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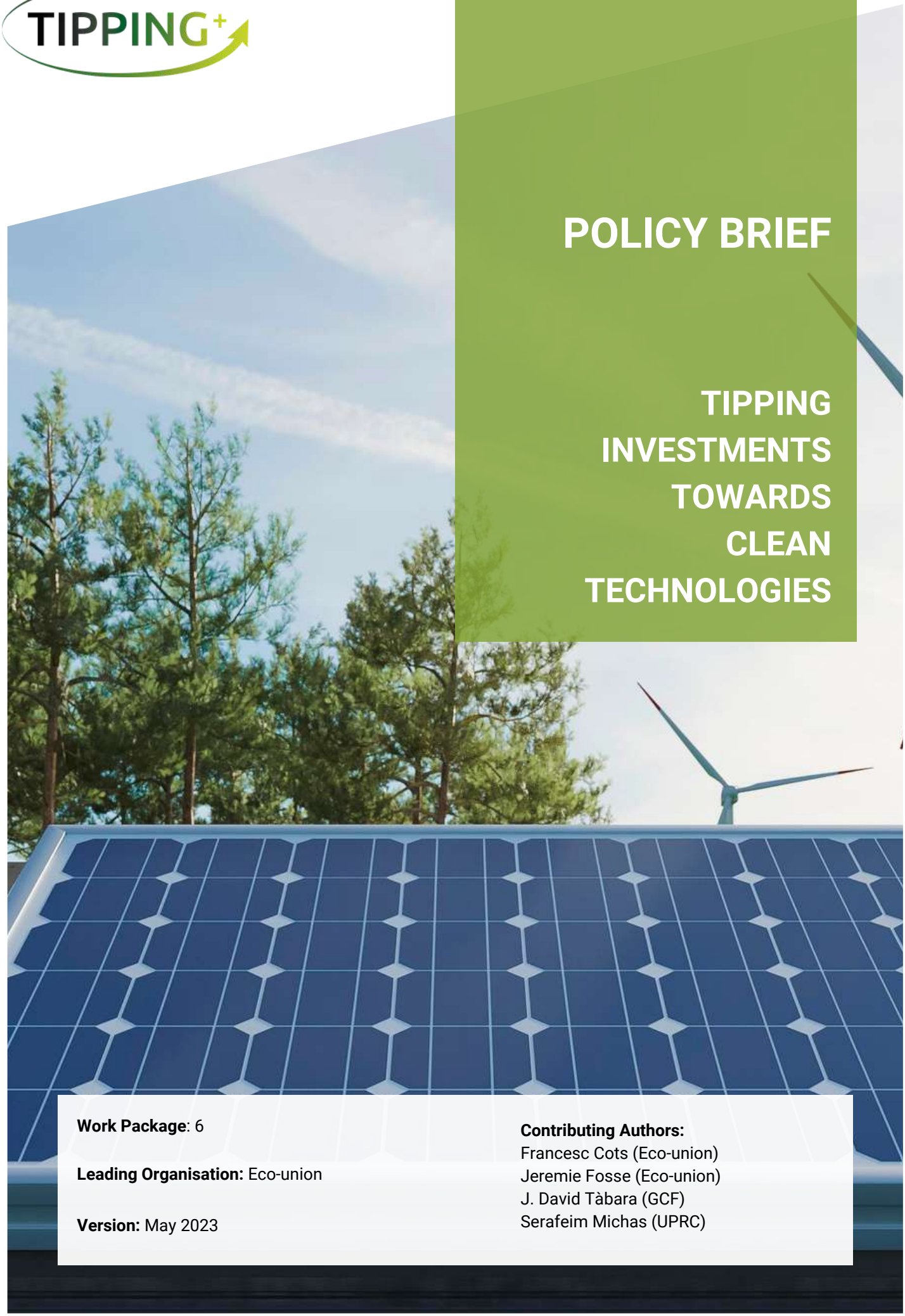
POLICY BRIEF

TIPPING INVESTMENTS TOWARDS CLEAN TECHNOLOGIES



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Summary

This policy brief draws on the results of the TIPPING+ research project and its case studies, to share insights on **how to accelerate systemic investments** towards clean technologies in **Coal and Carbon Intensive Regions (CCIRs)**. In order to do that, it adopts a full-systems transformations perspective, that highlights the importance for policy makers and economic entrepreneurs, to identify the key opportunity spaces, actors, needs, capacities and a portfolio of required **strategic sensitive interventions**, necessary to connect and synergize investments chains in both **upstream** (e.g., extraction) and **downstream** (end- products production) technological and market operations.

This is the case, for instance, of **high-energy intensive sectors**, where large public investments are needed to connect **steel production** to green energy sources, such as with **green hydrogen**. At the different stages of such complex tranformative processes, it may be necessary to deploy a variety and tailor-made **financial incentives,, infrastructural support, and regulations**. These may include **carbon pricing, or removal of perverse subsidies** to prompt research and development in strategic areas and raise **consumer awareness** for the benefits of low-carbon alternatives that favour technological change, as is the case with electric mobility.

A **positive tipping point** in this area occurs when, as a result of multiple **R&D learning feedbacks**, the costs of investing in green technologies are reduced, and the revenues generated from them increase to a **critical threshold** whereby it becomes more profitable to invest in **green development pathways**. From there, multiple self-reinforcing processes supported by **policy interventions**, further accelerate economic returns, social innovations and spill over positively to other sustainability goals.

Objective

The **acceleration of investments** in clean technologies is not only the result of attaining EU and international **climate policy objectives** to decarbonise energy production and phase out coal, but it is also an autonomous and endogenous development derived from their **increased profitability**. A key challenge is matching both new demand-driven trends in citizens' lifestyles towards greener patterns **of consumption**, with **new energy production alternatives and technologies** that reduce reliance on fossil fuels.

Strategic investments in clean technologies can create **quality jobs**, stimulate green **economic growth**, and improve **economic competitiveness,** thus generating further positive feedbacks in the **reduction of energy costs** for consumers and businesses. Additional **co-benefits** include generating products and services that improve **public health**, which is of particular importance in urban contexts and communities that have been traditionally disproportionately affected by pollution. In this policy brief, we provide some insights on **how to accelerate distributed forms of investments**, triggering self-propelling positive shifts toward low-carbon energy technologies.

Background

Different policy measures identified within the TIPPING+ case studies can contribute to generating the conditions for accelerated investments in clean technologies. These include early strategic **public support in disruptive technologies**, the **removal of perverse subsidies** to coal and carbon infrastructures, the deployment of a suit of diverse **economic incentives**, more stringent **environmental regulations**, as well as **education and training programs**, aimed at supporting **research and development** processes, as well as, new **start-ups** and **businesses**.

However, each of these measures need to be combined, timely applied, and targeted to different actors, to avoid, among other things, excessive capital concentration at early stages of development. A **diversified portfolio and combination of policy measures** can create the transformative conditions to move the investment ecosystem to a critical mass, where positive feedbacks will overcome potential resistances and inertias to change.

Aligned with Wright's Law', with appropriate policy measures, the **costs of technologies will fall** due to their cumulative production, reinforcing feedbacks derived from learning by doing and further economies of scale, thus making the new ones increasingly affordable. These technologies and their products and services, may also become more attractive because of their improved **quality and reliability**. And in doing so, they will also turn out to be **more accessible**, as the new and more efficient solutions may also be accompanied with the development of additional **public infrastructures** and **public-private partnerships**, aimed at increasing the scale of their implementation.

Policy measures to support investments in clean technologies in CCIRs:

- ✓ **Financial tools**: tax credits, grants, and low-interest loans.
- ✓ **Environmental Regulations** that penalize the use of high-carbon sources and favour clean technologies.
- ✓ **Public investment** in research and development to drive innovation and reduce costs.
- ✓ **Education and training programs** in clean technology installation, maintenance, and management.
- ✓ **Consumer awareness** about the benefits of clean technologies through education and communication.
- ✓ **Financial incentives** through carbon pricing systems, carbon taxes, phase out of fossil subsidies, etc.
- ✓ Investments in **clean energy infrastructure and transmission grids**.
- ✓ **Public-private partnerships** to bring together government, industry, and academia.
- ✓ **Public disclosure of potential stranded carbon assets**, taking into account various climate scenarios and time scales, to accelerate financial flows towards green technologies.

Key Messages

In exploring the economics of the emergence of **new technologies**, positive feedback loops are associated with multiple factors and **three main stages**:

1. **Preparing the conditions for systemic change**: Create the previous transformative endogenous conditions for building a disruptive technology.
2. **Triggering the tipping point**: Due to an additional relatively small innovation or investment, eventually such disruptive technologies, cross a given threshold of feasibility, affordability and profitability.
3. **Managing new system conditions**: Spread, upscale and connect such technologies and their multiple co-benefits, to multiple applications and sectors, e.g., in a form of industrial ecosystem.

In addition, such positive tipping points in green technology investments, can be associated to deliberate strategies that have to do with:

- **The management of self-reinforcing expectations of the viability**, **cost effectiveness**, **and profitability** of the novel technologies.
- **The learning effects leading to further reduction of costs** as production is optimised. And in particular, ensuring that the increase in the use of one technology reinforces other technologies and practices that make it more useful.
- **Network building**, **public-private partnerships**, **and coordination effects**, so that the benefits of going along with others are fairly distributed.
- **The creation of economies of scale** which imply lower unit costs of the technology, once the initial fixed costs have been incurred. But at the same time, avoid excessive concentration that may negatively affect economic resilience.
- **The diffusion of new social norms and changes in consumer preferences** that increase acceptability of the novel technology.

1. Building the conditions for disruptive technologies to emerge

Even though many clean technologies are mature enough (e.g., solar PV, wind turbines, etc.), in many other fields there are still lots of **uncertainties** about which type of technologies will prevail, and thus on where to invest capital accordingly. It is therefore possible that new **disruptive green technologies** could emerge. So keeping a diversified portfolio in green technologies is a cautionary way to proceed at this stage. On the other hand, still half of the required emissions reductions to reach net zero, demand technologies which are not yet commercially viable, such as, clean hydrogen, carbon capture, etc. At this early stage, focusing on **open knowledge research**, managing Intellectual Property, and understanding the potential and limitations of different types of low-carbon technologies in an exploratory fashion, plays a key role in reducing uncertainties about which technologies will prevail. This stage is followed, by an **evolutionary process** that moves from identifying an initial, highly diverse mix of technologies, to a more reduced and viable range of technological and investment options, as knowledge and experience keeps accumulating.

At this stage, the role of **early adopters and frontrunners** becomes critical, but public authorities need to identify and support them, addressing those **entrepreneurs** that have more **innovation potential**, and whose products and services could have a **bigger impact** in the reduction of carbon emissions across sectors. For that, **public authorities** can make use of **governmental procurement**, such as **innovative tenders** and other financing tools, to ensure that the talent and capacities associated with low-carbon technological innovators is not lost or neglected. This stage applies to the selection and promotion of **pilot projects** which will allow for an earlier identification of needs, barriers and most feasible solutions. In this stage, the creation of **public-private partnerships** is also importnat, to implement and develop the most promising projects, bringing together adequate resources and expertise of the government, industry, and academia.

2. Accelerating change with relatively small additional investments and concerted policy measures

It must be borne in mind that some more promising technologies may have already been identified, and thus they may interact with each other. At this point, a relatively small innovation or investment has the potential to create a cascade of **positive feedback loops**, triggering a larger sectoral or even systemic transformation. So, this is the moment where it is worth investing in those technologies, more likely to take up and amplify **positive effects on other clean technologies**. For instance, investing in new materials for batteries using a full supply-demand chain, can have positive effects in the development of solar panels, electric vehicles and many other products and services. Furthermore, regulatory frameworks and schemes can help not only to promote the emerging technologies, but also to initiate the phase-out of the old technologies. This may be achieved by applying specific measures, such as carbon pricing schemes or Pigovian taxes, which can contribute in keeping energy prices relatively low, and/or allowing cleaner industries in the region to have competitive advantages.

The monitoring and assessment of **research and development programs**, should then allow to qualify the outcomes of pilot projects, in a way that the so-called **sensitive intervention points** (i.e., those interventions with larger systemic effects) could be implemented. It is a moment where the system may be getting closer to a larger **sectoral or systemic change**, so efforts should be allocated to discern and choose the **mix of technologies** that should be upscaled. The appropriate selection of the technology, considering not only what will be **upscaled** but how it will be **diffused** and which **effects** could have on other **social or environmental dimensions**, is crucial. This will determine the success or failure of the investments at larger scales that will follow.

In this regard, it is important to anticipate the different kinds of consequences of upscaling the technology, taking into account not only whether the technology is mature enough, but also the **implications for the whole system** in which it embeds. This includes the **availability of the workforce and re-skilling needs**, how to connect the full **supply chain**, and the required **infrastructure investments**, such as green energy grids. Hence, focusing first on those technologies that are more available, even though they imply a lower degree of ambition in carbon emissions reduction, such as gas-based technologies instead of renewables, may not be the most adequate strategy. Instead, it may delay an early adoption of most disruptive technologies, and may be counterproductive, since all the efforts to transition the workforce and supply change capacities will need to be restarted too late.

3. Spreading, upscaling and consolidating investements in clean technologies

At this stage, certain technologies will have already proven their **market viability**. From here, their increased **feasibility**, **affordability** and **profitability** mean that investments can be spread to the design of new and different products, and to meeting needs previously covered by older and less carbon-efficient technologies. At this stage, when the breakthrough of low-carbon technologies has already been achieved, their diffusion can potentially have far-reaching tipping effects that might also be quantified on a macroeconomic scale (e.g., the case of the creation of new jobs and green economic growth). This can create amplifying synergies of consumption-production, derived from changes in consumer preferences and a growing awareness about the benefits of clean technologies.

To support those changes, **education and marketing** campaigns can help to adopt these new products, and in turn further lower the costs of their production. **Policy programs** may then be directed to support the implementation of **new production processes**, in ways that are adapted to a **diversity of regional conditions**, reflecting the specificities of different EU Coal and Carbon Intensive Regions. In addition, the **public disclosure** of potentially stranded financial assets, e.g., derived from more stringent decarbonisation policies, may accelerate even further investment flows towards green technologies.

Insights from Case Studies

In former coal city of **Andorra (Spain)**, large energy operators, international investors and local companies competed for access to the 1,200 MW energy network that was freed up following the closing down of the coal thermal power plant in June 2020. **Endesa**, through its renewable subsidiary Enel Green Power España, has been the winner of the public tender from the governmental Spanish Institute for Just Transition, obtaining the right to connect 953 megawatts (MW) and the option to confirm up to 1,200 MW. The project includes innovative aspects such as the hybridisation of solar and wind renewable projects, energy storage and the development of green hydrogen projects to decarbonise the area's industries. However, there are concerns that this technological transition and the relevant investments will not lead to adequate low-carbon, economic and business diversification, as the projects will be run by the same actors.

In **Austria**, the efforts for climate neutral basic material production related to **green hydrogen** are promoted by large and highly emitting companies. These companies are seen as forerunners and their technology experience will hopefully spillover to small and medium-sized companies, hence leading to a self-amplifying effect. However, a relevant prerequisite for the scale-up of green hydrogen technologies is the expansion of renewables and the electricity grid, as well as the expansion of transport infrastructure for hydrogen and CO2. Therefore, investing in the **expansion of renewables and the electricity grid** can create positive feedback loops for the development of other green technologies and infrastructures at large scale.

Modelling results showed that much of the electricity demand in the lignite region of **Megalopolis in Greece** could be met by the planned 500MW of photovoltaics, if they are accompanied with a battery energy storage system. At the same time, Megalopolis could be transformed into a **green energy centre** that increases Peloponnese's and Greece's renewable energy share. Furthemore, investing in energy efficiency and electrification in the **heating sector** could lead to larger reduction in the residential final energy consumption, lower CO2 emissions in 2050, and lower household energy costs, compared to using natural gas as an intermediate fuel. Therefore, questions are raised about the viability of the newly built natural gas distrubution network and the natural gas boilders that are being supplied to households free of charge. Hence, analysing alternative scenarios of decarbonisation trajectories can play a central role in planning and creating the transformative conditions for local tipping points towards decarbonisation.

In 2017, the **Italian** government validated the national energy strategy that foresaw the phase-out of coal-fired power plants, and the development of a gas pipeline for **Sardinia**. In 2019, the government approved the national integrated energy and climate plan that established the coal phase-out by 2025, and opened the discussion over what form of coal-to-gas transition to undertake, creating destabilisation dynamics over the island energy security and industrial re-opening in Sulcis. Afterwards, in 2021, the option of developing the methane pipeline project was abandoned, supporting a lighter coal-to-gas transition, and the green electrification for Sardinia. This case shows that focusing first on those technologies that are more available even though they imply a lower degree of ambition in CO2 reduction, such as gas-based technologies instead of renewables, may not be the most adequate strategy, as this may delay an early adoption of the most disruptive technologies and may be counterproductive since all the efforts to transition the workforce and supply change capacities, will need to be restarted too late.

Policy Recommendations

Enable positive tipping points in low-carbon investments by creating the right conditions from the policy perspective.

This may be achieved by implementing a combination of policy measures (financial tools and incentives, environmental regulations, public investment, public-private partnerships, etc.), as well as by supporting public campaigns aimed at raising awareness about consumption and production alternatives, among other deliberate actions.

Use a diverse portfolio of measures at different stages of the transformative tipping point processes.

For instance, at early stage, avoid the overlooking of technologies that may seem too unfeasible, by ensuring that the most disruptive ones are also being considered. Also, avoid perpetuating older, less carbon-efficient technologies that may delay the upscaling of disruptive technologies, and the reskilling of quality jobs to implement them.

After a tipping point is crossed, consider the effects of such disruptive developments across multiple dimensions and alternative pathways of development, with particular attention on equity.

Managing and enhancing multiple cascades of positive feedback loops, may affect other sectors and systems. This may have many consequences on diverse distributional and environmental aspects that need to be taken into account, as is the case with low-carbon transformations that may further push capital concentration, neglect dimensions of equity, or negatively affect biodiversity conservation.

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About TIPPING+

TIPPING+ provides an empirical in-depth social science understanding of fundamental changes in sociodemographic, geographical, psychological, cultural, political, and economic patterns which give rise to Social-Ecological Tipping Points (SETPs), both positive and negative in relation to socio-energy regional systems. Such empirical and theoretical insights sheds new light on the interdependencies between changes in regional socio-cultural structures and the technological, regulatory and investment-related requirements for embracing (or failing to embrace) low-carbon, clean-energy and competitive development pathways in selected coal and carbon intensive case study regions (CCIRs). The overall goal is to understand why and under which conditions a given social-ecological regional system heavily dependent on coal and carbon-intensive activities may flip into a low-carbon, clean energy development trajectory – or on the contrary may fall into an opposite trajectory with all its negative implications. Towards this goal, main focus of TIPPING+ is the participatory co-production of knowledge on the driving forces and deliberate tipping interventions leading to the emergence of positive tipping points toward clean energy transitions in European CCIRs.

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PARTNERS

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