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# Pursuing sustainability transitions and open strategic autonomy. A policy mix perspective on synergies and trade offs

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## Contents

## Abstract

With this concept paper we aim to stimulate discussions on how the new policy objective of open strategic autonomy (OSA) should be fitted together with the existing objective of achieving just sustainability transitions (ST) – and what the practical means are to pursue these dual policy objectives more effectively together. Both OSA and ST are vital for the future of Europe and require profound and rapid structural changes. Hence, recognising synergies and trade-offs between the two and seeking ways to align them is important. We do so by drawing both from academic literature and recent EU policy developments to examine these objectives and their interconnections. We start by introducing the conceptualisation and challenges around OSA and related terms, followed by explaining policy mix thinking in transition studies and recent attention to policy intervention points and transformative outcomes. We then deliberate how OSA should be addressed in the context of public policy influencing ST by integrating it as an additional policy objective into the transition policy mix – a mix that requires coordination across multiple policy fields. We discuss how security policy, green industrial policy and trade policy generate connections between ST and OSA.

***Authors***

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## Executive summary

### *Introduction*

Open strategic autonomy (OSA) has recently received growing attention both in policy making and in academic research on innovation and transformation. This paper argues for linking OSA as a policy objective with the policy objective of sustainability transitions (ST), i.e. transforming European production and consumption systems to be more environmentally and socially sustainable. Achieving both simultaneously requires well aligned policy interventions to improve the resilience of societies against more turbulent geopolitical and geoeconomic conditions as well as risks and threats arising from climate change and other environmental crises. With this concept paper we aim to lay the foundations for a well-informed policy discourse on aligning OSA and ST.

### *Policy research on strategic autonomy*

Strategic autonomy has been defined as 'the capacity of a country or region to pursue strategically important activities free of foreign interference'; adding 'open' to the term, emphasises global interdependencies and the importance of international partnerships (Kroll, 2024, p. 4). In the EU, policy interest on OSA originated in defence and foreign policy, but has more recently expanded to many other sectors, such as energy and industrial policy. References are frequently made to increasing domestic production and sourcing, improved resource efficiency, and diverse and more reliable international networks as means to pursue OSA. Pertaining to EU trade policy, OSA has created a shift from global openness towards 'geopolitisation of trade' and 'trade as foreign policy' (Schmitz and Seidl, 2023).

Technology sovereignty is a related concept, oriented to technological capabilities in Europe, and the EU's dependencies in this regard on countries outside of the EU, e.g. in telecommunications, computers and electronics. There is also concern around other areas, where dependencies are seen as potentially too critical, such as the medical sector (e.g. drugs), energy (e.g. solar PV), critical materials (e.g. cobalt) and batteries (e.g. for electric vehicles).

Policy ideals, objectives and efforts related to OSA are not limited to the EU. The OECD (2023) has divided policies for 'Technology Strategic Autonomy' into protection (e.g., export control, foreign direct investment), promotion (e.g., bolstering industrial capacity, reducing reliance on foreign suppliers) and projection (e.g., STI alliances, technical standards). Most prominently, the United States and China with their globally powerful positions have been enacting new protective industrial policies which create rivalries that also impact Europe and the EU's OSA policies. Such protection measures run the risk of hindering sustainability transitions by limiting international competition – a key driver of technological innovation and cost reductions – through restrictions on export and import of green technologies, whereas promotion and projection policies may support the greening of the economy and the formation of transformational networks.

### *Policy research on sustainability transitions*

Over the past two decades, sustainability transitions have been investigated by the interdisciplinary field of socio-technical transition studies. Initially, this research focused on how green niche innovations with the potential for improving environmental sustainability emerge, expand and develop amidst the challenges they face from being radically deviant from existing socio-technical systems. Transitions require breaking rigid structures and their rules to develop novel solutions via trial-and-error approaches. Drawing on a range of interdisciplinary approaches, empirical studies

have increased our understanding of historic transition processes as well as the governance of unfolding transitions.

The acceleration of sustainability transitions calls for harnessing the forces of creative destruction in innovation policy mixes, thereby making room for the wider diffusion of novel solutions. Such policy mix approaches supporting the new while also targeting the destabilising of unsustainable regimes have to some degree been visible in the recent EU Recovery and Resilience Facility. Most recently, policy-oriented transitions research has emphasised particular policy intervention points that transition policy mixes should tackle to achieve transformative outcomes.

The need for such a policy shift in innovation and industrial policy is justified by the "directionality-failure" of innovation policy, addressing the lack of normative orientation to solve environmental and social problems in traditional innovation/ industrial policies. This insight is incorporated in the move to challenge-led, transformative and mission-oriented innovation and industrial policies. Thereby, transitions research is also increasingly used to support policymaking, especially in the European Union.

### *Connecting sustainability transitions and open strategic autonomy*

The objectives of sustainability transitions and open strategic autonomy can be bridged through several connecting elements, two key examples being security considerations and green industrial policy.

*Security as a connecting element*: There is nascent research that connects sustainability transitions to questions of international and national security and trade. The key arguments made is that sustainability transitions are shaped by developments in global geopolitics and security, and, that transitions, when accelerating or gradually stabilising into new socio-technical system configurations, will alter security and trade. These connections are relevant for OSA in a sense that transitions have implications that can enhance or reduce the dependencies and resilience of states in terms of geopolitics, international trade and crises. Future knowledge and research needs at the interface of OSA and ST pertain to, for instance, ST and health and agro-food transitions.

*Green industrial policy as a connecting element*: Green industrial policy connects ST and OSA in a straightforward manner: targeting green technologies and industries serves sustainability transitions directly, while OSA comes to play in the design of industrial policy that aims to improve the EU's self-sufficiency, security of supply and capabilities regarding these technologies and industries. The 'international dynamics' resulting from the adoption of green industrial policies in countries around the world can play out as potential drivers for accelerating ST but can also impede acceleration through industrial protectionism and trade disputes motivated by OSA.

*Further interconnections*: Differences in regional capabilities, alongside regional path dependencies, influence how sustainability transitions proceed in different EU member states. Hence, OSA may lead to a partly different selection of key technologies and new industries for different regions. At the same time, a multitude of regions and member states in the EU aim to become leaders in battery technology and green hydrogen. The focus OSA places on the state-level and international relations extends the idea of network building in transitions to the international and national level.

### *Exploring synergies, trade-offs and alignment between ST and OSA*

Starting from the Green Deal and its pursuit of ST in Europe, and adding the pursuit of OSA has changed the policy setting in the EU. Some policies, such as the RePowerEU package, have already attempted to combine policies supporting both ST and OSA as dual policy objectives. Potential

synergies and trade-offs between OSA and ST are illustrated for future policy making in the EU, categorised by policy intervention points and transformative outcomes (see Table 3). Initial propositions are made on how to create alignment between these two policy objectives. The concrete means by which to promote this alignment can vary by sector.

***Conclusions***

With the heightening importance of geopolitical risks and new security concerns, policy makers and analysts in the EU are faced with new challenges. Yet, it is fundamentally important that addressing these concerns does not lead to a neglect of the equally critical problems related to exacerbating climate change, biodiversity loss and other environmental crises – that is, the policy ambitions to achieve sustainability transitions need to be maintained on the policy agenda. Hence, a combined approach to the two policy objectives of ST and OSA is needed. This paper provides some starting points for improved alignment of both objectives.

First, creating improved alignment between the two policy objectives means an increasingly heightened role for cross-domain policy networks and coordination. For example, this would support the identification of critical sectors, key technologies, needed capabilities and favourable international relations that benefit both OSA and ST.

Second, for innovation and industrial policy engaged with the development of new green technologies and industries, the alignment of the two policy objectives implies the integration of the means often associated with OSA into sustainability policies, i.e., increasing clean domestic production and sourcing, improving resource efficiency, and creating and maintaining diverse and more reliable international networks supporting sustainability objectives.

Third, already established sustainability innovations (e.g. related to renewable energy, energy efficiency, circular economy, demand response services, plant-based proteins, mobility services) provide plenty of potential for OSA, but require replication in different locations within the EU and the wider diffusion of such innovations. This can be achieved by supporting the corresponding new socio-technical system configurations in areas where such innovations are available.

Fourth, combining OSA and ST also present challenges from the human capital perspective: There is a need to improve skills, capabilities, competencies and education in critical sustainability solutions across all sectors of the economy as well as in public sector organisations. Alignment of OSA with ST requires active efforts from decision makers and the public sector together with private sector actors leading in sustainability. Policy mixes coupling OSA with ST will require:

- Development of competencies across ST and OSA (training, education, recruitment, networking across administrative and industrial sectors).
- R&D funding and experimental innovation policies in support of technological and service innovations that benefit both ST and OSA.
- Revision of fiscal policies to be of supportive of both ST and OSA.
- International collaboration and diplomacy combining ST and OSA.
- Policies to improve local resilience covering geopolitical and trade as well as climate and environment-related risks.
- Continuation of EU policies oriented to networking between EU regions and combining just transitions with new sustainability sectors and job opportunities.

— Improved and interconnected foresight and transition-oriented arenas – resulting in new policy visions, strategies and programmes bridging OSA and ST.

— Creating tools, models and evaluation frameworks for ex-ante and interim assessments of the OSA impacts of unfolding sustainability transitions and the ST impacts of OSA policies.

# 1 Introduction

Open strategic autonomy (OSA) has recently received growing attention in both policymaking and academic research on innovation and transformation. In policymaking, OSA has emerged as a policy objective and a rationale to safeguard the EU's independence from other countries, in particular in relation to the security of supply of many commodities, international relations and defence. In academia, research on OSA is nascent, but of increasing importance, with early contributions focusing on the related concept of technology sovereignty (TS) in the context of science, technology and innovation policy. We argue that it is important to link OSA as an emerging new policy objective with the well-established policy objective of transforming European production and consumption systems to be more environmentally and socially sustainable. That is, we view open strategic autonomy and sustainability transitions as two different policy objectives. Achieving both simultaneously requires well aligned policy interventions, the implementation of which is vital to improve the resilience of societies against more turbulent geopolitical and geoeconomic conditions as well as risks and threats arising from climate change and other environmental crises. One of our key messages is that while OSA is of increasing importance in the current era, its pursuit needs to be embedded in the urgently needed advancement of sustainability transitions for tackling climate change and other environmental challenges. Aligning the two policy objectives requires efforts to explicitly recognise their synergies and trade-offs as a precondition for making coherent political decisions and consistent policy choices, thereby, ensuring policy effectiveness in achieving the profound and rapid structural changes required by both policy objectives - OSA and ST.

OSA is related to a pursuit of increasing Europe's independence in terms of production and reducing one-sided dependencies on concentrated supplier countries or companies. It has been described as "the European Union's (EU) capacity to act independent of other countries in strategically vital areas, including, for example, the economy, defence and energy" (Trippl et al., 2024, p. 1). It captures the attempt to lessen the EU's external dependencies in critical sectors (Miró, 2023) and to seek openness while being resilient and assertive (Schmitz and Seidl, 2023). This conceptualisation is very broad and open, thereby accommodating political buy-in from diverse actors. Technology sovereignty (TS), as a closely related concept, can be described as the plan of action or a process how to advance OSA in the context of technological innovation and industrial activities. Recent academic literature presents what could be called an 'ideal' case of applying TS in relation to science, technology and innovation (STI) policy. In this context, Edler et al. emphasise that TS implies 'sovereignty of government action' and a process and means towards something, instead of an end-state for STI policy (Edler et al., 2023). TS has also been depicted as specific "competences to identify, understand, assess, develop, advance, produce, use, and incorporate those key technologies" that are most important for political and economic sovereignty of member states of the EU (March and Schieferdecker, 2023). More broadly, the literature on TS emphasises the importance of innovation and industrial policy for OSA. Politically, OSA and TS have also been connected to the rediscovery of industrial policy, whereas the opportunities provided differ for and interests are not aligned between different regions (Trippl et al., 2024). Another term connected to OSA in EU policy is that of 'resilience' (Miró, 2023; Roth et al., 2021) which has multiple different interpretations in different contexts (e.g. ecosystems, climate change, societal crises and technical systems).

Sustainability transitions (ST) are urgently required large-scale shifts in socio-technical systems to become more environmentally and socially sustainable (Köhler et al., 2019). This means that systems formed over several decades around the provision of energy, food, mobility, water and their associated industries, need to be altered to reduce their greenhouse gas emissions and other environmental impacts – as well as improve their resilience to impacts of climate change and other

external risks and threats. Since the late 1990s, extensive scientific literature has developed around this field, with a collection of evidence on how such systemic changes take place and which factors can support or hinder sustainability transitions (van den Bergh et al., 2021). A key insight is that systemic change towards sustainability is not only about technological change, but requires supportive changes in public policy and regulations, markets, practices and behaviour, i.e. socio-technical, socio-political and socio-cultural changes. Such transformative change towards sustainability is bound to create disruption, contestation, competition and tensions, thereby, slowing down and hindering such transitions (Hebinck et al., 2022; Kivimaa et al., 2021). In addition, the advancement of sustainability transitions can be influenced by sudden disruptions or 'shocks' in the broader global context, such as wars, conflicts and pandemics (Johnstone and Schot, 2023). Addressing such challenges requires transition policies that simultaneously support the creation of the new and carefully manage phasing-out of the old (Kivimaa and Kern 2016), taking on board implications for justice (Kaljonen et al., 2024). Such policy mix thinking can be seen in the EU Green Deal, and several other initiatives by the European Commission, such as the just transition funding in coal regions and beyond (e.g., Kelemen, 2020; Miedzinski et al., 2021).

There are many open questions as to how the policy objective of open strategic autonomy (OSA) should be fitted together with the aim of achieving just sustainability transitions (ST) – and what the practical means are to pursue these dual objectives more effectively together. With this concept paper we aim to lay the foundations for a well-informed policy discourse on aligning OSA and ST. We start by introducing research on open strategic autonomy as a policy concept and outline its associated challenges (section 2). We then provide an introduction to research on sustainability transitions, with a focus on how the academic literature has been thinking about policy mixes and policy intervention points for achieving such transitions (section 3). Subsequently, we tie the policy objective of OSA into this transition policy thinking by shedding light on two connecting streams of development (section 4): the emergence of security policy as key context for OSA but also as new but important consideration for ST; and the increased attention to green industrial policy, which is tied both to 'green' transitions (ST) and to increasing domestic production in the EU (OSA). We also offer some thoughts on further interconnections between ST and OSA by discussing capabilities, resources and trade. After having laid these foundations, in section 5 we suggest how to integrate OSA into policy intervention points and policy mixes for sustainability transitions and explore potential synergies and trade-offs between the two policy objectives, with selected examples from the domains of energy and transport. We close by offering some initial policy implications for pursuing sustainability transitions and open strategic autonomy (section 6).

# 2 Policy research on open strategic autonomy

Strategic autonomy has been defined as 'the capacity of a country or region to pursue strategically important activities free of foreign interference', while adding 'open' to the term, emphases global interdependencies and the importance of international partnerships (Kroll, 2024, p. 4). In the EU, policy interest on strategic autonomy, or more specifically open strategic autonomy (OSA), originated in the domain of defence and foreign policy (Damen, 2022), and has since been expanding to many other domains, such as energy and industrial policy (Schmitz and Seidl, 2023). Since 2020, geopolitical tensions and disruptions in global value chains have increased political attention to OSA (Kroll, 2024). When OSA is discussed, references are frequently made to increasing domestic production and sourcing, improved resource efficiency, and diverse and more reliable international networks as means to pursue OSA. OSA has also been differentiated based on innovation autonomy, i.e., knowledge creation, and economic autonomy, value creation and production (Kroll, 2024).

Pertaining to EU trade policy, OSA has created a shift from global openness towards 'geopolitisation of trade' and 'trade as foreign policy' (Schmitz and Seidl, 2023). Indeed, Miró argued that OSA is tightly connected to 'geopoliticising' where issues or policies are constructed as geopolitical matters (Miró, 2023). Especially in the current era of global health and security crises, almost all policies are increasingly becoming connected to security and geopolitics. On the one hand, security and geopolitical implications of any policy should not be ignored. On the other hand, geopolitics and security should not become the sole purpose of public policymaking.

The related concept of technology sovereignty (TS) is particularly oriented to technological capabilities in Europe, and the EU's dependencies in this regard on countries outside the EU.[1] Telecommunications, computers and electronics represent the sectors where the EU has the highest technological dependencies (Dachs et al., 2023). In particular, semiconductors and microchips are used in multiple vital sectors, such as military and aerospace, consumer electronics, as well as energy and mobility (Trippl et al., 2024), amplifying the challenges of the EU's external dependencies. However, there is also plenty of concern, discussion, assessments and policy activity around other areas, where dependencies are seen as potentially too critical, such as the medical sector (e.g. drugs), energy (e.g. solar PV), critical materials (e.g. cobalt) and batteries (e.g. for electric vehicles).

Edler et al. argue that TS is about state-level agency within the international system, and hence about sovereignty of governmental action instead of sovereignty over something territorial (Edler et al., 2023).They see it as a means to the ends of innovation policy, i.e. to keep hold of the EU's (or national) competitiveness and create capacity for transformative policies. They emphasise both EU/domestic technological capacity and solid networks of international relations and partnerships. They also argue that TS does not imply inward-looking and closed EU/national policies – in contrast, they regard autarky-inspired efforts to cut global innovation networks as unfit for purpose, especially for smaller countries (Edler et al., 2023). However, the ambiguous and loose definitions of TS (and OSA) have been argued to leave too much space for autarkical and nationalist interpretations (March and Schieferdecker, 2023). Nevertheless, resource scarcity is a vital

[1] Although this paper is oriented to discussing OSA in the EU context, similar principles could be seen to be pursued on a national, Member State level. When pursued on a national level, there are risks that some of the policies implemented would undermine the EU single market efforts.

contributor to discussions around TS, which means that territorial questions are intertwined with questions of its governance.

Another challenge for trying to achieve sovereignty in technological capabilities (or more broadly) is continuously ongoing change, necessitating to perpetually identify and keep in the race for new key technologies, be aware of their vulnerabilities and security threats and the power such technologies may give to large multinational corporations. This is very visible in the digitalisation of the economy, but also in the rapid advancement in renewable energy and transport electrification. This implies the need to regulate technologies (March and Schieferdecker, 2023) before they threaten OSA or environmental sustainability too much, but also require state capacity in this regard. Such transformative capacity of public sector organisations (Borras et al., 2024) and resulting policies oriented at ensuring open strategic autonomy and sustainability need to constantly co-evolve with the changing socio-technical systems and the broader landscape containing, e.g., geopolitical and geoeconomic developments.

Policy ideas, objectives and efforts related to OSA are not limited to the EU. Especially, the United States and China hold globally powerful positions, creating rivalries that also impact Europe and the EU's OSA policies (Broeders et al., 2023). Accordingly, the OECD (2023) has divided policies for 'Technology Strategic Autonomy' into protection (e.g., export control, foreign direct investment), promotion (e.g., bolstering industrial capacity, reducing reliance on foreign suppliers) and projection (e.g., STI alliances, technical standards). Such policies can exist simultaneously, but the chosen policy mix may differ between the EU, US and China due to different understandings of strategic autonomy (see Box 1). China and the US, for example, show an increasing orientation towards policies for promotion (new industrial policies) and protection (new types of subsidy or control programmes) – while less attention seems to be given to new projection measures. Protection measures may run the risk of decelerating sustainability transitions by limiting international competition through restrictions on export and import of green technologies[2], whereas promotion and projection policies may accelerate the greening of the economy and the formation of transformational networks. However, there may be dynamic trade-offs between cost reductions arising from international competition and trade on the one hand, and domestic jobs, welfare creation and public acceptance for ST on the other hand, calling for a well-balanced policy approach. Finally, when looking at policies related to OSA, some focus on TS (e.g. new industrial policies), whereas other debates also place attention to foreign policy, security and defence (e.g. Indian foreign policy shifts as well as NATO enlargement).

[2] For instance, much of the recent expanded EU solar capacity has been achieved by cheap imports from China (supported by industrial policy), negatively impacting EU production capacity. A similar dynamic is anticipated for electric vehicles manufactured in China, and the threat to EU, US and other countries automotive industry is currently tackled by import tariffs. On the one hand, in the short term such policies risk delaying the electrification of transport and thus the reduction of GHG emissions due to higher technology costs; on the other hand, in the long term, if implemented as part of a transformative policy mix they may support the net-zero transition of the domestic automotive industry, thereby safeguarding a key sector with its welfare and job creation, which in turn may maintain or even increase public acceptance for continued sustainability transitions. However, without transformative policy mixes addressing both OSA and ST, such protective measures alone will hinder sustainability transitions by limiting competition and increasing costs.

**Box 1.** Understandings of strategic autonomy in selected countries

**China** has a leading or advanced position in many strategic technologies, e.g. 5G, batteries and wind turbines (OECD, 2023). It has had long term measures in place for the acquisition and control of production and supply chains of critical raw materials beyond the geographical area of China, and has set conditions making sure foreign companies can use certain minerals only in production facilities placed in China and by collaborating with Chinese companies (Criekemans, 2018; Freeman, 2018). These highlight especially promotional tactics but to a degree also protection. Examples of policies include: Made in China 2025 Strategy; 14th Five-Year Plan; Dual Circulation Strategy; Military-Civil Fusion; Government Guidance Funds; China Standards 2035; Belt and Road Initiative (OECD, 2023).

The **United States** is seen to balance protection and promotion measures with active industrial policy. While many of its policies may primarily target strategic sovereignty from China, they also severely impact Europe and the rest of the world. Policy examples include: CHIPS and Science Act; Inflation Reduction Act; Infrastructure Investment and Jobs Act; Indo-Pacific Economic Framework for Prosperity; Group of Seven (G7) Partnership for Global Infrastructure and Investment (OECD, 2023).

**India** has moved from non-alignment with the United States to an issue-based alignment. In 2015, the governments of India and the United States created a "joint strategic vision for the Asia-Pacific and Indo-Ocean region" (Khurshid, 2023). In addition, India formed with France the Indo-French bilateral partnership, emphasising maritime security and defence to support trade, space, blue economy, and ocean biodiversity (Bharti and Singh, 2023).

The relevance of OSA and TS for sustainability transitions has been established in the recent literature by connecting them to innovation policy (Edler et al., 2023; March and Schieferdecker, 2023) – which is one of the key means for advancing sustainability transitions (addressed next in Section 3).

# 3 Policy research on sustainability transitions

Over the past two decades, sustainability transitions have been investigated by the interdisciplinary field of transition studies (Markard et al., 2012). Initially, this line of research focused on how green niche innovations with the potential for improving environmental sustainability emerge, expand and develop amidst the challenges they face from being radically deviant from existing socio-technical systems (Kemp et al., 1998). Research continues to explore experimentation as a central feature of socio-technical transitions – taking place in different spheres in protective niche spaces where innovations are developed (Torrens et al., 2019), such as in the area of urban transformation (Fuenfschilling et al., 2019). The idea is to generate novel solutions via trial-and-error approaches, thereby breaking rigid structures and their rules. Understanding how such novel solutions can lead to transitions, the Multi Level Perspective (MLP) offers an analytical approach emphasising the dynamic relationship of radical niche innovations (such as solar PV, wind turbines or electric vehicles in their early stages) with the so-called regime level – the deep rule structure of an existing, unsustainable socio- technical system (such as large-scale, centralised, fossil-fuel based electricity generation) – and the landscape level – the external context to the socio-technical regime and the niches (such as digitalisation, climate change or geopolitical conflicts). Drawing on the MLP and other analytical approaches, such as transition management (Loorbach and Rotmans, 2010), empirical studies have increased our understanding of historic transition processes as well as the governance of unfolding transitions (Hansmeier et al., 2021; Zolfagharian et al., 2019). About a decade ago, transitions research began to scrutinise more systematically the role of public policy in ST and its legitimation due to transformative system failures having to be addressed in addition to structural system failures and market failures (Weber and Rohracher, 2012). Such research has early on demonstrated the relevance of technology-specific policies for niche development (Sandén and Azar, 2005) and the importance of strategic policy making which combines long-term targets with supportive instruments to promote investments in green innovation (Schmidt et al., 2012).

Policy research on sustainability transitions has consolidated around the understanding that comprehensive policy mixes are needed to address the various market and system failures hindering transformative change rather than seeking single bullet solutions such as carbon pricing alone (Rogge and Reichardt, 2016). Combining credible policy strategies with a consistent mix of policy instruments designed to create synergies and avoid conflicts is key to promote low-carbon innovation (Rogge and Schleich, 2018). Importantly, the acceleration of sustainability transitions calls for harnessing the forces of creative destruction in policy mixes by supporting novel solutions and making room for their wider diffusion by destabilising the unsustainable regime (Kivimaa and Kern, 2016). Examples of such policy mix approaches have to some degree been visible in the recent EU Recovery and Resilience Facility (Kivimaa et al., 2023), although more typically 'real-world' policy mixes suffer from incoherent policies and political difficulties in adopting phase-out policies. In effect, the adoption of such transformative policy mixes is often hindered by opposition from vested interests, which has been addressed in research focusing on the politics and power in transitions (Avelino, 2021; Meadowcroft, 2011). For example, Rinscheid (2020) shows how structurally powerful businesses can strategically shape voting behaviour around contested energy policy issues. Opponents to more ambitious climate action employ various discourses of climate delay to slow down progress, such as by redirecting responsibility, pushing non-transformative solutions and emphasising the downsides (Lamb et al., 2020). Discourse analysis can trace the development of coalitions in favour of or opposition to technologies, fuels, practises or solutions, such as coal-phase out, thereby enabling the identification of more powerful positions which made it into final policies (Markard et al., 2021). Consequently, policy mix research has started to draw attention to the need for investigating the politics and policies of transitions and how they play out

in real world policy mixes (Kern et al., 2019; Kern and Rogge, 2018). Research has also investigated experimentation in policy development and institutional changes in public governance to become more supportive of transformative change (Kivimaa and Rogge, 2022).

Most recently, policy-oriented transitions research has emphasised particular policy intervention points and associated transformative outcomes. Drawing from the MLP (Geels, 2006), policy intervention points refer to places where public policies can influence transition trajectories, or address the broader repercussions of transitions, including: stimulating different niches, accelerating niches, destabilising the regime, addressing the broader repercussions of regime destabilisation, providing coordination for multi-regime interaction, and tilting the landscape (Kanger et al., 2020). In turn, also resonating with the idea of niches, their acceleration and regime destabilisation, Ghosh et al. (2021) provided particular processes that public policies should aim at to create so-called transformative outcomes that benefit overall transition processes. Kivimaa et al. (2023) combined these for a framework to analyse the transformativeness of policy mixes (see Table 1 below).

**Table 1**: Framework to analyse the transformative characteristics of a policy mix

| **Macro-process** | **Role of Policy** | **Policy Approaches** | **Transformative outcome** |
|---|---|---|---|
| 1. Promoting and nurturing niches<br>(Ghosh et al., 2021) | To support the development of a variety alternatives to incumbent systems | Targeted research, development and innovation (RDI) funding; Stimulating real world experimentation and learning; Supporting grassroots innovations; Improving data generation, information sharing and monitoring | 1.1 Shielding<br>1.2 Learning<br>1.3 Networking<br>1.4 Navigating expectations |
| 2. Expanding and mainstreaming niches<br>(Ghosh et al., 2021) | To scale up promising niches and align niches | Regulation and regulatory incentives; Market adoption strategies; Standard development; Sustainable public procurement; Promoting sustainable finance; Networks and platforms for knowledge exchange; Infrastructure development | 2.1 Upscaling<br>2.2 Replicating<br>2.3 Circulating<br>2.4 Institutionalising |
| 3. Opening up and unlocking regimes (Ghosh et al., 2021) | To destabilise the incumbent regime structures that hinder transformative change | Regulatory intervention for system and practice phase-out; Changing incentive structure; Institutional divestment | 3.1 De-aligning and destabilising<br>3.2 Unlearning and deep learning in regimes<br>3.3 Strengthening regime-niche interactions<br>3.4 Changing perceptions of landscape pressures |

| Macro-process | Role of Policy | Policy Approaches | Transformative outcome |
|---|---|---|---|
| 4. Repercussions of regime destabilization (Kanger et al., 2020; Lazarevic et al., 2022) | To mitigate and manage the broader social impacts of phase out and system change | Regional Development Policies; just transition initiatives; education; retraining | 4.1 Reducing socio-economic impact<br>4.2 Social deliberation |
| 5. Provide coordination to multi regime interaction (Kanger et al., 2020; Lazarevic et al., 2022) | To facilitate policy coherence between regimes and provide coordination for goals that span across sectoral silos | National strategies and visions; Pan-national sustainability programmes; Platforms for data service coordination; mechanisms/instruments for horizontal coherence & policy integration | 5.1 Strengthening regime-regime interactions (horizontal)<br>5.2 Strengthening multi-level governance interactions (vertical) |

*Source: (Kivimaa et al., 2023)*

The research on how to transform public policies connects with the debate and pursuits of challenge-led, transformative and mission-oriented innovation and industrial policies. The need for such a policy shift in innovation and industrial policy is justified by the "directionality-failure" of innovation policy, meaning a lack of normative orientation to solve environmental and social problems in traditional innovation/industrial policies (Weber and Rohracher, 2012). Initiated by academic calls for mission-oriented (Robinson and Mazzucato, 2019) and transformative innovation policies (Schot and Steinmueller, 2018), much more practice-oriented work has followed, especially by the OECD and the EU. This policy shift aims for innovation and industrial policy to deliberately contribute to solving global environmental and social problems (i.e. introducing directionality), involving a broader and more diverse group of stakeholders in policy processes, and conducting experimental approaches to support these endeavours in different settings (Diercks et al., 2019; Ghosh et al., 2021; Schot and Steinmueller, 2018). Recent research suggests the combination of anticipatory, participatory, reflexive and tentative governance modes for missions to deal with the complexity, uncertainty and contestation associated with sustainability transitions (Wiarda et al., 2024).

Transitions research has also been increasingly used to support policy making, especially in the European Union (Geels et al., 2019; Kaljonen et al., 2021; Kelemen, 2020). A report conducted for the European Environment Agency (EEA) in 2019 to support the State of the Environment 2020 report, summarised key insights from transition studies and provided policy recommendations. It noted that the following characteristics of sustainability transitions are key (Geels et al., 2019): the multi-dimensional nature of changes in socio-technical systems; transitions as multi-actor, multi-scalar processes; the importance of goal-oriented directionality (visions, pathways to sustainability); the disruptive nature of transitions (involving winners and losers); transitions as open-ended and uncertain processes (learning and experimentation), often connected to surprises and unintended consequences (evaluation, reflection); as well as the urgency of change and difficulties in acceleration (diffusion, phase out, exnovation). This means that public policies aiming to advance transitions need to recognise and address such characteristics.

It is this line of research on policies for sustainability transitions that we draw upon in the following sections to unpack connections between ST and OSA through a policy mix lens.

# 4 Connecting sustainability transitions and open strategic autonomy

Positioning sustainability transitions (ST) and open strategic autonomy (OSA) as two key policy objectives to be tackled by policy mixes implies the need to coordinate policy interventions from several policy fields. Table 2 illustrates that multiple policy fields can be linked with ST and OSA policy objectives, hence, requiring increased efforts to improve their alignment. As illustrated in Table 2, some policy fields may be more relevant to one over the other policy objective, but a range of multiple policy fields can serve both policy objectives. For example, for addressing ST, environmental and climate policy as well as energy and mobility policy are likely to be of primary importance; whereas for tackling OSA, industrial policy as well as security and trade policy seem most relevant. Yet, these different policy fields are also of relevance to the other of the two policy objectives in the focus of our paper, OSA and ST, even if only in a supplementary manner. This implies a great need for policy coordination to arrive at effective policy mixes simultaneously achieving ST and OSA objectives by harnessing synergies and avoiding conflicts as far as possible.

**Table 2**: Policy fields of relevance for transition policy mixes aiming at ST and OSA

| **Policy objectives (and illustrative means how to achieve them)** | | |
|---|---|---|
| Policy Fields | Sustainability Transition (ST) | Open Strategic Autonomy (OSA) |
| Climate Policy | Connected to ST by aiming to mitigate climate change by reducing GHG emissions via socio-technical system-level change (e.g. carbon pricing through emission trading or taxes, CO2 standards, bans, nudging). | Connected to OSA by aiming to create a level playing field among international competitors with different climate policy stringency levels (e.g. by carbon border tax adjustments) and increasing EU-based production of net-zero technologies (e.g. by subsidies, expanding renewables). |
| Environmental Policy | Primarily aims at achieving environmental sustainability objectives such as biodiversity and ecosystem preservation, clean air and water (e.g. banning microplastics, pollution taxes, mandatory reporting, minimum standards). | Aims at level playing field among international competitors with different environmental policy stringency levels (e.g. by international agreements, such as Montreal Protocol, Biodiversity Framework Convention). |
| Energy Policy | Environmental and social sustainability are among the general objectives of energy policy which aims at reliable, secure, affordable and clean energy system balancing supply and demand (e.g. feed-in tariffs for renewable energies, support for grid expansion). | OSA considerations can be targeted when focusing on the domestic production and sourcing of energy, internationally competitive prices and reliable and diverse suppliers of fuels, minerals, and technological components required by the energy system (e.g., energy efficiency labels, locally specified renewables auctions, minimum sourcing requirements, the critical raw materials act). |

| Policy objectives (and illustrative means how to achieve them) | | |
|---|---|---|
| Policy Fields | Sustainability Transition (ST) | Open Strategic Autonomy (OSA) |
| Mobility Policy | Sustainability considerations in mobility policy can be achieved via socio-technical system-level change targeting structures and behaviours (e.g. subsidising public transport, providing digital infrastructure for service solutions, supporting build-up of charging infrastructure, maintaining and upgrading networks). | OSA considerations in mobility policy can be tackled by local sourcing for infrastructure investments (e.g. charge points), fair distribution of costs for infrastructure use among domestic and foreign users (e.g. road tolls) and ensuring open mobility of goods and services across borders (e.g. Schengen). |
| Innovation Policy | Primarily aims at supporting the development of novel solutions for addressing sustainability challenges and dissemination of such knowledge within open innovation networks (e.g. R&D funding support for technological and social innovation projects, orchestration of networking events). | Aims at supporting the development of novel solutions for areas of strategic importance, based on an assessment of critical risks (e.g. catching up in battery development, R&D support for ICT solutions). |
| Economic Policy | Aims at stable economic framework conditions, in particular ensuring the internalisation of external costs and fair competition for green products and services (e.g. socio-ecological tax and subsidy reform, sustainability monitoring, circular economy standards). | Aims at stable economic framework conditions, including protecting the European Single Market, made in Europe provisions, or protecting domestic SME's from market power of foreign incumbents and multi-nationals (e.g. local content requirements in public procurement, regulation regarding foreign ownership of critical infrastructure, regulatory exemptions for domestic SMEs). |
| Industrial Policy | Aims at altering the structure of economic activity towards higher sustainability (e.g. investment & production support and local content requirements for clean tech, providing information, training and consulting services for sustainable industry, just transition investments). | Aims at altering or preserving the structure of economic activity towards areas of critical risk and strategic importance (e.g. investment & production support and local content requirements for ICT or batteries, energy tax exemptions for energy-intensive industries). |
| Trade Policy | Including sustainability considerations in the overall trade strategy, trade agreements and trade instruments (e.g. selection of environmental standards, preferences and services regulation, such as export or import restrictions for environmentally harmful products and services). | Including OSA considerations in the overall trade strategy, trade agreements and trade instruments (e.g. selection of standards, preferences and services regulation in areas of critical risk, such as export or import restrictions for critical raw materials, import tariffs for electric vehicles). |

| Policy objectives (and illustrative means how to achieve them) | | |
|---|---|---|
| Policy Fields | Sustainability Transition (ST) | Open Strategic Autonomy (OSA) |
| Security Policy | Can be oriented to advancing sustainability by creating synergies between zero-carbon solutions and security (of supply), such as, reducing exported fossil fuel flows, and developing low-carbon defence systems. Example policy measures include programmes for energy efficiency of defence operations and premises, safeguarding renewable energy infrastructure, and R&D support and deployment subsidies advancing the security of smart zero-carbon energy systems. | OSA considers security and defence as a vitally important area, and as a policy objective for security policy it includes pursuits towards capacity to act independently from other actors in defence, security of critical infrastructure and data protection. Examples of measures include regulation for AI and GDPR, and increasing defence funding and defence R&D. |

*Source: Author's own elaboration*

Since sustainability and digital transitions are happening in parallel, effectively OSA needs to be appreciated in the context of such twin transitions, thereby representing even greater challenges for the effective coordination and collaboration between policy areas, public and private actors and different governance levels, ranging from the EU to national, regional and local levels (Domnick et al., 2023). The ultimate aim remains the same: to strive for synergies between OSA and twin transitions and to minimise tensions. The same is true for other objectives, such as territorial and social cohesion, calling for the involvement of stakeholders at different territorial levels to help identify investment opportunities relevant to OSA. In this context, it is important to note that Member State policies oriented to strategic autonomy may, however, cause risk to EU- level policies pursuing OSA in case subsidies or other policies hinder competition within the EU. Therefore, 'a delicate balance' is required 'between reinforcing strategic autonomy and preserving internal market competition' (Domnick et al., 2023, p. 4).

In the following, we further unpack security and industrial policy as two connecting elements between ST and OSA, before moving on to some further interconnections between the two.

## 4.1 Security as a connecting element between ST and OSA

There is nascent research in the sustainability transitions field that connects transitions to questions of international and national security and trade. The key arguments it makes is, first, that sustainability transitions are shaped by developments in global geopolitics and security, and, second, that transitions, when accelerating or gradually stabilised into new socio-technical systems, will alter security and trade (Kivimaa, 2024; Kivimaa et al., 2022; Kivimaa and Sivonen, 2023). Transitions can also be connected to peace building (Huda, 2024). These connections are relevant for open strategic autonomy (OSA) in a sense that transitions have implications that can enhance or lessen the dependencies and resilience of states in terms of geopolitics, international trade and crises. In the following, we mainly draw on examples on the interconnections between OSA and sustainable energy transitions, given the prevalence of examples from that domain and only nascent or lacking research on other empirical domains.

In the energy context, the effects of transitions on security have, overall, been perceived positive for OSA as transitions enable reduced consumption of energy and/or increased domestic production of electricity powered by solar PV, wind power and heat pumps, with reduced dependencies on international trade of fossil fuels. However, taking the example of the electrification of transport, such net-zero transitions can shift dependencies from oil to critical raw materials and technical components required in the manufacture of EVs. Yet, improving capacity and capabilities for the production of such components in the EU is more feasible than increasing the production of oil within EU member states. Nonetheless, the affordability of renewable energy technologies such as solar PV through cost reductions achieved by scaling production and supply of Chinese manufacturers – and supported by green industrial policies in China and demand pull policies in the EU – has been vital in the advancement of the energy transition thus far (Quitzow, 2015). This means that policy efforts to support the domestic production of such technologies in the EU, while potentially strengthening OSA, must be well designed and embedded into a broader transformative policy mix to avoid jeopardising the advancement of decarbonisation in Europe.

Several questions around dependencies on technological components, minerals and metals have been raised, but the effects are not as impactful on the daily availability of energy as is the case with fossil fuels (IRENA, 2024; Kivimaa and Sivonen, 2023; Lee et al., 2020). New interdependencies in the energy sector are more regional (instead of global), as electricity is traded between neighbouring countries. In addition, a transition to more decentralised and local renewable energy sources backed up by stationary and mobile storage solutions (e.g. home storage, EV batteries), may create potential for improved local energy security. A previous analysis in the interface of (energy) transition policy and security and defence policy has suggested four key insights (Kivimaa and Sivonen, 2023): (a) unlearning old ways of security thinking is vital to complement transitions (this applies also to how OSA is seen); (b) the effects of transitions on country alliances and states' reactions should be considered; (c) new networks need to be formed between the sector in question (e.g., energy, food, mobility) and security actors; and (d) negative security implications of transitions can be alleviated with a focus on social justice on different scales (from cities to the global level).

Future knowledge and research needs at the interface of OSA and ST pertain to, for instance, sustainability transitions and health. For example, the medical sector is dominated by globally operating organisations and characterised by structural couplings between global, national and local scales, impacting its transition accordingly (de Haan et al., 2021). For instance, the Covid-19 pandemic visibly showed the dependencies of Europe on China and India regarding critical medical supplies, ventilators and masks (Varma, 2024). Similarly, the food system and its need to transition is much influenced by global trade and supply chains amidst local efforts to decarbonise (Hebinck et al., 2021).

## 4.2 Green industrial policy as a connecting element between ST and OSA

Green industrial policy connects ST and OSA in a straightforward manner: targeting green technologies and industries serves sustainability transitions directly, while open strategic autonomy comes to play in the design of industrial policy that aims to improve the EU's self-sufficiency, security of supply and capabilities regarding these technologies and industries. However, green industrial policy has also been heralded as option to overcome resistance to stringent climate policy hindering the decarbonisation of the economy. More specifically, the sequencing of policies has been proposed as a way to build coalitions for net-zero transitions (Meckling et al., 2017). The idea here is to start with green industrial policy, such as the adoption of the Inflation Reduction Act in the US, and introduce carbon pricing (or make it more stringent) once supportive coalitions of

ambitious climate policy have been formed. In this context, net-zero innovation has been identified as enabler of ratcheting up climate policy over time, for example through cost reductions resulting from technological progress (Schmidt and Sewerin, 2017). That is, building supportive coalitions, improving net-zero technologies, and empowering change agents (those most likely to destabilise unsustainable regimes) though creation policies, can help prepare the ground for the later adoption of destruction policies, such as fossil fuel subsidy reform (Schmidt et al., 2017). This, in turn, can accelerate net-zero transitions by harnessing the power of sequenced policy mixes for creative destruction.

In addition, the 'international dynamics' resulting from the adoption of green industrial policies in countries around the world, on the one hand, can function as potential driver for accelerating ST (Kern and Rogge, 2016; Rogge and Goedeking, 2024). On the other hand, such international dynamics can also impede acceleration through industrial protectionism (Hughes and Meckling, 2018; Meckling and Nahm, 2019) and trade disputes (Hughes and Meckling, 2018) motivated by OSA. For policy making, this implies a renewed focus on green industrial policy as an important part of the overarching transition policy mix that harnesses synergies rather than generating conflicts. For example, simultaneously tackling ST and OSA may imply the establishment of strategic resource partnerships[3] or trade clubs among like-minded partner countries, as called for in the EU's Critical Raw Materials Act or applied in the US Inflation Reduction Act. Additionally, connecting ST with OSA through green industrial policy should account for justice considerations, which may require policy coordination for establishing sustainable and just global value chains, for example, for critical minerals (Sovacool et al., 2020).

## 4.3 Further interconnections between ST and OSA: capabilities, resources and trade

The debate on open strategic autonomy (OSA) ties sustainability transitions (ST) more concretely to empirical experiences and real-life events. It raises questions about where something needed for socio-technical transitions is created and produced, and what resources and capabilities are required for this. Such resources and capabilities may not be – and are likely not to be – fully available in a given region or a state, hence, requiring cross-border collaboration (in the form of learning, networks, vision building, replication of experiments and good solutions). There are differences in regional capabilities, which alongside regional path dependencies influence how sustainability transitions proceed in different EU Member States. Hence, OSA may lead to a partly different selection of key technologies and new industries for different regions. At the same time, one can see a multitude of regions and Member States in the EU to aim to become leaders in new net-zero technologies, such as batteries and green hydrogen. Further exploration is needed regarding the role of circular economy transitions in supporting OSA alongside ST, as well as which pathways could be sought pertaining to food system transitions and OSA.

Bridging OSA and ST objectives in socio-technical transitions calls for transformative capacity of public sector organisations (Borras et a. 2024). This applies to public sector organisations across all governance levels, including the local level (Bhatia et al., 2024). The increasing knowledge needs in the public sector on developments pertaining to OSA create a challenge for governments, requiring

[3] Such strategic partnerships already exist in the area of security and defence (Koops and Pacheco Pardo, Ramon, 2023) and their principles can inform efforts in establishing or strengthening strategic resource partnerships.

more resources for training and new recruitment. For this it is perhaps useful to draw on the experience of ST research on learning-based networks (Caniëls and Romijn, 2008; Romijn et al., 2010). The focus OSA places on the state-level and international relations extends the idea of network building in transitions to the international and state-level. While cities and urban areas have frequently been recognised as hubs for sustainability transitions (Torrens et al., 2019), global innovation systems, trade and supply chains also bring attention to such change processes occurring across state and jurisdictional borders.

Transitions do not only disrupt business-level actor-networks (Johnstone et al., 2020) but cause shifts in the relations and power-positions of states (Kivimaa et al., 2022; Scholten et al., 2020). Such disruption may also, in some cases, lead to globally increasing security risk. In general, the diffusion of power has been argued to lead to more peaceful societies and improvement in positive security (Kivimaa et al., 2022; Scholten et al., 2020; Vakulchuk et al., 2020). Thereby, sustainability transitions are also connected to policies that have cross-border relevance, such as trade and security policies. However, it is worth noting the word of caution by Edler et al. in the context of technology sovereignty that "potentially disruptive policies outside the traditional domain of innovation policy (industrial, trade, investment or security policy) should be deployed carefully and with moderation. In fact, new measures seem to be justified only when there is an obvious structural failure of past innovation policies, when the global technological system or domestic societal preferences have substantially changed, or when there is a need to respond to a lack of systemic resilience and redundancy in the face of crises such as COVID-19" (Edler et al., 2023).

# 5 Exploring synergies, trade-offs and alignment of sustainability transitions and open strategic autonomy

Starting from the Green Deal and its pursuit of sustainability transitions (ST) in Europe, and adding on the additional pursuit of open strategic autonomy (OSA) has changed the policy setting in the EU. Some policies, such as IPCEI Batteries or the RePowerEU package, have attempted to combine policies supporting both ST and OSA as policy objectives.

In the former case, the aim is to build an integrated European battery ecosystem, catching up with market leaders in Asia, building up domestic production capacity, thereby reducing reliance on imports from China, and securing the future competitiveness of the European automotive industry. However, the effectiveness of policy efforts could be strengthened beyond such singular innovation policy measures, for example by annually increasing the stringency of net-zero emission vehicle sales targets and by phasing-out tax benefits and/or subsidies for GHG emitting vehicles. Norway serves as an example of the impact an effective policy mix can have on electric vehicle demand (Ryghaug and Skjølsvold, 2023). Such policy mix changes harnessing the power of creative destruction, modulated with measures directed at OSA – such as specifying local content requirements for batteries as a core component of electric vehicles – could create a more level playing field, increase domestic market demand and thus accelerate innovation dynamics for the new technological trajectory. However, some states are more reluctant than others to disrupt their domestic automotive industry, with incumbents able to create regulatory capture in systems of political coordination aiming at consensus-driven negotiations, thereby slowing down technological change (Meckling and Nahm, 2019).

Regarding the latter case, efforts to accelerate the diffusion of renewable energy and to increase energy efficiency contribute to both reducing greenhouse gas emissions and reducing reliance on fossil fuel imports outside the EU. However, REPowerEU also included contrary goals to sustainability transitions, such as improved liquified natural gas (LNG) investments and infrastructure. After Russia invaded Ukraine in 2022, many EU Member States took rapid actions to acquire LNG shipments and provided public support for the construction of new (floating) LNG terminals to secure gas supply because import from Russia was halted. In addition, some EU Member States (e.g., Estonia) and Norway changed policy to strengthen support for domestic fossil fuel production – that is, some countries have opted for the recontinuation or restabilisation of fossil fuel production which supports OSA but not ST (Kivimaa, 2024).

Table 3 below takes as starting point the policy intervention points (identified in section 3) for how public policies can govern transitions (Kanger et al., 2020; with an addition by Rogge and Goedeking, 2024). The detailed explanation of the intervention points and the associated policy instruments draws from work on transformative outcomes (Ghosh et al., 2021) and their application to policy analysis (Kivimaa et al., 2023; Lazarevic et al., 2022). New insights created for this concept paper include the three right-side columns describing potential synergies and trade-offs between ST and OSA pursuits, and initial propositions on how to create alignment between these two policy objectives. The columns on potential synergies and trade-offs represent stylised situations where such synergies and trade-offs might emerge in policy making (with some examples provided). The suggestions for alignment contain to policy approaches which have the potential to support improved policy alignment between ST and OSA, by utilising the transformative outcomes and other core ideas from transition studies as basis (e.g., the notions of experimenting, navigating expectations, networking, replication, institutionalisation, unlearning, destabilising). The concrete means by which to promote this alignment can vary by sector and context.

**Table 3**: Linking open strategic autonomy (OSA) to sustainability transitions (ST) via seven policy intervention points

| **Policy intervention point** | **Explanation for transitions** | **Policy instruments** | **Potential synergies** | **Potential trade-offs** | **Creating alignment between ST and OSA** |
|---|---|---|---|---|---|
| 1. Building and nurturing innovation niches | To support the development of a variety of more sustainable alternatives to the polluting incumbent status quo, by learning, networking and navigating expectations. | Targeted RDI funding; stimulating real-world experimentation and learning; supporting grassroots innovations; and improving data generation, information sharing, and monitoring. | Selection of key sectors and critical technologies that improve sustainability. Identification of such sectors and technologies beyond the energy sector (e.g. food, water, mobility, circular economy, ICT) is important. | Niche innovations that depend on technology, material and skills input from few selected countries without opportunities for diversification.<br>OSA is far removed from grassroot innovation (emphasised in some transitions research) and is more top-down oriented. | Developing competences to identify and assess technology and system needs that promote both transitions and domestic/EU innovation/production or foreign policies supporting transformative innovation outside the EU.<br>Targeted RDI funding and tax exemptions during early adoption to those sustainable/green solutions which are critical and where EU competencies are currently lacking.<br>Experimenting in innovation policies that support ST and OSA. This could be done in different regions, e.g., PRI pilot regions.<br>Emphasis on local resilience via recognising benefits of smaller grassroots activities as part of OSA from the perspective of local/city-level security.<br>Navigating expectations to mutually supportive directions, in different networks and interactive platforms (e.g., ST-OSA transition arenas, policy labs).<br>Building networks to multiple countries with necessary resources, technologies and skills. |

| Policy intervention point | Explanation for transitions | Policy instruments | Potential synergies | Potential trade-offs | Creating alignment between ST and OSA |
|---|---|---|---|---|---|
| 2. Expanding and mainstreaming innovation niches | To scale up promising sustainable niches and align niches: upscaling, replicating, circulating, institutionalising. | Regulation and regulatory incentives, market adoption strategies, standard development, sustainable public procurement, promoting sustainable finance, networks and platforms for knowledge exchange, and infrastructure development. | Regulation, tax relief and public procurement directed to those sustainable innovation options where there is more domestic/EU production or diversification of trade (potential). | Scaling up dependent on technology, material and skills input from few selected countries; guidance of regulation may be limited by trade agreements. | Developing and increasing competences for domestic/EU skills and sourcing of materials, technologies, e.g., via education, training, and circulation of people and knowledge.<br>Replicating promising examples from one sector or region to another, benefiting from active exchange of knowledge and people across sectors and regions (e.g., JRC PRI initiative) and globally.<br>Promoting the institutionalisation of niche innovations that have ST and OSA enhancing characteristics (e.g., electricity demand response innovation). Tax cuts and/or subsidies for sustainable technologies where future production potential in Europe exists. |
| 3. Opening and unlocking regimes | To destabilise the incumbent regime structures that hinder transformative change, via de-aligning, unlearning, changing-perceptions of landscape pressures, and strengthening niche-regime interactions. | Regulatory intervention for system and practice phase-out, changing incentive structure, institutional divestment. | In cases where destabilisation and phase-out of unsustainable activities also reduces dependence on external and/or concentrated supplies (e.g., fossil fuels).<br>Unlocking existing high-consumption patterns from a functioning regime can also reduce supply dependencies. | In cases where destabilisation and phase-out increases dependence on external and concentrated supplies (e.g., to a degree some critical materials controlled largely by China) - link to intervention point 4 (building the new regime). | *Planning destabilisation of old systems in a way that magnifies benefits to OSA*, e.g., the shift from fossil fuels to critical materials still reduces overall magnitude of dependency.<br>*Unlearning established and old ways of thinking security of supply* (e.g., via stockpiles of fossil fuels and limited alliances).<br>*Developing means to improve anticipation and foresight* – and how actors build expectations – pertaining to landscape developments in geopolitics, security and trade.<br>*Gradual removal of subsidies and tax exemptions* from those technologies and services which are unsustainable and dependent on import from outside the EU. |

| Policy intervention point | Explanation for transitions | Policy instruments | Potential synergies | Potential trade-offs | Creating alignment between ST and OSA |
|---|---|---|---|---|---|
| 4. Building the new regime | Establishing the institutional framework conditions influencing the expanding sustainable trajectory (e.g., market design, regulation, standards). | Update market designs (e.g., for electricity), regulate data access and ownership, set product and green finance standards, incentivize faster portfolio shifts to clean tech. | When out of the possible trajectories towards sustainability one is supported that increases OSA (e.g., by building incentives for sufficiency and regional development). | When out of the possible trajectories towards sustainability a trajectory is supported that reduces OSA (e.g. by neglecting circular economy considerations and new one-sided dependencies). | *Creating rules and support for the newly emerging sustainable regimes* in a way that minimizes conflicts with and harnesses benefits to OSA.<br>*Coordinating between ministries and other actors* that are responsible for sustainability, trade and security to support establishment of mutually supportive ST and OSA rules of the game.<br>*Co-creating policy mixes* with multiple stakeholders taking on board and integrating different policy objectives in a balanced and synergetic manner (ST, OSA, competitiveness, justice, etc.) |
| 5. Addressing broader repercussions of regime destabilisation | To mitigate and manage the broader social impacts of phase-out and system change, e.g., reducing negative socio-economic impacts, including social deliberation, and address security implications. | Regional development policies, just transition initiatives, education, and retraining. Ex-ante valuation and foresight that assess security impacts of transitions. | When efforts for OSA lead to new employment in regions, it can be compatible with just transitions.<br>When efforts to address the security implications of transitions also reduce security of supply and trade risks. | | Design policies for regional development and just transition so that they, whilst addressing the repercussions of transitions, also create new industries and employment facilitating OSA.a<br>Creating mechanisms that at the earliest opportunity evaluate and address potential negative security of supply and trade security implications of transitions.<br>Compensating to those 'losing' from the transition both within and outside the EU. For instance, foreign aid targeting areas where fossil fuels, meat, or other unsustainable products have been previously imported from. |

| Policy intervention point | Explanation for transitions | Policy instruments | Potential synergies | Potential trade-offs | Creating alignment between ST and OSA |
|---|---|---|---|---|---|
| 6. Providing coordination to multi-regime interactions | To facilitate policy alignment between regimes and provide coordination for goals that span across sectoral silos. | National strategies and visions, pan-national sustainability programmes, platforms for data service coordination, and mechanisms/instruments for horizontal coherence and policy integration. | Coordination across regimes is allowing for both ST and OSA by enabling the identification of multi-regime interdependencies (e.g. across low-carbon energy and mobility, trade, security and defence). | New regimes (e.g. for energy, mobility, food, defence) are developed in siloes and with single-purpose, thereby foregoing potential synergies and risking trade-offs. | *Creating policy visions, strategies and programmes* that aim for sustainability transitions that improve OSA.<br>*Improving interactions between the regimes of critical sectors and emerging sustainability niches* with potential to improve OSA.<br>*Coordinating between ministries and other actors* that are responsible, for instance, for sustainable energy and mobility, domestic and international trade, and national defence. |
| 7. Tilting the landscape | Enabling a common directionality of change. | Establish and further develop international policy bodies (e.g. Intergovernmental Global Circular Economy Alliance, World Circular Economy Forum); active involvement in EU and product policy instruments; contribute to the integration of ST and OSA objectives into EU trade agreements. | EU-level OSA and international collaboration have potential to tilt the landscape to better support UN-SDGs. | If OSA pursuits lead to more nationalistic and autarkical approaches, transitions to sustainability may be slowed down. | *Engaging in international negotiations and agreements* that support the advancement of UN SDGs and international STI collaboration (e.g. the Indo-French bilateral agreement that focuses on security, trade and climate change). |

*Source: (Ghosh et al., 2021; Kanger et al., 2020; Kivimaa et al., 2023; Lazarevic et al., 2022; Rogge and Goedeking, 2024)*
*a) This links to previous calls to find synergies between OSA and social and territorial cohesion policy (see Domnick et al., 2023)*

# 6 Conclusions

In addition to the climate change and biodiversity challenge, policy makers and analysts in the EU are faced with new, additional challenges with the heightening importance of geopolitics and new security concerns alongside shifts in international trade relations resulting from a global rise in more protective policies and climate change-induced trade disruptions. It is important that addressing these new concerns do not overtake the substantial problems related to exacerbating climate change, biodiversity loss and other environmental crises – and that the policy ambitions to achieve sustainability transitions are maintained on the agenda, such as those in the Green Deal. Hence, a combined approach to the two policy objectives of sustainability transitions (ST) and open strategic autonomy (OSA) is needed – which together can contribute to increasing the competitiveness of Europe. Drawing from the academic literature and our own insights generated for this concept paper, we provide some starting points for an improved alignment of ST and OSA.

First, creating improved alignment between the policy objectives for sustainability transitions and open strategic autonomy means an increasingly heightened role for cross-domain policy networks and coordination – i.e. identification of critical sectors, key technologies, needed capabilities and favourable international relations that benefit both OSA and ST. It is not sufficient that such networks are ad-hoc and informal, but rather they require formalised processes to improve policy coherence. Important conditions for such increased strategic intelligence and improved coordination are foresight capacity, geopolitical skills and sustainability monitoring, to name but a few examples of the required state capacity.

Second, for innovation and industrial policy engaged with the development of new technologies and industries, the alignment of the two policy objectives implies the integration of the means often associated with OSA, i.e., increasing domestic production and sourcing of clean tech, improving resource and energy efficiency, and creating and maintaining diverse and more reliable international networks. This calls for balancing OSA with ST objectives, such as resource and energy demand reduction, or the wider diffusion of green technologies in just sustainability transitions. The latter needs to consider not only questions of justice within Europe and current generations but also global and intergenerational justice.

Third, already existing sustainability innovations (e.g. related to renewable energy, energy efficiency, circular economy, demand response services, plant-based proteins, mobility services aimed for reduced car ownership) provide plenty of potential for OSA, but require replication in different locations within the EU, the scaling and wider diffusion of such innovations by supporting the emerging new socio-technical regimes in areas where such innovations are available. Such support is more effective when it also includes the deliberate discontinuation of unsustainable technologies, fuels and practises, such as through pricing GHG emissions or phasing out preferential tax treatment for fossil fuels. In addition, the emergence and diffusion of sustainability solutions benefits from the EU remaining open to international STI and RTD collaboration and trade, to complement its own capabilities and resources for carrying out sustainability transitions.

Fourth, combining OSA and ST also presents challenges from the human capital perspective: There is a need to improve skills, capabilities, competencies and education in critical sustainability solutions across all sectors of the economy as well as in public sector organisations. At the same time, efforts need to be made to advance the unlearning of old ways of thinking. Indeed, for transitions to be successful in achieving sustainability objectives alongside open strategic autonomy, existing institutions that have led to unsustainable systems and critical dependencies

will have to be disrupted, phased-out and replaced with adjusted rules governing Europe's systems of production and consumption.

In sum, alignment of OSA with ST requires active efforts from decision makers and the public sector together with private sector actors leading in sustainability. Actors need to be willing to unlearn established yet unsustainable ways of thinking, organising and doing; they also need to increase their interactions across sectors and organisations; and they must invest to increase their transformative capacity. This requires the allocation of new financial and human resources by public and private sectors alike – with potential payback from successful alignment activities. And it requires a clear vision and division of roles for achieving this vision of a future that bridges sustainability and open strategic autonomy objectives.

Implementing such a vision call for policy mixes integrating OSA with ST, which will require:

- Development of competencies across ST and OSA (training, education, recruitment, networking across administrative and industrial sectors).
- R&D funding and experimental innovation policies in support of technological and service innovations that benefit both ST and OSA.
- Revision of fiscal policies to be of supportive of both ST and OSA.
- International collaboration and diplomacy combining ST and OSA.
- Policies to improve local resilience covering geopolitical and trade as well as climate and environment-related risks.
- Continuation of EU policies oriented to networking between EU regions and combining just transitions with new sustainability sectors and job opportunities.
- Improved and interconnected foresight and transition-oriented arenas – resulting in new policy visions, strategies and programmes bridging OSA and ST.
- Creating tools, models and evaluation frameworks for ex-ante and interim assessments of the OSA impacts of unfolding sustainability transitions and the ST impacts of OSA policies.

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