POLICY ANALYSIS

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NOT ALL DEPENDENCIES ARE EQUAL:

EUROPE'S ENERGY TRANSITION IN THE WAKE OF GEOPOLITICAL CRISIS

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EXECUTIVE SUMMARY

This Policy Analysis argues that Europe's energy transition is no longer primarily a climate project but increasingly a geopolitical and technopolitical transformation shaped by three tensions: the shift from fossil resource dependence to technological dependence, the balance between European integration and energy sovereignty, and the political legitimacy of new energy infrastructures.

KEY INSIGHTS

1 **Renewable energy is becoming a pillar of European energy security.**
Fossil fuel supply chains depend on continuous flows of resources through pipelines, shipping routes, and geopolitical chokepoints. Electricity from domestic wind and solar power, by contrast, cannot easily be embargoed or disrupted by foreign actors.

2 **The energy transition does not eliminate dependency; it transforms it.**
As fossil fuel imports decline, Europe becomes increasingly reliant on global manufacturing supply chains for renewable technologies and critical raw materials, many of which are currently dominated by China. Yet technological dependence differs from fossil resource dependence: once installed, renewable technologies continue producing energy, whereas fossil systems require uninterrupted fuel flows. Rapid deployment of renewable technologies may therefore reduce Europe's overall geopolitical vulnerability even if it temporarily relies on Chinese manufacturing.

3 **Renewable energy creates a new tension between integration and sovereignty.**
Large-scale European grid integration improves efficiency and stability, while decentralized renewable systems strengthen local resilience and energy autonomy. Managing this balance will be central to Europe's future energy architecture.

4 **The energy transition is also a technopolitical transformation.**
Energy infrastructure shapes political legitimacy and public participation. The expansion of rooftop solar systems and energy communities across Europe shows that citizens are becoming active participants in energy systems rather than passive consumers.

Taken together, these developments suggest that Europe's energy transition must be understood as the design of resilient sociotechnical systems capable of navigating geopolitical uncertainty.

ZUSAMMENFASSUNG

Diese Kurzanalyse zeigt, dass Europas Energiewende nicht mehr in erster Linie ein Klimaprojekt ist, sondern zunehmend eine geopolitische und technopolitische Transformation, die von drei Spannungen geprägt wird: dem Übergang von der Abhängigkeit von fossilen Ressourcen hin zur technologischen Abhängigkeit, dem Gleichgewicht zwischen europäischer Integration und Energiesouveränität sowie der politischen Legitimität neuer Energieinfrastrukturen.

KEY INSIGHTS

Vier zentrale Erkenntnisse ergeben sich daraus:

1 Erneuerbare Energien werden zu einem Pfeiler der europäischen Energiesicherheit.
Lieferketten für fossile Brennstoffe hängen von kontinuierlichen Strömen über Pipelines, Schifffahrtsrouten und geopolitische Engpässe ab. Elektrizität aus heimischen Wind- und Solarkraftanlagen hingegen kann von ausländischen Akteuren nicht so leicht blockiert oder gestört werden.

2 Die Energiewende beseitigt Abhängigkeiten nicht, sondern transformiert sie.
Mit abnehmenden fossilen Brennstoffimporten wird Europa zunehmend auf globale Produktionsketten für erneuerbare Technologien und kritische Rohstoffe angewiesen, von denen viele derzeit von China dominiert werden. Technologische Abhängigkeit unterscheidet sich jedoch von fossiler Rohstoffabhängigkeit: Einmal installierte erneuerbare Technologien produzieren kontinuierlich Energie, während fossile Systeme einen ununterbrochenen Nachschub benötigen. Ein schneller Ausbau erneuerbarer Technologien kann daher Europas geopolitische Verwundbarkeit insgesamt reduzieren, auch wenn vorübergehend eine Abhängigkeit von chinesischer Produktion besteht.

3 Erneuerbare Energien schaffen eine neue Spannung zwischen Integration und Souveränität.
Eine großflächige europäische Netzintegration verbessert Effizienz und Stabilität, während dezentrale erneuerbare Systeme lokale Resilienz und Energieautonomie stärken. Das Management dieses Gleichgewichts wird zentral für die künftige Energiearchitektur Europas sein.

4 Die Energiewende ist auch eine technopolitische Transformation.
Energieinfrastrukturen prägen politische Legitimität und öffentliche Partizipation. Der Ausbau von Photovoltaik auf Dächern und Energiegenossenschaften in ganz Europa zeigt, dass Bürger zunehmend aktive Teilnehmer an Energiesystemen werden, statt nur passive Verbraucher zu sein.

Zusammengefasst deuten diese Entwicklungen darauf hin, dass Europas Energiewende als Gestaltung resilienter soziotechnischer Systeme verstanden werden muss, die geopolitische Unsicherheiten bewältigen können.

1. ENERGY SECURITY RETURNS TO GEOPOLITICS

Energy has made a dramatic re-entry onto the geopolitical stage. Europe's reawakening to the fragility of hydrocarbon supply chains has transformed renewable energy technologies from the domain of green policy enthusiasts into a question of hard security, economic stability, and strategic survival. This paper examines the geostrategic dynamics of that shift.

Disruptions to fossil fuel supply chains, first triggered by Russia's invasion of Ukraine in 2022 and more recently by the outbreak of war involving Iran, the United States, and Israel in early 2026, have pushed the energy transition out of the realm of environmental concern and into the sphere of hard security (Hobhouse, 2025; Shirreff, 2026).

The Russian invasion of Ukraine in 2022 marked a major turning point for Europe. When Russia began weaponizing gas exports, energy suddenly reappeared on Europe's geostrategic horizon (Kuzemko et al., 2022). The war revealed the extent to which Europe had underestimated the strategic risks embedded in its energy system. For years, much of Europe's industrial competitiveness and household energy supply have relied on relatively cheap Russian gas. Germany's economic model depended heavily on this arrangement, while Austria likewise maintained a high dependence on Russian gas for industrial production and residential heating (The Economist, 2022). Importantly, these relationships were not just economic; they were also deeply embedded in political and institutional networks across Europe (Faiola & Mekhennet, 2022).

The immediate consequence of the supply shock was a dramatic increase in energy prices across the continent. Concerns about electricity shortages briefly raised the possibility of rolling blackouts in parts of Europe (Hook et al., 2022). As a result, Europe scrambled to diversify its gas suppliers since 2022, substituting Russian gas (still constituting 13% of supplies in 2025) with gas from Norway (31%), the United States 25%, North Africa (13 %), Qatar (6%), as well as Azerbaijan (4%) and others (6%) (European Union, 2026; Kuzemko et al., 2022).

Yet despite Europe's ability to very quickly expand LNG infrastructure the attempt to restore energy security by diversifying away from Russian gas has proven short-lived. Within days of the United States' and Israel's attack on Iran, global oil prices surged by more than 30 percent and European natural gas benchmarks nearly doubled. If the Strait of Hormuz were to remain closed, price shocks could quickly translate into physical shortages (Economist, 2026b).

The new Gulf war, as well as the increasing unreliability of the United States as a partner, have reinforced not just the economic but also the geostrategic importance of disentangling Europe's energy landscape from the long and fraught hydrocarbon supply chains. As domestically generated energy, electricity from renewables reduces exposure to external supply shocks. Technological advances in the electrification of "everything" mean that, increasingly, each kilowatt hour of electricity that can be produced in Europe, reduces the unions dependency on fossil imports.

As a result, renewable energy technology is essential not only for climate policy but also for industrial competitiveness, economic stability, and geostrategic resilience.

2. CRISIS-INDUCED DECARBONIZATION: WHEN ENERGY TRANSITIONS EMERGE FROM DISRUPTION

Energy transitions are often imagined as the outcome of deliberate climate policy and long-term planning. Yet in many parts of the world renewable energy technologies are spreading for very different reasons. In contexts where centralized electricity systems collapse or become unreliable, decentralized renewable technologies often emerge not as instruments of climate policy but as pragmatic coping mechanisms.

This dynamic can be described as crisis-induced decarbonization: the rapid diffusion of renewable energy technologies in response to energy shortages, economic disruption, or infrastructure failure (Stubenberg, 2026a).

Over the past decade, this phenomenon has been particularly visible in fragile and conflict-affected regions. In countries such as Lebanon, Pakistan, Syria, and more recently Cuba, the deterioration of centralized electricity supply has pushed households and businesses to adopt decentralized solar systems at remarkable speed (Aklan & Al-Eryani, 2025; Economist, 2026a; Gardiner, 2025; Matallah et al., 2025). The declining cost of photovoltaic panels and battery storage has made it possible for users to bypass dysfunctional electricity systems and generate electricity locally (McKibben, 2024).

Lebanon offers one of the most striking examples of this dynamic. Following the country's financial collapse in 2019 and the subsequent breakdown of its electricity sector, large parts of the population lost reliable access to grid electricity (Human Rights Watch, 2023; Mackenzie, 2021). In response, households and businesses rushed to install solar home systems (Khzam, 2024; Moussa, 2022; Stubenberg, 2025). Within only a few years, decentralized photovoltaic systems became a central component of the country's electricity supply. Today, in rural areas, a majority of households rely on rooftop solar systems as their primary source of electricity (Khzam, 2024; Stubenberg, 2026b).

What makes these developments particularly instructive is not only the speed with which new technologies were deployed, but also the social adaptations that accompanied them. In off-grid energy systems, energy users often become active participants in managing electricity demand. Households and businesses adjust their daily routines to periods of energy abundance and scarcity. For example, many households shift energy-intensive activities such as doing the laundry to sunny mornings, while some businesses have ended their the practice of nightshifts to save on energy costs (Stubenberg, 2025).

These experiences highlight an oft-overlooked dimension of energy resilience. The stability of electricity systems does not depend solely on infrastructure and generation capacity. It also depends on the ability of users to adapt their behavior to changing energy conditions. When energy systems become more decentralized, the relationship between infrastructure and everyday life becomes more visible, and often more flexible.

In this sense, crisis-driven energy transitions reveal a broader sociotechnical dynamic. The emergence of new energy systems is not simply a matter of deploying new technologies. It also involves the gradual adaptation of social practices, economic routines, and everyday habits to new technological possibilities. Energy systems and social behavior therefore evolve together.

Although Europe's electricity systems are far more stable and integrated than those in fragile states, elements of this dynamic have also begun to appear within the European Union. Following Russia's invasion of Ukraine in 2022, soaring energy prices and fears of supply disruptions triggered a surge in demand for rooftop solar systems across many European countries.

In Austria, photovoltaic installations expanded rapidly, with roughly 6 gigawatts of solar capacity installed between 2022 and 2025, more than doubling the country's previously total-installed capacity of around 2.7 gigawatts in 2021 (Biermayr et al., 2025). Importantly, most of these new installations consist of small and medium-sized rooftop systems rather than large utility-scale solar parks. This suggests that the recent expansion of renewable energy in Austria has been driven by citizens and small businesses investing in their own electricity generation. In parallel, Austria has also seen a rapid expansion of energy communities, enabling citizens to collectively produce, share, and manage renewable electricity at the local level (Fischer et al., 2024).
The boom in distributed solar installations slowed once energy prices stabilized in 2024 and 2025 and emergency policy incentives were gradually phased out (Biermayr et al., 2025). This pattern suggests that energy insecurity and price volatility can act as powerful accelerators of renewable technology adoption, often more immediately than climate policy itself. Recent escalation of geopolitical tensions in the Middle East and the resulting volatility in global energy markets may therefore reinforce similar dynamics in the years ahead. If fossil fuel supply disruptions once again drive up energy prices, decentralized renewables will likely experience another surge in Europe and beyond.

Taken together, these developments illustrate an important lesson for energy policy. Renewable energy technologies are not only instruments of climate mitigation; they are increasingly tools of energy security and economic resilience. In contexts of crisis or uncertainty, decentralized energy systems allow households, businesses, communities and regions to regain a degree of control over their electricity supply and price developments.

Yet the rapid diffusion of renewable technologies also reveals a new dimension of Europe's energy transition. While solar panels, wind turbines and batteries allow energy to be produced locally technologies themselves are embedded in global industrial supply chains. As a result, the acceleration of renewable energy deployment is not eliminating geopolitical dependencies, it is transforming them (Overland, 2019). This shift from resource dependence to technological supply-chain dependence is the subject of the following section.

3. DEPENDENCY INVERSION: REWIRING ENERGY GEOPOLITICS

The energy transition does not eliminate geopolitical dependencies; it rewires them. As Europe decarbonizes its energy system, dependence on imported fossil fuels is gradually being replaced by dependence on the global industrial supply chains that manufacture renewable energy technologies. This shift can be understood as a process of dependency inversion: a transition from reliance on continuous flows of imported fuels to reliance on globally distributed manufacturing systems that produce the technologies of electrification (Overland, 2019; Scholten, 2018).

To understand the implications of this shift, it is useful to compare the geopolitical characteristics of fossil fuel systems with those of renewable energy technologies.

Fossil fuel systems are inherently vulnerable to geopolitical disruption because of their physical structure. Oil and gas must be extracted from specific geological deposits, transported across long distances, and refined in centralized facilities before they can be consumed. A relatively small number of regions control a large share of global reserves, while pipelines and tanker routes pass through transit corridors and maritime chokepoints such as the Strait of Hormuz or the Red Sea. These infrastructural characteristics not only shaped the global political economy, but also create multiple points of vulnerability that can be disrupted by conflict, political disputes, or sabotage, as illustrated by repeated energy crises over the past half century (Mitchell, 2011). Renewable energy technologies change this geopolitical landscape in important ways. Wind turbines and solar panels generate electricity locally and do not rely on the continuous import of fuels. Each kilowatt hour produced by a wind or solar installation replaces energy that previously had to be imported through complex hydrocarbon supply chains. However, the technologies that enable this transformation are themselves embedded in global manufacturing networks. The market for solar PV modules, batteries, electric vehicles, inverters, and many critical materials necessary for their production is dominated by China.

Chinese companies today account for roughly 80–90 percent of global solar photovoltaic manufacturing capacity (Hobhouse, 2026; Kuzior et al., 2025). The country also produces around three quarters of the world's lithium-ion batteries and has emerged as the leading manufacturer of electric vehicles and energy storage systems. Beyond manufacturing, China occupies a dominant position in the processing, and to a lesser extent the extraction, of critical raw materials such as graphite, cobalt, lithium, and rare earth elements (Andrews-Speed & Hove, 2023). As a result, the rapid expansion of renewable energy capacity in Europe and elsewhere is deeply intertwined with Chinese industrial and technological capabilities.

This concentration has raised concerns among policymakers that Europe may simply replace dependence on hydrocarbons from Russia or the Gulf with dependence on Chinese manufacturing. These concerns have prompted a range of policy initiatives aimed at strengthening European industrial capacity, including the Net-Zero Industry Act, the Critical Raw Materials Act, and the REPowerEU strategy.

Together, these initiatives form part of the European Union's emerging strategy of "de-risking" economic relations with China. Rather than pursuing full decoupling, European policymakers have increasingly emphasized the need to reduce strategic vulnerabilities in critical sectors while preserving the benefits of global trade. This balancing act raises an important strategic question. Efforts to reduce technological dependence must be weighed against the urgent need to rapidly expand renewable energy capacity. Slowing deployment to rebuild domestic manufacturing could inadvertently prolong Europe's exposure to the far more volatile geopolitics of fossil fuel markets.

3. HOW TECHNOLOGICAL DEPENDENCE DIFFERS FROM FOSSIL DEPENDENCE

Fossil fuel systems rely on continuous resource flows. Oil and gas must be extracted, transported, and delivered every day in order to sustain economic activity. Interruptions to these flows can have immediate and severe consequences, as repeated energy crises have demonstrated. Renewable energy technologies operate differently. Solar panels, wind turbines, and battery systems are capital goods: they require an upfront investment but continue to generate electricity for decades once installed. Even if geopolitical tensions were to disrupt supply chains for new equipment, the existing installed capacity would continue to produce energy.

This distinction has important strategic implications. A country that depends on imported oil or gas can be placed under immediate pressure if supply flows are interrupted. In contrast, relying on imported technologies creates a different set of vulnerabilities. While the expansion of infrastructure may be constrained, existing electricity generation continues to function. The case of Russia (currently sanctioned from accessing most advanced western technologies) suggests that foreign technology supply chains are easier to circumvent, substitute and copy than resources.

Importantly, Europe and the rest of the world have also benefited enormously from China's industrial scale in renewable manufacturing. China's dominance in solar modules, batteries, and related components has driven down costs dramatically, turning renewables from a niche option into some of the cheapest forms of electricity generation available (Garcia Herrero & Mu, 2026). This creates a strategic paradox: the concentration that now generates fears of dependence is also what made rapid decarbonization economically feasible.

Yet the risks of this dependence are real and unfold differently over time. In the short term, reliance on Chinese manufacturing accelerates deployment and reduces Europe's immediate exposure to fossil-fuel price shocks and geopolitical coercion. In the medium and long term, however, it creates new strategic vulnerabilities. These lie not only in the concentration of manufacturing capacity for solar modules, batteries, inverters, and power electronics, but also upstream in critical raw materials such as lithium, cobalt, rare earths, and processed minerals, where supply chains are often even more geographically concentrated. Europe thus faces a double dependence: on where clean-energy technologies are made and on where the materials underpinning them are mined, refined, and processed.

These supply chains may themselves become instruments of geopolitical leverage. Unlike fossil fuels, they do not threaten the immediate daily flow of energy once infrastructure is installed. But they can constrain the speed of deployment, repair, maintenance, upgrading, and future system expansion through export controls, industrial policy, or strategic disruption. At the same time, the growing digitalization of energy infrastructure introduces additional vulnerabilities. Smart inverters, battery management systems, and grid control software create cybersecurity and maintenance risks that must now be treated as part of energy security.

Nevertheless, the comparison with fossil dependence still points to an important strategic trade-off. Slowing renewable deployment in order to reduce reliance on Chinese manufacturing could prolong Europe's exposure to the more immediate and volatile geopolitics of fossil-fuel markets (Overland, 2019). Rapid deployment may therefore remain the more prudent course: it reduces hydrocarbon dependence now, while buying time to diversify supply chains, strengthen cybersecurity, expand recycling, and rebuild domestic industrial capacity. Dependency inversion, in this sense, does not eliminate risk. It shifts Europe toward a form of dependence that is generally less immediate, less coercive, and more manageable than dependence on imported fossil fuels.

4. INTEGRATION VS SOVEREIGNTY: AN EMERGING STRATEGIC TENSION

Renewable electricity systems are defined by a fundamental technical constraint: variability. Wind and solar power fluctuate across time and space: the sun does not always shine, the wind does not always blow, and both are unevenly distributed across Europe. Unlike fossil-fuel systems, where energy can be dispatched on demand, renewable-based systems must continuously balance these fluctuations.

Two principal strategies exist to manage this variability. One is to expand the spatial scale of the system, integrating electricity grids across regions so that surplus generation in one area can compensate for shortages in another. The other is to balance supply and demand more locally, through storage technologies such as pumped hydropower or batteries, as well as through adapting patterns of consumption. In practice, renewable energy systems combine both approaches, but the balance between them has important political and institutional implications (Kallbekken et al., 2026). Energy infrastructure is never purely technical. Decisions about how electricity is produced, distributed, and governed shape economic interests, political authority, and public participation (Boyer, 2014). The design of renewable energy systems is therefore also a question of technopolitics: how technological infrastructures interact with social practices and political institutions (Hecht, 2012; Hughes et al., 2001).

The transition to renewable energy thus not only alters Europe's external dependencies, it also reshapes the internal organization of its energy systems. Large-scale integration promises efficiency, cost reduction, and system stability. At the same time, renewable technologies enable new forms of decentralization, allowing households, communities, and regions to generate and manage electricity closer to where it is consumed. Crucially, however, decentralization does not take a single form.

On the one hand, decentralized energy systems can strengthen resilience and political legitimacy. Rooftop solar, local storage, and energy communities enable citizens to participate directly in energy production and increase local ownership. At the same time, a growing share of small-scale, distributed generation can pose new challenges for grid management, including issues of balancing, cost allocation, and system stability (Hirth & Diermann, 2025). However, such challenges should not negate the value of decentralization; rather, they underscore the need for appropriate market design, grid investment, and digital coordination.

On the other hand, local opposition to energy infrastructure, including transmission lines, wind farms, or large-scale solar projects, can constrain system integration. Such resistance is often driven by concerns over landscape, fairness, or distributional impacts, but is also increasingly mobilized within broader political narratives skeptical of European integration or climate policy (Drikx, 2024; Mathiesen & Camut, 2024; Weisskircher & Volk, 2026). While both dynamics invoke ideas of “local control” or “sovereignty,” they have fundamentally different implications: one expands participation within the energy system, the other can obstruct the infrastructure required to make that system function at scale.

The emerging tension is therefore not simply between integration and decentralization, but between different visions of how authority, participation, and infrastructure should be organized across scales. Managing this tension will be central to the design of resilient and politically sustainable energy systems.

Austria illustrates this dynamic. On the one hand, Alpine hydropower reservoirs already function as a form of large-scale energy storage within the European electricity system, absorbing excess electricity, particularly solar power from southern Germany, and releasing it when demand rises. In this sense, the Austrian Alps effectively act as a “battery,” contributing to grid stability across Central Europe (Landry, 2025). At a larger scale, proposals for a European supergrid aim to further expand such cross-border integration.

On the other hand, Austria has also seen rapid growth in rooftop solar systems and local energy communities. These initiatives not only contribute to renewable energy deployment, but also create new forms of local ownership and participation. Importantly, such forms of decentralization do not replace large-scale infrastructure; they complement it. While integrated systems are essential for balancing variability and supporting industrial demand, local participation can enhance resilience in times of crisis and strengthen societal support for the larger scale shifts in Europe’s energy landscape. (Mey et al., 2025; Nilson & Stedman, 2023).

5. TOWARD A RESILIENT EUROPEAN ENERGY SYSTEM: CONCLUSIONS AND POLICY RECOMMENDATIONS

Europe's energy transition can no longer be understood as a process of decarbonization alone. As this paper has argued, it is simultaneously a geopolitical realignment, a transformation of technological dependencies, and a reconfiguration of the relationship between energy infrastructure and political legitimacy. The transition away from fossil fuels reduces Europe's exposure to volatile and conflict-prone hydrocarbon supply chains, yet introduces new forms of dependence on global manufacturing networks and critical materials.

This shift should not be misunderstood as a simple move from dependence to independence. Europe is not escaping interdependence; it is reorganizing it. The central strategic question is therefore not whether dependency can be eliminated, but whether it can be shifted from forms that are immediate, coercive, and crisis-prone toward forms that are slower-moving, more governable, and more politically manageable.

The same applies to the organization of the energy system itself. The challenge is not to choose between integration and sovereignty, but to design systems that combine both. A resilient European energy system will likely resemble a layered structure: interconnected grids that balance variability across regions, complemented by decentralized generation, storage, and flexible demand at the local level. Such a system can enhance both technical robustness and political legitimacy, provided that citizens and communities are not treated merely as end-users, but as active participants in shaping energy systems.

The implications for energy policy are clear. Europe's energy transition must be guided not only by efficiency, but by the need to manage dependency inversion strategically: reducing vulnerability to fossil-fuel coercion while diversifying technological supply chains, strengthening infrastructure resilience, and embedding energy systems within society.

1. DESIGN FOR RESILIENT INTERDEPENDENCE

Europe should move beyond the false choice between integration and sovereignty. A resilient energy system combines both: deep cross-border integration to balance variability at scale, and decentralized generation and storage to increase redundancy and absorb shocks. The goal is not energy independence, but interdependence that is diversified, layered, and robust.

2. USE CRISES TO ACCELERATE STRUCTURAL CHANGE

Energy crises reveal how quickly households, firms, and institutions can adapt under pressure. Policies should lock in these adaptive capacities by promoting demand-side flexibility, dynamic pricing, digital energy management, and distributed storage. The aim should be to turn temporary crisis responses into durable system features.

3. BUILD LEGITIMACY THROUGH PARTICIPATION

The energy transition will only succeed if it is socially embedded. Policies should integrate citizens, communities, and local actors as active participants through energy communities, distributed generation, and fair market access and locally responsive price signals. Participation strengthens resilience and broadens ownership, while also helping secure support for the larger infrastructure needed to operate the system at scale.

4. MANAGE DEPENDENCIES STRATEGICALLY, NOT DEFENSIVELY

Europe cannot eliminate external dependencies, but it can shape them. Rapid deployment of clean technologies should remain the priority, even where this requires reliance on global supply chains in the short term. At the same time, targeted investments in domestic capabilities, supply diversification, recycling, and cybersecurity can reduce strategic vulnerabilities over time without slowing the transition.

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