] (ibid., p. 453). Further, it was detected that transformative capacity tends to occur more rarely in sectors dominated by techno-efficiency and sectors oriented along orthodox economic paradigms. Interestingly, among others in energy-related initiatives UTC criteria were rather underrepresented (ibid., p. 460). Another observation was that once the criterion of reflexivity was met in an initiative, then also other UTC criteria tended to be met: "[i]nitiatives that displayed a high degree of reflexivity and social learning automatically considered inclusive and multiform forms of urban governance, deliberately tried to empower communities, exhibited foresight practices, and worked across levels of human agency and scales" (ibid.). The authors conclude that it might be the case that initiatives with higher levels of reflexivity are more likely to enhance UTC, however, more research into this question is required (c.f. also Ziervogel et al., 2016; ibid.). Hence, it is useful to turn towards approaches that can support reflection and reflexivity when aiming to foster transformative urban innovation as this report attempts.

2.2. INNOVATION AND UNINTENDED SIDE-EFFECTS: SOCIAL-ECOLOGICAL IMPLICATIONS

Innovation inevitably entails risk and willingness to expose a project to uncertainties (Jalonen, 2011), both of which can result in unintended negative side effects. It is, therefore, essential for PEDs to engage with risks and uncertainties as immanent properties of any new undertaking. In particular, before replicating or upscaling solutions, possible side-effects and risks need to be addressed, as well as uncertainties drawn attention to.

Risks and uncertainties may pertain to different areas, ranging from social, economic, ethical, demographic and health to technical, environmental and political. In the following, in order to illustrate which unintended effects may occur, the technical-environmental rebound effect and the social process of green gentrification will be looked into in further detail as potential unintended side effects of the creation of a PED area.

The literature is rich with examples of rebound effects connected to renewable energy (c.f. Nyangon & Byrne, 2021; Seebauer, 2018; Walzberg et al., 2020). Berkhout and Hertin (2001) have defined three levels on which rebound effects may occur: 1st-order impacts, i.e., "direct environmental effects of the production and use of ICTs"; 2nd-order impacts, i.e., "indirect environmental impacts related to the effect of ICTs on the structure of the economy, production processes, products and distribution systems", and 3rd-order impacts, i.e., "indirect effects on the environment, mainly through the stimulation of more consumption and higher economic growth by ICTs, and through impact on lifestyles and value systems" (2001, p. 2).

In the context of energy, a rebound effect can be defined as "the social and behavioural response to the introduction of more energy-efficient technologies and processes by which there is a corresponding increase in energy service demands" (Ehrhardt-Martinez & Laitner, 2010). Three types of rebound effects may be distinguished: direct RE "lower energy cost induces price reductions that trigger an increase in the demand for the cheaper good [...]"; indirect RE "when a resource is used more efficiently and its price goes down, it induces the consumption of other commodities", and economy-wide RE "appear when declining energy prices induce a reduction in the prices of intermediate and final goods throughout the economy and cause structural changes in production patterns and consumption habits. For example, cheaper gasoline enables people to live further away from their workplace by making it less expensive to drive longer distances to work" (Gossart, 2015, p. 438). Indirect rebound effects have been observed in Austria concerning the consumption of e-cars and e-bikes as well as improved housing insulation, which is described as an act that "demonstrates accordance with social demands [...] [and makes] the adopter [...] feel licensed to consume more in other domains" (Seebauer, 2018, p. 316).

In social terms, an unintended implication that has been written on in the context of the development of PEDs is green gentrification (c.f. Dooling, 2009; Gould & Lewis, 2017; Yazar et al., 2020). Green gentrification refers to "the implementation of an environmental planning agenda […] that leads to the displacement or exclusion of the most economically vulnerable population" (Dooling, 2009, p. 630). In the worst case, green urban planning initiatives may be strategically executed to attract a certain type of residents (usually wealthy) in a specific urban area as a result of the revaluation of housing prices (Gould & Lewis, 2017). Even the creation of social-ecological infrastructure (including parks) in existing neighbourhoods with a low median income run the risk of creating a shift in real estate value that can eventually result in the displacement of lower social classes as was the case with the Lene-Voigt-Park in Leipzig (Libertson et al., 2021, p. 152). An example closely connected to one of the cases in the TRANS-PED project is Hammarby Sjöstad 1.0., the precedent of Hammarby 2.0. Imagined as an ecological district with sustainability practices, innovative infrastructure and partially rented, partially cooperative-owned buildings, Hammarby Sjöstad 1.0. came to exhibit "practices of water and energy use and waste production which are barely distinctive from those of average Stockholm residents elsewhere in the city" (Rutherford, 2020, p. 146), and "constitute a clear case of at least partial eco-gentrification", with the majority of apartments being privately owned (ibid., p. 147).

Responding to this dynamic, Marggraf et al. (2019) have made the case that the creation of PEDs should not solely pursue energy-related goals, but at the same time ensure social policies that tackle energy poverty and guarantee affordable housing, e.g., through the introduction of rent caps, quotas for social housing, etc. Related, Nguyen and Batel (2021) have developed the notion of human-centric PEDs, and foreground the importance of engaging with the following dimensions: risk perception and trust; distributive justice regarding the costs and benefits of novel energy technology; procedural justice in the sense of public decision-making about energy decisions; recognition justice and the response to varying needs, e.g., through adapted tariffs; and the reconfiguration of practices and routines through an alteration of structural factors (ibid.).

To meaningfully engage with potential risks and lingering uncertainties, and consider the application of the precautionary principle (c.f.Sunstein, 2005), as well as to become aware of potential rebound effects (as described above) when making a decision for or against a certain technological option, PEDs may benefit from consulting a range of stakeholders that are capable of conducting risk assessments (c.f. ISO, 2009; ISO, 2018; IRGC, 2017). This assessment should go beyond a mere cost-benefit analysis (c.f. e.g., Wegner & Pascual, 2011) but should include future impacts along the range of dimensions listed above in connection with possible risks. Therefore, innovation governance mechanisms that consider risk mitigation measures (c.f. Ahmed, 2017) are essential. Moreover, in cases in which PEDs are framed as "experiments", and potentially also in cases where PEDs are not, experiments should always be consciously viewed as fail-able, and are thus in need of mechanisms, that a) allow for failure without large-scale long-term consequences, and b) draw lessons from them. In the following, approaches that can help address risks and uncertainties through reflective learning processes (Gordijn et al., 2018) will be introduced. These can allow for a further step towards the formalisation of learning in the context of PED innovation.

3. THE RRI APPROACH

RRI is far from constituting a neatly-defined notion and has been argued to be rather an empirical question to be explored in interdisciplinary settings, with different definitions and tools in different branches of science (Delgado & Åm, 2018). Perhaps, the most abstract aim of RRI can be conceived of as "a shift in the organization of moral labour" (Rip, 2014), creating structures and institutions that render actors responsible beyond those that have already made steps to institutionalise responsibility, or, that have traditionally been the carriers of moral labour. Egeland et al. (2019) with a reference to Rip (2014) point to the fact that RRI has been understood in at least three different ways: as "a fundamental reconfiguration of the relation between science and society"; an attempt at outlining conditions for RRI, such as suggested by Stilgoe et al. (2013): anticipation, reflexivity, inclusion and responsiveness; and finally, a bundle of broader policy targets by the European Commission. A fourth, less widely spread understanding of RRI that Egeland et al. list is the interpretation of RRI as a learning process (Kupper et al., 2015). That structured learning processes are essential to any undertaking under the umbrella of RRI is what we will elaborate on further below to avoid RRI becoming merely a "box-ticking" project (Technopolis, 2017, p. 44).

Firstly, as has been described RRI is aimed at reconfiguring science-society-technology relations. It hence contains a governance element that aims at aligning innovative, emerging technologies with societal priorities (c.f. Matthews et al., 2019; Directorate-General for Research and Innovation [European Commission], 2013; Stilgoe et al., 2013). RRI is intended to "replace a notion of innovation that is a-moral" (van den Hoven, 2022, p. 135). As van den Hoven's statement reflects, in the RRI approach "[a]n innovation […] is morally acceptable only if it aims at solving a societal problem, without creating new problems, or exacerbating existing problems" (2022, p. 135). This reconfiguration of relations between science-society-technology is dependent on novel processes. Hence, one approach to RRI rooted in EU policy contexts and values foregrounds the importance of "a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process […] in order to allow a proper embedding of scientific and technological advances in our society" (von Schomberg, 2014, p. 39). This entails the inclusion of relevant stakeholders, the assessment of different alternatives and the application of a lens that considers "societal needs and moral values" (European Commission, 2013). In this regard, the RRI approach has the potential to render PEDs more socially relevant and contextually embedded.

RRI as a bundle of policy tools becomes relevant in relation to mentioned prospective responsibility, which is requested against the backdrop of "societal challenges" that call for "inclusive and sustainable solutions" (The Rome Declaration on RRI in the EU, 2014). Similarly, under the framework programme Horizon 2020 several "grand challenges" have been defined that link to the normative anchor points contained in the Treaty on the European Union, such as the "promotion of scientific and technological advance", the "promotion of social justice, equality […], solidarity, [and] fundamental rights", the provision of a high "quality of life, high level of protection [of] [h]uman health and environment", a "[c]ompetitive social [m]arket economy", and sustainable development, among others (von Schomberg, 2014).

Conditions for research and innovation programmes that can enhance responsibility have been outlined with the so-called AIRR model, referring to the following dimensions: 1) anticipation, 2) reflexivity, 3) deliberation and 4) responsiveness. (Stilgoe et al., 2013). Anticipation refers to the employment of methods that allow for foresight and the cultivation of resilience, such as TA, horizon scanning, or scenario planning (Stilgoe et al., 2013), whereas the notion of reflexivity refers to the "holding a mirror up to one's own activities, commitments and assumptions, being aware of the limits of knowledge" (ibid.: 1571). The notion of responsiveness engenders the capacity for the reorientation of a project based on stakeholder feedback or changing public values and context factors (Stilgoe et al., 2013). More recently, and likely in light of the grand challenges, "sustainability" and "care" have been added as emerging dimensions in some descriptions of RRI (Burget et al., 2017).

Von Schomberg (2014) describes RRI process dimensions as being: 1) TA and foresight, 2) application of the precautionary principle, 3) normative/ethical principles to design technology, 4) innovation governance and stakeholder involvement, and 5) public engagement. Other authors have tried to define quality criteria for the evaluation of research and innovation that is considered "responsible", in particular regarding necessary preconditions, including "socially relevant and solution-oriented", "sustainability-centred and future scanning", "diverse and deliberative", "reflexive and responsive" (Wickson & Carew, 2014, p. 261). How these criteria translate into methods will be further elaborated on below.

Thus, RRI aims at preventing potential (negative) impacts of emergent innovation and research through reflexivity (also concerning risks), principle-guided design and the inclusion of transdisciplinary knowledges. Yet, at the same time, RRI subsumes a list of policy targets that are aimed to be addressed through responsible innovation and research practices, and processes guided by the principles outlined above.

3.1. METHODS AND TOOLS IN THE CONTEXT OF RRI

Methods and tools in the context of RRI can be summarised as "approaches intended for the effective engagement, anticipation and mitigation of potential risks that research and innovation might bear" (Thapa et al., 2019, p. 2477). A central challenge that RRI tools aim at tackling is the integration of different knowledge, often guided by the principle of shared responsibility for the future (ibid.). Yet, a major weakness of RRI so far has been the translation of the academic and policy discourse on responsibility in research and innovation into concrete practices, structures and institutions enabling these (de Saille, 2015b). Recently, authors have tried to identify core practices, and good practice examples of RRI (Kupper et al., 2015; Schuijff & Dijkstra, 2020). Based on a review of 52 articles on RRI practice, Schuijff and Dijkstra (2020) conclude that the most common RRI practices mentioned in the literature include stakeholder involvement, reflection among researchers/innovators, anticipation, and RRI governance. These will be elaborated on in the following.

To begin with, most RRI practices have centred around stakeholder involvement, in particular connecting experts with other stakeholders, and are rarely connected to large-scale societal dialogues. Methods supporting stakeholder engagement ranged from one-off workshops, e.g., scenario workshops, to workshop series and the establishment of institutions that continually ensure stakeholder engagement such as a "multi-stakeholder advisory committee" (Ravesteijn et al., 2014). To allow for meaningful exchange between stakeholders, it has been stressed in the literature that "safe discussion arenas" that balance out different levels of information ought to be established (Bakker et al., 2014) and professionally facilitated and evaluated (Gemen et al., 2015). Further, clarity for the non-expert stakeholders on how their contributions will be used is essential to endow their contributions with meaning beyond legitimacy gains for a project (de Saille, 2015a). Societal dialogues, which have been realised only rarely as an RRI practice according to the review conducted by Schuijff and Dijkstra (2020) go beyond a "series of events" but are a process that aims at institutionalising dialogue (n/a).

Secondly, following stakeholder engagement, a somewhat common practice in the context of RRI seems to be the initiation of a reflection process for researchers and innovators "on the potential impacts and consequences of their work on society, the environment, or other aspects" (Schuijff & Dijkstra, 2020, n/a). RRI practice shows that reflection may occur at different moments in time – before, during, and after the research. Notably, researchers may be nudged to already reflect on potential risks associated with their project at the proposal-writing stage, ideally with guidance from the social sciences (Owen & Goldberg, 2010). During the research process, Fisher and Rip's (2013) socio-technical evaluation research methodology, including an "embedded humanist", may serve as a guidepost. In addition, procedures for the initiation of reflection have been described for certain fields such as nanotechnology or robotics (e.g., Malsch, 2013; McBride & Stahl, 2014; Stahl et al., 2015).

Thirdly, RRI practices have so far manifested in the form of anticipation of ethical, legal and social implications in the earlier phases of research and innovation, including "value-sensitive design" approaches (van den Hoven, 2013) and orientation around the precautionary principle (von Schomberg, 2014). This approach differs from the approach described just above in that they do not involve an external researcher guiding reflection. Impact assessment and foresight methods fall into this methodological category (Schuijff & Dijkstra, 2020) often in the context of TA (von Schomberg, 2014).

Fourthly, RRI practices also connect to attempts at establishing (different degrees of) governance systems for responsible research and innovation "[s]ince responsibility in RRI surpasses the responsibility an individual researcher is able to bear" (Schuijff and Dijkstra (2020) with a reference to Spruit et al. (2016)). The approaches related to governance range from the establishment of international standards for RRI (Wickson & Forsberg, 2015) to considerations related to intellectual property rights (e.g., open-source licences for the potential benefit of society) (König et al., 2015). Despite – or perhaps because of – "current governance landscape(s) of new and emerging research and innovation […] not [being] properly equipped to deal with the new demands of RRI", these suggestions often refer to soft governance, i.e., the adoption of code of conducts (e.g., Asveld et al., 2015). However, there are also suggestions for mixed governance, combining voluntary elements and clear legal guidance, e.g., related to life-cycle questions (Ellwood et al., 2013).

Schuijff and Dijkstra (2020), further, found that most RRI practices relate to stakeholder-engagement, and/or communication beyond immediately involved groups of people in the research and design process; however, these can take different levels of intensity, and merely involve reporting to rather than communicating with the public. The authors also foreground that "including more reflection on the theoretical implications of a practice will contribute to further the conceptual RRI discourse"; in that regard, not only should reflection constitute a part of RRI, but also the reflection about RRI practices is core to doing justice to the theoretical vision behind the concept.

In the following, concrete methods that fall into the categories that were elaborated on above will be introduced. The list is by no means comprehensive, and will draw on a combination of the EU RRI Tools project – in particular on the deliverable by Kupper et al. (2015) – which set out to map RRI practices as part of an EU-funded project; Stilgoe et al.'s (2013) summary of techniques employed in RRI, and some of the authors mentioned in earlier paragraphs of this section to fill in the gaps. To contextualise RRI tools, when setting out to map RRI practices, Kupper et al. (2015, p. 12) found that RRI projects, programmes and organisations were notably more prominent than actual specific RRI tools.

SELF-ASSESSMENT TOOLS	PARTICIPATORY APPROACHES
Self-reflection tool (RRI Tools) Responsible Impact Tool (Coffay et al., 2022) Responsible Innovation Tool (Coffay et al., 2022)	Engagement workshops, collaborative socio-technical integration, action research (Thapa et al., 2019) Social/Living labs[3] and preceding stakeholder mapping (Timmermans et al., 2020) Responsible Innovation Labs (Coffay et al., 2022) Focus groups, science shops, deliberative polling, lay membership in expert bodies (Stilgoe et al., 2013) User-centred design, open innovation (Stilgoe et al., 2013) Social experimentation (Thapa et al., 2019)
TRAINING	**PROTOCOLS/REQUIREMENTS**
RRI Training, e.g., how to include RRI in citizen science or bring into higher education etc. (RRI Tools) Multidisciplinary collaboration and training (Stilgoe et al., 2013) Inclusion of RRI competencies in doctoral curricula (Kupper et al., 2015)	Embedding of social scientists and ethicists in labs/innovation processes (Stilgoe et al., 2013) Codes of conduct, moratoria (Stilgoe et al., 2013) Funding requirements (e.g., the Engineering and Physical Sciences Research Council (EPSRC) Framework) (Kupper et al., 2015)
POLICY-MAKING APPROACHES	**FORESIGHT**
By experimentation (Thapa et al., 2019) Creation of thematic research programmes, e.g., technology roadmaps (Stilgoe et al., 2013) Niche management, stage gates, alternative intellectual property regimes, e.g., open-access requirements (Stilgoe et al., 2013) Value-sensitive design requirements (Stilgoe et al., 2013)	Transdisciplinary foresight and risk anticipation (Thapa et al., 2019) Horizon scanning, scenario analysis, vision assessment (Stilgoe et al., 2013)
SCIENCE COMMUNICATION	**DECISION-MAKING METHODS**
Online platform/Online knowledge sharing Walkshop approach Gamification (Kupper et al., 2015)	Informed consent (Thapa et al., 2019) Participatory appraisal (open exploration of uncertainties and consideration of alternatives) (Thapa et al., 2019) Consensus conferences, citizens' juries and panels (Stilgoe et al., 2013) Technology Assessment (Thapa et al., 2019)

Table 1: Methods supporting the implementation of RRI principles: an overview (own compilation)

3 Living labs, however, in our perception in fact go beyond a participatory approach. They represent laboratories for experimentation in real-world settings, of which responsibility and reflection are central components.

This evaluation shows that projects under the umbrella of RRI mainly draw on already known methodologies, scientific research strategies and methods, as well as citizen and stakeholder participation schemes and democratic decision-making processes. Methods that have been developed specifically for RRI have often taken the form of questionnaires as illustrated by the RRI Tools self-reflection tool that aims to "help you reflect on RRI principles that can improve [...] research and innovation practices" (*RRI Tools*). RRI Tools was an EU-funded project that took place between 2013 and 2016 and was based on the collaboration of 26 European organisations, coordinated by the Spanish foundation la Caixa (*RRI Tools*: *FAQ; RRI Tools*: *Final Conference Results*). Core goals were the development of a working definition of RRI, the mapping of stakeholders' needs, and the production of an RRI toolkit (ibid.). The material developed was structured along the six RRI keys (Rip, 2016, p. 300), i.e., ethics, science education, gender equality, open access, governance and public engagement.

The self-reflection tool, which among other results was developed within the project, concerns questions such as among others, the integrity of R&I practices, participation and decision-making mechanisms, and the incorporation of ethics principles (RRI Tools). Interestingly, the same tool also offers examples of possible answers that may serve as an inspiration for project organisers, e.g., for the assurance of the integrity of R&I practices, the tool suggests the following measures (ibid.):

- Aligning our practices with the Code of Conduct for Research Integrity in all phases, from research design to reporting results
- Encouraging critical peer review and internal discussion on research integrity throughout the process
- Consulting an external research ethics expert or ethics committee

The RRI Tools project targets different groups that might realise RRI such as policy-makers, researchers, educators, business and industry representatives, and civil society organisations (RRI Tools 2022b). Information for policy-makers includes, e.g., how to incorporate RRI principles in a funding call, how to set up a participatory research agenda and how to incorporate RRI in higher education institutions. For the research community, advice is, for example, given on how to co-create community-based participatory research, and how to embed RRI in citizen science (*RRI Tools*: *How Tos*).

3.2. LIMITS AND SHORTCOMINGS OF RRI

RRI, which may be more accurately considered rather as a process than a solid framework with clearly defined boundaries (Rip 2016) has been recently criticised for its observable limitations. After "rapid political capture" by the EU and its main funding programmes at its inception in the early 2000s, in the late 2010s, reflections occurred regarding the possibility of "a shift toward more decentralized and diverse forms of responsible innovation policy […] allow[ing] learning and insight, rather than budgetary categories" (Fisher, 2018, p. 253). Young scholars in the field have raised their "discomforts" about the funding and scientific practice landscape around RRI (Shanley et al., 2022). Among them is the relative uncertainty about the effectiveness of RRI regarding enhanced public involvement in responsible research and innovation processes combined with a perceived disconnect between the RRI community and the general public (Shanley et al., 2022, p. 125). While RRI poses the important and central question of the purpose of innovation and links innovation to broad societal questions connected through the concept of the Grand Challenges, it has so far failed to bring about "general agreement on the principles, methods and tools for achieving 'beneficial' societal outcomes or on how to stimulate the 'right' processes to achieve these goals" (ibid., p. 2331).

That the RRI community has been described as a "bubble" may link to the heavy technical jargon, and Eurocentrism concerning core concepts (Wakunuma et al., 2021), which may prevent meaningful exchange with the public unaware of these (ibid., p. 126). Scholars have stressed that the principles underlying RRI are fundamentally rooted in the thinking of the Global North, including a spin of techno-economic orientation, which the authors refer to as a capital-oriented RRI as opposed to a livelihood-oriented RRI (Wakunuma et al., 2021). The authors highlight the contrast between top-down governance with a focus on "high-tech, export-oriented, large-scale, private-based" innovations as part of the conceptualisation of RRI in countries of the Global North, and rather bottom-up "low technology, livelihood-oriented, small-scale, collective-based" innovations as part of the concept in countries of the Global South (ibid., p. 279). According to the authors, the conceptualisation of RRI in countries of the Global North tends to rank lower the priority of rural areas, social innovation, and low-capital grassroots initiatives and tends to favour certain funding applications based on the availability of expertise in a project consortium, thus reducing the likelihood of involvement of the general public and CSOs/NGOs vis-à-vis academia and policy-makers (ibid., p. 280-281). For the context of PEDs, a Eurocentric logic implies the danger of focusing too narrowly on technological aspects of newly built districts, rather than considering more broadly what kind of constellation of innovations (social and technological) could serve the generation of ecologically and socially viable livelihoods.

In addition, "RRI may have failed to bring about a much-needed structural and institutional change in our thinking about science and new technology" (van den Hoven, 2022, p. 134) and served instead rather as an ivory-tower flavoured "diplomatic tool in the greater European project" (Shanley et al., 2022, p. 126). This critique goes hand in hand with the observation that RRI oftentimes does not transcend the realm of research, and hence has been found to be too narrow to consider innovation in all its contextuality (Coenen & Morgan, 2020). Departing from the understanding that innovation is necessarily research-driven or research-accompanied, the concept of RRI conveys on the one hand the normative assumption that innovation must be connected to research, yet at the same time denies the reality of innovation processes that occur independently of research, and nevertheless – or perhaps even more so – require ethical guidance (Jakobsen et al., 2019). With this, the concept of RRI tends to be rather ignorant towards alternative types of innovation, which however may play a role in PED development, such as "experience-driven innovation in different business sectors, user-driven innovations, social innovations and public sector innovations" (ibid., p. 2332). However, it may be that future PEDs (or elements of PEDs) will be developed in the context of larger European research projects (e.g., on hydrogen infrastructures).

In the course of such R&D projects, scientific questions and technical solutions may need to be addressed for which RRI could provide a viable framework. For this, however, the currently used RRI practice would have to be improved based on the recently articulated criticism.

Given this blind spot, also a critical analytic economic lens has been found to be missing from RRI conceptualisations and inquiries, and RRI has been described to have the tendency to be decontextualized from economic realities, such as profit interests and economic growth as core motivations for innovation (Jakobsen et al., 2019). This leads to the problem that – as some scholars have observed – economic growth remains an uncritically adopted positive target in conceptualisations of innovation prominent in RRI research, which reflects the uncritical translation of orthodox economic thought into RRI discourses (de Saille & Medvecky, 2016). But not only in research, but also in politics, innovation and GDP growth in a competitive market economy have come to be inextricably viewed in tandem (de Saille, 2022). Connected, the usage of the notion of innovation itself has been criticized for too often being used in unreflected ways in the RRI discourse; among others, it is "self-evidently seen as (1) technological innovation, (2) is primarily perceived from an economic perspective, (3) is inherently good and (4) presupposes symmetry between moral agents and moral addressees [original emphasis]" (Blok & Lemmens, 2015, p. 19). That innovation is predominantly conceived of as technological innovation means that other categories of innovation that are very likely essential to tackling global challenges will not be considered in the discussion such as agro-ecological innovation, attitudinal innovations (Blok and Lemmens, 2015: 29), social innovation (Haxeltine et al., 2013; Tommasi, 2015; Farzad et al., 2020), and transformative social innovation (Novy, 2017; Avelino et al., 2019). Transformative social innovations are targeted precisely at overcoming what has been criticized above by "changing social relations and satisfying needs, e.g., through participatory modes of governance" and operate under the awareness of wicked problems within the multiple crises, centrally among which social inequality and insecurity are featured (Novy, 2017, p. 3).

De Saille (2022), consequently, pledges to shine a light on and radically question the role innovation has been assigned, and to reflect on who benefits from its current conceptualization (ibid.). As a consequence, "[a]n in-depth discussion of how to understand and handle the societal and environmental consequences of economic growth has been lacking" (Jakobsen et al., 2019, p. 2332) despite ecological economic scholars, earth scientists and political scientists having provided abound research on the disastrous consequences of economic growth, and the interlinkage between economic growth, social inequality and ecological crises, notably the climate crisis (Brand, 2009; Steffen et al., 2015; Hickel, 2019). That innovation has come to be linked to the desirability of increases in economic growth stands in contrast to an initial conceptualization of innovation that targets the improvement of conditions for the most marginalized: Albertson et al. (2021, p. 295) write that "it is reasonable to define a responsible innovation system as one in which the greatest possible benefits of the innovation accrue to the least-advantaged members of society". Thus, "responsible innovation must be judged by its impact on both material returns and the agency [original emphasis] of the most vulnerable – including the agency of future generations" (Albertson et al., 2021, p. 296). This goes hand in hand with the finding that innovation that is primarily aimed at boosting economic growth has historically resulted in wealth increases for societal elites and thus intensified social inequity rather than contributed to universal flourishing (Albertson et al., 2021). Additionally, the RRI literature has come to be described as being marked by a general sense of "placelessness", i.e., a lack of engaging with space and territory regarding innovation, and looking into specific features or constellations of circumstances that may render RRI more or less realistic (Jakobsen et al., 2019). Given the fact that the economy has reached globalised extents, multi-scalar approaches to understanding the implementation of RRI, e.g., along globalised trade chains, and connected innovation activities. Jakobsen et al. (2019, p. 2340) identify the Global Innovation Network literature (e.g., Chaminade & Vang, 2008) as a potential pathway towards acknowledging and responding to the spatial context of research and innovation.

The scholars critical of RRI as practised so far suggest a repoliticisation of responsibility in research and innovation by exchanging with social movements that fundamentally question existing paradigms, and direct funds in research projects towards "new participatory experiments" such as social labs "in which all kinds of change agents are brought together to experiment with alternative forms of practising and evaluating R&I, beyond the status quo" (Shanley et al., 2022, p. 127). PEDs would lend themselves well to being conceptualised and planned as such social labs. Other authors have stressed that while RRI exhibits a range of shortcomings, the time has not yet come to abandon the concept but rather to reinvigorate it by expanding it. As de Saille (2022, p. 138) argues, "[a]s a knowledge project aimed at institutional change, […] RRI's emergence is still incomplete". For example, M. Steen foregrounds the overlooked need for the focus on slow innovation in RRI, involving the engagement with "uneasy questions, vulnerable experiences, awkward moments and uncertainty" (2021, p. 256). Szymanski et al. (2021) make the case for a post-anthropocentric RRI approach that acknowledges relationality between human and non-human species, and thus make the case for the engagement with multispecies studies. As mentioned above, Wakunuma et al. (2021) argue for a broadening of the conceptualisation of RRI by reflecting on North-centric assumptions and actively including perspectives from the Global South, including e.g., a shift from capital-oriented towards livelihood-oriented understandings of RRI, thus rendering the RRI discourse more globally relevant. Related, Macdonald et al. (2021) elaborate on the reconceptualization of RRI in the context of social-ecological challenges and the employment of technology in and by Indigenous communities in community-centred governance schemes. Further, authors have made the case for deepening those dimensions of RRI that relate to social inclusion, i.e., equity, care, welfare, etc., in contrast to blindly following capital-driven logics that are naturalised in growth-based economic systems; thus assessing impact also in terms of "agency of the most vulnerable – including the agency of future generations" (Albertson et al., 2021, p. 296). In short, "a key question confronting advocates of responsible innovation today is to use insights gained over the last ten years and weave together old and new approaches, such as social innovation, ecological economics, (techno)feminism, care ethics, postcolonialism, slow science, and others with the aim of reconstituting RRI anew" (van Oudheusden & Shelley-Egan, 2021).

So far, the discourse on RRI has highlighted the importance of responsibility in the context of innovation to solve urgent and complex societal problems. Mostly within European research programmes, attempts have been made to operationalise the concept. However, up to now, the practical application of RRI has fallen far short of expectations. On the one hand, this has to do with the tendency to over-institutionalise the concept and, on the other, with an under-theorisation of the role and significance of responsibly conducted innovation, as an essential part of which we view critical reflection and learning, in societal transformation processes. Similarly, emerging from a neoliberal knowledge context, RRI as a concept has yet to emancipate itself from a capital-centred logic, and could be enriched by inter-species perspectives of responsibility, non-Western conceptualisations of responsibility, and life-and community-centred approaches to innovation.

Despite these obvious shortcomings, the concept of RRI could represent a helpful guidepost for the design of research-based PED projects in the future when mindfully navigating the aforementioned limitations of RRI, and ideally confronting limited conceptualisations of innovation in practice. Concrete research on PEDs may in return inform RRI theory, and aid the broadening of the concept beyond techno-centric, Eurocentric, research-centric, and growth-centric imaginaries.

3.3. EMERGING FROM RRI CRITIQUE: MOMENTS OF REFLECTION AND THE ROLE OF IDENTITY

In his critique of RRI practice to date, Rip concludes that the best that the concept can do is offer "a space where further developments are explored and experienced" (Rip, 2016, p. 292). Rip (2016) further suggests that these developments could benefit from social scientists' and humanities scholars' contributions, e.g., to create more reflection-enabling settings, "or at least, to introduce reflexive moments"[4] (Rip, 2016, p. 295). As M. Steen (2021) foregrounds, RRI should manifest in posing questions that instil reflection rather than providing answers, which means "creating time for uneasy questions, vulnerable experiences, and uncertainty" (ibid., p. 256).

Moments of reflection may take the form of "bridging events" (Garud & Ahlstrom, 1997), which involve "enactors" (technology developers, or, insiders) and "selectors" (outsiders) (Rip & te Kulve, 2008) to "probe each other's 'realities'" (Garud & Ahlstrom, 1997, p. 44). Essentially, "enactors" will tend to foreground the positive sides of an innovation, potentially turning a blind eye to risks and criticism by focusing on rather narrow evaluation criteria, and accepting less extensive trial periods for new technology (ibid.). We will refer to this group as "insiders".

"Selectors" – which we refer to as "outsiders" –, on the other hand, conceive of alternatives, and thus may engage in acts of comparison (Rip & te Kulve, 2008). The latter may either be professionally skilled "selectors", thus engaging in comparison and the selection of options based on existing processes and predefined indicators, or amateur selectors, including consumers and citizens – in some cases represented by a civil society organisation or an NGO (Rip & te Kulve, 2008). In the case of PEDs, inhabitants and social movements in the context of the energy transition could likely make for constructively critical outsiders. In other words, while insiders may foreground the benefits of an innovation only, outsiders might have a more nuanced evaluation, including benefits and drawbacks (Garud & Ahlstrom, 1997, 40f). Bridging events aimed at integrating and fine-tuning those parties' perspectives do not necessarily have to take the form of actual events, but are points in time, where (also e.g., due to a shift in legitimacy) interaction between enactors and selectors occurs, and may also take the form of structural entanglements between the parties mentioned (Garud & Ahlstrom, 1997). These bridging events, according to a "soft intervention approach of Constructive TA" may be "support[ed] and orchestrate[d]" (Rip & te Kulve, 2008 n/a) to increase the level of interaction between insiders and outsiders.

Since so-called enactors or insiders tend to identify more with an innovation in whose creation, they were involved than outsiders who may take a more detached stance, it makes sense to look at the role of identity in innovation processes. "Identity work" refers to the work that occurs to stabilise and maintain an identity, i.e., "a range of activities that individuals engage in to create, present, and sustain personal identities that are congruent with and supportive of the self-concept" (Snow & Anderson, 1987, p. 1348). In processes that follow an open-innovation approach (Chesbrough, 2010 (2003)), hence involving stakeholders "on the margins of knowledge boundaries either socially or knowledge-wise" (Lifshitz-Assaf, 2018, p. 747 with a reference to Jeppesen & Lakhani, 2010) naturally involve the negotiation of boundaries that were established by professionals to "gain legitimacy and help distinguish experts from laypeople" (Lifshitz-Assaf, 2018, p. 747 with a reference to (Lifshitz-Assaf 2018, 747 with a reference to Abbott, 2007). These initially established boundaries by R&D professionals, however, prevent the influx of knowledge from other groups that may not share the same status but may contribute in ways that propel innovation (Lifshitz-Assaf, 2018).

4 Throughout this report, we will be using the notion of "moments of reflection", for which Rip's (2016) initial idea of "reflexive moments" is an inspiration; yet, we have expanded on the concept and prefer the term of "moments of reflection" as it more clearly points to the curated, conscious action of reflecting as the core component of such a moment.

The shift towards an inclusion of knowledge outside of the boundaries may require internal "boundary dismantling work", and thus a sharing of information with outsiders, as well as the inclusion of knowledge by outsiders (ibid., p. 760). However, it is likely that some insiders will prefer to engage in "boundary protection work" (ibid., p. 765), thus disregarding any external input or feedback to their established knowledge. Relating these two types of boundary-related responses to identity, Lifshitz-Assaf (2018, 767f) found that shifts in knowledge work could be traced back to shifts in R&D practitioners' professional identity; hence, identity work and knowledge work are inextricably linked. In their study on NASA's identity work as an organisation that benefitted from the transcendence of boundaries, Lifshitz-Assaf (2018) could identify two tendencies in regard to the renegotiation of identity: firstly, those R&D professionals open to negotiating knowledge boundaries, to external knowledge, and who shifted their role actively "from problem solvers to solution seekers" (ibid., p. 769); secondly, those R&D professionals that protected their boundaries, and maintained the responsibility to solve problems by themselves, or within their community (ibid.). While the former has been found to result in capacity-building and creative problem-solving, and thus potentially more successful solution-finding, the latter retains the status quo of a (relatively) closed community and may result in the repetition of (similar or identical) knowledge-finding processes inside and outside of the established boundary (ibid.). That "boundary protection work" occurs may be a response to perceived identity threat, including a potential loss of social status (Elsbach, 2003). We may also relate this phenomenon to the identity of an entire project, e.g., a PED project team, initiators of a PED in a municipality, and its perceived distinctiveness, which could in the worst case result in a defensive reasoning mindset (Chris Argyris, 2003, p. 1186) towards problems that have occurred with a PED. This may be coupled with a technology bias, i.e., the strong and automatic favouring of one technological option over others once this option has been given more attention or has been selected; thus, alternatives become invisible (Schreuer et al., 2010). While useful learnings could be extracted from "bad" decisions, in reality, a high level of identification with a project may prevent self-critical in-depth reflection and sharing of mistakes to avoid in other PEDs. For this reason, one may assume that it is of key importance that social players with outsider identities are involved in reflection processes. Their identity ideally may even reinforce a critical perspective, and learning processes can thus become more profound.

The reason this is relevant for PEDs concerns the fact that PEDs present settings in which innovative solutions are being explored, tested, and often presented to the general public as finished/complete solutions. However, often it remains uncommunicated by insiders whether other solutions could have been more fitting in social-ecological terms, or whether anything implemented should be prevented the creation of a different PED. Based on the experience from the present project, we assume that the identification with a solution as an insider may prevent the critical engagement with this very project, and hence foreground insiders' knowledge. This may also be the case, due to the perceived distinctiveness of a PED project, and related "identity threat" to a group of stakeholders' "place identity" (Bradley, 2017) once outsiders challenge insider assumptions. In order to counter these tendencies, we argue, the introduction of moments of reflection with actors involved in the development of PEDs (as will be elaborated on below), and outsiders (who are somewhat knowledgeable about the project, yet critically engage with it), could become a core instrument for responsible innovation in the context of urban transformation projects.

Moments of reflection, in which insider knowledge is critically questioned by outsiders, should open up possibilities for second-order learning processes. We will discuss this topic in more detail below.

4. SECOND-ORDER LEARNING IN PEDS

As we saw, RRI is primarily concerned with the establishment of an institutional framework for cutting-edge innovation so that research and development can be carried out in a socially responsible way. The following chapter focuses on how to reflect on the experiences made in innovation processes at a fundamental level. Certainly, learning processes and critical assessments are important elements of RRI, yet reflective learning[5] deserves some additional attention.

The learning mode that we are focusing on in this chapter is referred to in the literature as second-order learning, and hope to make the case for why second-order learning is an essential precondition for responsible PED development for urban energy transitions. This mode of learning based on practical experience allows one to challenge underlying assumptions, compare alternative options, and identify problems, unintended consequences and risks in innovation processes.

With the aim to inform the Responsible Innovation in and for PEDs Framework for PED practitioners, in this chapter, we look into the principles of second-order learning, highlight the role of identity of involved actors, compare the conditions for learning processes in structured and unstructured contexts, explore how capacities for second-order learning can be built, discuss issues of timing, possible methods as well as gaps in the literature, and conclude by discussing options for better institutional anchoring of reflective learning in innovation contexts.

4.1. NOTIONS OF LEARNING AND LEARNING AS A PROCESS

Learning has been historically looked at in various research fields, ranging from educational sciences and management studies to complex system thinking, policy sciences and institutional economics (van Mierlo & Beers, 2020). Each of these has given rise to different but mutually influencing conceptualisations of learning and connected learning traditions. Some of them are policy learning (political sciences), learning in communities of practice (management studies), and transformative learning (educational sciences) (van Mierlo & Beers, 2020, p. 266). In the context of sustainability transitions, the authors have identified four learning traditions that they argue are valuable to understanding learning during and for societal change, which are: collaborative learning; organisational learning; social learning in natural resource management; and interactive learning in the learning economy (ibid.). These learning traditions tend to differ in their underlying aims, time frames and social configurations (ibid., p. 259). However, most of them have in common the process dimension, i.e., learning is not described as a singular event, but rather as a long-term project that may occur in loops of action-reflection-adaptation (such as described in organisational learning), or involve initial meetings that then result in larger follow-up projects (such as described for collaborative learning) (ibid.). Similarly, a diversity of knowledges and/or competences appears to be a precondition to all types of learning. Yet, at the same time, diversity is not uncritically embraced as a purely positive feature, but e.g., different opinions are also perceived as challenges that may be overcome through collaborative learning (ibid., p. 260).

5 In this report, we use the term "reflective learning" as described by e.g., Gordijn et al. (2018) synonymously with "second-order learning" (c.f. Sterling (2011)).

In terms of aims, collaborative learning is often task-focused, e.g., "the development of a niche experiment […], the development of normative future visions or transition pathways with diverse actors […], and the translation of lessons learned in a pilot project to the context of a niche or regime" (van Mierlo & Beers, 2020, p. 260). Organisational learning, as revealed in the title, is concerned with the reconfiguration of organisational practices, systems and routines. While social learning often aims at solution-finding in the context of complex problems, on the other end of the spectrum, interactive learning in the learning economy is primarily concerned with development and progress in firms and a contribution to GDP growth (ibid., p. 259). Interestingly, both organisational and interactive learning are closely connected with the process of unlearning or as referred to by Schumpeter (1994) "creative destruction", i.e., abandoning the dysfunctional, which has been described as a notion that is "absent from the transition studies" (ibid., p. 257). Similarly, Becker (2010) elaborates on unlearning at an organisational level in times that require and are prone to change. While unlearning is not further elaborated on in this report, we deem it an essential component of learning processes in the context of transformation. Societal learning brings to the table complex social-ecological relations and is often action-oriented, e.g., the connection of actors for joint action, which can also take the form of informal networks (ibid., p. 263). Activities include "forecasting and backcasting (future visioning) and collaborative problem analysis" (ibid., p. 264). Interactive learning reminds of the value inherent in extracting and connecting codified and tacit knowledge (Nelson & Winter, 1994), and finely distinguishes between different types of knowing. Similarly, it brings in system perspectives that go beyond a group, organisation or network (van Mierlo & Beers, 2020, p. 266). Yet, at the same time, interactive learning in and for a learning economy has been criticised for accepting contextual conditions and merely operating within them rather than challenging unsustainable structures at a deep level as is essential for a sustainability transition (ibid., p. 265).

All of the approaches to learning discussed have in common an exchange based on experiences rather than learning based on literature. This is reminiscent of the "experiential learning" approach, which is prominent in responsible innovation literature, and defined as "a continuous process of learning through experience with experience being transformed into knowledge" (Timmermans et al., 2020, p. 417 with a reference to Moon, 2013). This rhymes with a prominent approach to learning in transition studies, where learning has come to be viewed as the exchange and aggregation of experiences emerging from pilot projects that will influence how new pilot projects are being curated (Geels & Deuten, 2006). Methods aimed at facilitating exchange that have emerged in this context are so-called "eye-opener workshops" (van Mierlo et al., 2010), but also experiments in real-world contexts (Lake et al., 2016). This kind of learning is aimed at the development, testing, evaluation and re-design of interventions addressed at social challenges (Kolb & Kolb, 2011).

While every PED harbours the potential to generate learnings for urban transformation more broadly, one should be aware of the potential limitations of local learning: due to its heavy contextuality, it may apply only to certain actors over a certain period and thereby potentially "conceal more overt conflicts and detrimental practices playing a role in transitions" (van Mierlo & Beers, 2020). As Wolfram et al. (2019) outline in their elaboration on learning in urban climate governance, they highlight the centrality of parallel learning, which is the interaction with actors in similar processes, and thus consulting exogenous sources (ibid., p. 5).

In the context of RRI – as introduced above – Kupper et al. (2015, p. 24) distinguish between three types of learning connected to their objectives in the context of RRI, namely: learning for governance, learning for doing, and learning for learning. Learning for governance relates to the creation, testing or informing of policies in connection with the furthering of RRI practices; this may also include the reflection on the framing of RRI intentions such as the defined "grand challenges" and can take the form of platforms, boards and other fora in which stakeholders can exchange (ibid., p. 26). Learning for doing concerns the development and realisation of RRI practices (ibid., p. 27). Lastly, learning for learning refers to practices related to science education and science communication (ibid., p. 25).

4.2. FIRST AND SECOND-ORDER LEARNING

According to Chris Argyris (2003, p. 1179), "learning occurs when understanding, insight and explanations are connected with action" – this action is referred to as an act of correction. Learning may occur as single-loop learning, where mismatches are adjusted within an existing system, or as double-loop learning[6] where correction goes beyond the bounds of a system, changing "underlying values and other features of the status quo" (Chris Argyris, 2003, p. 1179). In fact, double-loop learning, "requires that new routines be created […] based on a different conception of the universe" (ibid.).

Bateson's (1972) theory of learning distinguishes three levels of learning: in the following first-order learning, and second-order learning will be elaborated on in greater detail. Third-order learning, which will not play a central role here, has been entitled "epistemic learning", and is concerned with a profound confrontation of (and thus becoming aware of) the very basis of experiencing the world, i.e., worldviews (Sterling, 2011, p. 23). It may result in "a dramatic shift in consciousness" that allows for the deconstruction and reconstruction of paradigms (ibid.). These three levels are nested in one another, with higher-level experiences influencing lower-level learning (ibid., p. 24). Learning in this case aims at transformative change ("seeing things differently") (Sterling, 2011, p. 25). The development of the PED vision, namely that urban neighbourhoods will be self-sufficient in terms of energy and completely climate-neutral in the future, is based on such third-order learning processes, which have recognised that climate change is inextricably linked to the burning of fossil fuels, and hence a profound change in the usage of energy is required to avert the worst consequences of the climate crisis.

Sterling (2011, p. 22) argues that in formal education settings, most learning can be attributed to first-order learning, thus passing on knowledge without "challeng[ing] the assumptions or beliefs of the learner" (ibid.). Second-order learning, in contrast, occurs at a deeper level by questioning pre-conceived notions and long-held values (ibid, p. 23). While first-order learning is about the improvement and fine-tuning of existing processes (i.e., "doing things better") without calling into question norms that underlie them, second-order learning fundamentally challenges the purpose and meaning of a process, thus aiming for "doing better things" (ibid.). Hence, first-order learning can be described as "conformative", whereas second-order learning can be considered "reformative"; the creation of a truly "transformative" learning experience or third-order learning that leads to a paradigm shift remains a challenge (Sterling, 2011, p. 25). While first-order learning, which is often linked to monitoring, is important for the successful implementation of PEDs, if it stands alone, it may result in a PED project being mainly guided by technological solutionism. To ensure that solutions are socially and ecologically viable – both intra- and intergenerationally – critical systemic questions, as are part of second-order learning processes are required.

6 While according to Chris Argyris (2003, p. 1179) double-loop and second-order learning are sometimes used synonymously, we follow the author's definition and distinguish between the two notions, bearing in mind that second-order learning may occur "by going meta on single or double-loop learning" (ibid.).

Second-order learning, also referred to as meta-learning (Sterling, 2011, p. 24) or "deutero-learning" (Bateson n/a in C. Argyris & Schön., 1974) refers to "reflecting on first-order actions" (Chris Argyris, 2003, p. 1179). Second-order learning as a meta-reflection may either occur within the frame of single-loop learning or double-loop learning, with the latter depending on more resources (ibid.). Whereas single-loop learning "remains within the accepted routines" by repairing problems within them, double-loop learning refers to the creation of novel routines "based on a different conception of the universe", and thus, a questioning of values (Chris Argyris, 1999), worldviews and tacit assumptions such as technological solutionism or the ascription to economic growth as an indicator of societal wellbeing (Quist & Tukker, 2013). Quist and Tukker (2013) foreground that second-order learning is particularly important in the context of several global crises in which sustainability innovations emerge in niches and are required systemically (ibid.). The authors conclude that "without learning and knowledge collaboration, diffusion of needed (radical) sustainable innovation in society will not take place" (ibid, pp. 173-174). Yet, they at the same time stress that learning in niches alone is insufficient to bring about transitions, and pose the question of how these can transpire into societal learning and overall system innovation (ibid.). System innovation aiming at "radical changes" is juxtaposed with optimisation and redesign, which emerge from first-order learning, and result (only) in incremental change (ibid.). PEDs, however, in order to fulfil their aims require fundamental changes that cannot be brought about by first-order learning alone. Thus, second-order learning appears to be a precondition to bringing about urban transitions.

Particularly in the case of second-order learning, learning experiences may bring about elements of resistance in the learners due to "threat(s) to existing beliefs" (Sterling, 2004, p. 286) and thus involve an existential dimension (Rogers, 1994). In order to challenge the so-called "defensive reasoning mindset" (Chris Argyris, 2003, p. 1186), which is likely to occur with who we refer to as project "insiders", we deem it relevant that critical "outsiders" support with their critical examination capacities regarding decisions made during an innovation process.

Thus, in the PED context, the definition for the two types of learning could go as follows: while first-order learning mainly aims at fixing bugs within an existing structure and set of values, second-order learning questions decisions about processes on a more fundamental level, and thinks beyond the local context and seemingly closed system, but is aware of social-ecological implications that go beyond the present, and beyond the immediate surroundings of a PED. A question related to first-order learning is: how can we make this system work/work more efficiently? In fact, many issues addressed in the context of technical monitoring of PEDs fall into this category. Questions related to second-order learning, in contrast, include: Which alternative solutions could/should we have chosen to avoid unintended negative side effects? How can unnecessary risks, unsustainable path dependencies and rebound effects be avoided? Which alternatives could be possibly explored to reduce negative side effects? Hence, second-order learning allows for reflection that purposefully targets potential side effects and potential risks of innovation.

That said, monitoring and reflection are complementary, with reflection bringing in qualitative elements beyond pure numerical assessments of a PED or any other urban development project. van Mierlo et al. (2010) have developed a guideline for reflexive monitoring in action, which serves as orientation in the process of reflecting on a project's ambitions, practices and institutions, and changes in the system that may enable system innovation. Reflection is considered stage 3 of a 4-part monitoring cycle, including observation, analysis and reporting, reflection and adjustment of activities where relevant (ibid., pp. 18f). The authors recommend so-called interventions based on monitoring activities that stir reflection; a specific role is assigned to the so-called monitor, i.e., a person who closely observes a project, and intervenes whenever necessary to raise questions or open up discussions about unresolved issues in the project that may also remain unclear to the project manager and participants (van Mierlo et al., 2010). This role comes relatively close to what we referred to as "selectors" earlier, i.e., an outside voice of a person not too closely associated with a project, yet aware of its context, challenges and implementation stages.

4.3. EXPERIMENTAL DESIGNS VS. UNSTRUCTURED CONTEXTS

Now that the relevance of second-order learning for knowledge generation on urban transformation has been introduced, we shall turn to the contexts in which second-order learning is more likely to occur, and discuss urban experimental designs vis-à-vis unstructured contexts of "regular urban development". To begin with, experimental designs refer to approaches such as urban experimentation, urban living labs (ULLs), niche experiments, bounded socio-technical experiments (BSTE), grassroots experiments, transition experiments and sustainability experiments (Sengers et al., 2019). From Rose et al.'s (2022) typology of urban experimentation for sustainability, the concept of "sustainability experiments" as listed above is excluded due to a lack of contrast to the other concepts mentioned. In the following, some of the approaches listed, notably urban experimentation, urban living labs, niche experiments, transition experiments and bounded socio-technical experiments will be elaborated on in detail.

Urban experimentation is associated with municipalities seeking ways to navigate challenges posed by the climate crisis, and due to their limited capacity and knowledge publicly demonstrate their willingness to act by pairing up with actors considered more knowledgeable, including private actors (Bulkeley et al., 2015). Which kind of actors are invited to join the experimentation/solution-finding process depends, among others, on the problem definition, i.e., whether a problem is considered to be primarily of a technical kind, or a broader overarching social-ecological question, which is where power relations are central (ibid.). Experiments are aimed at transgressing into institutions and becoming part of daily routines (ibid.). According to Sengers et al. (2019), the concept and practice of urban living labs (ULL) has emerged from the frame of urban experimentation. These will be elaborated on in the following.

ULLs bring together a range of stakeholders in real-life urban settings to collaboratively work towards innovation and sustainability solutions by engaging in the design and/or testing of technologies and new ways of living, i.e., behavioural change (Voytenko et al., 2016). Additionally, the more general category of social labs has been described as a meaningful approach to practising RRI principles (Timmermans et al., 2020). Social labs are "platforms for addressing complex social challenges that have three core characteristics: they are social […] experimental […] [and] systemic" (Hassan, 2014, p. 3). Timmermans et al. (2020) propose to base social labs on stakeholder mapping processes of people (directly and indirectly) related to the challenge at hand. Core to the knowledge-generation process is experiential learning (Moon, 2013).

In the 2013 JPI Urban Europe Funding Call *Creating Attractive, Sustainable and Economically Viable Urban Areas,* urban living labs were described as "[a] forum for innovation, applied to the development of new products, systems, services and processes, […] integrat[ing] people into the entire development process as users and co-creators, to explore, examine, experiment, test and evaluate new ideas […] and creative solutions in complex and real contexts". Hence, the co-creation of processes and products with users is a key element of urban living labs, but also the exchange of knowledge between different stakeholders, and thus learning through experimentation (K. Steen & van Bueren, 2017). However, depending on who initiates urban living labs, they may serve different key purposes – although the overall features listed above may be shared: priorities for the initiation of ULLs can range from the strategic creation of testbeds to assess innovations for commercial use to the exploration of urban development priorities in collaboration between municipal, academic and local private actors (Marvin et al., 2018, p. 8).

Rooted in the Strategic Niche Management Approach (SNM) (Kemp et al., 1998), niche experiments refer to the governance of the "locus for radical innovations" (Geels, 2011). They may take the form of "R&D laboratories, subsidized demonstration projects, or small market niches" (Geels, 2011, p. 27) where niche actors, often private actors devise "innovations that deviate from existing regimes" (ibid.) with the vision of establishing themselves in the regime or replacing elements of it (ibid.). Niche experiments focus in a somewhat narrow fashion on the knowledge generation around a particular technology or service innovation (Sengers et al., 2019) without necessarily considering "wider institutional or cultural innovations" (Rose et al., 2022). Niche experiments tend to have clear, predefined project durations, and highlight the importance of involving innovative actors outside of the mainstream to foster creative solutions (Hoogma et al., 2002). Whereas niche experiments involve the quadruple helix of actors, the role of participants is often limited to "users" (Rose et al., 2022). In the past, niche experiments have shown to be advantageous in their problem-centred approach, and engagement with windows of opportunity; however, they have failed to show impact beyond their local context, and engage with structures on a systemic level (ibid.).

Transition experiments can be considered parts of the transition management approach (Rotmans et al., 2001). Perhaps somewhat in contrast to niche experiments, transition experiments are linked to a high level of risk, which however at the same time bears the potential of significantly contributing to a transition (ibid.). Modified to fit suggested transition paths, they address social challenges on a larger scale than niche experiments, including questions related to provisioning (van den Bosch, 2010). Contrary to niche experiments, transition experiments tend to touch on more profound questions related to cultural practices, infrastructures and paradigms (Rose et al., 2022). They usually rely on a carefully selected network of actors but do not necessarily involve civil society (ibid.). Transition experiments may occur on a relatively small scale, however with the long-term goal to transpire into society at large, and bringing about a sustainability transition (Loorbach, 2007). Learning is a vital element of transition experiments in that they "provide a way of thinking about governance that is concrete enough for implementation but simultaneously allows enough room for reflection, adaptation and learning" (Loorbach, 2007, 281f).

Finally, bounded socio-technical experiments (BSTE) refer to the introduction of "new technology or service on a scale bounded in space and time" (Brown et al., 2003, p. 292). Addressing larger social issues, BSTE are concerned with the exploration of unsustainable practices that prevent transitions to more sustainable systems, and therefore also engage critically with social practices and preferences (Vergragt & Brown, 2004). Similarly to transition experiments – not least due to the involvement of a variety of actors – socio-technical experiments can take numerous outcomes and are thus faced with uncertainty (Rose et al. 2022). Solutions may go beyond merely technical fixes, and involve the deeper challenging of structures, including provisioning infrastructure; thus questions of mobility, for example, go beyond the transition from diesel cars to e-cars, but question mobility systems overall (Vergragt & Brown, 2004). This "radically call[ing] into question [of] entire structures and frameworks and consider[ation] of alternatives that fundamentally differ from anything existing" (Rose et al., 2022, p. 8) is an advantage of the approach albeit one that comes with the challenge of providing the resources to facilitate in-depth discussions (ibid.). If challenges are reasonably dealt with, BSTE can generate higher-order learnings (ibid.).

Due to transformative urban development being a comprehensive and complex task, including multiple perspectives across a variety of actors, experimental settings can allow for a fitting learning environment that meaningfully addresses risks and uncertainties attached to the realisation of a PED. If PEDs are framed as experiments, that also allows them to engage with risks and uncertainties – even if only rendering them visible as immanent properties of real-world experiments. Hence, whether there is a higher likelihood for learning to occur in a PED context may be determined by whether a PED is conceived of and designed as an experiment. When setting up a PED as an experiment, it can be useful to accompany it with an evaluative scheme for sustainability transition experiments such as the one developed by Luederitz et al. (2017), which due to its "generic, comprehensive, operational and formative" (ibid., p. 61) nature aims to apply to a wide range of practical cases. Previously, this scheme has also been adapted a-posteriori to identify gaps and problems in a failed urban development project and has thus generated learnings for future similar endeavours (Lipp et al., 2020).

Unstructured contexts, in contrast, are contexts of urban development that were not primarily intended as experimental spaces with potential learnings, but that were instead realised in the context of "regular" (urban) development. Examples from the TRANS-PED project for such contexts are Graz Reininghaus and Brunnshög and to some degree Sonnendorf. The reason we refer to these contexts as "unstructured" does not relate to the urban development projects emerging entirely without structure, but rather to the fact that those projects are not embedded in a structure that has the core aim to generate knowledge along the dimensions of first and second-order learning. These examples can be contrasted with another case in the TRANS-PED project, i.e., Hammarby Sjöstad 2.0, which frames itself as a testbed (*About Us*: *Hammarby Sjöstad 2.0.)*. Core to the project, and embedded in its structure, is to learn, test and improve.

The framework, for which this report serves as a backbone, ought to be relevant for all kinds of PEDs, meaning both those that were set up as experimental designs from the very start (such as Hammarby Sjöstad 2.0) and those that emerged in an unstructured learning context. Whereas the former are less dependent on external input to guide their learning experiences, the latter may very well benefit from some additional moments of reflection. In our understanding, society at large would benefit from reflection processes in newly emerging PEDs, independent of whether they were set up for knowledge generation or designed as regular city-development projects in order to generate learnings for the energy transition.

4.4. CAPACITY-BUILDING FOR SECOND-ORDER LEARNING

Next to citizen participation and stakeholder interaction, capacity-building is mentioned as one of the eight key challenges and requirements for PEDs in the SET Plan (Baer et al., 2021). Besides the overall importance of capacity-building in innovation processes that aim to be transformative, a specific kind of capacity-building is of vital importance for the implementation of second-order learning processes. This will be discussed in more detail in the following.

According to Baer et al. (2021), capacity-building can take a range of forms, including professional capacity building and community capacity building, e.g., through intra-project exchanges, and higher education. It may be directed towards either a limited number of stakeholders, e.g., users, or a broad variety of stakeholders, including grid operators, building owners, policy-makers, users, investors, developers, and municipalities (Baer et al., 2021). In the literature on education, capacity-building has been interpreted mainly along two lines, one referring to the so-called "readiness" for change (Harris, 2011, p. 627), the other referring to learning and associated concepts such as "learning communities" for profound societal shifts (Mitchell & Sackney, 2011). This term, emerging from education science, we borrow to refer to constellations of actors that – when in structured interaction with each other – have the potential to generate second-order learnings. Related concepts are "communities of practice" and "situated learning" (Wenger, 2003). Such communities can allow for the transfer of (tacit) knowledge, which "cannot be captured easily in language and symbols and instead requires "practising together" (Quist & Tukker, 2013, p. 170). Through "mutual engagement" a "shared repertoire" of knowledge can be developed (Wenger, 2003). Capacity-building is, however, not merely limited to the generation of theoretical and practical knowledge, but also the generation of motivation for change (Fullan, 2010). Capacity-building is, further, collaborative in that it relies on "collective responsibility where professionals are working together to improve practice through mutual support, mutual accountability and mutual challenge" (Harris, 2011, p. 627). Central to capacity-building for change appear to be "engagement and commitment", processes of a collective nature, "[a]ligned, coherent and supportive system policies and practices", and resources (ibid., p. 628). Community capacity building, emerging from the health literature but transferrable to other contexts, has been described as not only the "development of sustainable skills [and] resources", but also as structures enabling such learning processes (Clinical and Translational Science Awards Consortium 2011). This argument relates to capacity-building being "both a determinant of sustainability and an outcome of it" (Hacker et al., 2012).

The concept of capacity-building has also been filled with meaning in the context of urban transformation (Meyer et al., 2021), and strongly relates to the notion of urban transformative capacity (UTC) (as introduced above). Wolfram (2016, pp. 127–128) introduces 10 key components of UTC, sorted into 3 categories, including a) relational dimensions (reflexivity and social learning, working across agency levels, working across political-administrative levels and geographical scales), b) core development processes (system(s) awareness and memory, urban sustainability and foresight, community-based experimentation with disruptive solutions, innovation embedding and coupling), and c) agency and interaction forms (inclusive and multiform urban governance, transformative leadership and empowered and autonomous communities of practice. Based on their multiple case study focusing on Europe and China, Meyer et al. (2021) find elements of UTC building assessed based on Wolfram's (2016) framework: among others, Stockholm has put measures in place "that support and sustain different transformative capacity domains across the entire policy cycle", in particular, the co-creation of a shared vision for Stockholm with a plurality of stakeholders that serves as a frame of reference for urban development (Meyer et al., 2021, p. 238).

Targets emerging from this cross-departmental collaboration within the city administration and with partners in the private sector were translated into legally binding objectives, e.g., through the inclusion in city planning documents and requirements for land allocation (ibid., pp. 238f). Reports by the Stockholm Development Administration focussing on developers' contributions to the achievement of the city's sustainability objectives, feedback to property developers, and the dissemination of monitoring results are considered core elements of learning for the City of Stockholm (ibid.). Capacity-building in the context of urban development may also include training for municipalities, the experimentation with alternative forms of governance and the exploration of novel funding options, such as the exchange of property between public and private owners (Meyer et al., 2021, 240f).

According to Ziervogel et al. (2016, p. 7) essential for the "cultivation" of urban transformative capacity are the following elements: "(1) an awareness of and a re-connection to life support systems; (2) a well-developed sense of agency; and (3) social cohesion". The first point refers to bringing to the surface human-made systems and "their dependencies [on] as well as the damage caused to both ecosystem function and human [...] equality" (ibid., p. 8 with a reference to Folke & Gunderson, 2012). As regards the second point, the authors foreground agency as a precondition for creative innovation (Ziervogel et al., 2016, p. 9). Touching on the social fragmentation occurring in urban contexts, the third point refers to "human communion at all scales: bonds, community ties, wider social networks", which according to the authors contribute to the strengthening of resilience (ibid.). Second-order learning will likely benefit from already cultivated dimensions of urban transformative capacity, e.g., through the provision of resources, competences and other prerequisites for substantive reflection. In turn, practised and reflected learning processes help to increase transformative capacity.
Two aspects that may require further elaboration but are beyond the scope of this report are potential different capacity requirements for different stakeholders, including "insiders" and "outsiders", as well as connected structural requirements that may enable and facilitate capacity-building continuously to ensure long-term resources for an urban energy transition are established.

4.5. THE ROLE OF TIMING (WHEN AND HOW OFTEN?)

Moments of reflection in the PED development process ought to be well-timed to be meaningful. In PED projects there will be "logical" moments in time, or so-called "windows of opportunity" when e.g., decisions are being made that lend themselves to larger reflection processes. Similarly, moments of (external) evaluation such as applying for certification or the like may provide moments in time that bring knowledge to the surface that was only implicitly present in the day-to-day life of planning and decision-making, or perhaps, only known to some actors. These two moments were identified in the context of a TRANS-PED workshop (PED Lab Sweden in Helsingborg, May 2022) along with several other moments that will be elaborated on in the following.

PEDs that have been set up as testbeds, and are thus conceived of as experiments may be more likely to have put structures in place that allow for regular reflection. A prime example of this are energy meetings taking place every quarter year in Hammarby Sjöstad. Similarly, in Hammarby Sjöstad meetings with local energy managers, residents and researchers serve as moments to reflect, potentially resulting in the reorientation of energy-related decisions (c.f., Interview 3 TRANS-PED). Similarly, the launch of an innovation that monitors energy usage and supply, such as an app that traces emissions, may serve as a moment of reflection. In PEDs that have not been set up as testbeds primarily, moments of reflection may occur when problems arise, e.g., when some members of the innovation community realise that a decision made has turned out to be problematic, or important elements have been overlooked in the planning process, such as the omission of access for ambulance vehicles to a new neighbourhood as has been mentioned as a challenge in Lund. Finally, certification procedures and environmental impact assessments have been mentioned as moments in time that spur reflection, perhaps due to the realisation that the project may be less ambitious than intended once it does not qualify for certification, or pass an impact assessment well (workshop at the PED-Lab Sweden in Helsingborg, May 2022). At times, meetings initiated by local authorities, such as city district management, etc., can serve as spaces for reflection by bringing to the surface different solutions to a problem as well as by bringing to the table a range of perspectives, including the so-called "enactors" and "selectors" (Rip & te Kulve, 2008), or "insiders" and "outsiders".

The workshop held in the context of TRANS-PED in Helsingborg (May 2022) also revealed "desirable" moments in time for reflection; in particular, it was mentioned that external interventions can be useful when a project greatly deviates from the original objectives, especially by city authorities, such as in the case of Hammarby 1.0 (Rutherford, 2020). Further, participants highlighted that in-depth reflection processes should occur before large decisions with long-lasting implications are made such as the continuation or creation of path dependencies. This would have been desirable, for example, in the case of Graz Reininghaus before the decision was made to link its energy supply to the waste heat of the steel mill Marienhütte.

To conclude, second-order learning is not intended to be practised throughout all phases of a PED-making process, but rather at specifically selected moments in time that lend themselves specifically well to reflexivity. These moments may emerge out of a situation, but can also be specifically cultivated by generating fora that allow a learning community to form and collectively reflect on decisions, alternatives, and mistakes.

4.6. METHODS FOR SECOND-ORDER LEARNING

Overall, it appears to be the case that only a few methods have been developed specifically for second-order learning, or that are explicitly referred to as methods for second-order learning.

In their *Practical guide for trainers and facilitators*, Gordijn et al. (2018) suggest different methods for what they refer to as "reflective learning" and what we treat synonymously with second-order learning, some of which have been extracted and interpreted for the PED context below. The authors define reflective learning as a sensemaking process that involves "consciously thinking about and analysing a new experience", and thereby relating an experience to existing knowledge and previous experiences (ibid., p. 12).

Hence, it is essential for participants and facilitators engaging in reflective learning processes to become aware of and to explicitly voice their intentions, underlying motivations and objectives. Related, since decision-making in PED contexts is a complex process that usually goes beyond an individual decision-maker, but rather represents a compilation of interests that ought to be balanced, it may be useful to reflect either before decisions are made or in retrospect on the role of each of the elements listed in the following graph:

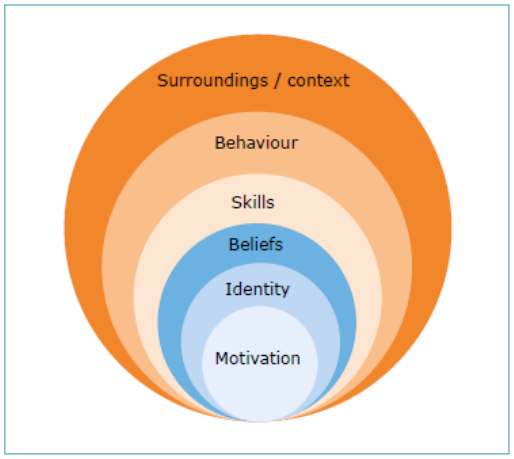

Image 1: Bateson's (n/a) framework of logical levels, retrieved from Gordijn et al. (2018, p. 74)

This may include reflections on, e.g., whether decisions were made because of an underlying motivation that was not transparent, e.g., political or economic motivations. It allows for reflecting on which role identity (c.f. above) might have played in a decision-making process, e.g., was a decision mainly made because it seemed to fit a local context/was aligned with other local intentions, or seemed unique and contributed to a specific representation of a place to produce a coherent narrative? Which beliefs underlay decision-making, and which beliefs remained untranslated into actuality? These might relate to very concrete questions such as the promised efficiency improvement that however might have been outbalanced by a rebound effect. Similarly, the decision for one technological alternative vis-à-vis another might be largely based on the skills available locally; questions of external help and guidance come in here. Behaviour relates to questions of practice, and ways of organising/doing.

Hence, it may be useful to pose the question of whether planning a PED may require behaviour changes with public and private actors, and to what degree the lack of changed practices may result in undesirable results (or reinforce unsustainable pathways). The context can be understood both in geographical terms, but also in political, material, cultural, economic terms, etc. The contextual dimension might be the most difficult to grasp/most abstract dimension to reflect on due to the high level of complexity, uncertain system dynamics and emergent features.

A different method suggested is "reflection with symbols", which allows for the creation of a deck of cards reflecting certain aspects and areas that ought to be covered in an exchange, and lends itself to intuitive quick responses. While this may appear to stand in contrast to deep reflection, the authors of the *Practical guide for trainers and facilitators* consider this as a tool supporting reflective learning (Gordijn et al., 2018). In a PED context, symbols developed could reflect guiding questions related to risks, uncertainties, positive side-effects, negative side-effects, path dependencies, etc.

Overall, it is useful to become aware of the different types of questions that might be posed in an exercise that is aimed to provoke reflective learning. According to Gordijn et al. (2018), questions may pertain to thinking, feeling, double-loop learning or systemic considerations. Below a few examples are listed for each category, inspired by (Gordijn et al., 2018, p. 29) and adapted for the PED context.

FEELING	THINKING
– How has the experience of being part of the PED development/project team or: of being a PED inhabitant affected you? – Which events happened during the PED development process that made you feel inspired/frustrated/satisfied/dissatisfied, and why was this the case? – Do you feel comfortable about the processes (decision-making etc.) that are part of the PED development?	– Which underlying assumptions did you bring (or: were brought by others) into the decision-making process when choosing one technological option over another? – What did it mean for the project that you decided to…? – What does it mean to you that the chosen solution has some potential long-term side effects?
DOUBLE-LOOP LEARNING	**SYSTEMIC QUESTIONS**
– Are you using the right strategy to achieve the overall aim of becoming a PED? – Were there any things that weren't talked about/left out of the conversation when deciding on the chosen technology? – Are there other ways to look at the problem you are encountering, other than fixing the bug? – Which elements of becoming a PED are/were the most challenging, and what does that reveal about the project team and context?	– When did this first turn out to be a problem throughout the PED development? – To what degree is there agreement that this is a key problem? Who agrees? – How does this problem fit together with the values of the PED practitioner community? – Should there have been any additional people involved in decision-making that were not? – What stood in the way of choosing the alternative option? – What are the gains/losses of deciding for/against…?

Table 2: Questions supporting second-order learning in the PED context

4.6.1. CORE METHODOLOGICAL RECOMMENDATIONS FOR SECOND-ORDER LEARNING PROCESSES

Based on our experience, second-order learning settings that ideally involve a range of different stakeholders, and thus conceptualizations of the world, epistemologies and vocabularies, require certain methodological care. The following considerations represent a mix of methodological insights from the literature, other PED projects and knowledge gathered within the bounds of the TRANS-PED project, which may help "learning intermediaries"[7] (or other agents) in the process of implementing second-order learning processes.

To begin with, due to the diverging interests brought to the table by different stakeholders, according to the Södertörn model (KTH, n/a), it is essential that a "win-win mindset" is cultivated among participating actors, which may relate to a "common vision" of the exercise or beyond (Larsson Kolessar, p. 7). This is in line with findings and recommendations from TRANS-PED as reflected in the *Participatory Action Research: 10 Key Principles* deliverable that refers to the possibility of mutual learning, and the creation of "strategic alliances" and "synergies" (Confluences & Vrije Universiteit Brussel, 2022). In the case of PEDs, such a vision could be the generation of learnings that can be passed on to other PED practitioners, which should overall result in the improvement of PEDs and the avoidance of mistakes with irreversible negative consequences. In the best case, this can result in a situation in which the agendas of different stakeholders are meaningfully combined. In addition, minimizing power imbalances (and related epistemic inequalities) should be a core criterion for second-order learning processes (Confluences & Vrije Universiteit Brussel, 2022).

When involving different stakeholders in an exchange process, it is important to consider carefully which roles to assign to them. In the context of the workshop, we conducted as part of the PED-Lab Austria, we assigned the roles of "insiders" and "outsiders" (analogue to "enactors" and "selectors" to the participants in an exercise that was intended to generate second-order learnings. While in principle the participants could identify well with the roles assigned – primarily due to the clear definition of the exercise in advance – some suggested that alternative framings, e.g., "critical friend" or "informed, constructive critic" would have been more desirable than "outsiders". Similarly, some "insiders" felt pressured into a position of "expertise" although they merely wanted to share their experiences. We attempted at minimizing power imbalances TRANS-PED by letting researchers not automatically adopt the role of critical outsiders in all cases, but to ensure that practitioners (who predominantly took the role of insiders) switch roles (to an outsider) in the second round. There, however, would be room for improvement to ensure power is more evenly distributed across participants. In addition, we assigned a comparatively passive role to most researchers, i.e., the role of a note-taker to ensure a less content-shaping contribution on their part. While the feedback we received on our workshop suggests that people largely felt comfortable with speaking up, we cannot comment on the implicit power dynamics and would like to highlight the importance of considering differences in gender, cultural, educational, etc. differences in the perception of legitimacy to take up speaking time. This goes hand in hand with a recommendation by (Gordijn et al., 2018, p. 32) which stresses that cultural differences may render it easier or more difficult for people to reflect, also influenced by the educational system, the level of culturally legitimized expressiveness and the political landscape (level of public authority) in the country that the participants became accustomed to. A learning that emerges, therefore, is to carefully think about how to officially name the roles in a given reflection exercise, e.g., "insiders" may experience less pressure in their role if referred to as "persons with experiences in PED x". Other possible names for the insider role include (Larsson Kolessar, p. 15) "core team", "involved" and "informed" participants. In a project consortium, one can assume that all participants, independently of their affiliation or background, have gathered some prior knowledge on the case studies that are part of the project.

7 "Learning intermediary" is a concept connected to the facilitator role in learning processes that is currently developed by Andrew Karvonen et al. as part of the TRANS-LEARN project and is based on the notion of "intermediaries" in sustainability transitions as described by e.g., Kanda et al. (2020) and Kivimaa et al. (2019).

We were initially concerned that the naming of "insiders" vs. "outsiders" could result in the adoption of a defensive reasoning mindset on the side of the "insiders"; instead, however, due to the familiarity across the consortium (the workshop was conducted in month 19 of the TRANS-PED project) and the small workshop groups, participants reported that a sense of trust had been established that allowed for open exchange, thus giving rise to some novel, sometimes unexpected realisations.

In our workshop, we aimed to prepare participants in a way that they would speak frankly about challenges, missed opportunities, and avoidable mistakes and recommendations regarding decisions made in PED development, thereby aiming for the generation of both socially and scientifically relevant knowledge. We also encouraged outsiders to pose the question of what kind of further research is needed in a specific PED context, and which options need to be further explored from a practical perspective. Finally, as recommended in the TRANS-PED Co-Production Toolbox, we encouraged dissent and disagreement in a respectful, constructive way, allowing for the consideration of alternative pathways than the solution a PED project ended up choosing. We thereby aimed to "offer spaces where different perspectives and interests can be confronted with each other" (Confluences & Vrije Universiteit Brussel, 2022).

In addition, we realized that one challenge that remains is building a common vocabulary in collective reflection settings for socially and technologically more complex questions/discussions. To ensure some common ground, it would have been helpful to provide "outsiders" with some basic knowledge and prepare vocabulary about the technical cases they are discussing, or alternatively, find mechanisms to ensure that participants feel comfortable with asking clarification questions on terminology and concepts that are beyond their realm of knowledge.

To conclude, our enquiry into methods for second-order learning has shown that there are still numerous gaps. Although it is often emphasized that in-depth reflection is of great importance, and reflexivity as a normative goal ought to be enhanced in innovation processes, specific methods for this purpose can be barely found. In the TRANS-PED project, this has led to the development of a specific methodological design (structured insider-outsider conversation). However, this lack of concrete methods can certainly be compensated by more general methodological rules and epistemological considerations. If it is clear what second-order learning means, (all) relevant actors are involved, appropriate questions are discussed and the results are documented, reflective learning can take place even without a dedicated method.

In other words, familiarity with the concept, and an awareness of the relevance of second-order learning may be more central than a sophisticated methodological design.

4.7. APPROACHES TOWARDS INSTITUTIONALISING SECOND-ORDER LEARNING

We have extensively written on the role of identity as a hindrance to second-order learning. Yet, another hindrance may be the tendency for funding bodies and research programmes to prioritise positive results and thus foster self-presentation, rather than self-reflection. That positive outcomes are favoured over failed attempts reflects a culture of impact and efficiency-oriented policy-science interfaces and the connected commercialisation of research and developments towards result-oriented research management (M. Gibbons et al., 1994; Nowotny et al., 2003). Yet, in particular, in connection with the development of innovations for PEDs, and other energy-related novelties for an urban transformation, it could be particularly useful to draw attention to failed attempts, arising problems, and unfulfilled intentions, and to analyse their underlying reasons, and avoid a replication thereof. Consequently, it may be advisable for funding bodies to set up research programmes in a manner that a) provides specific funding for reflective activities as part of a research project, as well as for the dissemination of emerged learnings to render the uncomfortable work of critical self-reflection an integral part of any research endeavour; and to b) provide resources for the inclusion of critical outsiders in a project.

In their publication *Reflexive Monitoring in Action*: *A guide for monitoring system innovation projects*, van Mierlo et al. (2010) suggest the assignment of a particular role to a project, i.e., that of a monitor to projects that aim at systemic change who can decide to set interventions that aim at "support[ing] the system innovation ambitions" as announced in the project proposal, and holding project members accountable if the project falls short of them (ibid., p. 15). A monitor is a person with a "constructive and exploratory mindset", an "involved outsider" who critically accompanies a project and provides "norms and structures" that also help "tackle system barriers" (ibid., pp. 21-22). The moment in which the monitor becomes active represents "at the same time an intervention to encourage reflection and learning aimed at system innovation" (ibid.). Interventions may either occur as a result of the monitor's initiative, or, upon request from the project members, and thus the monitor is not merely observant, but actively facilitating the innovation process and "encourage[ing] participants to reflect upon the relationships between the project and its context, between project activities, and between short-term objectives and long-term ambitious […] [thereby] let[ting] them break away from old patterns of thinking and acting" (ibid.: 16). Part of their *Reflexive Monitoring in Action* (RMA) approach is the purposeful intervention in cases in which milestones, lessons learnt, and failures remain unrecorded. Thus, the monitor also holds responsibility for the documentation of lessons learnt and further enables "the project to be anchored in the wider network and its context" (ibid., p. 18). van Mierlo et al. (2010) developed an RMA cycle, which relies on observation, analysis, reflection, and adjusting project activities (ibid., p. 19). If additional funding was provided institutionally for a monitor, and/or the role of a monitor became an official requirement to receive funding for an innovation project, reflection and the documentation of learning processes could be ensured.

In addition, evaluation schemes of research programmes and projects could be adapted to foster learning. Regeer et al. (2016) argue that while both accountability and learning should be part of the evaluation of research programmes and projects, it is not a given that learnings are equally well considered. In the worst case, evaluations that are focused on learning are rejected by funding bodies (ibid., p. 7). This may lead to a situation in which project members' expectations regarding evaluation centre around "presenting discrete results and clear recommendations" instead of focussing on "in-depth reporting on learning experiences, failures, [and] mistakes". (ibid.). Accountability is often linked to reporting activities with a strict set of requirements, and is thus often inherently goal-oriented (ibid., pp. 8f). By splitting the notion of accountability into three dimensions, i.e., upwards accountability (to funders), downwards accountability (those affected by research/innovation), and internal accountability (to the initiative or organisation leading research/innovation), and thereby foregrounding that goal-oriented evaluation can only be but one dimension of the project evaluation (Regeer et al., 2016, p. 13), traditional reporting appears in a different light. Thus, it is of central importance that learning becomes a core aspect of evaluation for funding bodies, in order not to lose valuable knowledge (about gaps, further requirements, failed attempts) that can be passed on to connected projects, and may in return inform the funding body about needs and challenges in a specific research community.

5. CONCLUSION

As described, when discussing innovation for urban sustainability transitions such as PEDs, it is of utmost importance to approach these in a socially and ecologically responsible manner, which entails reflection. Learning, and particularly second-order or reflective learning, is an essential component and precondition for meaningfully moving further towards a responsible energy transformation, in that it poses the critical question of whether chosen solutions to address the climate and energy crisis are truly socially and ecologically viable, or merely apparent solutions with unsustainable path-dependencies and unintended side-effects that stand in contrast to transformative intentions.

Responsible innovation within PEDs does not only require structures and processes within PED initiatives but is particularly dependent on networking, mutual learning and the joint consolidation of knowledge about risks and impacts. The growing community of PED practitioners in Europe provides an excellent basis to advance the PED concept and to test and evaluate promising socio-technical solutions. Intensive exchange of knowledge, also and in particular about findings from second-order learning processes, offers an essential point of departure for the further improvement of PEDs. This allows potential risks and unintended side-effects to be identified at an early stage and positive and negative implications to be better anticipated and assessed. Similarly, the notion of PEDs themselves can be negotiated by tapping into co-creative processes that allow for different stakeholders to voice their needs as part of reflection processes.

In the report at hand, we discussed the notion of RRI, which in the EU setting has served as a visionary umbrella under which the importance of responsibility in the form of inclusion and reflexivity has been put in the spotlight of several EU research projects. We also engaged with the limitations of the concept – particularly concerning its practical applicability, and neoliberal, Western conceptualisations of innovation.

As a response, we turned towards "moments of reflection" as a low-key, less conceptually charged means to introduce reflection and generate second-order learnings in PED-making processes. The role of second-order learning was elaborated on in greater detail and it was juxtaposed with first-order learning, towards which we currently see a bias in PED developments. Without wanting to deny the great relevance of first-order assessments, we highlighted the centrality of second-order considerations in order to address unintended social-ecological side effects, path-dependencies, risks and other long-term consequences that may unintentionally result from PED development.

We also found that while the methods for second-order learning appear rather underdeveloped, a specific constellation of stakeholders, involving insiders open to reflection as well as critical outsiders can give rise to second-order learning experiences.

These findings have led us to the following recommendations: When it comes to funding bodies, we would like to foreground to prioritise projects that explicitly engage with responsible innovation and second-order learning. Reflection processes giving rise to learnings that can be shared beyond a project should play a more vital (and potentially conditional) role in funding allocation in the coming years. Critical reflection and second-order learning need additional expertise and research time, and hence require precise identification of roles and additional resources that can allow for capacity-building. Related infrastructures such as online platforms where learnings generated in PED developments can be exchanged could play an additional role. In fact, reflective knowledge that was developed locally ought to be disseminated and made available to the PED community (and city planners). This could be realised, for example, in the setting of conferences and workshops that centrally focus on social-ecological risks and side effects connected to the urban energy transition. Another way to intensify the exchange on reflective knowledge is to include relevant categories such as "Lessons Learnt" in PED databases. In addition to categories such as "success factors" or "barriers", insights from second-order learning processes, for example about path dependencies or social-ecological side-effects, should also be included.

To generate urban transformative capacity and to reduce the risk of innovations further contributing to the intensification of the multiple social-ecological crises, it is of utmost importance that PED innovation processes are accompanied by procedures that meaningfully generate, exchange and spread learnings gained through reflection with relevant stakeholders.

More information on Responsible Innovation

For more information on this topic, see the reports on the Trans-PED website.

All about the Trans-PED project

Check out the Trans-PED website for details on the project, the international consortium of partners, as well as the participating PEDs.

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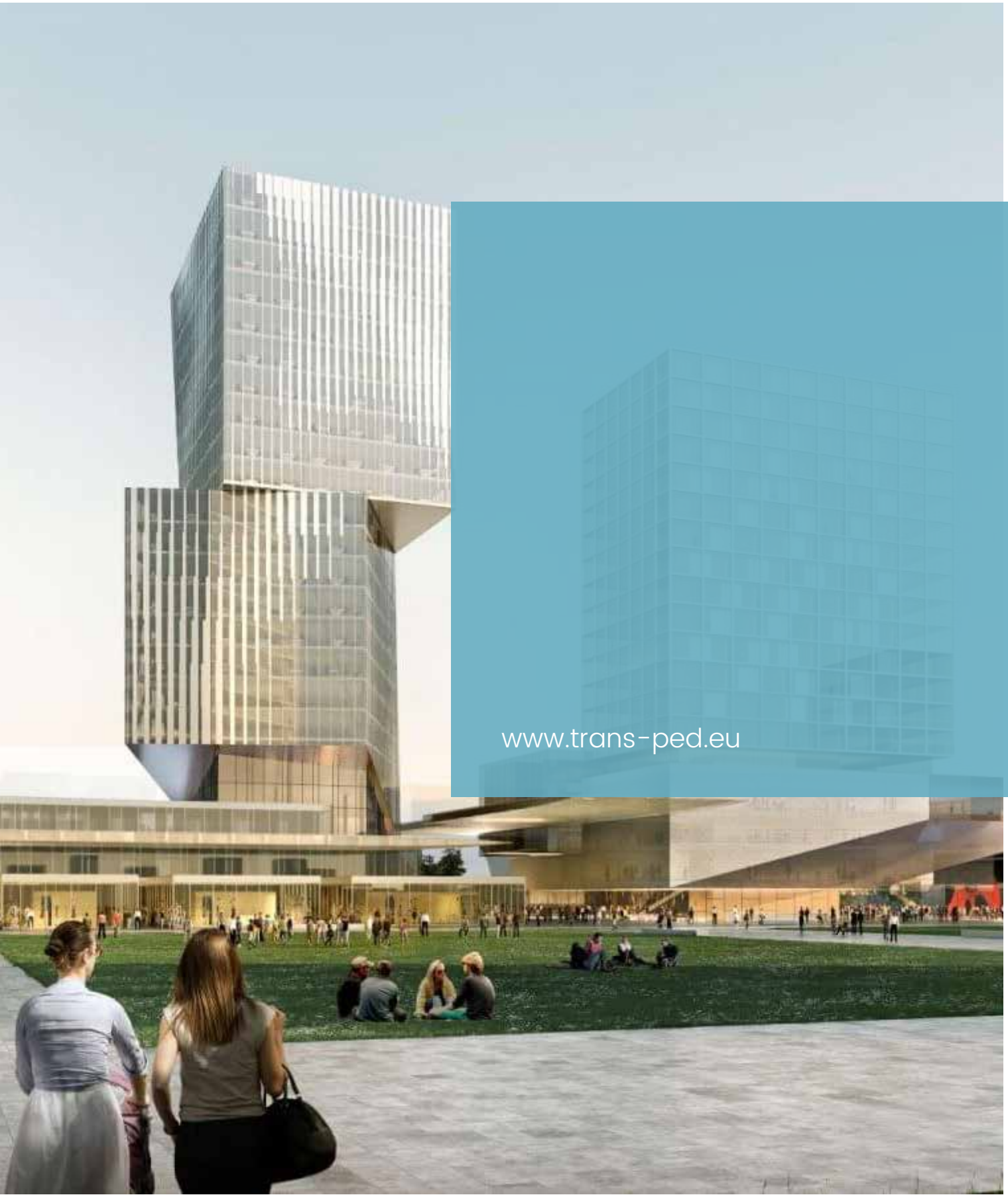

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