Social Tipping Processes in the Transformation of Civitavecchia's Socio-energy System

Daniel Delatin Rodrigues and Marco Grasso

Abstract The chapter introduces the notion of 'social tipping processes', an interdisciplinary framework for the analysis of complex transformation processes which helps to identify the sequence of, broadly understood, socio-political events that can trigger positive or negative dynamics of transformations of current social-ecological systems. Social tipping processes are first framed and delineated, then this category is applied to a spatially and temporally delimited empirical case, the long-standing Italian energy city of Civitavecchia—near Rome—to investigate the transformation to renewables of the local socio-energy systems as a dynamic and relational process. The chapter concludes by outlining the main paths forward for a sustainable future, as advocated by the social tipping processes perspective put into action in the case under scrutiny.

Keywords Agents of transformation · Destabilisation · Disruption · Fossil machine · Social tipping processes · Socio-energy systems · Transformation

1 Introduction

Since the post-war 'Great Acceleration', the consumption of natural resources, land use changes (with a vertiginous growth in deforestation rates), greenhouse gas emissions, and the world's population have produced disastrous consequences for our planet (McNeill & Engelke, 2016). These changes are directly associated with the expansion of urban infrastructure, the construction of dams, the increase in transport of people and goods, telecommunications, the use of fertilizers for agriculture, and mostly by the consolidation of socio-productive models and lifestyles intensively dependent on the use of fossil fuels (Steffen et al., 2015). The planet's temperature has skyrocketed (Bova et al., 2021; Kaufman et al., 2020), causing a

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sharp increase in the frequency and intensity of extreme weather events. The crossing of safe boundaries (climate change being one of them, the others linked to ocean acidification, stratospheric ozone depletion, freshwater use, biodiversity loss, interference with global nitrogen and phosphorus cycles, land use change, atmospheric aerosol rates) signals a path toward existential conditions hitherto unknown (Rockstrom et al., 2009). The repercussions are devastating, both concerning the conditions of ecological and climatic stability required by the multiplicity of Earth's living forms, and with respect to the ability of current sociocultural and political systems to respond to these events in ways that ensure the continuity of such systems.

Unfortunately, current attempts to transform global socioeconomic systems are inadequate to address the impending ecological and climatic crises (IPCC, 2021; IISD, 2022). This situation illustrates a political and analytical chasm between the seriousness of the events and the responses given so far in terms of effective commitment to changing the current non-sustainable socio-economic model.

To avoid, or at least mitigate, the effects of the global ecological crisis, humanity should pursue a socio-economic future different from today's dependence on fossil fuels and the current radical extractivist approach (Chagnon et al., 2022; UNEP, 2022). The enormity of this task requires considering the processes of sustainable transformations of societies from within the existing socio-technical, political, ecological, and climatic entanglements. This implies admitting that no general model can guide these transformations. The compounding climate and ecological crises indicate that human activities and ecological systems are in continuous coevolution through complex and interdependent feedback dynamics (Mathias et al., 2020), and this marks a breaking point in different disciplinary domains that until recently sought to understand social and climate and ecological dimensions in an isolated and autonomous manner (Orr et al., 2015). Moreover, the nonlinear processes that characterize both social and ecological dynamics reduce the possibility of identifying management strategies that maintain or restore the sustainability of social-ecological systems and that can guide a way out of this catastrophic path.

Caution is required, however. And it is with caution and a sense of exploration that this chapter develops the notion of 'social tipping processes' and applies it to a spatially and temporally delimited empirical case. This category derives from the notion of tipping points, i.e. a small perturbation can be enough to irreversibly push a system into a qualitatively different mode of operation due to strongly self-amplifying feedback (Lenton et al., 2008).

Social tipping processes, as an interdisciplinary framework for the analysis of complex transformation processes, help to identify the sequence of, broadly understood, socio-political events that can trigger positive or negative dynamics of transformations of current social-ecological systems. Destabilization and disruption will be considered here as mechanisms that can trigger these processes. Today, it is uncontroversially accepted that to avoid dangerous biophysical tipping points, it is necessary to trigger substantial changes (Otto et al., 2020; Hinkel et al., 2020; Lenton et al., 2019) or activate "sensitive intervention points" (Farmer et al., 2019) that could move the current socio-economic system in a new direction.

The category of social tipping processes will be used in the case study of Civitavecchia—the long-standing 'fossil energy' city close to Rome—where different agents concurred to obstruct and eventually to terminate the planned fossil-to-fossil conversion of a coal plant to natural gas in favour of a renewable future. In our analysis, social tipping processes are triggered by multiple heterogenous agents and practices in different scales and temporalities.

The notion of process, however, requires the identification of the agents and practices of destabilisation and rupture, as well as the events that marked changes in the trajectory towards the transformation of socio-energy systems (SEnS), defined here as "the technical, political, social, and economic arrangements and assemblages of people, institutions, organisations, technologies, and machineries in which the forms of production, distribution, and consumption of energy, their supply chains, and their lifecycles are organised" (Grasso & Delatin Rodrigues, 2022, 2). This chapter first frames social tipping processes, then introduces the categories of destabilisation and disruption as elementary mechanisms through which social tipping processes can be triggered, and finally presents the case of the transformation of Civitavecchia's SEnS through the categories given above. In this chapter we present a dynamic and relational process of effective transformation of fossil socio-energy systems.

2   Social Tipping Processes

Sustainability transformations involve, among other objectives, a structural evolution towards a low-carbon world with yet unknown socioeconomic, cultural, and political implications. Thus, they require a profound change in attitudes, behaviours, values, norms, incentives, and policies (Tàbara et al., 2019; Fazey et al., 2020), where the roles, actions, and interactions of multiple actors are critical to overcome resistance and force and/or guide the incumbent regime to move toward a low-carbon future (Geels et al., 2017; Skjærseth et al., 2021).

Practices of destabilization and disruption, analysed in the following section, aim to create moral values that denaturalise the use of fossil fuels from sustainability transformations that can be triggered. These practices should be understood as mechanisms to promote social tipping processes to fill a gap between climatic and ecological change and socio-political processes. Considering these interactive processes, each one with its specificity, as units of analysis has been recurrent in the history of the social and natural sciences (Stengers, 2010, 2011). However, as noted by Milkoreit et al., (2018: 2), "It remains unknown whether tipping points in natural systems, such as a lake or the climate, display the same underlying mechanisms as tipping points in social systems, such as in financial markets or political institutions." It becomes then necessary to recognise that the methodological and analytical procedures used for scientific research in the two systems are different and belong to different ontologies: the prospect of their unification should be considered with caution and involves much more transdisciplinary effort.

The cross-cutting promise of the category of social tipping processes invites researchers to pay particular attention to the unit of analysis. It is an invitation to improve the empirical tools available to allow—even partially—to follow this socio-ecological entanglement as a process and to understand how to promote transformative actions. A further issue is that of temporality, which in the social sciences explicitly calls for the historicity proper to a trajectory considered in its specificity.

To be useful, the category of social tipping processes requires detailed descriptions of the types of trajectories undertaken over time; it also implies making explicit the socio-ecological environment in which destabilisation and disruption practices will take place. Only in this way will it be possible to establish the conditions to generate effective transformations. By looking at the social tipping processes over a bounded period, we can identify how and in what ways initial disturbances in a given social-ecological system can create conditions for the bifurcation of the initial trajectory. Therefore, the question that arises is investigating how these conditions can be generated.

It is important to note that if social tipping processes suggest a symmetrical analysis of social and ecological systems, this implies extending the relational attribute of the existing against a static and overly functional notion of the individual or social institutions with precise boundaries and identities (Orr et al., 2015). If the ecological system is in constant process, the same should be considered of the social one—implying changing identities, values, and political systems: agents are co-produced through interactions, implying not just values but evaluation judgement and power relations (Flyvbjerg, 2001). How researchers will define the edges of entities is crucial to the outcomes that may emerge (Tàbara et al., 2022). The consideration, for instance, of the political and social stability of fossil fuel dependence as a relational effect allows to better explore practices of destabilisation and disruption from the point of view of the effects they generate and the agents that produce them.

To move toward a sustainable future, it is necessary to first destabilise and disrupt the—running at full speed, seemingly out of control—fossil machine (FM): this is a conceptual category inspired by its focus on the coalescence of vested interests to what the Italian Marxist philosopher Antonio Gramsci (1929) defined a 'transnational historical bloc'. The category of machine used here should not be understood only in its technical dimension. This is the most important lesson brought either by the philosophy of technology (Simondon, 1958; Deleuze & Guattari, 1987; Anders, 2007) or by the field of science and technology studies (Latour, 1996; Appel et al., 2015; Appel et al., 2018; Watts, 2019): it operates at the intersection between the biophysical, climatic, and ecological dimensions and the socio-technical and political dimensions. As noted by philosopher Felix Guattari:

> *Les machines ne sont pas des totalités refermées sur elles-mêmes. Elles entretiennent des rapports détermines avec une extériorité spatio-temporelle, ainsi qu'avec des univers de signes et des champs de virtualité. (*Guattari, 2018*: 500).*
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> *Il articule l'outil, la machine à son environnement social, humain, corporel, à la gestuelle machiniste et aux rapports culturels qui les supportent* (Guattari, 2018: 253).

It is therefore possible to consider the FM dynamically as a continuous process of assemblage (*agencement*) of the social environment to ensure its functional continuity over time and, in turn, to elucidate the variety of actions necessary to block or stop the extraction, circulation and combustion of fossil fuels and their products. The notion of the machine, moreover, points to a particular property of the social environment to which it is linked: that of widespread 'extractivism' as a means of sustaining relentless economic growth, which includes conditions for the machine's reproducibility and expansion. In the definition adopted here, the FM is usually set up, coordinated, and led by fossil-fuel companies and is composed of governments and policymakers at various levels, formal institutions, industry representatives, unions, other industries dependent on fossil fuels, the agricultural system, the financial system, managerial elites, the military, epistemic communities, PR companies, think tanks, pundits, advocacy groups, private foundations, religious institutions and communities. The ubiquity of the FM requires adequate knowledge about how and where to erode its power, which guarantees its resistance to change and the reproduction of its modes. The destabilisation and disruption of a FM are carried out by 'agents of transformation' (ATs), entities—individuals or groups, potentially every subject—that contribute to overcoming the FM's power and win its resistance against the limitation and/or termination of the current carbon-intensive model and to compelling or inducing it to adopt more sustainable behaviours. ATs are, therefore, 'political entrepreneurs' (Tilly, 2008) who seek to change politics through practices of destabilisation and disruption. ATs' actions, initiatives, behaviours, and provisions destabilise and disrupt the ambits and ramifications relevant to the FM to favour the achievement of a just and rapid decarbonisation of SEnS in the public interest.

The adopted approach argues that there are countless ways to generate this transformation: they will depend on ATs' capacity to enact practices that interfere with and/or block the FM. This chapter focuses on the case of Civitavecchia, the long-standing 'fossil energy' city close to Rome, Italy, where a planned coal-to-gas conversion of a fossil energy plant was recently abandoned. In particular, the chapter investigates the interactions between different ATs (individuals, groups, institutions), an FM, the local environment and global climate transformations from the category of social tipping processes. Civitavecchia is a point in the worldwide infrastructure of energy production and a source of carbon emissions that contribute to global climate change, but it is also a territory that hosts a FM whose singular historical trajectory, social composition, interests, and conflicts can usefully be considered through the perspective of social tipping processes.

3   Destabilisation and Disruption

The categories of destabilisation and disruption are useful analytical tools to identify ATs that can trigger social tipping processes. It is first necessary to clarify what the   practices—actions,   initiatives,   behaviours,   and   provisions—of

sustainability-oriented destabilisation and disruption are and, therefore, the difference between the two families of practices. To this end, a specification of ATs is necessary. They cannot be sorted out in terms of identity, but ATs should rather be categorized in terms of activity. Regarding the FM, a particular AT can be simultaneously involved in destabilisation in a context and/or point in time and engaged in disruption in another context and/or point in time. For instance, an environmental NGOs working on climate change may try to destabilise the oil industry through awareness-raising initiatives, but as a shareholder of an oil company, the same NGO, at the same or at a different point in time, can attempt to disrupt it through resolutions and other initiatives aimed at slowing down the company's FM. At the same time, identifying an AT, such as a social movement, cannot be considered in itself: an AT must be relationally situated among other ATs and practices. As we shall see in the case study, the effect on FM depends on the correlation of different ATs and practices in a given social environment. In this sense, considered as a rupture process, this perspective offers empirical description and analytical insight to investigate the points a FM addresses and its ramifications.

In light of these specifications, ATs, by and large, employ practices of destabilisation to break the consensus about the naturalized use of fossil fuels and to promote dissent against the fossil-centric model. Destabilisation engages the part of the social environment – including the communities not directly involved by the FM – and have the goal to foster and maintain social/moral norms and principles and good practices that, for instance, favour the acknowledgement of the harmfulness of fossil fuels, emphasise the harmful behaviour of the FM, discourage high-carbon lifestyles, support the rectification of the harm done, and, more generally, try to shape behaviours in favour of a less harmful low-carbon world also through the opposition to strategies and practices of climate denial, delay, disablement, and obstruction (Grasso 2022). In short, practices of destabilisation shape and steer individual and collective agents in different contexts and at different levels towards progressively less carbon-intensive behaviours. At the same time, ATs carry out in multiple contexts—not necessarily only proximate to the site of production of fossil fuels—disruption practices through existing institutional, political, and economic arrangements that directly target the FM to slow down/halt the reproduction of the fossil model and its overall functioning, fruition, and continuity. These practices consist, for instance, of lawsuits, legal and administrative provisions, divestment initiatives, shareholders resolutions, alternative options, alternative projects and plans. By subtracting modalities and space to the FM and its fossil reproduction, disruption can trigger social tipping process and open new opportunities to enact sustainable futures.

Destabilisation and disruption target the FM's discursive, institutional, and material power (Avelino & Rotmans, 2009) and its protective carbon lock-ins (Seto et al., 2016). ATs who operate destabilisation are called 'primary' and use practices that mostly erode the discursive power of the FM; practices of disruption are carried out by 'operational' ATs, by and large, target the institutional and material power of the FM: the latter practices are more feasible when destabilisation has raised the awareness of the urgency to phase out fossil fuels. Practices of destabilisation and

disruption occur along transformation axes, internally homogeneous societal ambits recurrent in the, so to speak, energy and social sciences literature (e.g. Köhler et al., 2019; Kivimaa et al., 2021; Grasso & Delatin Rodrigues, 2022). They are context-dependent but can generally be grouped according to the set of issues predominantly addressed: socioeconomic-technological, institutional-political, and educational-informational; those relevant to the Civitavecchia case study are reported in Table 1.

Besides the relationality between ATs and practices of destabilisation and disruption, the current perspective is inclusive: it covers all spheres penetrated by the FM—recurrent in the literature on transition and transformation (Köhler et al., 2019; Kivimaa et al., 2021) but also in that of social tipping points and processes (Stadelmann-Steffen et al., 2021). The generation of positive transformations towards sustainability cannot be done without promoting goals that redefine the social environment and without the material redefinition of the links that associate them.

4   Methods: The Case of Civitavecchia

The power plants in Civitavecchia were installed in the immediate post-war period. Work began in the summer of 1951 in Fiumaretta, where the first fossil–coal and then naphtha—plant remained in operation from 1953 to 1990.

Altogether, the power plants in Civitavecchia were part of a narrative about progress after the city was reduced to rubble in the second world war. By generating jobs and professional qualifications for young people, the National Electricity Board

Table 1 Destabilisation and disruption axes and examples of practices of destabilisation and disruption of the Civitavecchia's FM

Set of issues	Axis	Practice
Socioeconomic-technological	Social cohesion	Communitarian meetings, assemblies, and demonstrations
	Economy	Strikes
	Science and technology	Alternative low carbon projects
Institutional-political	Governance	Community/policy-makers joint initiatives
	Law	Legal appeals against the fossil industry
	Policy	Regulations and laws against fossil fuels
Educational-informational	Culture	Protest and dissent artworks
	Education and awareness	Civic science program in epidemiology
	Media and communication	Formation of counternarratives

Source: authors

(*Ente Nazionale per l'Energia Elettrica*—ENEL) could present itself as a promoter of local development. In 2019 the Italian Ministry of Economic Development published the national integrated energy climate plan (PNIEC—*Piano Nazionale Integrato per l'Energia e il Clima*). It stated that by 2025 all Italian coal-fired power stations should stop operating. Our research focuses on this crucial moment that triggered an intensely local and extra-local mobilization (Viale, 2021)—investigating it as a social tipping process makes it possible to identify important events and to correlate ATs, practices of destabilisation and disruption, and outcomes.

Between April and June 2022, a total of 8 non-structured interviews were carried out with the primary and operational ATs of Civitavecchia reported in Table 2, along with the axes of destabilisation and disruption they predominantly worked on and examples of types of the practices they carried out. In September 2022, two structured interviews were conducted with the two previously interviewed ATs with the deepest and most comprehensive knowledge of the issues at stake and the role of all the other ATs involved.

The first contestations against fossil energy production started in earnest in the 1980s. The first destabilisation practices demanded the right to health, a clean environment, and professional (non-fossil) alternatives for local workers. The long-running controversy divided the local community between "those who defended the environment and those who defended jobs". In the words of a member of the '*No al fossile*' group:

> "Until 2003, the year of the authorisation [to shift the energy production from oil to carbon], there was a strong tension in Civitavecchia that literally split parties, unions, associations, and even families. The mobilisation was very strong; the municipal council of Civitavecchia was occupied for several days. We also occupied the tracks and interrupted the Rome-Genoa-Ventimiglia railway line. The level of conflict was high, but we couldn't couple the struggle on environmental and public health with that for good employment. The historical context was different, and the immature technologies we had prevented the proposition of an alternative." (De Girolamo & Pezzopane, 2022).

This juxtaposition—between environment/health and economy/employment—was used to justify pro-fossil choices and ensured the support of part of citizens, unions, and political groups to fossil continuity at the expense of health and environmental concerns. The narrative of a conflict between environment and employment limited the horizon of action of the ATs preventing them from opening up to other problems and alliances. As an AT of the '*Forum Ambientalista*' group states: "ENEL has polluted not only the environment but also people's consciousness".

In 2019 ENEL presented its plan for converting to gas the existing coal plants 3 and installing new fossil plants in Civitavecchia. According to a '*No al fossile*' AT: "The switch from coal to gas would not guarantee the polluted territories employment, environmental protection, or public health".

During this period, with the decision to abandon coal and the proposal to switch to gas, ATs decided to engage directly in generating a socio-technical alternative to fossil production. "We started reading books on chemistry and physics and learning how an energy plant actually worked", one AT said. Instead of relegating this work to experts and professionals, the activists established alliances with them to keep

Table 2 Ts interviewed, axes of destabilisation and disruption, and types of destabilisation/disruption

ATs	Axes of destabilisation/disruption	Types of destabilisation/disruption
Città Futura (environmental group)	Social cohesion, Science and Technology, Culture, Education and awareness, Media and communication	Meetings; research; cultural events; educational events; information though social media and various other channels
Comitato Sole (environmental group)	Social cohesion, Science and Technology, Culture, Education and awareness, Media and communication	Meetings; research; cultural events; educational events; information though social media and various other channels
Confederazione Nazionale dell'Artigianato (the Civitavecchia chapter of the National Confederation of Crafts and Small and Medium-sized Enterprises)	Economy, Governance, Law, Policy	Lobby; participation in institutional and political processes;
Forum Ambientalista (environmental group)	Social cohesion, Science and Technology, Culture, Education and awareness, Media and communication	Meetings; cultural events; educational events; information though social media and various other channels; demonstrations; citizen science
Fridays for Future (social movement)	Social cohesion, Science and Technology, Culture, Education and awareness, Media and communication	Meetings; cultural events; educational events; information though social media and various other channels; demonstrations;
No al Fossile (social movement)	Social cohesion, Science and Technology, Culture, Education and awareness, Media and communication	Meetings; cultural events; educational events; information though social media and various other channels; demonstrations; protests
Technical committees (professionals, firms, and agencies to support the offshore wind farm and 'Porto Bene Comune' projects)	Social cohesion, Science and technology	Technical support to developing non fossil alternatives
Unione Sindacale di Base (labour union)	Social cohesion, Economy, Governance, Law, Policy	Participation in institutional and political processes; strikes; "state of agitation"

Source: authors

technical and social issues together. The alternative to fossil fuels was a set of projects based on renewable energy. Direct engagement in this process allowed the generation of other socio-technical imaginaries that included other agents, not just environmental groups. According to a USB unionist, this shift from protest to

project allowed "the deactivation of ENEL's narrative" based on the contraposition between environment and work.

The first alternative project proposed—the '*Porto Bene Comune*'—focused on the energy conversion of the port of Civitavecchia and was submitted to the Italian Ministry of Economic Development (*Ministero dello Sviluppo Economico*—MISE) within the EU-ERC Horizon 2020 call for proposals. Although it appears as a place of energy consumption rather than production, it was through the port that ATs began to elaborate socio-technical alternatives. The port was a laboratory that allowed them to take a step forward from protest to constructive proposals. The port project envisaged using green hydrogen to make this infrastructure the first zero-emission port in the Mediterranean. This project was considered fundamental since, according to an AT of the '*No al Fossile*' committee, it synthesised the local energy transition process.

The second alternative project was an offshore wind farm with a total capacity of 270 MW and an annual production potential of approximately 935 GWh. Its construction would have an employment impact in Civitavecchia of between 300 and 1000 units; the Italian Ministry for the Ecological Transition (currently named Ministry of the Environment and Energy Security) has started in June 2022 the environmental impact assessment (*Valutazione di Impatto Ambientale*—VIA) of this project. Altogether it is an inclusive and overarching project which pays particular attention to employment.

5   Results: Destabilisation, Disruption and Social Tipping Processes in Civitavecchia

The rejection of the fossil continuity, the construction of alliances, and the emergence of new collective subjects should be considered in a timeline where different ATs perform destabilisation and disruption synchronously and diachronically: it is from the material and immaterial 'disturbance' of a given social environment that possible alternative trajectories begin to emerge. However, as we will see, to generate social tipping processes, destabilisation and disruption practices must create socio-ecological conditions that can anchor hese trajectories in new stable conditions. These practices are not limited to the local dimension; international, national, or regional decisions can favour or obstruct the FM and transform SEnS. The approval of the national PNIEC, for example, setting a time limit to quit coal, created a possible bifurcation between fossil continuity and its abandonment: "The date is 31 December 2025, but the same document proposed a transition to gas or renewables. This quickly led the city to imagine itself differently." (De Girolamo & Pezzopane, 2022).

The importance of this event is fundamental but not enough to trigger generalisable transformation processes—as the experience of Civitavecchia shows. Citizens' committees, environmental movements, and professional organisations (such as

doctors and lawyers) became the most prominent ATs that opposed fossil fuel longevity. The environmental health concern is the concern that crossed the power plant's history, being redefined with each new piece of information and articulation. The formation of dissident, citizen-driven expertise made the consequences of continuous exposure to fossil fuel-generated pollution explicit. Studies carried out by popular epidemiology groups and citizens—a form of civic monitoring, understood here as a practice of destabilisation—showed the dramatic incidence of some forms of cancer directly linked to the activity of coal-fired power plants.

This favoured the dissemination of devices that allowed environmental control by citizens; these data became ingredients used in scientific journals, journalistic reports and/or in preparing manifestos and documents critical of the plant. These practices of making the environmental and health damage explicit have allowed the erosion of the consensus regarding the benefit of the coal-fired power station, as well as the legitimacy of its continuation—generating lawsuits for the adoption of pollutant control measures..

In short, they became ingredients that communicated directly with the experience of the subjects involved in a dramatic way in the local reality: several interviewees declared that no family in Civitavecchia had not suffered health issues or developed a disease due to the environmental degradation created by local combustion plants.

A second aspect to highlight is that of the media and communication axis. Once again, it seems necessary to precisely define what is communicated and how communication occurs. The messages, just like the practices producing them, change over time (Tilly, 2008), are enriched, receive new ingredients from the encounters and frictions generated in local and extra-local interaction (Tsing, 2005), and lose or gain relevance depending on the existing socio-technical conditions. The existence of technical solutions to produce renewable energy, for example, gave significance and credibility to the proposal: the social conditions of opposition to the local FM and social re-composition promoted by ATs could be anchored and articulated in the available technological solutions.

From the heterogeneity of subjects and practices and the socio-technical existence of an alternative, ATs structured a narrative that emphasised what they defined 'fossil slavery as the result of a series of decisions over time, which conditioned and limited the horizon of the political imagination of a life outside fossil fuel.

Discussions about the possibility of a switch to renewables in Civitavecchia gained momentum in 2019. However, with the Covid-19 health emergency, ATs had to develop alternatives to discuss the options publicly. In that period, face-to-face meetings were forbidden. The alignment of the local radio and television company TRC allowed ATs free access to the network's programming; several meetings and debates were held from more traditional information and entertainment devices—such as radio and television—widely used by the city's older population.

Processes under the 'Policy' axis—like those of communication—are complex, composed of varied dynamics and formulated from local and extra-local problematic aspects over a long period. During the coal conversion 2003, several ATs reported that this event caused irreversible political ruptures in existing groups and

organisations. Instead of a division between right and left, political forces were split between a 'coal party' and an 'anti-coal party', a name that was irrevocably modified when in 2019, the switch from coal to gas was decided. At this point, the alignment was redefined as the 'ENEL party', encompassing actors, organisations, parties, and institutions aligned to the company's industrial plan.

The votes against the conversion to gas of coal-fired power plants that took place in municipal and regional chambers set a limit to the FM's action (first Civitavecchia City Council resolution 130 of 24 October 2019 and the Lazio region's 2021 provision banning fossil production in the city), although positively received by local groups, was considered by some ATs as 'not enough'. Political forces organised and active in state institutions did not seem seriously committed to the sustainable transformation of the local energy production infrastructure and to building alternative socio-energetic pathways. This aspect invites us to be cautious about how policymakers are described and evaluated in these processes.

In the case of direct or indirect workers of the fossil industry, disruption practices happened along the axes 'Economy' and 'Governance' and were configured as a declaration of 'state of unrest' (*stato di agitazione*) or through strikes in the plants or in the supply chain linked to it. The installation of the power plant provided the local workforce with a horizon for training and professional occupation. The fundamental change occurred only when the consequences—in terms of occupation—of converting coal-fired power plants to gas became known simultaneously as the availability of alternative technologies and a strong social commitment to the transformation existed.

In relation to the 'Law' axis, while in 2003, groups that opposed the conversion of oil to coal filed an unsuccessful appeal in the courts to stop them, in 2019, ATs planned to resort to legal action if ENEL had continued with its initial coal to gas conversion project; the decision to abandon the project made it unnecessary.

ATs acted along the 'Social cohesion' axis from the available conflictual repertoires (Tilly, 2008), whether authorised or unauthorised, mostly through street demonstrations, occupations of public buildings, occupation and blocking of railways and highways, and hunger strikes. These destabilisation practices concurred with reconstructing the social context torn apart by decades of fossil continuity. Attacks and confrontations with public authorities and ENEL's leaders were also recurrent—such as throwing vegetables at ENEL's executives visiting the city. Along the 'culture' axis, ATs have endeavoured to create content—songs, banners, shows—affecting the public perception of the harmful aspects of fossil fuels and the territorial dependence on the energy monoculture that could destabilise the FM. Along the 'Governance' axis, the consensus that the future of the city's SEnS should be outside fossil fuels made it possible to initiate meetings between different parties to discuss models of governance of the new alternative projects. Political parties of different matrices, initially "functional in the maintenance of FM", argued an AT of '*Città Futura*', began to push territorial demands and perspectives at the institutional level. They constituted permanent negotiation spaces, effectively creating a political representation at the institutional level of the diffuse destabilisation and

disruption practices. Table 3 reports and categorizes some of the more remarkable among such practices within the axes outlined.

6   Discussion: Looking into Civitavecchia's Case: Lessons and Ways Forward for Sustainability Transformations

A first lesson we can draw from the Civitavecchia case is that transformations need multiple ATs working at different levels at different times, albeit on such a non-linear process. ATs repositioning, disruptive events—such as the pandemic and the Russian military aggression on Ukraine—can modify the pace, practices, and socio-political alignments. We find it difficult to provide other generalisations since the framework given by social tipping processes is context-dependent.

Table 3 Destabilisation and disruption practices in Civitavecchia

Axis	Destabilisation	Disruption
Social cohesion	Meetings, demonstrations, and protests at the local, regional, and national level	Job creation through alternative projects
Economy	Reports and initiatives to clarify the economic potential of renewable alternatives	Lobby by the business community against, and exit from, fossil fuels Strikes
Science and technology	Environmental and health monitoring Citizen science campaigns	Advancement of technical solutions for the alternative projects
Governance	Bottom-up initiatives and alliances that bonded the local community to political representatives at various levels, in particular the regional one	Permanent table for a low carbon future Strikes
Law	Pollution reporting to legal institutions Environmental rules and regulations (bottom-up proposals)	Lawsuits (projected, not implemented)
Policy	Occupations of city councils	Regulations and laws at the municipal and regional level
Culture	Tour of the power plants Songs Banners Online graphic	n.a.
Education and awareness	Awareness campaigns (e.g., on the possibility of overcoming of the job/health dichotomy) Self-education programs Popular epidemiology, physics, chemistry	n.a.
Media and communication	Narratives shaping Careful use of social media (Facebook, WhatsApp, Instagram)	Subtraction of narrative spaces for the reproduction of fossils

More broadly, with this framework, it is possible to dynamically define a set of conditions and constraints that favour or block social tipping processes; through this set, it is possible to identify the ATs and means used to disseminate new norms and values—here called destabilisation—as well as the practices necessary to initiate new trajectories—defined as disruption.

As the case of Civitavecchia clarifies, the different conditions imply specificities of axes, ATs, and practices of destabilisation and disruption, which, however, change over time. To analyse social tipping processes, it is, therefore, necessary to consider how dissemination occurs and what consequences it may generate. The instruments, targets, narratives, and counter-narratives must be made explicit to reveal how transformation processes can be framed and promoted and to evaluate how effective they can be in triggering these processes—that is, what methodological instruments should be used to evaluate these effects.

While disruption on one axis may require a long period of destabilisation (as usually happens on the political axis), in other axes—because of the modification of the social environment and the alignment to the related axes—it can occur at a faster pace, as seen often on the economy axis. The analysis must therefore find the points of fracture, and for this, it is necessary to clearly establish the unit of analysis and which transformation will be the object of investigation: in our case, Civitavecchia's FM has allowed a controlled study whose limits should stimulate the development of new analytical instruments and research strategies.

This case study shows that the notion of FM should not be considered only from a technical point of view—as a mere energy infrastructure. It is maintained through the material and immaterial assemblage of resources, people, political, legal and cultural institutions, and media systems. The alternative of renewable energy production signals a procedural opening to other forms of assemblages—which, in the case of Civitavecchia, means in very concrete terms the establishment of other forms of work, professional figures, political relations, environmental conditions, and social acceptance.

The empirical analysis confirms that ATs are both primary and operational and that the same AT can play roles in the same transformation axis, not necessarily at different times. Unlike the dominant perspective that places great emphasis on policymakers, the case of Civitavecchia shows that without agents 'from below' and without the transformation of the social environment carried out by them, the transformation would hardly have occurred. At the same time, political allies in the Lazio region government allowed these actors to accelerate the process—an aspect that all the interviewees recognized.

The potential for disabling power articulations to address sustainability transformation in the case of Civitavecchia shows that the more FM's forms of power are targeted, the greater the chances of success. To capture these processes, it is necessary to broaden the gaze and follow agents and practices along every axis—specifying the target and the means used—functional to the legitimate continuity of FM. While destabilisation can be successfully accomplished by a single AT, disruption largely requires multiple ATs; since the latter aims to obstruct and occupy the various spaces of fossil reproduction, it must be deployed in several different ways,

at different levels, and over extended periods. This aspect shows us that processes of social tipping process can be triggered by combining destabilising practices simultaneously with disruptive ones that effectively subtract spaces for the reproduction and expansion of FM. This shows that despite being necessary, destabilisation practices are not sufficient to take the current socio-economic system in another direction; for this, it is necessary that other agents—defined here as operatives—effectively prevent the continuation of FM through actions across the whole set of interests.

Consistent with the demand for a systemic perspective as voiced by the more recent transition literature (e.g., Davidson, 2019; Kivimaa et al., 2021; Van Oers et al., 2021), a focus on the Civitavecchia's FM highlights how disablement blurs the usual distinction between sectoral and systemic levels and shows that a process apparently targeted only to decarbonise the local energy system can involve an entire community/socio-economic ambit and can thus be part of a systemic effort towards a sustainable future. However, this does not exclude that systemic community success in one place may generate negative consequences in other places—where the social environment favours installing fossil energy plants.

This evidence suggests three broad ways forward. First, the social tipping processes can be followed by identifying ATs, those who hold new values and whose practices can potentially transform the current socio-ecological system through an evolutive process of learning which becomes a social self-propelling process of transformation. Second, social bias processes occur through concomitant practices, the successful combination of agents to destabilize and disrupt the FM, and the existence of solid and viable renewable alternatives. This point is important because it emphasizes the need to move, so to speak, from 'protests to projects', that is, to move from a social dimension to a more explicit socio-technical dimension (Jasanoff, 2015). Third, notions of FM and destabilizing and disruption practices are powerful metaphors to support transformative narratives. By emphasizing the socio-political and climatic-ecological entanglement, these notions allow us to individualize specific objectives for the social tipping processes, and also to recognize the relational and processual dimension of ATs, practices of destabilisation and disruption, and of the FM itself. ATs and practices are modified both about the effects produced in the FM through its practices and due to the modification of the social environment where this machine is sustained; on the other hand, the FM resists the attempts of deactivation through forms of power—discursive, legal and material—that can block or delay sustainable transformation processes and thus preserve a social environment conducive to its continuity.

7 Conclusion

The Civitavecchia case study shows that the category of social tipping processes constitutes a useful framework for understanding and explaining the processes of change and rupture—of transformation, in fact—that have occurred. First, by emphasizing the processual dimension, it allows to identify practices that can have

positive effects. In this case, it constrains to pay attention to how they are generated and propagated from and within a particular social-ecological environment.

The framework should communicate the particularities of the scale of the research object and not just impose itself on it. This means that when analysing these processes, at the macro or micro scales, it is necessary to clearly define which transformative processes this framing helps to shed light on. As shown in this chapter, the case of Civitavecchia required following the micro-socioecological aspects of destabilizing the 'naturality' of fossil energy and the practices that disrupted its reproduction and expansion. The agents declared that energy production plant had broken the relational fabric of the community. The re-composition of this fabric took on the character of a clear opposition to the continuation of 'fossil slavery'. What started as minority groups acquired the social consistency and legitimacy to decisively oppose fossil fuel energy. In this sense, social transformation processes allow us to follow this evolution, offering useful tools to make the complexity of this process intelligible. The exit from fossils was possible because conditions of acceptability had been constructed, and the anti-fossil relational fabric had been consistently generated to sustain the transformation to a different trajectory.

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